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Human Health and Ecological Risk Assessment Work Plan

Topock Compressor Station
Needles, California

August 2008

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Acronyms and Abbreviations

AOC	area of concern
APE	area of potential effects
ARAR	applicable or relevant and appropriate requirement
BAF	bioaccumulation factor
BaP_{Eq}	benzo(a)pyrene equivalent
BCW	Bat Cave Wash
bgs	below ground surface
BNSF	Burlington Northern Santa Fe
bss	below sediment surface
BTAG	Biological Technical Assistance Group
BW	body weight
CACA	Corrective Action Consent Agreement
CalEPA	California Environmental Protection Agency
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CHHSLs	California Human Health Screening Levels
CMS/FS	corrective measures study/feasibility study
COPC	constituent of potential concern
COPEC	constituent of potential environmental concern
cPAH	carcinogenic polycyclic aromatic hydrocarbons
CSF	cancer slope factor

CSM	conceptual site model
CTR	California Toxics Rule
DAF	dilution attenuation factor
DTSC	Department of Toxic Substances Control
DUA	data usability assessment
EcoNote	Ecological Risk Assessment Note
Eco-SSL	Ecological Soil Screening Level
ECV	ecological comparison value
EPC	exposure point concentration
ERA	ecological risk assessment
FMIT	Fort Mohave Indian Tribe
GMP	Groundwater and Surface Water Monitoring Program
HEAST	Health Effects Assessment Summary Tables
HERD	Human and Ecological Risk Division
HHRA	human health risk assessment
HI	hazard index
HMW	high molecular weight
HNWR	Havasu National Wildlife Refuge
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
IM	interim measure
IRIS	Integrated Risk Information System
kg	kilogram

km^2	square kilometers
LOAEC	lowest-observed adverse effects concentration
LMW	low molecular weight
LOAEL	lowest-observable-adverse-effects-level
m^3/day	cubic meters per day
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg-bw/day	milligrams per kilogram body weight per day
mg/m^3	milligrams per cubic meter
MCL	maximum contaminant level
NAWQC	national ambient water quality criteria
NCEA	National Center of Environmental Assessment
NCP	National Contingency Plan
ND	non-detect
NOAEC	no-observed adverse effects concentration
NOAEL	no-observed-adverse-effect-level
NRWQC	National Recommended Water Quality Criteria
OEHHA	Office of Environmental Health Hazard Assessment
ORNL	Oak Ridge National Laboratory
PAH	polycyclic aromatic hydrocarbon
PBA	Programmatic Biological Assessment
PG&E	Pacific Gas and Electric Company
ppb	parts per billion

PRG	Preliminary Remedial Goal
QAPP	Quality Assurance Project Plan
RBRG	risk-based remediation goals
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference doses
REL	reference exposure levels
RFI/RI	RCRA facility investigation/remedial investigation
RL/2	half the reporting limit
RME	reasonable maximum exposure
(the) site	Pacific Gas and Electric Company (PG&E) Topock Compressor Station
STSC	Superfund Health Risk Technical Support Center
SUF	site-use factor
SVOC	semivolatile organic compound
SWMU	solid waste management unit
(the) System	National Wildlife Refuge System
TEC	threshold effects concentration
TEF	toxicity equivalency factor
TPH	total petroleum hydrocarbons
TRV	toxicity reference value
TRW ALM	Technical Review Workgroup Adult Lead Model
UCL	upper confidence limit
UF	uncertainty factor

µg/dL	micrograms per deciliter
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meters
USBLM	U.S. Bureau of Land Management
USBOR	U.S. Bureau of Reclamation
USDOI	U.S. Department of Interior
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UTL	upper tolerance limit
VOC	volatile organic compound
work plan	Human Health Risk Assessment and Ecological Risk Assessment Work Plan, PG&E Topock Compressor Station, Needles, California

1. Introduction

This Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) Work Plan (work plan) describes the general proposed approach for evaluating the potential risks to human health and ecological receptors that could be exposed to constituents at identified Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) at the Pacific Gas and Electric Company (PG&E) Topock Compressor Station (the site).

The site is located in eastern San Bernardino County, approximately 12 miles southeast of Needles, California (Figure 1-1). The compressor station occupies approximately 15 acres of a 65-acre parcel of PG&E-owned land. However, the study area for investigative and remedial activities covers additional surrounding land owned and/or managed by a number of government agencies including the U.S. Bureau of Land Management (USBLM), U.S. Bureau of Reclamation (USBOR), U.S. Fish and Wildlife Service (USFWS), San Bernardino County, California Department of Transportation, and Burlington Northern Santa Fe (BNSF) Railroad.

