Revised

Feasibility Study, Laborde Canyon (Lockheed Martin Beaumont Site 2) Beaumont, California

Prepared for:

LOCKHEED MARTIN

Prepared by:

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TC# 28535-02.0104/ November 2013

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LOCKHEED MARTIN

November 25, 2013

Mr. Daniel Zogaib
Southern California Cleanup Operations
Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Subject: Submittal of the Revised *Feasibility Study, Laborde Canyon (Lockheed Martin Beaumont Site 2), Beaumont, California*

Dear Mr. Zogaib:

Please find enclosed one hard copy of the body of the report and two compact disks with the report body and appendices of the Revised *Feasibility Study, Laborde Canyon (Lockheed Martin Beaumont Site 2), Beaumont, California.*

If you have any questions regarding this submittal, please contact me at 818-847-9901 or brian.thorne@lmco.com.

Sincerely,

Gene Matsushita for Brian

Brian Thorne, Project Lead

Enclosure: Revised *Feasibility Study, Laborde Canyon (Lockheed Martin Beaumont Site 2), Beaumont, California*

Copy: Gene Matsushita, LMC (electronic and hard copy)
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Brian Beck, Western Regional Conservation Authority (electronic copy)
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FEASIBILITY STUDY, LABORDE CANYON (LOCKHEED MARTIN BEAUMONT SITE 2) BEAUMONT, CALIFORNIA

Prepared for:

Lockheed Martin Corporation

Prepared by:

Tetra Tech, Inc.

November 2013

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ACRONYMS AND ABBREVIATIONS

AGR	agricultural water supply (surface water beneficial use)
ARAR	applicable or relevant and appropriate requirement
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
bgs	below ground surface
Cal/EPA	California Environmental Protection Agency
Cal/OSHA	California Occupational Safety and Health Administration
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDHS	California Department of Health Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CEQA	California Environmental Quality Act
CF	cubic foot
CFR	Code of Federal Regulations
CHHSL	Cal/EPA Human Health Screening Level
CIWMB	California Integrated Waste Management Board
CLC	California Labor Code
CLU-IN	USEPA Technology Innovation and Field Services Division Contaminated Site Clean-Up Information
CWC	California Water Code
CY	cubic yards
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene

DTSC	California Department of Toxic Substances Control
DWNL	drinking water notification level
EMWD	Eastern Municipal Water District
EPC	exposure point concentration
ERT	electrical resistivity tomography
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
FGC	California Fish and Game Code
FRTR	Federal Remedial Technologies Roundtable
FS	feasibility study
ft/day	feet per day
ft^2/day	square feet per day
ft/ft	feet per foot
GCR	Grand Central Rocket Company
GHG	greenhouse gases
gpd	gallons per day
gpm	gallons per minute
gpm/ft	gallons per minute per foot
GRA	general response action
GW	groundwater
GWR	groundwater recharge
HHERA	human health and ecological risk assessment
HHRA	human health risk assessment
HI	hazard index
HSC	California Health and Safety Code

HQ	hazard quotient
IC	institutional control
IND	industrial service supply (surface water beneficial use)
ISCO	*in situ* chemical oxidation
ITRC	Interstate Technology & Regulatory Council
K	hydraulic conductivity
LAC	Lockheed Aircraft Corporation
LF	linear feet
LMC	Lockheed Martin Corporation
LOAEL	lowest-observed adverse-effect level
Lockheed Martin	Lockheed Martin Corporation
LPC	Lockheed Propulsion Company
LUC	land use covenant
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MEF	Mount Eden formation
µg/kg	micrograms/kilogram
mg/kg	milligrams/kilogram
mS	milliSiemens
µg/L	micrograms/liter
msl	mean sea level
MUN	municipal and domestic supply (surface water beneficial use)
MVS	Mining Visualization System
NA or N/A	not available/not analyzed/not applicable
NAAQS	National Ambient Air Quality Standards
ND	not detected

NESHAPS	National Emission Standard for Hazardous Air Pollutants
NOAEL	no-observed adverse-effect level
NOx	nitrogen oxides
NPDES	National Pollution Discharge Elimination System
NPV	net present value
OEHHA	California Environmental Protection Agency, Office of Environmental Health Hazard Assessment
Ogden	Ogden Technology Laboratories, Inc.
OM&M	operations, maintenance, and monitoring
P&T	pump and treat
PCB	polychlorinated biphenyl
PERA	predictive ecological risk assessment
PHG	Public Health Goal
PM_{10}	particulate matter less than 10 microns in diameter
PRB	permeable reactive barrier
PRC	California Public Resources Code
PRG	preliminary remediation goals
PROC	industrial process supply (surface water beneficial use)
PVC	polyvinyl chloride
RAO	remedial action objective
RBC	risk-based concentration
RBSL	risk-based screening level
RCRA	Resource Conservation and Recovery Act
RCWMD	Riverside County Waste Management Department
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
REC1	water contact recreation (surface water beneficial use)

REC2	non-contact water recreation (surface water beneficial use)
RME	reasonable maximum exposure
RSL	Regional Screening Level
RWQCB	Regional Water Quality Control Board
SARWPCB	Santa Ana River Basin Regional Water Pollution Control Board
SARWQCB	Santa Ana Regional Water Quality Control Board
SCAQMD	South Coast Air Quality Management District
SERDP	Strategic Environmental Research and Development Program
SF	square feet
site	Laborde Canyon
SKR	Stephens' kangaroo rat
SOx	sulphur oxides
STBC	southern Test Bay Canyon
STF	San Timoteo Formation
SVOC	semivolatile organic compound
SWRCB	State Water Resources Control Board
T&E	threatened and endangered
TBC	to be considered
TCE	trichloroethene
Tetra Tech	Tetra Tech, Inc.
TMV	toxicity, mobility, or volume
TPHg	total petroleum hydrocarbons as gasoline
TPHd	total petroleum hydrocarbons as diesel
TRV	toxicity reference value
TOC	total organic carbon
UIC	Underground Injection Control

U.S.	United States
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UV	ultraviolet
UVOx	ultraviolet oxidation
VOC	volatile organic compound
WARM	warm freshwater habitat (surface water beneficial use)
WDA	Waste Discharge Area
WDR	Waste Discharge Requirements
WILD	wildlife habitat (surface water beneficial use)
WQOs	water quality objectives

EXECUTIVE SUMMARY

On behalf of Lockheed Martin Corporation, Tetra Tech, Inc. has prepared this feasibility study for Laborde Canyon (the site), located southwest of Beaumont, California. This report was prepared in response to Consent Order 88/89-034 promulgated by the California Department of Toxic Substances Control. The overall objective of the feasibility study is to develop and evaluate potential remedial action alternatives for the site that will protect human health and the environment, and be cost-effective and sustainable.

The former Lockheed Martin Corporation property (Figure ES-1) consists of 2,688 acres of land, and is currently owned by the County of Riverside, California. Between 1958 and 1974, portions of the property were used by Grand Central Rocket Company and Lockheed Propulsion Company for small rocket motor assembly, rocket motor testing operations, propellant incineration, and minor disposal. Ogden Technology Laboratories, Inc. leased portions of the property in the 1970s (Radian, 1986), and according to interviews with personnel familiar with the property, a portion of the property was also used by General Dynamics for testing a ground-penetrating radar instrument in the late 1980s (Tetra Tech, 2009a). A second property (the Gateway Property, located on Highway 60) was also part of the former Lockheed Martin facility. No historical operations are known to have been conducted on the Gateway Property.

Two major contaminant source areas are present at the property: southern Test Bay Canyon, and the Waste Discharge Area. Groundwater flow is generally to the south. In southern Test Bay Canyon, there are perchlorate impacts in soil to the water table and there is a perchlorate groundwater plume that extends approximately 1,700 feet to the south (downgradient). In the Waste Discharge Area, perchlorate, volatile organic compounds, and metals are present in soil; perchlorate, 1,4-dioxane, volatile organic compounds, and hexahydro-1,3,5-trinitro-1,3,5-triazine are present in groundwater. The Waste Discharge Area perchlorate plume extends approximately 3,700 feet to the south (downgradient), and likely extends somewhat beyond the southern boundary of the property. Samples from groundwater monitoring wells located approximately 800 feet beyond the southern boundary of the property do not contain detectable concentrations of perchlorate. Numerical groundwater flow and contaminant transport modeling (Tetra Tech, 2010b and 2011b) indicate that the southern Test Bay Canyon and Waste Discharge Area groundwater plumes are currently increasing in mass and extent. A contaminant attenuation evaluation did not identify significant attenuation of contaminants relative to the current plume mass flux rates. Attenuation by evapotranspiration and degradation due to reducing aquifer conditions may be occurring in a riparian corridor located south of the property, but these processes have not been quantitatively assessed since the riparian area is not owned or controlled by Lockheed Martin Corporation. Secondary perchlorate source areas are also present at the property in the Area M garbage disposal area and the Area K centrifuge area. However, these areas combined constitute less than one percent of the total perchlorate mass at the site.

The human health and ecological risk assessment for the site (Tetra Tech, 2012b) identified potential risks to human receptors due to exposure to a small area of cadmium-impacted shallow (less than 5 feet deep) soil at the Waste Discharge Area. Potential risks to ecological receptors were identified in both major source areas: 1) At the southern Test Bay Canyon, there is potential exposure to perchlorate in shallow soil; and 2) At the Waste Discharge Area, there is potential exposure to lead (collocated with the cadmium) in shallow soil. Risks to human receptors were also identified from potential consumption of groundwater, both on-property and potentially in the off-property area immediately downgradient of the property boundary.

Based on CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act of 1980) guidance, applicable or relevant and appropriate requirements, the results of the remedial investigation, and the risks identified by the human health and ecological risk assessment, the following medium-specific remedial action objectives were developed:

- Protect human receptors from exposure to site contaminants in soil through ingestion, inhalation, and dermal contact at concentrations exceeding preliminary remediation goals.
- Protect ecological receptors from exposure to site contaminants in soil through ingestion and food consumption at concentrations exceeding preliminary remediation goals.
- Protect human receptors from exposure to site contaminants in groundwater by ingestion at concentrations exceeding preliminary remediation goals.
- Protect groundwater resources outside the current groundwater plume by limiting the off-property migration of site contaminants at concentrations exceeding levels that are protective of designated beneficial uses.

General response actions that address one or more of the remedial action objectives were then developed and used to identify remedial technology types and process options that were potentially applicable to the site. Areas of the property where remedial actions were considered are shown in Figure ES-2. The remedial technologies and process options were then screened based on the CERCLA criteria of effectiveness, implementability, and cost. The process options that remained after screening were then used to assemble 14 remedial alternatives for the entire site that could potentially achieve the remedial action objectives. These remedial alternatives were then screened based on the CERCLA criteria of effectiveness, implementability, and cost to arrive at a subset of alternatives for detailed analysis.

General descriptions of the remedial alternatives retained for detailed analysis are as follows:

- Alternative 0—No Action (required for compliance with CERCLA)

- Alternative 3A—Limited removal of shallow soil in southern Test Bay Canyon and the Waste Discharge Area based on the results of the human health and ecological risk assessment, plume containment at the southern boundary of the property, and institutional controls

- Alternative 5A—Moderate removal of perchlorate mass in both soil and groundwater in southern Test Bay Canyon, limited removal of shallow soil in both southern Test Bay Canyon and the Waste Discharge Area based on the results of the human health and ecological risk assessment, plume containment at the southern boundary of the property, and institutional controls

- Alternative 5B—Moderate removal of perchlorate mass in groundwater in southern Test Bay Canyon, limited removal of shallow soil in southern Test Bay Canyon and the Waste Discharge Area based on the results of the human health and ecological risk assessment, plume containment at the southern boundary of the property, and institutional controls

For the detailed analysis, the alternatives were evaluated with respect to the following CERCLA criteria:

- Threshold criteria of overall protection of human health and the environment; and compliance with applicable or relevant and appropriate requirements

- Balancing criteria of long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost

Sustainability was considered as an eighth evaluation factor, based on Lockheed Martin's corporate commitment to environmental stewardship. The two threshold criteria must be met for an alternative to be eligible for selection as the site remedy; thus the balancing criteria and sustainability are the primary criteria upon which the evaluation is based.

The detailed analysis consisted of evaluating each of the alternatives against the seven CERCLA criteria and the sustainability criterion. A comparative analysis of the alternatives was then conducted, in which the relative performance of each alternative was compared with respect to each of the evaluation criteria.

Based on the results of the detailed and comparative analyses, Alternative 3A was selected as the recommended alternative for the site. This alternative consists of the following actions:

- Excavation and *ex situ* biotreatment of approximately 1,490 cubic yards of shallow soil with perchlorate concentrations that exceed preliminary remediation goals in southern Test Bay Canyon

- Excavation and off-site disposal of approximately 60 cubic yards of shallow soil with metals concentrations that exceed preliminary remediation goals in the Waste Discharge Area

- Installation of a biobarrier in south Laborde Canyon to prevent further off-property migration of perchlorate in impacted groundwater, with a contingency to switch from a biobarrier to a hydraulic containment and *ex situ* treatment system to treat perchlorate, 1,4-dioxane, and volatile organic compounds if 1,4-dioxane concentrations at the property boundary exceed drinking water standards in the future

- Implementation of institutional controls that prohibit the installation of groundwater supply wells at the property and prohibit the extraction of on-property groundwater for use as drinking water.

In a conditional approval letter dated October 24, 2013, the Department of Toxic Substances Control recommended that a pilot study of *in situ* chemical oxidation focused on remediation of the 1,4-dioxane groundwater plume be conducted. The remedial action plan for the site will therefore include a pilot study of *in situ* chemical oxidation, and a contingency for implementing a source area remedy for 1,4-dioxane. It is anticipated that the pilot study would be conducted as part of remedy implementation.

Executive Summary Figures

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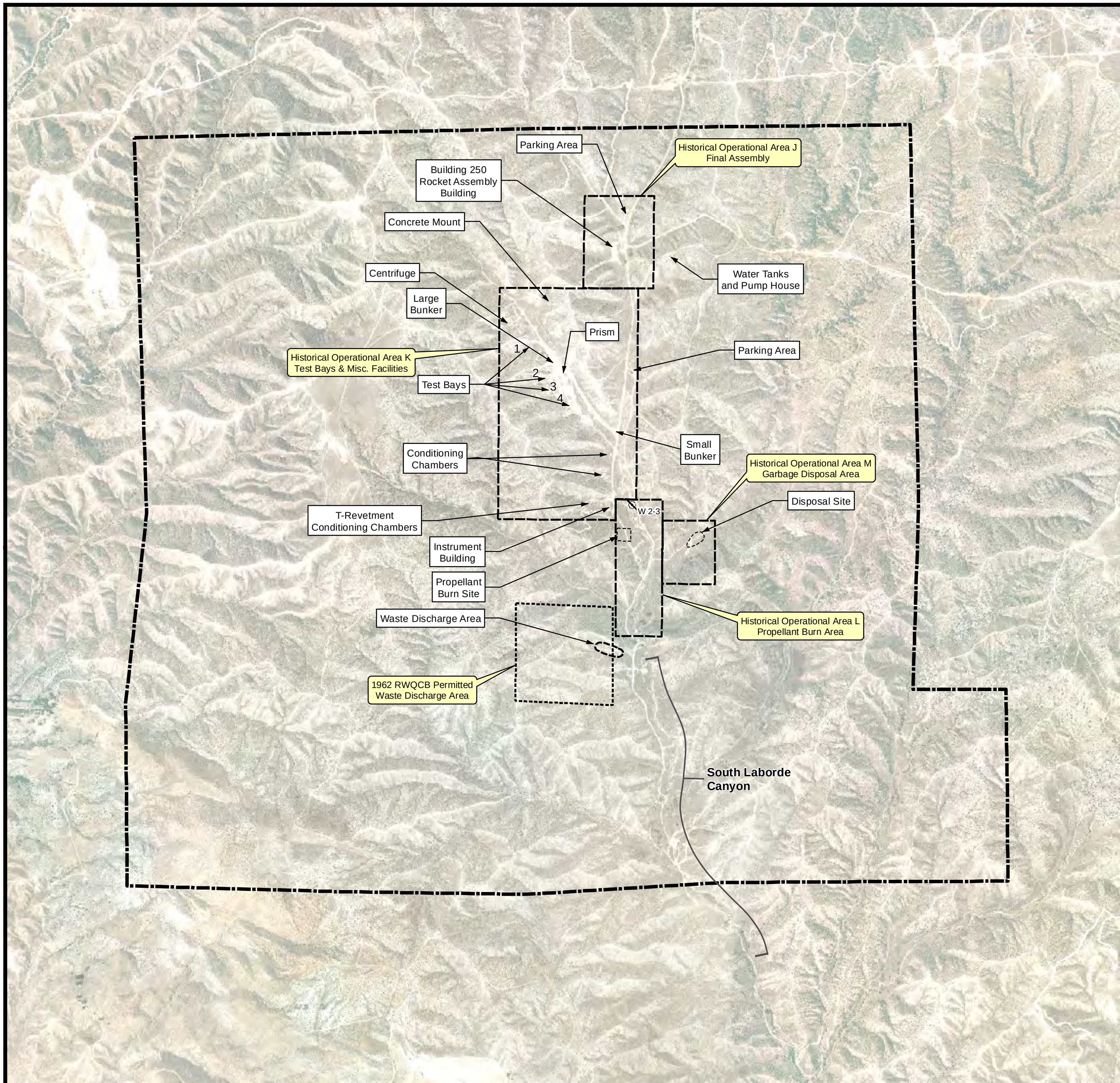

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Feet

Adapted from:

March 2007 aerial photograph.

LEGEND

Destroyed Production Well Location

RWQCB Permitted Waste Discharge Area

Historical Operational Area Boundary

Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)

Note: Laborde Canyon property boundary (Lockheed Martin Beaumont Site 2) from Hillwig-Goodrow survey, May 2004.

Disposal and Propellant Burn Site perimeters are estimated (Radian, 1986).

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure ES-1
Historical Operational Areas and Site Features

TETRA TECH

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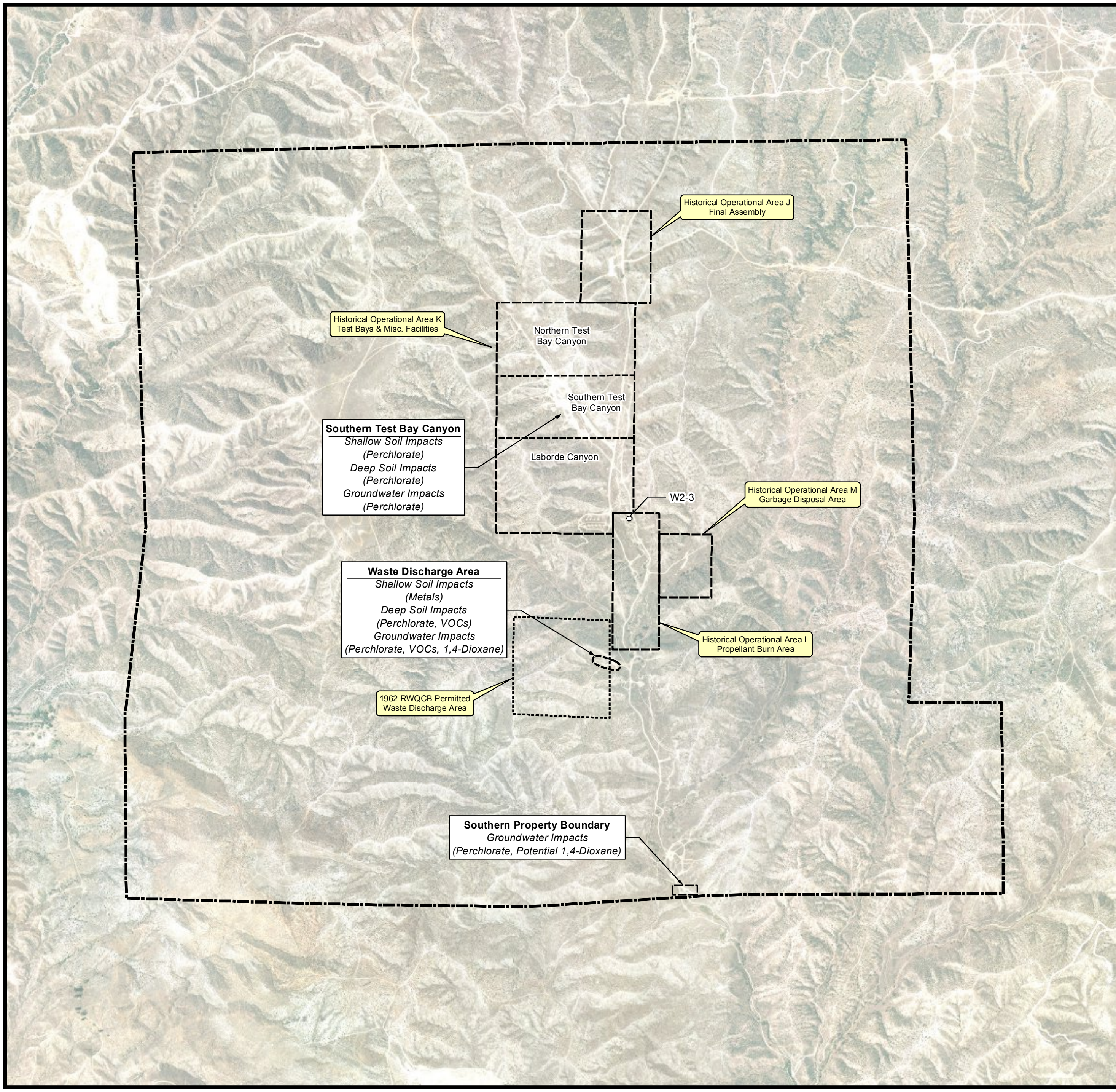

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Adapted from:
March 2007 aerial photograph.

LEGEND

- 1962 RWQCB Permitted Waste Discharge Area
- Historical Operational Area Boundary
- Beaumont Site 2 Property Boundary

Note: Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure ES-2

Potential Remediation Areas

TETRA TECH

Section 1
Introduction

On behalf of Lockheed Martin Corporation, Tetra Tech, Inc. (Tetra Tech) has prepared this Feasibility Study for Laborde Canyon (the site), located southwest of Beaumont, California. This report was prepared in response to Consent Order Health and Safety Code Sections 25, 25355.5 (a)(1)(B), 25355.5 (a)(1)(C) [Docket # HSA 88/89-034] issued by the California Department of Toxic Substances Control, that requires Lockheed Martin Corporation to investigate and appropriately remediate releases of hazardous substances to the air, soil, surface water, and groundwater at or from the site.

1.1 STUDY OBJECTIVE AND APPROACH

The overall objective of the feasibility study is to develop and evaluate potential remedial action alternatives for the site that will protect human health and the environment, and are cost-effective and sustainable. To achieve this objective, the feasibility study was prepared in accordance with the requirements and guidelines provided in the United States Environmental Protection Agency National Oil and Hazardous Substances Pollution Contingency Plan (USEPA, 1990) and *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988). Although the site does not fall under the jurisdiction of the federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), this process was followed to provide a standardized, well-understood framework for evaluating the remedial alternatives.

1.2 REPORT ORGANIZATION

The feasibility study report has been prepared to meet the general format requirements specified in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988). The report is organized into an executive summary and nine sections:

- <u>Section 1—Introduction</u>: Describes the purpose and objective of the feasibility study and the organization of the report.

- Section 2—Conceptual Site Model: Summarizes the conceptual site model for the site, including the background and history of the former Lockheed Martin Corporation property; physical setting; geology and hydrogeology; surface water; previous remedial actions; nature and extent of soil, soil gas, groundwater, and surface water contamination; contaminant fate and transport modeling; contaminant attenuation evaluation; and human health and ecological risk assessments.

- Section 3—Applicable or Relevant and Appropriate Requirements: Provides a listing and description of the applicable or relevant and appropriate requirements and other guidance criteria for the site.

- Section 4—Remedial Action Objectives: Describes the remedial action objectives for soil and groundwater, and preliminary remedial goals based on risk-based screening levels and the applicable or relevant and appropriate requirements.

- Section 5—Development of General Response Actions and Screening of Remedial Technologies and Process Options: Describes the development of general response actions and the identification and screening of remedial technologies and process options to address impacted media at the site based on effectiveness, implementability, and cost.

- Section 6—Development and Screening of Preliminary Remedial Alternatives: Provides a description of the remedial alternatives, evaluation criteria, and screening results for the preliminary list of remedial alternatives developed for the site.

- Section 7—Detailed and Comparative Analysis of Remedial Alternatives: Presents detailed and comparative analyses of the short list of remedial alternatives retained after screening the preliminary list of remedial alternatives. The detailed and comparative analyses were conducted in accordance with CERCLA criteria, and include an evaluation of the environmental impact of each alternative.

- Section 8—Recommended Remedy: Summarizes the recommended remedial alternative for the site.

- Section 9—References: Lists documents referenced in the report.

Section 2
Conceptual Site Model

2.1 BACKGROUND AND HISTORY OF THE FORMER LOCKHEED MARTIN CORPORATION PROPERTY

The former Lockheed Martin Corporation (Lockheed Martin) property consists of 2,668 acres of land located southwest of Beaumont, California (the site; Figure 2-1). Prior to 1958, the parcels that comprise the property were owned by individuals and the United States (U.S.) government, and were used for agricultural purposes. Between 1958 and 1960, portions of the property were purchased by Grand Central Rocket Company (GCR) for use as a remote rocket motor test facility (Radian, 1986). In 1960, Lockheed Aircraft Corporation (LAC) purchased one-half interest in GCR. In 1961, GCR became a wholly owned subsidiary of LAC. The remaining parcels of land that comprise the property were purchased from the U.S. government between 1961 and 1964. In 1963, Lockheed Propulsion Company (LPC) became an operating division of LAC, and was responsible for the operation of the property until closure in 1974. In 2007, the property was sold to the County of Riverside, California. A second property (the Gateway Property, located on Highway 60) was also formerly owned by Lockheed Martin. The Gateway Property is physically separate from the 2,668-acre former Lockheed Martin facility, and is not discussed further since no historical operations are known to have been conducted on the Gateway Property.

From 1958 to 1974, the property was used by GCR and LPC for small rocket motor assembly, rocket motor testing operations, propellant incineration, and minor disposal (Radian, 1986). Ogden Technology Laboratories, Inc. (Ogden) leased portions of the property in the 1970s (Radian, 1986). According to interviews with LPC personnel familiar with the property, a portion of the property was also used by General Dynamics for testing remote sensing devices in the late 1980s (Tetra Tech, 2009a). Figure 2-2 shows the locations of historical operational areas and features of the property.

In 1989, the California Department of Health Services (CDHS), now the California Department of Toxic Substances Control (DTSC), issued Consent Order 88/89 034 (amended in 1991) requiring LAC to clean up contamination at the site related to past testing activities (CDHS, 1989 and

1991). In response to site characterization and cleanup activities performed by LAC from 1990 to 1993, the DTSC issued a Report of Completion of Removal Action dated April 30, 1993, stating that no further action was necessary (DTSC, 1993).

At the request of the DTSC, a groundwater sample was collected from an inactive groundwater production well (W2-3; Figure 2-2) in January 2003, and analyzed for volatile organic compounds (VOCs), perchlorate, and 1,4-dioxane. VOCs and 1,4-dioxane were not detected in the groundwater sample, but perchlorate was detected at a concentration of 4,080 micrograms per liter (µg/L), which exceeded the then-current State of California action level of 4 µg/L. The perchlorate action level was raised to 6 µg/L in 2004, and the current Maximum Contaminant Level (MCL) of 6 µg/L was established in 2007. Given the detection of perchlorate in groundwater in 2003, the DTSC requested further assessment of the site.

Tetra Tech (2003) identified four historical operational areas (Areas J, K, L, and M) at the property; Areas A through I are associated with the Lockheed Martin Potrero Canyon site. Based on new information obtained since 2003, a fifth area, the Waste Discharge Area (WDA), was identified at the property as a potential source area (Tetra Tech, 2007 and 2009b). Various activities associated with rocket motor assembly, testing, and propellant burning were conducted in each area. The locations of the four historical operational areas and the WDA are shown on Figure 2-2. A brief description of each operational area follows.

2.1.1 Historical Operational Area J—Final Assembly

Area J consists of a former building (Building 250) and related facilities that were used for the final assembly and shipment of rocket motors for the Short Range Attack Missile program from 1970 to 1974. Rocket motor casings containing solid propellant were manufactured off-property and transported to Building 250, where final hardware was assembled (Radian, 1986). Assembly operations reportedly included installation of the motor nozzle and headcap, pressure check of the motor, installation of electrical systems, and preparation of the assembled motor for shipment (Radian, 1986).

2.1.2 Historical Operational Area K—Test Bays and Miscellaneous Facilities

Area K is the largest historical operational area, and has been divided into three subareas for discussion purposes. The northern Test Bay Canyon subarea includes the location of a test centrifuge and Test Bay 4, a former rocket motor test bay. The centrifuge and Test Bay 4 were located in small side canyons on the western side of the northern portion of the Test Bay Canyon.

The southern Test Bay Canyon (STBC) subarea includes three rocket motor test bays (Test Bays 1, 2, and 3), two control bunkers (the small and large bunkers), and a large earthen structure referred to as the “Prism.” The test bays were located in three small side canyons located on the western side of Test Bay Canyon, and were used for testing rocket motors. The small bunker was located near the junction of Test Bay Canyon and Laborde Canyon, and was used as a control bunker during early operations at the property. The large bunker is located between Test Bays 1 and 4, and was used as a control bunker during later testing operations. The Prism was reportedly constructed by General Dynamics for testing remote sensing equipment (Tetra Tech, 2009a). Field observations suggest that up to 10 feet of soil excavated from the surrounding area may have been used for construction of the Prism. The Prism is largely intact, although the southern face of the structure is eroded.

The Laborde Canyon subarea of Area K includes three sets of conditioning chambers located in three side canyons on the western side of Laborde Canyon. The conditioning chambers were reportedly used to examine the effects of extreme temperatures on rocket motors and to meet specification requirements (Radian, 1986). A T-shaped earthen berm and revetments (referred to as the “T Revetment”) are present farther to the south. Nine conditioning chambers were reportedly present in the T Revetment area (Radian, 1986; Tetra Tech, 2009a).

2.1.3 Historical Operational Area L—Propellant Burn Area

Area L is located immediately south of Area K. According to Radian (1986), large slabs of solid propellant were reportedly transported to Area L and placed on the ground for burning. Diesel fuel was reportedly used to initiate combustion, and once ignited, the propellant would burn rapidly. Reportedly, no pits or trenches were dug as part of the burning process.

No obvious man-made structures (*e.g.*, concrete pads, regularly shaped depressions, berms, or other features) are present within Area L that may indicate where propellant burning could have taken place. Historical aerial photographs reviewed by Tetra Tech (2009a) showed no evidence of brush clearing or other activities suggesting that propellant burning occurred within Area L. Low levels of perchlorate were detected in shallow and deep soil in previous investigations. The results from this work found no credible evidence for the presence of a source of perchlorate or other chemicals in soil. Based on these results, it is concluded that Area L was not used for propellant burning. It is possible that propellant burning activities at the property may have been conducted in the WDA (Section 2.1.5) rather than Area L.

2.1.4 Historical Operational Area M—Garbage Disposal Area

Area M is located in a major side canyon located on the eastern side of Laborde Canyon south of Area L. Materials disposed in Area M by LPC reportedly included scrap metal, paper, wood, and concrete. According to Radian (1986), hazardous materials, including explosives and propellants, were never disposed of at the garbage disposal area by LPC. The Area M disposal area was also used by Ogden, a company that tested valves and explosive items and reportedly disposed of hazardous materials at the disposal area (Radian, 1986).

In 1972, a Lockheed Safety Technician was exposed to vapor-phase unsymmetrical-dimethylhydrazine from a pressurized gas container located within the disposal area. Given potential exposure risks to workers, LPC's safety group required Ogden to take measures to remove any potentially hazardous materials from the disposal area. Shortly thereafter, a disposal company was reportedly contracted by Ogden to clean up the disposal area (Radian, 1986).

In 1993, a removal action was conducted at the Area M disposal area with oversight from DTSC (Radian, 1993). As part of the removal action, surficial debris was removed and 816.45 tons of nonhazardous waste materials were excavated and disposed off-site. A Report of Completion of Removal Action for the Area M disposal area was subsequently issued by the DTSC on April 30, 1993 (DTSC, 1993).

2.1.5 Waste Discharge Area

A copy of Santa Ana River Basin Regional Water Pollution Control Board Resolution 62-24, issued to LPC on September 14, 1962 (SARWPCB, 1962), was discovered by Lockheed Martin in

2007. This document contained previously unknown information about the property. Resolution 62-24 prescribed requirements for the "discharge of industrial wastes (rocket fuel residuum) to excavated pits." The discharge area was described as two shallow basins protected by 2-foot berms, located in a small canyon on the western side of Laborde Canyon, in the southwest quarter of the northwest quarter of Section 19, Township 3 South, Range 1 West, San Bernardino Baseline and Meridian. Resolution 62-24 contained a description of the wastes to be discharged as "residue remaining after the manufacturing refuse is burned," and indicated that the amount of material to be discharged was "approximately 5,000 gallons per year."

The exact nature of the waste proposed for discharge is not clear from the language of Resolution 62-24. The description of the waste material suggests that the area may have been used for propellant burning, but the use of volume units to describe the quantity of material to be discharged suggests that the waste may have been liquid rather than solid. A 1961 aerial photograph shows the WDA as a large cleared area with roads leading to two circular earthen structures, suggesting that the WDA may have been in use as early as 1961 (Tetra Tech, 2009a). The brush clearing suggests use of the area for propellant burning rather than disposal of liquids. Perchlorate and chlorinated solvent impacts in both soil and groundwater were found during the investigation of this area (Tetra Tech, 2007 and 2009b).

2.2 PHYSICAL SETTING

The site is located within the San Timoteo Badlands, an area of badlands topography characterized by steep slopes, sparse vegetation, and complex drainage patterns developed primarily in poorly indurated Pliocene- and Pleistocene-age non-marine sedimentary rocks of the San Timoteo formation (STF). Mass wasting processes are of particular importance in the evolution of the San Timoteo Badlands landscape. Manson et al. (2002) documented approximately 8,500 landslides along the Highway 60 corridor between Jack Rabbit Trail (located to the east of the site) and Gilman Springs Road, where Highway 60 emerges from the Badlands. Manson et al. (2002) noted that virtually all of the slopes in the Badlands are debris slide slopes, formed by the coalesced scars of numerous small debris flows and debris slides.

The topography of the site and surrounding area is shown in Figure 2-3. The principal topographic feature of the site is Laborde Canyon, a major north-south oriented canyon that extends from a drainage divide roughly 2,000 feet south of Highway 60 to the San Jacinto Valley, a distance of approximately 4.5 miles. The elevation at the head of Laborde Canyon is roughly 2,380 feet above mean sea level (msl), and drops to approximately 1,550 feet msl where Laborde Canyon enters the San Jacinto Valley, a gradient of approximately 0.035 feet per foot (ft/ft).

2.3 GEOLOGY

The regional geologic setting, geologic units, and geologic structure of the site and surrounding area are briefly summarized in the following sections.

2.3.1 Regional Setting

The site is located at the northern end of the San Jacinto Mountains block of the northern Peninsular Ranges geologic province of California (Morton, 2004). The San Jacinto Mountains block consists of a thick sequence of Miocene- to Pleistocene-age non-marine sedimentary rocks, underlain by crystalline basement consisting of Jurassic to Cretaceous age plutonic rocks of the Southern California Batholith and metamorphic rocks (primarily marbles and gneisses) of inferred Paleozoic age (Morton, 2004).

2.3.2 Geologic Units

A geologic map of Laborde Canyon and the surrounding area is shown in Figure 2-4. Geologic units exposed at the site and surrounding area include the following:

- <u>Crystalline Basement</u>: Crystalline basement rocks in the area of the site include Cretaceous-age plutonic rocks of the Southern California Batholith (Morton, 2004) that are exposed to the east and to the southwest of the former operational areas of the site. Undifferentiated metasedimentary rocks and marbles are also part of the basement complex; these rocks are exposed to the east and south of the former operational areas of the site.

- <u>Mount Eden formation (MEF)</u>: The MEF consists of Miocene and early Pliocene sandstones, mudstones, conglomeritic sandstones, and sedimentary breccia that are exposed primarily to the south of the site. The MEF has been subdivided by Morton (2004) into five informal members that include, from youngest to oldest, the upper sandstone member, mudrock member, lower sandstone member, arkosic sandstone member, and conglomeratic sandstone member. The arkosic sandstone member is exposed in the lower portion of Laborde Canyon.

- <u>San Timoteo formation</u>: The STF (Frick, 1921) comprises approximately 2,000 feet of non-marine arkosic sandstones, mudstones, and conglomerates of Pliocene- to lower Pleistocene-age (Morton, 2004). Morton (2004) has informally subdivided the STF into upper, middle, and lower members. The upper and middle members are exposed to the north of the historical operational areas; the lower member is the primary geologic unit of interest at the site. The lower member of the STF consists of grayish brown, massive to thickly bedded, fine-grained, poorly indurated sandstones and mudstones, with localized gravel conglomerate lenses and rare, relatively thin beds of medium- to coarse-grained carbonate-cemented sandstone. The lower member of the STF has been interpreted as a braided stream complex (Albright, 2000).

The STF characteristically forms steep ridges and hillsides throughout the site. Slopes developed in the STF are typically mantled by a thin regolith veneer; in general, the STF is poorly exposed except in localized areas with near vertical slopes and in recently formed gullies. No distinctive marker beds have been noted in the STF at the site, and individual beds cannot be traced between outcrops with any degree of confidence.

The STF is deeply weathered within the major canyons at the site. The degree of induration generally tends to increase with depth, although poorly indurated beds are encountered throughout the section to a depth of at least 250 feet. The STF also appears more indurated at shallow depths in borings drilled in side canyons compared with those drilled near the midline of the major canyons. These observations suggest that the STF is most deeply weathered near the center of the major canyons, and becomes less deeply weathered toward the canyon margins.

- <u>Quaternary Deposits</u>: Quaternary deposits at the site include alluvium and colluvium. Alluvium consists of stratified gravel, sand, silty sand, and silt deposits that floor the major canyons throughout the site. Colluvium consists mainly of poorly to well-graded sand and silty sand deposits with minor gravel. Colluvium characteristically forms steeper slopes than alluvial deposits, and typically occurs as aprons at the base of steep hillsides and as flooring in the minor side canyons. Colluvial and alluvial deposits likely interfinger laterally along the margins of the main canyons.

2.3.3 Geologic Structure

The San Timoteo anticline, a northwest-plunging fold that roughly parallels the San Jacinto Fault Zone, extends along much of the southern portion of the San Timoteo Badlands. The axis of the anticline is located approximately 8,000 feet south of the property. The anticline is asymmetric, with a steeply dipping southwestern limb and a gently dipping northeastern limb. The site lies on the northeastern limb of the anticline. Mapping by Dibblee (2003) shows bedding near Laborde Canyon dipping generally to the north northeast, at angles ranging from horizontal to 5°; whereas Morton (2004) shows dips ranging from 12° to 25°, toward both the northeast and northwest. Field measurements by Tetra Tech agree with the steeper dip angles indicated by Morton (2004).

No faults are shown within the former operational areas of the site on published geologic maps by Dibblee (2003) and Morton (2004). The most prominent faults in the area of the site are the San Jacinto and Claremont faults, which are active right-lateral strike-slip faults located more than two miles south of property. Morton (2004) mapped several west-northwest trending faults that cross Laborde Canyon approximately 3,000 feet south of the property.

Tetra Tech conducted a lineament study (Tetra Tech, 2009d, Appendix L) to evaluate the site for potential faults. The study found scant evidence for faulting at the site; however, Tetra Tech speculated in the study that four northwest-trending linear side canyons, including Test Bay Canyon, may be fault-controlled.

2.4 HYDROGEOLOGY

The regional hydrogeologic setting and characteristics of the site are briefly summarized in the following sections.

2.4.1 Regional Setting

Figure 2-5 shows watershed boundaries and groundwater basins in the vicinity of Laborde Canyon as described by the Santa Ana Regional Water Quality Control Board (SARWQCB, 1995). The site is located within the San Jacinto River watershed. The drainage divide defining the northern boundary of the watershed lies roughly 3,200 feet north of the northern boundary of the property, and roughly 2,000 feet south of Highway 60. The Santa Ana River watershed lies to the north of the drainage divide.

The site is not located within a defined groundwater basin. Basin maps included in the Water Quality Control Plan for the Santa Ana River Basin (SARWQCB, 1995) show the San Timoteo Badlands as lying outside the basin boundaries. The San Jacinto Groundwater Basin lies to the south (downgradient) of the site. The San Jacinto Groundwater Basin consists of several alluvium-filled valleys bounded by barrier faults and relatively impermeable plutonic and metamorphic rocks of the Southern California Batholith. The basin is internally subdivided into subbasins (referred to as "management zones" in SARWQCB, 1995) by bedrock restrictions, barrier faults, groundwater divides, and flow system boundaries. The San Jacinto Upper Pressure Groundwater Management Zone, the subbasin that lies downgradient from the site, is bounded by the San Jacinto fault zone to the northeast, by the Casa Loma and Bautista Creek faults to the southwest, and by a flow system boundary with the San Jacinto Lower Pressure Groundwater Management Zone to the northwest (Eastern Municipal Water District [EMWD], 2005). Surface water recharge occurs primarily in the forebay area located in the southeastern portion of this subbasin, and confined conditions exist in the pressure area in the northwestern portion. Groundwater flow within the San Jacinto Upper Pressure Groundwater Management Zone is generally to the southwest (EMWD, 2005).

The San Gorgonio Pass groundwater basin (Bloyd, 1971; Rewis et al., 2006) lies to the north (upgradient) of the site. The San Timoteo Groundwater Management Zone (Bloyd, 1971), one of 13 subbasins comprising the San Gorgonio Pass basin, lies directly north of the site area. Based on a groundwater contour map prepared by Bloyd (1971), groundwater flow within the San Timoteo Groundwater Management Zone is generally toward the northwest.

2.4.2 Hydrostratigraphic Units

Groundwater at the site occurs mainly in two hydrostratigraphic units: weathered sandstones and siltstones within the weathered portion of the STF, and water-yielding intervals of unweathered STF. These units are separated by non-water-yielding intervals of the unweathered STF.

The uppermost (first) groundwater is generally unconfined or semi-confined and found within the weathered portion of the STF, with a saturated thickness of roughly 20 feet. Near the southern boundary of the property, the water table is located near the contact between alluvial deposits and the weathered STF, and first groundwater may periodically occur in alluvium during periods when water levels are higher. Perched groundwater is present in the centrifuge area in northern Test Bay Canyon, where groundwater was encountered in two soil borings at elevations much higher than in nearby monitoring wells located in the main canyon (Tetra Tech, 2010a).

Deeper groundwater at the site is most commonly found in unweathered, poorly indurated, fine- to medium-grained sandstone lenses within the STF. The saturated thickness of individual water-bearing zones within the unweathered STF is typically 5 to 10 feet, and groundwater is confined. Based on the depositional environment and observed characteristics of the STF, individual water-bearing zones within the unweathered STF are likely discontinuous and of limited lateral extent.

2.4.3 Flow System

Groundwater elevations for wells screened in first groundwater for the second quarter 2011 (Tetra Tech, 2012a) are shown in Figure 2-6. Depth to first groundwater at the site ranges from approximately 70 feet below ground surface (bgs) in well TT-MW2-17S, located in Test Bay

Canyon, to approximately 14.5 feet bgs in well TT-MW2-8, located near the southern boundary of the property. Little seasonal variation in groundwater levels is observed; longer-term groundwater level variations are typically only 1 to 3 feet over the limited period of record (from 2006 to 2012).

The horizontal groundwater gradient in the weathered STF aquifer is approximately 0.030 ft/ft, with little spatial variability. An exception is Test Bay Canyon, where the gradient locally flattens to 0.005 ft/ft, in agreement with the higher hydraulic conductivities in this area relative to downgradient areas. The difference between the groundwater gradient of 0.030 ft/ft and topographic gradient of 0.035 ft/ft results in a decreasing depth to first groundwater noted from north to south. Groundwater is interpreted as flowing down the major tributary canyons to Laborde Canyon, and then to the south, subparallel to the direction of surface water flow and topographic relief.

Vertical gradients are generally downward in the northern portion of the site, and are generally upward in the southernmost area of the property and in the riparian corridor to the south of the property. Recharge conditions thus exist in the northern portion of the site, and discharge conditions exist in the southern portion of the site.

2.4.4 Hydrologic Boundaries

The depth to the base of the weathered STF is greatest near the center of Laborde Canyon, and becomes shallower toward the canyon margins, where relatively unweathered STF is exposed or present at shallow depths in the adjacent hillsides. Thus, the weathered STF aquifer thins to the east and west toward the margins of Laborde Canyon and the major side canyons. Boundaries for water-bearing zones within the competent STF are not well defined. Based on the likely limited lateral extent and discontinuous nature of the water-bearing zones, it is probable that individual water-bearing zones of interest for contaminant transport within the unweathered STF are limited to the area underlying the weathered STF aquifer.

Based on the presence of contaminants in the unweathered STF aquifer within the contaminant source areas, the base of the weathered STF aquifer appears to represent a leakage boundary for flow into the competent STF. Leakage boundaries are also likely to exist between individual water-bearing zones within the competent STF, although leakage rates between these units are likely to be small.

2.4.5 Hydraulic Properties

Three constant-rate aquifer tests and 36 slug tests (Tetra Tech, 2010b; 2010e; and 2012d) have been conducted to evaluate aquifer hydraulic properties at the site. The constant-rate aquifer test data are summarized in Table 2-1; slug test data are summarized in Table 2-2.

Hydraulic conductivity values in both the weathered STF and competent STF aquifers are highly variable, reflecting the heterogeneous nature of the STF. Hydraulic conductivity values in the weathered STF aquifer have a geometric mean of about 0.16 feet per day (ft/day); hydraulic conductivity values in the competent STF have a geometric mean of about 0.04 ft/day.

2.4.6 Water Budget

The steady-state saturated zone water budget for the site (Tetra Tech, 2011b) is summarized in Table 2-3. The overall size of the water budget is about two acre-feet per year, as is the recharge rate of about two acre-feet per year (approximately 1.2 gallons per minute [gpm]). The recharge of two acre-feet per year corresponds to an annual recharge rate of about 0.1 inches per year. The size of the water budget and the recharge rate are small with respect to the overall size of the watershed. However, the small water budget is consistent with underflow calculations based on aquifer test and hydraulic gradient data, water level hydrographs that show very small seasonal variations, aquifer storage calculations that show only small seasonal changes in aquifer volume, and the lack of surfacing groundwater in the discharge area to the south of the property, which indicates that discharge rates are small enough that evapotranspiration alone is sufficient to prevent surface discharge.

2.5 SURFACE WATER

Aside from surface runoff associated with heavy, prolonged precipitation events, the only surface water present in Laborde Canyon is a spring located approximately 3,700 feet south of the southern boundary of the property, between monitoring wells TT-MW2-19S/D and TT-MW2-20S/D (Figure 2-19). The source of the water at the spring is unknown, but the elevation of the spring discharge is approximately 45 feet above the water table, strongly suggesting that shallow groundwater is not the source of the water discharging at the spring.

2.6 PREVIOUS REMEDIAL ACTIONS

Previous remedial actions at the site include a polychlorinated biphenyl (PCB) spill cleanup, removal of the Area M garbage disposal area, and filing of land use covenants with the Riverside County Recorder in conjunction with the sale of the property to Riverside County in 2007.

2.6.1 PCB Spill

Radian (1986) documented a PCB spill cleanup conducted in 1984. In April 1984, trespassers vandalized three large transformers located east of Building 250 in Area J. Approximately 360 gallons of oil were discharged to an asphalt and concrete pad and to the surrounding ground surface. Sampling results indicated that the oil contained less than 6 milligrams/kilogram (mg/kg) of PCBs. A cleanup plan was submitted to the County of Riverside and the SARWQCB in July 1984, and approximately 320 square feet of contaminated asphalt and 170 cubic feet of sand and gravel around the pad were subsequently removed and disposed at a Class I landfill. Letters issued by Riverside County and the SARWQCB document that the cleanup was satisfactory. All remaining transformers were removed from the site in August 1984.

2.6.2 Area M Removal Action

A removal action was conducted in Area M in 1993 (Radian, 1993). The removal action included characterization and excavation of the Area M garbage disposal area with oversight from the DTSC. Investigation activities included an electromagnetic survey to assess the extent of debris in the subsurface, drilling 12 hand-auger borings to visually confirm the presence of debris in the geophysical survey area, and excavating three trenches to assess the extent of debris in the subsurface. Following the investigation, approximately 816 tons of debris were excavated and disposed off-site. The excavation was backfilled with soil borrowed from the immediate area. Three perimeter confirmation soil samples were collected and analyzed for VOCs, semivolatile organic compounds (SVOCs), and metals. Very low concentrations of acetone, ethylbenzene, methyl ethyl ketone, methylene chloride, trichloroethene (TCE), xylenes, and bis(2-ethylhexyl)phthalate were detected in one or more of the confirmation samples. Metals concentrations were comparable to those detected during subsequent investigations in Area M (Tetra Tech, 2005).

The DTSC issued a Report of Completion of Removal Action on April 30, 1993 (DTSC, 1993). Based on the information known at the time of the letter, the DTSC stated that appropriate response actions had been completed, that all acceptable engineering practices were implemented, and that no further removal/remedial action was necessary.

2.6.3 Land Use Controls

As part of the sale of the property to Riverside County in 2007, land use covenants (LUCs) were recorded with the Riverside County Recorder. The LUCs apply to a portion of the property that includes all of the historical operational areas, Laborde Canyon, and the major side canyons within the property. Specific restrictions on land use include the following:

- Prohibitions on residential development and sensitive land uses, including hospitals, schools, and day care facilities
- Prohibitions on the installation of water production wells, extraction of groundwater, and use of groundwater for any purpose other than groundwater monitoring or treatment as approved by Lockheed Martin and either the DTSC or the RWQCB
- Prohibitions on use of the property as an off-road vehicle park, or any other recreational use which could penetrate ground surfaces or interfere with landscaping or vegetation
- Prohibitions on use of the property for raising of food, including cattle and food crops
- Prohibitions on any use or development of any portion of the property containing a liner or layer designed to prevent exposure to residual hazardous substances, which does not preserve or which alters the integrity of the liner or layer

A copy of the document as filed with the Riverside County Recorder's Office is provided in Appendix A.

2.7 NATURE AND EXTENT OF CONTAMINATION

The following sections summarize the nature and extent of contamination at the site by medium (i.e., soil, soil gas, groundwater, and surface water). More detailed summaries of the data presented below are provided in Tetra Tech (2010a), Tetra Tech (2010d), Tetra Tech (2010e), and Tetra Tech (2012a).

2.7.1 Soil Impacts

Soil impacts at the site are summarized by historical operational area in Table 2-4. Two primary high concentration areas, STBC and the WDA, have been identified at the site; northern Test Bay Canyon and Area M are impacted to a much lesser extent. The remaining areas, including Area J, Area K (Laborde Canyon subarea), Area L, and south Laborde Canyon, are not considered to be significantly contaminated. Each area is discussed in the subsections below.

2.7.1.1 Southern Test Bay Canyon

Southern Test Bay Canyon is one of two relatively highly impacted areas at the site. Soil characterization in STBC has included drilling 38 soil borings, sampling 10 surface locations, and analyzing 456 samples for one or more potential contaminants. Soil sampling locations in STBC are shown in Figure 2-7.

The site characterization results show that perchlorate is the primary soil contaminant in STBC. The extent of perchlorate in soil is illustrated in Figure 2-8. Perchlorate concentrations between 100 and 1,000 micrograms per kilogram (µg/kg) are relatively widespread in STBC. However, except for two relatively small areas at depths of 10 and 30 feet near Test Bay 2, perchlorate concentrations exceeding 1,000 µg/kg are limited to the Test Bay 3 area. The highest perchlorate concentration at Test Bay 3 is 130,000 µg/kg, in boring K-54-SB116 at a depth of 20 feet. Perchlorate impacts extend from the ground surface to the water table at depths of 55 to 60 feet bgs; thus the perchlorate in soil in STBC is a source to groundwater. Perchlorate concentrations up to 27,000 µg/kg are present in shallow soil (*i.e.*, at depths of 0 to 5 feet bgs) at Test Bay 3.

The conditions described above were slightly modified by a pilot-scale soil treatability study conducted in the Test Bay 3 area in 2011 to 2012 (Tetra Tech, 2012d). Verification sampling performed as part of the treatability study suggests that approximately 20 pounds of perchlorate were removed from the vadose zone, primarily at depths of 30 feet bgs and greater, near the edge of the area of the most contaminated portion of Test Bay 3 area. Although the treatability study resulted in some removal of perchlorate mass, it is unlikely that the contaminant distribution after the test differs significantly from conditions prior to the test. Additional information regarding the treatability study is provided in Section 5.2.3.

2.7.1.2 Waste Discharge Area

The WDA is the second area of the site with highly impacted soils. Soil characterization at the WDA has included drilling 13 soil borings and analyzing 117 soil samples for one or more potential contaminants. Soil sampling locations in the WDA are shown in Figure 2-9.

The site characterization results show that perchlorate, VOCs, and metals are the primary soil contaminants at the WDA. The extent of perchlorate in soil is illustrated in Figure 2-10. Perchlorate concentrations up to 114,000 µg/kg have been detected in soil at the WDA, with impacts extending from the ground surface to the water table; thus the perchlorate in soil in the WDA is a source to groundwater. The highest perchlorate concentration was found in boring SB1, at a depth of 35 feet. The highest perchlorate concentration detected in shallow soil is 322 µg/kg, in boring Pond4 at a depth of 0.5 feet.

Fifteen VOCs were detected in soil at the WDA; however, only 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), and TCE are considered to be significant. Methylene chloride was detected at concentrations as high as 21,000 µg/kg; however, the highest methylene chloride detection appears to be anomalous, as methylene chloride was not detected in soil gas samples collected at the WDA and was detected only at very low concentrations in groundwater. The remaining VOCs are either common laboratory contaminants, were infrequently detected, or were detected only at low concentrations. The highest concentration of 1,2-DCA (35 µg/kg) was found in boring SB2, at a depth of 40 feet. The highest concentrations of TCE (680 µg/kg) and methylene chloride (21,000 µg/kg) were found in boring SB2, at a depths of 45 feet bgs. The highest 1,1-DCE concentration (31 µg/kg) was found in boring SB4 at a depth of 50 feet. With the exception of 1,1-DCE, VOC impacts were found mainly in borings SB1 and SB2, at depths greater than 35 feet.

Three metals (cadmium, lead, and zinc) were detected at elevated concentrations at the WDA. The maximum concentrations were 5.37 mg/kg (cadmium), 236 mg/kg (lead), and 1,720 mg/kg (zinc), all in boring Pond3 at a depth of 0.5 feet. The concentrations of all three metals attenuate with depth to near-background concentrations at 10 feet bgs. Boring Pond3 is located in a shallow depression, on the opposite side of the side canyon from the bermed areas used for disposal. The depression appears to be man-made, and for the purpose of estimation, elevated metals concentrations are assumed to be restricted to the depression, which measures approximately 20 feet across.

The compounds 1,4-dioxane and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) have been detected in groundwater at the WDA at concentrations exceeding drinking water criteria. Although samples from the WDA have been analyzed for both of these compounds, neither has been detected in soil.

2.7.1.3 Northern Test Bay Canyon

Northern Test Bay Canyon is one of two secondary areas of soil contamination at the site. Soil characterization has included drilling 16 soil borings and analyzing 212 soil samples for one or more potential contaminants. Soil sampling locations in northern Test Bay Canyon are shown in Figure 2-11.

Perchlorate is the primary contaminant in soil in the northern Test Bay Canyon. The extent of perchlorate in soil is illustrated in Figure 2-12. The maximum perchlorate concentration detected in northern Test Bay Canyon was 690 µg/kg at 30 feet bgs in boring K-54-SB104, located near Test Bay 4. The largest area of perchlorate-impacted soil is in Test Bay 4; smaller impacts are also present in the centrifuge area, in Test Bay Canyon near Test Bay 4, and adjacent to the large bunker.

2.7.1.4 Area M

Area M is also a secondary area of soil contamination at the site. Soil characterization has included drilling 13 soil borings and analyzing 117 soil samples for one or more potential contaminants. Soil sampling locations in Area M are shown in Figure 2-13.

Perchlorate is the primary contaminant in soil in Area M. The extent of perchlorate in soil is illustrated in Figure 2-14. Perchlorate-impacted soils are restricted to a relatively small area (approximately 5,500 square feet, or 0.1 acre); the maximum perchlorate concentration detected was 3,100 µg/kg at 30 feet bgs in boring M-58-SB103. The area of perchlorate-impacted soil does not coincide with the former disposal area, suggesting that the perchlorate impacts may be related to surface disposal rather than disposal within the Area M disposal trench.

2.7.1.5 Other Areas

The remaining areas of the site (Area J, the Laborde Canyon subarea of Area K, Area L, and south Laborde Canyon) have been investigated and are not considered to have significant soil impacts. Characterization results for these areas are described below:

- Area J: Nineteen soil borings were drilled and 50 soil samples were analyzed; sampling locations are shown in Figure 2-15. Perchlorate and other potential contaminants were either not detected, or were detected only at very low concentrations.

- Area K (Laborde Canyon subarea): Thirty soil borings were drilled and 63 soil samples were analyzed; sampling locations are shown in Figure 16. Perchlorate was detected in 2 samples, at concentrations of 45.2 and 640 µg/kg. Both of these samples were collected at or near the water table, and the detections are consistent with proximity to perchlorate-contaminated groundwater originating from Test Bay Canyon. Perchlorate was not detected in any soil samples collected at shallow depths.

- Area L: Twenty-two soil borings were drilled and 124 soil samples were analyzed; sampling locations are shown in Figure 2-17. Perchlorate was detected in 15 of 123 samples analyzed, at concentrations ranging from 1.1 to 357 µg/kg. Perchlorate concentrations greater than 13 µg/kg were limited to depths of 30 feet or greater; the highest perchlorate concentration detected at a depth shallower than 30 feet was 6.2 µg/kg. The perchlorate detections at depths of 30 feet and greater appear to be related to proximity to perchlorate-contaminated groundwater originating from Test Bay Canyon rather than surface releases within Area L.

- South Laborde Canyon: Seven soil borings were drilled and 26 soil samples were analyzed; sampling locations are shown in Figure 2-18. Perchlorate was detected in 11 of 26 samples analyzed, at concentrations ranging from 5.1 to 89.3 µg/kg. Depth to groundwater in south Laborde Canyon ranges from approximately 14 to 17 feet bgs; the perchlorate detections in soil are consistent with proximity to perchlorate-contaminated groundwater originating from the WDA rather than surface releases in south Laborde Canyon.

2.7.1.6 Contaminant Mass Estimates

Estimates of the mass of perchlorate in vadose zone soil in each of the impacted areas are summarized in Table 2-5. The mass estimates were developed using Mining Visualization System (MVS) software (C Tech, 2012), a geostatistical data modeling and visualization tool that uses kriging to interpolate concentration data between sampled locations. Mathematically, kriging computes the best linear unbiased estimation of a spatially regionalized variable, and has been recognized by the United States Environmental Protection Agency (USEPA) as the best means for interpolation of measured data (e.g., Boeckenhauer et al., 2000). MVS was used to develop three-dimensional contaminant distribution models for each perchlorate-impacted soil area; the MVS volumetrics module was then used to estimate contaminant mass.

The results of this analysis (Table 2-5) show that approximately 99% of the total mass of perchlorate in soil at the site is located within the STBC and WDA areas; northern Test Bay Canyon and Area M account for less than one percent of the total perchlorate mass. In STBC, approximately 83% (295 pounds) of the total perchlorate mass is at concentrations of 1,000 µg/kg or higher, nearly all of which is in the Test Bay 3 area. In the WDA, approximately 62% (approximately 262 pounds) of the total perchlorate mass is at concentrations exceeding 10,000 µg/kg, and approximately 95% of the total mass (approximately 404 pounds) is at concentrations exceeding 1,000 µg/kg.

The estimated masses of VOCs and metals in the WDA are much less than 1 pound each.

2.7.2 Soil Gas Impacts

Soil gas samples were collected from 62 soil gas probes at 47 locations across the site. An unknown light hydrocarbon was detected in one probe located in STBC. This was the only chemical detected in the soil gas samples from Operational Areas J, K, L, and M. Five VOCs (benzene, 1,1-DCE, 1,1,1-trichloroethane, TCE, and 1,2,4-trimethylbenzene) were detected at the WDA. One sample had a TCE concentration greater than the Cal/EPA Human Health Screening Level (CHHSL) for residential land use, but less than the CHHSL for commercial/industrial land use. All other detections were at concentrations less than soil gas CHHSLs for residential land use.

2.7.3 Groundwater Impacts

Four groundwater plumes, each associated with one of the primary or secondary impacted soil areas (i.e., STBC, WDA, northern Test Bay Canyon, and Area M), have been identified at the site. Each of these impacted soil areas was determined to have an associated groundwater plume, and is thus termed a source area. In addition, perchlorate concentrations below the MCL of 6 µg/L have been detected consistently in monitoring well TT-MW2-19S, which is located approximately 4,500 feet south of the southern boundary of the property (see inset on Figure 2-19). This area of perchlorate-impacted groundwater is disconnected from the main groundwater plumes at the site, and is referred to as a “stranded plume.” Contaminants associated with each of the groundwater plumes are summarized in Table 2-6. Isoconcentration maps showing the extent of contaminants in groundwater are provided in Figure 2-19 (perchlorate), Figure 2-20 (1,4-dioxane), Figure 2-21 (TCE), and Figure 2-22 (RDX). The isoconcentration maps are based on data for the second quarter 2011 (Tetra Tech, 2012a), supplemented by groundwater grab sample data collected in 2008 and 2009 (Tetra Tech, 2010a). These figures illustrate that perchlorate is the dominant compound in groundwater at the site. As Figure 2-22 illustrates, RDX occurs persistently in only one well in the WDA and one well in Laborde Canyon.

2.7.3.1 Southern Test Bay Canyon Plume

Perchlorate is the primary contaminant present in the STBC groundwater plume. Figure 2-19 shows that the perchlorate plume originates at the source area near Test Bay 3, and extends roughly 1,800 feet downgradient into Laborde Canyon, terminating north of TT-MW2-12. The highest perchlorate concentration in the source area was 250,000 µg/L in well TT-MW2-38A during the second quarter of 2011; perchlorate concentrations remain above 10,000 µg/L downgradient to TT-MW2-18, which is located near the terminus of the plume. The STBC groundwater plume shows no evidence of detachment from the source area, suggesting a continuing source.

Relatively high perchlorate concentrations also extend approximately 250 feet upgradient from the Test Bay 3 source area. In this area, perchlorate concentrations at the water table are lower than at depth (i.e., there is a "concentration inversion"). In the second quarter 2011, a groundwater sample from well TT-MW2-17S, which is completed at the water table, had a perchlorate concentration of 1,300 µg/L, while a sample from collocated well TT-MW2-17D (screened from 94 to 99 feet bgs) had a perchlorate concentration of 90,000 µg/L. The upgradient location of perchlorate with respect to the apparent source and the concentration inversion in the water column support a conceptual model of stratigraphically controlled migration of perchlorate in the down-dip (northward) direction through the vadose zone, likely during a time when water levels were significantly lower than today. This conceptual model is in agreement with long-term precipitation records, which show unusually low precipitation in southern California from the early 1940s until the mid-1970s, which includes the entire period when operations were conducted at the property. This model also suggests that a residual perchlorate source may be present below the water table in the STBC source area.

Low concentrations of RDX have consistently been detected in well TT-MW2-13, located in Laborde Canyon (Figure 2-22). The RDX concentration in well TT-MW2-13 was 0.83 µg/L during the second quarter 2011.

2.7.3.2 Waste Discharge Area Groundwater Plume

The primary contaminants in the WDA groundwater plume include perchlorate, 1,4-dioxane, and TCE; secondary contaminants include methylene chloride, 1,1-DCE, 1,2-DCA, and RDX. Figure 2-19 shows that the highest source area perchlorate concentration in the WDA was 160,000 µg/L in well TT-MW2-24 during the second quarter 2011. The WDA perchlorate plume also exhibits the largest downgradient extent in the study area, reaching roughly 3,700 feet downgradient to the riparian corridor located south of the property boundary, just north of well TT-MW2-41A. Perchlorate concentrations in this plume attenuate to concentrations less than 10,000 µg/L over a distance of approximately 300 feet from the source area, and to concentrations less than 1,000 µg/L over a distance of approximately 1,150 feet. The perchlorate plume shows no evidence of detachment from the source area, suggesting a continuing source.

The highest source area 1,4-dioxane concentration in the WDA during the second quarter 2011 was 340 µg/L in well TT-MW2-24. Figure 2-20 shows that 1,4-dioxane in the WDA plume extends roughly 1,600 feet downgradient, terminating somewhat south of TT-MW2-5.

The highest source area TCE concentration during the second quarter 2011 was 420 µg/L in well TT-MW2-22. Figure 2-21 shows that TCE in the WDA plume does not extend appreciably beyond the source area. The secondary contaminants 1,1-DCE, 1,2-DCA, and methylene chloride have lateral extents similar to TCE. Figure 2-22 shows that RDX in the WDA is only present in source area well TT-MW2-24.

2.7.3.3 Northern Test Bay Canyon Groundwater Plume

The northern Test Bay Canyon groundwater plume was identified based on two grab samples collected in the centrifuge area during 2008 and 2009 (Tetra Tech, 2010a). These samples were collected at different elevations, both of which are significantly higher than the water table in the main portion of northern Test Bay Canyon, suggesting that the groundwater represents laterally discontinuous perched zones. Perchlorate is the primary contaminant in the northern Test Bay

Canyon groundwater plume; the maximum detected concentration was 370 µg/L in the grab sample collected from boring K-54-SB102 (Figure 2-11).

2.7.3.4 Area M Groundwater Plume

Perchlorate and TCE are the primary contaminants in the Area M groundwater plume. The maximum perchlorate concentration detected in this area during the second quarter of 2011 was 210 µg/L in well TT-MW2-11; the highest TCE concentration was 5.9 µg/L, also in TT-MW2-11. A somewhat higher perchlorate concentration of 560 µg/L was detected in a grab sample collected from boring M-58-SB103 (Tetra Tech, 2010a).

2.7.3.5 Stranded Plume

Perchlorate concentrations below the MCL of 6 µg/L have been detected consistently in monitoring well TT-MW2-19S, which is located approximately 4,500 feet south of the southern boundary of the property (see inset on Figure 2-19). This area of perchlorate-impacted groundwater is disconnected from the main groundwater plumes at the site. During the second quarter 2011, the perchlorate concentration in well TT-MW2-19S was 4.7 µg/L. The source of perchlorate in this area is unknown, but could be related potentially to intermittent surface flow of impacted water in the Laborde Canyon drainage channel in the past. Perchlorate is also known to be naturally-occurring in arid environments, including the Atacama Desert of Chile and the southwestern United States (Rao et al., 2007).

2.7.3.6 Contaminant Mass Estimates

The MVS software was used to develop three-dimensional contaminant distribution models for perchlorate and 1,4-dioxane in the STBC, WDA, and Area M groundwater plumes, and to estimate perchlorate and 1,4-dioxane masses in groundwater. Perchlorate mass estimates are summarized in Table 2-7, which shows that approximately 4,370 pounds of perchlorate are in the site plumes, using an assumption of 35% soil porosity in the saturated zone. More than 80% of the perchlorate mass is within areas of the plumes with perchlorate concentrations greater than 10,000 µg/L. Perchlorate in the STBC groundwater plume constitutes approximately 96% of the total perchlorate mass in groundwater at the site. Approximately 60% of the mass of the STBC plume is present in the source area. The WDA groundwater plume constitutes about four percent of the total perchlorate plume mass; the northern Test Bay Canyon and Area M groundwater plumes each constitute well under one percent of the total perchlorate mass in groundwater.

The estimated mass of 1,4-dioxane in the WDA groundwater plume (the only area with a 1,4-dioxane plume) is less than one pound; total VOC and RDX masses are much less than one pound each.

2.7.4 Surface Water Impacts

The only perennial surface water in Laborde Canyon is a spring located approximately 6,300 feet south of the southern boundary of the property, between wells TT-MW2-19S/D and TT-MW2-20S/D (Figure 2-19). Perchlorate concentrations in the spring are generally non-detectable; however, low perchlorate concentrations (0.1 µg/L or less) have been detected in spring water samples during two of the 12 sampling events. Because perchlorate is detected only intermittently and at very low concentrations, surface water contamination, if present, is not considered to be significant.

2.8 NUMERICAL GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODELING

Groundwater flow and contaminant transport modeling results are summarized in two modeling reports (Tetra Tech, 2010b and 2011b). The conceptual hydrogeologic model and water budget presented in Section 2.4 were used as the basis for developing the groundwater flow model; the contaminant distribution presented in Section 2.7 was used as the basis for developing the numerical contaminant transport model. Modeling results are discussed in the following sections.

2.8.1 Numerical Groundwater Flow Model

The numerical groundwater flow model was developed using MODFLOW (Harbaugh et al., 2000) and the GWVistas preprocessor (Environmental Simulations, 2008). The flow model was initially calibrated for steady-state conditions using water level data from fall 2006. Calibrated water levels from the steady-state model were then used as initial conditions for transient calibration over the period from fall 2006 to spring 2010. Water levels predicted using the calibrated model were in good agreement with observed water levels (relative error 2.4%), and the transient model water balance agreed well with the conceptual water budget for the site, indicating that the flow model was adequately calibrated for transient conditions.

2.8.2 Numerical Contaminant Transport Model

The numerical contaminant transport model was developed using the code MT3D (Zheng and Wang, 1999) and the MODFLOW groundwater flow model. The transport model was calibrated for perchlorate, using the transient flow model calibration for fall 2006 to spring 2010, and fall 2006 perchlorate concentrations as initial conditions. Correlation between measured and simulated perchlorate concentrations was fair (relative error 6.1%). Perchlorate concentrations predicted by the model were in fair agreement with both spatial and temporal trends in perchlorate concentrations measured in monitoring wells, and model simulations successfully reproduced migration of the STBC and WDA plumes down Laborde Canyon and major side canyons, and areas of high perchlorate concentration in the Test Bay Canyon, WDA, and Area M source areas. The calibrated transport model estimates of the perchlorate mass and mass flux budget also agreed with the conceptual mass and mass flux budget; the perchlorate source mass flux (247 pounds/year) estimated from the model is in good agreement with the upper range of values from the conceptual mass flux model (15 to 247 pounds/year). Model runs using a lower source mass flux value of 24 pounds/year resulted in an increase in relative error from 6.1 to 16%, which supports the higher range of source mass flux estimates from the conceptual model.

Although the model successfully predicted many features of the site plumes, several features were not predicted in detail, such as the following:

- The model tends to underpredict the sharp concentration boundaries observed at the downgradient fringes of the plumes, despite using a longitudinal dispersivity of five feet, which is considered small for plumes of this scale.

- The model predicted more rapid concentration increases in well TT-MW2-9S, located downgradient from the source in the WDA perchlorate plume, than were observed. This could be accounted for potentially by a higher local effective porosity value, but other factors, such as a lower hydraulic conductivity or a lower water budget, could also account for the discrepancy. At present, there is no basis for further refinement of the flow model; future modeling efforts conducted when a longer period of record is available for calibration could incorporate additional data regarding spatial variability to adjust model behavior in this area of the site.

- The model tended to overpredict perchlorate concentrations in the riparian area downgradient from the southern boundary of the property. This may be due to the relatively high perchlorate concentrations observed in short-screened wells TT-MW2-7 and TT-MW2-8, which may not represent the average aquifer conditions that the model was designed to predict.

Despite the limitations described above, the calibrated transport model is considered to be adequate for the purposes of this feasibility study, given the relative error of 6.1% and the inherent difficulty in re-creating historical source conditions.

2.8.3 Simulations

Three scenarios were simulated using the numerical models: two no action scenarios (one with a high source-release rate, and one with a low source-release rate), and a source removal scenario (where the source area mass flux is set at zero). Since the four-year calibration period for the model is rather short for predicting long-term groundwater management alternatives, a 16-year future simulation period was chosen for the Laborde Canyon model. Future hydrologic conditions were estimated by replaying four sequences of the historical hydrologic conditions observed during the four-year calibration period. Source release rates are based on estimates from the conceptual mass flux analysis and the vadose zone fate and transport analysis discussed above.

2.8.3.1 High Source-Release Rate, No Action Scenario

The no action (high source-release rate) scenario consists of current groundwater conditions, with continued release of perchlorate from groundwater and soil sources at the upper bound rate of 247 pounds/year. Perchlorate concentrations in the STBC and WDA source areas predicted for 2026 are similar to current conditions, with no detachment of the groundwater plume hot spot from the soil source areas. The downgradient limits of the plume expand, with the Test Bay Canyon plume starting to comingle with the WDA plume, and the WDA plume expanding to the downgradient limit of the riparian area at a concentration of 10,000 µg/L.

2.8.3.2 Low Source-Release Rate, No Action Scenario

The no action (low source-release rate) scenario consists of current groundwater conditions, with continued release of perchlorate from soil and groundwater sources at the lower bound release rate of 24 pounds/year. Perchlorate concentrations in the STBC and WDA source areas predicted for 2026 are generally two orders of magnitude lower than current conditions, due to the lower perchlorate release rates. The Test Bay Canyon plume hot spot is predicted to migrate downgradient approximately 1,500 feet and decline in concentration from 100,000 µg/L to 30,000 µg/L; the WDA plume hot spot is predicted to migrate approximately 4,000 feet downgradient and decline in concentration from over 100,000 µg/L to 10,000 µg/L. The downgradient limits of the plume expand, and are essentially identical to the limits for the no action (high source-release rate) scenario, discussed above.

The current groundwater plume configuration shows no detachment from the soil hot spot, despite the 35- to 51-year age of the plume. This observation and comparison to model predictions in this section suggests that this scenario is less likely than the high source-release rate, no action scenario.

2.8.3.3 Source Removal Scenario

The source removal scenario consists of current groundwater conditions, with no continued release of perchlorate from the source areas. Source area concentrations predicted for 2026 fall below 6 μg/L MCL for perchlorate, and the perchlorate plume hot spots migrate downgradient to approximately the same configuration as for the low source-release rate, no action scenario. The downgradient limits of the plume increase, and are almost identical to the no action (high source-release rate) and no action (low source-release rate) scenarios. Removal of perchlorate mass at the sources could result in more rapid depletion of plume mass over a significant period of time, although this effect is relatively minor over the simulation period due to the low groundwater velocity.

2.9 CONTAMINANT ATTENUATION EVALUATION

A contaminant attenuation evaluation (Tetra Tech, 2011a; Tetra Tech, 2012c) was conducted to evaluate natural processes contributing to the attenuation of contaminants in groundwater, and the rates at which these processes are taking place. The results of this study did not identify significant attenuation of contaminants relative to the current plume mass flux rates. However, two mechanisms for the potential removal of contaminants from groundwater were identified at the site: discharge by evapotranspiration, and degradation due to reducing aquifer conditions. Both of these mechanisms are likely to be active primarily in the riparian area south of the property boundary. Plant tissue sampling conducted in the riparian corridor (Tetra Tech, 2012b) found that phyto-uptake of perchlorate is currently occurring, and aquifer redox conditions in the riparian area are mixed oxic-anoxic, and potentially could degrade perchlorate. However, these processes have not been quantitatively assessed since the riparian corridor is not owned or controlled by Lockheed Martin.

2.10 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

The human health and ecological risk assessment (HHERA) (Tetra Tech, 2012b) consists of a human health risk assessment (HHRA) and a predictive ecological risk assessment (PERA) prepared in accordance with USEPA and DTSC guidance. The risk analyses are based on the findings of the site investigations conducted since the DTSC requested further characterization of the site in 2003. Only fully validated analytical data supported by appropriate quality assurance/quality control procedures were used in the HHERA.

2.10.1 Human Health Risk Assessment

The HHRA evaluated potential health risks for five groups of current and potential future receptors at the site:

- Current and future adult trespassers
- Current and future teen-age trespassers
- Future industrial workers
- Future construction workers
- Future residents

Each group of receptors was assumed to be exposed to chemicals of potential concern detected in six areas of concern, including the five former operational areas (Areas J, K, L, M, and the WDA) and south Laborde Canyon (i.e., the portion of Laborde Canyon located south of the WDA). Although access to and use of groundwater as a source of drinking water is expressly prohibited by LUCs for the site, groundwater use was evaluated under beneficial use conditions.

Each group of receptors was assumed to have direct contact with the chemicals of potential concern in soil, to inhale airborne dusts and vapors emitted from soil, and to inhale vapors emitted from soil gas and groundwater to indoor air (for commercial/industrial workers only), depending on the chemicals of potential concern identified in each area of concern. Exposures were also evaluated for the Test Bay 3 area in Area K, which comprises about 0.25 acres or about 0.2% of the total area of Area K, where elevated concentrations of perchlorate were detected in surficial soils. Use of groundwater for drinking water supply in the area south of the property boundary was also evaluated for chemicals of potential concern in the WDA groundwater plume.

Two sets of exposure parameters were used to evaluate trespassers: an upper bound, reasonable maximum exposure (RME) scenario; and an average, or central tendency exposure scenario. Although it is likely that trespassers would contact only surface soil at the site, an alternative set of exposure point concentrations (EPCs) was also evaluated for trespassers, based on EPCs calculated for surface (0.5 ft bgs) or surface plus subsurface soils (0-10 feet bgs), whichever was higher. The HHRA results include the following:

- Trespassers: Carcinogenic risk estimates for the Adult RME scenario range from 7×10^{-10} to 2×10^{-6}. All risk estimates are below the point of departure of 1×10^{-6}, except for the assumed exposure to cadmium at the WDA. Carcinogenic risk estimates for the Adult RME scenario with alternate EPCs range from 7×10^{-9} to 9×10^{-6}. Risks of 8×10^{-6} to 9×10^{-6} were estimated for exposure to cobalt in subsurface soil in Areas J, K, L, and the Test Bay 3 area. However, the risk estimates are comparable to those calculated for exposures to background concentrations of cobalt; incremental risks ranged from 4×10^{-8} to 1×10^{-6}. Thus, the risks estimated for trespassers in Areas J, K, L, and the Area K hotspot are within acceptable levels. Risk estimates for trespassers in Area M are below the point of departure of 1×10^{-6}, whereas those for the WDA are the same as determined for exposure to cadmium in the Adult RME scenario. None of the noncarcinogenic hazard indices (HIs) calculated for trespassers exceed the threshold of 1.

- Industrial Workers: Carcinogenic risk estimates are below the point of departure of 1×10^{-6} for all areas of concern, and none of the noncarcinogenic HIs exceed the threshold HI of 1.

- Construction Workers: Carcinogenic risk estimates are below the point of departure of 1×10^{-6} for all areas of concern. Noncarcinogenic HIs for Area L, the WDA, and South Laborde Canyon are below the threshold of 1. The noncarcinogenic HIs in Areas J, K, and M and in the Area K hotspot exceed 1, all with HIs of 2 due to assumed exposure to vanadium. However, the HIs are comparable to HIs calculated for exposures to background concentrations of vanadium; incremental HIs range from 0.1 to 0.4. Thus, the noncarcinogenic hazards estimated for construction workers in Areas J, K (including the hotspot), and M are within acceptable levels.

- Lead: Health risks potentially associated with lead were estimated by comparing the residential and industrial worker CHHSLs to the lead EPCs in soil in each area of concern. None of the lead EPCs exceeds either CHHSL in Areas J, K, K hotspot, L, or M. The lead EPC in the WDA exceeds the residential CHHSL of 80 mg/kg, but not the industrial worker CHHSL of 320 mg/kg.

- Groundwater: Exposure pathways are likely to be incomplete for human receptors because groundwater is not used for drinking water supply purposes, and there is a deed restriction preventing installation of water supply wells and the use of groundwater on the property. However, since a groundwater plume containing perchlorate extends to the southern boundary of the property and to some extent beyond, exposure to groundwater was considered under beneficial use conditions (i.e., groundwater was considered to be a source of drinking water). Beneficial uses of groundwater were evaluated by comparing chemical of potential concern concentrations in groundwater to drinking water criteria, including MCLs, drinking water notification levels (DWNLs), and USEPA lifetime Health Advisory levels. Perchlorate, six organic compounds (1,1-DCE, 1,2-DCA, methylene chloride, TCE, RDX, and 1,4-dioxane), and five metals (arsenic, barium, chromium, molybdenum, and nickel) exceed their respective drinking water criteria. Elevated concentrations of perchlorate and organic chemicals of potential concern were detected at, or in the immediate vicinity of the WDA source area, suggesting they are related to site contamination. There does not appear to be a consistent pattern for the metals exceeding their respective drinking water criteria, suggesting that metals are not related to site contamination.

Potential human health concerns identified by the risk assessment are summarized by area in Table 2-8.

2.10.2 Additional Lead Evaluation

The DTSC recently issued Lead Spread 8, a tool for evaluating lead exposures that was not available at the time that the HHRA was finalized. This tool was used to evaluate the lead EPC in the WDA that was previously compared with residential and industrial worker CHHSLs. For this evaluation, the Lead Spread 8 default exposure parameters were replaced with the trespasser exposure parameters used in the HHRA, and a 90th percentile concentration corresponding to a benchmark change in blood lead concentration of 1 microgram per deciliter was then calculated (Appendix B). The calculated 90th percentile lead concentration of 193 mg/kg is less than the EPC of 236 mg/kg, suggesting that exposure in the WDA could result in unacceptable blood lead concentrations for trespassers.

2.10.3 Summary of Ecological Risk Assessment

The PERA evaluated exposures of ecological receptors that have been observed in site-specific biological surveys, or are considered potentially present based on habitat associations identified in background data reviews. The ecological receptors assessed included the following:

- Plants (*i.e.*, herbaceous plants, shrubs, and trees)
- Soil invertebrates
- Amphibians
- Herbivorous, insectivorous, and carnivorous birds
- Herbivorous, insectivorous, and carnivorous mammals

Each group of receptors was assumed to be exposed to chemicals of potential concern detected in seven areas of concern, including the five former operational areas (Areas J, K, L, M, and the WDA), the Prism within Area K, and south Laborde Canyon. Exposures of wide-ranging carnivorous birds and mammals were also evaluated collectively across the entire site. Reptiles, which were not evaluated quantitatively, were considered likely to be protected by evaluations for birds and mammals.

Soil exposure pathways were evaluated in each area of concern. Plants and soil invertebrates were assumed to be exposed to chemicals of potential concern in soil through root uptake and absorption/ingestion, respectively. Birds and mammals were assumed to directly ingest chemicals of potential concern in soil, and to ingest chemicals of potential concern bioaccumulated in plant, invertebrate, and small mammal tissues from soil. A soil gas exposure pathway was evaluated for inhalation by burrowing mammals at the WDA. An exposure pathway was evaluated for trees exposed via root uptake from shallow groundwater in the WDA plume in south Laborde Canyon. Birds and mammals were also assumed to ingest chemicals of potential concern bioaccumulated in tree leaf tissues from shallow groundwater in south Laborde Canyon. Finally, a surface water exposure pathway was evaluated for amphibians exposed to ephemeral standing water in a low spot in a road in Area L.

Exposures were estimated for plants and soil invertebrates using applicable EPCs for soil and shallow groundwater. Exposures were estimated for bird and mammalian receptor groups on the basis of nine representative species, using applicable exposure equations, exposure factors, bioaccumulation models, and EPCs. To reduce uncertainty in exposures to perchlorate via ingestion of plants, bioaccumulation models were supplemented with results from two site-specific studies on uptake of perchlorate by plants.

The resulting ranges of hazard quotients (HQs) for specific media, chemical of potential concern groups, and receptors are summarized below:

- All HQs for organic chemicals of potential concern were less than 1. For birds and mammals, most HQs resulting from metals were below 1 or only moderately elevated (i.e., less than 5). Multiple lines of evidence were used to evaluate the significance of hazards identified by HQs exceeding 1. These lines of evidence included the magnitudes of HQs, comparisons to background metal concentrations, incremental hazards relative to background, frequency of detection, confidence in bioaccumulation models, toxicity effect level, confidence in toxicity reference values (TRVs) and alternate TRVs, habitat quality in potentially affected areas, and presence of special-status species. Based on these multiple lines of evidence, no chemicals of potential concern are considered likely to pose hazards to ecological receptors in Areas J, L, or M, or in south Laborde Canyon.

- Perchlorate in soils in Area K may pose potential hazards to populations of herbivorous birds (represented by the house finch) based on growth and behavioral effects, and the Stephens' kangaroo rat (SKR) based on reproductive effects. Focused biological surveys suggest that potential hazards to herbivorous birds from perchlorate in soil are likely of limited ecological significance due to the relatively low value of grassland habitat compared to other habitats in the area of concern that support larger populations and numbers of bird species. Within Area K, the major contributors to these hazards are soil concentrations at Test Bay 3 (0.25 acres, or about 0.2% of Area K) and at the Prism.

- Within the Test Bay 3 area, the HQ based on the no-observed adverse-effect level (NOAEL) for perchlorate, calculated for the SKR based on reproductive effects, approaches 5, indicating a potential for decreased reproductive success. Perchlorate in soils at the Prism may pose potential hazards to the SKR based on reproductive effects. However, focused biological surveys suggest that the HQ indicating potential reproductive effects to the SKR may not represent significant impacts to populations or individuals, because the Prism provides habitat of limited value to the SKR, based on (1) the limited size of the Prism (i.e., about 0.7 acres, or 0.5% of Area K), (2) extremely steep slopes and relatively low quality of habitat for the SKR, (3) trace to low densities of kangaroo rat signs observed on a portion of the Prism, and (4) physical disturbances at the Prism.

- Lead and zinc in soils in a localized area within the WDA could impact ecological receptors. Potentially significant hazards to the SKR were identified from lead, and to plants and soil invertebrates from zinc. Additional evaluations indicated that these hazards are within acceptable levels, except for the limited area represented by one sample location (Pond3). Given the limited area of zinc contamination, the hazards to plants and invertebrates, which are protected at the community rather than individual level, are considered to be acceptable.

Potentially significant ecological concerns identified by the risk assessment are summarized in Table 2-8.

Section 2 Tables

Table 2-1
Constant-Rate Aquifer Test Data

Well	Test Phase[1]	Transient Drawdown Analysis									Specific Capacity Analysis	Drawdown Distance Analysis	Best Estimate Transmissivity (ft^2/day)
		Theis Type Curve Method[2]		Cooper-Jacob Method[3]		Leaky Aquifer Type Curve Method[4]			Average Transmissivity[5] (ft^2/day)	Average Storativity[6]			
		Transmissivity (ft^2/day)	Storativity	Transmissivity (ft^2/day)	Storativity	Transmissivity (ft^2/day)	Storativity	r/B			Transmissivity (ft^2/day)	Transmissivity (ft^2/day)	
Site Boundary Area (Tetra Tech, 2010e)													
TT-EW2-1	P	0.90	NA	0.63	NA	NA	NA	NA	0.69	NA	2.4	1.9	2
	R	0.75	NA	0.53	NA	NA	NA	NA					
TT-PZ2-2	P	1.6	2.0E-03	1.4	1.7E-03	NA	NA	NA	1.4	0.0019	NA		
	R	1.2	2.3E-03	1.2	1.7E-03	NA	NA	NA					
TT-MW2-8	P	8.3	2.6E-03	7.9	4.5E-03	NA	NA	NA	9.2	0.0031	NA		
	R	10	3.2E-03	11	2.3E-03	NA	NA	NA					
Waste Discharge Area (Tetra Tech, 2012d)													
TT-EW2-3	R	0.22	NA	0.24	NA	0.13	NA	0.58	0.19	NA	1.1	NA	1
TT-PZ2-4	R	0.22	0.0018	0.28	0.0014	0.12	0.0014	0.90	0.20	0.0015	NA		
TT-MW2-24	R	6.5	0.14	13	0.10	NA	NA	NA	9.0	0.12	NA		
Test Bay Canyon (Tetra Tech, 2012d)													
TT-EW2-2	P	6.5	NA	6.3	NA	6.1	NA	0.027	6.5	NA	11	NA	10
	R	6.7	NA	6.9	NA	6.5	NA	0.021					
TT-PZ2-3	P	57	0.020	59	0.018	NA	NA	NA	57	0.067	NA		
	R	57	0.11	53	0.12	NA	NA	NA					
TT-MW2-39	P	5.0	0.0018	4.9	0.0016	4.0	0.0019	0.23	4.3	0.0020	NA		
	R	4.4	0.0024	4.5	0.0020	3.3	0.0024	0.33					

Notes:
Pumping rate is 0.82 gpm for 72 hours.
NA: Not applicable
- : No drawdown observed
1. P indicates pumping phase of test; R indicates recovery phase of test.
2. Data interpreted using Theis type curve method
3. Data interpreted using Cooper-Jacob semilog method
4. Data interpreted using leaky aquifer type curve method
5. Geometric mean of Theis type curve, Cooper-Jacob, and/or leaky aquifer type curve methods
6. Mean of storativity values

Table 2-2
Slug Test Data

Well	Hydraulic Conductivity (feet per day)		
	Falling Head[1]	Rising Head[2]	Average[3]
TT-MW2-1	9.3	9.4	9.4
TT-MW2-3	1.3	1.1	1.2
TT-MW2-4S	0.011	0.010	0.011
TT-MW2-5	0.33	0.88	0.61
TT-MW2-6D	4.4	6.0	5.2
TT-MW-2-7	0.042	0.038	0.040
TT-MW2-7D	0.090	0.079	0.085
TT-MW2-84	0.50	0.49	0.49
TT-MW2-9	0.19	0.19	0.19
TT-MW2-9D	0.32	0.29	0.31
TT-MW2-10	0.65	0.91	0.78
TT-MW2-11	0.011	0.014	0.012
TT-MW2-13	0.16	0.17	0.17
TT-MW2-14	0.12	0.11	0.11
TT-MW2-17S	0.051	0.048	0.050
TT-MW2-17D	1.3	1.3	1.3
TT-MW2-19S	0.0012	-	0.0012
TT-MW2-19D	0.00059	-	0.00059
TT-MW2-21	0.11	0.097	0.10
TT-MW2-22	0.097	0.11	0.10
TT-MW2-23	0.016	0.017	0.017
TT-MW2-24	0.16	0.16	0.16
TT-MW2-28	0.00073	0.00064	0.00068
TT-MW2-30A	0.77	0.71	0.74
TT-MW2-30B	0.053	0.045	0.049
TT-MW2-30C	0.011	0.010	0.011
TT-MW2-36A	2.7	2.2	2.5
TT-MW2-37A	0.019	0.015	0.017
TT-MW2-37B	0.0080	0.0067	0.0073
TT-MW2-38A	0.65	0.15	0.40
TT-MW2-38B	0.086	0.073	0.080
TT-MW2-38C	0.026	0.040	0.033
TT-MW2-39	4.9	2.1	3.5
TT-MW2-40A	3.1	2.7	2.9
TT-MW2-41A	0.00051	0.0040	0.0023
TT-MW2-42A	0.065	0.043	0.054

Notes:

- : no data

1. Data collected during falling-head (slug-in) phase of test
2. Data collected during rising-head (slug-out) phase of test
3. Mean of hydraulic conductivity values for falling- and rising-head tests

Table 2-3
Water Budget Summary

Water Balance Element	wSTF Aquifer	STF Aquifer	Notes
Recharge			
Direct Precipitation	2	0	
Direct Recharge from Creek	0	0	
Underflow	0	0	
Injection/Spreading	0	0	
Leakage from STF Aquifer	0.1	-	1
Leakage from wSTF Aquifer	-	0.4	2
Total Recharge	**2.1**	**0.4**	
Discharge			
Extraction	0	0	
Evapotranspiration	0.7	0	3
Discharge to Creek	0	0	
Underflow	1	0.3	
Leakage to STF Aquifer	0.4	-	4
Leakage to wSTF Aquifer	-	0.1	5
Total Discharge	**2.1**	**0.4**	
Net Budget	**0**	**0**	

Notes

All values are in acre-feet per year.

- : not applicable

STF: San Timoteo formation

wSTF: Weathered San Timoteo formation

1. Based on leakance factor of 2×10^{-6} day^{-1}, area of 40 acres, and head difference of 3 feet
2. Based on leakance factor of 2×10^{-6} day^{-1}, area of 165 acres, and head difference of 3 feet
3. Estimated range of values is 0.5 to 1
4. Based on leakance factor of 2×10^{-6} day^{-1}, area of 165 acres, and head difference of 3 feet
5. Based on leakance factor of 2×10^{-6} day^{-1}, area of 165 acres, and head difference of 3 feet. Leakance from STF aquifer to deeper portions of STF aquifer is estimated to be 0.1 acre-feet per year, and is neglected in steady-state model.

Table 2-4
Soil Impacts by Historical Operational Area

Area	Contaminants									
	Perchlorate	TPHg	TPHd	VOCs	SVOCs	PCBs	Metals	1,4-Dioxane	RDX	NDMA
Primary Source Areas										
Area K - Southern Test Bay Canyon	✓	-	-	-	-	-	-	-	NA	NA
Waste Discharge Area	✓	NA	NA	✓	-	NA	✓	-	-	-
Secondary Source Areas										
Area K - Northern Test Bay Canyon	✓	-	-	-	-	-	-	-	NA	NA
Area M	✓	-	-	-	-	-	-	-	NA	-
No Significant Impacts										
Area J	-	-	-	-	-	-	-	-	NA	NA
Area K - Laborde Canyon	-	-	-	-	-	-	-	-	-	NA
Area L	-	-	-	-	-	-	-	-	NA	-
South Laborde Canyon	-	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Metals: California Title 22 metals
NDMA: N-Nitrosodimethylamine
PCBs: Polychlorinated biphenyls
RDX: Hexahydro-1,3,5-trinitro-1,3,5-triazine
SVOCs: Semivolatile organic compounds
TPHg: Total petroleum hydrocarbons as gasoline
TPHd: Total petroleum hydrocarbons as diesel
VOCs: Volatile organic compounds
✓ indicates significant impacts present.
- indicates significant impacts not present.
NA indicates not analyzed.

Table 2-5
Perchlorate Mass Estimates: Soil Source Areas

Area	Concentration Range (µg/kg)	Estimated Perchlorate Mass (pounds)	% of Mass in Source Area	% of Total Mass in Soil at Site
Northern Test Bay Canyon	100-1,000	3.3	100%	0.4%
	Subtotal:	3.3	100%	0.4%
Southern Test Bay Canyon	100-1,000	61	17%	8%
	1,000-10,000	175	49%	22%
	10,000-100,000	120	34%	15%
	>100,000	0.04	0.01%	0%
	Subtotal:	356	100%	45%
Area M	100-1,000	3.9	87%	0.5%
	1,000-10,000	0.62	14%	0.1%
	Subtotal:	4.5	100%	0.6%
WDA	100-1,000	21	4.9%	3%
	1,000-10,000	142	33%	18%
	10,000-100,000	256	60%	32%
	>100,000	6.1	1.4%	1%
	Subtotal:	425	100%	54%
Total Mass		**789**	**-**	**100%**

Notes:

1. Perchlorate masses estimated from geostatistical model developed using Mining Visualization System software.

Table 2-6
Groundwater Impacts by Plume

Groundwater Plume	Contaminants						
	Perchlorate	**VOCs**	**SVOCs**	**Metals**	**1,4-Dioxane**	**RDX**	**NDMA**
Primary Groundwater Plumes							
Southern Test Bay Canyon	✓	-	-	-	-	✓	-
Waste Discharge Area	✓	✓	-	-	✓	✓	-
Secondary Groundwater Plumes							
Northern Test Bay Canyon	✓	-	NA	NA	NA	NA	NA
Area M	✓	-	-	-	-	-	-

Notes:
Metals: California Title 22 metals
NDMA: N-Nitrosodimethylamine
RDX: Hexahydro-1,3,5-trinitro-1,3,5-triazine
SVOCs: Semivolatile organic compounds
VOCs: Volatile organic compounds
✓ indicates significant impacts present.
- indicates significant impacts not present.
NA indicates not analyzed.

Table 2-7
Perchlorate Mass Estimates: Groundwater Plumes

Area	Concentration Range (µg/kg)	20% Porosity			35% Porosity			% of Plume Mass	% of Total Mass in Groundwater
		Estimated Total Plume Mass (pounds)	Estimated Source Area Mass (pounds)	Estimated Downgradient Mass (pounds)	Estimated Total Plume Mass (pounds)	Estimated Source Area Mass (pounds)	Estimated Downgradient Mass (pounds)		
Southern Test Bay Canyon	6-10	0.4	0.1	0.3	0.6	0.2	0.4	0.02%	0.0%
	10-100	5.9	2.3	3.6	10	4.0	6.0	0.2%	0.2%
	100-1,000	46	13	33	81	22	59	1.9%	1.8%
	1,000-10,000	340	69	270	590	120	470	14%	14%
	10,000-100,000	1000	460	540	1760	800	960	42%	40%
	>100,000	990	970	20	1740	1700	40	42%	40%
	Subtotal:	2380	1510	870	4180	2650	1540	100%	96%
WDA	6-10	0.3	0	0.3	0.6	0.1	0.5	0.3%	0.0%
	10-100	6.2	0.4	5.8	11	1.3	9.7	5.7%	0.2%
	100-1,000	31	2.3	29	55	8.1	47	28%	1.2%
	1,000-10,000	42	13	30	73	34	40	39%	1.7%
	10,000-100,000	29	29	0	50	50	0	27%	1.2%
	>100,000	0.4	0.4	0	0.8	0.8	0	0.4%	0.0%
	Subtotal:	109	45	65	190	94	97	100%	4%
Northern Test Bay Canyon	6-10	-	-	-	-	-	-	-	-
	10-100	-	-	-	-	-	-	-	-
	100-1,000	-	-	-	-	-	-	-	-
	Subtotal:	<1	-	-	<1	-	-	0%	0.0%
Area M	6-10	0.03	-	-	0.05	-	-	5%	0.0%
	10-100	0.3	-	-	0.6	-	-	62%	0.0%
	100-1,000	0.2	-	-	0.3	-	-	33%	0.0%
	Subtotal:	0.6			1.0			100%	0.0%
Total Mass		**2490**	**1560**	**940**	**4370**	**2740**	**1640**	**-**	**100%**

Notes:
1. Perchlorate masses estimated from geostatistical model developed using Mining Visualization System software.

Table 2-8
Risk Assessment Summary

Area	Receptor	Human Health		Ecological	Primary Contributor
		Risk	Blood Lead Concen-tration (µg/dl)	Hazard Quotient	
Southern Test Bay Canyon	SKR	-	-	1.2	Perchlorate
	Herbivorous Birds	-	-	7	Perchlorate
Waste Discharge Area	Adult Tresspasser	2E-06	-	-	Cadmium
		-	1.2	-	Lead
	SKR	-	-	1.1	Lead

Notes:

Only risks or hazards considered potentially significant in the risk assessment are shown.

µg/dl: micrograms per deciliter

- indicates not applicable.

SKR: Stephens' kangaroo rat

Section 2 Figures

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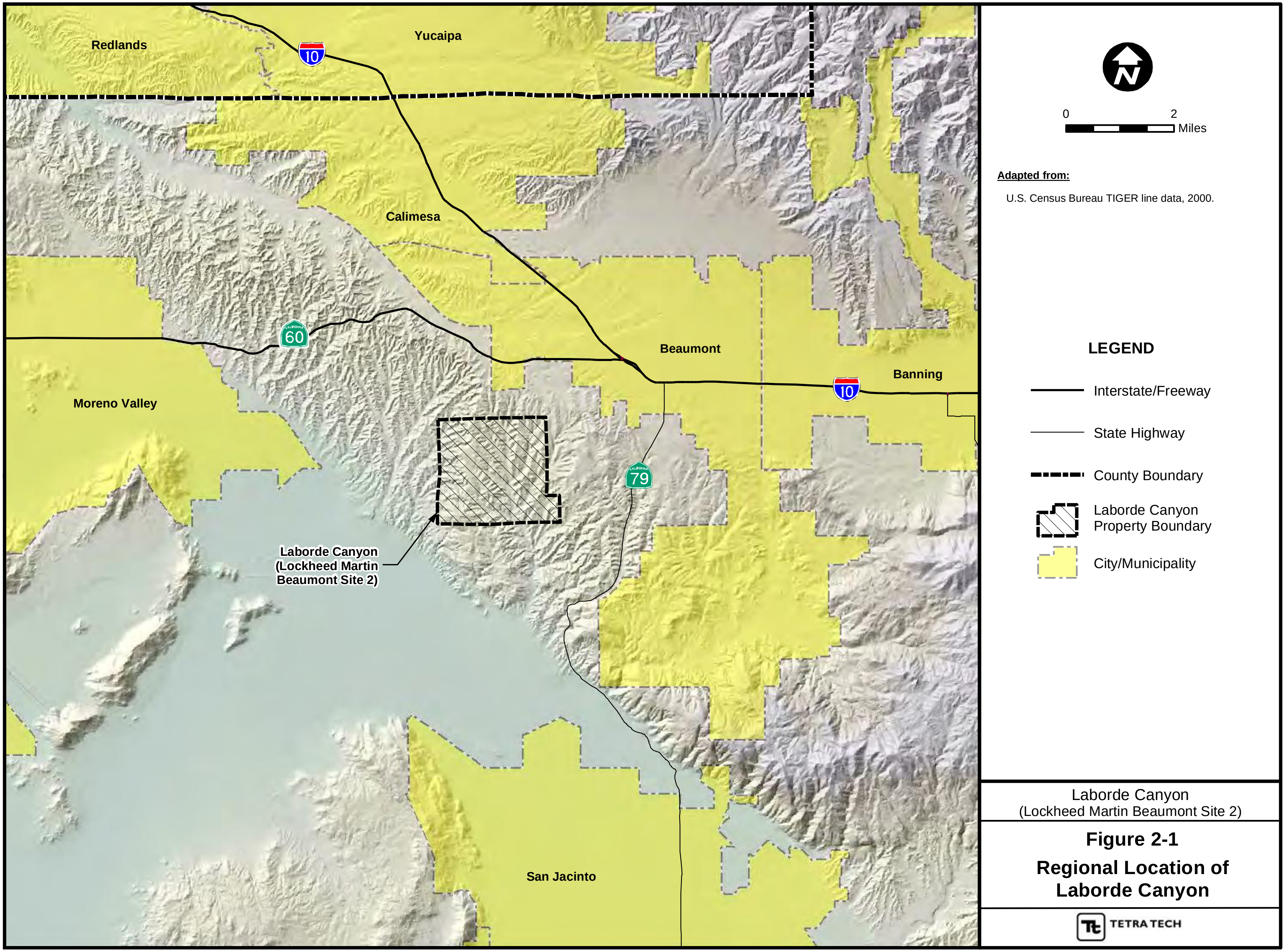

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-1

Regional Location of Laborde Canyon

TETRA TECH

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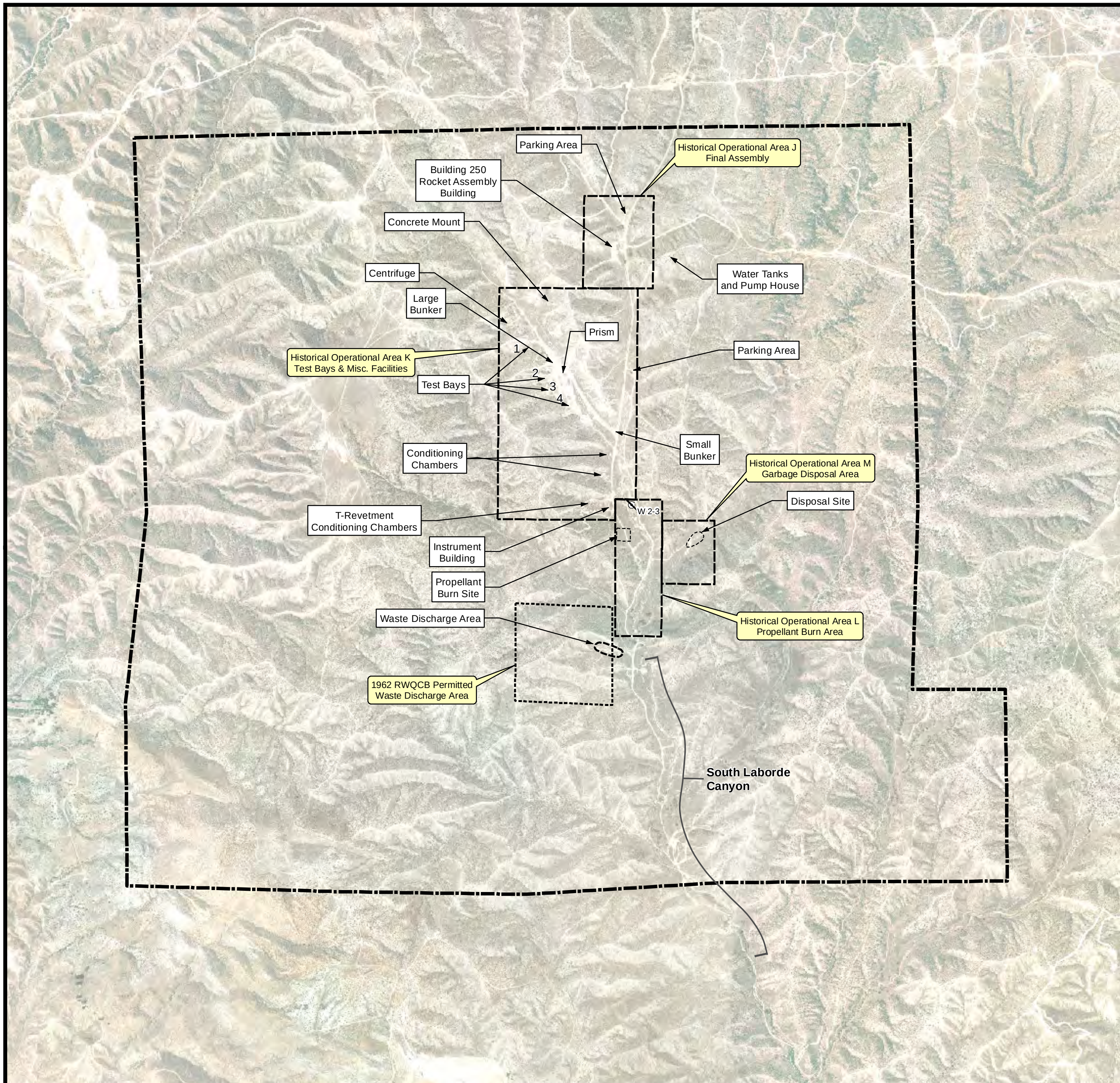

N

0 1,000 2,000
Feet

Adapted from:

March 2007 aerial photograph.

LEGEND

- Destroyed Production Well Location
- RWQCB Permitted Waste Discharge Area
- Historical Operational Area Boundary
- Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)

Note: Laborde Canyon property boundary (Lockheed Martin Beaumont Site 2) from Hillwig-Goodrow survey, May 2004.

Disposal and Propellant Burn Site perimeters are estimated (Radian, 1986).

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-2
Historical Operational Areas and Site Features

TETRA TECH

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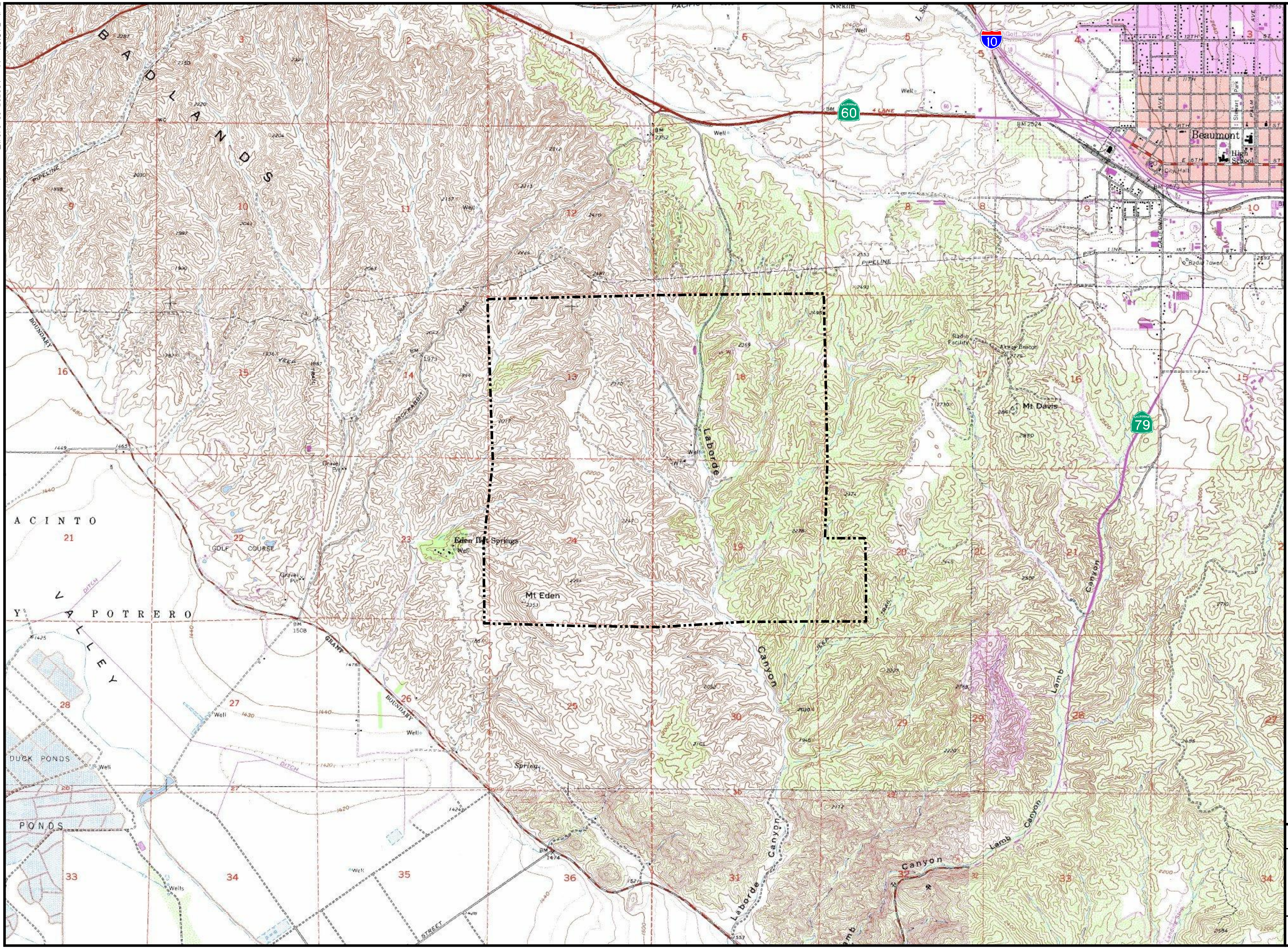

0 1,500 3,000
Feet

Adapted from:
USGS 7.5' topographic quadrangle, El Casco, CA 1979.
USGS 7.5' topographic quadrangle, Lakeview, CA 1979.
USGS 7.5' topographic quadrangle, San Jacinto, CA 1979.
USGS 7.5' topographic quadrangle, Beaumont, CA 1988.

LEGEND

Beaumont Site 2 Property Boundary

Note: Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-3

Site Topography

TETRA TECH

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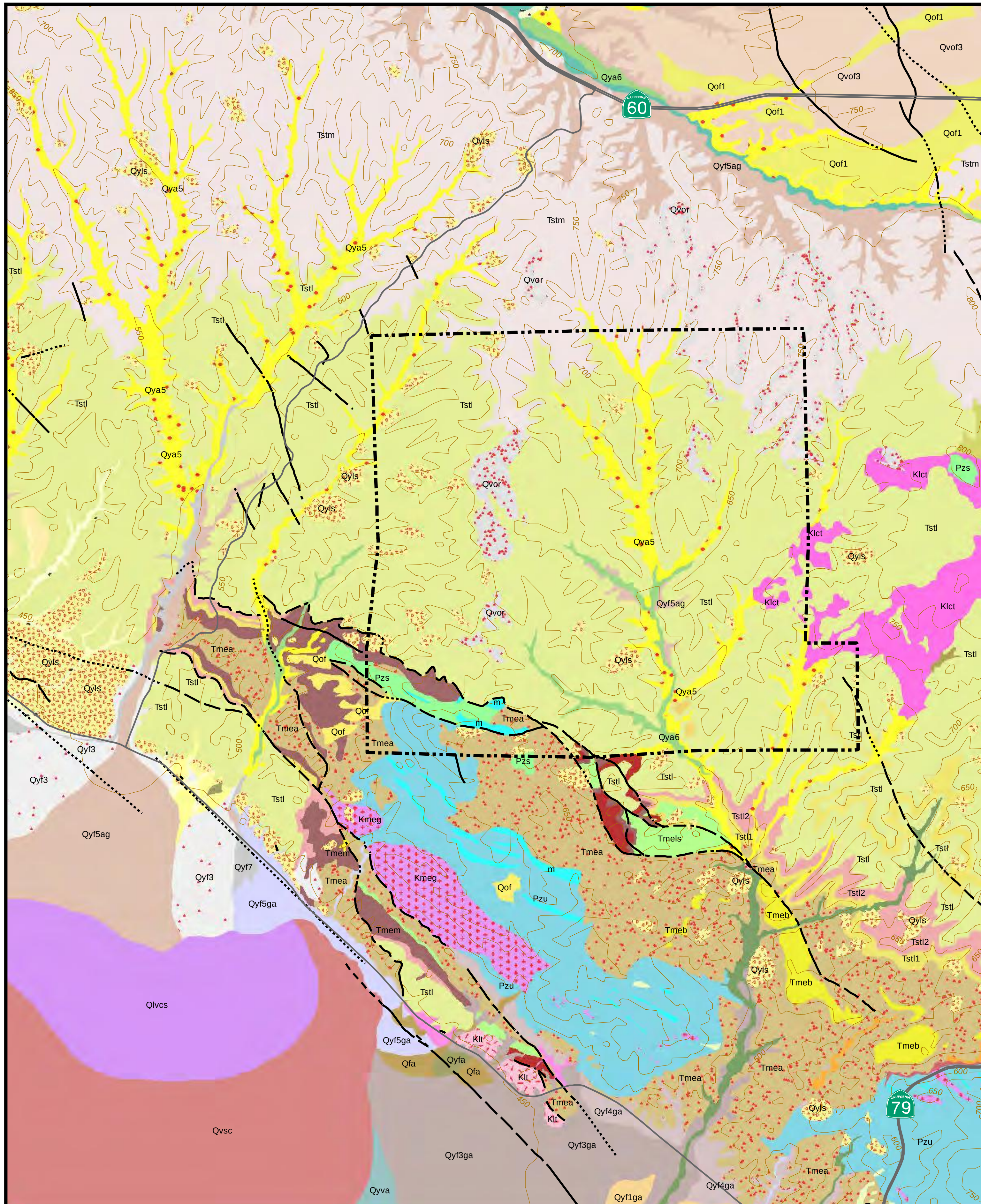

LEGEND

Faults

- Fault-accurately located
- Fault-approximately located
- Fault-concealed
- Fault-inferred

Roads

- Road - primary
- Road - secondary

Ground Surface Elevation Contour (50-meter interval msl)

Beaumont Site 2 Property Boundary

GEOLOGY

Qf1	Alluvial fan deposits, Unit 1
Qfa	Alluvial fan deposits, arenaceous
Qfga	Alluvial fan deposits, gravelly sand
Qlvcs	Lacustrine and fluvial deposits, clayey silt
Qoa	Old axial channel deposits
Qoc	Old colluvial deposits
Qof	Old alluvial fan deposits
Qof1	Old alluvial fan deposits, Unit 1
Qof3	Old alluvial fan deposits, Unit 3
Qos	Old surficial deposits, undivided
Qvoa	Very old axial channel deposits
Qvof3	Very old alluvial fan deposits, Unit 3
Qvofa	Very old alluvial fan deposits, arenaceous
Qvor	Very old regolith
Qvsc	Alluvial valley deposits, silty clay
Qwa	Wash deposits, arenaceous
Qwag	Wash deposits, arenaceous gravel
Qya3	Young axial channel deposits, Unit 3
Qya5	Young axial channel deposits, Unit 5
Qya6	Young axial channel deposits, Unit 6
Qyaag	Young axial channel deposits, arenaceous gravel
Qyf	Young alluvial fan deposits
Qyf1	Young alluvial fan deposits, Unit 1
Qyf1ga	Young alluvial fan deposits, Unit 1, gravelly sand
Qyf3	Young alluvial fan deposits, Unit 3
Qyf3ga	Young alluvial fan deposits, Unit 3, gravelly sand
Qyf4ga	Young alluvial fan deposits, Unit 4, gravelly sand
Qyf5ag	Young alluvial fan deposits, Unit 5, arenaceous gravel
Qyf5ga	Young alluvial fan deposits, Unit 5, gravelly sand
Qyf7	Young alluvial fan deposits, Unit 7
Qyfa	Young alluvial fan deposits, arenaceous
Qyfga	Young alluvial fan deposits, gravelly sand
Qyls	Young landslide deposits
Qyva	Young alluvial valley deposits, arenaceous
Qywa	Young wash deposits, arenaceous
Tme	Mount Eden Formation of Fraser (1931)
Tmeus	Mount Eden Formation of Fraser (1931), upper sandstone member
Tmem	Mount Eden Formation of Fraser (1931), mudrock member
Tmels	Mount Eden Formation of Fraser (1931), lower sandstone member
Tmea	Mount Eden Formation of Fraser (1931), arkosic sandstone member
Tmeb	Mount Eden Formation of Fraser (1931), arkosic sandstone member, tongues of monolithic tonalite boulder breccia
Tmec	Mount Eden Formation of Fraser (1931), conglomeratic sandstone member
Tstl	San Timoteo beds of Frick (1921), middle member
Tstl1	San Timoteo beds of Frick (1921), lower member
Tstl2	San Timoteo beds of Frick (1921), lower member, arkosic sandstone
Tstm	San Timoteo beds of Frick (1921), lower member, claystone, siltstone, and sandstone
m	Paleozoic (?) rocks, undifferentiated, marble bodies
Klct	Tonalite of Lamb Canyon, Peninsular Ranges batholith
Klt	Tonalite near mouth of Laborde Canyon, Peninsular Ranges batholith
Kmeg	Granite of Mount Eden, Peninsular Ranges batholith
Pzs	Biotite schist
Pzu	Paleozoic(?) rocks, undifferentiated

Source: Preliminary Digital Geologic Map of the Santa Ana 30' x 60' Quadrangle, Southern California, version 2.0. USGS 2004.