The California Environmental Protection Agency (CalEPA) Department of Toxic Substances Control (DTSC) is the lead agency responsible for oversight of Resource Conservation and Recovery Act (RCRA) corrective action activities being conducted at the site. In February 1996, PG&E and DTSC entered into a Corrective Action Consent Agreement (CACA) pursuant to Section 25187 of the California Health and Safety Code (CalEPA, 1996a). Under the terms of the CACA, PG&E is conducting the RCRA facility investigation/remedial investigation (RFI/RI) at the compressor station (under the oversight of DTSC).

The U.S. Department of the Interior (USDOI) is the lead federal agency on land under its jurisdiction, custody, or control and is responsible for oversight of response actions being conducted by PG&E pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Portions of the site where hazardous substances from the Topock Compressor Station have come to be located are on or under land managed by the USBLM, USFWS, and USBOR (collectively the “federal agencies”). In July 2005, PG&E and the federal agencies entered into an Administrative Consent Agreement to implement response actions at the site as set forth in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; USEPA, 1990) (USDOI, 2005).

A complete description of the site background can be found in the *Revised Final RCRA Facility Investigation/Remedial Investigation Report Volume 1* (Revised Final RFI/RI Volume 1; CH2M HILL, 2007a).

Since 1996, there have been multiple phases of investigation at the Topock site to:

- Investigate past facility operations and sources of releases
- Document significant features (biological, cultural, archaeological, historical, and hydrogeological)
- Sample and analyze environmental media potentially affected by releases (soil, sediment, surface water, groundwater, and air) to determine the nature and extent of contamination from the release.

Much of the focus of these investigations has been on defining the extent of hexavalent chromium in groundwater at the site. Additional investigations are currently planned, as discussed in Section 2, to further delineate the distribution of hexavalent chromium and other metals in groundwater and to complete the characterization of soil at locations outside the compressor station fence line. As of the submittal of this work plan, PG&E is in discussions with the agencies regarding the schedule for phasing the soil sampling work within the compressor station that was identified in the Draft RFI/RI Work Plan Part B (CH2M HILL 2007d). Such phasing may result in portions of the soil characterization within the fence line of the compressor station being performed after PG&E no longer uses the property for utility purposes. These discussions may affect the timing of components of the HHRA (e.g., worker exposure to soils within the compressor station). After soil characterization within the compressor station is completed, the sections of this work plan that pertain to risks and exposures within the fence line will be reviewed and implemented. For example, future land-use options may have changed, and considerations for potential exposure and associated risks can be designed to address those potential uses. Currently, the Occupational Safety and Health Administration standards and practices are in place to protect the PG&E workers within the fence line of the compressor station.

In coordination with the RFI/RI Volume 2 (CH2M HILL, 2008b), forthcoming Volume 2 Addendum, and Volume 3, risk assessments for soil and groundwater will be prepared, and applicable or relevant and appropriate requirements (ARARs) will be identified. Prior to the completion of a corrective measures study/feasibility study (CMS/FS), a determination will be made as to which of the SWMUs, AOCs, and other undesignated areas at the site will be carried forward from the RFI/RI to the CMS/FS (CH2M HILL, 2007b). The risk assessments, to be completed in general accordance with this work plan, provide the key information on those chemicals, media, and specific geographic locations where human health or ecological risks may need to be controlled or eliminated.

1.1 General Approach

This work plan has been prepared as a component of the RFI/RI in accordance with guidance from the U.S. Environmental Protection Agency (USEPA, 1989a; 1991a,b; 1994; 1997a; 1998) and CalEPA (1992; 1996b).

As specified by USEPA (1989a), two key objectives of the baseline risk assessment are: (1) to help determine whether additional response actions at a site are necessary; and (2) to provide a basis for determining residual constituent levels that are adequately protective of human health and the environment. The approaches presented in this work plan address these two key objectives and include the following general steps of the standard risk evaluation process:

1. Evaluating available usable data for risk assessment that describes the nature and extent of contamination.

2. Selecting constituents of potential concern (COPCs) for humans and constituents of potential environmental concern (COPECs) for ecological populations, and comparing concentrations of those constituents to background concentrations.

3. Identifying the human and ecological receptor populations to be evaluated in the risk assessment according to the current and anticipated future land use, available habitat, and biological assessment data.

4. Developing conceptual site models (CSMs) indicating the potentially complete pathways through which human and ecological receptor populations could be exposed to site-related constituents. The CSMs are developed based on: a) the potential or suspected sources of contamination; b) release and potential migration mechanisms (transport pathways); and c) potential exposure points and exposure routes through which receptors may contact COPCs/COPECs associated with the site.

5. Identifying exposure assumptions for the potentially exposed populations and the complete exposure pathways.

6. Identifying exposure areas and the appropriate data sources for estimating exposure point concentrations (EPCs).

7. Identifying toxicity values for potentially complete exposure pathways for COPCs for humans and COPECs for ecological receptor populations.

8. Estimating risks and hazards for potentially complete exposure pathways for use in subsequent risk management decisions regarding the need for further action (e.g., remediation or ecological validation study).

9. Developing risk-based remediation goals (RBRGs) and/or identifying regulatory criteria to be used in the CMS for risk management decisions.

10. Describing the uncertainties underlying the risk assessment and the qualitative evaluation of their impact on the risk assessment findings.

In order to fulfill the two key stated objectives of the risk assessment process, all steps above are incorporated into this risk assessment work plan for soil and groundwater, as described in Sections 4 through 6. It is noted that concentrations of total chromium and hexavalent chromium have been detected in the groundwater above applicable drinking water criteria (i.e., California maximum contaminant levels [MCLs]). As a result of this groundwater plume characterization information, and at DTSC’s direction, PG&E has been extracting and treating groundwater at the site since March 2004. The purpose of these interim measures (IMs) is to maintain hydraulic control of the groundwater plume boundaries until a final corrective action is in place at the site. Current site data do not indicate the presence of a complete migration and exposure pathway whereby current populations are exposed to plume groundwater. Estimating risks and hazards for such contact does not represent current site conditions. However, as specifically requested by DTSC, step number 8 above will evaluate potential groundwater contact for the hypothetical future groundwater user. Such groundwater use is not now occurring and may or may not actually occur in the future.

Both the soil and groundwater risk evaluations will address all the steps identified above for potential future land use and associated receptors, with the objective of determining the residual levels of all potential site-related constituents in soil and groundwater that are adequately protective of human health and the environment and in compliance with applicable and relevant regulatory criteria.

Although this work plan addresses both soil and groundwater media, the HHRA and ERA for groundwater and soil will be completed in two separate phases: (1) groundwater evaluation for human and ecological receptors (ecological receptors will not be exposed directly to groundwater; the ecological scoping assessment [Section 7] addresses the potential for discharge of chemically affected groundwater to surface water); and (2) soil evaluation for human and ecological receptors. The reason for separating the risk assessments by media is that there is a significant amount of information available on the overall groundwater impacts and, therefore, sufficient information to begin proceeding toward the CMS/FS phase of the project for the groundwater remedy. In contrast, several soil investigation activities will begin in mid-2008 and will likely not be complete until the end of 2009. Based on these timing differences and the need to continue to move forward with the remedy selection process for the groundwater, the risk assessments for the groundwater, including an evaluation of the potential groundwater to surface water pathway, is planned to be completed in late 2008; whereas the soil risk assessments will be completed following the collection of the additional soil characterization information.

1.2 Work Plan Organization

The remainder of this work plan is organized as follows:

- **Section 2: Site History and Characteristics** – This section describes the historical operations, previous and ongoing investigations, and physical characteristics of the site.

- **Section 3: Data Evaluation for Baseline Risk Assessment** – This section describes how the dataset for each environmental medium will be summarized and evaluated, the data usability criteria for risk assessment, and the general methods that will be used to select COPCs to be included in the risk assessments.

- **Section 4: Human Health Risk Assessment Approach for Soil** – This section describes the purpose of and plan for evaluating human health risks associated with potential exposure to site-related constituents in soils within the SWMUs and AOCs.

- **Section 5: Human Health Risk Assessment Approach for Groundwater** – This section describes the purpose of and the approach that will be used in evaluating potential human health risks associated with potential exposure to site-related constituents in groundwater.

- **Section 6: Ecological Risk Assessment Approach for Soil** – This section describes the scoping assessment results and the approach to the Phase I Predictive ERA process for soil.