0 1,500 3,000 Feet

Laborde Canyon (Lockheed Martin Beaumont Site 2)

Figure 2-4

Regional Geology

TETRA TECH

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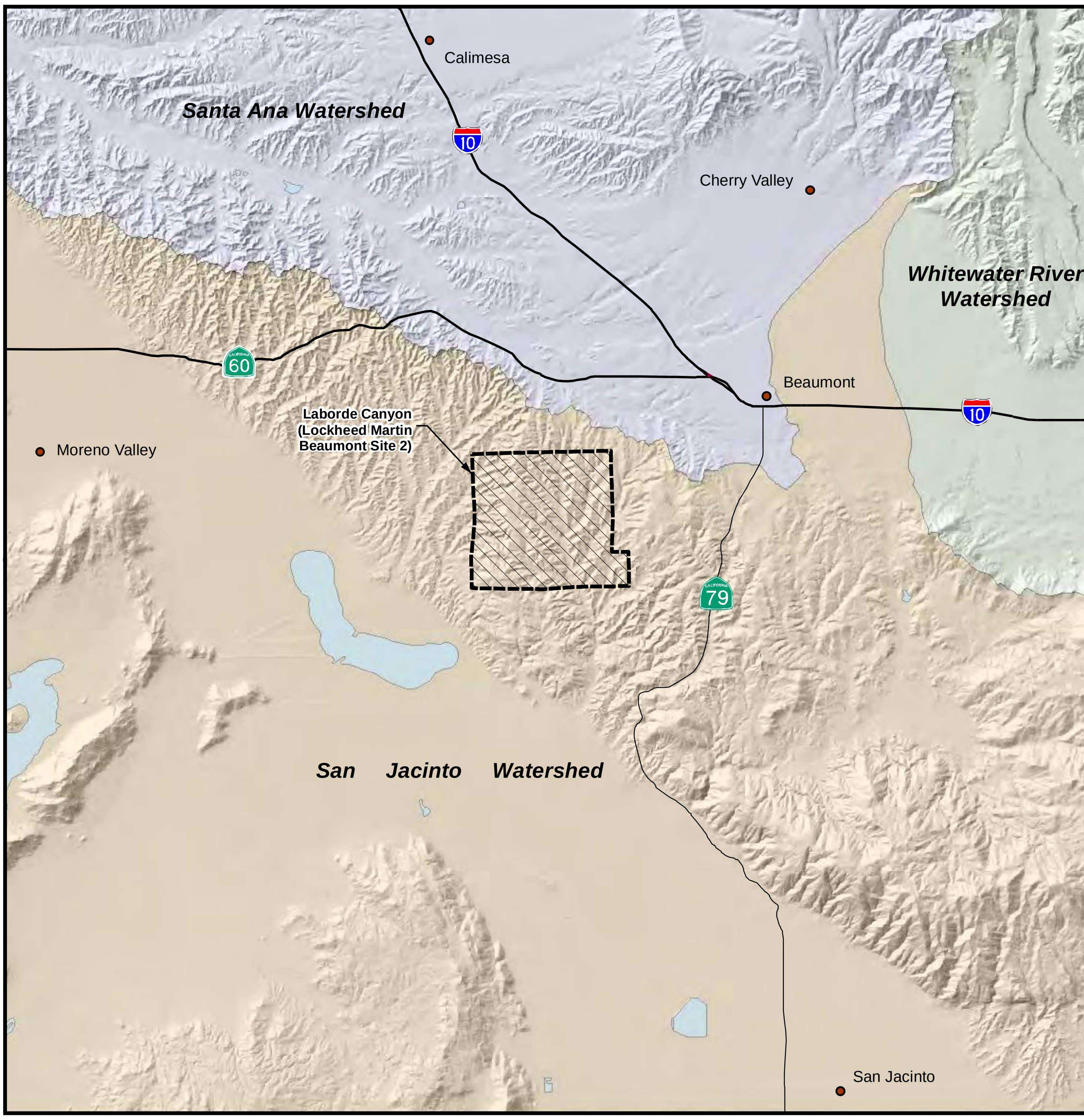


0 2 Miles

Adapted from:

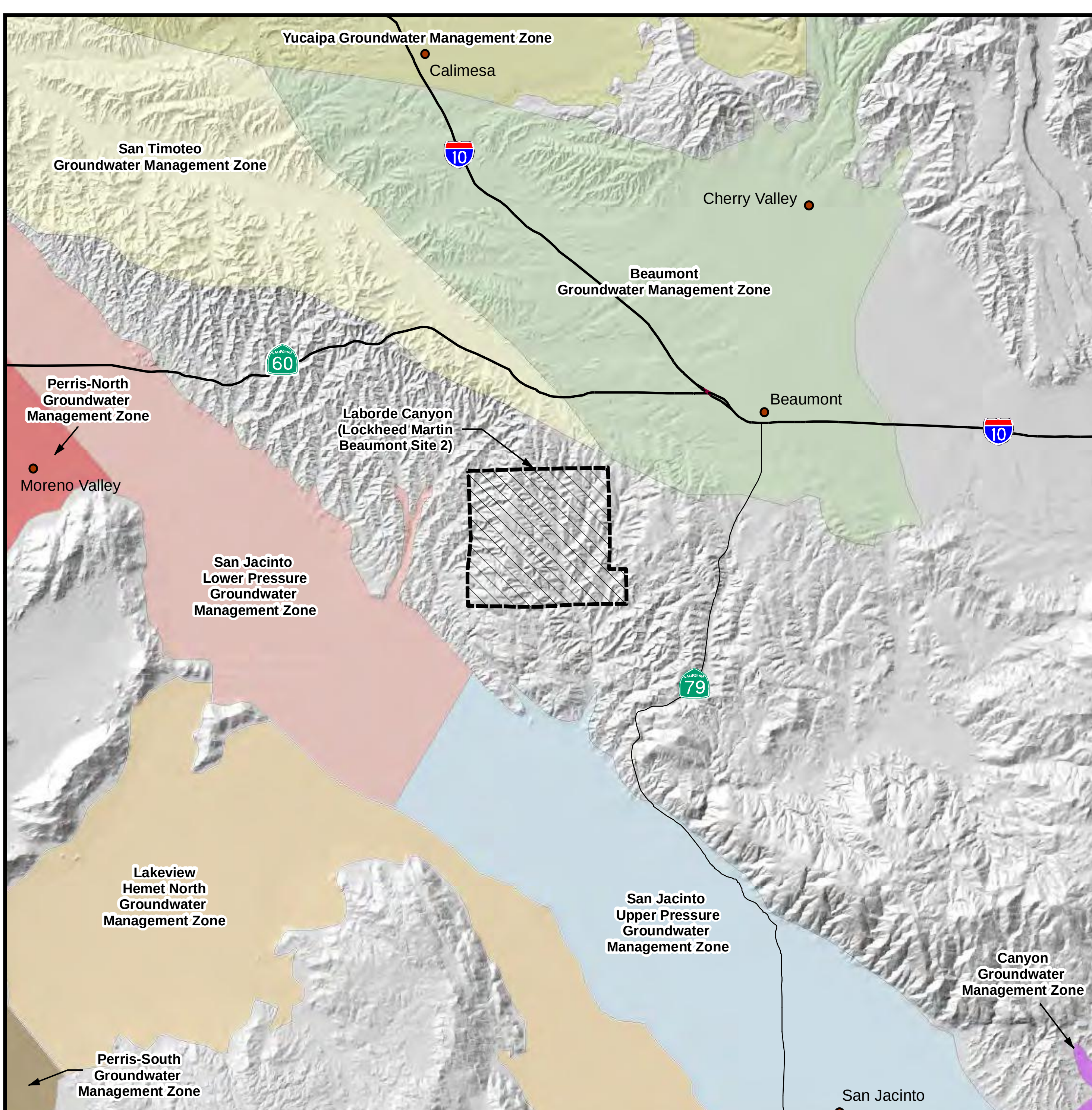
U.S. Census Bureau TIGER line data, 2000.

LEGEND

Interstate/Freeway

State Highway

Laborde Canyon Property Boundary



LEGEND

Interstate/Freeway

State Highway

Laborde Canyon Property Boundary

Source:
Wildermuth Environmental, Inc. 2003

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-5
Regional Watershed Boundaries and Groundwater Basins

TETRA TECH

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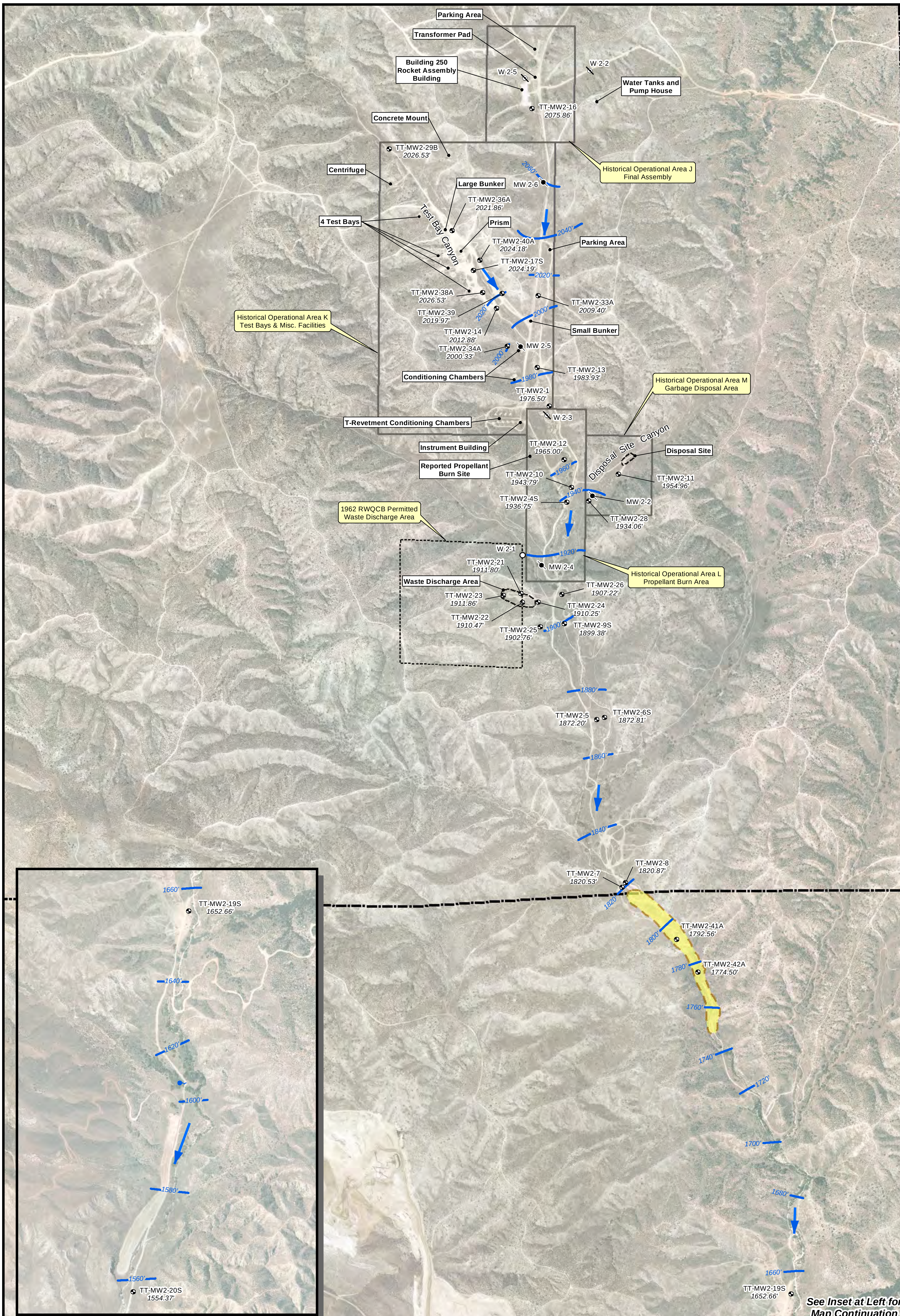

LEGEND

- Monitoring Well Location with Groundwater Elevation (feet msl)
- Destroyed Production Well Location
- Destroyed Monitoring Well Location
- Reported Production Well Location
- Groundwater Elevation Contour
- Groundwater Flow Direction
- Spring
- Riparian Corridor
- RWQCB Permitted Waste Discharge Area
- Historical Operational Area Boundary
- Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)

0 500 1,000 Feet

Adapted from: April 2007 aerial photograph

Notes: Laborde Canyon property boundary (Lockheed Martin Beaumont Site 2) from Hillwig-Goodrow survey, May 2004

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-6

Groundwater Contours for First Groundwater Second Quarter 2011

TETRA TECH

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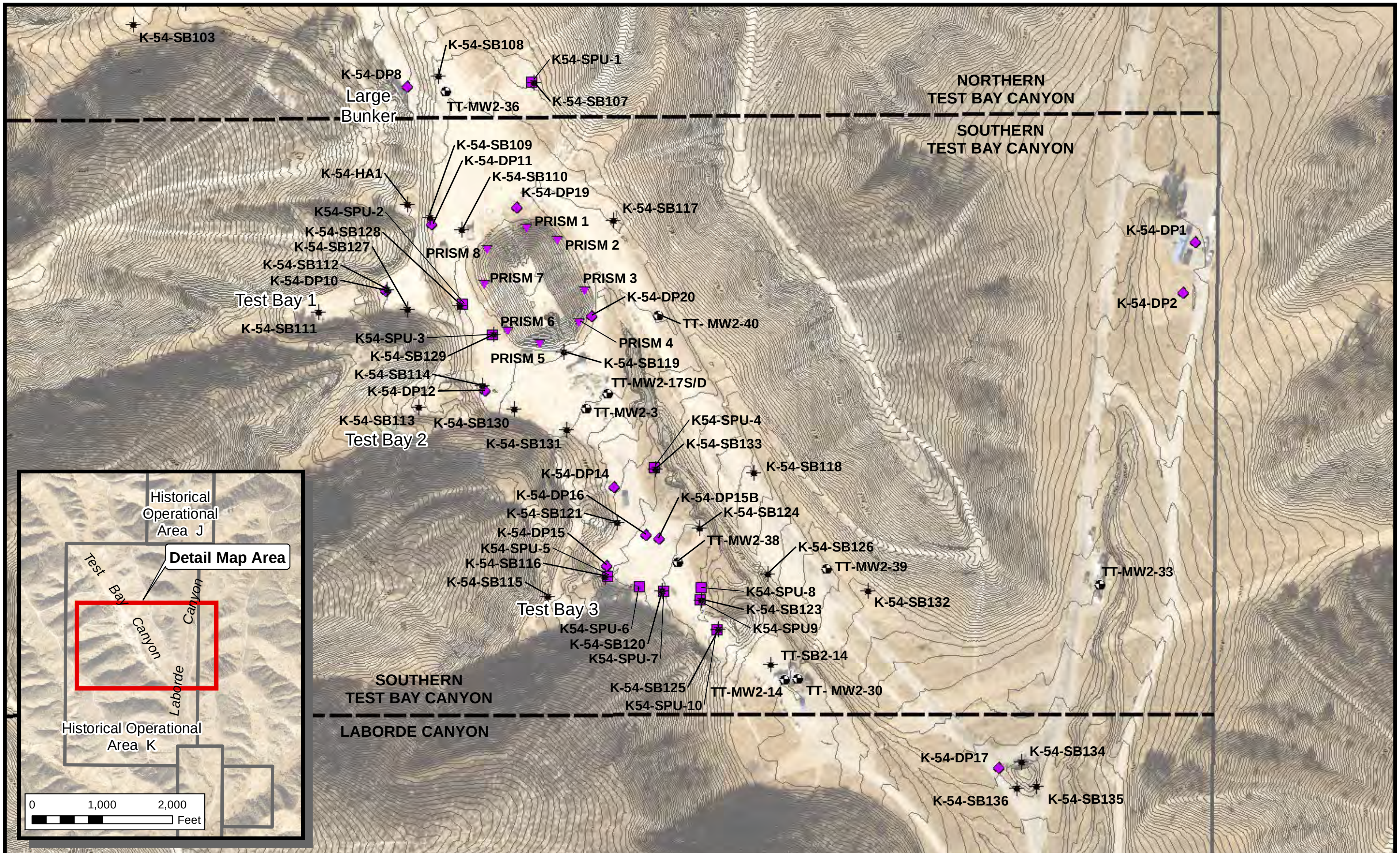

LEGEND

- Soil Boring Location
- Monitoring Well Location
- Soil Boring/Soil Gas Sample Location
- Surface Sample Location
- Subarea Boundary
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Historical Operational Area Boundary

0 100 200 Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-7
Sample Locations
Southern Test Bay
Canyon Subarea
Historical Operational Area K

TETRA TECH

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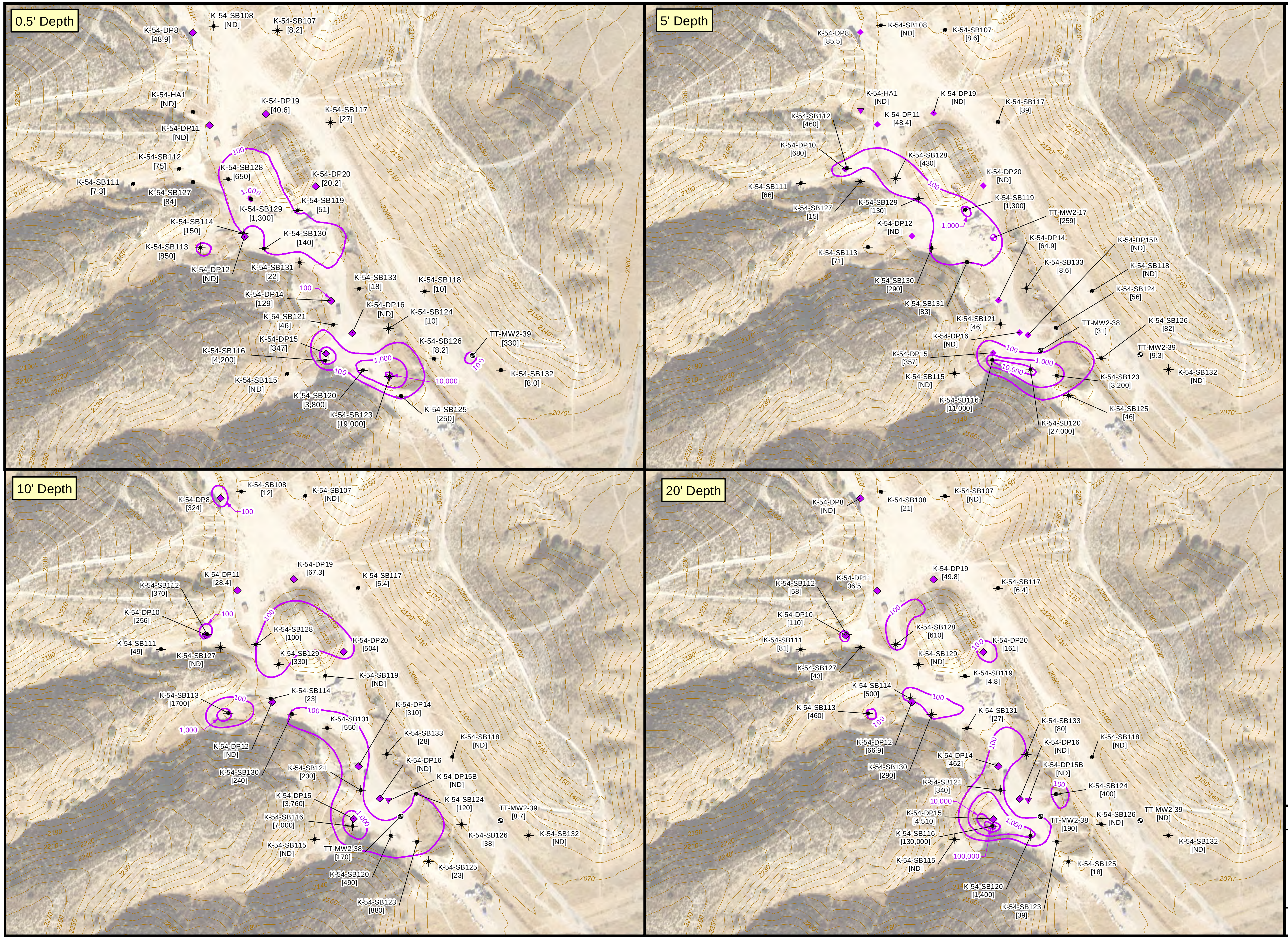

0 100 200 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Soil Boring Location
- Monitoring Well Location
- Soil Boring/Soil Gas Sample Location
- Perchlorate Isoconcentration Contour (dashed where inferred)
- Ground Surface Elevation Contour (10-foot interval - feet msl)

Note:

[#] Perchlorate results in µg/kg.

[ND] Non-Detect.

Laborde Canyon
(Lockeed Martin Beaumont Site 2)

Figure 2-8
Perchlorate Concentrations in Soil
Southern Test Bay
Canyon Subarea
Historical Operational Area K

TETRA TECH

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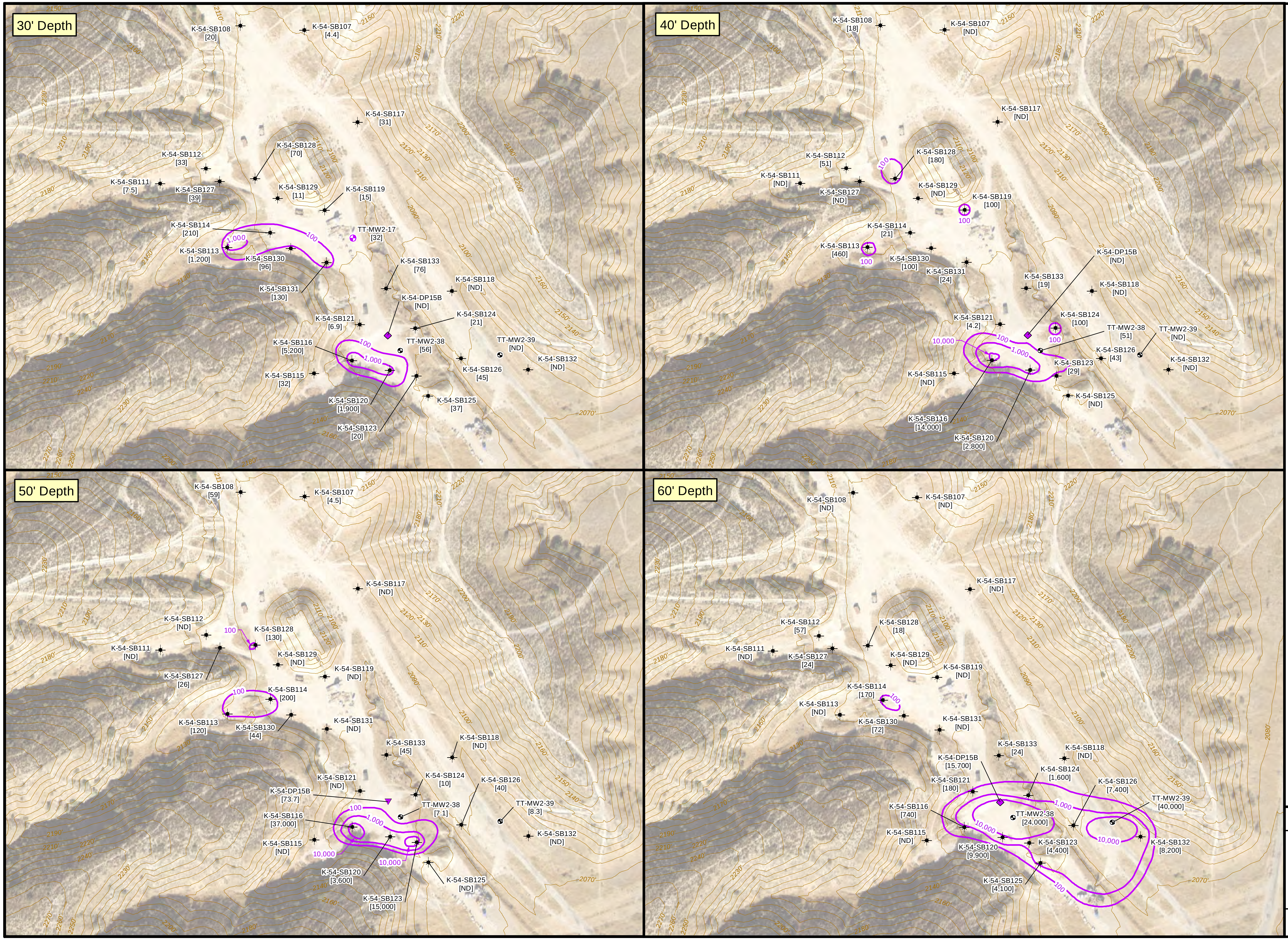

N

0 100 200 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- DSI Soil Sample Location
- Monitoring Well Location
- Soil Boring/Soil Gas Sample Location
- Perchlorate Isoconcentration Contour (dashed where inferred)
- Ground Surface Elevation Contour (10-foot interval - feet msl)

Note:

[#] Perchlorate results in μg/kg.

[ND] Non-Detect.

Laborde Canyon
(Lockeed Martin Beaumont Site 2)

Figure 2-8 (cont.)
Perchlorate Concentrations in Soil
Southern Test Bay
Canyon Subarea
Historical Operational Area K

TETRA TECH

Adapted from: March 2007 aerial photograph.

LEGEND

- Soil Gas Sample Location
- Soil Boring Location
- Monitoring Well Location
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Historical Operational Area Boundary

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-9

**Sample Locations
Waste Discharge Area**

TETRA TECH

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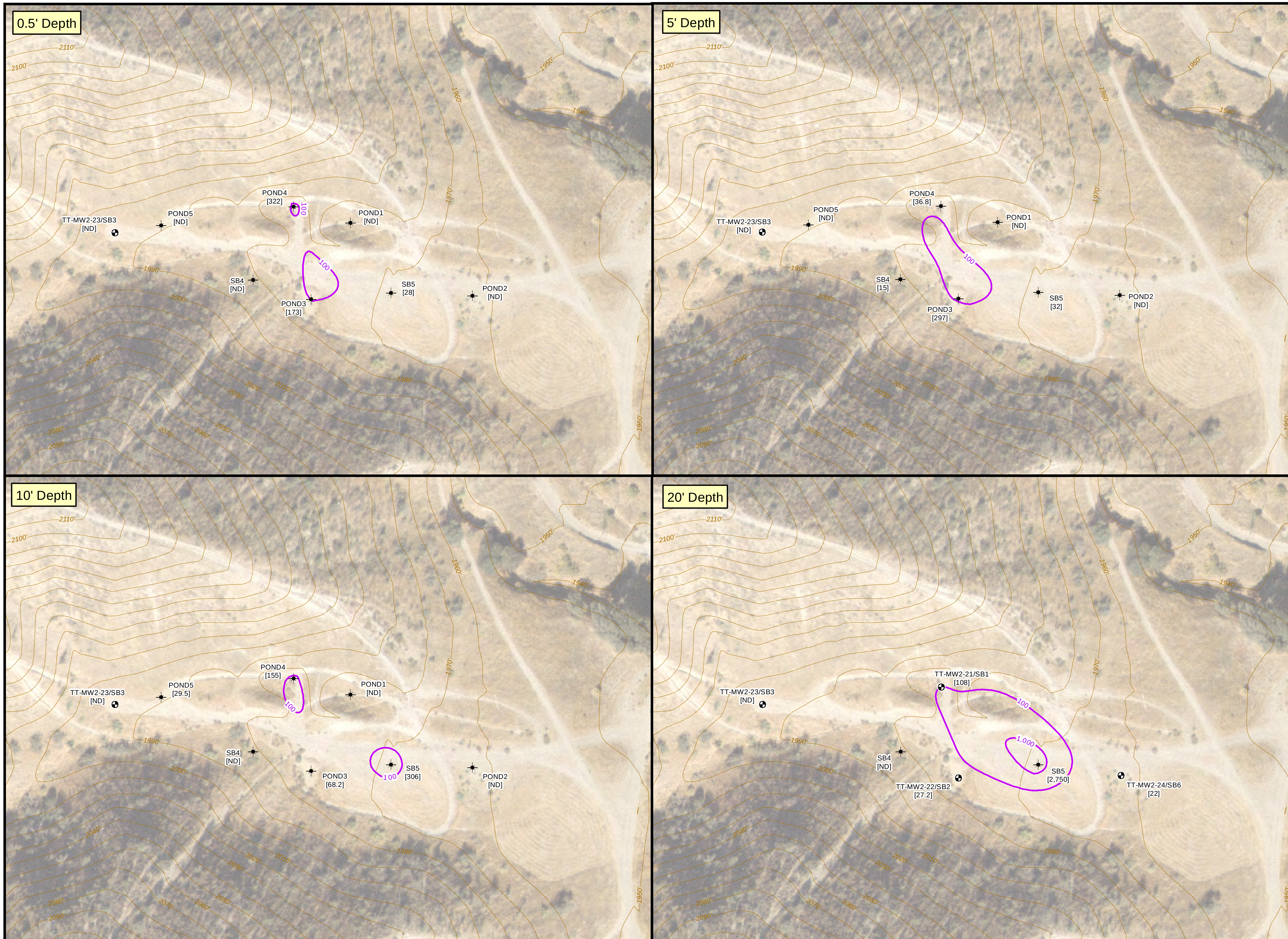


N

0 50 100
Feet

Adapted from: March 2007 aerial photograph.

LEGEND

Soil Boring Location

Monitoring Well Location

Perchlorate Isoconcentration Contour
(dashed where inferred)

Ground Surface Elevation Contour
(10-foot interval - feet msl)

Note:

[#] Perchlorate results in µg/kg.

[ND] Non-Detect.

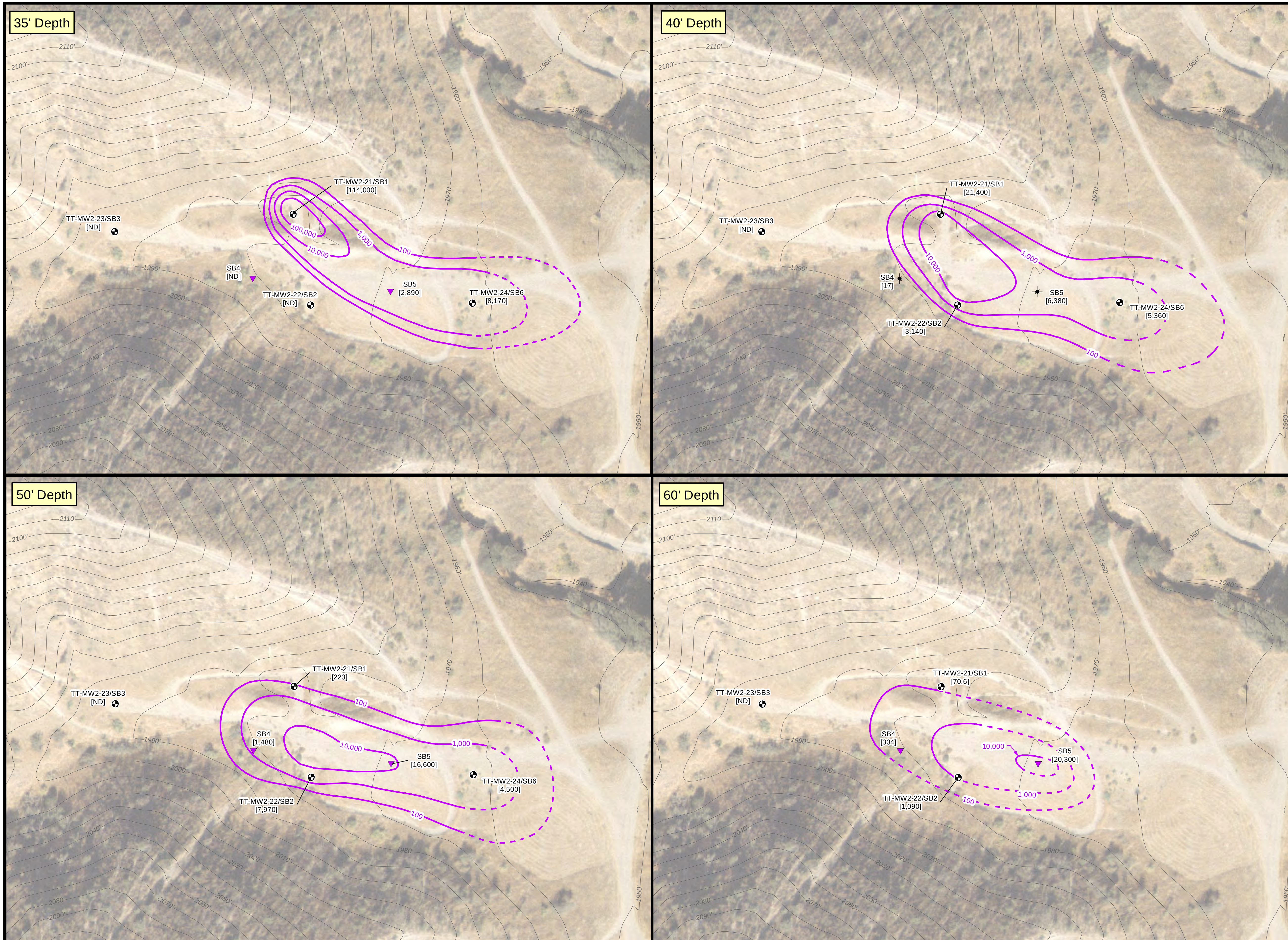
Laborde Canyon
(Lockeed Martin Beaumont Site 2)

Figure 2-10

Perchlorate Concentrations in Soil Waste Discharge Area

TETRA TECH

P:\GIS\Lockheed 28535_02_0404\isopleths_WDP_2.mxd



0 50 100
Feet

Adapted from: March 2007 aerial photograph.

LEGEND

Soil Boring Location

Monitoring Well Location

Perchlorate Isoconcentration Contour
(dashed where inferred)

Ground Surface Elevation Contour
(10-foot interval - feet msl)

Note:

[#] Perchlorate results in µg/kg.

[ND] Non-Detect.

Laborde Canyon
(Lockeed Martin Beaumont Site 2)

Figure 2-10 (cont.)

Perchlorate Concentrations in Soil Waste Discharge Area

TETRA TECH

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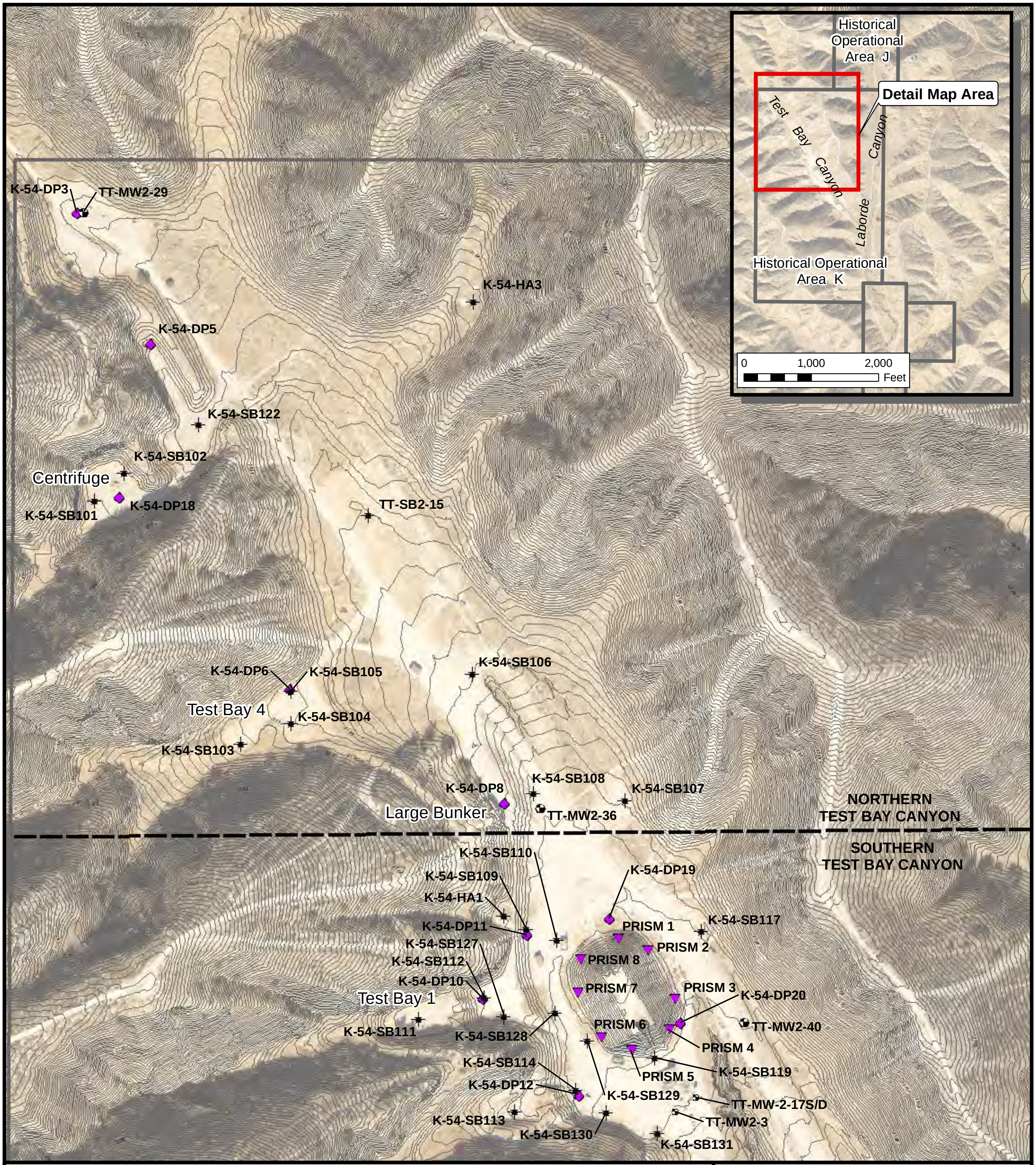

LEGEND

- Soil Boring Location
- Monitoring Well Location
- Soil Boring/Soil Gas Sample Location
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Subarea Boundary
- Historical Operational Area Boundary

0 100 200
Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-11
Sample Locations
Northern Test Bay
Canyon Subarea
Historical Operational Area K

TETRA TECH

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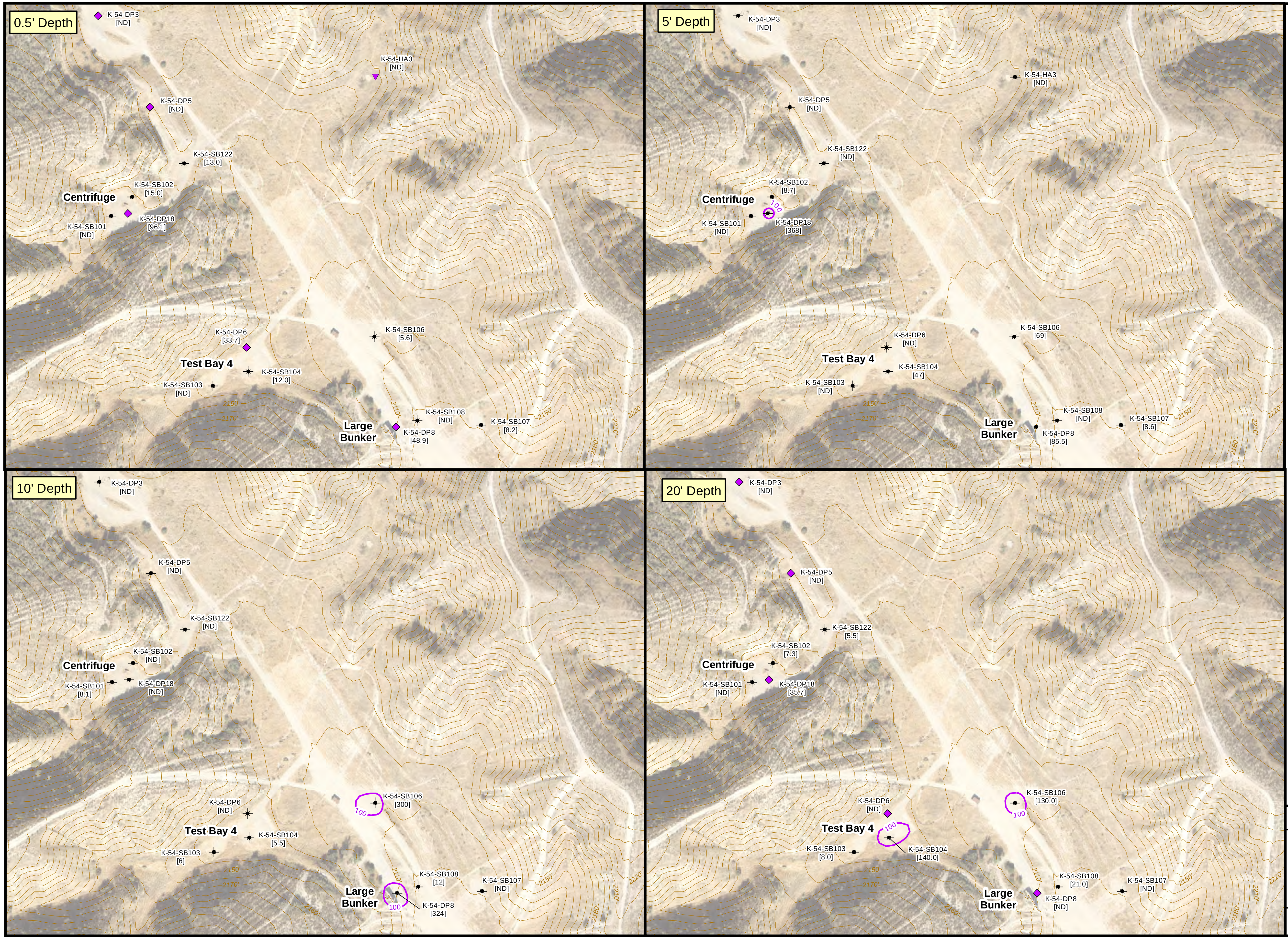

0 100 200 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Soil Boring Location
- Soil Boring/Soil Gas Sample Location
- Perchlorate Concentration Contour (dashed where inferred)
- Ground Surface Elevation Contour (10-foot interval - feet msl)

Note:

[#] Perchlorate results in µg/kg.

[ND] Non-Detect.

Laborde Canyon
(Lockeed Martin Beaumont Site 2)

Figure 2-12
Perchlorate Concentrations in Soil
Northern Test Bay
Canyon Subarea
Historical Operational Area K

TETRA TECH

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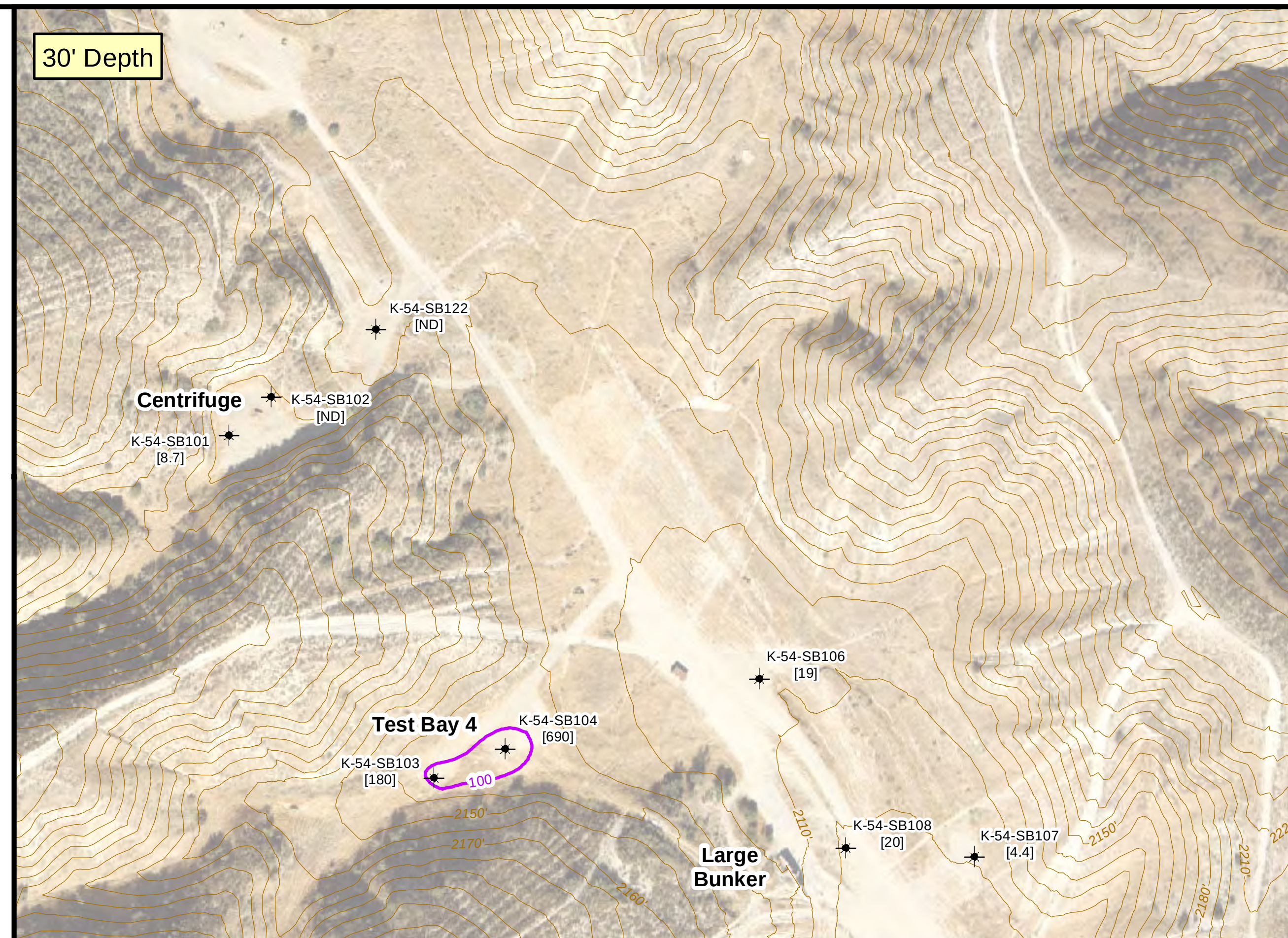
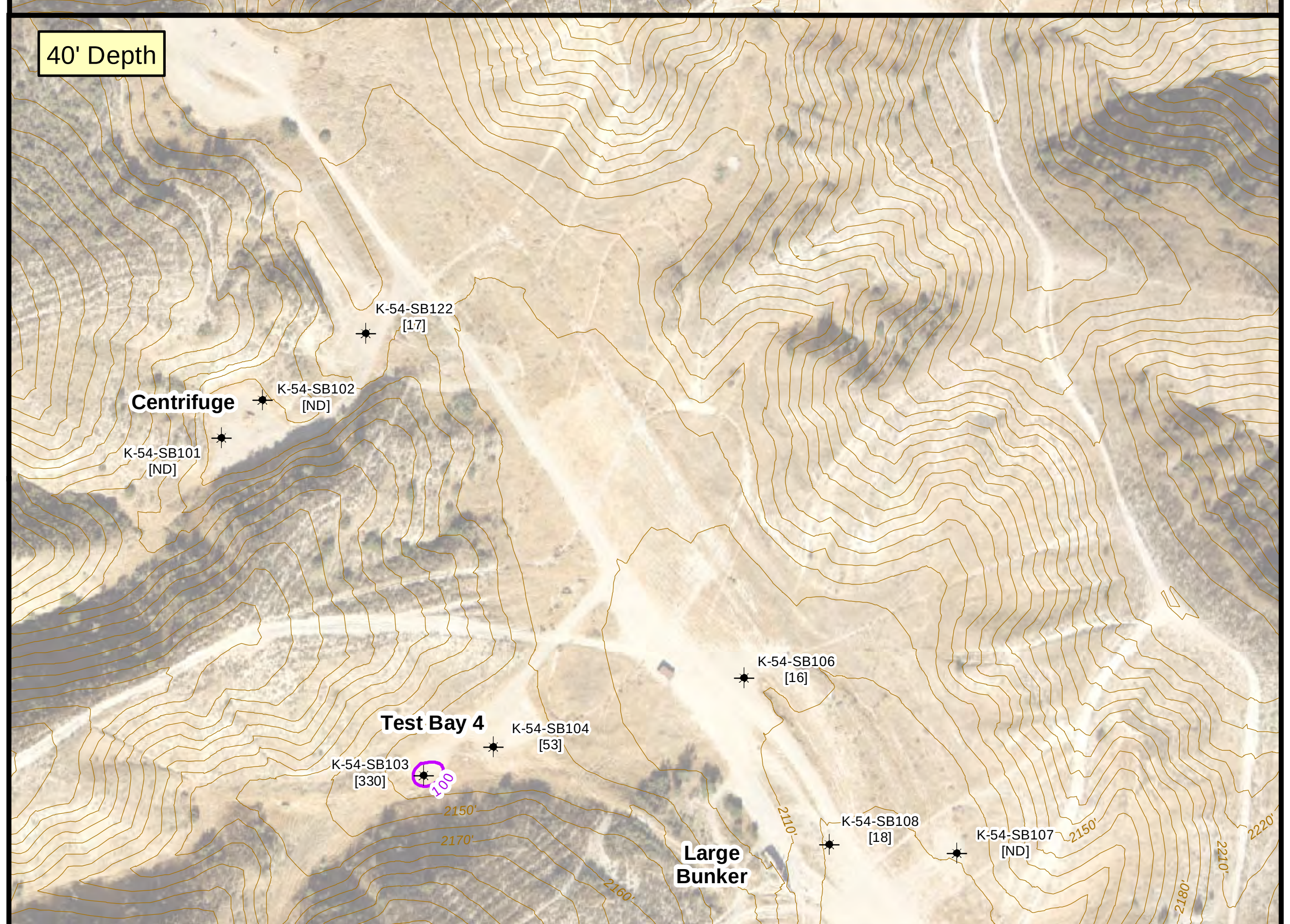




Adapted from: March 2007 aerial photograph.

LEGEND

Soil Sample Location

Soil Boring/
Soil Gas Sample Location

Perchlorate Concentration Contour
(dashed where inferred)

Ground Surface Elevation Contour
(10-foot interval - feet msl)

Note:

[#] Perchlorate results in µg/kg.

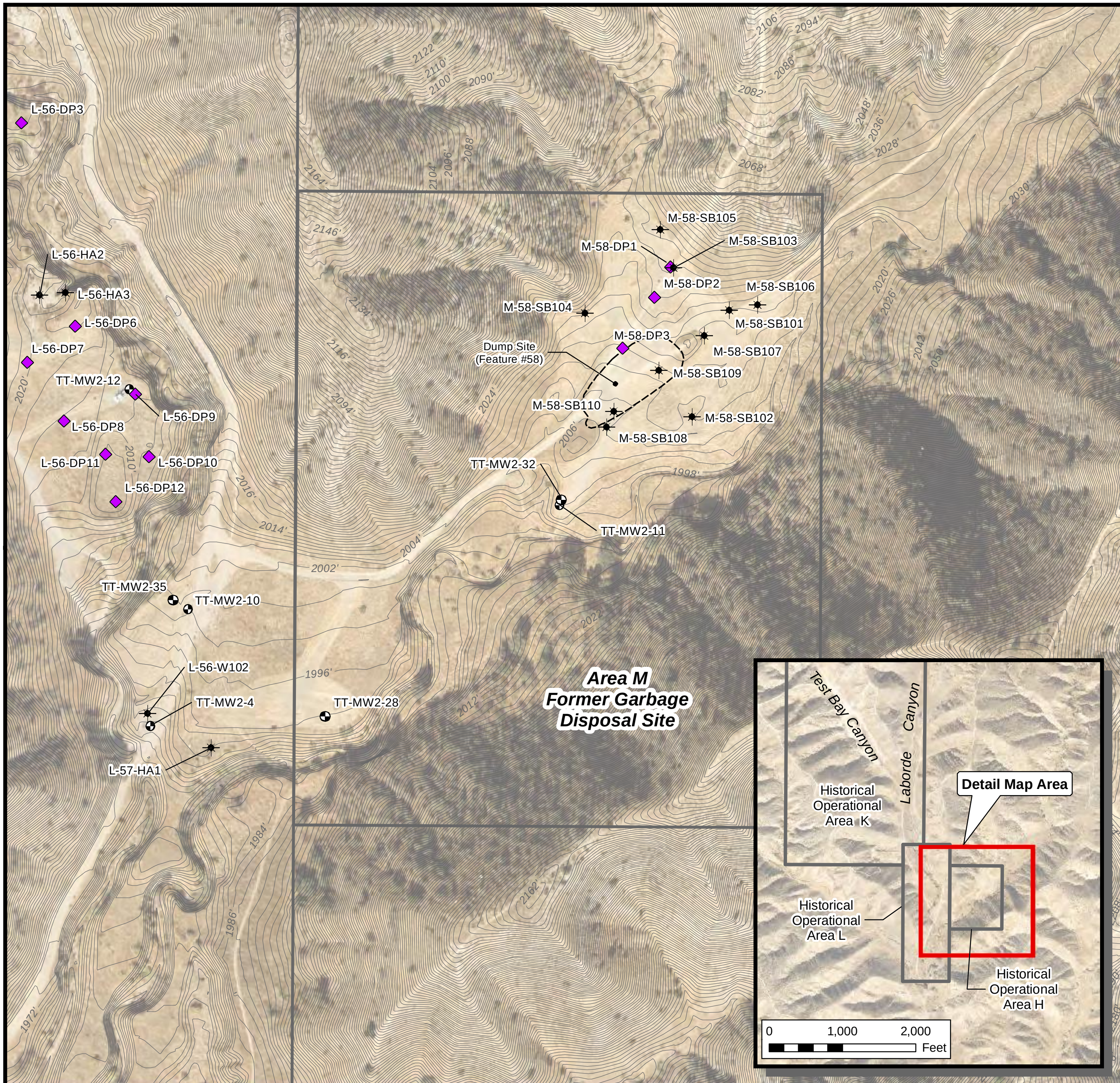
[ND] Non-Detect.

Laborde Canyon
(Lockeed Martin Beaumont Site 2)

Figure 2-12 (cont.)

**Perchlorate Concentrations in Soil
Northern Test Bay
Canyon Subarea
Historical Operational Area K**

TETRA TECH



0 100 200 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Soil Boring Location
- Monitoring Well Location
- Soil Boring/Soil Gas Sample Location
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Historical Operational Area

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-13

Historical Operational Area M Sample Location Map

TETRA TECH

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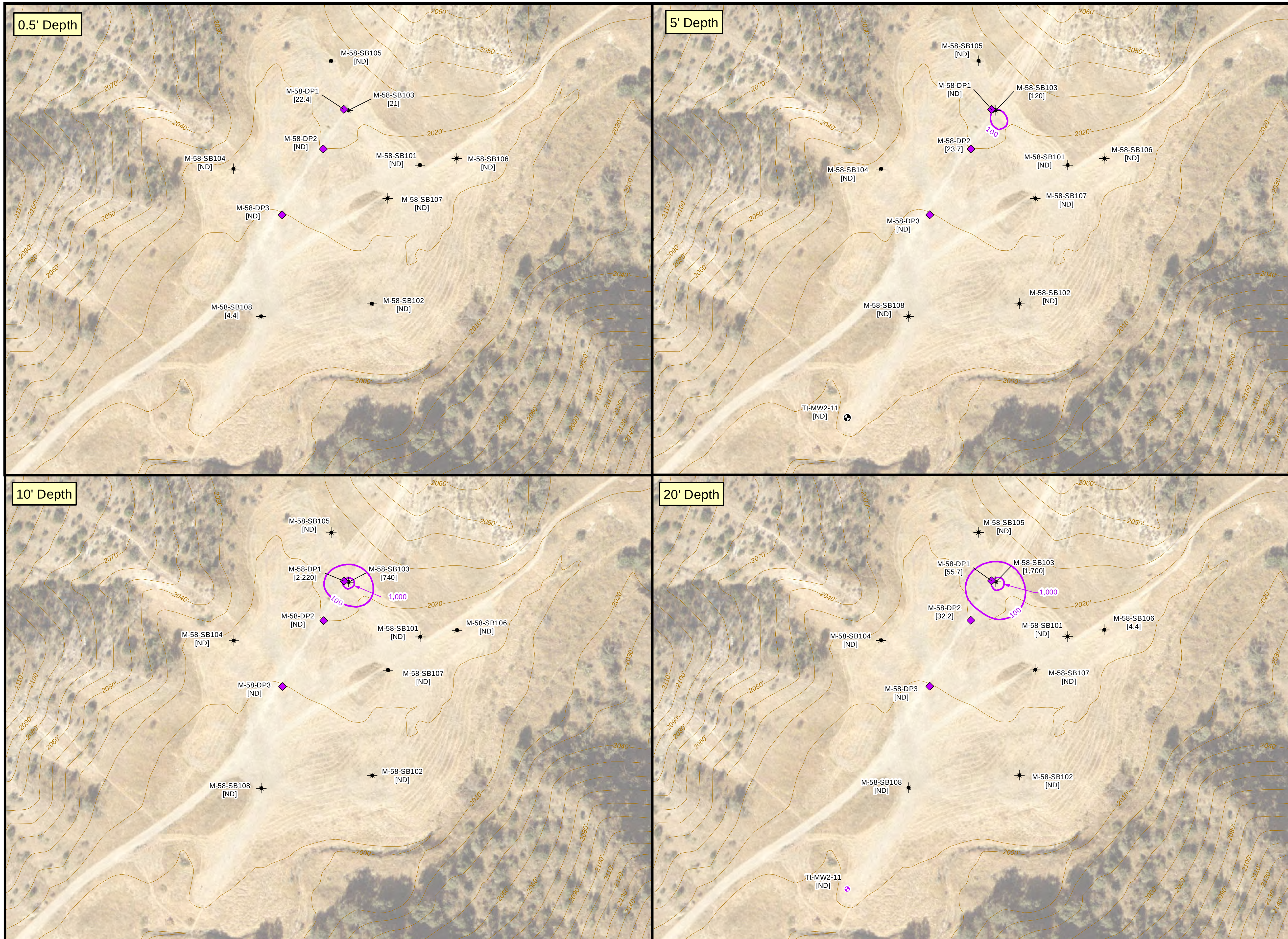

0 50 100 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Soil Boring Location
- Soil Boring/Soil Gas Sample Location
- Monitoring Well Location
- Perchlorate Isoconcentration Contour (dashed where inferred)
- Ground Surface Elevation Contour (10-foot interval - feet msl)

Note:

[#] Perchlorate results in µg/kg.

[ND] Non-Detect.

Laborde Canyon (Lockeed Martin Beaumont Site 2)

Figure 2-14

Perchlorate Concentrations in Soil Historical Operational Area M

TETRA TECH

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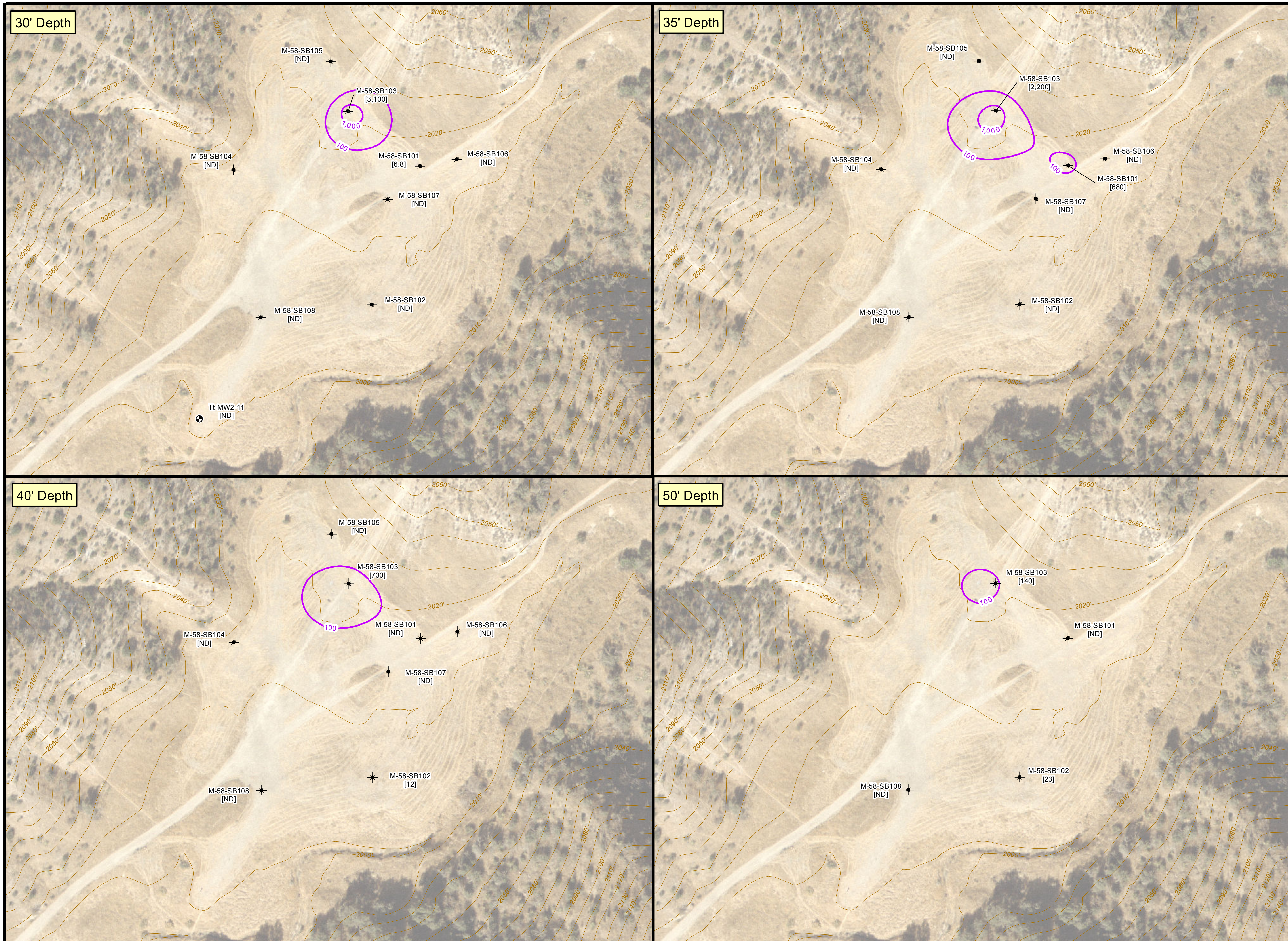

0 50 100
Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Soil Boring Location
- Soil Boring/Soil Gas Sample Location
- Monitoring Well Location
- Perchlorate Isoconcentration Contour (dashed where inferred)
- Ground Surface Elevation Contour (10-foot interval - feet msl)

Note:

[#] Perchlorate results in µg/kg.