- **Section 7: Ecological Risk Assessment Approach for Evaluating Groundwater-to-Surface Water Pathway** – This section describes the scoping assessment approach for potential surface water exposure pathways for ecological receptors. Specifically, this section describes how the potential groundwater-to-surface water pathway will be evaluated in the scoping assessment. The scoping assessment for surface water supports the development of the groundwater CMS/FS.

- **Section 8: Reporting and Next Steps** – This section describes the format and approximate schedule and sequencing for the risk assessment reports, as well as a short summary of additional steps that could occur in the risk assessment process.

- **Section 9: References** – This section provides the references for documents relied upon in the preparation of this work plan.

2. Site History and Characteristics

This section presents information on historical and current operations and previous and ongoing investigations with information obtained primarily from the *Draft RCRA Facility Investigation/Remedial Investigation Report* (Draft RFI/RI; CH2M HILL, 2005a). The physical and ecological characteristics of the site were also obtained from the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a) and the Programmatic Biological Assessment (PBA; CH2M HILL, 2007c).

2.1 Site Historical Operations

In December 1951, the Topock Compressor Station began operations to compress natural gas supplied from the southwestern United States for transport through pipelines to PG&E’s service territory in central and northern California. The state of California owned the property on which the compressor station was built. From 1951 to 1965, PG&E leased the property from the state. In 1965, PG&E purchased the property from the state (CH2M HILL, 2007a).

Current operations at the compressor station are very similar to the operations that occurred from the start of facility operations in 1951. Operations at the compressor station consist of six major activities: compression of natural gas, cooling of the compressed natural gas and compressor lubricating oil, water conditioning, wastewater treatment, facility and equipment maintenance, and miscellaneous operations. The greatest use of chemical products at the facility involves treatment of cooling water, and the greatest volume of waste produced consists of blowdown from the cooling towers (i.e., water that is routinely removed from the towers to prevent chemical buildup and scale formation).

Historically, hexavalent chromium was added to cooling water to inhibit corrosion, minimize scale formation, and control biological growth. From 1951 to 1964, untreated wastewater containing hexavalent chromium was discharged to the Bat Cave Wash (BCW), an ephemeral drainage that extends from the Chemehuevi Mountains to the north. From 1964 to 1969, PG&E treated the wastewater by converting the hexavalent chromium to trivalent chromium. In 1969, the process was expanded to two steps that converted hexavalent chromium to trivalent chromium (Step 1), and then removed trivalent chromium via precipitation (Step 2). Beginning in May 1970, treated wastewater was discharged to an injection well (PGE-08) located on PG&E property (Figure 2-1), and discharges to BCW generally ceased. A description of BCW is presented later in this section and is shown on Figures 2-1 and 2-2.

In 1971, after wastewater discharge to BCW ceased, four single-lined evaporation ponds were constructed, and in 1985, PG&E discontinued use of hexavalent chromium in its cooling water. In 1989, the single-lined ponds were replaced with four new, Class II (double-lined) ponds, located approximately 1.2 miles northwest of the former single-lined ponds. The wastewater treatment system and the single-lined ponds were physically removed and clean-closed between 1988 and 1993. The four, Class II double-lined ponds are still in use and are operated under jurisdiction of the Regional Water Quality Control Board, Colorado River Basin Region (CH2M HILL, 2007a).

2.1.1 Solid Waste Management Units/Areas of Concern

The potential SWMUs and AOCs at the Topock Compressor Station identified by DTSC in the CACA or in subsequent DTSC directives included 14 SWMUs, 20 AOCs, and two undesignated areas. All SWMUs and AOCs that have not received regulatory closure will be included in the risk assessment. The closure criteria for those SWMUs/AOCs/Units that have already received regulatory closure were based on background concentrations as described in Section 5 of the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a). Data for these closed areas will be included in the risk assessment if additional sampling indicates chemical concentrations of potential concern in these areas.

Six SWMUs (SWMUs 2, 3, 4, 7, and 10 and Unit 4.6) and two AOCs (AOC 2 and AOC 3) have already been closed and require no further investigation (CH2M HILL, 2007a). However, as shown on Table 2-1, AOC 2 (PGE-08 injection well) was retained for further investigation of groundwater conditions in the vicinity of the well, and depending on the results, may move forward in the groundwater risk assessment. The SWMUs and AOCs that will be carried forward into the RFI/RI are discussed below and identified on Table 2-1. Depending on the outcome of ongoing investigations that are reported in the RFI/RI Volume 2 (CH2M HILL, 2008b) and the forthcoming Volume 2 Addendum and Volume 3 Reports, the list of SWMUs, AOCs, and/or undesignated areas that are currently identified for inclusion in the risk assessment(s) may be refined. Changes to the list of SWMUs, AOCs, and/or undesignated areas that are currently identified for inclusion in the risk assessment(s) will be documented in the applicable risk assessment.