[ND] Non-Detect.

Laborde Canyon
(Lockeed Martin Beaumont Site 2)

Figure 2-14 (cont.)

Perchlorate Concentrations in Soil Historical Operational Area M

TETRA TECH

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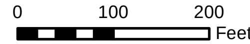


Adapted from: March 2007 aerial photograph.

LEGEND

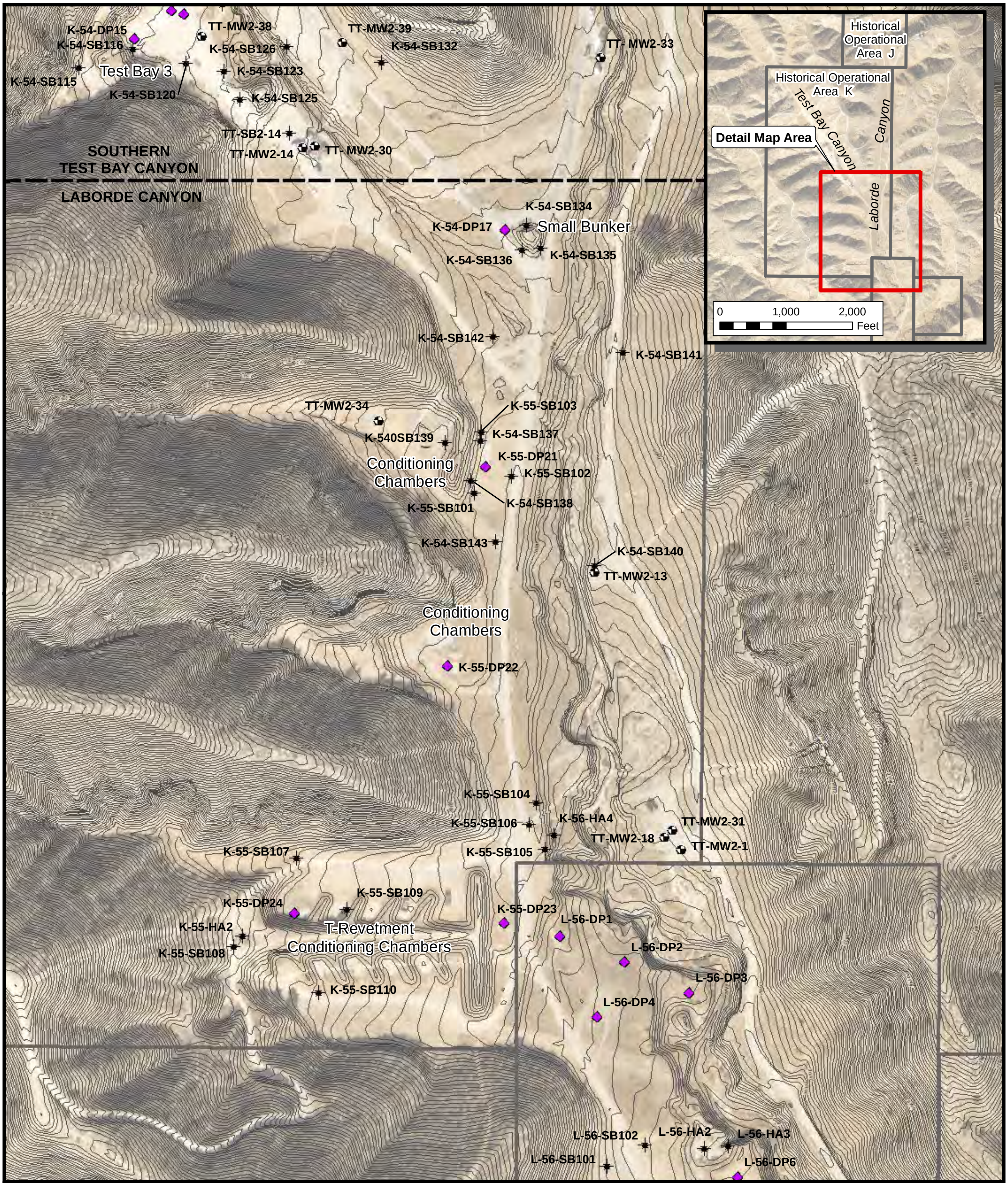
- Soil Boring Location
- Monitoring Well Location
- Soil Boring/Soil Gas Sample Location
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Historical Operational Area

Note: Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-15
Sample Locations Historical Operational Area J

TETRA TECH



P:\GIS\Lockheed 28535_02_0404\Laborde Samples.mxd

LEGEND

- Soil Boring Location
- Monitoring Well Location
- Soil Boring/ Soil Gas Sample Location
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Subarea Boundary
- Historical Operational Area Boundary

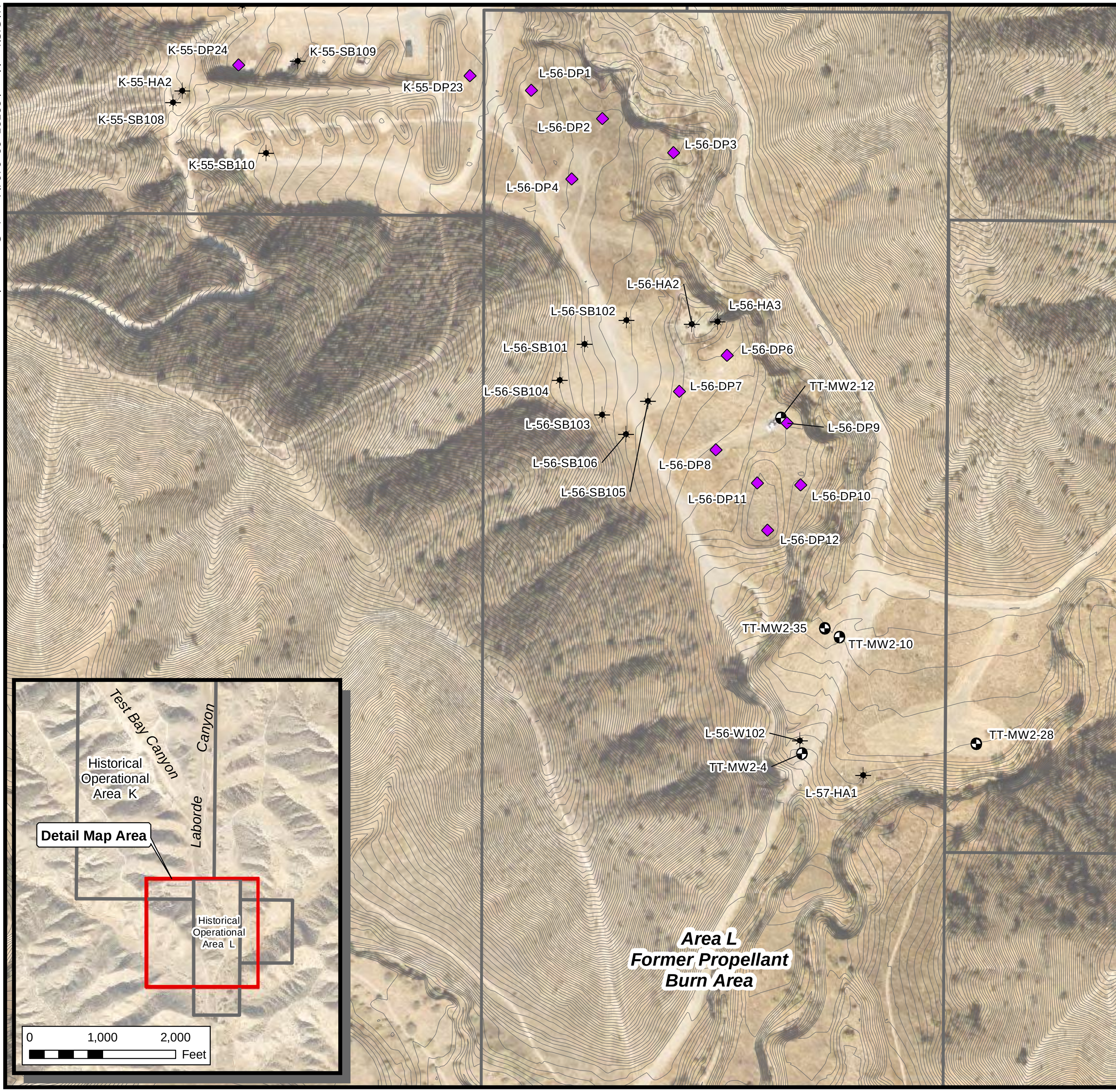
0 100 200 Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-16
Sample Locations
Laborde Canyon Subarea
Historical Operational Area K

TETRA TECH

X:\GIS\Lockheed 28535_02_0404\Area L_Samp.mxd



0 100 200 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Soil Boring Location
- Monitoring Well Location
- Soil/Soil Gas Sample Location
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Historical Operational Area

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-17

Sample Locations
Historical Operational Area L

TETRA TECH

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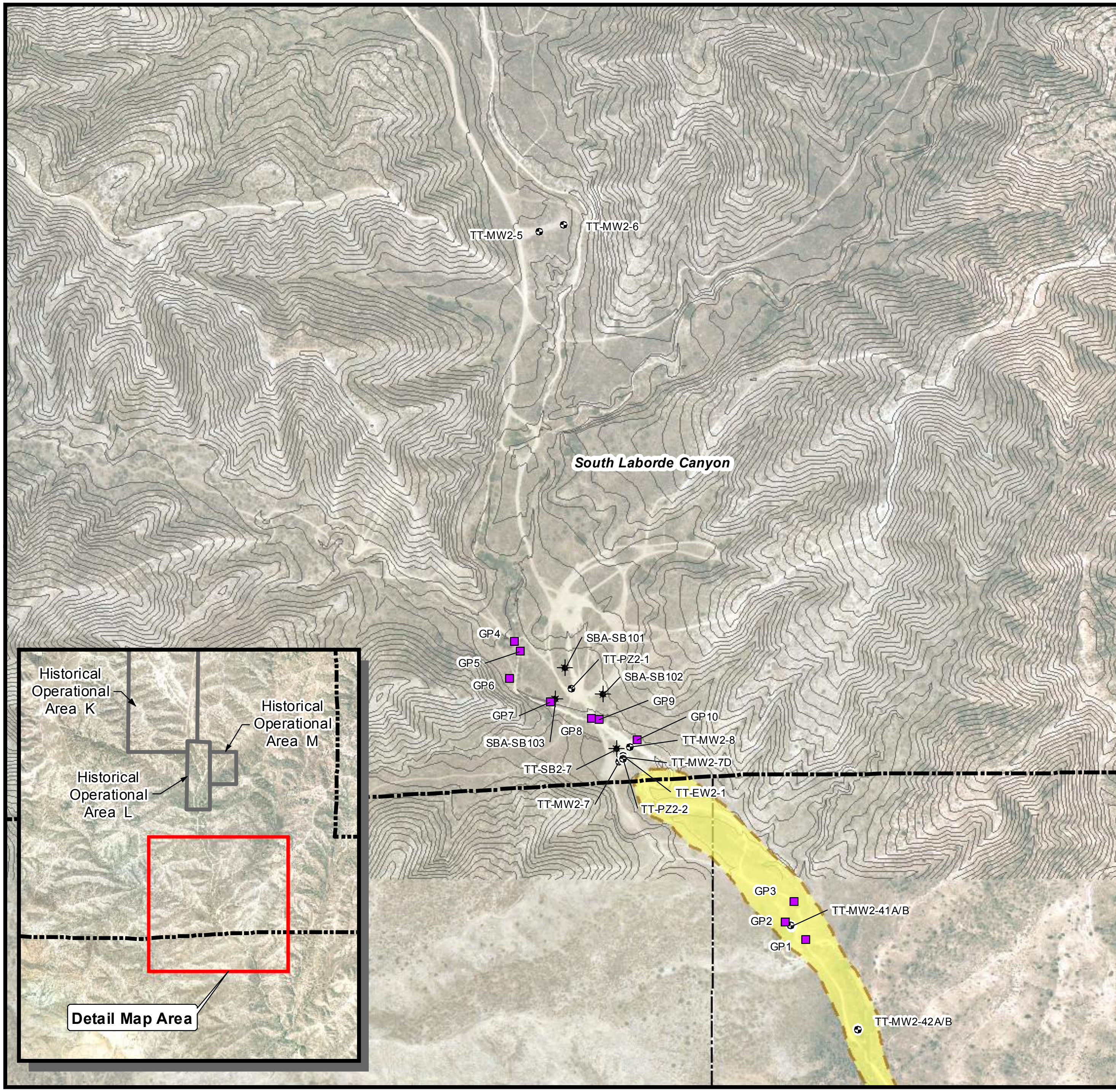


Adapted from: March 2007 aerial photograph.

LEGEND

- Surface Sample Location
- Soil Boring Location
- Monitoring Well Location
- Riparian Corridor
- Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)
- Ground Surface Elevation Contour (5-foot interval - feet msl)

Note: Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

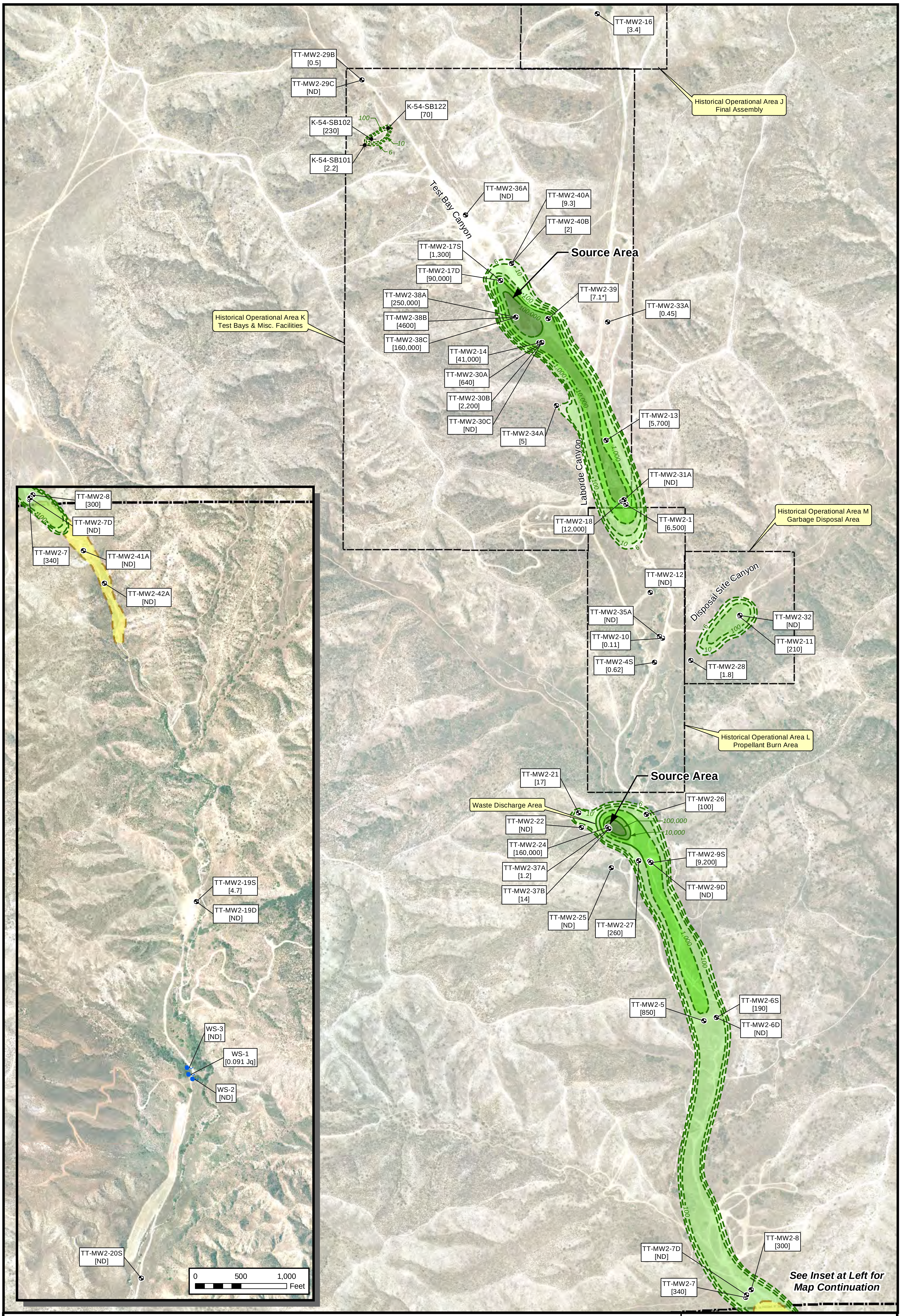
Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-18

Sample Locations South Laborde Canyon

TETRA TECH

P:\GIS\Lockheed 28535_02_0404\Perc.mxd



LEGEND

- Grab Sample Location
- Well Sample Location with Perchlorate Concentration [µg/L]
- Spring Sample Location with Perchlorate Concentration [µg/L]
- Perchlorate Isoconcentration Contour (based on grab sample data only)
- Perchlorate Isoconcentration Contour (Dashed where inferred)
- Riparian Corridor
- Historical Operational Area Boundary
- Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)

Adapted from: April 2007 aerial photograph.

Notes: Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

Results shown for sampled locations only.

* Anomalous value not used in contour.

N

0 300 600
Feet

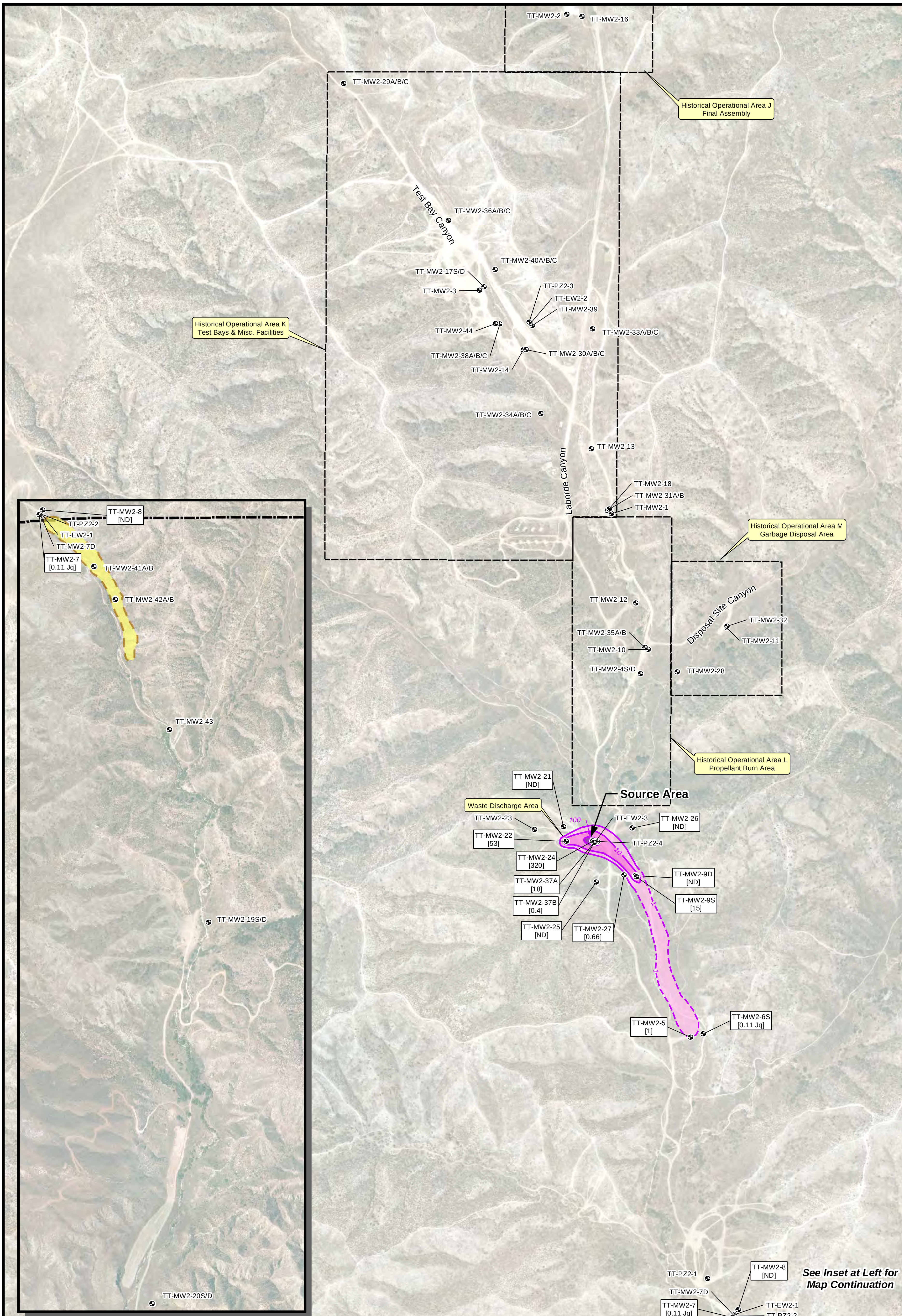
Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-19

Perchlorate Isoconcentration Map (µg/L) Second Quarter 2011

TETRA TECH

P:\GIS\Lockheed 28535_02_0404\DIOX.mxd



LEGEND

- Well Sample Location with 1,4-Dioxane Concentration [µg/L]
- 1,4-Dioxane Isoconcentration Contour (Dashed where inferred)
- Riparian Corridor
- Historical Operational Area Boundary
- Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)

Adapted from: April 2007 aerial photograph.

Notes: Results shown for sampled locations

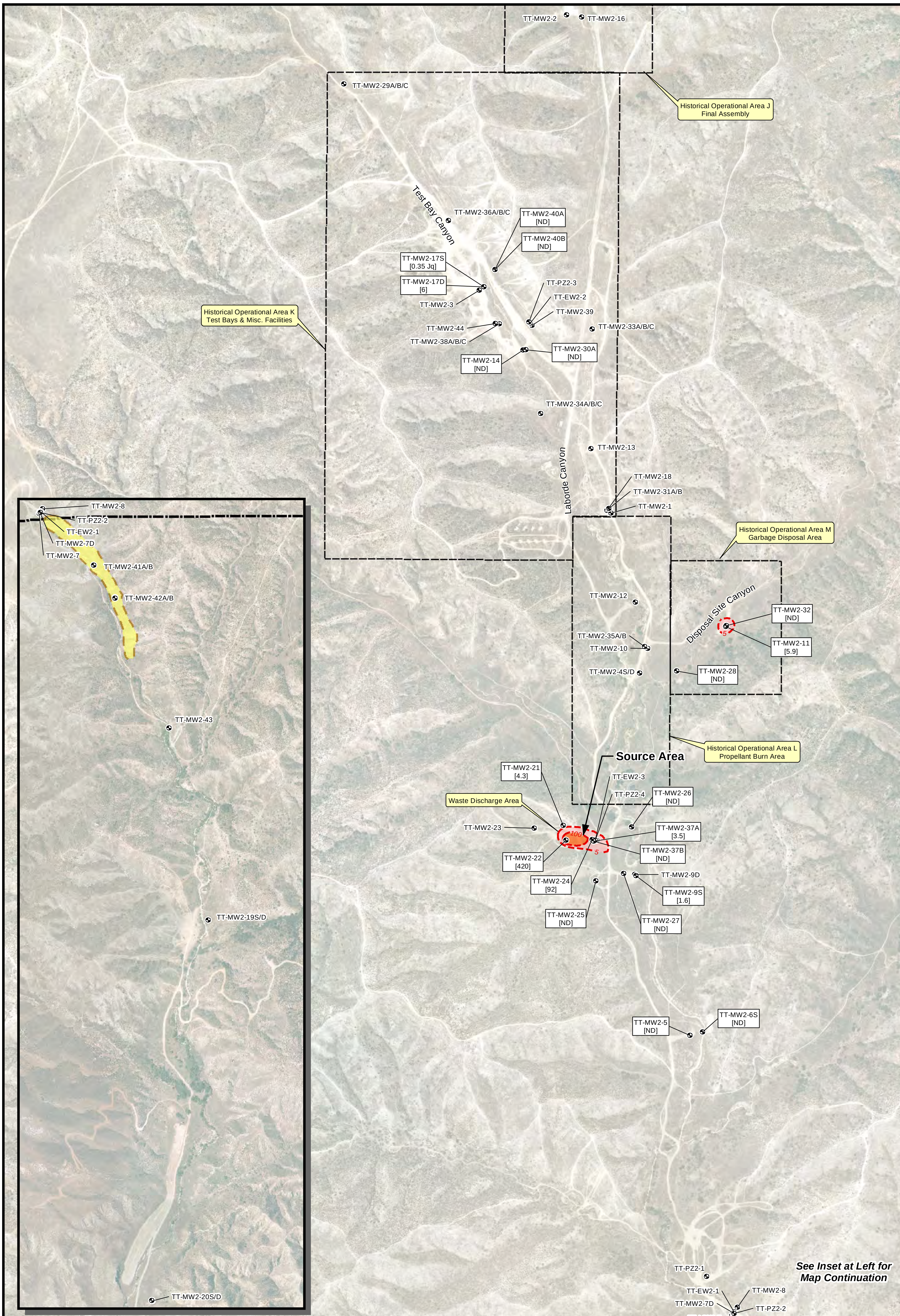
0 300 600 Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-20
1,4-Dioxane
Isoconcentration Map (µg/L)
Second Quarter 2011

TETRA TECH

Path: P:\GIS\Lockheed 28535_02_04\04\TCE_Isocon.mxd



LEGEND

- Well Sample Location with TCE Concentration [µg/L]
- Trichloroethene Isoconcentration Contour (Dashed where inferred)
- Riparian Corridor
- Historical Operational Area Boundary
- Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)

0 300 600 Feet

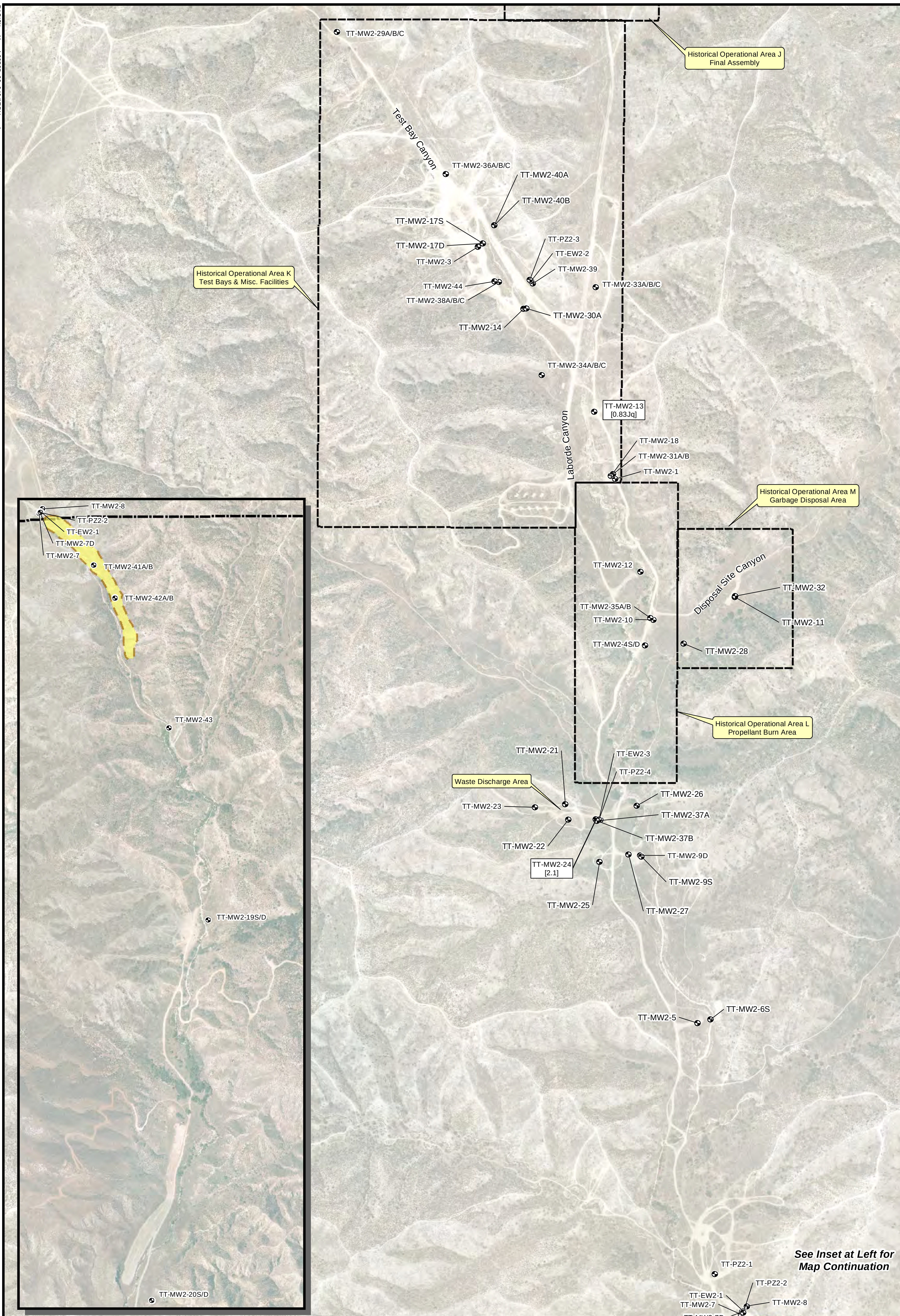
Adapted from: April 2007 aerial photograph.

Notes: Results shown for sampled locations only.

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-21
Trichloroethene (TCE)
Isoconcentration Map (µg/L)
Second Quarter 2011

TETRA TECH



LEGEND

- Well Sample Location with TCE Concentration [μg/L]
- Riparian Corridor
- Historical Operational Area Boundary
- Laborde Canyon Property Boundary (Lockheed Martin Beaumont Site 2)

0 300 600 Feet

Adapted from: April 2007 aerial photograph.

Notes: Results shown for sampled locations only.

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 2-22
RDX
Isoconcentration Map (μg/L)
Second Quarter 2011

TETRA TECH

Section 3
Applicable or Relevant and Appropriate Requirements

Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requires that remedial actions implemented at CERCLA sites attain any federal or more stringent state environmental standards, criteria, or limitations that are determined to be either applicable or relevant and appropriate, unless a waiver is justified and granted in the decision document. This section identifies and evaluates potential applicable or relevant and appropriate requirements (ARARs) that could affect remedial alternative selection at the site.

'Applicable' requirements are those cleanup standards, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. A requirement is applicable if the jurisdictional prerequisites of the environmental standard show a direct correspondence when compared objectively with the conditions at the site.

'Relevant and appropriate' requirements are those cleanup standards, control standards, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well suited to the conditions of the site. United States Environmental Protection Agency (USEPA) guidance provides criteria for screening 'relevant' requirements to determine which are also 'appropriate,' and hence ARARs. Relevant requirements are not considered to also be appropriate when:

- "…another requirement is available that more fully matches the circumstances at the site."
- "…another requirement is available that has been designed to apply to that specific situation, reflecting an explicit decision about the requirements appropriate to that situation."

For a state requirement to qualify as an ARAR, it must be promulgated, legally enforceable, more stringent than any corresponding federal requirement, consistently applied, and identified in a timely manner (Title 40 of the Code of Federal Regulations (CFR) Section 300.400(g)(4)). The criteria for determining relevance and appropriateness are listed in 40 CFR §300.400(g)(2).

In addition to ARARs, nonpromulgated advisories, guidance, or criteria issued by federal or state agencies that are not legally binding may also provide useful information or recommended procedures for remedial actions, and thus may be considered when developing remedial alternatives. These 'to be considered' (TBC) criteria do not meet the definition of an ARAR, but still may be useful in determining whether to take action at a site or to what degree action is necessary, particularly when there are no ARARs for a site, action, or contaminant. Although TBC criteria do not have the status of ARARs, they are typically considered together with ARARs to establish the required level of cleanup necessary for the protection of human health or the environment. The critical difference between a TBC criterion and an ARAR is that an entity is not required to comply with or meet a TBC criterion when implementing a remedial action, unless the TBC has been used to establish a cleanup level. TBC criteria are defined in 40 CFR §300.400(g)(3).

ARARs and TBC criteria are generally classified as chemical-specific, location-specific, or action-specific. These categories were developed to help define ARARs; however, some ARARs do not fall precisely within one group. These categories of ARARs are defined below.

- Chemical-specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set numerical health- or risk-based concentration limits or discharge limitations for specific hazardous substances. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the most stringent of the requirements should generally be applied. An example of a chemical-specific ARAR is a groundwater quality standard.

- Location-specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the contaminants or the proposed remedial actions. These requirements may limit the placement of a remedial action, or impose additional constraints on a remedial action. Location-specific ARARs may refer to activities near endangered species habitat, wetlands, or areas of historical significance.

- Action-specific ARARs are requirements that apply to specific actions associated with site remediation. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy, and often define acceptable handling, treatment, and disposal procedures for hazardous substances. Examples of action-specific ARARs include requirements applicable to landfill closure, wastewater discharge, hazardous waste disposal, and air emissions.

Lists of potential chemical-specific, location-specific, and action-specific ARARs and TBC criteria are provided in Tables 3-1, 3-2, and 3-3, respectively. The identification of ARARs for the site will be an iterative process, with the lists being updated as appropriate during remedial action planning and remedial design.

3.1 POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBC CRITERIA

Chemical-specific ARARs are generally health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of a cleanup level. Seven potential federal and state chemical-specific ARARs and nine potential TBC criteria have been identified for this site and are summarized in the following text. More detailed descriptions are provided in Table 3-1.

The following potential federal chemical-specific ARARs have been identified:

- Safe Drinking Water Act, National Primary Drinking Water Standards, 40 CFR § 141.61-141.62: **relevant and appropriate** for groundwater that has the potential to be used as drinking water

- Clean Water Act, California Toxics Rule, 40 CFR § 131.38: **applicable** for discharges to surface water

- Toxic Substances Control Act, PCB-contaminated materials, 40 CFR § 761.61(a)(4), (b), (c): **potentially applicable**, as polychlorinated biphenyl (PCB) concentrations found at the site were well below the 50 milligrams/kilogram (mg/kg) threshold for this regulation; however, this regulation would become applicable if PCB concentrations greater than 50 mg/kg are found during remedial actions at the site.

The following potential California chemical-specific ARARs have been identified:

- California Safe Drinking Water Act, California Primary Drinking Water Standards (California MCLs), 22 CCR § 64421-64444: **relevant and appropriate** for groundwater that has the potential to be used as drinking water

- Porter-Cologne Water Quality Control Act, CWC § 13000: **applicable** for establishing the need for cleanup

- Porter-Cologne Water Quality Control Act, Water Quality Control Plan for the Santa Ana River Basin (Basin Plan), CWC § 13240 et seq.: **applicable**, although the site is not located within a groundwater basin designated by the Basin Plan (SARWQCB, 1995). However, it is a tributary to a groundwater basin that is designated in the Basin Plan; therefore, the Basin Plan, which designates the beneficial uses of groundwater, is also applicable to groundwater at the site.

- Porter-Cologne Water Quality Control Act, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304, State Water Resources Control Board (SWRCB) Resolution 92-49: **applicable** for establishing cleanup levels

- Porter-Cologne Water Quality Control Act, Sources of Drinking Water Policy, SWRCB Resolution 88-63: **applicabl**e for establishing beneficial uses of surface water and groundwater

Potential federal chemical-specific TBC criteria include:

- Safe Drinking Water Act, Maximum Contaminant Level Goals (MCLGs)

- Safe Drinking Water Act, National Secondary Drinking Water Standards (Secondary MCLs)

- Clean Water Act, National Recommended Water Quality Criteria

- USEPA Superfund Guidance, USEPA Region IX Regional Screening Levels (RSLs)

- USEPA Superfund Guidance, USEPA Health Advisories

Potential California chemical-specific TBC criteria include:

- California Safe Drinking Water Act, California Secondary MCLs

- California Safe Drinking Water Act, California Public Health Goals (PHGs)

- California Safe Drinking Water Act, California Drinking Water Notification Levels (DWNLs) and Response Levels

- Cal/EPA Brownfields Guidance, Cal/EPA Human Health Screening Levels (CHHSLs)

Many of these chemical-specific ARARs and TBC criteria are water quality standards that are applicable at the tap for drinking water supply systems; others designate actual and potential beneficial uses for specific groundwater and surface water bodies. In the latter case, applicable water quality standards may be determined from the designated beneficial uses of the groundwater or surface water body.

Generally, all waters of the State of California are considered by the SWRCB to have beneficial uses. Twenty beneficial uses of surface water and groundwater are currently recognized within the Santa Ana Region (SARWQCB, 1995). In general, municipal and domestic supply is considered to be a beneficial use of all surface water and groundwater in California. Exceptions to the municipal or domestic beneficial use designation include groundwater bodies that have total dissolved solids or naturally occurring contaminants at concentrations that are not conducive to treatment, or water sources that do not yield sufficient water to supply a single well capable of producing an average yield of 200 gallons per day. The applicability of these and other potential exceptions or mitigating factors to ARARs that directly or indirectly impact groundwater cleanup standards based upon beneficial use is discussed in the development of preliminary remediation goals (PRGs) for the site in Section 4.3.

3.2 POTENTIAL LOCATION-SPECIFIC ARARS AND TBC CRITERIA

The following eight general resource categories are associated with evaluating and identifying location-specific ARARs: cultural resources, wetland protection, floodplain management, hydrologic resources, biological resources, coastal resources, other natural resources, and geologic characteristics. Considering the geological setting of the site, past site operations, and the presence of several endangered or protected species at the site, only two of these evaluation categories were initially discounted; coastal resources (the site is not located near coastal resources) and floodplain management (the site is not located on a designated floodplain).

Seven potential federal and six potential state ARARs for the protection of these resources were identified. A more detailed discussion of each is provided in Table 3-2.

The following potential federal location-specific ARARs have been identified:

- <u>National Archaeological and Historical Preservation Act, Protection of archeological resources, 36 CFR Part 65</u>: **potentially applicable**, as previous surveys have not identified archeological resources in areas where actions are proposed. Additional surveys may need to be conducted prior to construction in areas that have not been surveyed.

- <u>National Historic Preservation Act, Protection of historic resources, 36 CFR Part 800:</u> **potentially applicable**, as some former facilities are greater than 50 years old and may have Cold War era significance. This regulation would be applicable if these or other resources are listed or eligible for listing on the National Register of Historic Places, and actions could potentially cause damage.

- <u>Clean Water Act Section 404, Water pollution prevention and control, 33 USC §1344</u>: **potentially applicable** if actions involve construction (dredge and fill) within the Laborde Canyon drainage channel.

- Executive Order No. 11990, Protection of Wetlands, Protection of wetlands, 40 CFR §6.302(a): **potentially applicable** if actions involve either construction in wetlands areas or may impact groundwater elevations or groundwater quality in riparian areas.

- Endangered Species Act, Protection of federally-listed threatened and endangered species and their critical habitat, 50 CFR Parts 200 and 402: **applicable**, as the site is habitat for the federally endangered Stephens' kangaroo rat (SKR), as well as other threatened or endangered animals and plants. A Habitat Conservation Plan and Incidental Take Permit for SKR will be required by the United States Fish and Wildlife Service (USFWS) for remediation activities in critical habitat.

- Fish and Wildlife Coordination Act, Protection and conservation of wildlife, 40 CFR §302: **potentially applicable**, if actions involve either construction within the stream channel or that may impact groundwater elevations or groundwater quality in riparian areas.

- Migratory Bird Treaty Act, Protection of Native Birds, 50 CFR Parts 10 and 20: **potentially applicable** if actions affect native migratory birds.

The following potential California state location-specific ARARs have been identified:

- California Register of Historical Resources, Protection of California historic resources, 14 CCR §4850 et seq.: **potentially applicable**. Facilities eligible for the National Register of Historic Places are automatically eligible for the California Register of Historical Resources.

- California Endangered Species Act, Protection of California-listed threatened and endangered species and their critical habitat, Fish and Game Code (FGC) §2080 and 3005: **applicable**, as the site is habitat for the SKR, as well as other threatened or endangered animals and plants. Endangered species-related permitting will require coordination between the USFWS and California Department of Fish and Game (CDFG).

- Native Plant Protection Act, Protection of endangered and rare native plants, FGC §1900 et seq.: **potentially applicable** if actions affect endangered or rare native plant species.

- California Fish and Game Code, Protection of aquatic habitat and species in California, CFGC §5650: **potentially applicable** if actions involve construction within the stream channel.

- California Fish and Game Code, Protection of certain species of birds, CFGC §3511: **potentially applicable** if actions affect protected bird species.

- California Streambed Alteration Program, California Streambed Alteration Agreement, CFGC §1600-1616: **potentially applicable** if actions involve construction (dredge and fill) within the stream channel.

- Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda, Protection of wetland habitat in California, Fish and Game Commission

Wetlands Policy included in FGC Addenda: **potentially applicable** if actions impact groundwater elevations or groundwater quality in riparian areas.

3.3 POTENTIAL ACTION-SPECIFIC ARARS AND TBC CRITERIA

Action-specific ARARs apply to actions such as waste handling, treatment, and disposal that are associated with specific remediation activities and, as such, will vary based upon the final remedy selected for implementation. Twelve federal and 11 state potential ARARs that address compliance with these regulations were identified. A more detailed discussion of each potential ARAR is provided in Table 3-3.

Potential federal action-specific ARARs that may apply during remedial activities at the site include those from the following sources:

- Safe Drinking Water Act
- Clean Water Act
- Resource Conservation and Recovery Act
- Hazardous Material Transportation Act
- Clean Air Act
- Occupational Safety and Health Act

Potential state and local action-specific ARARs that may apply during remedial activities at the site include those from the following sources:

- Porter-Cologne Water Quality Control Act
- Hazardous Waste Control Act
- California Integrated Waste Management Board and SWRCB Consolidated Regulations for Treatment, Storage, Processing, or Disposal of Solid Waste
- South Coast Air Quality Management District Regulations for air emissions
- California Occupational Safety and Health Act
- California Health and Safety Code
- California Civil Code
- California Well Standards
- Riverside County Ordinances

Section 3 Tables

Table 3-1
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Federal ARARs and TBCs				
Safe Drinking Water Act (42 USC §300 et seq.)				
National Primary Drinking Water Standards (MCLs)	40 CFR §141.61 – 141.62	Enforceable, chemical-specific drinking water standards	Relevant and appropriate	Applicable at the tap for drinking water supply systems; potentially relevant and appropriate for groundwater that has the potential to be used as drinking water
Maximum Contaminant Level Goals (MCLGs)	40 CFR §141.50 – 141.51	Chemical-specific drinking water criteria pertaining to known or anticipated health effects	To be considered	To be considered for groundwater with multiple chemicals of concern that has the potential to be used as drinking water. MCLGs that are equal to zero are not considered ARARs or TBC criteria.
National Secondary Drinking Water Standards (Secondary MCLs)	40 CFR §143.3	Chemical-specific standards for consumer acceptance of drinking water	To be considered	Secondary MCLs are based on aesthetic criteria, and are therefore not risk-based.
Clean Water Act (33 USC §1251 et seq.)				
National Recommended Water Quality Criteria	Clean Water Act, Section 304(a)	Chemical-specific surface water quality criteria for the protection of aquatic life and human health	To be considered	Recommended criteria for discharges to surface water
California Toxics Rule	40 CFR §131.38	Chemical-specific water quality standards for the protection of aquatic life and human health in the enclosed bays and estuaries and inland surface waters of California	Applicable	Applicable for discharges to surface water
USEPA Superfund Guidance				
USEPA Region 9 Regional Screening Levels (RSLs)	USEPA Region 9	RSLs include numeric human health-based criteria for soil and tap water. The RSLs assume either residential or commercial/industrial worker receptors. For certain chemicals, DTSC recommends the use of California Human Health Screening Levels (CHHSLs) or the 2004 USEPA Region 9 California-modified Preliminary Remediation Goals (PRGs) in place of RSLs.	To be considered	RSLs are advisory only. A quantitative human health risk assessment has been performed and will be used to evaluate site-specific risks.
USEPA Health Advisories	USEPA	Health advisories are non-enforceable human health-based criteria for unregulated chemicals.	To be considered	Health advisories are advisory only.
Toxic Substances Control Act (15 USC §2601 et seq)				
Regulations pertaining to PCB-contaminated materials	40 C.F.R. §761.61(a)(4), (b), and (c)	Regulates storage and disposal of materials contaminated with PCBs at concentrations greater than 50 mg/kg.	Potentially applicable	PCB concentrations at the site are well below 50 ppm. However, these requirements are applicable if PCB concentrations greater than 50 ppm are discovered during remedial actions.

Table 3-1
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
State ARARs and TBCs				
California Safe Drinking Water Act (HSC §116270 et seq.)				
California Primary Drinking Water Standards (California MCLs)	22 CCR §64421 - 64444	Enforceable, chemical-specific drinking water standards. California MCLs that are more stringent than federal MCLs, or which apply to chemicals not addressed by federal MCLs, are considered to be potential ARARs.	Relevant and appropriate	Applicable at the tap for drinking water supply systems; relevant and appropriate for groundwater that has the potential to be used as drinking water.
California Secondary Drinking Water Standards (California Secondary MCLs)	22 CCR §64449	Chemical-specific standards for consumer acceptance of drinking water. Secondary MCLs are based on aesthetic criteria, and are therefore not risk-based.	To be considered	Secondary MCLs are based on aesthetic criteria, and are therefore not risk-based.
California Public Health Goals (PHGs)	HSC §116365	PHGs are drinking water contaminant levels developed by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA), that help protect human health over a lifetime of exposure.	To be considered	PHGs are advisory only; public water systems are not required to comply with PHGs.
California Drinking Water Notification Levels (DWNLs) and Response Levels	HSC §116455	DWNLs are health-based advisory levels established by the CDPH for contaminants in drinking water for which MCLs have not been established. Response levels are levels at which CDPH recommends removal of a drinking water source from service. Response levels are chemical-dependent, and range from 10 to 100 times the DWNL; the response level for 1,4-dioxane is currently 35 times the DWNL. DWNLs are established as precautionary measures for contaminants that may be considered candidates for establishment of MCLs, but have not yet undergone or completed the regulatory standard-setting process prescribed for the development of MCLs.	To be considered	DWNLs and Response Levels are non-regulatory and are not drinking water standards.
Porter-Cologne Water Quality Control Act (CWC §13000 et seq.)				
Intent of legislature with respect to water quality	CWC §13000	Defines the legislative intent to attain the highest water quality reasonable, considering all of the demands that are being made on those waters and the total values involved.	Applicable	Applicable for establishing the need for cleanup; relevant and appropriate for actions which involve reinjection

Table 3-1
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Water Quality Control Plan for the Santa Ana River Basin (Basin Plan)	CWC §13240 et seq.	Describes the water resources of the Santa Ana River Basin, including both surface water and groundwater. Establishes beneficial uses of surface water and groundwater within the region. Establishes water quality objectives, including narrative and numerical standards, to protect the beneficial uses of surface water and groundwater. Describes implementation plans and other control measures designed to ensure compliance with state-wide plans and policies. Allows Regional Boards to specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted.	Applicable	The site is not located within a groundwater basin designated in the Basin Plan, but is a tributary to the San Jacinto Upper Pressure groundwater management zone of the San Jacinto Groundwater Basin. Specific waters that are not listed in the Basin Plan have the same beneficial uses as the groundwater basins or subbasins to which they are tributary or overlie. Designated beneficial uses of groundwater in the San Jacinto Upper Pressure groundwater management zone include MUN (municipal and domestic supply), AGR (agricultural supply), IND (industrial service supply) and PROC (industrial process supply).Designated beneficial uses of surface water in Laborde Creek include MUN, AGR, groundwater recharge (GWR), contact recreation (REC1), non-contact recreation (REC2), warmwater habitat (WARM), and wildlife habitat (WILD)
Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304	SWRCB Resolution 92-49, as amended on April 21, 1994 and October 2, 1996	Requires that dischargers "clean up and abate the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored."	Applicable	Applicable narrative standards for establishing groundwater cleanup levels
Sources of Drinking Water Policy	SWRCB Resolution. 88-63, as revised by SWRCB Resolution No. 2006-0008	Designates all surface water and groundwater in the state as suitable or potentially suitable for municipal or domestic use. Specific exceptions include 1) waters where total dissolved solids exceed 3,000 mg/L or electrical conductivity exceeds 5,000 µS/cm; 2) waters with contamination, unrelated to the specific pollution incident, that cannot reasonably be treated for domestic use; 3) water sources that do not provide sufficient water to supply a single well capable of producing an average, sustained yield of 200 gallons per day (0.14 gallons per minute); 4) waters regulated as a geothermal resource or exempted for the purpose of injection of fluids for production of geothermal energy or hydrocarbons; or 5) waters located in certain treatment systems or a system designed to convey or store agricultural drainage.	Applicable	Applicable narrative criteria for establishing the beneficial uses of surface water and groundwater

Table 3-1
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Cal/EPA Brownfields Guidance				
Cal/EPA California Human Health Screening Levels (CHHSLs)	"Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties," dated January 2005.	CHHSLs are numeric human health-based criteria for soil, soil gas, and ambient air. The CHHSLs assume either residential or commercial/industrial worker receptors.	To be considered	CHSSLs are advisory only. A quantitative site-specific risk assessment has been performed; these results will be used to evaluate human health risk.

<u>Acronyms and Abbreviations</u>:
ARARs: Applicable or Relevant and Appropriate Requirements
AGR: Agricultural water supply
Basin Plan: Water Quality Control Plan for the Santa Ana River Basin
Cal/EPA: California Environmental Protection Agency
CCR: California Code of Regulations
CDPH: California Department of Public Health
CFR: Code of Federal Regulations
CHHSLs: California Human Health Screening Levels
CWC: California Water Code
DTSC: California Environmental Protection Agency, Department of Toxic Substances Control
DWNLs: California Drinking Water Notification Levels
GWR: Groundwater recharge
HSC: California Health and Safety Code
IND: Industrial service supply (surface water beneficial use)
MCL: Maximum Contaminant Level
MCLGs: Maximum Contaminant Level Goals
MUN: Municipal and domestic supply (surface water beneficial use)
OEHHA: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment
PCB: Polychlorinated biphenyl
PHGs: Public Health Goals
PRGs: Preliminary Remediatio n Goals
PROC: Industrial process supply (surface water beneficial use)
REC1: Water contact recreation (surface water beneficial use)
REC2: Non-contact water recreation (surface water beneficial use)
RSLs: Regional Screening Levels
SWRCB: State Water Resources Control Board
TBC: To be considered
USEPA: United States Environmental Protection Agency
USC: United States Code
WARM: Warm freshwater habitat (surface water beneficial use)

Table 3-2
Potential Location-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Federal ARARs and TBCs				
National Archaeological and Historical Preservation Act (16 USC §469)				
Protection of archeological resources	36 CFR Part 65	Requires actions to recover and preserve artifacts if activities threaten significant scientific, prehistoric, historic, or archaeological resources.	Potentially applicable	Previous surveys have not identified archeological resources in areas where actions are proposed. Additional surveys may need to be conducted prior to construction in areas that have not been surveyed.
National Historic Preservation Act (16 USC §470)				
Protection of historic resources	36 CFR Part 800	Requires actions to minimize harm to historic properties listed on or eligible for listing on the National Register of Historic Places.	Potentially applicable	The site has structures greater than 50 years old, and the former LPC facilities are greater than 50 years old and may have Cold War era significance. Applicable if these or other resources are listed or eligible for listing on the National Register of Historic Places, and actions could potentially cause damage.
Clean Water Act Section 404 (33 USC §1344)				
Water pollution prevention and control	33 USC §1344	Requires permits for discharge of dredged or fill material into waters of the United States. Applies to navigable waters and tributaries.	Potentially applicable	Applicable if actions involve construction (dredge and fill) within the stream channel
Executive Order No. 11990, Protection of Wetlands				
Protection of wetlands	40 CFR §6.302(a)	Requires actions to minimize the destruction, loss, or degradation of wetlands.	Potentially applicable	Applicable if actions involve construction in wetlands areas, or which may impact groundwater elevations or quality in riparian areas
Endangered Species Act (16 USC §1531 et seq.)				
Protection of federally listed threatened and endangered species and their critical habitat	50 CFR Parts 200 and 402	Requires actions to conserve listed species and their habitat. Includes requirements for consultation with the USFWS.	Applicable	The site is habitat for the federally endangered Stephens' kangaroo rat (SKR), as well as other threatened or endangered animals and plants. A Habitat Conservation Plan and Incidental Take Permit for SKR will be required by the USFWS for remediation activities in critical habitat.
Fish and Wildlife Coordination Act (16 USC §661 et seq.)				
Protection and conservation of wildlife	40 CFR §302	Restricts diversion, channeling, or other activity that modifies a stream or river and affects fish and wildlife.	Potentially applicable	Applicable if actions involve construction within the stream channel or which may impact groundwater elevations or quality in riparian areas
Migratory Bird Treaty Act (16 USC §703 et seq.)				
Protection of native birds	50 CFR Parts 10 and 20	Protects almost all species of native migratory birds in the U.S. from unregulated "take," which can include poisoning at hazardous waste sites.	Potentially applicable	Applicable if actions affect native migratory birds

Table 3-2
Potential Location-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
State ARARs and TBCs				
California Register of Historical Resources (PRC §5020 et seq.)				
Protection of California historic resources	14 CCR §4850 et seq.	Requires actions to minimize harm to historic properties listed on or eligible for listing on the California Register of Historical Resources.	Potentially applicable	Sites eligible for the National Register of Historic Places are automatically eligible for the California Register of Historical Resources.
California Endangered Species Act (FGC §2050 et seq.)				
Protection of California-listed threatened and endangered species and their critical habitat	FGC §2080 and 3005	Requires actions to conserve listed species and their habitat. Includes requirements for coordination with the CDFG for species that are both federally and state-listed.	Applicable	The site is habitat for the federally endangered Stephens' kangaroo rat (SKR), as well as other threatened or endangered animals and plants. Endangered species-related permitting will require coordination between the USFWS and CDFG.
Native Plant Protection Act (FGC §1900 et seq.)				
Protection of endangered and rare native plants	FGC §1900 et seq.	Requires actions to conserve endangered and rare native plants.	Potentially applicable	Applicable if actions affect endangered or rare native plant species.
California Fish and Game Code § 5650				
Protection of aquatic habitat and species in California	CFGC §5650	Prohibits the deposition into state waters of petroleum products, factory refuse, and any substance deleterious to fish, plants, or birds.	Potentially applicable	Applicable if actions involve construction within the stream channel
California Fish and Game Code § 3511				
Protection of certain species of birds	CFGC § 3511	Prohibits the taking of protected birds	Potentially applicable	Applicable if actions result in the killing of any protected birds
California Streambed Alteration Program (FGC §1600-1616)				
California Streambed Alteration Agreement	CFGC §1600-1616	Requires notification of any physical impacts to rivers, streams, or lakes.	Potentially applicable	Applicable if actions involve construction (dredge and fill) within the stream channel
Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda				
Protection of wetland habitat in California	Fish and Game Commission Wetlands Policy included in FGC Addenda	Requires actions to assure that there is no net loss of wetlands acreage or habitat value. Action must be taken to preserve, protect, and enhance California's wetland acreage and habitat value.	Potentially Applicable	Applicable if actions impact groundwater elevations or quality in riparian areas

Acronyms and Abbreviations:
ARAR: Applicable or Relevant and Appropriate criteria
CCR: California Code of Regulations
CDFG: California Department of Fish and Game
CFR: Code of Federal Regulations
FGC: California Fish and Game Code
LPC: Lockheed Propulsion Company
PRC: California Public Resources Code
SKR: Stephens' kangaroo rat
TBC: To be considered
USFWS: United States Fish and Wildlife Service
USC: United States Code

Table 3-3
Potential Action-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Federal ARARs and TBCs				
Safe Drinking Water Act (42 USC §300 et seq.)				
Underground Injection Control Program	40 CFR §144	Prohibits injection wells from causing a violation of primary MCLs in the receiving waters and adversely affecting the health of persons.	Potentially applicable	Applicable to actions that include reinjection of treated groundwater into an aquifer
Clean Water Act (33 USC §1251 et seq.)				
National Pollution Discharge Elimination System (NPDES) Discharge Permit	40 CFR §122 et seq.	Criteria for discharge of pollutants to surface water, including NPDES permit requirements	Potentially applicable	Applicable to actions that involve the discharge of treated groundwater to surface water
NPDES Stormwater Permit	40 CFR §122 et seq.	Criteria for stormwater discharges, including NPDES Stormwater Permit requirements	Potentially applicable	Applicable to actions that involve the disturbance of more than one acre of land
Resource Conservation and Recovery Act (42 USC §6901 et seq.)				
Definition of RCRA hazardous waste	22 CCR §66261 40 CFR §261	Defines RCRA hazardous wastes.	Potentially applicable	Potentially applicable to excavated contaminated soil, extracted groundwater, and treatment residuals, if these are determined to be hazardous wastes.
Hazardous waste generator requirements	22 CCR §66262 40 CFR §262	Standards for generators of hazardous waste, including accumulation, storage, manifesting, recordkeeping, and reporting requirements. Applies to both RCRA and non-RCRA hazardous wastes.	Potentially applicable	Potentially applicable to excavated contaminated soil, extracted groundwater, and treatment residuals, if these are determined to be hazardous wastes.
Hazardous waste transporter requirements	22 CCR §66263 40 CFR §263	Standards for transporters of hazardous waste, including manifesting and recordkeeping requirements. Applies to both RCRA and non-RCRA hazardous wastes.	Potentially applicable	Potentially applicable to excavated contaminated soil, extracted groundwater, and treatment residuals, if these are determined to be hazardous wastes.
Hazardous waste treatment, storage, and disposal requirements	22 CCR §66264 et seq. 40 CFR §264 et seq.	Includes standards for disposal of hazardous wastes, including land disposal restrictions, treatment standards, and technology requirements. Applies to both RCRA and non-RCRA hazardous wastes.	Potentially applicable	Potentially applicable to excavated contaminated soil, extracted groundwater, and treatment residuals, if these are determined to be hazardous wastes.
Hazardous Material Transportation Act (49 USC §5101 et seq.)				
Hazardous material transportation requirements	40 CFR §171 et seq.	Standards for transportation of hazardous materials	Potentially applicable	Applicable to actions that involve off-site treatment or disposal of excavated contaminated soil, extracted groundwater, or treatment residuals

Table 3-3
Potential Action-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Clean Air Act (42 USC §7600 et seq.)				
National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR §61	Establishes emissions standards for designated hazardous air pollutants and sources, and sets emissions standards for fugitive emissions due to equipment leaks.	Potentially relevant and appropriate	NESHAPs have not been established for specific activities associated with potential actions at the site, but are potentially relevant and appropriate for emissions of designated pollutants. In general, toxic air pollutants are reviewed by SCAQMD as part of its permitting process.
National Ambient Air Quality Standards (NAAQS)	40 CFR §50	Primary and secondary standards for six criteria pollutants	Potentially applicable	The NAAQS for particulates is applicable to actions involving soil excavation.
New Source Performance Standards (NSPS)	40 CFR §60	Establishes emissions standards for new stationary sources of air pollutants.	Potentially applicable	The NSPS are applicable to actions that involve the treatment of soil and/or groundwater.
Occupational Safety and Health Act (29 USC §651 et seq.)				
Worker safety requirements	29 CFR Part 1910	Establishes Occupational Safety and Health Administration (OSHA) standards for worker safety. Includes 29 CFR §1910.120 (Hazardous Waste Operations and Emergency Response) regulations.	Applicable	Relevant portions of OSHA regulations, including 29 CFR §1910.120, are applicable to all actions at the site.
State ARARs and TBCs				
Porter-Cologne Water Quality Control Act (CWC §13000 et seq.)				
Laboratory certification requirements	CWC §13176	Analysis of materials required under CWC §13000 et seq. must be performed in a State certified laboratory.	Potentiallyapplicable	Applicable to actions regulated by the SWRCB or RWQCB; relevant and appropriate for actions that include analysis of soil or groundwater samples
Statement of Policy With Respect to Maintaining High Quality of Waters in California ("Anti-Degradation Policy")	SWRCB Resolution 68-16	Establishes requirements for activities involving the discharge of contamination directly into surface water and groundwater. Specifically, "Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained."	Potentially applicable	Applicable to actions that include the injection or discharge of treated effluent to groundwater or surface water, or injection of amendments into the subsurface

Table 3-3
Potential Action-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304	SWRCB Resolution 92-49, as amended on April 21, 1994, and October 2, 1996	Establishes criteria for "containment zones," that are specific portions of a water bearing unit where it is unreasonable to remediate to the level that achieves water quality objectives. Dischargers are required to take all actions necessary to prevent the migration of pollutants beyond the boundaries of the containment zone in concentrations that exceed water quality objectives, and must verify containment with an approved monitoring program and must provide reasonable mitigation measures to compensate for any significant adverse environmental impacts attributable to the discharge.	Potentially relevant and appropriate	Relevant and appropriate for actions that include groundwater containment
National Pollution Discharge Elimination System, General Permit for Discharges of Storm Water Associated with Construction Activity	Water Quality Order No. 99-08-DWQ	Requires containment or control of storm water in areas where construction and earthmoving activities result in the disturbance of at least one acre.	Potentially applicable	Applicable to actions that involve clearing, grading, excavation, and stockpiling of soil or other materials
Hazardous Waste Control Act (HSC §25100 et seq)				
Definition of non-RCRA (California) hazardous waste	22 CCR §66261.101	Defines non-RCRA (California) hazardous wastes. Generator, transporter, and treatment, storage, and disposal requirements are discussed (above in this table) under RCRA.	Potentially applicable	Applicable to excavated contaminated soil, extracted groundwater, and treatment residuals, if these are determined to be non-RCRA hazardous wastes
Requirements for land use covenants	22 CFR §67391.1	DTSC requirements for establishing land use covenants on property where hazardous waste, hazardous materials or constituents, or hazardous substances remain on the property.	Potentially applicable	Applicable for locations where hazardous waste, hazardous material or constituents, or hazardous substances will remain after remedial action
Consolidated Regulations for Treatment, Storage, Processing or Disposal of Solid Waste (PRC §40000 et seq. and CWC §13000 et seq.)				
Exemptions to Title 27 requirements	27 CCR §20090(d)	Actions to clean up unauthorized releases taken at the direction of public agencies are exempt from Title 27 requirements, provided that wastes removed from the immediate place of release and discharged to land are managed in accordance with Title 27 classification and siting requirements, an d that wastes contained or left in place comply with Title 27 requirements to the extent feasible.	Applicable	Applicable to monitoring and cleanup actions at sites where wastes have been discharged to land
SWRCB general landfill construction and containment criteria	27 CCR §20310 and 20320	SWRCB criteria for the design and construction of landfills and landfill containment structures	Potentially relevant and appropriate	Applicable for actions that include on-site disposal of non-hazardous waste; relevant and appropriate for actions that include landfill capping.
General water quality monitoring requirements for waste management units	27 CCR §20415	Requires general groundwater, surface water, and vadose zone monitoring at waste management units	Relevant and appropriate	Relevant and appropriate for sites where wastes have been discharged to land

Table 3-3
Potential Action-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Site characterization requirements for waste management units	27 CCR §20425	Requires an assessment of the nature and extent of a release at a waste management unit, including a determination of the spatial distribution and concentration of each contaminant	Relevant and appropriate	Relevant and appropriate for sites where wastes have been discharged to land
Corrective action requirements for waste management units	27 CCR §20430	Requires implementation of corrective action measures for a release at a waste management unit that ensure that 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.	Relevant and appropriate	Relevant and appropriate for sites where wastes have been discharged to land
SWRCB general standards for closure of landfills	27 CCR §20950	SWRCB general standards for closure of solid waste management units, including performance goals	Potentially applicable	Applicable for actions that include landfill capping or on-site disposal of non-hazardous waste
SWRCB landfill closure and post-closure maintenance requirements	27 CCR §21090 and 21132	SWRCB requirements for closure and post-closure maintenance, including final cover design and maintenance, grading, and post-closure maintenance requirements, as well as emergency response plan review requirements. Also includes requirements for clean closure of landfills.	Potentially applicable	Applicable for actions that include landfill capping, clean closure, or on-site disposal of non-hazardous waste
SWRCB landfill closure and post-closure maintenance plan requirements	27 CCR §21769	SWRCB requirements for Closure and Post-closure Maintenance Plans, including preliminary and final plans.	Potentially applicable	Applicable for actions that include landfill capping or on-site disposal of non-hazardous waste
CIWMB landfill closure and post-closure maintenance requirements	27 CCR §21100 et seq.	CIWMB requirements for closure and post-closure maintenance, including post-closure emergency response plan, final cover, final grading, slope stability, drainage and erosion control, landfill gas control, post-closure maintenance, and post-closure land use requirements.	Potentially applicable	Applicable for actions that include landfill capping or on-site disposal of non-hazardous waste
CIWMB landfill gas monitoring requirements	27 CCR §20920 et seq.	CIWMB requirements for landfill gas monitoring and control	Potentially applicable	Applicable for actions that include landfill capping or on-site disposal of non-hazardous waste
CIWMB landfill closure plan requirements	27 CCR §21790 and 21800	CIWMB requirements for preliminary and final closure plans	Potentially applicable	Applicable for actions that include landfill capping or on-site disposal of non-hazardous waste
CIWMB landfill post-closure maintenance plan requirements	27 CCR §21825 and 21830	CIWMB requirements for preliminary and final post-closure maintenance plans.	Potentially applicable	Applicable for actions that include landfill capping or on-site disposal of non-hazardous waste
South Coast Air Quality Management District Regulations				
Rule 401 (Visible Emissions)	SCAQMD Regulation IV (Prohibitions)	Limits visible emissions from any single source.	Potentially applicable	Applicable to actions involving soil excavation

Table 3-3
Potential Action-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
Rule 402 (Nuisance)	SCAQMD Regulation IV (Prohibitions)	Prohibits discharge of any material, including odorous compounds, that causes injury, detriment, nuisance, or annoyance to the public; endangers human health, comfort, repose, or safety; or has a natural tendency to cause injury or damage to business or property.	Potentially applicable	Applicable to actions involving soil excavation
Rule 403 (Fugitive Dust)	SCAQMD Regulation IV (Prohibitions)	Limits site activities or man-made conditions so that the concentrations of fugitive dust beyond the property line shall not be visible and the downwind particulate concentration shall not be more than 50 mg/m3 above upwind concentrations.	Potentially applicable	Applicable to actions involving soil excavation
Rule 404 (Particulate Matter)	SCAQMD Regulation IV (Prohibitions)	Limits particulate matter for volumetric gas flow.	Potentially applicable	Potentially applicable to actions involving certain on-site soil or groundwater treatment
Rule 466 (Pumps and Compressors)	SCAQMD Regulation IV (Prohibitions)	Limits liquid and gas leakage from pumps and compressors handling reactive organic compounds.	Potentially applicable	Potentially applicable to actions involving certain on-site soil or groundwater treatment
Rule 466.1 (Valves and Flanges)	SCAQMD Regulation IV (Prohibitions)	Limits liquid and gas leakage from valves and flanges.	Potentially applicable	Potentially applicable to actions involving certain on-site soil or groundwater treatment
Rule 467 (Pressure Relief Devices)	SCAQMD Regulation IV (Prohibitions)	Requires pressure relief valves to be vented to a vapor recovery or disposal system, or subject to inspection and maintenance requirements.	Potentially applicable	Potentially applicable to actions involving certain on-site soil or groundwater treatment
Rule 1150 (Excavation of Landfill)	SCAQMD Regulation XI (Source Specific Standards)	Requires preparation and implementation of an Excavation Management Plan, which shall include measures for mitigating public nuisance conditions.	Potentially applicable	Applicable to actions involving excavation or capping of the landfill
Rule 1166 (Volatile Organic Compound Emissions from Decontamination of Soil)	SCAQMD Regulation XI (Source Specific Standards)	Requires control of VOC emissions from VOC-contaminated soils.	Potentially applicable	Applicable to actions involving soil excavation in areas with VOC contamination
Rule 1401 (New Source Review of Toxic Air Contaminants)	SCAQMD Regulation XIV (Toxics and other Non-Criteria Pollutants)	Establishes risk standards for permitting stationary sources.	Potentially applicable	Potentially applicable to actions involving certain on-site soil or groundwater treatment
California Occupational Safety and Health Act (CLC §6300 et seq.)				
Worker safety requirements	8 CCR Division 1, Chapter 4	Establishes Cal/OSHA standards for worker safety in California.	Applicable	Relevant portions of Cal/OSHA regulations are applicable to all actions at the site.

Table 3-3
Potential Action-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Requirement, Standard, or Criterion	Citation	Description	ARAR or TBC Determination	Comments
California Health and Safety Code, Miscellaneous Health and Safety Provisions (HSC §24000 et seq.)				
Institutional Controls	California Health and Safety Code §25220 et seq.	Requires notification to the planning and building department of each city, county, or regional council of governments of any recorded land use restriction imposed within the jurisdiction of the local agency	Applicable	Applicable to actions that include institutional controls
Land Use Controls	California Health and Safety Code §25355.5(a)(1)	Establishes a process for the DTSC to enter into an enforceable agreement with land owners to restrict the use of property.	Applicable	Applicable to actions that include land use controls
California Civil Code §1457 et seq. (Transfer of Obligations)				
Land Use Controls	California Civil Code §1471	Establishes conditions under which land use controls will apply to successive owners of land.	Potentially applicable	Applicable to actions that include land use controls
California Well Standards				
California Well Standards	California Department of Water Resources Bulletin 74-91, as supplemented by Bulletin 74-90	Standards for the construction and decommissioning of public water supply wells.	Potentially relevant and appropriate	Relevant and appropriate to action s that involve the installation and/or decommissioning of groundwater monitoring, extraction, or injection wells
Riverside County Ordinances				
Well Permits	Riverside County	Requires permits for installation of groundwater wells.	Potentially applicable	Applicable to actions that include installation of groundwater extraction or monitoring wells
Grading Permits	Riverside County	Requires grading permits for excavations exceeding 25 cubic yards.	Potentially applicable	Applicable to actions that include excavation
Building Permits	Riverside County	Requires permits for certain construction activities, such as electrical and plumbing systems.	Potentially applicable	Potentially applicable to actions involving certain on-site soil or groundwater treatment

<u>Acronyms and Abbreviations:</u>
ARAR: Applicable or Relevant and Appropriate criteria
Cal/OSHA: California Occupational Safety and Health Administration
CCR: California Code of Regulations
CFR: Code of Federal Regulations
CIWMB: California Integrated Waste Management Board
CLC: California Labor Code
CWC: California Water Code
HSC: California Health and Safety Code
MCL: Maximum Contaminant Level
NAAQS: National Ambient Air Quality Standards
NESHAPs: National Emission Standards for Hazardous Air Pollutants
NPDES: National Pollution Discharge Elimination System
NSPS: New Source Performance Standards
OSHA: Occupational Safety and Health Administration
PRC: California Public Resources Code
RCRA: Resource Conservation and Recovery Act
SCAQMD: South Coast Air Quality Management District
SWRCB: State Water Resources Control Board
TBC: To be considered
USC: United States Code
VOCs: Volatile organic compounds

Section 4
Remedial Action Objectives

Establishing remedial action objectives (RAOs) is the initial step in the development and screening of remedial alternatives. RAOs are general cleanup objectives that consider the site contaminants of concern, contaminated media, potential exposure routes, receptors, and chemical- or media-specific cleanup goals developed by evaluating applicable or relevant and appropriate requirements (ARARs), to be considered (TBC) criteria, and site-specific risk-based concentrations (RBCs) that protect human health and the environment.

Sections 4.1 and 4.2 present the RAOs developed for soil and groundwater at the site. The RAOs are presented generically, (i.e., without citing specific cleanup goals). Media- and chemical-specific preliminary remediation goals (PRGs) are developed in Section 4.3.

4.1 REMEDIAL ACTION OBJECTIVES FOR SOIL

RAO S1 - Protect human receptors from exposure to site contaminants in soil through ingestion, inhalation, and dermal contact at concentrations exceeding protective levels.

This RAO addresses potential health risks resulting from exposure of human receptors (trespassers, industrial workers, and construction workers) to contaminants present in soil. The only human health risks identified by the human health and ecological risk assessment (HHERA) (Tetra Tech, 2012b) were carcinogenic health risks exceeding the point of departure of 10^{-6} for adult trespassers at the Waste Discharge Area (WDA) due to exposure to cadmium via inhalation of airborne dust emitted from soil, and changes in blood lead concentration that slightly exceed the benchmark of 1 microgram per deciliter for adult trespassers in the WDA due to exposure to lead via inhalation of airborne dust emitted from soil. This RAO may be addressed either by eliminating the relevant exposure pathway, or by reducing exposure point concentrations to protective levels.

RAO S2 - *Protect ecological receptors from exposure to site chemicals of concern in soil through ingestion and food consumption (for mammals and birds) at concentrations exceeding protective levels.*

This RAO addresses potential ecological risks resulting from exposure of wildlife to contaminants present in soil. The HHERA (Tetra Tech, 2012b) identified the following as the primary risk drivers for ecological receptors: hazard quotients (HQs) exceeding 1 for the Stephens' kangaroo rat (SKR) and herbivorous birds due to exposure to perchlorate in southern Test Bay Canyon (STBC); and HQs exceeding 1 for SKR due to lead exposure in the WDA. This RAO may be addressed either by eliminating the relevant exposure pathways, or by reducing exposure point concentrations to protective levels.

4.2 REMEDIAL ACTION OBJECTIVES FOR GROUNDWATER

RAO GW1 - *Protect human receptors from exposure to site chemicals of concern in groundwater by ingestion, dermal contact, and inhalation at concentrations exceeding protective levels.*

This RAO addresses potential human health risks resulting from exposure to contaminated groundwater. Exposure pathways for human receptors on the property are incomplete because groundwater is not currently used for drinking water supply, and existing deed restrictions prohibit the installation of water supply wells and the use of groundwater beneath the property in the future. However, since the WDA groundwater plume currently extends to the southern boundary of the property and to some extent beyond, exposure to contaminated groundwater to the south of the property, although unlikely, is still possible. Risks associated with groundwater at the site were evaluated in the HHERA (Tetra Tech, 2012b) by comparing chemical concentrations in the WDA groundwater plume with potentially applicable drinking water criteria. Seven chemicals in groundwater were identified as exceeding potential drinking water criteria, including perchlorate, trichloroethene (TCE), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), methylene chloride, 1,4-dioxane, and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). After further evaluation of contaminant concentrations across the entire site (Section 2.6.3), two additional chemicals (benzene and nitrate) were also identified as exceeding potential drinking water criteria. This RAO may be addressed either by eliminating exposure pathways or by reducing exposure point concentrations (EPCs) to levels that do not present a potential health risk under the beneficial use conditions assumed in the HHERA.

RAO GW2 **-** *Protect groundwater resources outside the current groundwater plume by limiting the off-property migration of site chemicals of concern at concentrations exceeding levels that protect designated beneficial uses.*

RAO GW2 addresses the protection of beneficial uses of groundwater rather than potential human health or ecological risk. Actual and potential beneficial uses of groundwater in the Santa Ana Region are designated in the *Water Quality Control Plan for the Santa Ana River Basin (8)* (Basin Plan; SARWQCB, 1995). Although the site is not located within a groundwater basin designated in the Basin Plan, it is located in an area that is a tributary to the San Jacinto Upper Pressure Groundwater Management Zone of the San Jacinto Groundwater Basin (Figure 2-5). Per the Basin Plan, groundwaters that are not specifically listed have the same beneficial uses as the groundwater basins or subbasins to which they are a tributary or overlie. Designated beneficial uses of groundwater in the San Jacinto Upper Pressure Groundwater Management Zone include agricultural supply, industrial service supply, industrial process supply, and municipal and domestic supply. These beneficial uses are discussed in more detail in Section 4.3.2.2.

4.3 PRELIMINARY REMEDIATION GOALS

Preliminary Remediation Goals are numerical target concentrations that are developed to evaluate the areas or volumes of impacted media at the site that require remedial action to meet the RAOs defined in Sections 4.1 and 4.2. The PRGs must therefore protect current and anticipated future human and ecological receptors identified at the site, as well as potential beneficial uses of groundwater. In addition, PRGs must be reasonably achievable using current remediation technologies.

Preliminary remediation goals can be developed based on site-specific risk calculations or chemical-specific ARARs and TBC criteria. In the following sections, site-specific risk calculations are used to develop PRGs for soil, and chemical-specific ARARs and beneficial use considerations are used to develop PRGs for groundwater. The presence of chemicals at concentrations greater than background may also be considered in developing PRGs. However, background concentrations for chemicals at the site appear to be lower than risk-based screening levels for soil (Section 4.3.1) and chemical-specific ARARs for groundwater (Section 4.3.3), and were therefore not considered in developing PRGs.

4.3.1 Preliminary Remediation Goals for Soil

The HHERA (Tetra Tech, 2012b) identified cadmium in soil at a level resulting in carcinogenic risks exceeding 1×10^{-6} for adult trespassers in the WDA, and lead in soil at a level that results in increases in blood lead concentrations greater than the benchmark of 1 microgram per deciliter. Site-specific risk-based screening levels (RBSLs) were developed for cadmium and lead to protect adult trespassers. The RBSL for cadmium was calculated by using the risk equations to solve for an EPC corresponding to a specified target risk. The calculations were performed using the same exposure parameters and toxicity values used to calculate risks in the HHERA (Tetra Tech, 2012b), include all exposure pathways that adult trespassers are assumed to encounter, and are based on a target risk of 1×10^{-6}. The calculated human heath RBSL for cadmium is 2.8 milligrams/kilogram (mg/kg), as shown in Table 4-1, and will be used as the PRG for cadmium in soil. The RBSL for lead was calculated using Lead Spread 8 (Appendix B), and is 193 mg/kg, as shown in Table 4-1. This value is compared with the ecological RBSL for lead in the following three paragraphs.

The HHERA (Tetra Tech, 2012b) identified the following two chemicals in soil in two areas that pose potential hazards to ecological receptors: perchlorate in surface soil in the Test Bay 3 area of STBC, and lead in surface and subsurface soil in the WDA. A two-step process was used to develop site-specific RBSLs that protect ecological receptors. First, RBCs in soil were developed for each chemical and receptor using the dose equations, exposure parameters, and toxicity reference values (TRVs) applied in the HHERA (Tetra Tech, 2012b). To provide a range of potential RBSLs, risk-based concentrations were calculated using both the no-observed adverse-effect level (NOAEL) and the lowest-observed adverse-effect level (LOAEL) TRVs for each receptor. The RBCs calculated for perchlorate and lead are presented in Table 4-1. A single RBSL was then selected from the set of calculated RBCs for each chemical of concern, which adequately protects all ecological receptors.

For perchlorate, the NOAEL-based RBC of 1.7 mg/kg for the SKR was selected as the RBSL. The NOAEL TRV represents the highest dose at which no adverse effects occur, and thus protects the special-status SKR. The RBC of 1.7 mg/kg is also less than the LOAEL-based RBCs for the house finch, and thus is likely to provide an adequate level of protection against population-level effects on this species.

For lead, both the NOAEL-based RBC of 205 mg/kg for SKR and the LOAEL-based RBC of 1,390 mg/kg are greater than the human health RBSL of 193 mg/kg. The selected ecological RBSLs are presented in Table 4-1. The perchlorate ecological RBSL will be used as the PRG for perchlorate in soil; the human health RBSL will be used as the PRG for lead in soil.

4.3.2 Preliminary Remediation Goals for Groundwater

The RAOs for groundwater include objectives to protect human health (RAO GW1), and objectives to protect the beneficial use of groundwater resources (RAO GW2). The PRGs for these groundwater RAOs are presented in the following sections, and are based on evaluation of chemical-specific ARARs and TBC criteria and the evaluation of beneficial uses of on- and off-site groundwater.

4.3.2.1 Numerical Chemical-Specific ARARs and TBC Criteria

Numerical chemical-specific ARARs and TBC criteria for groundwater identified in Section 3.1 include drinking water standards (i.e., federal and California Maximum Contaminant Levels (MCLs), federal Maximum Contaminant Level Goals (MCLGs), California Public Health Goals (PHGs), and California drinking water notification levels (DWNLs) and water quality objectives (WQOs) for the San Jacinto Upper Pressure Groundwater Management Zone specified in the Basin Plan (SARWQCB, 1995). Chemical-specific ARARs and TBC criteria for site contaminants identified as exceeding drinking water standards are summarized in Table 4-2. For chemicals with multiple drinking water standards, the lowest ARAR (federal MCL, California MCL, or WQO) was selected as the PRG. The compounds 1,4-dioxane and RDX do not have MCLs, MCLGs, or PHGs; the California DWNLs, which are TBC criteria, were therefore selected as the PRGs for these chemicals.

4.3.2.2 Evaluation of Beneficial Uses

The site is tributary to the San Jacinto Upper Pressure Groundwater Management Zone, and potential beneficial uses of groundwater include agricultural supply, industrial service supply, industrial process supply, and municipal and domestic supply. The Basin Plan narrative (SARWQCB, 1995) indicates that agricultural supply, industrial service supply, and industrial process supply beneficial uses may be impaired by excessive boron, chloride, fluoride, sodium, total dissolved solids, or hardness concentrations, or by pH values less than 6 or greater than 9. None of these constituents were released as a direct result of site activities. Agricultural supply beneficial uses also include livestock watering, which may be affected by perchlorate contamination. The Basin Plan does not provide numerical standards for perchlorate that are protective of agricultural water supply beneficial uses, and estimating levels of perchlorate which would be protective of agricultural beneficial uses is problematic. However, Tetra Tech suggests that a remedy that is protective of municipal and domestic supply beneficial uses in the San Jacinto Groundwater Basin will also be protective of agricultural supply beneficial uses.

Although the Basin Plan indicates that municipal and domestic supply is a potential beneficial use of site groundwater, State Water Resources Control Board Resolution No. 88-63 ("Sources of Drinking Water Policy") provides several exceptions to that designation. One of the exceptions is for water sources that do not provide sufficient water to supply a single well capable of producing an average sustained yield of 200 gallons per day (gpd). Aquifer testing results (Tetra Tech, 2010b; 2010e; 2012d) indicate that hydraulic conductivity values on and off the property are quite low, suggesting that average well yields may not be sufficient to supply at least 200 gpd to a single well. Potential well yields were estimated based on the available hydraulic data using the specific capacity method (Driscoll, 1986, Appendix 16.D). The results of this analysis (Appendix C) indicate that the average well yield in Laborde Canyon is roughly 110 gpd, and likely lower, which is well under the 200 gpd threshold promulgated in Resolution No. 88-63. On-property groundwater, as well as groundwater in the area south of the property boundary, may therefore be exempt from the municipal and domestic supply beneficial-use designation. This finding has several implications for the site:

- <u>On-Property Groundwater</u>: The ARARs and PRGs summarized in Table 4-2 do not apply to on-property groundwater, because existing land use covenants (LUCs) prevent access to and use of groundwater, and the groundwater is exempt from municipal- and domestic-supply beneficial uses.

- <u>Off-Property Groundwater within Laborde Canyon</u>: Off-property exposure to groundwater is possible, because there are no LUCs in this area and Lockheed Martin Corporation does not own the property. The PRGs summarized in Table 4-2 therefore apply to the off-property groundwater plume to protect human health.

- <u>Off-Property Groundwater in the San Jacinto Upper Groundwater Management Zone</u>: Contaminated groundwater discharging from Laborde Canyon could potentially impact both human health and the environment if it migrates to the San Jacinto Upper Pressure Groundwater Management Zone. However, contaminants have not been detected in monitoring well TT-MW2-20S, the well nearest to the point of discharge, indicating that the site is in compliance with ARARs relating to beneficial uses of groundwater in the San Jacinto Upper Groundwater Management Zone.

Section 4 Tables

Table 4-1
Preliminary Remediation Goals for Soil

Chemical	Receptor	Receptor Exposure Depth (feet bgs)	10^{-6} Target Risk RBC (mg/kg)	1 µg/dl Blood Lead Threshold (mg/kg)	NOAEL RBC (mg/kg)	LOAEL RBC (mg/kg)	PRG (mg/kg)	Notes
Human Receptors								
Cadmium	Adult Trespasser	0.5	2.8	-	-	-	2.8	
Lead	Adult Trespasser	0.5	-	193	-	-	193	
Ecological Receptors								
Perchlorate	SKR	1.5	-	-	1.7	19	1.7	NOAEL helps protect special-status SKR
	House finch	0.5	-	-	0.28	3.0		
Lead	SKR	1.5	-	-	205	1,390	-	

Notes:
bgs: Below ground surface
LOAEL: Lowest-observed adverse-effect level
mg/kg: Milligrams per kilogram
µg/dl: Micrograms per deciliter
NOAEL: No-observed adverse-effect level
PRG: Preliminary remediation goal
RBC: Risk-based concentration
SKR: Stephens' kangaroo rat

Table 4-2
Preliminary Remediation Goals for Groundwater

Compound	ARARs			TBC Criteria			PRG (µg/L)
	Federal MCL (µg/L)	California MCL (µg/L)	WQO (µg/L)	Federal MCLG (µg/L)	California PHG (µg/L)	California DWNL (µg/L)	
Nitrate (as N)	10,000 (as N)[1]	45,000 (as NO_3)[1]	7,000 (as N)[2]	10,000 (as N)[1]	45,000 (as NO_3)[1]	-	7,000 (as N)
Perchlorate	-	6	-	-	6	-	6
Benzene	5	1	-	zero[3]	0.15	-	1
1,2-Dichloroethane	5	0.5	-	zero[3]	0.4	-	0.5
1,1-Dichloroethene	7	6	-	7	10	-	6
1,4-Dioxane	-	-	-	-	-	1	1
Methylene chloride	5	5	-	zero[3]	4	-	5
RDX	-	-	-	-	-	0.3	0.3
Trichloroethene	5	5	-	zero[3]	1.7	-	5

Notes
ARARs: Applicable or Relevant and Appropriate Requirements
DWNL: Drinking Water Notification Level
MCL: Maximum Contaminant Level
MCLG: Maximum Contaminant Level Goal
µg/L: Micrograms per liter
PHG: Public Health Goal
PRG: Preliminary remediation goal
RDX: Hexahydro-1,3,5-trinitro-1,3,5-triazine
TBC: To be considered
WQO: Water quality objective
1. 10,000 µg/L of nitrate measured as N is equivalent to 45,000 µg/L of nitrate measured as NO_3.
2. Maximum benefit water quality objective
3. Federal MCLGs for carcinogens are set at zero, and are not considered to be TBCs.

Section 5
Development of General Response Actions and Screening of Remedial Technologies and Process Options

The identification of viable remedial technologies is the second step in the development of remedial alternatives for the site. This section of the feasibility study addresses the following topics:

- The development of general response actions (GRAs), which are actions that can be taken to satisfy the remedial action objectives (RAOs) identified in Section 4.0
- Identification of remedial technologies and process options applicable to each GRA, and initial screening to eliminate those that cannot be technically implemented at the site
- Evaluation and screening of remedial technologies and process options based on their implementability, effectiveness, and relative cost

5.1 GENERAL RESPONSE ACTIONS

General response actions that may be used to satisfy one or more of the RAOs presented in Section 4.0 were developed for the impacted media at the site: soil and groundwater. The GRAs considered for the site include the following:

- <u>No Action</u>: This GRA is required to be retained for evaluation per guidance from the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA; 40 CFR §300.430). This GRA assumes that no remedial actions, other than those that have previously been conducted at the site, will be performed.
- <u>Monitoring (groundwater only)</u>: Periodic groundwater monitoring identifies the effectiveness of other actions, such as containment, treatment, or extraction actions. Natural attenuation monitoring identifies the effectiveness of natural processes in reducing contaminant concentrations.
- <u>Institutional and Engineering Controls</u>: Institutional and engineering controls are used to prevent exposure to contaminants. Examples include land use covenants, which are used to prohibit land uses that may involve exposure to sensitive receptors such as human

residents, and fencing, which prevents receptors from coming into physical contact with impacted soil.

- Containment: Containment is used to eliminate exposure pathways or reduce the mobility of contaminants. Examples include capping, which can be used to eliminate exposure to contaminated soil; pumping, which can be used to hydraulically contain impacted groundwater; and permeable reactive barriers, which can be used to prevent groundwater contaminants from migrating beyond a specified location.

- Treatment: *In situ* or *ex situ* treatment reduces contaminant concentrations in impacted soil or groundwater. In some instances, *in situ* treatment may be used to eliminate exposure pathways, and may also decrease contaminant mobility or volume, depending upon the level of treatment and properties of the contaminants and impacted media.

- Removal, Transportation, and Disposal (soil only): Removal reduces the volume of impacted soil. Removal may be combined with *ex situ* treatment to reduce contaminant concentrations in excavated impacted soil, or may be combined with transportation and off-site disposal to reduce the volume of impacted soil. The disposal component of this GRA also includes on-site reuse of treated soil.

- Extraction, Transportation, and Disposal (groundwater only): Groundwater extraction reduces the volume of impacted groundwater and contaminant concentrations in impacted groundwater. Extraction is usually combined with *ex situ* treatment and on-site disposal of treated groundwater. Off-site disposal is usually reserved for treatment residuals.

5.2 TREATABILITY STUDIES

Two bench-scale treatability studies and one pilot-scale treatability study were conducted to more fully evaluate potential biological treatment of perchlorate as a potential remedial technology for soil and groundwater at the site. The results of these studies are summarized in the following sections.

5.2.1 Bench-Scale Treatability Studies

Bench-scale studies were conducted to evaluate biological treatment of perchlorate for biobarrier applications and source area groundwater and soil treatment applications. The biobarrier application study (Tetra Tech, 2009c) evaluated the following three potential carbon substrates: compost, EOS 598 (a proprietary emulsified vegetable oil substrate manufactured by EOS Remediation, LLC), and EHC® (a proprietary carbon substrate/zero-valent iron mixture manufactured by FMC Corporation). The soil and groundwater samples used in the studies were collected near the southern boundary of the property, where a biobarrier would likely be located. Both microcosm and column studies were performed for all three substrates. The study results found that all three substrates were very effective in stimulating biological perchlorate reduction, with complete reduction occurring within 5 to 12 days. Addition of nutrients did not affect the observed degradation rates. There were indications that the longevity of EHC® in the subsurface may be slightly lower than EOS. Solubilization of metals was negligible for EOS, whereas significant solubilization of iron was noted for EHC®.

The source area groundwater application study (Tetra Tech, 2010c) evaluated the following five potential carbon substrates: EOS 598, glycerin, high fructose corn syrup, acetic acid, and sodium acetate. Soil and groundwater samples collected in the Test Bay 3 area of southern Test Bay Canyon were used in the study. Microcosm studies found that EOS 598, glycerin, and sodium acetate were all effective in stimulating biological perchlorate degradation, and that nutrient addition had little effect on perchlorate degradation rates. Based on these results, EOS 598 and glycerin were advanced to column studies. Column studies were not performed using sodium acetate, based on concerns with adding salts to the aquifer. The column study results found that glycerin had to be continuously added to the system to effectively stimulate and maintain perchlorate degradation, whereas a single application of EOS resulted in steady removal of perchlorate with no additional amendment. Solublization of metals was found to be negligible for both EOS and glycerin.

The source area vadose zone soil study (Tetra Tech, 2010c) evaluated the following five potential carbon substrates: glycerin, high fructose corn syrup, sodium acetate, ethyl acetate, and a liquefied petroleum gas/hydrogen/carbon dioxide mixture. Soil samples collected in the Test Bay 3 area of southern Test Bay Canyon were used in the study. No perchlorate degradation was observed with any of the substrates in microcosm tests run at 15% and 25% moisture content; however, perchlorate treatment was successfully induced with sodium acetate under saturated conditions. Perchlorate degradation rates were somewhat higher in microcosms with added nutrients. Column studies designed to create at least temporary saturated conditions were conducted using EOS and glycerin as carbon substrates. Little or no perchlorate degradation was observed in batch application column tests, where the column was initially saturated, allowed to drain for one day, and then sealed. However, complete perchlorate degradation was observed in column tests in which water was continuously recirculated through the column. Several possible conditions, including salinity, unfavorable pH, or unbalanced fermentation may have resulted in inhibition of biodegradation in the unsaturated microcosm and column tests, but the cause of inhibition was ultimately not determined.

5.2.2 Pilot-Scale Treatability Study

A pilot-scale treatability study was conducted to evaluate the potential for remediating perchlorate-impacted soil and groundwater by continuously infiltrating carbon substrate-amended water into the vadose zone via a shallow infiltration gallery. This process option is referred to as bioflushing. Bioflushing relies on two processes to remediate vadose zone soils: biodegradation of perchlorate under induced anaerobic conditions, and solubilization and transport of perchlorate to groundwater. This process may also treat perchlorate in groundwater through anaerobic biodegradation enhanced by the added carbon source. The pilot-scale study was conducted in the Test Bay 3 area of southern Test Bay Canyon (Figure 5-1).

For the test, potable water was trucked to the study area and stored in an aboveground tank. The water was then amended with glycerin, a soluble organic carbon substrate, and gravity-fed into a 10- by 15-foot infiltration gallery, where it was allowed to percolate into the vadose zone under constant-head conditions. A variety of techniques were used to monitor the test. Flow readings and other system measurements were collected on a weekly basis to monitor infiltration and substrate amendment rates. Electrical resistivity tomography (ERT), a geophysical imaging technique, was used to periodically monitor the three-dimensional geometry of the moisture front over time. A dye tracer (sodium fluorescein) was added to the infiltrating solution at the beginning of the test to allow detection of the moisture front as it migrated vertically through the vadose zone to groundwater. The chemistry of the infiltrating solution (total organic carbon [TOC], perchlorate, and tracer concentrations) was monitored in the vadose zone by collecting pore water samples from three pressure-vacuum lysimeters located adjacent to the infiltration gallery. The effect of the test on groundwater chemistry was monitored by collecting groundwater samples from a monitoring well located adjacent to the infiltration gallery.

The geometry of the moisture-affected zone in the subsurface, based on the electrical conductivity reflected in the ERT results, is illustrated in plan view in Figure 5-2, and in cross-section in Figure 5-3. The moisture-affected zone reached its maximum extent after about 116 days of operation, and then decreased in size until the test was terminated by ceasing infiltration after 204 days. The decrease in the extent of the moisture-affected zone is correlated with a decline in the observed flow rate to below 0.2 gallons per minute, which is attributed to biofouling within or immediately below the infiltration gallery.

Perchlorate and TOC concentrations in porewater and groundwater samples are shown in Figure 5-4. Total organic carbon and fluorescein breakthrough occurred at a depth of 35 feet below ground surface (bgs) within nine days of the start of treatment, indicating that flow through the upper portion of the vadose zone is predominantly through preferential pathways. This is in agreement with the relatively high flow rates observed during the first few weeks of the test, and with the observation that a lysimeter installed at a depth of 20 feet bgs did not yield water samples during the test. Total organic carbon and fluorescein breakthrough at a depth of 50 feet occurred 11 weeks later, suggesting that matrix flow is dominant in the lower portion of the vadose zone. In both the 35-foot and 50-foot lysimeters, as well as the groundwater monitoring well located adjacent to the infiltration gallery, perchlorate declined to nearly non-detectable concentrations shortly after TOC breakthrough occurred, which indicates that biodegradation was occurring.

The effectiveness of vadose zone treatment was evaluated by analyzing collocated soil samples collected before and after the test. Ten soil borings were drilled at various distances from the infiltration gallery prior to the start of treatment. The samples collected from these borings were frozen and held by the laboratory until the test was completed. After the test, five of the ten pre-treatment boring locations were resampled by drilling soil borings within two feet of the original borings. A sixth boring, located at the center of the infiltration gallery, was also sampled during the post-treatment sampling event. The pre- and post-treatment soil samples were analyzed for perchlorate, total organic carbon, and moisture content. The Mining Visualization System (MVS) software was then used to model the pre- and post-treatment distribution of perchlorate in the vadose zone, and to quantitatively estimate the amount of perchlorate removed by treatment (Figure 5-5). The MVS modeling indicates that approximately 50% of the perchlorate mass was removed from the vadose zone by bioflushing. The results of the pilot test for this technology indicate that it may be well-suited for reducing the mass of perchlorate in portions of the vadose zone.

5.3 IDENTIFICATION AND INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

Following the development of the GRAs outlined above, potentially applicable technology types were identified by media for each GRA. For example, the treatment GRA for soil was expanded to include *in situ* and *ex situ* physical, biological, chemical, and thermal treatment technologies applicable to one or more of the site contaminants.

Each technology was screened initially for technical implementability at the site, either as a stand-alone option or in combination with other technologies, based on site characteristics, chemical types, impacted media, contaminant distribution, and volume or concentration. The purpose of this initial screening step was to eliminate technologies that were clearly not implementable at the site. None of the technologies were eliminated at this stage of the screening process.

Each technology type was then populated with one or more representative process options for further screening. Process options were obtained from several sources, including in-house experience with a variety of remedial technologies, and a search of readily available literature on remedial technologies and applications. Major sources for technology information included the following:

- USEPA: The United States Environmental Protection Agency Technology Innovation and Field Services Division Contaminated Site Clean-Up Information (CLU-IN) website (USEPA, 2012) contains a variety of technology-specific and contaminant-specific remediation resources, including brief Web-based treatment technology overviews and links to publications issued by the USEPA and others.

- Federal Remedial Technologies Roundtable (FRTR): The FRTR website (FRTR, 2012a) has numerous technology resources, including the Technology Screening Matrix (FRTR, 2012b) and a searchable cost and performance case studies database (FRTR, 2012c).

- Interstate Technology and Regulatory Council (ITRC): The ITRC has prepared a number of contaminant-specific and technology-specific technology review documents, which are available on the ITRC website (ITRC, 2012). Of particular note are reports pertaining to perchlorate remediation (ITRC, 2008), *in situ* bioremediation (ITRC, 2002), *in situ* chemical oxidation (ITRC, 2005), and permeable reactive barriers (ITRC, 2011).

- Environmental Security Technology Certification Program (ESTCP) and Strategic Environmental Research and Development Program (SERDP): The ESTCP and SERDP have sponsored a wide range of remediation technology research, including the development of protocols for evaluating natural attenuation of perchlorate in groundwater (Lieberman and Borden, 2008); demonstrations of various perchlorate remediation technologies (Evans et al., 2009; Hatzinger and Diebold, 2009; Deshusses and Matsumoto, 2010); and an evaluation of 1,4-dioxane biodegradation (Steffan et al., 2007).

A complete listing of the media-specific process options considered for the site, including a brief description of each option, is provided in Tables 5-1 (soil technologies) and 5-2 (groundwater technologies).

5.4 SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

The process used to screen the remedial technologies and process options is described in the following sections.

5.4.1 Screening Criteria

Each process option was evaluated based on the CERCLA evaluation criteria of effectiveness, implementability, and cost (USEPA, 1988). The effectiveness screening includes the following three evaluation factors: the effectiveness of the process option in handling the estimated areas or volumes of impacted media and in meeting the RAOs; potential short-term impacts to human health and the environment during remedial construction and implementation; and whether the process is proven and reliable with respect to the contaminants and conditions at the site (USEPA, 1988). The implementability evaluation includes consideration of the overall implementability of the process option, which includes institutional implementability (i.e., potential permitting issues, the availability of services, equipment, and/or workers, etc.) as well as technical implementability. The cost evaluation was limited to evaluation of relative costs within a given technology type. The evaluation criteria and relative weighting assigned to each used in screening are summarized in Table 5-3.

The USEPA feasibility study guidance indicates that the process option evaluation should focus on effectiveness factors (USEPA, 1988). Therefore, the effectiveness criterion was assigned twice the importance, or weighted twice as heavily, as implementability and cost. The three evaluation factors considered within the effectiveness criterion were assigned equal weights (i.e., each of the evaluation factors were considered equally important). Based on the weighting factors, an overall weight for each criterion and evaluation factor was calculated, as indicated in Table 5-3.

5.4.2 Technology Screening Results

The technology screening consisted of qualitatively ranking each process option as high, medium, or low for each of the evaluation criteria. Numeric scores (0, 5, or 10) corresponding to the qualitative rankings for each evaluation criterion and factor were then assigned and multiplied by the corresponding weighting factors. The weighted scores were then summed to arrive at an overall score.

The results of the screening evaluation are summarized in Tables 5-1 (soil) and 5-2 (groundwater). Process options with an overall score of 7.5 or higher were considered to be the best suited for site conditions, and were retained for use in developing remedial alternatives. Rejected process options are shaded in gray in Tables 5-1 and 5-2. The no action GRA was retained for comparison purposes in accordance with USEPA guidance. The retained technologies and process options include the following:

Soil Technologies

- No Action
- Land Use Controls
- Community Awareness
- Erosion Control (retained in combination with capping and excavation)
- Capping
- Excavation
- Transportation (retained in combination with excavation and on-site or off-site disposal)
- *In Situ* Biological Treatment
- *In Situ* Physical Treatment (retained as a variant of *in situ* biological treatment for 1,4-dioxane, which is not readily biodegradable)
- *Ex Situ* Biological Treatment (retained in combination with excavation and on-site disposal)
- On-Site Disposal (retained as a disposal option for treated soil in combination with excavation and *ex situ* biological treatment)

- Off-Site Disposal (retained as a disposal option in combination with excavation and transportation)

Groundwater Technologies

- No Action
- Sampling and Analysis
- Monitored Natural Attenuation
- Land Use Controls
- Community Awareness
- Hydraulic Containment (retained in combination with *ex situ* biological, chemical, and physical groundwater treatment and on- and off-site disposal)
- Permeable Reactive Barrier
- *In Situ* Biological Treatment
- *Ex Situ* Biological, Chemical, and Physical Treatment (process options are retained singly or in combination as treatment train options for hydraulic containment and groundwater extraction)
- Groundwater Extraction (retained in combination with *ex situ* biological, chemical, and physical groundwater treatment and on- and off-site disposal)
- On-Site Disposal (retained as a disposal option for treated groundwater)
- Off-Site Disposal (retained as a disposal option for *ex situ* treatment residuals)

In a conditional approval letter dated October 24, 2013, DTSC stated that the rationale for rejecting *in situ* chemical oxidation (ISCO) as a process option for groundwater was not adequate, and recommended that an ISCO pilot study focused on remediation of the 1,4-dioxane groundwater plume be conducted.

The rationale for not carrying ISCO forward in the screening process was based primarily on aquifer properties. Aquifer materials at Laborde Canyon in general have low hydraulic conductivities and are relatively heterogeneous. These characteristics are not conducive to ISCO, which requires direct contact between the contaminants of interest and the oxidant for treatment. Furthermore, oxidants which have demonstrated effectiveness for 1,4-dioxane treatment (persulfate, Fenton's reagent, and ozone) have half-lives on the order of seconds to weeks in the subsurface, which limits the extent to which hydraulic transport can be relied upon to redistribute an oxidant in the subsurface after introduction, due to the low groundwater velocity.

Despite these potential limitations, Lockheed Martin recognizes that there are also potential benefits to treating 1,4-dioxane source areas. The remedial action plan for the site will therefore include a pilot study of ISCO for treatment of 1,4-dioxane in groundwater, and a contingency for implementing a source area remedy for 1,4-dioxane. It is anticipated that the pilot study would be conducted as part of remedy implementation. If the pilot study results indicate that ISCO is a potentially viable 1,4-dioxane treatment technology, a focused feasibility study would be performed to evaluate additional remedial alternatives for the 1,4-dioxane plume. The results of the focused feasibility study would then be used to assess whether full-scale implementation of ISCO is warranted.

Section 5 Tables

Table 5-1
Soil Technology Screening Summary

General Response Action	Technology Type	Process Option	Description	Effectiveness (Primary): Effectiveness in Handling Volume of Impacted Media	Effectiveness (Primary): Impacts During Implementation	Effectiveness (Primary): Reliability	Implementability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
No Action	N/A	N/A	No action is taken for site contamination.	Low	Low	Low	High	Low	6.7	Retain	Baseline for comparison with other technologies
Institutional and Engineering Controls	Land Use Controls	Land Use Covenants	Land use covenants are recorded with the County Assessor to restrict future land use.	High	Low	Medium	High	Low	9.2	Retain	Restrictions on on-site land use have already been recorded with County Assessor; may not be implementable for downgradient properties.
		Governmental Controls	Zoning, permitting, or other governmental restrictions are placed on a property to control future land use.	High	Low	Medium	Low	Low	6.7	Reject	Implementation depends on current property owner.
		Property Owner Controls	Restrictions on land use are imposed by the property owner.	High	Low	Medium	Low	Low	6.7	Reject	Implementation depends on current property owner.
	Community Awareness	Warning Signs	Warning signs are posted in areas of concern to reduce exposure to human receptors.	High	Low	Low	High	Low	8.3	Retain	Signage is not effective for ecological receptors.
		Public Notices	Notices of environmental contamination are distributed to the local community to enhance awareness of potential hazards and remedies.	High	Low	Low	Low	Low	5.8	Reject	Notices cannot be readily targeted to primary exposed population (trespassers) and will need to be coordinated through the property owner (RCWMD) and DTSC.
		Information and Education Programs	Comprehensive community information and educational programs are undertaken to enhance awareness of potential hazards and remedies.	High	Low	Low	Low	Low	5.8	Reject	Information and programs cannot be readily targeted to primary exposed population (trespassers) and will need to be coordinated through the property owner (RCWMD) and DTSC.
	Access Restrictions	Exclusion Fencing	Areas of concern are enclosed by fencing to reduce exposure to human and/or ecological receptors.	High	Low	Low	Low	Low	5.8	Reject	High potential for vandalism reduces effectiveness and implementability of fencing.
		Surveillance/ Security	Areas of concern are patrolled by a security service to control access by human receptors.	Low	Medium	Medium	Low	High	1.7	Reject	Nighttime patrols not implementable due to size of site and presence of nocturnal endangered species.
Containment	Erosion Control	Inspection	Periodic visual inspections are conducted in areas where near-surface contaminants are present in areas subject to erosion.	High	Low	Low	High	Low	8.3	Retain	Must be combined with other process options if indications of potential exposure are found.
		Vegetative Cover	Vegetation is planted and maintained to reduce erosion.	Medium	Low	Medium	High	Low	8.3	Retain	Retained as a measure to reduce erosion in areas disturbed by other actions. As a stand-alone remedy, effectiveness is limited by plant uptake of contaminants.
		Grading/Terracing	The ground surface is recontoured by removal or addition of material to alter drainage patterns; may include alteration of drainage channel.	Medium	Medium	Medium	High	Low	7.5	Retain	Retained as a measure to reduce erosion in areas disturbed by other actions. May require Clean Water Act Section 404/401 permits and CDFG Streambed Alteration Agreement, depending on location.
		Armoring	Areas subject to erosion, such as drainage channels, are lined with gabions, riprap, or concrete to reduce erosion.	Medium	High	Medium	Medium	Moderate	4.2	Reject	Likely to severely impact stream hydraulics due to narrow width of drainage channel; may require Clean Water Act Section 404/401 permits and CDFG Streambed Alteration Agreement, depending on location.
	Dust Control	Wind breaks	Trees, soil berms or fencing are installed to reduce ground-level wind speeds and minimize both wind erosion and the migration of surficial contaminants.	Low	Low	Low	Medium	Low	5.4	Reject	Dust control (other than during construction activities) is not anticipated to be necessary for protection of human and ecological receptors.

Table 5-1
Soil Technology Screening Summary

General Response Action	Technology Type	Process Option	Description	Effectiveness (Primary): Effectiveness in Handling Volume of Impacted Media	Effectiveness (Primary): Impacts During Implemen-tation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Containment	Vapor Control	Vapor Barrier	An impermeable membrane, with or without a venting system, is placed below the ground surface to reduce upward migration of volatiles.	Medium	Medium	Medium	Medium	Low	6.3	Reject	Vapor control not anticipated to be necessary to protect human and ecological receptors
	Capping	Geomembrane Cap	A geomembrane is placed over impacted area or landfill to reduce leaching of contaminants by infiltrating water and prevent contact with contaminated soil or landfill waste.	High	Medium	High	High	Low	9.2	Retain	Implementablilty score assumes no permitting required by CIWMB or RWQCB.
		Earthen Cap	A clean compacted soil layer is placed over impacted area or landfill to prevent direct contact with contaminated soil or landfill waste.	High	Medium	High	High	Low	9.2	Retain	Implementablilty score assumes no permitting required by CIWMB or RWQCB.
		Landfill Cap	An engineered landfill cap is constructed over impacted area or landfill to reduce leaching of contaminants by infiltrating water and prevent contact with contaminated soil or landfill waste.	High	Medium	High	High	Low	9.2	Retain	Implementablilty score assumes no permitting required by CIWMB or RWQCB.
		Evapotranspiration Cap	An engineered evapotranspiration cap is constructed over impacted area or landfill to reduce leaching of contaminants by infiltrating water and prevent contact with contaminated soil or landfill waste.	High	Medium	High	High	Low	9.2	Retain	Implementablilty score assumes no permitting required by CIWMB or RWQCB.
	Grouting	Source Area Grouting	Conventional grout or chemical grout is injected into vadose zone and/or saturated zone source areas to reduce leaching of contaminants.	Low	Medium	Low	Low	High	0.8	Reject	Difficult to implement due to heterogeneous bedrock geology
Removal	Excavation	Shallow Conventional Excavation	Shallow soils are excavated with conventional construction equipment from unsloped, sloped or shored excavations.	High	Medium	High	High	Low	9.2	Retain	Must be combined with *ex situ* treatment or transportation and disposal options. T&E species issues may impact schedule.
		Deep Conventional Excavation	Deep soils are excavated with conventional construction equipment from unsloped, sloped or shored excavations.	High	High	High	Low	Moderate	4.6	Reject	Deep excavations are not implementable due to location of source areas in narrow side canyons with steep slopes; must be combined with *ex situ* treatment or transportation and disposal options.
		Large-Diameter Auger Borings	Contaminated soils are excavated using overlapping large-diameter soil borings; borings are backfilled with slurry to allow for overlap.	Low	Medium	Medium	Low	High	1.7	Reject	Not implementable due to difficult drilling conditions; must be combined with transportation/*ex situ* treatment/disposal options.
	Transportation	Trucking	Excavated soil is moved on-site or off-site by means of construction equipment or trucks.	High	Medium	High	High	Low	9.2	Retain	Must be combined with excavation and *ex situ* treatment or disposal options
Treatment	*In Situ* Biological Treatment	Enhanced Bioremediation	Electron donor, electron acceptors, and/or nutrients are introduced into the subsurface using wells or infiltration galleries to stimulate or increase the rate of contaminant degradation by microorganisms.	High	Low	Medium	High	Low	9.2	Retain	Not effective for shallow soil. Contaminants may be flushed to groundwater, where they will require treatment or recovery.
		Enhanced Bio. (Gaseous Electron Donor)	A gaseous electron donor (e.g. hydrogen, propane, etc.) is delivered to contaminated soils to stimulate anaerobic biodegradation.	Medium	Low	Medium	Medium	Moderate	5.8	Reject	Low moisture content of soils is likely to impact implementability.
		Bioventing	Atmospheric air is delivered to contaminated unsaturated soils by forced air movement to increase oxygen concentrations and stimulate aerobic biodegradation.	Low	Low	Low	Medium	Low	5.4	Reject	Not effective for site contaminants, which biodegrade under anaerobic conditions; heterogeneous bedrock geology limits implementability.
		Phytoremediation	Plants are used to remove, transfer, stabilize, and/or destroy contaminants in soil and sediment.	Low	Medium	Low	Medium	Low	4.6	Reject	Difficult to implement due to dry season water requirements for plants; ecological risks may result from plant uptake.

Table 5-1
Soil Technology Screening Summary

General Response Action	Technology Type	Process Option	Description	Effectiveness (Primary): Effectiveness in Handling Volume of Impacted Media	Effectiveness (Primary): Impacts During Implementation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Treatment	*In Situ* Physical Treatment	Water Flushing	Water is introduced into the vadose zone to transport soluble contaminants to the groundwater for treatment or recovery. This technology excludes flushing with electron donor solutions (see Enhanced Bioremediation).	High	Low	Medium	High	Low	9.2	Retain	Contaminants flushed to groundwater will require *in situ* treatment or extraction and *ex situ* treatment.
		Surfactant Flushing	An aqueous surfactant solution is infiltrated or injected into the vadose zone to mobilize contaminants to the saturated zone for treatment or recovery.	High	Low	Low	Medium	Moderate	5.8	Reject	Not effective for site contaminants, which do not include free-phase petroleum or chlorinated solvents
		Soil Vapor Extraction	A vacuum is applied to induce a controlled flow of air to remove volatile and some semivolatile contaminants from soil. Enhancement technologies include steam or hot-air injection, radio frequency or electrical heating, etc.	Medium	Low	Low	Medium	Low	6.3	Reject	Not effective for perchlorate or 1,4-dioxane; heterogeneous bedrock geology limits implementability
		Solidification	Contaminants are bound physically in a solid matrix by *in situ* mixing of soil with a binding agent such as portland or pozzolanic cement.	Medium	High	Low	Medium	Moderate	3.3	Reject	Not effective for site contaminants
		Stabilization	Stabilizing agents are introduced into soil to reduce the mobility of contaminants.	Medium	Medium	Low	Medium	Moderate	4.2	Reject	Not effective for site contaminants
	In Situ Chemical Treatment	Chemical Oxidation (liquid oxidants)	Strong oxidizing agents are introduced or injected into the subsurface to convert contaminants to less-toxic or non-toxic compounds. Oxidants may include permanganate, persulfate, and Fenton's reagent.	Low	Medium	Low	Low	High	0.8	Reject	Not effective for perchlorate; very difficult to implement due to heterogeneous bedrock geology and need for contact with reagents
		Chemical Oxidation (gaseous oxidants)	Ozone is injected into the subsurface to convert contaminants to less-toxic or non-toxic compounds.	Low	Medium	Low	Low	High	0.8	Reject	Not effective for perchlorate; very difficult to implement due to heterogeneous bedrock geology and need for contact with reagents
		Chemical Reduction	Reducing agents are injected into the subsurface to convert contaminants to less-toxic or non-toxic compounds. This technology excludes injection of electron donor.	Low	Medium	Low	Medium	Moderate	3.3	Reject	Not effective for site contaminants (reagents for perchlorate reduction are currently being researched); very difficult to implement due to heterogeneous bedrock geology and need for contact with reagents.
	In Situ Thermal Treatment	Vitrification	Soils are brought to their melting point, typically with an electrical current, to form a glass. Contaminants are driven off, decomposed, or immobilized by this process.	Low	High	Medium	Low	High	0.8	Reject	Very high energy and equipment costs; not cost-effective for site contaminants
	Ex Situ Physical Treatment	Separation	Contaminants or foreign materials (such as trash) are separated from soil using a variety of methods, including gravity, magnetic, or size separation (screening); also includes retrieval by hand-picking.	Medium	Low	Medium	Medium	Moderate	5.8	Reject	Not effective for site contaminants
		Soil Washing	Contaminants are separated from excavated soil by washing in an aqueous solution, which may be amended with leaching agents, surfactants, or chelating agents. This option also includes washing with unamended water.	Low	Medium	Medium	Medium	Moderate	4.2	Reject	Implementability limited by excess water consumption
		Solidification	Contaminants are physically bound by mixing excavated soil with a binding agent, such as asphalt or portland cement, to reduce mobility.	Low	Low	Low	Medium	Low	5.4	Reject	Not effective for site contaminants
		Stabilization	Stabilizing agents are added to soil to reduce the mobility of contaminants.	Medium	Low	Low	Medium	Low	6.3	Reject	Not effective for site contaminants

Table 5-1
Soil Technology Screening Summary

General Response Action	Technology Type	Process Option	Description	Effectiveness (Primary): Effectiveness in Handling Volume of Impacted Media	Effectiveness (Primary): Impacts During Implementation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Treatment	*Ex Situ* Chemical Treatment	Chemical Oxidation	Strong oxidizing agents are mixed with excavated soil to convert contaminants to less-toxic or non-toxic compounds. Oxidants include permanganate, persulfate, Fenton's reagent, etc.	Low	High	Low	Low	Moderate	1.3	Reject	Not effective for perchlorate; difficult to implement due to health and safety issues associated with reagents
		Chemical Reduction	Reducing agents are mixed with excavated soil to convert contaminants to less-toxic or non-toxic compounds. This technology excludes addition of electron donor (discussed under *Ex Situ* Biological Treatment).	Low	High	Low	Low	Moderate	1.3	Reject	Not effective for perchlorate; difficult to implement due to health and safety issues associated with reagents
		Dehalogenation	Excavated soil is heated with a reagent (sodium bicarbonate or polyethylene glycolate) to decompose or dehalogenate chlorinated organic compounds to reduce toxicity.	Low	Medium	Low	Medium	High	2.1	Reject	Not effective for site contaminants
		Chemical Extraction	Contaminants are separated from excavated soil by a chemical extraction process, typically using acids or solvents. (Extraction using water as solvent is discussed under Soil Washing.)	Low	Medium	Medium	Medium	Moderate	4.2	Reject	Not effective for site contaminants; difficult to implement due to health and safety issues associated with reagents.
	Ex Situ Biological Treatment	*Ex Situ* Bioremediation	Excavated contaminated soil is mixed with electron donor, bulking agents, or other amendments to promote aerobic or anaerobic biologic activity.	Medium	Low	Medium	High	Low	8.3	Retain	Must be combined with excavation and transportation options
		Phytoremediation	Plants are used to remove, transfer, stabilize, or destroy contaminants in excavated soil or sediment.	Low	Medium	Low	Low	Low	3.3	Reject	Difficult to implement due to dry season water requirements for plants; ecological risks may result from plant uptake
		Landfarming	Excavated contaminated soil is placed in beds and periodically turned to aerate and promote biologic activity.	Medium	Low	Low	Medium	Low	6.3	Reject	Not effective for site contaminants, which biodegrade under anaerobic conditions
		Biopiles	Excavated contaminated soil is mixed with amendments and actively aerated to promote biologic activity.	Medium	Low	Low	Medium	Moderate	5.0	Reject	Not effective for site contaminants, which biodegrade under anaerobic conditions
		Slurry Phase Biological Treatment	A slurry is formed using excavated contaminated soil, water and amendments and then mixed to promote biologic activity.	Low	Low	Low	Medium	High	2.9	Reject	Implementability limited by excess water consumption
	Ex Situ Thermal Treatment	Thermal Desorption	Contaminated soil is heated to moderate temperatures to volatilize water and contaminants. The contaminants are captured in an air stream for treatment.	Medium	Medium	Low	Medium	Moderate	4.2	Reject	Not effective for perchlorate
		Incineration	Excavated soil is heated to high temperatures (>1,000 °F) to volatilize and combust organic compounds.	Medium	Medium	High	Low	High	3.3	Reject	Difficult to implement because no incineration facilities are located near site; effective for site contaminants, but most applicable to PCBs, SVOC, dioxins, and explosives
		Pyrolysis	Excavated soil is heated to moderate temperatures (~800 °F) in the absence of oxygen to decompose organic compounds.	Medium	Medium	High	Medium	High	4.6	Reject	Difficult to implement because no facilities are located near site. Effective for site contaminants, but most applicable to SVOC and pesticides
Disposal	On-site Disposal	Reuse of Treated Soil	Treated soil is reused on-site as excavation backfill or fill material.	High	Low	Medium	Medium	Low	7.9	Retain	Requires WDR permit from RWQCB; must be combined with excavation, transportation, and *ex situ* treatment options
		On-site Landfill	Treated or untreated soil is disposed in an authorized on-site repository or landfill.	High	Medium	High	Low	Low	6.7	Reject	Property owner (RCWMD) is unlikely to approve construction of a landfill at the site; extensive permitting requirements; must be combined with excavation and transportation options.