2.1.1.1 Outside Compressor Station

The SWMUs, AOCs, and undesignated areas outside the compressor station are listed in Table 2-1 and all but the Potential Pipeline Disposal Area are shown on Figure 2-1.

These include SWMU 1; AOCs 1, 4, 9, 10, 11, 12, and 14; the Potential Pipeline Disposal Area (this area is approximately 1,200 feet southwest of AOC 1 and is shown on Figure 6-1 of the Draft RFI/RI Work Plan Part A [CH2M HILL, 2006a]. which is provided in Appendix B for the reader's convenience); and the Former 300B Pipeline Liquids Tank. Figures 2-2 through 2-9 present previous and proposed soil and sediment sample locations within SWMU 1 and AOCs outside the compressor station as presented in the *Draft RCRA Facility Investigation/Remedial Investigation Soil Investigation Work Plan Part A* (Draft RFI/RI Work Plan Part A; CH2M HILL, 2006a) and modified through subsequent discussions with the regulatory agencies and stakeholders. The existing and proposed sampling locations for the Former 300B Pipeline Liquids Tank area are shown on Figure 6-25 of the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a), which is provided in Appendix B for the reader's convenience. As shown in Table 2-1, certain areas discussed above will be included in the risk assessment.

2.1.1.2 Inside Compressor Station

The compressor station occupies approximately 15 acres of a 65-acre parcel of PG&E-owned land. The SWMUs and AOCs inside the compressor station are listed in Table 2-1 and, except as noted, the areas that will be included in the risk assessment are presented on Figure 2-1. The areas inside the compressor station are SWMUs 5, 6, 8, and 9; Units 4.3, 4.4, and 4.5; and AOCs 5, 6, 7, 8, 13, 15, 16, 17, 18, 19, and 20. Additional investigations were proposed at ten of the AOCs, and Figures 2-10 through 2-19 present previous and proposed soil sample locations as presented in the *Draft RCRA Facility Investigation/Remedial Investigation Soil Investigation Work Plan Part B* (Draft RFI/RI Work Plan Part B; CH2M HILL, 2007d). The remaining eight areas inside the compressor station were previously closed (SWMUs 5, 6, 8, 9; AOC 18; Units 4.3, 4.4, and 4.5). but additional investigations were requested by DTSC in a letter dated July, 13, 2006 (CalEPA, 2006). Whether these latter eight areas will be included in the future risk assessments will depend on results from the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d).

2.1.1.3 Known Groundwater Plume

Groundwater data indicate that the hexavalent chromium plume (greater than California's MCL of 50 micrograms per liter [µg/L]) is confined to the alluvial aquifer and extends over a distance of approximately 2,800 feet from the southern edge of the Alluvial Aquifer (upper BCW) to the Colorado River floodplain, covering about 90 acres (refer to Figure 2-2 from the Draft CMS/FS Work Plan [CH2M HILL, 2007b], which is provided in Appendix B for the reader's convenience). At the northern and eastern limits of the plume, reducing conditions are observed in groundwater. In this area, hexavalent chromium reverts to trivalent chromium and is strongly sorbed to aquifer materials or precipitates. This natural reducing condition significantly limits the movement of hexavalent chromium and results in a sharp decrease in hexavalent chromium concentrations in groundwater in the floodplain (CH2M HILL, 2008b).

2.2 Previous Investigations

Previous investigations inside and outside the compressor station are discussed in the Draft RFI/RI (CH2M HILL, 2005a). The Topock Groundwater and Surface Water Monitoring Program (GMP) was initiated in 1998 as a continuation of the RFI groundwater investigations and continues today (CH2M HILL, 2005d). Additional upcoming investigations proposed for the areas outside the compressor station (offsite) are addressed in the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a), as well as the *Revised Work Plan for East Ravine Groundwater Investigation* (CH2M HILL, 2008c) and the *Work Plan for Groundwater Characterization on Arizona Shore of the Colorado River at Topock, Arizona* (CH2M HILL, 2007e). Additional upcoming investigations inside the compressor station (onsite) are addressed in the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d). A discussion of previous investigations is presented below. A discussion of additional investigations, to be conducted in the near future, is presented in Section 2.3.