Table 5-1
Soil Technology Screening Summary

General Response Action	Technology Type	Process Option	Description	Effectiveness (Primary): Effectiveness in Handling Volume of Impacted Media	Effectiveness (Primary): Impacts During Implemen-tation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Disposal	Off-site Disposal	Landfill	Excavated soil is transported off-site for treatment or disposal at an authorized facility.	High	Low	High	High	High	7.5	Retain	Permanently removes contaminants from site. Must be combined with excavation and transportation options

Notes:
Shading indicates process option or technology screened out.

Scoring Notes (scores are listed in order from best to worst):
Effectiveness in handling volumes of impacted media
High: Process option can readily handle both anticipated volumes of media and anticipated contaminant concentrations.
Medium: Process option can readily handle either anticipated volumes of media or anticipated contaminant concentrations.
Low: Process option can readily handle neither anticipated volumes of media nor anticipated contaminant concentrations.
Impacts during implementation
Low: Implementation expected to have few temporary impacts.
Medium: Implementation expected to have moderate temporary impacts.
High: Implementation expected to have large temporary impacts or unmitigatable impacts.
Reliability
High: Process option is reliable and permanent for all contaminants.
Medium: Process option is reliable and permanent for perchlorate, but not for 1,4-dioxane and/or VOC.
Low: Process option is not reliable for perchlorate or not reliable for any site contaminants.
Implementability
High: Simple and straightforward to construct; administrative approvals readily obtained.
Medium: Construction feasible, but complicated by site-specific geology/hydrogeology; administrative approval moderately difficult to obtain.
Low: Implementation severely impacted by site-specific geology/hydrogeology; administrative approvals difficult to obtain.
Cost
Low: Cost low relative to other process options.
Moderate: Cost moderate relative to other process options.
High: Cost high relative to other process options.

Acronyms and Abreviations:
CDFG: California Department of Fish and Game
CIWMB: California Integrated Waste Management Board
DTSC: California Department of Toxic Substances Control
N/A: not applicable
PCBs: Polychlorinated biphenyls
RCWMD: Riverside County Waste Management Department
SVOC: Semivolatile organic compound
T&E: Threatened and endangered
VOC: Volatile organic compound
WDR: Waste Discharge Requirements

Table 5-2
Groundwater Technology Screening Summary

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness (Primary)			Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
				Effectiveness in Handling Volumes of Impacted Media	Impacts During Implement-ation	Reliability					
No Action	N/A	N/A	No action is taken for site contamination.	Low	Low	Low	High	Low	6.7	Retain	Baseline for comparison with other technologies
Monitoring	Sampling and Analysis	Groundwater Monitoring	Samples are collected and analyzed to monitor contamination.	High	Low	High	High	Low	10	Retain	Likely to be required as a component of any groundwater remedy.
	Monitored Natural Attenuation	Natural Attenuation Monitoring	Samples are collected and analyzed to monitor contaminant attenuation.	High	Low	Medium	High	Low	9.2	Retain	Potential component of groundwater remedy; not effective for 1,4-dioxane.
Institutional and Engineering Controls	Land Use Controls	Land Use Controls	Land use covenants are recorded with the County Assessor to restrict future groundwater use.	High	Low	Medium	High	Low	9.2	Retain	Restrictions on onsite groundwater use have already been recorded with County Assessor; may not be implementable for downgradient properties.
		Governmental Controls	Zoning, permitting, or other governmental restrictions are placed on a property to control future groundwater use.	High	Low	Medium	Low	Low	6.7	Reject	Implementation dependent on current property owner.
		Property Owner Restrictions	Restrictions on groundwater use are imposed by the property owner.	High	Low	Medium	Low	Low	6.7	Reject	Implementation dependent on current property owner.
	Community Awareness	Warning Signs	Warning signs are posted in areas of concern to reduce exposure to human receptors.	High	Low	Low	High	Low	8.3	Retain	Effective for humans but not ecological receptors; human exposure to groundwater is unlikely.
		Public Notices	Notices of environmental contamination are used to enhance awareness of potential hazards and remedies within the local community.	High	Low	Low	Low	Low	5.8	Reject	Exposure to groundwater is unlikely; cannot be readily targeted to primary exposed population (trespassers); will need to be coordinated through the property owner (RCWMD) and DTSC.
		Information and Education Programs	Comprehensive community information and educational programs are undertaken to enhance awareness of potential hazards and remedies.	High	Low	Low	Low	Low	5.8	Reject	Exposure to groundwater is unlikely; cannot be readily targeted to primary exposed population (trespassers); will need to be coordinated through property owner (RCWMD) and DTSC..
Containment	Physical Barriers	Slurry Wall	A trench is excavated into the saturated zone and filled with a bentonite slurry to retard or divert groundwater flow.	Medium	Medium	Medium	Low	High	2.5	Reject	Depth to groundwater limits implementability over most of site; groundwater extraction may be needed to minimize undesired hydraulic effects.
		Grout Curtain	Conventional or chemical grout is injected into the saturated zone through closely-spaced injection points to form a continuous low-permeability vertical curtain which retards or diverts groundwater flow.	Medium	Medium	Medium	Low	High	2.5	Reject	Depth to groundwater and heterogeneous bedrock geology limits implementability over most of site; groundwater extraction may be needed to minimize undesired hydraulic effects.
		Driven Pile Wall	Interlocking sheet pile is driven into the saturated zone to retard or divert groundwater flow.	Medium	Medium	Medium	Low	High	2.5	Reject	Depth to groundwater limits implementability over most of site; groundwater extraction may be needed to minimize undesired hydraulic effects.
	Hydraulic Containment	Groundwater Extraction	Groundwater is extracted to create a groundwater depression that prevents contaminated groundwater from flowing in an undesired direction. Groundwater extraction and treatment technologies are described elsewhere.	High	Low	High	High	Moderate	8.8	Retain	Must be combined with *ex situ* treatment and disposal options.
		Injection Barrier	Water in injected to create a groundwater divide that prevents contaminated groundwater from flowing in an undesired direction.	Medium	Low	High	Low	Low	6.7	Reject	Difficult to implement in narrow canyon setting; must be combined with groundwater extraction and *ex situ* treatment process options or an alternate water source.

Table 5-2
Groundwater Technology Screening Summary

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness (Primary): Effectiveness in Handling Volumes of Impacted Media	Effectiveness (Primary): Impacts During Implement-ation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Containment	Permeable Reactive Barrier	Biobarrier	Groundwater passively flows through a permeable barrier where electron donors, electron acceptors, and/or nutrients are added to promote biologic activity. Various configurations possible (trenches, funnel-and-gate, injection, etc.).	High	Low	Medium	High	Low	9.2	Retain	Effective for perchlorate and chlorinated solvents; not effective for 1,4-dioxane; trench implementation not straightforward.
		Zero-Valent Iron Barrier	Groundwater passively flows through a permeable barrier containing ZVI, that promotes destruction of chlorinated compounds. Various configurations possible (trenches, funnel-and-gate, etc.).	High	Medium	Low	Medium	Moderate	5.0	Reject	Effective for chlorinated solvents, not effective for perchlorate or 1,4-dioxane; trench implementation not straightforward.
		Metal-Enhanced Reduction Barrier	Groundwater passively flows through a permeable barrier containing basic oxygen furnace slag. Various configurations possible (trenches, funnel-and-gate, etc.).	High	Medium	Low	Medium	Moderate	5.0	Reject	Not effective for site contaminants; trench implementation not straightforward..
		pH Control Barrier	Groundwater passively flows through a permeable barrier containing limestone to adjust pH. Various configurations possible (trenches, funnel-and-gate, etc.).	High	Medium	Low	Medium	Moderate	5.0	Reject	Not effective for site contaminants; trench implementation not straightforward..
		Redox Barrier	Groundwater passively flows through a permeable barrier containing calcium polysulfide, sodium dithionite, or other reducing agents. Various configurations possible (trenches, funnel-and-gate, injection, etc.).	High	Low	Low	Medium	Moderate	5.8	Reject	Effective for chlorinated solvents; not effective for perchlorate or 1,4-dioxane.
		Sorptive Barrier	Groundwater passively flows through a permeable barrier containing sorptive material (GAC, zeolite, ion exchange resin, apatite, etc.) to remove contaminants. Various configurations possible (trenches, funnel-and-gate, injection, etc.).	High	Medium	Low	Medium	High	3.8	Reject	Not effective for site contaminants; trench implementation not straightforward..
	Immobilization	Source Area Grouting	Grout or chemical grout is injected into the saturated zone through closely-spaced injection points to reduce groundwater flux through a submerged source area.	Medium	Medium	Medium	Low	High	2.5	Reject	Not implementable due to heterogeneous bedrock geology.
		Chemical Fixation	Chemical reagents are introduced to the subsurface to change the valance state or solubility of contaminants to reduce their mobility	Medium	Medium	Low	Medium	High	2.9	Reject	Not effective for site contaminants.
Treatment	*In Situ* Biological Treatment	Enhanced Bioremediation	Amendments (electron donor, nutrients, etc) are injected into the saturated zone to promote biologic activity.	High	Low	Medium	High	Low	9.2	Retain	Effective for perchlorate and chlorinated solvents; not effective for 1,4-dioxane.
		Thermally Enhanced Bioremediation	Portions of the subsurface are heated to moderate temperatures to enhance biodegradation rates.	Medium	Low	Medium	Medium	High	4.6	Reject	No advantage over enhanced bioremediation for site climate.
		Biosparging	Atmospheric air is injected into the saturated zone at a low rate to promote aerobic biologic activity.	High	Low	Low	Low	Low	5.8	Reject	Not effective for site contaminants, which biodegrade under anaerobic conditions; difficult to implement due to heterogeneous bedrock geology.
		Phytoremediation	Phreatophyte plants are used to remove, transfer, stabilize, and/or destroy contaminants in the saturated zone.	Medium	Low	Medium	Low	Low	5.8	Reject	Not implementable because depth to groundwater is >10-15 feet throughout site.
	In Situ Physical Treatment	Air Sparging	Atmospheric air is injected into the saturated zone to volatilize contaminants, which are collected or treated in the vadose zone.	Medium	Low	Low	Low	Low	5.0	Reject	Difficult to implement due to heterogeneous bedrock geology; not effective for perchlorate or 1,4-dioxane.
		Bioslurping	Contaminants in the saturated zone are treated through a combination of bioventing and vacuum-enhanced free product recovery.	Medium	Low	Low	Medium	Low	6.3	Reject	Not effective for site contaminants, which biodegrade under anaerobic conditions.

Table 5-2
Groundwater Technology Screening Summary

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness (Primary): Effectiveness in Handling Volumes of Impacted Media	Effectiveness (Primary): Impacts During Implement-ation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Treatment	*In Situ* Physical Treatment	In-Well Air Stripping	Air is injected into a dual-screen well, causing water to be drawn in through the lower screen and forced out of the upper screen. VOCs are removed from the water by air stripping action in well.	Low	Low	Low	Low	Moderate	2.9	Reject	Difficult to implement due to heterogeneous bedrock geology; not effective for perchlorate or 1,4-dioxane.
	In Situ Thermal Treatment	Steam Injection	Steam is injected into the saturated zone to heat and increase the volatility of contaminants in the saturated zone. Contaminants are recovered with recovery wells or from the vadose zone by vapor extraction.	Low	Medium	Low	Medium	High	2.1	Reject	Not effective for site contaminants at concentrations found at site.
		Radio Frequency Heating	Radio frequency electromagnetic energy is used to heat and increase the volatility of contaminants in the saturated zone to facilitate extraction with recovery wells or from the vadose zone by vapor extraction.	Low	Medium	Low	Medium	High	2.1	Reject	Not effective for site contaminants at concentrations found at site.
		Electrical Resistance Heating	An electrical current is used to heat and increase the volatility of contaminants in the saturated zone to facility extraction with recovery wells or from the vadose zone by vapor extraction.	Low	Medium	Low	Medium	High	2.1	Reject	Not effective for site contaminants at concentrations found at site.
	In Situ Chemical Treatment	Chemical Oxidation (liquid injection)	Strong oxidizing agents are injected into the saturated zone to convert contaminants to less-toxic or non-toxic compounds. Oxidants may include permanganate, persulfate, Fenton's reagent, etc.	High	Medium	Low	Low	Moderate	3.8	Reject	Difficult to implement due to heterogeneous bedrock geology; not effective for perchlorate.
		Ozone Sparging	Ozone is injected into the saturated zone to oxidize contaminants to less-toxic or non-toxic compounds	High	Medium	Low	Low	Moderate	3.8	Reject	Difficult to implement due to heterogeneous bedrock geology; not effective for perchlorate.
		Chemical Reduction	Reducing agents are injected into the saturated zone to convert contaminants to less-toxic or non-toxic compounds.	High	Medium	Low	Low	Moderate	3.8	Reject	Difficult to implement due to heterogeneous bedrock geology; effective for VOCs; not effective for 1,4-dioxane; reagents for perchlorate reduction are currently being researched.
	Ex Situ Chemical Treatment	Adsorption	Dissolved contaminants are concentrated at the surface of an adsorption agent (other than granular organic carbon), reducing concentrations in the bulk solution.	High	Low	Low	High	High	5.8	Reject	Not effective for site contaminants.
		GAC	Groundwater pumped through a series of canisters containing granular activated carbon, which adsorbs organic contaminants.	High	Low	High	High	Moderate	8.8	Retain	Effective for VOCs; must be combined with other *ex situ* treatment process options to treat all contaminants.
		TGAC	Groundwater pumped through a series of canisters containing tailored granular activated carbon (GAC with an additional surface coating), which adsorbs contaminants, including perchlorate.	Medium	Low	Medium	High	High	5.8	Reject	Less effective than ion exchange for perchlorate treatment; must be combined with other *ex situ* treatment process options to treat all contaminants.
		Advanced Oxidation	Contaminants in water are oxidized using a combination of UV radiation, ozone, and/or hydrogen peroxide.	High	Low	High	High	Moderate	8.8	Retain	Effective for 1,4-dioxane; must be combined with other *ex situ* treatment process options to treat all contaminants.
		Ion Exchange	Groundwater pumped through a series of canisters containing an ion exchange resin, which removes inorganic contaminants.	High	Low	High	High	Moderate	8.8	Retain	Effective for perchlorate; must be combined with other *ex situ* treatment process options to treat all contaminants.
		Precipitation	Dissolved contaminants are removed from water by pH adjustment or addition of a precipitating agent.	High	Low	Low	Low	Moderate	4.6	Reject	Not effective for site contaminants.
		Batch Chemical Reduction	Groundwater is batch treated in storage tanks by addition of strong reducing agents that convert contaminants to less-toxic or non-toxic compounds	Low	Medium	Low	Medium	Moderate	3.3	Reject	Effective for chlorinated solvents; not effective for 1,4-dioxane; reagents for perchlorate reduction are currently being researched.

Table 5-2
Groundwater Technology Screening Summary

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness (Primary): Effectiveness in Handling Volumes of Impacted Media	Effectiveness (Primary): Impacts During Implement-ation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Treatment	*Ex Situ* Chemical Treatment	Batch Chemical Oxidation	Groundwater is batch treated in storage tanks by addition of strong oxidants that convert contaminants to less-toxic or non-toxic compounds.	Medium	Medium	Medium	Medium	Moderate	5.0	Reject	Applicable for treatment of liquid residuals; however, no treatment options that produce liquid residuals are retained.
	Ex Situ Biological Treatment	Bioreactor	Contaminated water is brought into contact with an attached or suspended biological system to destroy contaminants.	High	Low	Medium	High	Low	9.2	Retain	Effective for perchlorate and chlorinated solvents; must be combined with other *ex situ* treatment process options to treat all contaminants.
		Batch Biotreatment	Groundwater is batch treated in storage tanks by addition of amendments (electron donor, nutrients, etc) to promote biologic activity.	Medium	Medium	Medium	Medium	Moderate	5.0	Reject	Applicable for treatment of liquid residuals; however, no treatment options that produce liquid residuals are retained.
		Constructed Wetlands	Contaminants are treated using natural biologic and geochemical processes in an artificial wetland ecosystem.	High	Low	Medium	Low	Moderate	5.4	Reject	Surface application of impacted water may attract ecological receptors and create new ecological exposure pathways; may require permitting from several state and federal agencies; may require large effort to properly maintain.
	Ex Situ Physical Treatment	Air Stripping/ Air Diffusing	Volatile organics are removed from groundwater by increasing the surface area exposed to air.	High	Low	High	High	Low	10.0	Retain	Effective for VOCs; must be combined with other process options to treat all contaminants.
		Distillation	Contaminants are removed from groundwater by distillation.	Low	Medium	Low	Medium	High	2.1	Reject	Not effective for mixture of organic and inorganic contaminants found at site; not implementable for low concentrations of organic contaminants.
		Reverse Osmosis	Contaminants are removed from groundwater by reverse osmosis.	Medium	Medium	Medium	Medium	High	3.8	Reject	Very high equipment and energy costs; waste stream containing concentrated contaminants still requires treatment or disposal.
		Membrane Pervaporation	Extracted groundwater is heated, and contaminants are removed by diffusion through a membrane, where they are collected and condensed as a liquid.	Low	Medium	Low	Medium	High	2.1	Reject	Not effective for mixture of organic and inorganic contaminants found at site; not implementable for low concentrations of organic contaminants.
		Evaporation	Volume of extracted groundwater or treatment residual is reduced by evaporation.	Medium	Low	High	Low	Low	6.7	Reject	Effective for reducing volume of liquid treatment residuals; however, no treatment options that produce liquid residuals are retained.
Extraction	Extraction	Extraction	Groundwater is extracted from vertical wells, horizontal wells, or extraction trenches.	High	Low	High	High	Moderate	8.8	Retain	Must be combined with *ex situ* treatment and disposal process options.
		Dual-Phase Extraction (dual pump)	Groundwater and air are simultaneously extracted from wells using separate pump systems. The application of vacuum increases the rate of groundwater extraction.	High	Low	Medium	Medium	Moderate	6.7	Reject	Most effective for VOCs and LNAPL; advantages are limited for 1,4-dioxane and perchlorate in low hydraulic conductivity conditions. Requires *ex situ* treatment and disposal of extracted groundwater.
		Multi-Phase Extraction (total fluids)	Groundwater and air are simultaneously extracted by applying a vacuum to a dip tube set below the water table.	High	Low	Medium	Medium	Moderate	6.7	Reject	Most effective for VOCs and LNAPL; advantages are limited for 1,4-dioxane and perchlorate in low hydraulic conductivity conditions. Requires *ex situ* treatment and disposal of extracted groundwater.
		French Drains	Drains are installed to redirect groundwater away from building foundations or low areas.	Low	Low	Medium	Low	Low	5.0	Reject	Not implementable due to depth to groundwater.
		Pumped Excavations	Groundwater is extracted from an existing open excavation using sump pumps.	Low	Low	High	Low	Low	5.8	Reject	Deep excavations are not implementable at site due to narrow canyons with steep slopes.

Table 5-2
Groundwater Technology Screening Summary

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness (Primary): Effectiveness in Handling Volumes of Impacted Media	Effectiveness (Primary): Impacts During Implement-ation	Effectiveness (Primary): Reliability	Implement-ability	Relative Cost	Numeric Score	Retain or Reject	Screening Comments
Disposal	Onsite Disposal	Reinjection	Treated groundwater is disposed on-site by reinjection into contaminated aquifer.	High	Low	High	Medium	Low	8.8	Retain	Will require UIC and WDR permits.
		Deep Well Injection	Treated or untreated groundwater is disposed on-site by deep well injection.	Low	Medium	High	Low	High	2.5	Reject	Not implementable due to low hydraulic conductivity of deep San Timoteo formation.
		Sewer Discharge	Treated or untreated groundwater is disposed to the sanitary sewer.	Medium	Low	High	Low	High	4.2	Reject	No sewer connection at or in vicinty of site.
		Surface Discharge	Treated groundwater is disposed to the surface water drainage channel.	High	Low	High	Medium	Low	8.8	Retain	Will require NPDES permit.
		Infiltration	Treated groundwater is disposed by infiltration outside of the drainage channel.	High	Low	High	Medium	Low	8.8	Retain	Will require UIC and WDR permits.
	Offsite Disposal	Off-site Treatment	Extracted groundwater or treatment residual is transported off-site to an authorized facility for treatment.	Low	Low	High	Low	High	3.3	Reject	Effective for treatment of liquid residuals that are difficult to treat on-site; however, no treatment options that produce liquid residuals are retained.
		Off-site Disposal	Extracted groundwater or treatment residual is transported off-site to an authorized facility for disposal.	High	Low	High	High	High	7.5	Retain	Effective for disposal of wastes generated from treatment processes (e.g., activated carbon).

Notes:
Shading indicates process option or technology screened out.

Scoring Notes (scores are listed in order from best to worst):
<u>Effectiveness in handling volumes of impacted media</u>
High: Process option can readily handle both anticipated volumes of media and anticipated contaminant concentrations.
Medium: Process option can readily handle either anticipated volumes of media or anticipated contaminant concentrations.
Low: Process option can readily handle neither anticipated volumes of media nor anticipated contaminant concentrations.
<u>Impacts during implementation</u>
Low: Implementation expected to have few temporary impacts.
Medium: Implementation expected to have moderate temporary impacts.
High: Implementation expected to have large temporary impacts or unmitigatable impacts.
<u>Reliability</u>
High: Process option is reliable and permanent for all contaminants.
Medium: Process option is reliable and permanent for perchlorate, but not for 1,4-dioxane and/or VOCs.
Low: Process option is not reliable for perchlorate/ not reliable for any site contaminants.
<u>Implementability</u>
High: Simple and straightforward to construct; administrative approvals readily obtained.
Medium: Construction feasible, but complicated by site-specific geology/hydrogeology; administrative approval moderately difficult to obtain.
Low: Implementation severely impacted by site-specific geology/hydrogeology; administrative approvals difficult to obtain.
<u>Cost</u>
Low: Cost low relative to other process options.
Moderate: Cost moderate relative to other process options.
High: Cost high relative to other process options.

Acronyms and Abreviations:
DTSC: California Department of Toxic Substances Control
GAC: Granular activated carbon
LNAPL: Light non-aqueous phase liquid
N/A: Not applicable
NPDES: National Pollution Discharge Elimination System
RCWMD: Riverside County Waste Management Department
SVOC: Semivolatile organic compound
T&E: Threatened and endangered
TGAC: Tailored granular activated carbon
UIC: Underground Injection Control
UV: Ultraviolet
VOC: Volatile organic compound
WDR: Waste Discharge Requirements
ZVI: Zero-valent iron

Table 5-3
Technology Screening Criteria

Screening Criteria	Relative Weight	Evaluation Factors	Relative Weight	Overall Weight
Effectiveness	50%	Effectiveness in Handling Areas/Volumes of Impacted Media and Meeting RAOs	33%	16.7%
		Short-Term Effectiveness during Construction and Implementation	33%	16.7%
		Technology Reliability	33%	16.7%
Implementablity	25%	Technical and Institutional Implementability	-	25%
Relative Cost	25%	Relative Cost	-	25%
Total:				100%

Acronyms and Abreviations:
RAOs: Remedial action objectives

Section 5 Figures

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LEGEND

- Verification Boring
- Lysimeter
- Monitoring Well
- Ground Surface Elevation Contour (2-foot interval - feet msl)

0 15 30 Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 5-1

Treatability Study Lysimeter, Monitoring Well, and Soil Boring Locations

TETRA TECH

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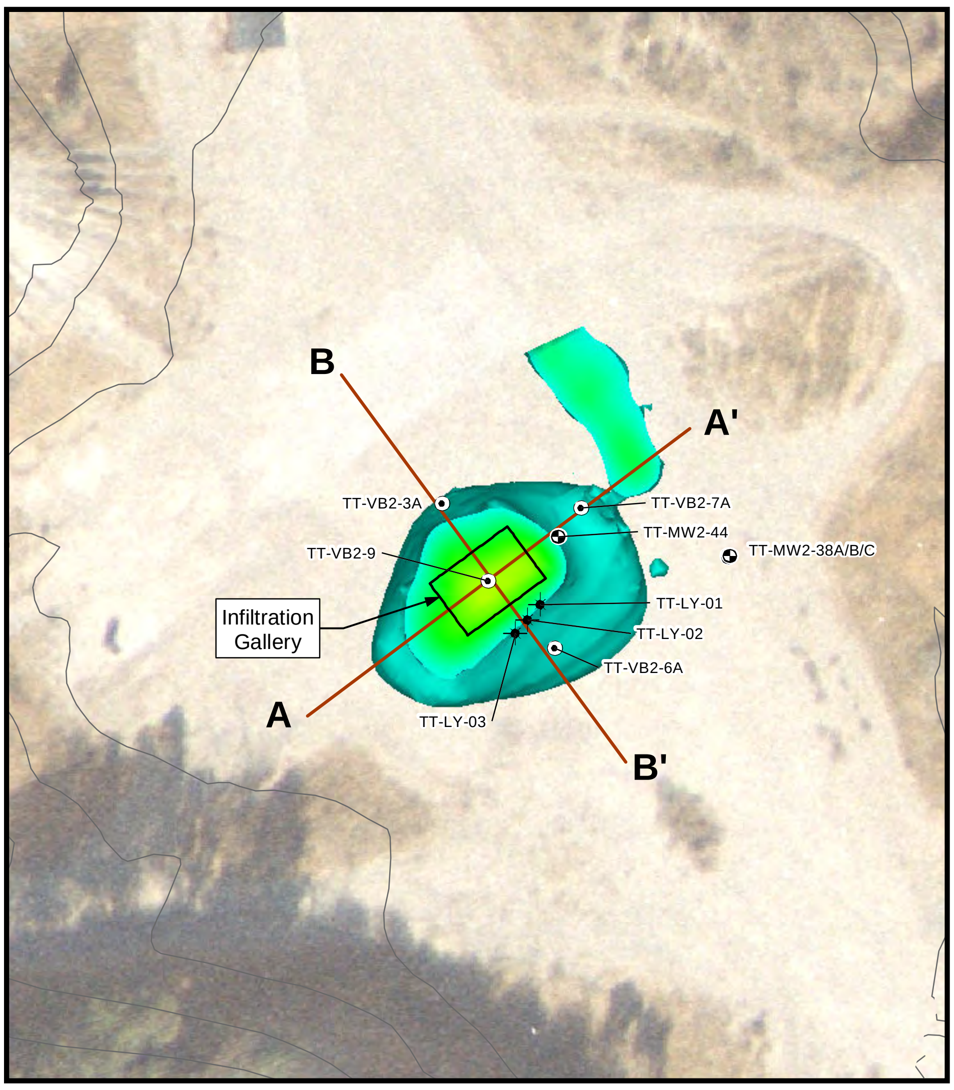
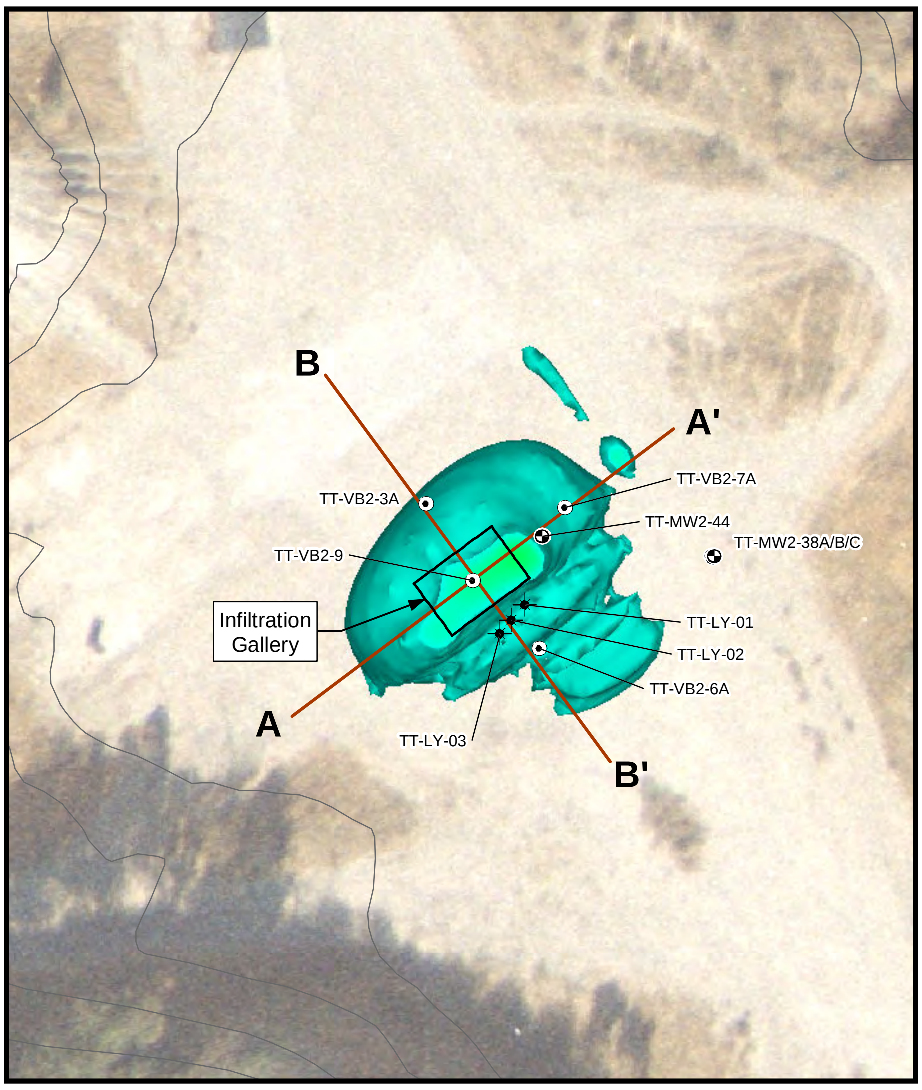
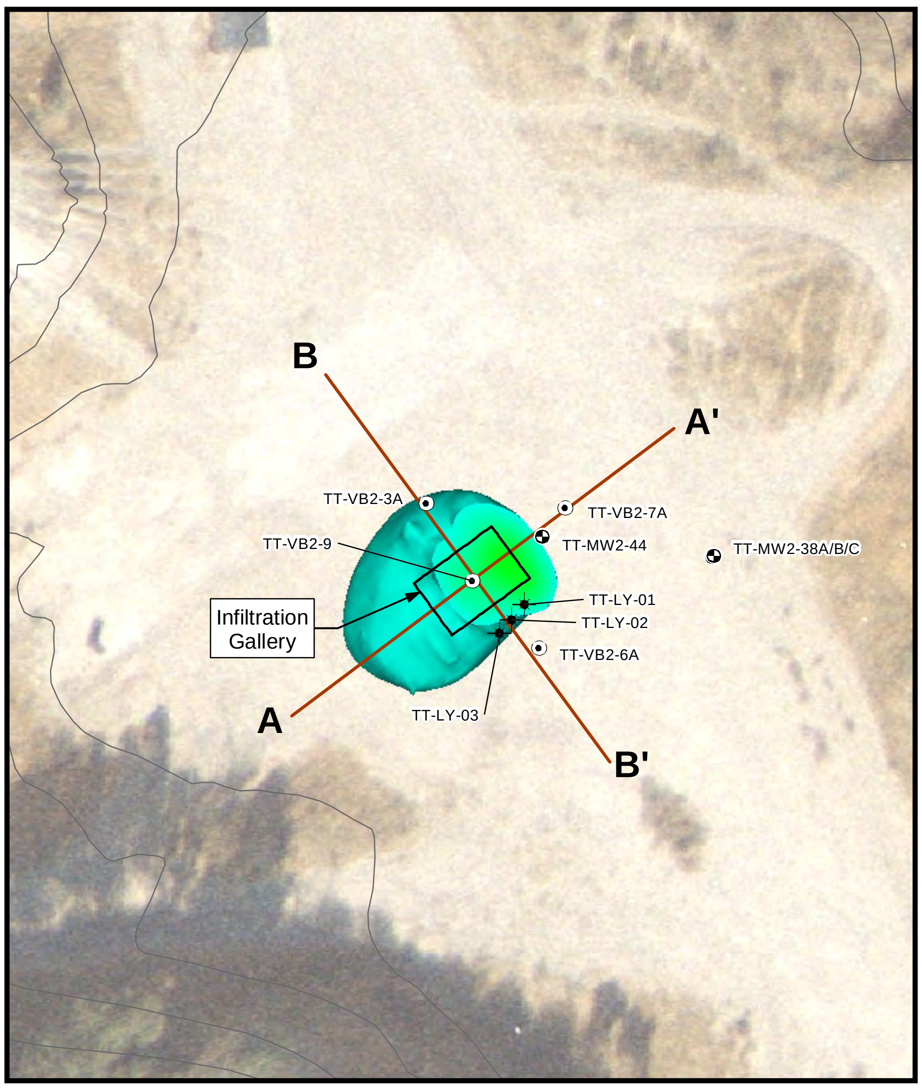


61 DAYS



116 DAYS



204 DAYS

LEGEND

- Verification Boring
- Lysimeter
- Monitoring Well Location
- Cross Section Location
- Topographic Elevation Contour (5-ft interval)

Conductivity in milliSiemens (mS)

70 mS
60 mS
50 mS
40 mS
30 mS
20 mS

N

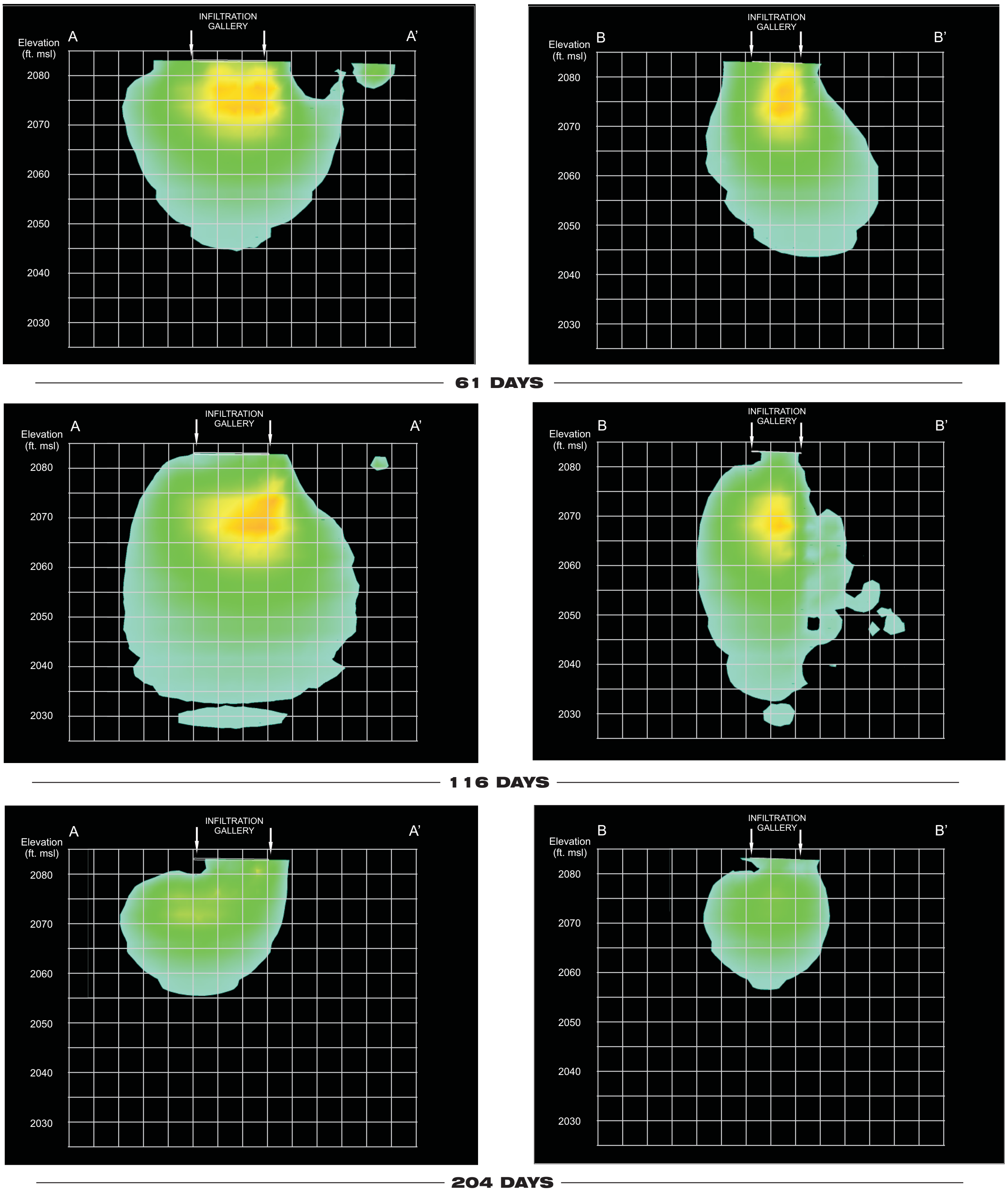
0 15 30 Feet

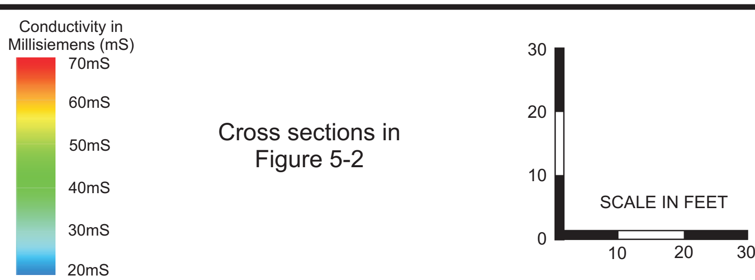
Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 5-2

Extent of Electrical Conductivity >30 milliSiemens

TETRA TECH





Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 5-3

Electrical Conductivity Cross Sections A-A' and B-B'

TETRA TECH

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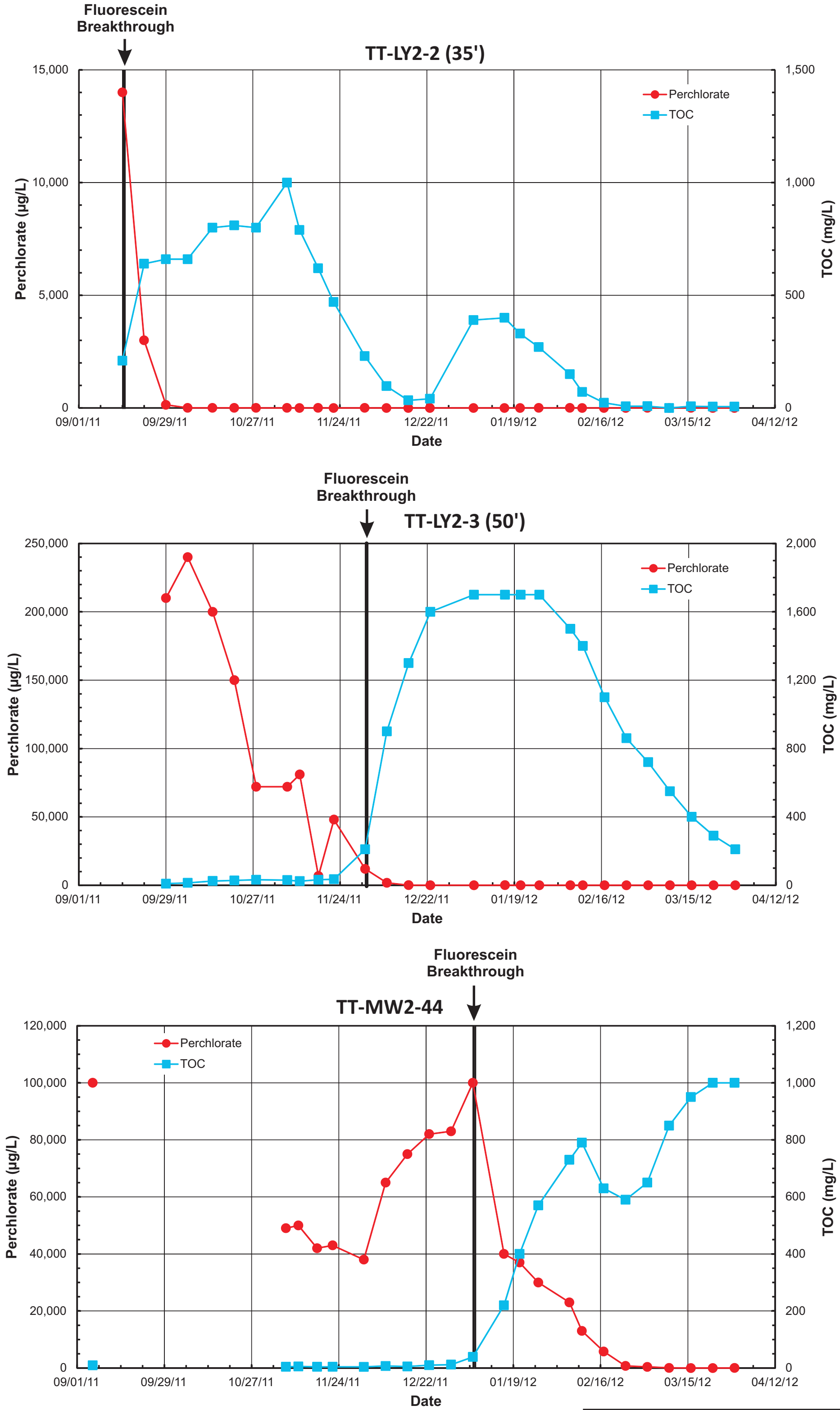

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 5-4
Perchlorate and TOC Concentrations in Pore Water and Groundwater

TETRA TECH

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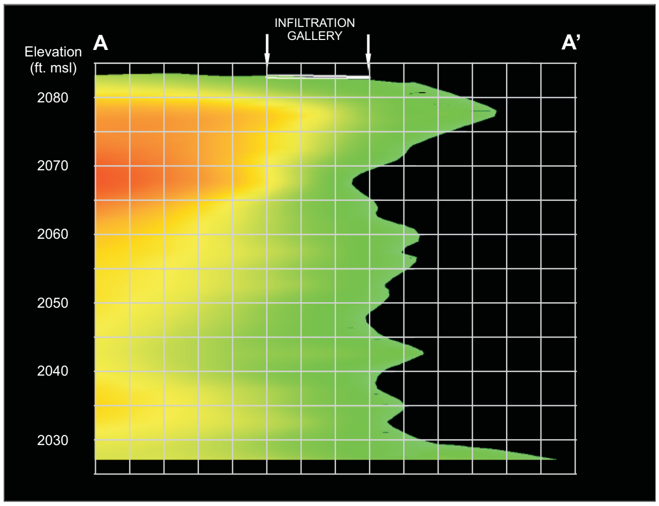
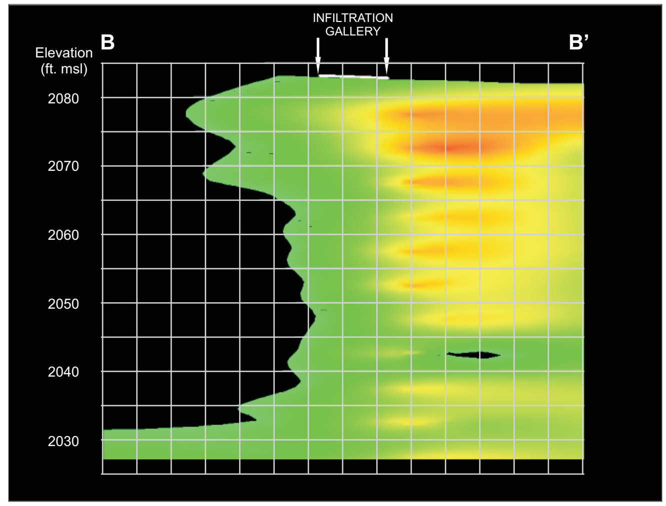
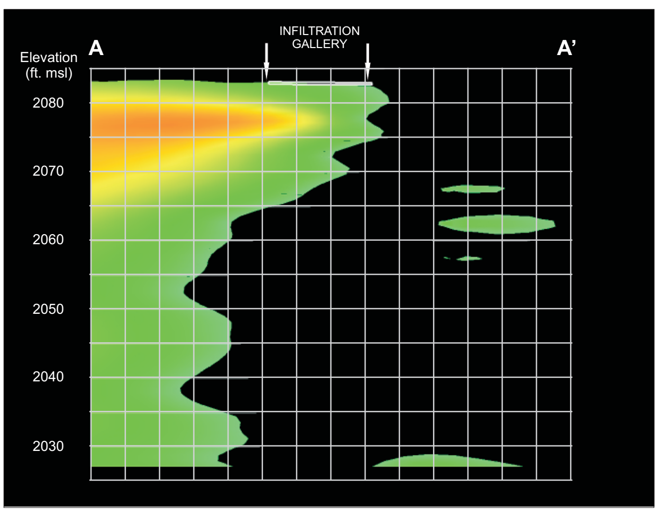


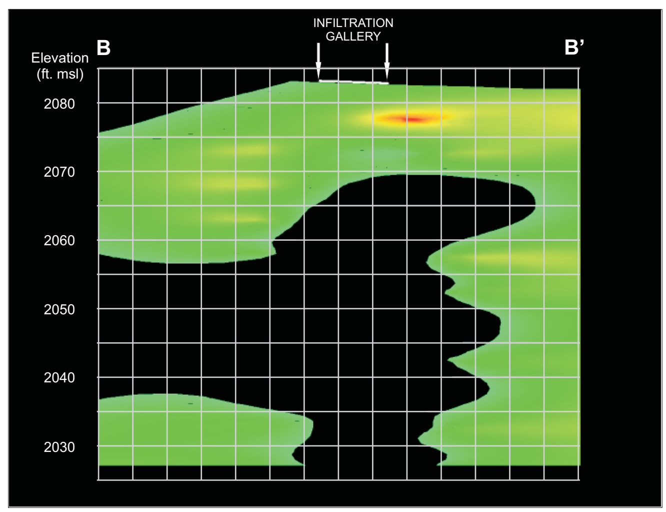
Section A-A’
Pre-Treatment



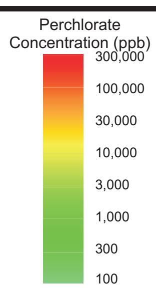
Section B-B’
Pre-Treatment



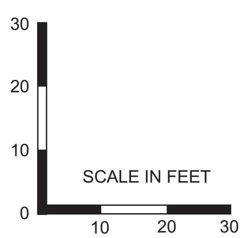
Section A-A’
Post-Treatment



Section B-B’
Post-Treatment



Cross sections in
Figure 5-2



Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 5-5

**Perchlorate Concentration
Cross Sections A-A' and B-B'**

TETRA TECH

Section 6
Development and Screening of Preliminary Remedial Alternatives

This section provides a description of the process used to develop and screen the initial list of remedial alternatives, describes the remedial alternatives, and summarizes the results of the screening process. The process narrows down the list of alternatives to those that best meet both the remedial action objectives (RAOs) for the site and Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) evaluation criteria of effectiveness, implementability, and cost. Alternatives that are retained from this initial screening process are carried forward for detailed evaluation in Section 7.

6.1 DEVELOPMENT OF PRELIMINARY REMEDIAL ALTERNATIVES

The methodology used to develop the preliminary list of remedial alternatives, and criteria and procedures used for screening the alternatives, are presented below.

6.1.1 Alternative Development Methodology

The technologies that remain following screening of the comprehensive list of remedial technologies presented in Section 5.0 were initially combined into alternative components that could be used to address one or more of the RAOs in specific areas and media at the site. For this initial stage of analysis, shallow soil (i.e., soil at depths of 5 feet below ground surface [bgs] or less) was considered separately from deep soil (i.e., soil at depths greater than 5 feet bgs), because different technologies were identified to address shallow and deep soils, and because different RAOs may apply to soil, depending on depth. Potential interactions between media, such as leaching of perchlorate from soil to groundwater, were also considered in developing the alternative components.

The initial area- and media-specific technology combinations are summarized in Table 6-1. All areas of the site were considered in this initial evaluation. However, no actions other than land use covenants (LUCs) were proposed for Area J, Area K (northern Test Bay Canyon), Area K

(Laborde Canyon), Area L, and Area M, based on one or more of the following: findings of no human health and ecological risk from exposure to contaminated soil; very small soil and groundwater contaminant masses with respect to the major source areas; no evidence of releases of contaminants to soil; and evidence that groundwater contamination in these areas originates from other areas of the site. Because the LUCs have been implemented site-wide basis rather than applied to specified areas, the areas listed above will not be considered further in the alternative development process.

The area- and media-specific technology combinations were then combined into six generalized remedial alternatives for the entire site. The generalized alternatives include:

- <u>Alternative 0</u>: No Action (required by CERCLA)
- <u>Alternative 1</u>: Institutional Controls
- <u>Alternative 2</u>: Containment and Institutional Controls
- <u>Alternative 3</u>: Shallow Soil Removal, Plume Containment, and Institutional Controls
- <u>Alternative 4</u>: Combinations of Containment/Shallow Soil Removal, Plume Containment, and Institutional Controls
- <u>Alternative 5</u>: Source Area Mass Removal (southern Test Bay Canyon [STBC]), Shallow Soil Removal, Plume Containment, and Institutional Controls
- <u>Alternative 6</u>: Source Area Mass Removal (STBC and Waste Discharge Area [WDA]), Shallow Soil Removal, Plume Containment, and Institutional Controls

These generalized alternatives were further developed by including subalternatives representing different remedial approaches. A complete listing of the preliminary alternatives, including subalternatives, is provided in Table 6-2. The alternatives and subalternatives summarized in Table 6-2 do not consider *in situ* chemical oxidation for 1,4-dioxane treatment. This process option will be further evaluated in a pilot study, which is expected to be conducted during remedy implementation.

To streamline the alternative development process, a series of intermediate screening evaluations was conducted to select technology combinations to carry forward into other alternatives. For example, an intermediate screening was conducted to select a plume containment technology to carry forward into other alternatives. Without this intermediate screening, subsequent alternatives would need to include both plume containment alternatives in the matrix of subalternatives to be complete. Performing an intermediate screening step at this point greatly reduces the complexity of the alternative development and screening process.

6.1.2 Screening Methodology

The methodology used for conducting the intermediate screening steps is described in the following sections. This procedure was also used for conducting the remedial alternative screening and selection of alternatives for detailed analysis (Section 6.3).

6.1.2.1 Screening Criteria

The intermediate screening steps (and the remedial alternative screening presented in Section 6.3) were conducted by evaluating each alternative with respect to the CERCLA criteria of effectiveness, implementability, and cost, as described in the United States Environmental Protection Agency (USEPA) feasibility study guidance document (USEPA, 1988). For each of these screening criteria, specific evaluation factors and subfactors were developed based on the narrative descriptions provided in the USEPA guidance. This approach provided a systematic and consistent framework for the alternative screening. The evaluation factors and subfactors considered for each of the CERCLA criteria are summarized in Table 6-3. As an example, the effectiveness screening criterion includes long-term effectiveness, short-term effectiveness, and reduction of toxicity, mobility, or volume through treatment as evaluation factors. The long-term effectiveness evaluation factor includes four subfactors: prevention of human health risks, minimization of ecological risks, residual potential risk, and technology reliability. The short-term effectiveness evaluation factor includes the time to achieve RAOs and potential unmitigatable adverse impacts during construction and operations, maintenance and monitoring (OM&M) as subfactors. The reduction of toxicity, mobility, or volume evaluation factor includes destruction of hazardous constituents and irreversibility of treatment as subfactors. Similarly, the implementability screening criterion includes technical and administrative implementability as evaluation factors, each of which in turn includes additional subfactors for evaluation. The cost evaluation criterion includes capital cost and OM&M costs as evaluation factors, with no subfactors being considered.

In addition to the criteria listed above, Lockheed Martin Corporation (Lockheed Martin) has included sustainability as a fourth screening criterion in the alternative screening process.

Inclusion of environmental considerations such as energy use, air impacts, and water resource impacts is consistent with the Department of Toxic Substances Control (DTSC) Green Remediation Initiative and the Lockheed Martin “Go Green” program. The screening criteria, evaluation factors, and evaluation subfactors were each assigned weights based on their importance relative to other criteria within the same group. For example, effectiveness, implementability, cost, and environmental considerations were assigned weights of 200, 100, 75, and 50, respectively, to reflect their relative importance in the screening process. The evaluation factors and subfactors were also assigned weights to reflect their relative importance within each subgroup. The relative weights were then used to calculate overall weights for each factor considered in the evaluation. The weighting scheme and overall weights for each evaluation factor or subfactor are summarized in Table 6-3.

To conduct the screening, each alternative was scored on a scale of 0 to 10 for each of the evaluation factors or subfactors, using the scoring template presented in Appendix D. When scoring was completed, the individual scores for each factor or subfactor were multiplied by the corresponding overall weight. These results were then summed to obtain a final weighted score, which also ranged from 0 to 10. Comparison of the numerical scores was used to rank and retain or screen out subalternatives during the intermediate screening steps, or to retain or screen out entire alternatives in the remedial alternative screening. The results of the intermediate screening evaluations are presented with the descriptions of the alternatives in Section 6.2; the results of the remedial alternative screening are presented in Section 6.3

6.2 ALTERNATIVE DESCRIPTIONS

The following sections provide narrative descriptions of the remedial alternatives developed for the site. Design details of the individual process options, as well as the sizing requirements for treatment technologies and estimates of remediation time frames, are conceptual for the preliminary screening process, reflecting approximately 10% design completion. In the screening process, relative capital and OM&M costs are qualitatively compared based on engineering estimates with an accuracy range of approximately -50% to +100%. Each alternative is evaluated as to whether costs are low (0-20% of maximum cost), moderately low (21-40% of maximum cost), moderate (41-60% of maximum cost), moderately high (61-80% of the maximum cost) or high (81-100% of the maximum cost). Estimated costs for all alternatives are summarized in Table 6-4.

In addition to the elements described below, each alternative (except for Alternatives 0 and 1) includes long-term groundwater monitoring, site maintenance activities (maintenance of roads, gates, signage, and other infrastructure at the site), and activities to support biological and cultural resources.

6.2.1 Alternative 0—No Action

The No Action alternative (Alternative 0) is required by the National Contingency Plan as a baseline for comparison with other remedial alternatives. The No Action alternative is also evaluated to document an alternative for no active remediation, monitoring, or institutional controls.

6.2.2 Alternative 1—Institutional Controls

Alternative 1 consists of implementing institutional controls at the site to prevent or reduce exposure to impacted media. Institutional controls include LUCs, which have already been implemented at the property, and placement of warning signs throughout the site to notify the public of the presence of potential human health risks.

The LUCs currently in place at the property were previously described in Section 2.6.3. These include prohibitions on the installation of wells and use of groundwater as a source of drinking water, and prohibitions on nonrecreational land uses and use of the property as an off-road vehicle park. Prohibiting access to and the use of groundwater as a source of drinking water is a highly effective means of eliminating exposure to groundwater on the property.

Operations, maintenance, and monitoring for this alternative would consist of annual inspections to ensure that the terms of the LUCs are being met by the current owner of the property, and that warning signs remain visible and in good condition.

The cost to implement Alternative 1 (Table 6-4) is low in comparison to the maximum cost alternative.

6.2.3 Alternative 2—Containment and Institutional Controls

Alternative 2 consists of containment and institutional controls to eliminate exposure to impacted media. Two different remedial approaches for containment were evaluated. Both approaches use capping to eliminate exposure to impacted soil, but use different containment technologies to address potential human exposure to groundwater south of the property and potential threats to beneficial uses of groundwater in the San Jacinto Groundwater Basin. An intermediate screening was conducted to select a plume containment technology to carry forward during the development of other alternatives. Descriptions of the alternatives and the results of the intermediate screening are presented below.

6.2.3.1 Alternative 2A

Alternative 2A consists of the following elements:

1. Constructing a soil cap over impacted soil with perchlorate concentrations greater than the preliminary remedial goal (PRG) of 1,700 micrograms/kilogram (µg/kg) in STBC, as described below

2. Constructing a soil cap over impacted soil with metals concentrations exceeding PRGs in the WDA, as described below

3. Installing a biobarrier to remove perchlorate from impacted groundwater in southern Laborde Canyon, with a contingency to switch to hydraulic containment and *ex situ* groundwater treatment for perchlorate and 1,4-dioxane (if 1,4-dioxane concentrations eventually exceed PRGs), as described below

4. Institutional Controls, as described in Alternative 1 (Section 6.2.2)

This alternative consists of constructing soil caps over impacted soil in STBC and the WDA to eliminate exposure to human and/or ecological receptors. Conceptually, the caps would consist of a barrier layer comprised of one foot of six-inch crushed rock, which is intended to prevent Stephens' kangaroo rats (SKRs) and other burrowing animals from contacting impacted soil beneath the cap, and a three-foot layer of compacted clean soil placed over the barrier layer to provide additional protection and minimize permanent SKR habitat disturbance. The soil layer thickness is based on the 18-inch estimated burrowing depth of SKR (Montgomery, 2012), with a 100% safety factor. If necessary, SKRs would be trapped prior to construction of the caps to avoid take of SKR.

The impacted soil footprint in STBC is approximately 10,000 square feet (SF) and the impacted soil footprint in the WDA is approximately 400 SF. To allow for sloping, the caps would have areas of approximately 12,000 SF (STBC) and 600 SF (WDA). Exact dimensions and depth will be dependent on field observations and analytical data. Construction would require importing approximately 390 cubic yards (CY) of six-inch crushed rock and approximately 1,400 CY of clean soil or borrowing 1,400 CY of clean soil on-site. The upper surface of the caps would be graded to prevent ponding of storm water; surface drainage and/or runoff diversions may also be required to reduce the potential for erosion. The cap areas would be revegetated after construction is completed. This alternative would also include long-term OM&M of the caps, such as annual inspections, periodic repairs, and reporting.

Alternative 2A would also consist of constructing a biobarrier across Laborde Canyon near the southern property boundary (Figure 6-1) to address human health risk from potential consumption of groundwater south of the property boundary, and to minimize potential threats to the beneficial use of groundwater in the San Jacinto Groundwater Basin. Because perchlorate is the only contaminant currently present in groundwater at the property boundary, a biobarrier is considered to provide adequate protection at this time. However, 1,4-dioxane is present in upgradient wells at concentrations exceeding drinking water criteria, and if 1,4-dioxane concentrations eventually exceed drinking water criteria at the property boundary, the biobarrier would no longer provide protection. To account for this possibility, a contingency to replace the biobarrier with a hydraulic containment/*ex situ* treatment (pump and treat [P&T]) system is also included in this alternative. For the purpose of cost estimating, it has been assumed that the biobarrier would be replaced in Year 20. However, further advancements in 1,4-dioxane treatment technologies are likely to occur within the next 20 years, so a focused feasibility study to evaluate treatment alternatives will be performed prior to implementing this contingency.

A small portion of the WDA groundwater plume extends downgradient beyond the proposed biobarrier/P&T system location. This portion of the plume would not be treated if a biobarrier is installed on the property. The estimated mass of perchlorate in the untreated portion of the plume is roughly one pound, and it is anticipated that even the limited natural attenuation capacity of the off-property riparian area would be sufficient to reduce perchlorate concentrations to acceptable levels after transport through the riparian corridor.

The biobarrier would consist of approximately 43 injection wells, spaced 15 feet apart in a double row. Minor grading may be necessary near the canyon margins to provide a level area for drilling and well installation. A long-acting emulsified vegetable oil electron donor would be injected into the wells at 18-month intervals to induce the anaerobic conditions necessary for *in situ* perchlorate biodegradation.

Previous bench-scale testing (Tetra Tech, 2009c and 2010c) indicates that perchlorate-reducing bacterial populations are present in the aquifer, and that nutrient additions are not necessary. The substrate would be injected using a trailer-mounted pressure injection system consisting of a mixing tank, pumps, and a manifold that allows for injection into multiple wells at one time.

Operations, maintenance, and monitoring for the biobarrier would consist of performing annual substrate injections, with each injection event being completed over a 10-day period (approximately four wells per day), and providing quarterly effectiveness monitoring and reporting.

It is assumed that a P&T system would be constructed after 20 years of biobarrier operation. Based on a constant-rate aquifer test conducted near the southern property boundary (Tetra Tech, 2010e), the approximate capture radius of an extraction well near the canyon center is about 30 feet. To ensure complete capture of the plume in the heterogeneous weathered San Timoteo formation (STF) aquifer, a smaller radius of influence of 15 feet has been assumed. The groundwater extraction system would thus consist of approximately 26 extraction wells spaced 30 feet apart, with the wells arranged in two staggered rows. Each well is assumed to be approximately 50 feet deep. Given the low anticipated flow rates, automatic pneumatic pumps would be used for groundwater extraction. Groundwater would be conveyed from the wells to the treatment system through approximately 640 linear feet (LF) of polyvinyl chloride (PVC) double-contained piping, which would be placed underground to prevent vandalism. Compressed air piping for the pneumatic pumps would also be placed in the piping trenches. Assuming complete capture of the estimated underflow in the weathered STF aquifer, the long-term yield of the extraction system is estimated at approximately 0.6 gpm. Yields may be somewhat higher during the early years of operation, when groundwater would be removed from storage in the aquifer.

The groundwater would be treated sequentially through a 10 cubic foot (CF) fixed-bed ion exchange vessel (to treat perchlorate) and a 30-kilowatt ultraviolet oxidation (UVOx) reactor (to treat 1,4-dioxane and potentially volatile organic compounds [VOCs]). Storage tanks would be provided upstream from the ion exchange vessel to reduce cycling of the UVOx system. The treatment system would be located in a walled enclosure to prevent vandalism.

It is assumed that electrical power would be brought to the area from Highway 60 to provide power for the treatment system. Treated groundwater would be conveyed through approximately 210 feet of single-contained underground PVC piping to a 45- by 45-foot infiltration gallery located downgradient of the extraction system in the Laborde Canyon drainage channel. The infiltration gallery would consist of a four-foot deep excavation backfilled with two feet of ¾-inch crushed rock and two feet of soil. Perforated PVC piping would be placed within the gravel layer to ensure uniform distribution of water within the gallery. It is assumed that the excess soil from gallery construction would be uncontaminated, and would be placed and compacted outside of the stream channel area for disposal. The gallery footprint is assumed to be approximately 2,000 SF, based on the lowest percolation rates observed during operation of an infiltration gallery during the soil and groundwater treatability study (0.05 gallons per minute [gpm] for a gallery area of 150 SF; Tetra Tech, 2012d), and the estimated long-term yield for the P&T system (0.6 gpm). If necessary, trapping would be performed prior to construction to avoid take of SKR.

Infiltration was selected for disposal to minimize water losses due to evaporation, avoid potential impacts to downgradient riparian habitat, and to avoid creating new wetlands habitat at the site. The gallery would be placed within the drainage channel to maximize likely infiltration rates. The installation of wells and the infiltration gallery within the drainage channel would require Clean Water Act Section 401/404 permitting and a Streambed Alteration Agreement with the California Department of Fish and Game (CDFG).

Operations, maintenance, and monitoring for the P&T system would consist of weekly system maintenance checks, monthly effluent sampling to ensure that the system is successfully treating all contaminants prior to disposal, quarterly effectiveness monitoring and reporting, annual replacement of ultraviolet bulbs, supplementation of the UVOx system with hydrogen peroxide as needed, replacement and disposal of ion exchange resin, and utility costs. The P&T system is anticipated to continue to operate for an indefinite period of time, in excess of 50 years.

The cost for construction and OM&M of Alternative 2A (Table 6-4) is moderate in comparison to the maximum cost alternative.

6.2.3.2 Alternative 2B

Alternative 2B is identical to Alternative 2A, except that the P&T system is used to contain groundwater contamination at the property boundary for the full duration of treatment. A biobarrier is not installed under this alternative. Alternative 2B consists of the following elements:

1. Constructing a soil cap over impacted soil where perchlorate concentrations are greater than the PRG of 1,700 µg/kg in STBC, as described in Alternative 2A (Section 6.2.3.1)
2. Constructing a soil cap over impacted soil where metals concentrations exceed PRGs in the WDA, as described in Alternative 2A (Section 6.2.3.1)
3. Installing a hydraulic containment/*ex situ* treatment system to remove perchlorate from impacted groundwater in southern Laborde Canyon, with a contingency to treat both perchlorate and 1,4-dioxane (if 1,4-dioxane concentrations eventually exceed PRGs), as described below
4. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Element 3 of Alternative 2B is similar to the P&T system described in Alternative 2A, except that it is assumed that the groundwater treatment system will consist of ion exchange to treat perchlorate only during the first 20 years, with a contingency to expand the treatment system to include ion exchange and UVOx to treat both perchlorate and 1,4-dioxane after 20 years. Operations, maintenance, and monitoring for the P&T system would consist of weekly system maintenance checks, effluent sampling to ensure that the system is successfully treating all contaminants prior to disposal, quarterly effectiveness monitoring and reporting, as-needed replacement and disposal of ion exchange resin, and utility costs. After 20 years, OM&M would be expanded to include annual replacement of ultraviolet (UV) bulbs, and as-needed supplementation of hydrogen peroxide for the UVOx system. The P&T system is anticipated to continue to operate for an indefinite period of time, in excess of 50 years.

The cost for construction and OM&M of Alternative 2B (Table 6-4) is moderate in comparison to the maximum cost alternative.

6.2.3.3 Intermediate Screening of Alternatives 2A and 2B

An intermediate screening of plume containment technologies was performed to select between Alternative 2A, a biobarrier that is replaced by a P&T system to treat 1,4-dioxane after 20 years, versus Alternative 2B, a perchlorate-only P&T system that is upgraded for 1,4-dioxane treatment after 20 years. The results of the screening evaluation are presented in Table 6-5. Based on the numerical scores, Alternative 2A (a biobarrier replaced by a P&T system) was carried forward both to develop additional alternatives and to the final intermediate screening step.

6.2.4 Alternative 3—Shallow Soil Removal, Plume Containment, and Institutional Controls

Alternative 3 differs from Alternative 2 by using removal rather than containment to address risk from shallow soil containing perchlorate or metals concentrations that exceed PRGs in STBC and the WDA. Plume containment in south Laborde Canyon is retained in this alternative, because no other strategies are available to address human health risks south of the property and potential threats to water quality in the San Jacinto Groundwater Basin. Based on intermediate screening results (Section 6.3.2.1), the approach summarized in Alternative 2A was adopted. Institutional controls will be retained to limit exposure to groundwater on the property.

The following two remedial approaches were evaluated: Alternative 3A uses on-site biological treatment to reduce perchlorate concentrations in soil in STBC, with reuse of the treated soil as fill; Alternative 3B uses transportation and off-site disposal to completely remove the impacted soil from the site. No on-site treatment technologies were identified for metals-impacted soil, so both alternatives use excavation and off-site disposal for the small quantity of metals-impacted soil at the WDA. Alternatives 3A and 3B are described in more detail below.

6.2.4.1 Alternative 3A

Alternative 3A consists of the following elements:

1. Combination of excavation and *ex situ* treatment of soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg in STBC, as described below
2. Excavation and off-site disposal of soil where metals concentrations exceed PRGs in the WDA, as described below
3. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)
4. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Element 1 consists of excavating approximately 10,200 SF of soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg to a depth of approximately four feet in STBC. The excavation volume is estimated to be 1,500 CY. The four-foot excavation depth would allow for placement of a one-foot barrier layer at the bottom of the excavation, to prevent burrowing wildlife from contacting impacted soil at greater depth, and a three-foot soil layer above the barrier, to minimize permanent SKR habitat disturbance. If necessary, trapping would be performed prior to excavation to avoid take of SKR. The exact dimensions and depth will be dependent on field observations and analytical data.

Because the excavation would remain open for an extended period of time during biotreatment, the sidewalls would be sloped to maintain stability. Approximately one foot of six-inch crushed rock (370 CY) would be placed at the bottom of the excavation to prevent burrowing wildlife from contacting impacted soil at greater depth. Fencing would be installed around the excavation to limit human and wildlife access to the excavation during the treatment period.

The excavated soil would be transported to an on-site treatment area for aboveground anaerobic biotreatment. Soil treatment for perchlorate would consist of screening to break up the soil to a uniform size, placing the soil in lined treatment cells, flooding the cells with water amended with a soluble electron donor, and covering the cells to further promote the anaerobic conditions necessary for biological perchlorate biodegradation to develop. Because the treatment cells would be flooded with water, the ground surface beneath each cell would be graded level prior to construction. The treatment cells would be 40 by 100 feet in plan dimension, and accommodate approximately 300 CY of soil per cell. Based on the estimated excavation volume, five cells would be required to treat all of the soil at one time. The cells would be constructed from 20-foot lengths of concrete K-rail and lined with 30 mil polyethylene liners. Water amended with glycerin would be added to the treatment cells as they are filled with soil to achieve uniform saturation. A plastic cover would then be placed over each cell to exclude air.

The progress of anaerobic treatment would be monitored by periodically collecting soil samples (and water samples, if free water is present) from the treatment cells. Comprehensive confirmation sampling would be conducted when treatment is determined to be completed. The cells would then be opened and, if necessary, the soil dried by evaporation. The treated soil may be tilled or spread in a thin (one-foot) lift to accelerate drying. After the moisture content is sufficiently reduced, the soil would be placed back in the excavation and compacted. Excess treated soil would be placed in the Test Bay 3 area and compacted. The excavation and treatment areas would be revegetated when treatment is complete and the excavation backfilled. It is anticipated that biotreatment would require approximately 4 to 6 months, including the time needed to obtain approval to reuse the treated soil as backfill.

Element 2 consists of excavating 400 SF of soil where metals concentrations exceed PRGs to a depth of approximately four feet in the WDA. The total excavation volume is estimated to be 60 CY. The excavated soil would be transported to a more accessible staging area near Test Bay Canyon and placed in a covered stockpile on plastic sheeting, pending profiling and disposal at a Lockheed Martin-approved state-licensed landfill. The bottom of the excavation would be backfilled with approximately one foot of six-inch crushed rock (approximately 15 CY) to prevent burrowing animals from contacting impacted soil at greater depth. The balance of the excavation (approximately 45 CY) would be backfilled with clean imported soil or clean soil from an on-site borrow area, and compacted. If necessary, trapping would be performed prior to excavation to avoid take of SKR.

The cost for construction and OM&M of Alternative 3A (Table 6-4) is moderate in comparison to the maximum cost alternative.

6.2.4.2 Alternative 3B

Alternative 3B consists of the following elements:

1. Excavation and off-site disposal of soil where perchlorate concentrations exceed PRGs in STBC, as described below
2. Excavation and off-site disposal of soil in the WDA, as described in Alternative 3A (Section 6.2.4.1)
3. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)
4. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Alternative 3B is the same as Alternative 3A with the exception that perchlorate-impacted soil in STBC would be transported and disposed off-site rather than treated and reused on-site. In this approach, approximately 1,500 CY soil with perchlorate concentrations exceeding the PRG of 1,700 µg/kg would be excavated in STBC, as described in Alternative 3A. If necessary, trapping would be performed prior to excavation to avoid take of SKR. The excavated soil would then be stockpiled on plastic sheeting and covered pending profiling and disposal at a Lockheed Martin-approved state-licensed landfill. The bottom of the excavation would be backfilled with approximately one foot of a six-inch crushed rock/gravel/sand mixture (370 CY) to prevent burrowing animals from contacting impacted soil at greater depth. The balance of the excavation (1,120 CY) would be backfilled with clean imported soil or clean soil from an on-site borrow area, and compacted.

The cost for construction and OM&M of Alternative 3B (Table 6-4) is moderate in comparison to the maximum cost alternative.

6.2.4.3 Intermediate Screening of Alternatives 3A and 3B

An intermediate screening of shallow soil removal options was conducted to select between Alternative 3A (excavation/on-site treatment at STBC and excavation/off-site disposal at the WDA) versus Alternative 3B (excavation/off-site disposal at STBC and the WDA). The results of the screening evaluation are presented in Table 6-6. Based on the numerical scores, Alternative 3A (excavation/on-site treatment at STBC and excavation/off-site disposal at the WDA) was carried forward to develop additional alternatives and to the final intermediate screening step.

6.2.5 Alternative 4—Combinations of Containment/Shallow Soil Removal, Plume Containment, and Institutional Controls

Alternative 4 combines the capping and excavation approaches to shallow soil remediation described in Alternatives 2 and 3. This alternative was developed to explore potential synergies between these approaches. Two different combinations of capping and excavation were evaluated, as described in the following sections. Based on intermediate screening results (Section 6.3.2.1), the plume containment approach summarized in Alternative 2A (a biobarrier replaced by a P&T system after 20 years) was used in these alternatives.

6.2.5.1 Alternative 4A

Alternative 4A consists of the following elements:

1. Excavation and *ex situ* treatment of perchlorate-impacted soil in STBC, as described in Alternative 3A (Section 6.2.4.1)
2. Capping of metals-impacted soil at the WDA, as described in Alternative 2A (Section 6.2.3.1)
3. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)

4. Institutional controls, as described in Alternative 1 (Section 6.2.2)

The cost for construction and OM&M of Alternative 4A (Table 6-4) is moderate in comparison to the maximum cost alternative.

6.2.5.2 Alternative 4B

Alternative 4B consists of the following elements:

1. Capping of shallow perchlorate-impacted soil in STBC, as described in Alternative 2A (Section 6.2.3.1)
2. Excavation and off-site disposal of shallow metals-impacted soil in the WDA, as described in Alternative 3A (Section 6.2.4.1)
3. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)
4. Institutional controls, as described in Alternative 1 (Section 6.2.2)

The cost for construction and OM&M of Alternative 4B (Table 6-4) is moderate in comparison to the maximum cost alternative.

6.2.5.3 Intermediate Screening of Alternatives 4A and 4B

An intermediate screening of combinations of capping and excavation/on-site treatment or excavation/off-site disposal was conducted to select between these options. The results of the screening evaluation are presented in Table 6-7. Based on the numerical scores, Alternative 4A (excavation/on-site treatment in STBC and capping at the WDA) was carried forward to the final intermediate screening step.

6.2.6 Intermediate Screening of Alternatives 2A, 3A, and 4A

A final intermediate screening was conducted to select among the three remaining options for shallow soil remediation: Alternative 2A (capping at STBC and the WDA); Alternative 3A (excavation/on-site treatment at STBC and excavation/off-site disposal at the WDA); and Alternative 4A (excavation/on-site treatment at STBC and capping at the WDA). The results of the screening evaluation are presented in Table 6-8. Based on the numerical scores, Alternative 3A (excavation/on-site treatment in STBC and excavation/off-site disposal at the WDA) was carried forward to develop Alternatives 5A, 5B, 5C, 6A, 6B, and 6C.

6.2.7 Alternative 5—Source Area Mass Removal (STBC), Shallow Soil Removal, Plume Containment, and Institutional Controls

Alternative 5 includes limited shallow soil remediation, plume containment, and institutional control elements from Alternative 3A (selected above in an intermediate screening), with the addition of source-area mass reduction in STBC. Source-area mass reduction has the potential to reduce the time needed to achieve restoration of groundwater at the site. Southern Test Bay Canyon (Figure 6-1) was selected for treatment because it is located farthest from the containment system at the site boundary, so migration of contaminants from this area to the property boundary containment system would likely be a limiting step for site restoration. In addition, STBC contains approximately 45% of the perchlorate mass in soil and 96% of the perchlorate mass in groundwater on the property. However, due to the slow rates of contaminant migration, it is unlikely that even complete removal of all contaminant source areas would reduce restoration times to less than 100 years, and more likely it would require far longer. Plume containment is therefore retained in Alternative 5 (and in Alternative 6) to protect human receptors from potential exposure to impacted groundwater south of the property and to protect beneficial use of groundwater in the San Jacinto Groundwater Basin.

Three different remedial approaches were evaluated for mass removal in STBC in Alternative 5: combined *in situ* bioremediation of soil (bioflushing) and groundwater extraction/*ex situ* treatment to reduce contaminant mass in both soil and groundwater (Alternative 5A); *in situ* biotreatment to reduce contaminant mass in groundwater only (Alternative 5B); and an approach that combines Alternatives 5A and 5B to enhance contaminant mass reduction in groundwater (Alternative 5C). Alternatives 5A, 5B, and 5C are described below.

6.2.7.1 Alternative 5A

Alternative 5A consists of the following elements:

1. *In situ* treatment of deep soil where perchlorate concentrations exceed 1,000 µg/kg in STBC, as described below
2. Extraction and *ex situ* treatment of groundwater where perchlorate exceeds 100,000 micrograms/liter (µg/L) in STBC, as described below
3. Excavation and *ex situ* treatment of shallow soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg in STBC, as described in Alternative 3A (Section 6.2.4.1)

4. Excavation and off-site disposal of shallow soil where metals concentrations exceed PRGs in the WDA, as described in Alternative 3A (Section 6.2.4.1)

5. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)

6. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Element 3 of Alternative 5A is identical to Alternative 3A, except that a crushed rock barrier layer would not be placed at the bottom of the excavation, to allow for the subsequent construction of infiltration galleries within the excavation footprint. Because a barrier layer would not be used, all of the treated soil would be returned to the excavation following treatment.

Elements 1 and 2 of Alternative 5A consist of an *in situ* bioflushing system to treat deep soils where perchlorate concentrations exceed 1,000 µg/kg, and a P&T system located within the 100,000 µg/L groundwater isoconcentration contour to treat perchlorate-impacted groundwater and provide water for use in the bioflushing system. The bioflushing system would consist of a network of infiltration galleries overlying a 21,000 SF area of deep soils where perchlorate concentrations exceed 1,000 µg/kg. This area targets roughly 80% of the vadose zone perchlorate mass in STBC. The treatability study results (Tetra Tech, 2012d) indicate that a single 10- by 15-foot infiltration gallery can treat an area roughly 30 by 35 feet at approximately 30 feet bgs. To achieve complete coverage over a 21,000 SF target area, approximately 16 infiltration galleries would be needed. The average flow rate for the single infiltration gallery used in the treatability study was 0.4 gpm for the entire duration of the test. Full-scale implementation would use a larger number of galleries, so interactions between the moisture fronts from adjacent galleries would likely reduce per-gallery water consumption. An average water consumption of 0.2 gpm per gallery was therefore assumed at full scale, which corresponds to an average water use of 4 gpm for the entire bioflushing system. Water use was observed to be much higher at the beginning of the treatability study than at the end, which limits the number of galleries that could be started up at one time. It is anticipated that a phased startup period of 20 to 40 weeks (one to two weeks per gallery) may be required.

Water used in the bioflushing system would be obtained from a P&T system installed to treat perchlorate-contaminated groundwater within the 100,000 µg/L isoconcentration contour at the core of the STBC groundwater plume. This area targets approximately 65% of the source-area mass in the STBC groundwater plume. Specific capacity measured during a constant-rate aquifer test in STBC (Tetra Tech, 2012d) was 0.056 gallons per minute per foot (gpm/ft), which corresponds to a discharge of approximately 0.8 gpm per well at a drawdown of 15 feet. However, the aquifer test was conducted in the area with the highest hydraulic conductivity in STBC, so a lower value of 0.4 gpm per well is a more reasonable average value. Using these assumptions, an eight-well groundwater extraction system is sufficient to provide the 4 gpm of water required by the bioflushing system.

At 4 gpm, the P&T system would extract approximately 2,100,000 gallons of groundwater per year. The 100,000 µg/L perchlorate isoconcentration contour in STBC has a footprint of approximately 40,000 SF and a thickness of approximately 35 feet; assuming an effective porosity of 20%, one pore volume of groundwater is approximately 2,100,000 gallons. Thus, an eight-well groundwater extraction system can remove roughly one pore volume of groundwater per year within the core of the STBC groundwater source area. Extraction of roughly two pore volumes of groundwater is considered to be a reasonable goal for reducing source-area mass, so the P&T system would be operated for a period of approximately two years. This period of operation is expected to be more than adequate for the bioflushing system, even when the extended startup period is taken into account.

The bioflushing system infiltration galleries would be approximately 10 by 15 feet in plan dimension and four feet deep. If necessary, trapping would be performed prior to excavation to avoid take of SKR. The galleries would be backfilled with approximately two feet of ¾-inch imported crushed rock. Perforated distribution piping would be placed in the crushed rock to ensure uniform distribution of water within the galleries. The remainder of the gallery excavations would be backfilled with two feet of clean soil, with excess soil being placed in the Test Bay 3 area, and compacted. It is assumed that single-contained underground piping would be used to convey treated water amended with a soluble electron donor from the groundwater treatment system to the galleries. Gallery equipment and controls may include automated shut-off valves, metering pumps, timers, check valves, totalizers, water level controls, and various sensors and switches. The equipment and control specifications would be determined in the final remedial design.

The P&T system would consist of eight groundwater extraction wells installed to a depth of approximately 100 feet bgs. Based on the low anticipated flow rates, automatic pneumatic pumps would be used for groundwater extraction. Extracted groundwater would be conveyed through approximately 430 LF of PVC double-contained piping which would be placed underground to prevent vandalism. Compressed air piping for the pneumatic pumps would also be placed in the piping trenches. The groundwater would be treated with a 20 CF fixed-bed ion exchange vessel for removal of perchlorate prior to amendment with a soluble electron donor and infiltration in the bioflushing system. Storage tanks would be provided upstream from the ion exchange vessel to reduce pump cycling.

Treated groundwater from the ion exchange system would be conveyed from the treatment system to the infiltration galleries through approximately 590 feet of single-contained PVC piping. Control systems would be used to maintain balance between inflow of water from the groundwater extraction system and outflow of water to the bioflushing system.

Using untreated groundwater for bioflushing was also considered. This variation was rejected for several reasons, most importantly because groundwater containing relatively high concentrations of perchlorate could migrate away from the primary flowpath by capillary action, potentially resulting in increases in perchlorate concentrations in soil in the area outside of the treatment zone.

It was assumed that electrical power would be brought to the area to provide power for the treatment systems. Although the bioflushing treatability study used solar-powered equipment, a much larger number of solar panels would be needed to operate a full-scale system. Vandalism has been an ongoing problem at the property, and there is a substantial likelihood that cost increases due to replacement of vandalized equipment and increased system downtime would be greater than the cost of installing grid power.

The effectiveness of soil treatment would be evaluated by analyzing soil samples collected before and after the test. Borings to establish baseline conditions would be drilled prior to the start of the test. Post-test borings would be drilled adjacent to the baseline borings after the test was completed to evaluate changes in perchlorate concentrations.

Operations, maintenance, and monitoring activities would include weekly maintenance of the bioflushing and P&T systems, monthly effluent sampling of the groundwater treatment system to ensure that treatment is effective, quarterly groundwater sampling to monitor the effectiveness of the bioflushing and P&T systems, and replacement and disposal of ion exchange resin as required.

The cost for construction and OM&M of Alternative 5A (Table 6-4) is moderately high in comparison to the maximum cost alternative.

6.2.7.2 Alternative 5B

Alternative 5B consists of the following elements:

1. *In situ* bioremediation of groundwater in STBC where perchlorate concentrations exceed 100,000 µg/L, as described below
2. Combination of excavation and *ex situ* treatment of shallow soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg in STBC, as described in Alternative 3A (Section 6.2.4.1)
3. Excavation and off-site disposal of shallow soil where metals concentrations exceed PRGs in the WDA, as described in Alternative 3A (Section 6.2.4.1)
4. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1).
5. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Element 1 of Alternative 5B consists of *in situ* bioremediation of groundwater where perchlorate concentrations exceed 100,000 µg/L in STBC. This area targets approximately 65% of the source area mass in the STBC groundwater plume. Assuming a 12.5-foot radius of influence for injection, approximately 57 injection wells installed to a depth of 100 feet and spaced roughly 25 feet apart in a triangular pattern would be installed in the core of the STBC groundwater source area needed for approximate coverage of the 40,000 SF area of the 100,000 µg/L contour. Injection tests using a dye tracer would be conducted to confirm the radius of influence and estimated number of injection wells.

A long-acting emulsified vegetable oil substrate would be injected into the saturated zone to induce anaerobic conditions within the aquifer. The substrate would be injected using a trailer-mounted pressure injection system consisting of a mixing tank, pumps, and a manifold that allows for injection into multiple wells at one time. Injections would be completed over a three-week period, which would include water injections for substrate distribution following the substrate injections.

Operations, maintenance, and monitoring would consist of performing annual substrate and substrate distribution water injections for a period of two years, and semiannual monitoring and reporting during the period of active remediation and for a period of two years afterward.

The cost for construction and OM&M of Alternative 5B (Table 6-4) is moderate in comparison to the maximum cost alternative.

6.2.7.3 Alternative 5C

Alternative 5C combines the bioflushing/P&T approach described in Alternative 5A with the *in situ* bioremediation approach described in Alternative 5B to increase the efficiency of mass removal in groundwater. Alternative 5C consists of the following elements:

1. *In situ* treatment of deep soil where perchlorate concentrations exceed 1,000 µg/kg in STBC, as described in Alternative 5A (Section 6.2.6.1)
2. *Ex situ* treatment of groundwater where perchlorate concentrations exceed 100,000 µg/L in STBC, as described in Alternative 5A (Section 6.2.6.1)
3. Supplemental *in situ* treatment of groundwater with perchlorate concentrations exceeding 100,000 µg/L in STBC, as described below
4. Excavation and *ex situ* treatment of shallow soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg in STBC, as described in Alternative 3A (Section 6.2.4.1)
5. Excavation and off-site disposal of shallow soil where metals concentrations exceed PRGs in the WDA, as described in Alternative 3A (Section 6.2.4.1)
6. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)
7. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Alternative 5C uses the basic remedial approach of Alternative 5A, with the addition of carbon substrate injections to increase the efficiency of perchlorate mass removal in groundwater. In addition to the eight groundwater extraction wells included in Alternative 5A, a network of 20 injection wells would be installed within the 100,000 µg/L perchlorate isoconcentration contour. A water-soluble electron donor solution would be injected into the saturated zone to induce anaerobic conditions. The groundwater extraction system would be operated continuously during and after injection to help distribute the electron donor solution through the aquifer. The substrate would be injected using a trailer-mounted pressure injection system consisting of a mixing tank, pumps, and a manifold that allows for injection into multiple wells at one time. Injections would be completed over a four-day period, which would also include substrate distribution water injections following the substrate injections.

Operations, maintenance, and monitoring would be similar to Alternative 5A, with the addition of four separate substrate injection events, approximately six months apart.

The cost for construction and OM&M of Alternative 5C (Table 6-4) is moderately high in comparison to the maximum cost alternative.

6.2.8 Alternative 6—Source Area Mass Removal (STBC and WDA), Shallow Soil Removal, Plume Containment, and Institutional Controls

Alternative 6 includes all of the elements of Alternative 5 (limited shallow soil remediation, source area mass reduction in STBC, plume containment, and institutional controls), with the addition of source area mass reduction in the WDA. Three different remedial approaches are evaluated: combined bioflushing and groundwater extraction/*ex situ* treatment to reduce mass in both soil and groundwater in STBC and the WDA (Alternative 6A); *in situ* biotreatment to reduce mass in groundwater only in STBC and the WDA (Alternative 6B); and an approach that combines Alternatives 6A and 6B to enhance mass reduction in groundwater (Alternative 6C). Alternatives 6A, 6B, and 6C are described below.

6.2.8.1 Alternative 6A

Alternative 6A follows the same general approach as Alternative 5A, with the addition of deep soil and groundwater treatment at the WDA. Alternative 6A consists of the following elements:

1. *In situ* treatment of deep soil where perchlorate concentrations exceed 10,000 µg/kg at the WDA, as described below

2. *Ex situ* treatment of the groundwater where perchlorate concentrations exceed 10,000 µg/L of perchlorate at the WDA, as described below

3. *In situ* treatment of deep soil where perchlorate concentrations exceed 1,000 µg/kg at STBC, as described in Alternative 5A (Section 6.2.7.1)

4. *Ex situ* treatment of the groundwater where perchlorate exceeds 100,000 µg/L at Southern Test Bay Canyon STBC, as described in Alternative 5A (Section 6.2.7.1)

5. Excavation and *ex situ* treatment of shallow soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg in STBC, as described in Alternative 3A (Section 6.2.4.1)

6. Excavation and off-site disposal of shallow soil where metals concentrations exceed PRGs in the WDA, as described in Alternative 3A (Section 6.2.4.1)

7. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)

8. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Elements 1 and 2 follow the same general approach described in Alternative 5A for treatment of perchlorate-impacted soil and groundwater in STBC. The 10,000 µg/kg soil contour, which represents approximately 60% of the perchlorate mass in soil in this source area, will be targeted for remediation in the WDA. The area of the 10,000 µg/kg contour is approximately 11,000 SF, so approximately 11 infiltration galleries are needed to obtain full coverage. Assuming a flow rate of 0.2 gpm per gallery, approximately 2.2 gpm of water is needed to operate the gallery network.

Specific capacity measured during a constant-rate aquifer test at the WDA was approximately 0.0054 gpm/ft (Tetra Tech, 2012d). Based on this value and assuming a drawdown of 15 feet, a per-well discharge of roughly 0.08 gpm was estimated. However, the constant-rate aquifer test was performed in the area with the highest hydraulic conductivity in the WDA, so an average discharge of 0.04 gpm/well is considered to be more reasonable. Thus, approximately 55 extraction wells would be needed to supply enough water to operate the infiltration galleries. This is roughly the number of wells needed to obtain full coverage of the 10,000 µg/L perchlorate isoconcentration contour, which represents approximately 55% of the perchlorate mass in the groundwater source area at the WDA.

The bioflushing/P&T system would be similar to that described in Alternative 5A, with the exception that groundwater treatment would include both a fixed-bed ion exchange unit to treat perchlorate, and a small (30 kilowatt) UVOx system to treat 1,4-dioxane and VOCs. It was assumed that electrical power would be brought to the area from STBC to provide power for the treatment system.

The infiltration galleries and extraction system are anticipated to operate for a period of approximately two years. Operations, maintenance, and monitoring activities would be similar to Alternative 5A, with the addition of annual replacement of ultraviolet bulbs.

The cost for construction and OM&M of Alternative 6A (Table 6-4) is high in comparison to the maximum cost alternative.

6.2.8.2 Alternative 6B

Alternative 6B follows the same general approach as Alternative 5B, with the addition of source area groundwater treatment at the WDA. Alternative 6B consists of the following elements:

1. *In situ* bioremediation of groundwater in the WDA where perchlorate concentrations exceed 10,000 µg/L, as described below
2. *In situ* bioremediation of groundwater where perchlorate concentrations exceed 100,000 µg/L in STBC, as described in Alternative 5B (Section 6.2.7.2)
3. Excavation and *ex situ* treatment of shallow soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg in STBC, as described in Alternative 3A (Section 6.2.4.1)
4. Excavation and off-site disposal of shallow soil where metals concentrations exceed PRGs in the WDA, as described in Alternative 3A (Section 6.2.4.1)
5. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)
6. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Element 1 of Alternative 6B consists of *in situ* bioremediation of groundwater with perchlorate concentrations exceeding 10,000 µg/L in the WDA. Assuming a 7.5-foot radius of influence for injection, approximately 312 injection wells will be needed for complete coverage of the 55,000 SF area of the 10,000 µg/L contour. Injection tests using a dye tracer would be conducted prior to construction to confirm the radius of influence and estimated number of injection wells.

A long-acting emulsified vegetable oil substrate would be injected into the saturated zone to induce anaerobic conditions within the aquifer. The substrate would be injected using a trailer-mounted pressure injection system consisting of a mixing tank, pumps, and a manifold that allows for injection into multiple wells at one time. Injections would be completed over an 11-week period, which would also include substrate distribution water injections following the substrate injections.

Operations, maintenance, and monitoring activities would be similar to those described for Alternative 5B. The cost for construction and OM&M of Alternative 6B (Table 6-4) is moderately high in comparison to the maximum cost alternative.

6.2.8.3 Alternative 6C

Alternative 6C extends the general approach presented in Alternative 5C to both STBC and the WDA. Alternative 6C consists of the following elements:

1. *In situ* treatment of deep soil where perchlorate concentrations exceed 10,000 µg/kg at the WDA, as described in Alternative 6A (Section 6.2.8.1)
2. *Ex situ* treatment of groundwater where perchlorate concentrations exceed 10,000 µg/L at the WDA, as described in Alternative 6A (Section 6.2.8.1)
3. Supplemental *in situ* treatment of groundwater with perchlorate concentrations exceeding 10,000 µg/L at the WDA, as described below
4. *In situ* treatment of deep soil where perchlorate concentrations exceed 1,000 µg/kg at STBC, as described in Alternative 5A (Section 6.2.7.1)
5. *Ex situ* treatment of groundwater where perchlorate concentrations exceed 100,000 µg/L at STBC, as described in Alternative 5A (Section 6.2.7.1)
6. Supplemental *in situ* treatment of groundwater with perchlorate concentrations exceeding 100,000 µg/L at STBC, as described in Alternative 5C (Section 6.2.73)
7. Excavation and *ex situ* treatment of shallow soil where perchlorate concentrations exceed the PRG of 1,700 µg/kg in STBC, as described in Alternative 3A (Section 6.2.4.1)
8. Excavation and off-site disposal of shallow soil where metals concentrations exceed PRGs in the WDA, as described in Alternative 3A (Section 6.2.4.1)
9. Plume containment in south Laborde Canyon, as described in Alternative 2A (Section 6.2.3.1)
10. Institutional controls, as described in Alternative 1 (Section 6.2.2)

Alternative 6C uses the same remedial approach as Alternative 6A, with the addition of carbon substrate injections in the WDA to increase the efficiency of perchlorate mass removal in groundwater. Element 3 consists of installing a network of 80 injection wells within the 10,000 µg/L perchlorate isoconcentration contour at the WDA. A water-soluble electron donor solution would be injected into the saturated zone to induce anaerobic conditions within the aquifer; pumping from the groundwater extraction system would help distribute the electron donor through the aquifer. The substrate would be injected using a trailer-mounted pressure injection system consisting of a mixing tank, pumps, and a manifold that allows for injection into multiple wells at one time. Injections would be completed over a three-week period, which would also include substrate distribution water injections following the substrate injections.

Operations, maintenance, and monitoring would be similar to Alternative 6A, with the addition of four separate injection events, approximately six months apart.

The cost for construction and OM&M of Alternative 6C (Table 6-4) is the highest of all the alternatives.

6.3 SCREENING OF REMEDIAL ALTERNATIVES

The results of the remedial alternative screening are summarized in Table 6-9. The alternative screening only considered Alternatives 0, 1, 3A, 5A, 5B, 5C, 6A, 6B, and 6C. Alternative 2B was previously screened out based on the intermediate screening evaluation of plume containment technologies (Section 6.2.3.3). Alternative 3B was previously screened out based on the intermediate screening evaluation of shallow-soil removal options (Section 6.2.4.3). Alternative 4B was previously screened out based on the intermediate screening evaluation of combinations of containment and limited soil removal options (Section 6.2.5.3). Alternatives 2A and 4A were previously screened out based on the intermediate screening of the shallow soil remediation options (Section 6.2.6).

Based on their lower scores (summarized in Table 6-8), Alternatives 5C, 6A, 6B, and 6C were screened out. The following four alternatives will be carried forward for detailed analysis: Alternative 0 (required by the National Oil and Hazardous Substances Pollution Contingency Plan), Alternative 3A, Alternative 5A, and Alternative 5B.

Section 6 Tables

Table 6-1
Remedial Technology Combinations by Area and Media

Area	Media	RAOs Addressed	Technology Combinations[1]
Area J	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs (Note 2)
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs (Note 3)
	Groundwater	GW1/GW2	- LUCs (Note 4)
Area K Northern Test Bay Canyon	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs (Note 2)
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs (Note 3)
	Groundwater	GW1/GW2	- LUCs (Note 4)
Area K Southern Test Bay Canyon	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs - Capping/erosion control/LUCs - Excavation/*ex situ* biological treatment/on-site disposal (treated soil)/LUCs - Excavation/transportation/off-site disposal/LUCs
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs - *In situ* biologic treatment/LUCs
	Groundwater	GW1/GW2	- LUCs - Groundwater extraction/*ex situ* treatment/on-site disposal (treated water)/LUCs - *In situ* biologic treatment/LUCs
Area K Laborde Canyon	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs (Note 2)
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs (Note 3)
	Groundwater	GW1/GW2	- LUCs (Note 4)
Area L	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs (Note 2)
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs (Note 3)
	Groundwater	GW1/GW2	- LUCs (Note 4)
Area M	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs (Note 2)
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs (Note 3)
	Groundwater	GW1/GW2	- LUCs (Note 4)
Waste Discharge Area	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs/community awareness - Capping/erosion control/LUCs - Excavation/transportation/off-site disposal/LUCs
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs - *In situ* biologic treatment/*in situ* physical treatment/LUCs

Table 6-1
Remedial Technology Combinations by Area and Media

Area	Media	RAOs Addressed	Technology Combinations[1]
Waste Discharge Area	Groundwater	GW1/GW2	- LUCs - Groundwater extraction/*ex situ* treatment/on-site disposal (treated water)/LUCs - *In situ* biologic treatment/LUCs
South Laborde Canyon	Shallow Soil (<5 feet bgs)	S1/S2	- LUCs (Note 2)
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- LUCs (Note 3)
	Groundwater	GW1/GW2	- LUCs - Permeable reactive barrier/natural attenuation monitoring/LUCs - Hydraulic containment/*ex situ* treatment/on-site disposal (treated water)/natural attenuation monitoring/LUCs
Stranded Plume	Shallow Soil (<5 feet bgs)	S1/S2	- No action
	Deep Soil (>5 feet bgs)	S1/S2 GW1/GW2	- No action
	Groundwater	GW1/GW2	- Sampling and analysis (Note 5)

Notes
ARARs: Applicable or relevant and appropriate requirements
bgs: Below ground surface
LUCs: land use controls
RAOs: Remedial Action Objectives

1. Erosion control is included for all combinations involving earthwork; off-site disposal of treatment residuals is included in all combinations involving *ex situ* groundwater treatment.
2. No action other than LUCs proposed because human health and ecological risks were determined to be acceptable.
3. No action other than LUCs proposed because contaminant mass in vadose zone is <1% of total site mass and perchlorate concentrations are low relative to major source areas.
4. No actions other than LUCs proposed because groundwater plume mass is <1% of total site mass and perchlorate concentrations are low relative to major source areas.
5. No action other than sampling and analysis proposed because contaminant concentrations currently meet ARARs at downgradient well (TT-MW2-20S/D).

Table 6-2
Remedial Alternatives Summary

Remedial Action Objective	Medium	Risk Pathway	Area	Alternative 0	Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5			Alternative 6		
				No Action	**Institutional Controls**	**Containment and Institutional Controls**		**Shallow Soil Removal, Plume Containment, and Institutional Controls**		**Combinations of Containment/Shallow Soil Removal, Plume Containment, and Institutional Controls**		**Source Area Mass Removal (STBC), Shallow Soil Removal, Plume Containment, and Institutional Controls**			**Source Area Mass Removal (STBC & WDA), Shallow Soil Removal, Plume Containment, and Institutional Controls**		
				0	**1**	**2A**	**2B**	**3A**	**3B**	**4A**	**4B**	**5A**	**5B**	**5C**	**6A**	**6B**	**6C**
				No Action	**ICs**	**Capping + PRB at Property Boundary**	**Capping + Hydraulic Containment at Property Boundary**	**Excavation/On-site Treatment/Off-site Disposal + PRB at Property Boundary**	**Excavation/Off-site Disposal + PRB at Property Boundary**	**Combination of Excavation/On-site Treatment and Capping + PRB at Property Boundary**	**Combination of Capping & Excavation/Off-site Disposal + PRB at Property Boundary**	**Excavation/On-Site Treatment/Off-site Disposal + Source Area Bioflushing & Groundwater Extraction/Treatment + PRB at Property Boundary**	**Excavation/On-Site Treatment/Off-site Disposal + Source Area GW *In Situ* Biotreatment + PRB at Property Boundary**	**Excavation/On-Site Treatment/Off-site Disposal + Source Area Bioflushing & Groundwater Extraction/Treatment & *In Situ* Biotreatment + PRB at Property Boundary**	**Excavation/On-Site Treatment/Off-site Disposal + Source Area Bioflushing & Groundwater Extraction/Treatment + PRB at Property Boundary**	**Excavation/On-Site Treatment/Off-site Disposal + Source Area GW *In Situ* Biotreatment + PRB at Property Boundary**	**Excavation/On-Site Treatment/Off-site Disposal + Source Area Bioflushing & Groundwater Extraction/Treatment & *In Situ* Biotreatment + PRB at Property Boundary**
GW1 Protect human receptors GW2 Protect beneficial uses of groundwater	Groundwater	Ingestion of on-property groundwater	STBC	No Action	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use
			WDA	No Action	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use
			South Laborde Canyon	No Action	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use	LUCs controlling on-site GW use
		Ingestion of off-property groundwater Migration to San Jacinto Groundwater Basin	STBC	No Action	No Action	No Action	No Action	No Action	No Action	No Action	No Action	Extract/treat GW where perchlorate >100,000 μg/L in STBC. Amend treated GW with electron donor and use to bioflush soil where perchlorate >1,000 μg/kg.	*In situ* bioremediation of GW where perchlorate is >100,000 μg/L in STBC.	Combination of *in situ* GW biotreatment & extraction/treatment of GW where perchlorate is >100,000 μg/L in STBC. Amend treated GW with electron donor and use to bioflush soil where perchlorate is >1,000 μg/kg.	Extract/treat GW where perchlorate is >100,000 μg/L in STBC. Amend treated GW with electron donor and use to bioflush soil where perchlorate is >1,000 μg/kg.	*In situ* bioremediation of GW where perchlorate is >100,000 μg/L in STBC.	Combination of *in situ* GW biotreatment & extraction/treatment of GW where perchlorate is >100,000 μg/L in STBC. Amend treated GW with electron donor and use to bioflush soil where perchlorate is >1,000 μg/kg.
			WDA	No Action	No Action	No Action	No Action	No Action	No Action	No Action	No Action	No Action	No Action	No Action	Extract/treat GW where perchlorate is >10,000 μg/L in WDA. Amend treated GW with electron donor and use to bioflush soil where perchlorate is >10,000 μg/kg.	*In situ* bioremediation of GW where perchlorate is >10,000 μg/L in WDA.	Combination of *in situ* GW biotreatment & extraction/treatment of GW where perchlorate is >10,000 μg/L in WDA. Amend treated GW and use to bioflush soil where perchlorate is > 10,000 μg/kg.
			South Laborde Canyon	No Action	No Action	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Pump-and-treat system to treat perchlorate at property boundary. Switch to advanced oxidation treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.	Biobarrier to treat perchlorate at property boundary. Switch to groundwater extraction/treatment after year 20 to address 1,4-dioxane.
S1 Protect human receptors S2 Protect ecological receptors	Soil	Inhalation/ingestion/food	STBC	No Action	No Action	4-foot soil cap over ~10,000 SF of soil where perchlorate is >1,700 μg/kg.	4-foot soil cap over ~10,000 SF of soil where perchlorate is >1,700 μg/kg.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.	4-foot soil cap over ~10,000 SF of soil where perchlorate is >1,700 μg/kg.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.	Excavate ~10,000 SF of soil where perchlorate is >1,700 μg/kg to depth of 4 feet; treat soil by anaerobic biotreatment; reuse as excavation backfill.
			WDA	No Action	No Action	4-foot soil cap over ~ 400 SF of Cd/Pb impacted soil.	4-foot soil cap over ~ 400 SF of Cd/Pb impacted soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	4-foot soil cap over ~ 400 SF of Cd/Pb impacted soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.	Excavate ~400 SF of Cd/Pb impacted soil to depth of 4 feet; dispose off-site; backfill with clean soil.

Notes:
All alternatives include periodic groundwater monitoring, site maintenance, and natural/cultural resources support activities.

Definitions:
Cd: cadmium
GW: groundwater
ICs: Institutional controls
LUCs: Land use covenants
μg/kg: micrograms per kilogram
μg/L: micrograms per liter
Pb: Lead
PRB: permeable reactive barrier
SF: square feet
STBC: southern Test Bay Canyon
WDA: Waste Discharge Area

Table 6-3
Screening Analysis Criteria, Evaluation Factors, and Weights

Screening Criteria	Relative Weight	Evaluation Factors	Relative Weight	Evaluation Subfactors	Relative Weight	Overall Weight
Effectiveness	200	Long-Term Effectiveness	100	Prevent Human Health Risks	100	6.7%
				Minimize Ecological Risk	100	6.7%
				Residual Potential Risk	50	3.4%
				Technology Reliability	100	6.7%
		Short-Term Effectiveness	50	Time to Achieve RAOs	50	4.7%
				Unmitigatable Adverse Impacts	75	7.1%
		Reduction of Toxicity, Mobility, or Volume Through Treatment	50	Destruction of Hazardous Constituents	100	5.9%
				Irreversibility of Treatment	100	5.9%
Implementability	100	Technical Implementability	100	Constructability	75	5.9%
				Adaptability to Modify/Update	25	2.0%
				Effectiveness of Monitoring	50	3.9%
		Administrative Implementability	100	Availability of Experts and Technology	50	3.9%
				Obtaining Other Approvals	100	7.8%
Cost	75	Capital Cost	100	-	-	8.8%
		OM&M Cost	100	-	-	8.8%
Sustainability	50	Energy Use	75	-	-	5.9%
		Air Impacts	50	-	-	3.9%
		Water Resource Impacts	25	-	-	2.0%
						100.0%

Notes:
-: no subfactors used in evaluation.
OM&M: Operation, maintenance, and monitoring
RAOS: Remedial Action Objectives

Table 6-4
Screening Level Cost Summary

Alternative	Description	Current Value Costs				Net Present Value Costs			
		Capital	OM&M	Closure	Total	Capital	OM&M	Closure	Total
ALT 0	No Action	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
ALT 1	ICs	$ 62,114	$ 862,141	$ -	$ 924,255	$ 56,401	$ 227,604	$ -	$ 284,005
ALT 2A	ICs, Capping, Permeable Reactive Barrier	$ 3,425,329	$ 35,007,458	$ 134,025	$ 38,566,812	$ 1,731,453	$ 8,270,290	$ 117,063	$ 10,118,806
ALT 2B	ICs, Capping, Hydraulic Containment	$ 2,846,141	$ 37,188,953	$ 134,025	$ 40,169,120	$ 2,421,733	$ 9,268,329	$ 117,063	$ 11,807,125
ALT 3A	ICs, Excavation/On-site Treatment (TBC) and Excavation/Off-site Disposal (WDA), Permeable Reactive Barrier	$ 4,459,230	$ 31,027,106	$ 246,848	$ 35,733,185	$ 2,389,870	$ 7,462,446	$ 215,607	$ 10,067,923
ALT 3B	ICs, Excavation/Off-site Disposal (TBC and WDA), Permeable Reactive Barrier	$ 3,875,987	$ 34,991,933	$ 134,025	$ 39,001,945	$ 2,124,384	$ 8,203,528	$ 117,063	$ 10,444,975
ALT 4A	ICs, Capping (WDA) and Excavation/On-site Treatment (TBC), Permeable Reactive Barrier	$ 3,621,133	$ 35,447,333	$ 134,025	$ 39,202,491	$ 1,901,785	$ 8,317,309	$ 117,063	$ 10,336,156
ALT 4B	ICs, Capping (TBC) and Excavation/Off-site Disposal (WDA), Permeable Reactive Barrier	$ 3,450,350	$ 35,447,333	$ 134,025	$ 39,031,708	$ 1,752,616	$ 8,317,309	$ 117,063	$ 10,186,988
ALT 5A	ICs, Capping, Bioflushing (TBC), Groundwater Extraction/*Ex Situ* Treatment (TBC), Permeable Reactive Barrier	$ 5,037,757	$ 31,843,075	$ 512,071	$ 37,392,902	$ 3,183,103	$ 8,085,657	$ 447,263	$ 11,716,022
ALT 5B	ICs, Capping, *In Situ* Groundwater Biotreatment (TBC), Permeable Reactive Barrier	$ 4,833,369	$ 31,520,226	$ 917,590	$ 37,271,185	$ 3,087,111	$ 7,826,339	$ 801,459	$ 11,714,909
ALT 5C	ICs, Capping, Bioflushing (TBC), *In Situ* Groundwater Biotreatment and Groundwater Extraction/*Ex Situ* Treatment (TBC), Permeable Reactive Barrier	$ 6,015,193	$ 37,487,316	$ 668,939	$ 44,171,448	$ 4,399,456	$ 9,923,347	$ 418,726	$ 14,741,529
ALT 6A	ICs, Capping, Bioflushing (TBC and WDA), Groundwater Extraction/*Ex Situ* Treatment (TBC and WDA), Permeable Reactive Barrier	$ 8,008,288	$ 43,550,108	$ 898,417	$ 52,456,812	$ 6,240,866	$ 13,889,394	$ 408,063	$ 20,538,324
ALT 6B	ICs, Capping, *In Situ* Groundwater Biotreatment (TBC and WDA), Permeable Reactive Barrier	$ 10,128,818	$ 38,004,519	$ 1,669,626	$ 49,802,962	$ 9,428,744	$ 10,336,454	$ 1,211,925	$ 20,977,123
ALT 6C	ICs, Capping, Bioflushing (TBC and WDA), *In Situ* Groundwater Biotreatment and Groundwater Extraction/*Ex Situ* Treatment (TBC and WDA), Permeable Reactive Barrier	$ 9,181,053	$ 44,874,596	$ 27,086,121	$ 81,141,769	$ 7,265,204	$ 14,748,310	$ 495,162	$ 22,508,676

Notes:
ICs: Institutional Controls
OM&M: Operations, maintenance, and monitoring
TBC: Test Bay Canyon
WDA: Waste Discharge Area

Table 6-5
Intermediate Screening: Alternative 2A/Alternative 2B

Screening Criteria	Evaluation Factors	Evaluation Subfactors	Weight	Alternative 2A: Biobarrier + Extraction/*Ex Situ* Treatment after Year 20	Alternative 2B: Extraction/*Ex Situ* Treatment
Effectiveness	Long-Term Effectiveness	Prevent Human Health Risks	6.7%	8.3	8.3
		Minimize Ecological Risk	6.7%	8.3	8.3
		Residual Potential Risk	3.4%	10	10
		Technology Reliability	6.7%	5.0	7.5
	Short-Term Effectiveness	Time to Achieve RAOs	4.7%	10	10
		Unmitigatable Adverse Impacts	7.1%	7.5	6.3
	Reduction of Toxicity, Mobility, or Volume Through Treatment	Destruction of Hazardous Constituents	5.9%	10	10
		Irreversibility of Treatment	5.9%	10	10
Implementability	Technical Implementability	Constructability	5.9%	10	10
		Adaptability to Modify/Update	2.0%	7.5	10
		Effectiveness of Monitoring	3.9%	7.5	7.5
	Administrative Implementability	Availability of Experts and Technology	3.9%	10	10
		Obtaining Other Approvals	7.8%	5.0	5.0
Cost	Capital Cost	-	8.8%	2.5	0
	OM&M Cost	-	8.8%	5.0	0
Environmental	Energy Use	-	5.9%	5.0	0
	Air Impacts	-	3.9%	5.0	0
	Water Resource Impacts	-	2.0%	0	0
Score:				6.9	5.9

Notes:
Shading indicates alternative was screened out.
-: no subfactors used in evaluation
OM&M: Operation, maintenance, and monitoring
RAOS: Remedial Action Objectives

Table 6-6
Intermediate Screening: Alternative 3A/Alternative 3B

Screening Criteria	Evaluation Factors	Evaluation Subfactors	Weight	Alternative 3A STBC: Excavation/On-Site Treatment WDA: Excavation/Off-Site Disposal	Alternative 3B STBC & WDA: Excavation/Off-Site Disposal
Effectiveness	Long-Term Effectiveness	Prevent Human Health Risks	6.7%	8.3	8.3
		Minimize Ecological Risk	6.7%	8.3	8.3
		Residual Potential Risk	3.4%	10	10
		Technology Reliability	6.7%	5.0	7.5
	Short-Term Effectiveness	Time to Achieve RAOs	4.7%	7.5	10
		Unmitigatable Adverse Impacts	7.1%	7.5	5.0
	Reduction of Toxicity, Mobility, or Volume Through Treatment	Destruction of Hazardous Constituents	5.9%	10	0
		Irreversibility of Treatment	5.9%	10	10
Implementability	Technical Implementability	Constructability	5.9%	7.5	10
		Adaptability to Modify/Update	2.0%	7.5	7.5
		Effectiveness of Monitoring	3.9%	7.5	7.5
	Administrative Implementability	Availability of Experts and Technology	3.9%	10	10
		Obtaining Other Approvals	7.8%	7.5	10
Cost	Capital Cost	-	8.8%	0.0	0
	OM&M Cost	-	8.8%	0.0	0
Environmental	Energy Use	-	5.9%	5.0	0
	Air Impacts	-	3.9%	5.0	0
	Water Resource Impacts	-	2.0%	0	0
Score:				6.2	5.6

Notes:
Shading indicates alternative was screened out.
OM&M: Operation, maintenance, and monitoring
RAOS: Remedial Action Objectives
STBC: southern Test Bay Canyon
WDA: Waste Discharge Area
-: no subfactors used in evaluation

Table 6-7
Intermediate Screening: Alternative 4A/Alternative 4B

Screening Criteria	Evaluation Factors	Evaluation Subfactors	Weight	Alternative 4A STBC - Excavation/ On-site Treatment WDA - Capping	Alternative 4B STBC - Capping WDA - Excavation/ Off-site Disposal
Effectiveness	Long-Term Effectiveness	Prevent Human Health Risks	6.7%	8.3	8.3
		Minimize Ecological Risk	6.7%	8.3	8.3
		Residual Potential Risk	3.4%	10	10
		Technology Reliability	6.7%	7.5	5.0
	Short-Term Effectiveness	Time to Achieve RAOs	4.7%	7.5	10
		Unmitigatable Adverse Impacts	7.1%	7.5	6.3
	Reduction of Toxicity, Mobility, or Volume Through Treatment	Destruction of Hazardous Constituents	5.9%	7.5	0
		Irreversibility of Treatment	5.9%	10	10
Implementability	Technical Implementability	Constructability	5.9%	7.5	10
		Adaptability to Modify/Update	2.0%	7.5	7.5
		Effectiveness of Monitoring	3.9%	7.5	7.5
	Administrative Implementability	Availability of Experts and Technology	3.9%	10	10
		Obtaining Other Approvals	7.8%	7.5	10
Cost	Capital Cost	-	8.8%	0	2.5
	OM&M Cost	-	8.8%	0	0
Environmental	Energy Use	-	5.9%	2.5	0
	Air Impacts	-	3.9%	2.5	0
	Water Resource Impacts	-	2.0%	0	0
Score:				6.0	5.7

Notes:
Shading indicates alternative was screened out.
OM&M: Operation, maintenance, and monitoring
RAOS: Remedial Action Objectives
STBC: southern Test Bay Canyon
WDA: Waste Discharge Area
-: no subfactors used in evaluation

Table 6-8
Intermediate Screening: Alternative 2A/Alternative 3A/Alternative 4A

Screening Criteria	Evaluation Factors	Evaluation Subfactors	Weight	Alternative 2A	Alternative 3A	Alternative 4A
				STBC and WDA: Capping	STBC: Excavation/On-Site Treatment WDA: Excavation/Off-Site Disposal	STBC: Excavation/ On-Site Treatment WDA: Capping
Effectiveness	Long-Term Effectiveness	Prevent Human Health Risks	6.7%	8.3	8.3	8.3
		Minimize Ecological Risk	6.7%	8.3	8.3	8.3
		Residual Potential Risk	3.4%	10	10	10
		Technology Reliability	6.7%	5.0	7.5	7.5
	Short-Term Effectiveness	Time to Achieve RAOs	4.7%	10	8.8	8.8
		Unmitigatable Adverse Impacts	7.1%	7.5	6.3	7.5
	Reduction of Toxicity, Mobility, or Volume Through Treatment	Destruction of Hazardous Constituents	5.9%	0	8.8	8.8
		Irreversibility of Treatment	5.9%	10	10	10
Implementability	Technical Implementability	Constructability	5.9%	10.0	7.5	7.5
		Adaptability to Modify/Update	2.0%	7.5	7.5	7.5
		Effectiveness of Monitoring	3.9%	7.5	7.5	7.5
	Administrative Implementability	Availability of Experts and Technology	3.9%	10	10	10
		Obtaining Other Approvals	7.8%	10.0	7.5	8
Cost	Capital Cost	-	8.8%	2.5	0	0
	OM&M Cost	-	8.8%	0	10	0
Environmental	Energy Use	-	5.9%	0	2.5	2.5
	Air Impacts	-	3.9%	0	2.5	2.5
	Water Resource Impacts	-	2.0%	0	0	0
Score:				5.8	6.9	6.1

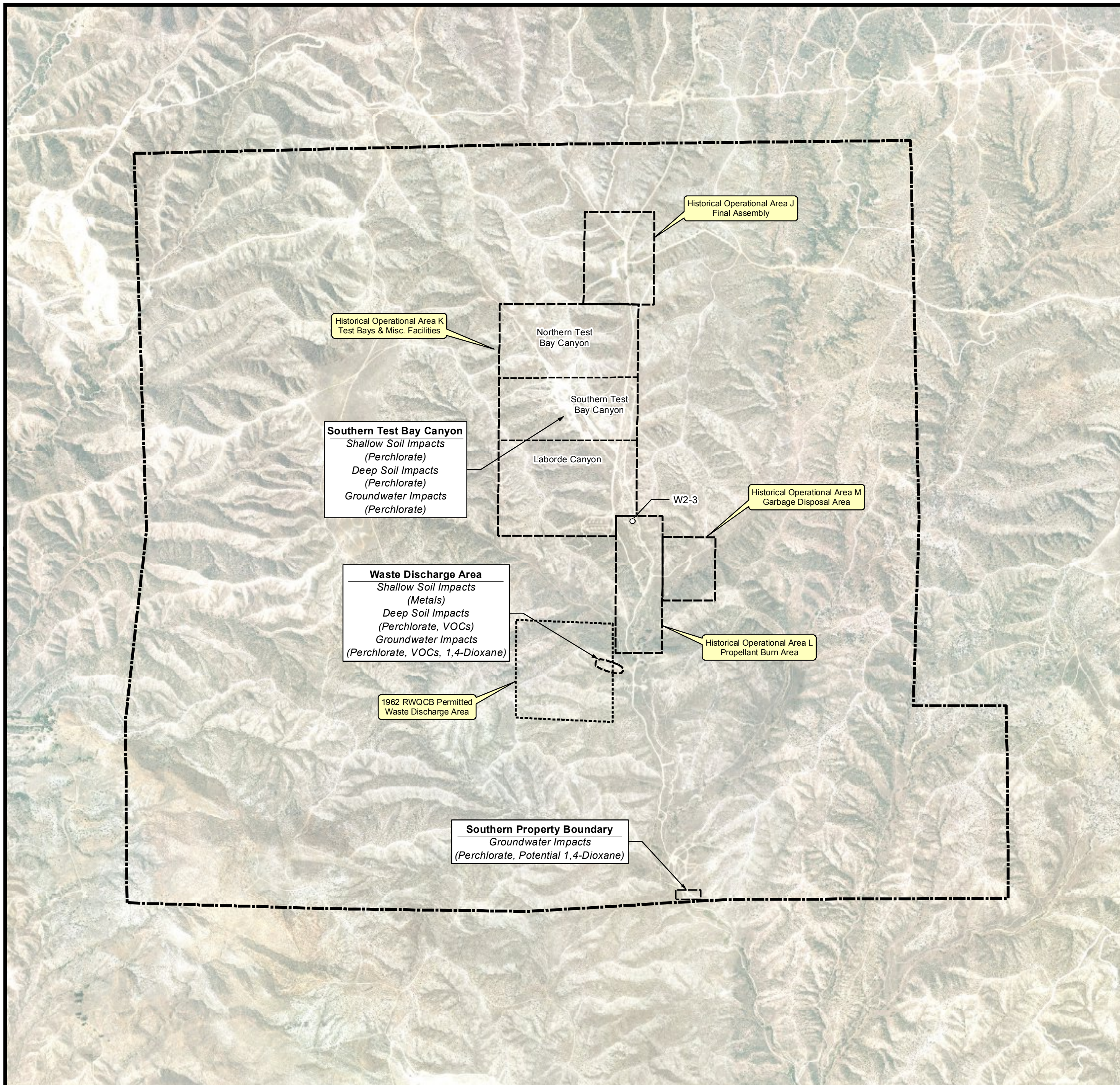
Notes:
Shading indicates alternative was screened out.
OM&M: Operation, maintenance, and monitoring
RAOS: Remedial Action Objectives
STBC: Southern Test Bay Canyon
WDA: Waste Discharge Area
-: No subfactors used in evaluation

Table 6-9
Remedial Alternative Screening Results

Screening Criteria	Evaluation Factors	Evaluation Subfactors	Weight	Alternative 0 No Action	Alternative 1 Institutional Controls	Alternative 3A Shallow Soil Removal; Plume Containment; Institutional Controls	Alternative 5A Source Area Mass Removal (Bioflush/P&T in STBC), Shallow Soil Removal, Plume Containment, Institutional Controls	Alternative 5B Source Area Mass Removal (*In Situ* Bioremediation in STBC), Shallow Soil Removal, Plume Containment, Institutional Controls	Alternative 5C Source Area Mass Removal (Bioflush/P&T/*In Situ* Bio in STBC), Shallow Soil Removal, Plume Containment, Institutional Controls	Alternative 6A Source Area Mass Removal (Bioflush/P&T in STBC and WDA), Shallow Soil Removal, Plume Containment, Institutional Controls	Alternative 6B Source Area Mass Removal (*In Situ* Bioremediation in STBC and WDA), Shallow Soil Removal, Plume Containment, Institutional Controls	Alternative 6C Source Area Mass Removal (Bioflush/P&T/*In Situ* Bio in STBC and WDA), Shallow Soil Removal, Plume Containment; Institutional Controls
Effectiveness	Long-Term Effectiveness	Prevent Human Health Risks	6.7%	3.3	3.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
		Minimize Ecological Risk	6.7%	0	0	8.3	8.3	8.3	8.3	8.3	8.3	8.3
		Residual Potential Risk	3.4%	0	0	10	10	10	10	10	10	10
		Technology Reliability	6.7%	0	0	7.5	6.3	5.0	6.3	6.3	5.0	6.3
	Short-Term Effectiveness	Time to Achieve RAOs	4.7%	0	0	10	10	10	10	10	10	10
		Unmitigatable Adverse Impacts	7.1%	10	10	7.5	7.5	6.3	5.0	2.5	2.5	2.5
	Reduction of Toxicity, Mobility, or Volume Through Treatment	Destruction of Hazardous Constituents	5.9%	0	0	0	7.5	5	7.5	10	7.5	10
		Irreversibility of Treatment	5.9%	0	0	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Implementability	Technical Implementability	Constructability	5.9%	10	10	7.5	6.3	6.3	6.3	5.0	5.0	5.0
		Adaptability to Modify/Update	2.0%	0	0	7.5	5.0	5.0	5.0	5.0	5.0	5.0
		Effectiveness of Monitoring	3.9%	0	10	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Administrative Implementability	Availability of Experts and Technology	3.9%	10	10	10	10	10	10	10	10	10
		Obtaining Other Approvals	7.8%	0	0	7.5	5.0	5.0	2.5	5.0	5.0	3
Cost	Capital Cost	-	8.8%	10	10	7.5	2.5	5.0	2.5	0.0	0	0
	OM&M Cost	-	8.8%	10	10	5.0	2.5	2.5	2.5	0	2.5	0
Environmental	Energy Use	-	5.9%	10	10	7.5	5.0	5.0	5.0	0	2.5	0
	Air Impacts	-	3.9%	10	10	7.5	7.5	5.0	5.0	2.5	2.5	2.5
	Water Resource Impacts	-	2.0%	0	0	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Score:				4.7	5.0	7.2	6.4	6.2	5.9	5.2	5.3	5.0

Notes:
Shading indicates alternative was screened out.
GW: Groundwater
OM&M: Operation, maintenance, and monitoring
P&T: Pump and Treat
RAOS: Remedial Action Objectives
STBC: southern Test Bay Canyon
WDA: Waste Discharge Area
-: no subfactors used in evaluation

Section 6 Figures



0 1,000 2,000 Feet

Adapted from:
March 2007 aerial photograph.