2.2.1 Biological Assessment

The PBA (CH2M HILL, 2007c) was prepared to evaluate potential effect on species protected under the federal Endangered Species Act resulting from past, present, or planned remedial and investigative activities up to the selection and implementation of the final remedy. The primary purpose of the PBA was to put into context the status and management of Endangered Species Act species within or near the area of potential effects (APE) and to better evaluate the effects of current and future proposed activities on those species and habitats. The APE was defined as the area that may be potentially affected by the RFI/RI activities and is shown on Figure 2 of the PBA (CH2M HILL, 2007c).

The PBA concluded a critical habitat effect determination of "no effect" for all but one special status species evaluated. The "no effect" species are southwestern willow flycatcher (*Empidonax traillii extimus*), Mojave desert tortoise (*Gopherus agassizii*), Yuma clapper rail (*Rallus longirostris yumanensis)*, Colorado pikeminnow

(*Ptychocheilus lucius*), and razorback sucker (*Xyrauchen texanus*). One species, bonytail chub (*Gila elegans*), was concluded to have a critical habitat effect determination of “may affect, but not likely to adversely affect.”

2.2.2 Soil and Sediment

The identification of SWMUs and AOCs began with the RCRA Facility Assessment in the 1980s (Kearny, 1987), followed by the DTSC in the CACA (CalEPA, 1996a), and subsequent efforts described in the Draft RFI/RI (CH2M HILL, 2005a). Soil data are defined as sample results collected from areas that are not inundated with water and are typically dry when there are no storm events. Soil data are available from several phases of RFI sampling and additional investigative sampling will be completed as part of the Part A and Part B soil sampling investigations (CH2M HILL, 2006a; 2007d). Sediment data are defined as sample results collected from areas that are typically inundated with water even in the absence of storm events. Sediment data are available from samples collected from the mouth of BCW and from the river bottom. Available soil and sediment data are presented in the Draft RFI/RI (CH2M HILL, 2005a) and the Porewater Study Report (CH2M HILL, 2006c).

2.2.2.1 Previous Investigations – Outside Compressor Station

Previous investigations for AOCs outside the compressor station were conducted from 1997 to 2005 and are described in the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a). Existing data are available for SWMU 1; AOCs 1, 4, 9, 10, and 14; and the Former 300B Pipeline Liquids Tank. The existing dataset for these areas addressed by the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a) consists of:

- Soil data collected through multiple phases of RFI sampling as presented in the Draft RFI/RI (CH2M HILL, 2005a)

- Confirmation soil data collected from evaluation of spills from the compressor station as presented in the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a)

- Data collected from tank closure activities at the Former 300B Pipeline Liquids Tank as presented in the Former 300B Pipeline Liquids Tank Closure Technical Memorandum (CH2M HILL, 2007h).

AOC 11, AOC 12, and the Potential Pipeline Disposal Area are the only three areas outside the compressor station not previously sampled. All will be sampled as part of the soil investigation described in the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a).

2.2.2.2 Previous Investigations – Inside Compressor Station

Previous investigations for AOCs inside the compressor station were conducted from 1997 to 2005 and are described in the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d). Existing data are available for SWMUs 5, 6, 8, and 9; AOCs 5, 6, 13, 15, 18, and 19; and Units 4.4 and 4.5. The existing dataset for 12 of the 18 areas addressed by the Part B Work Plan (CH2M HILL, 2007d) consists of:

- Soil data collected through multiple phases of RFI sampling as presented in the Draft RFI/RI (CH2M HILL, 2005a)
- Confirmation soil data collected from evaluation of spills from the compressor station as presented in the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a)
- Soil data collected during the RCRA closure process (CH2M HILL, 2007d)
- Samples collected during the March (2007) utility trenching effort at the compressor station (CH2M HILL, 2007d).

AOCs 7, 8, 16, 17, and 20 and Unit 4.3 are areas not previously sampled. These areas will be sampled as part of the soil investigation described in the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d). Sampling will occur in some areas that were previously closed as well as areas that need to be addressed for completion of corrective action.