LEGEND

- 1962 RWQCB Permitted Waste Discharge Area
- Historical Operational Area Boundary
- Beaumont Site 2 Property Boundary

Note: Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 6-1

Potential Remediation Areas

TETRA TECH

Section 7
Detailed and Comparative Analysis of Remedial Alternatives

This section presents a detailed evaluation of the remedial alternatives retained from the preliminary screening performed in Section 6 with respect to the criteria set forth in the United States Environmental Protection Agency (USEPA) National Oil and Hazardous Substances Pollution Contingency Plan [40 CFR, Part 300]. These criteria and their relative importance are described below.

- **Overall protection of human health and the environment (threshold criteria)**: Remedial alternatives must be assessed for adequate protection of human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances or contaminants at the site. This is accomplished by eliminating, reducing, or controlling exposure to contaminant levels exceeding preliminary remediation goals (PRGs), and is generally accomplished through treatment or engineering/institutional controls.

- **Compliance with applicable or relevant and appropriate requirements (threshold criteria)**: Alternatives must be assessed to determine whether applicable or relevant and appropriate requirements (ARARs) under federal environmental laws and state environmental or facility siting laws (see Section 2.3.2) are attained, or whether a waiver is warranted. In addition, all federal, state, and local permits must be obtained.

- **Long-term effectiveness and permanence (balancing criteria)**: Long-term effectiveness and permanence are evaluated in terms of the magnitude of residual risk and the adequacy and reliability of controls used to manage remaining waste (untreated waste and treatment residuals) over the long term. Alternatives that afford the highest degrees of long-term effectiveness and permanence leave little or no waste at the site, such that long-term maintenance and monitoring are unnecessary and reliance on institutional controls is minimized.

- **Reduction of toxicity, mobility, or volume through treatment (balancing criteria)**: The evaluation of alternatives regarding reduction of toxicity, mobility, or volume (TMV) through treatment addresses the anticipated performance of the treatment technologies used in a remedy. This evaluation relates to the statutory preference for selecting a remedial action that employs treatment to reduce the TMV of hazardous substances. Aspects of this criterion include the amount of waste treated or destroyed; the reduction in TMV; the irreversibility of the treatment process; and the type and quantity of residuals resulting from any treatment process.

- **Short-term effectiveness (balancing criteria)**: Evaluation of alternatives with respect to short-term effectiveness takes into account protection of workers and the community during the remedial action, environmental impacts from implementing the action, and the time required to achieve cleanup goals.

- **Implementability (balancing criteria)**: Under the analysis of implementability, each alternative is evaluated for technical and administrative feasibility of implementation and the availability of necessary goods and services. This criterion includes items such as the ability to construct and operate components of the alternatives; the ability to obtain services, capacities, equipment, and specialists; the ability to monitor the performance and effectiveness of technologies; and the ability to obtain necessary approvals from other agencies.

- **Cost (balancing criteria)**: Capital costs (remedial design, remedial implementation, project management), including both direct and indirect costs; annual operations, maintenance, and monitoring (OM&M) costs incurred over the life of the remedial action; and project closure costs incurred at the end of the project, are calculated for each alternative. The net present value (NPV) of the capital and OM&M costs, based on a maximum 50-year operating period, is used to provide an economic comparison of the alternatives. The NPV is obtained assuming a 7% discount rate, as per guidance from the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (USEPA, 1988). The cost estimate accuracy range is within the -30% to +50% order-of-magnitude guideline range (USEPA, 1988).

- **State acceptance (modifying criteria)**: The state acceptance criterion incorporates input from state agencies regarding the alternative selection process and final selected remedy. Regulator concerns that must be assessed include the position and key concerns of the USEPA and the state relative to the preferred and other alternatives, and USEPA and state comments on ARARs or the proposed use of waivers. These concerns cannot be evaluated until the agencies have reviewed and commented on the feasibility study (FS).

- **Community acceptance (modifying criteria)**: The FS, which includes the recommended remedial alternative, is made available to the public for review and comment. This criterion consists of community responses to the selected remedy. Comments from the public on the selected remedy will be assessed at the conclusion of the public comment period.

The two threshold criteria must be satisfied for an alternative to be eligible for selection, while the five balancing criteria are used to weigh the relative merits of the alternatives being evaluated. The modifying criteria must be considered during remedy selection, and are evaluated only after the FS has been reviewed by the Department of Toxic Substances Control (DTSC) and an alternative has been selected and public comments considered. Therefore, the modifying criteria are not addressed in this report.

One non-CERCLA criterion, sustainability, is also evaluated in this FS. Sustainability is an important consideration for both Lockheed Martin Corporation and DTSC, and is evaluated to minimize the environmental footprint of the remedial action, while still protecting human health and the environment.

Each alternative retained for detailed analysis is individually evaluated against the two threshold criteria, five balancing criteria, and sustainability in the detailed analysis. A comparative analysis is then performed, which compares the alternatives against each other to weigh their specific strengths and weaknesses with respect to each of the evaluation criteria. Based on the results of the detailed analysis and the comparative analysis, a preferred remedial alternative is selected for recommended implementation.

Prior to conducting the detailed analysis, the alternatives retained from the preliminary screening process were advanced from the conceptual descriptions in Section 6 to a more complete design. The detailed analysis of alternatives is provided in Section 7.1, and the comparative analysis of alternatives is provided in Section 7.2. Based on the results of the detailed and comparative analyses, the alternatives are scored using a methodology similar to that presented in Section 6.3. The alternative scoring methodology and results are presented in Section 7.3. The remedial alternatives advanced for detailed analysis include:

- Alternative 0—No Action
- Alternative 3A—Shallow Soil Removal, Plume Containment, and Institutional Controls
- Alternative 5A—Source Area Mass Removal (Soil and Groundwater in southern Test Bay Canyon [STBC]), Shallow Soil Removal, Plume Containment, and Institutional Controls
- Alternative 5B—Source Area Mass Removal (Groundwater Only in STBC), Shallow Soil Removal, Plume Containment, and Institutional Controls

7.1 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

As discussed above, each remedial alternative was evaluated based on the CERCLA threshold criteria, balancing criteria, and sustainability. Cost estimates were based on the alternative descriptions provided in Section 6. The estimates include both capital and OM&M costs incurred over a maximum 50-year operating period. The NPV costs were calculated assuming a 7%

discount rate, per CERCLA guidance (USEPA, 1988). The cost estimates are considered to have an accuracy of -30% to +50%. Copies of the cost estimates are provided in Appendix E.

For the detailed evaluation, sustainability was evaluated using the *SiteWise*™ software tool, which quantitatively estimates a number of sustainability metrics, including energy consumption, greenhouse gas (GHG) emissions, criteria air pollutant emissions, water consumption, worker safety, resource consumption, and the cost of footprint reduction for each remedial alternative based on site-specific data and knowledge of the qualitative metrics (ecological and community impacts). The results of the *SiteWise*™ analysis of the alternatives are provided in Appendix F.

7.1.1 Alternative 0—No Action

The detailed analysis of Alternative 0 is presented in the following sections.

7.1.1.1 Threshold Criteria

Overall protection of human health and the environment: The No Action alternative provides a baseline for comparing other alternatives. Long-term human health and environmental risks for the site essentially would be the same as were identified in the human health and ecological risk assessment (Tetra Tech, 2012b), because no remedial activities would be implemented with the No Action alternative. No control of exposure to contaminated soil and/or groundwater would be provided; therefore, there would be no reduction in risk to human health or ecological receptors.

Compliance with ARARs and other guidance: The No Action alternative would not meet chemical-specific ARARs for groundwater, because it does not address migration of contaminants beyond the southern boundary of the property or potential threats to beneficial uses of groundwater in the San Jacinto Groundwater Basin.

7.1.1.2 Balancing Criteria

Long-term effectiveness and permanence: This alternative would not provide long-term effectiveness and permanence. All current and potential future risks would remain under this alternative, and no controls would be implemented for managing exposure or remaining waste.

Reduction of toxicity, mobility, or volume through treatment: This alternative would not reduce TMV of the contaminated soil and groundwater through removal or treatment.

Short-term effectiveness: No additional risks would be posed to the community, workers, or the environment as a result of implementation of this alternative.

Implementability: This alternative is highly implementable since no action would be taken.

Cost: The NPV cost would be zero since no action would be taken.

7.1.1.3 Sustainability

Sustainability: Alternative 0 is highly sustainable, since no action would be taken. No energy or resources would be consumed, no GHG would be generated, and no waste would be generated.

7.1.2 Alternative 3A—Limited Soil Removal, Plume Containment, and Institutional Controls

Detailed analysis of Alternative 3A is presented in the following sections. Figures 7-1 through 7-3 show the excavation locations, potential treatment cell locations, the layout for the biobarrier in south Laborde Canyon and for the groundwater extraction and treatment system.

7.1.2.1 Threshold Criteria

Overall protection of human health and the environment: Alternative 3A will protect human health and the environment. Potential exposure to shallow perchlorate-contaminated soil that exceeds the PRG of 1,700 micrograms/kilogram (µg/kg) in STBC would be eliminated by excavation and *ex situ* biotreatment. Potential exposure to shallow metals-impacted soil that exceeds PRGs in the Waste Discharge Area (WDA) would be eliminated by excavation and off-site disposal.

Potential human exposure to groundwater on the property would be eliminated through institutional controls that prohibit the installation of groundwater wells and the use of groundwater. Potential human exposure to impacted groundwater south of the property boundary would be eliminated by the installation of a biobarrier in south Laborde Canyon, near the southern property boundary, which would prevent perchlorate contamination from migrating off-property. The small quantity (roughly one pound) of perchlorate that has already migrated off-property would be allowed to dissipate through natural attenuation within the off-property riparian corridor. Potential human exposure to 1,4-dioxane in off-property groundwater in the future would be addressed by including a contingency to switch from a biobarrier to hydraulic containment and *ex* *situ* treatment if concentrations eventually exceed Drinking Water Notification Levels (DWNLs) or other applicable drinking water criteria.

Groundwater within Laborde Canyon is not considered to be a potential source of drinking water because estimated average well yields are well under the 200 gallons per day threshold promulgated in State Water Resources Control Board Resolution No. 88-63 (Sources of Drinking Water Policy). Beneficial uses of groundwater resources in the San Jacinto Groundwater Basin will be protected by containing contamination at the property boundary, as discussed above, and through long-term monitoring of guard wells located upgradient of the basin.

Compliance with ARARs and other guidance: Alternative 3A will comply with all applicable ARARs presented in Section 3. Most of the identified chemical-specific ARARs and to be considered (TBC) criteria are either water quality standards for drinking water or documents specifying beneficial uses of groundwater resources. These standards do not apply to on-property groundwater because drinking water supply is not considered to be a beneficial use (as discussed above and in Section 4.3.2.2), and because the use of on-property groundwater for drinking water supply purposes is prohibited by existing land use covenants (LUCs). Compliance with chemical-specific ARARs in groundwater south of the property boundary would be achieved by containment of groundwater contamination at the southern boundary of the property with a biobarrier and hydraulic containment system, if necessary.

Compliance with location-specific ARARs would be accomplished through Endangered Species Act (ESA) and California Endangered Species Act permitting with the United States Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG), respectively; and by obtaining all necessary federal and state permits required for dredge-and-fill within the Laborde Canyon drainage channel. Compliance with other location-specific ARARs would be evaluated in more detail during the California Environmental Quality Act (CEQA) permitting process.

Compliance with action-specific ARARs would be achieved by obtaining all required permits and permissions, including Waste Discharge Requirements, for general construction activities, for the injection of an electron donor into groundwater, for discharge of treated groundwater to the subsurface, and for discharge of treated soil to land.

7.1.2.2 Balancing Criteria

Long-term effectiveness and permanence: Alternative 3A provides a high level of effectiveness and permanence since all shallow contaminated soil that exceeds PRGs would be either treated or removed from the site. Additionally, contaminants would be permanently removed from groundwater at the southern boundary of the property by the biobarrier or hydraulic containment system. Existing LUCs will effectively prevent use of groundwater on the property for drinking water supply purposes. The overall reliability of the controls is considered to be excellent.

Reduction of toxicity, mobility, or volume through treatment: Alternative 3A achieves protectiveness through the reduction of TMV of site contaminants, as well as through the implementation of LUCs. Treatment of soil at STBC would reduce the mass of perchlorate in soil, although the small quantity of metals-impacted soil at the WDA would be transported to an off-site landfill. The biobarrier and pump and treat (P&T) system in south Laborde Canyon would provide containment through the treatment of contaminants. All of the proposed treatment processes are irreversible.

Although Alternative 3A uses reduction of TMV as a strategy for achieving protectiveness, the total mass of contaminants to be removed or destroyed is relatively small: approximately 20 pounds of perchlorate from soil treatment in STBC, and less than one pound of perchlorate per year (under present conditions) at the southern property boundary, although this could increase to as much as 10 pounds of perchlorate per year once the higher concentration portion of the plume migrates to the property boundary.

Short-term effectiveness: Alternative 3A may temporarily increase exposure to dust due to soil excavation, treatment, and backfill activities. Dust generation would be minimized through engineering controls implemented by the contractor and specified in the work plan. There would be a nominal increase in transportation-related risks in the short term due to trucking required for hauling contaminated soil from the WDA to off-site disposal facilities, and importing clean soil and/or crushed rock to the site. Workers and ecological receptors could be exposed to site contaminants and construction-related risks during implementation of this alternative. Risks to workers would be minimized by compliance with requirements of the federal Occupational Safety and Health Administration and California Occupational Safety and Health Administration, including wearing appropriate personal protective equipment, adhering to site-specific health and safety procedures, and complying with general construction requirements. Risks to wildlife would be minimized by compliance with the requirements of ESA permits with the USFWS and CDFG.

During longer-term operation of the south Laborde Canyon plume containment system (biobarrier and P&T system), there would be nominal risks to the surrounding community from transportation of treatment chemicals to the site and transportation of spent ion exchange resin for off-site disposal. Transportation risks would be limited through compliance with United States Department of Transportation regulations.

Implementability: Alternative 3A is readily implementable. Shallow soil excavation is straightforward at STBC and the WDA, since contaminants targeted for removal are located in shallow soil and the soil can be excavated easily with standard, readily available equipment. Transportation and off-site disposal of soil from the WDA is readily managed through local transportation firms, and appropriate landfills are available that can accept the excavated soil. Treatment of the shallow soil from the STBC presents more complexity due to construction of the aboveground treatment cells for anaerobic treatment; however, qualified contractors are available to perform the work. Additional effort may be required in STBC for trapping and relocating SKR prior to construction. Implementation of this alternative would require trapping on an estimated 0.5 to 1 acre. Qualified personnel are locally available to perform this trapping.

Qualified contractors and required equipment are readily available for the installation of wells and piping for the south Laborde Canyon biobarrier and groundwater extraction system. Appropriate package treatment systems are available from a number of vendors. Power would need to be installed and extended to the South Boundary Area to operate the *ex situ* treatment systems. Power could be connected at Highway 60, and a number of qualified local electrical contractors are available to perform this work.

The resources, equipment, and materials required for sampling and maintenance of monitoring wells and remediation systems are readily available. Finally, Alternative 3A is feasible administratively with respect to obtaining approvals and/or necessary permits from local, state, and federal agencies.

Cost: Detailed cost estimates for Alternative 3A are included in Appendix E. A summary of the estimated costs for Alternative 3A is provided in the table below.

ALTERNATIVE 3A		
	Current Value	**Net Present Value**
Capital Cost (Implementation and Closure costs)	$4,720,000	$2,610,000
OM&M Cost	$31,030,000	$7,460,000
Total 50-year Cost	$35,740,000	$10,070,000

7.1.2.3 Sustainability

Alternative 3A is moderately sustainable since it will pose some short-term and long-term impacts from emissions (GHG, nitrogen oxides [NOx], sulphur oxides [SOx], and particulate matter less than 10 microns in diameter [PM_{10}]), energy use, and water consumed. Greenhouse gas, NOx, and SOx emissions and energy consumption impacts would be greatest during long-term OM&M due to vehicular trips for system inspections. Chemical consumption (e.g., electron donor, ion exchange resin, and hydrogen peroxide) would be the highest during the OM&M period. PM_{10} impacts would be greatest during the remedial action construction phase, primarily due to earthwork activities including excavation, construction of treatment cells, and soil transport to and from the treatment area.

If a P&T system is installed at the southern property boundary, it is estimated that it would use as much as 200,000 kilowatt hours of electrical power annually, although this rate would vary as groundwater quality changes over time. Treatment, and thus energy use, could be expected to continue for greater than 100 years. The electrical energy use of the system may indirectly lead to GHG generation if that power is generated from fossil fuels. Renewable energy sources could be investigated during the system design phase. Production of chemicals used in treatment would also contribute to energy use and GHG production. The P&T system would also consume hydrogen peroxide and generate spent ion exchange resin. Disposal of spent ion exchange resin is expected to occur as frequently as once every 5 years. Note that the P&T system is a contingency (but included in the costs presented for the alternative); a focused feasibility study will be conducted to evaluate potential alternatives if 1,4-dioxane treatment becomes necessary in the future.

7.1.3 Alternative 5A—Source Area Mass Removal (Bioflushing and Pump and Treat in Southern Test Bay Canyon), Shallow Soil Removal, Plume Containment, and Institutional Controls

The detailed analysis of Alternative 5A is presented in the following sections. Figures 7-1 through 7-3 show the excavation locations, potential treatment cell location, the layout for the biobarrier in south Laborde Canyon and for the groundwater extraction and treatment system. Figure 7-4 shows the layout of the groundwater extraction and bioflushing system.

7.1.3.1 Threshold Criteria

Overall protection of human health and the environment: Alternative 5A includes all of the elements of Alternative 3A, and will therefore similarly protect human health and the environment. Removal of perchlorate mass from deep soil in STBC will not increase the protectiveness of Alternative 5A, because potential human and ecological receptors would not be exposed to deep soil. Although removal of perchlorate mass from deep soil and groundwater in STBC is likely to reduce the overall time for groundwater restoration, these actions are not expected to reduce the restoration time frame to less than 100 years (and probably far longer), and do not address removal of perchlorate, 1,4-dioxane, and volatile organic compound mass in the WDA.

Compliance with ARARs and other guidance: Alternative 5A includes all of the elements of Alternative 3A, and will similarly meet all applicable ARARs, as discussed in Section 7.1.2.1.

7.1.3.2 Balancing Criteria

Long-term effectiveness and permanence: Alternative 5A includes all of the elements of Alternative 3A, and the common elements are considered to provide a similar level of long-term effectiveness and permanence.

Alternative 5A also includes *in situ* bioflushing of deep soils and extraction and *ex situ* treatment of groundwater to reduce the mass of perchlorate within the STBC source area. These technologies are both considered effective. The overall reliability of the controls is considered to be excellent.

Reduction of toxicity, mobility, or volume through treatment: Alternative 5A includes all of the elements of Alternative 3A, and the common elements are considered to provide a similar level of TMV reduction. Alternative 5A also includes *in situ* bioflushing of deep soils and extraction and *ex situ* treatment of groundwater to reduce the mass of perchlorate within the STBC source area, which is the largest source area at the site. The inclusion of these elements provides a higher level of TMV reduction compared with Alternative 3A alone.

Short-term effectiveness: Alternative 5A includes all of the elements of Alternative 3A, and the common elements are considered to have similar short-term effects on the community, workers, and the environment. The additional elements in Alternative 5A may result in temporary increases in dust exposure and transportation risks to the community, increased risk to workers, and increased risk to wildlife during construction and OM&M of the bioflushing and P&T system. These risks would be mitigated as described in Section 7.1.2.2.

Implementability: Alternative 5A includes all of the elements of Alternative 3A, and the common elements are considered to be similarly implementable. The addition of the bioflushing and P&T system causes additional construction and operational complexity, additional permitting requirements for the discharge of treated groundwater, and additional complexity in modifying the system, which relies on maintaining a balance between groundwater production from the extraction system (which is of uncertain reliability) and groundwater discharge to the infiltration galleries. The reliability of bioflushing and groundwater extraction for reducing contaminant mass is also uncertain, because of the heterogeneity of the San Timoteo formation (STF).

Cost: Detailed cost estimates for Alternative 5A are included in Appendix E. A summary of the estimated costs for Alternative 5A is provided in the table below.

ALTERNATIVE 5A		
	Current Value	**Net Present Value**
Capital Cost (Implementation and Closure)	$5,560,000	$3,640,000
OM&M Cost	$31,840,000	$8,090,000
Total 50-year Cost	$37,400,000	$11,720,000

7.1.3.3 Sustainability

Alternative 5A includes all of the elements of Alternative 3A, and the common elements are considered to have similar energy use, air emissions, and water resources impacts. Energy use and air emissions would increase due to construction and OM&M of the STBC bioflushing and P&T system. The bioflushing system would have negligible impacts to water resources because it would use treated groundwater as a water source. Impacts due to the use of manufactured ion exchange resin are nominal, due to the small amounts of resin used.

7.1.4 Alternative 5B—Source Area Mass Removal (*In Situ* Bioremediation of Groundwater in Southern Test Bay Canyon), Shallow Soil Removal, Plume Containment, and Institutional Controls

The detailed analysis of Alternative 5B is presented in the following sections. Figures 7-1 through 7-3 show the excavation locations, potential treatment cell locations, the layout for the biobarrier in south Laborde Canyon and for the contingency groundwater extraction and treatment system. Figure 7-5 shows the layout of the *in situ* biotreatment system layout.

7.1.4.1 Threshold Criteria

Overall protection of human health and the environment: Alternative 5B includes all of the elements of Alternative 3A, and will therefore similarly protect human health and the environment. Removal of contaminant mass from groundwater at STBC will not increase the protectiveness of Alternative 5B, because potential human and ecological receptors will not be exposed to groundwater. Although removal of contaminant mass from groundwater in STBC will reduce the overall time for groundwater restoration, these actions are not expected to reduce the restoration time frame to less than 100 years.

Compliance with ARARs and other guidance: Alternative 5B includes all of the elements of Alternative 3A and will similarly meet all applicable ARARs, as discussed in Section 7.1.2.1.

7.1.4.2 Balancing Criteria

Long-term effectiveness and permanence: Alternative 5B includes all of the elements of Alternative 3A, and the common elements are considered to provide a similar level of long-term effectiveness and permanence.

Alternative 5B also includes *in situ* bioremediation of groundwater to reduce the mass of perchlorate within the STBC source area. This technology is in common use, and is considered to be effective. The overall reliability of the controls is considered to be excellent.

Reduction of toxicity, mobility, or volume through treatment: Alternative 5B includes all of the elements of Alternative 3A, and the common elements are considered to provide a similar level of TMV reduction. Alternative 5B also includes *in situ* bioremediation of groundwater to reduce the mass of perchlorate within the STBC source area. The inclusion of this element provides a higher level of TMV reduction compared with Alternative 3A alone.

Short-term effectiveness: Alternative 5B includes all of the elements of Alternative 3A, and the common elements are considered to have similar short-term effects on the community, workers, and the environment. The additional elements in Alternative 5B may result in temporary increases in dust exposure and transportation risks to the community, increased risk to workers, and increased risk to wildlife during construction and OM&M of the *in situ* bioremediation system. These risks would be mitigated as described in Section 7.1.2.2.

Implementability: Alternative 5B includes all of the elements of Alternative 3A, and the common elements are considered to be similarly implementable. The addition of the *in situ* bioremediation element causes additional construction and operational complexity and additional permitting requirements for the injection of electron donor into groundwater. Modifying the *in situ* bioremediation system to encompass a larger or smaller area is straightforward; however, modifications to increase treatment efficiency in heterogeneous aquifer materials would increase the complexity of this alternative. The reliability of *in situ* bioremediation for reducing contaminant mass is uncertain due to the heterogeneous nature of the aquifer and the presence of fine-grained materials in the subsurface.

Cost: Detailed cost estimates for Alternative 5B are included in Appendix E. A summary of the estimated costs for Alternative 5B is provided in the table below.

ALTERNATIVE 5B		
	Current Value	**Net Present Value**
Capital Cost (Implementation and Closure)	$5,750,000	$3,900,000
OM&M Cost	$31,520,000	$7,830,000
Total 50-year Cost	$37,270,000	$11,720,000

7.1.4.3 Sustainability

Alternative 5B includes all of the elements of Alternative 3A, and the common elements are considered to have similar energy use, air emissions, and water resources impacts. Energy use, air emissions, and water resource impacts would increase during construction and OM&M of the *in situ* bioremediation system.

7.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

In the comparative analysis, the remedial alternatives are evaluated in relation to one another to identify the relative advantages and disadvantages of each with respect to the CERCLA evaluation criteria.

7.2.1 Overall Protection of Human Health and the Environment

Alternative 0 would not protect human health and the environment, because contaminants in soil that currently exceed human health and ecological PRGs would not be addressed, institutional controls would not be enforced, and contaminated groundwater would be allowed to continue to migrate off-property.

Alternatives 3A, 5A, and 5B equally protect human health and the environment through the following actions:

- Addressing risks to ecological receptors by excavation and *ex situ* treatment of shallow perchlorate-contaminated soil that exceeds the PRG of 1,700 µg/kg in STBC
- Addressing risks to human and ecological receptors by excavation and off-site disposal of shallow metals-impacted soil that exceeds PRGs in the WDA
- Addressing human exposure to contaminants in on-property groundwater by implementing LUCs that prohibit the installation of groundwater wells and the use of groundwater
- Addressing potential human exposure to contaminants in off-property groundwater and protecting beneficial uses of groundwater resources in the San Jacinto Groundwater Basin by: installing a biobarrier near the southern property boundary, which would prevent perchlorate contamination from migrating off-property, and by including a contingency to switch from a biobarrier to a hydraulic containment and *ex situ* treatment system if 1,4-dioxane concentrations eventually exceeded ARARs. The small quantity (roughly one pound) of perchlorate that has already migrated off-property will be allowed to dissipate through natural attenuation within the riparian corridor south of the property boundary. Long-term monitoring of guard wells located upgradient of the San Jacinto Groundwater Basin will further protect the beneficial uses of groundwater resources.

Alternatives 5A and 5B also include treatment to reduce the mass of perchlorate in deep soil and/or groundwater in STBC. Deep soil treatment does not increase protectiveness of Alternative 5A because potential human and ecological receptors would not be exposed to deep soil. Groundwater and deep soil treatment that reduces contaminant mass would also reduce the overall time for groundwater restoration, but these actions are not expected to reduce the restoration time frame to less than 100 years. These additional measures are therefore not considered to significantly increase the protectiveness of Alternatives 5A and 5B, relative to Alternative 3A.

7.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

All of the alternatives, except Alternative 0 (No Action), will comply with ARARs.

Most of the identified chemical-specific ARARs and TBC criteria are either water quality standards for drinking water or documents specifying beneficial uses of groundwater resources. These standards do not apply to groundwater beneath the property because drinking water supply is not considered to be a beneficial use (as discussed above and in Section 4.3.2.2), and because access to and use of groundwater beneath the property for drinking water supply purposes is prohibited by existing LUCs. Alternatives 3A, 5A, and 5B will comply with chemical-specific ARARs in groundwater south of the property boundary through containment of groundwater contamination at the southern boundary of the property with a biobarrier and hydraulic containment system.

Alternatives 3A, 5A, and 5B will comply with location-specific ARARs through Endangered Species Act and California Endangered Species Act permitting with the USFWS and the CDFG, respectively; and by obtaining all necessary federal and state permits required for dredge-and-fill within the Laborde Canyon drainage channel. Compliance with other location-specific ARARs will be evaluated in more detail during the CEQA permitting process.

Alternatives 3A, 5A, and 5B will comply with action-specific ARARs by obtaining all required permits and permissions, including Waste Discharge Requirements for the injection of electron donor into groundwater, discharge of treated groundwater to the subsurface, and discharge of treated soil to land.

7.2.3 Long-Term Effectiveness and Permanence

Alternative 0 does not provide long-term effectiveness or permanence because no actions would be taken to address contamination in soil and groundwater, institutional controls would not be enforced, and contaminated groundwater would be allowed to continue to migrate south of the property boundary.

Alternatives 3A, 5A, and 5B provide a similar degree of protection against residual risk, and the reliability of controls is considered to be very similar.

7.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 0 provides no reduction in TMV of the contaminants through treatment. Alternative 3A provides a small reduction in perchlorate mass in soil (roughly 20 pounds) through *ex situ* treatment of soil in STBC, and a small reduction in perchlorate mass in groundwater (<1 pound per year under current conditions, and approximately 10 pounds per year once the high concentration portion of the groundwater plume migrates to the property boundary) through the biobarrier in south Laborde Canyon.

Alternative 5A provides a larger reduction of TMV by addressing perchlorate mass in both deep soil and groundwater in STBC by bioflushing and groundwater extraction. Alternative 5B reduces TMV by addressing perchlorate mass in groundwater through *in situ* bioremediation. Although both alternatives reduce the source area contaminant mass in STBC, Alternative 5A has the greater potential for reducing TMV because it would reduce the contaminant mass in soil as well as groundwater, and thus reduce the long-term contaminant-mass flux from soil to groundwater.

7.2.5 Short-Term Effectiveness

Alternative 0 has no short-term impacts to the community, workers, or the environment because no actions would be taken. However, this alternative will not achieve the RAOs, and risks to human health and the environment will remain as they are currently.

Alternatives 3A, 5A, and 5B have similar impacts to the community and the environment. However, risks to workers are considered to be greater for Alternatives 5A and 5B relative to Alternative 3A, due to the greater amount of construction and OM&M associated with these alternatives and the higher potential for exposure to highly-contaminated soil and groundwater. Alternatives 3A, 5A, and 5B will achieve the RAOs over a similar time frame.

7.2.6 Implementability

Alternative 0 requires no action and is therefore readily implementable. Alternatives 3A, 5A, and 5B have similar implementability in terms of availability of technology and effectiveness of monitoring, but Alternatives 5A and 5B entail increased complexity and permitting, and are less adaptable than Alternative 3A. In addition, the reliability of bioflushing and groundwater extraction, or *in situ* bioremediation, for reducing contaminant mass is dependent on subsurface conditions. The STF is very heterogeneous and contains fine-grained materials, which reduce the reliability of Alternatives 5A and 5B compared with Alternative 3A. Of the three alternative that involve remedial actions, Alternative 3A is considered to the most implementable, followed by Alternatives 5A and 5B, which are considered equally implementable.

7.2.7 Cost

Capital and total NPV costs of each alternative are summarized below.

COST COMPARISON		
Alternative	**Current Value (Unescalated)**	**Net Present Value (Unescalated)**
Alternative 0	$ 0	$ 0
Alternative 3A	$ 35,740,000	$ 10,070,000
Alternative 5A	$ 37,400,000	$ 11,720,000
Alternative 5B	$ 37,270,000	$ 11,720,000

Alternative 0 has no associated costs. Both current value and NPV costs for Alternative 3A are somewhat lower than costs for Alternatives 5A and 5B. Detailed cost estimates are included in Appendix E.

7.2.8 Sustainability

Alternative 0 is highly sustainable, since no action would occur. No energy or resources would be consumed, no GHG would be generated, and no waste would be generated. Alternative 3A consumes energy and generates air emissions due to construction and operation of treatment systems. This alternative would also consume manufactured chemicals (i.e., electron donor, ion exchange resin, and/or hydrogen peroxide) used to treat perchlorate contamination at the south Laborde Canyon biobarrier, and potentially to treat 1,4-dioxane contamination if concentrations eventually exceed MCLs at the southern property boundary.

Alternative 5A includes all of the sustainability issues noted for Alternative 3A, plus additional energy use and air emissions from construction of the bioflushing and groundwater P&T systems in STBC, with associated OM&M. Construction of the infiltration galleries would involve transportation of crushed rock to the site and consumption of manufactured materials, such as polyvinyl chloride (PVC) piping. Treated groundwater would be used as the source of water for infiltration, thus reducing water consumption. This alternative would also consume manufactured chemicals (electron donor and ion exchange resin) used to treat perchlorate contamination in deep soil and groundwater.

Alternative 5B includes all of the sustainability issues of Alternative 3A, plus additional energy use for the installation of injection wells, which includes transportation for drilling activities and OM&M, as well as consumption of additional manufactured materials, such as PVC piping. Additionally, this alternative would consume manufactured chemicals (electron donor) used to treat perchlorate contamination present in groundwater.

Overall, Alternative 3A poses fewer impacts affecting sustainability than Alternatives 5A and 5B, although the differences between the alternatives are generally small.

7.3 SELECTION OF REMEDIAL ALTERNATIVE

7.3.1 Selection Criteria

The remedial alternatives were evaluated using the general methodology described in Section 6.3 for the preliminary alternative screening. Criteria used for alternative selection include the CERCLA balancing criteria (long-term effectiveness and permanence, reduction of TMV through treatment, short-term effectiveness, implementability, and cost), plus the sustainability criterion. The two threshold criteria (overall protection of human health and the environment, and compliance with ARARs) were not included in the evaluation because all alternatives considered in the detailed analysis (except for the No Action alternative) must satisfy these criteria to be eligible for selection. For each of the selection criteria, specific evaluation factors and subfactors were developed based on the narrative descriptions provided in the USEPA guidance. The evaluation factors and subfactors considered for each of the CERCLA criteria are summarized in Table 7-1.

The selection criteria, evaluation factors, and evaluation subfactors were each assigned weights based on their importance relative to other criteria within the same group in the hierarchy. For example, the selection criteria of long-term effectiveness and implementablity were each assigned a relative weight of 100, cost was assigned a relative weight of 75, and reduction of TMV through treatment, short-term effectiveness, and sustainability were all assigned relative weights of 50. The various evaluation factors and subfactors were also assigned weights to reflect their relative importance within each subgroup. The relative weights were then used to calculate an overall weight for each factor considered in the evaluation. The weighting scheme and overall weights for each evaluation factor or subfactor are also summarized in Table 7-1.

To conduct the selection analysis, each alternative was scored on a scale of 0 to 10 for each of the evaluation factors or subfactors, using the numerical scoring template provided in Appendix D. When scoring was completed, the individual scores for each factor or subfactor were multiplied by the corresponding overall weight. These results were then summed to obtain a final weighted score, which also ranged from 0 to 10. Comparison of the numerical scores was used as the basis for selection of the preferred remedial alternative.

7.3.2 Alternative Selection Results

The results of the remedial alternative selection are summarized in Table 7-1. Alternative 3A (limited soil removal, plume containment, and institutional controls) was selected as the preferred remedy for the site. Areas where Alternative 3A scored higher than the other alternatives include the following:

- <u>Short-term effectiveness</u>: Alternative 3A scored slightly higher than Alternatives 5A and 5B for protection of construction workers, because Alternative 3A involves less construction and the construction does not involve exposure to highly contaminated materials.

- <u>Implementability</u>: Alternative 3A scored slightly higher than Alternatives 5A and 5B for obtaining other approvals, constructability, technology reliability, and adaptability to modification. A slightly higher score was assigned to Alternative 3A for obtaining other approvals because Alternatives 5A and 5B would require obtaining additional Waste Discharge Requirements (a relatively complicated process) from the Santa Ana Regional Water Quality Control Board. The higher score for constructability was based on the lower complexity of Alternative 3A compared with Alternatives 5A and 5B. The higher score for technology reliability reflects the uncertainty as to whether the *in situ* and P&T technologies included in Alternatives 5A and 5B can successfully reduce mass in groundwater (and soil for Alternative 5A). The higher score for adaptability to modification was assigned to Alternative 3A because the *in situ* and P&T technologies included in Alternatives 5A and 5B may be very difficult to successfully modify if, during implementation, problems are encountered related to subsurface heterogeneity.

- <u>Cost</u>: Alternative 3A scored higher than Alternatives 5A and 5B based on the lower estimated capital cost. OM&M costs for all of the alternatives are driven mainly by plume containment, so all of the alternatives were assigned identical scores for OM&M costs.

Alternative 3A scored significantly lower than Alternatives 5A and 5B for one selection criterion: reduction of TMV through treatment. Alternative 3A was given a score of 1.25 for destruction of hazardous constituents, because the RAOs are primarily met by measures that reduce contaminant mass, even though the absolute amount of mass removed is relatively small. Alternatives 5A and 5B were assigned scores of 7.5 and 5, respectively, for this factor, based on the larger masses removed, and Alternative 5A scored higher than Alternative 5B because mass reduction in both soil and groundwater is addressed by Alternative 5A.

To investigate the robustness of the scoring, three sensitivity analyses were performed. In the first sensitivity analysis, the scores for destruction of hazardous constituents were adjusted to see if the relative rankings of the alternatives changed. No changes in the alternative rankings were observed, even when Alternative 3A was assigned a score of 0 and Alternatives 5A and 5B were each assigned scores of 10. The second sensitivity analysis involved adjusting the relative weight assigned to reduction of TMV. There were no changes in the relative rankings of the alternatives until the relative weight assigned to reduction of TMV was increased from 50 to 120, which is 20% higher than relative weights assigned to long-term effectiveness and implementability. In the third sensitivity analysis, the relative weight assigned to cost was adjusted to see if the relative rankings of the alternatives changed. No change in the relative rankings was observed, even when the weight assigned to cost was set at 0 (i.e., when cost was not considered in the scoring). Based on the results of these three sensitivity analyses, the selection of Alternative 3A is considered to be robust.

Section 7 Tables

Table 7-1
Detailed Analysis Scoring Results

Evaluation Criteria	Relative Weight	Evaluation Factors	Relative Weight	Evaluation Subfactors	Relative Weight	Overall Weight	Alternative 0	Alternative 3A	Alternative 5A	Alternative 5B
							No Action	**Limited Soil Removal, Groundwater Containment, Institutional Controls**	**Moderate Mass Removal (Bioflush/P&T in STBC), Groundwater Containment, Institutional Controls**	**Moderate Mass Removal (*In Situ* Bioremediation in STBC), Groundwater Containment, Institutional Controls**
Long-Term Effectiveness and Permanence	100	Prevent Human Health Risks	100	-	-	6.7%	3.33	8.3	8.3	8.3
		Minimize Ecologic Risks	100	-	-	6.7%	0	8.3	8.3	8.3
		Residual Potential Risk	50	-	-	3.4%	0	10	10	10
		Reliability of Controls	100	-	-	6.7%	0	10	10	10
Reduction of TMV Through Treatment	50	Destruction of Hazardous Constituents	50	-	-	5.9%	0	1.25	7.5	5.0
		Irreversibility of Treatment	50	-	-	5.9%	0	7.5	7.5	7.5
Short-Term Effectiveness	50	Time to Achieve RAOs	50	-	-	4.7%	0	10	10	10
		Unmitigatable Adverse Impacts	75	Protect Community	100	3.1%	10	7.5	7.5	7.5
				Protect Construction Workers	75	2.4%	10	7.5	5.0	5.0
				Minimize Environmental Impacts	50	1.6%	10	7.5	7.5	7.5
Implementability	100	Constructability	75	-	-	4.7%	10	7.5	6.25	6.25
		Technology Reliability	75	-	-	4.7%	0	7.5	5.0	5.0
		Adaptability to Modify/Update	25	-	-	1.6%	0	7.5	5.0	5.0
		Effectiveness of Monitoring	50	-	-	3.1%	0	7.5	7.5	7.5
		Obtaining Other Approvals	100	-	-	6.3%	0	7.5	5.0	5.0
		Availability of Experts and Technology	50	-	-	3.1%	10	10	10	10
Costs	75	Capital	50	-	-	8.8%	10	2	0	0
		OM&M	50	-	-	8.8%	10	0	0	0
Environmental	50	Energy Use	75	-	-	5.9%	10	0	0	0
		Air Emissions	50	GHG Emissions	50	1.0%	10	0	0	0
				NO_X Emissions	25	0.5%	10	0	0	0
				SO_X Emissions	75	1.5%	10	0	0	0
				PM_{10} Emissions	50	1.0%	10	2.5	2.5	0
		Impact on Water Resources	25	-	-	2.0%	10	0	0	0
Overall Score:						**100.0%**	**4.66**	**5.69**	**5.45**	**5.28**

Notes:
GHG: Greenhouse gases
NO_X: Nitrogen oxides
OM&M: Operations, maintenance, and monitoring
P&T: Pump and Treat
PM_{10}: Particulates less than 10 microns in diameter
RAO: Remedial Action Objective
SO_X: Sulfur oxides
STBC: Southern Test Bay Canyon
TMV: Toxicity, mobility, or volume

Section 7 Figures

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LEGEND

- Soil Boring
- Monitoring Well
- Soil Gas Sample Location
- Topographic Elevation Contour (2-ft interval)
- Extent of Elevated Cadmium, Lead, and Zinc
- Extent of Shallow Soil Excavation

0 25 50 Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 7-1

Alternatives 3A, 5A, 5B
Waste Discharge Area
Shallow Soil Excavation

TETRA TECH

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 7-2

Alternatives 3A, 5A, 5B
Test Bay Canyon
Shallow Soil Excavation/
On-Site Treatment

TETRA TECH

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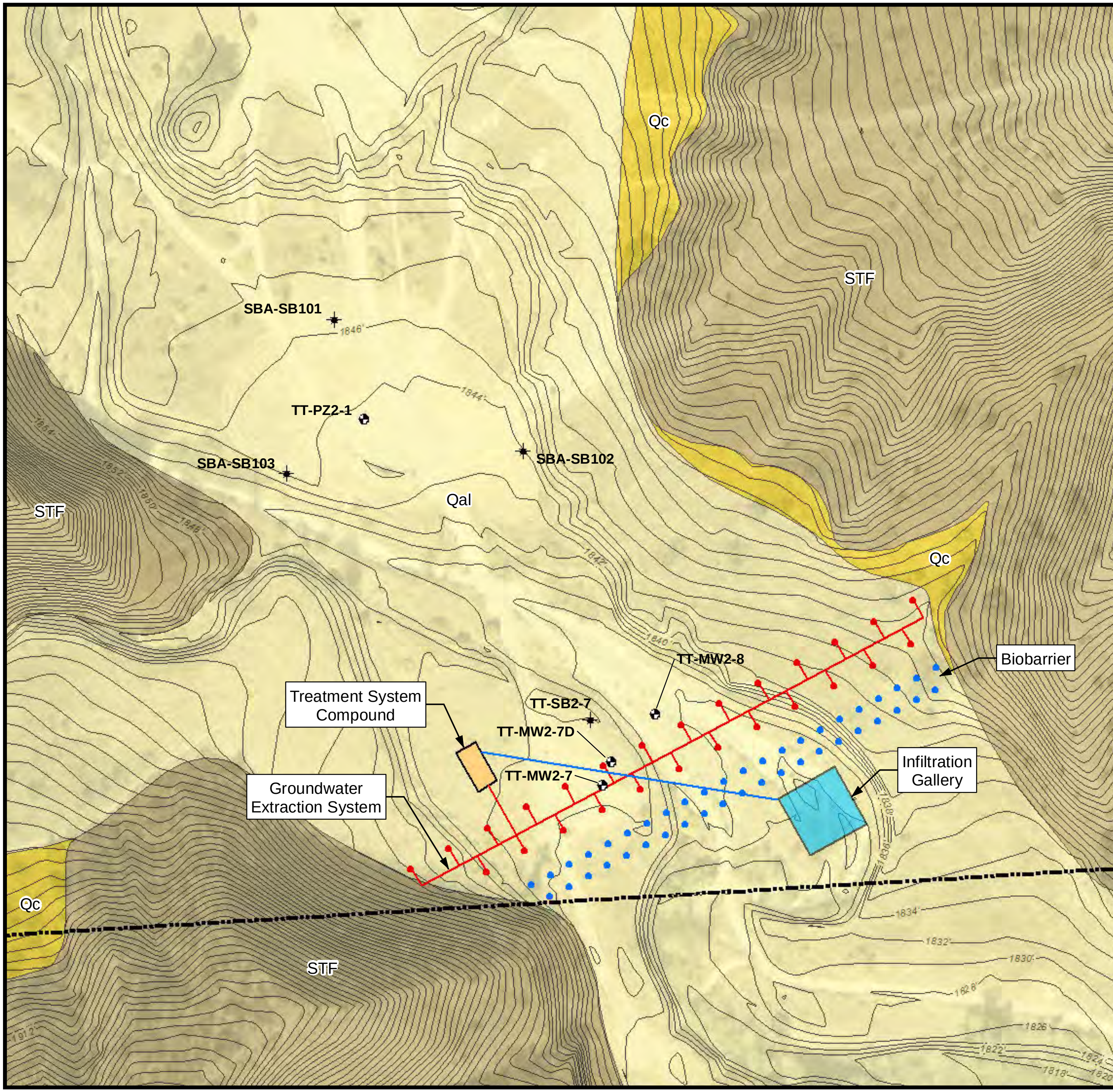


0 50 100 Feet

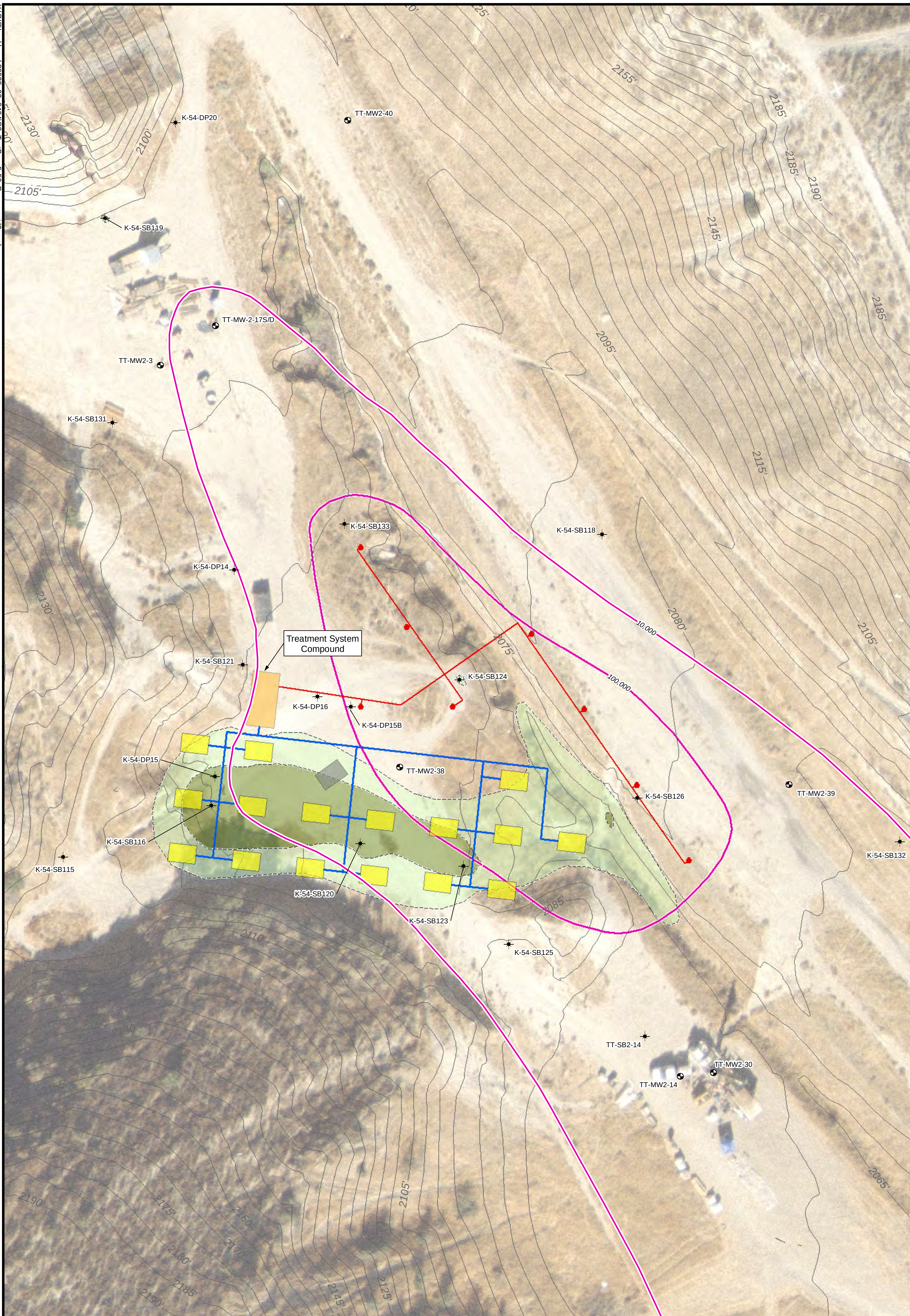
LEGEND

- Biobarrier Injection Well
- Groundwater Extraction Well
- Soil Boring
- Monitoring Well
- Contact (dashed where inferred)
- Ground Surface Elevation Contour (2-foot interval - feet msl)
- Double-Contained Piping
- Single-Contained Piping
- Beaumont Site 2 Property Boundary
- Qal Alluvium
- Qc Colluvium
- STF San Timoteo Formation

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 7-3
Alternatives 3A, 5A, 5B South Boundary Groundwater Containment System

TETRA TECH



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LEGEND

- Soil Boring
- Monitoring Well
- Topographic Elevation Contour (5-ft interval)
- Perchlorate in Groundwater Isoconcentration Contour (µg/L)
- Groundwater Extraction Well
- Single-Contained Piping
- Double-Contained Piping
- Infiltration Gallery
- Infiltration Gallery (Treatability Study)

Perchlorate Concentration in Deep (>5') Soil

- >1,000 µg/kg
- >10,000 µg/kg

N

0 25 50 Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 7-4
Alternative 5A
Test Bay Canyon
Groundwater Extraction/
Bioflush System Layout

TETRA TECH

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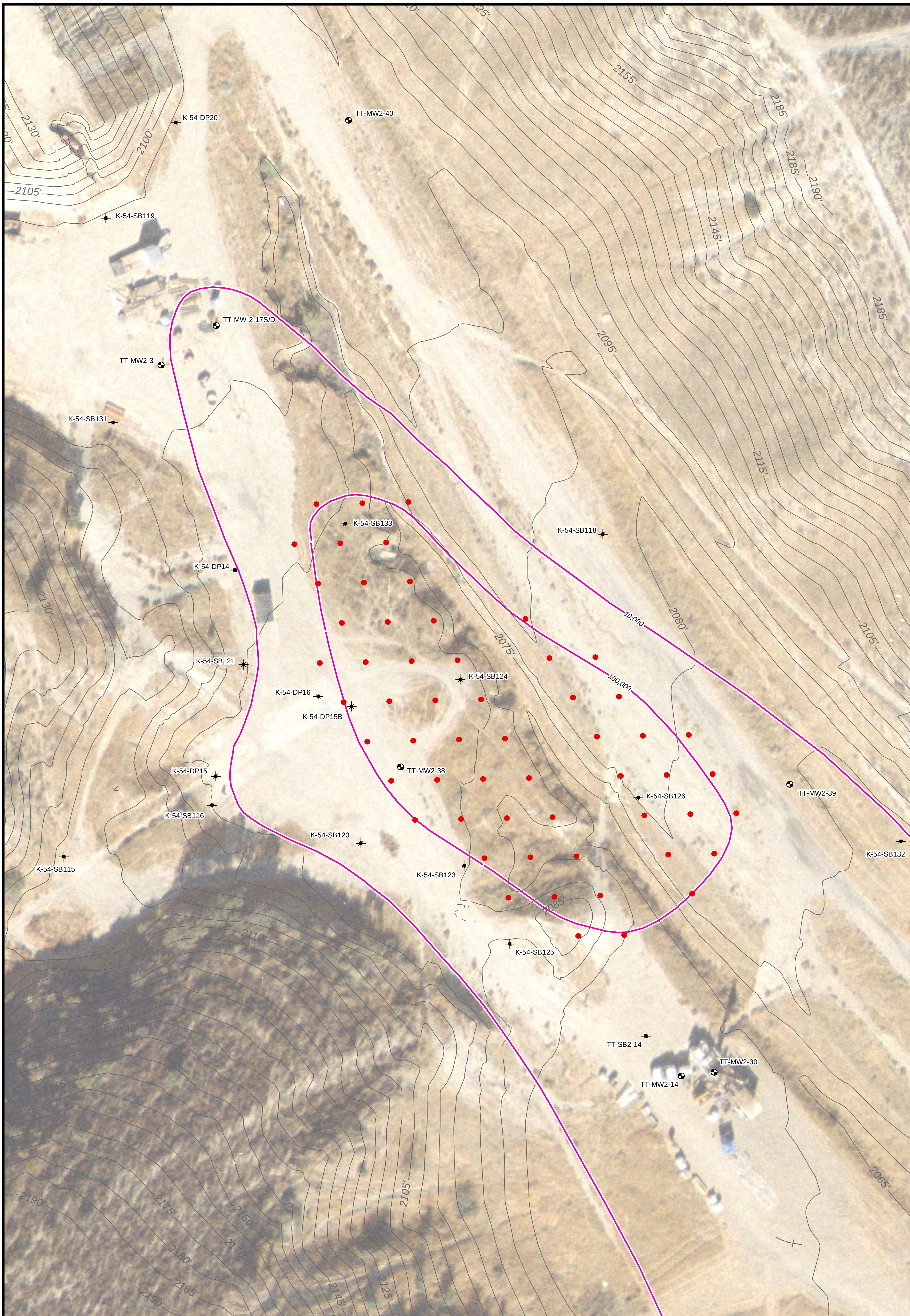

LEGEND

- Soil Boring
- Monitoring Well
- Injection Well
- Topographic Elevation Contour (5-ft interval)
- Perchlorate in Groundwater Isoconcentration Contour (µg/L)

0 25 50 Feet

Laborde Canyon
(Lockheed Martin Beaumont Site 2)

Figure 7-5

Alternative 5B
Test Bay Canyon
***In Situ* Biotreatment System Layout**

TETRA TECH

Section 8
Recommended Remedy

This section summarizes the recommended remedial alternative for Laborde Canyon based on the analyses summarized in this report. These analyses included the development of remedial action objectives, identification of applicable or relevant and appropriate requirements, identification and screening of remedial technologies appropriate for each medium of concern at the site, development and screening of site-wide remedial alternatives, and detailed analysis of the remedial alternatives that survived screening. All of these analyses were performed in accordance with prescribed feasibility study guidance (USEPA, 1988). The recommended remedy addresses the risks to human and ecological receptors identified in the Human Health and Predictive Ecological Risk Assessment (Tetra Tech, 2012b), and complies with applicable or relevant and appropriate requirements.

The recommended remedy (Alternative 3A) consists of excavation and *ex situ* biotreatment of approximately 1,490 cubic yards of shallow soil in which perchlorate concentrations exceed the preliminary remediation goal of 1,700 micrograms/kilogram in southern Test Bay Canyon; excavation and off-site disposal of approximately 60 cubic yards of shallow soil where metals concentrations exceed preliminary remediation goals in the Waste Discharge Area; installation of a biobarrier in south Laborde Canyon to prevent further migration of perchlorate-contaminated groundwater south of the property boundary (with a contingency to switch from a biobarrier to a hydraulic containment and *ex situ* treatment system to treat perchlorate, 1,4-dioxane, and volatile organic compounds, if 1,4-dioxane concentrations at the property boundary eventually exceed drinking water standards); and implementation of institutional controls to prevent the installation of on-property water supply wells and to prevent access to and use of groundwater at the property for drinking water purposes.

The recommended remedy does not consider *in situ* chemical oxidation for treatment of the 1,4-dioxane groundwater plume. This process option will be further evaluated in a pilot study, which is expected to be conducted during remedy implementation. If the pilot study results indicate that

ISCO is a potentially viable 1,4-dioxane treatment technology, a focused feasibility study would be performed to evaluate additional remedial alternatives for the 1,4-dioxane plume.

Section 9
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