2.2.2.3 Background Investigations

Ambient or background concentrations of inorganic compounds in soils were calculated in several studies for various portions of the site around the compressor station. The existing background soil dataset, as presented in the Draft RFI/RI (CH2M HILL, 2005a), consists of 34 samples from 12 locations (CH2M HILL, 2006a). The samples were collected between 0 to 10 feet below ground surface (bgs) from non-impacted locations in the vicinity of the compressor station. Existing background soil sample locations are shown on Figure 2-20.

Additional background soil samples will be collected to augment the existing background dataset. As currently planned, the proposed additional background dataset will consist of 53 additional samples from 16 locations, which will be collected as part of the Part A soil sampling investigation (CH2M HILL, 2006a; Figure 2-20). Samples will be collected at various depths and analyzed for California Title 22 metals, including hexavalent chromium. Surface samples will also be analyzed for polycyclic aromatic hydrocarbons (PAHs). Section 3.3.1.1 discusses the approach for comparing site data to background data.

Background concentrations of metals may vary among the three lithologic units in the study area. Section 4.2.2.1 of the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a) describes the process to be used to characterize background concentrations. To summarize, the data from the three lithologic units will be evaluated using the Wilcox Rank Sum test to determine if there are any significant differences between samples collected from the three lithologic units. The results of the soils background sampling and the statistical analyses describing the characteristics, uses, and limitations of the background soils dataset will be submitted separately from the risk assessments as a Technical Memorandum for review and approval by DTSC and the federal agencies (currently scheduled to be completed in November 2008). As an example, it is anticipated that the Technical Memorandum will provide the technical justification for grouping of the soils background data, and whether looking at the background samples collected from the three different lithologic units (described in the Draft RFI/RI Work Plan Part A [CH2M HILL, 2006a]) as one population is reasonable and appropriate.

2.2.3 Groundwater

Several phases of site investigation and characterization addressing groundwater were completed between June 1997 and June 2004, all of which are described and summarized in the Draft RFI/RI (CH2M HILL, 2005a). Since 2005, there have been ongoing groundwater investigations, conducted in accordance with the GMP (CH2M HILL, 2005d). Groundwater samples collected up through October 2007 are included in the RFI/RI Volume 2 (CH2M HILL, 2008b), as discussed in the next section, and will be used in the risk assessments. Groundwater monitoring is ongoing. The scope of additional investigations is described below in Section 2.3.2. Groundwater sample locations are shown on Figure 2-21.

In February 2004, DTSC directed PG&E to initiate immediate pumping, transport, and disposal of groundwater at the site to ensure that groundwater containing hexavalent chromium does not reach the Colorado River (CalEPA, 2004a). In March 2004, PG&E began extracting groundwater from a monitoring well cluster located on a bench above and to the west of the river floodplain (commonly referred to as the MW-20 bench). In

May 2004, an extraction well cluster (TW-2) was installed on the MW-20 bench to replace the existing monitoring wells. In July 2004, PG&E began treating the extracted groundwater to reduce the concentrations of hexavalent chromium in groundwater, prior to offsite disposal (CH2M HILL, 2005a). In late 2004 and into mid-2005, PG&E constructed a separate groundwater treatment plant and injection well field (IM-3) on property owned by PG&E to manage extracted groundwater generated by continued IM activities.

2.2.3.1 Previous Investigations

The RFI groundwater investigation was initiated in June 1997 and involved several phases of well installation. The majority of the site wells were sampled regularly for hexavalent chromium, total chromium, other site COPCs, and additional chemical parameters, yielding an extensive set of water levels and analytical data for characterizing groundwater conditions. Groundwater data collected from June 1997 through June 2004 are presented in the Draft RFI/RI (CH2M HILL, 2005a). Groundwater samples are still being collected in accordance with the GMP (CH2M HILL, 2005d). Groundwater and surface water investigations conducted between June 2004 and October 2007 are presented in the quarterly monitoring reports. Groundwater sampling data collected between 1997 and October 2007 were included in the RFI/RI Volume 2 (CH2M HILL, 2008b), submitted to the agencies on July 2, 2008. Additional groundwater data from select wells across the site and from the Arizona sampling, collected between November 2007 and May 2008, will be included in an RFI/RI Addendum, currently scheduled to be submitted in December 2008. Groundwater monitoring data collected up through May 2008, included in the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum, will form the basis of the dataset to be used in the upcoming risk assessments.

2.2.3.2 Background Investigations

PG&E implemented a groundwater background study to more completely evaluate the range of naturally occurring metals concentrations, including hexavalent chromium, in groundwater in the vicinity of the site (CH2M HILL, 2005a). The background groundwater study areas are shown on Figure 2-22. The groundwater background study was implemented in accordance with the *Work Plan for Assessing Background Metals Concentrations in Groundwater* (Background Study Work Plan; CH2M HILL, 2004b), and approved by DTSC on October 29, 2004 (CalEPA, 2004b). The approved Background Study Work Plan describes a process for identifying and evaluating potential background wells for sample collection and determining background metals concentrations in groundwater. The results of the groundwater background study, including the calculated background concentrations of trace metals in groundwater using data from the six sampling events at the approved 25 background study wells, were submitted to DSTC and the USDOI on January 14, 2008, in the report titled *Revised Groundwater Background Study Steps 3 and 4: Final Report of Results (*CH2M HILL, 2008a). Concurrence on the approach taken for the report and the statistics used to derive the regional background values is pending from DTSC.

2.2.4 Surface Water and Interstitial Water

Several phases of site investigation and characterization addressing surface water and interstitial water (i.e., porewater) were completed between June 1997 and June 2004, all of which are described and summarized in the Draft RFI/RI (CH2M HILL, 2005a) and the *Revised Pore Water and Seepage Study Work Plan* (CH2M HILL, 2005b). Surface water samples were all filtered, consistent with the governing sampling and analysis plan. Filtered sample results provide a better estimate of potential exposure for both human health and ecological receptors as dissolved concentrations estimate the bioavailable fraction of constituents in the water column more closely than total (i.e., unfiltered) concentrations (USEPA, 1993a). Based on recent discussions and agreements with DTSC and USDOI, filtered samples will be used in the risk assessments. However, unfiltered samples will be collected, beginning in September 2008, and may be used to supplement the risk evaluation in the event that recreational exposure to filtered surface water appears to be a significant exposure pathway.

Since 2005, there have been ongoing surface water investigations, collected in accordance with the GMP (CH2M HILL, 2005d). Surface water samples collected up through October 2007 were included in the RFI/RI Volume 2 (CH2M HILL, 2008b), as discussed in the following section, and will be used in the risk assessments. Interstitial water monitoring has been completed at this time; however, surface water monitoring is ongoing. The scope of additional investigations is described below in Section 2.3.2. Interstitial water and surface water sample locations are shown on Figure 2-21. Additional interstitial water sampling locations are shown on Figure 4-7 from the RFI/RI Volume 2 (CH2M HILL, 2008b), which is provided in Appendix B for the reader’s convenience.

2.2.4.1 Previous Investigations

From June 1997 through present, surface water samples have been collected from up to 18 locations (five locations were sampled at multiple depths) along an approximately

9.5-mile-long section of the Colorado River. Results of this sampling through June 2004 are presented in the Draft RFI/RI (CH2M HILL, 2005a). Beginning in mid-2005, additional surface water samples were collected from a boat in mid-channel at nine locations. Surface water investigations conducted between June 2004 and October 2007 are presented in the quarterly monitoring reports. Surface water sampling data collected between 1997 and October 2007 were included in the RFI/RI Volume 2 (CH2M HILL, 2008b) and will form the basis of the dataset to be used in the upcoming risk assessments.

Eight interstitial water samples were collected as part of the Draft RFI/RI (CH2M HILL, 2005a). The interstitial water samples were collected from within the sediment at approximately 2 to 3 feet below sediment surface (bss) of the Colorado River. Interstitial water samples were also collected at three to five locations at 16 transects along an approximately 9.5-mile-long section of the Colorado River for a total of 64 samples, as part of the *Revised Pore Water and Seepage Study Work Plan* (CH2M HILL, 2005b). Interstitial water samples collected as part of the Draft RFI/RI and the *Pore Water and Seepage Study* will form the basis of the dataset to be used in the upcoming risk assessments.

2.2.4.2 Background Investigations

Beginning in June 1997, surface water and interstitial water samples were collected upstream from where the groundwater plume approaches the river. These data may act as background samples for comparison to downstream samples, if needed.

2.3 Additional/Ongoing Investigations

2.3.1 Soil

Additional soil investigations will be completed as described in the Draft RFI/RI Work Plans Part A and Part B (CH2M HILL, 2006a; 2007d). Each of these is described briefly below.

2.3.1.1 Part A – Outside the Compressor Station

All ten AOCs outside the compressor station (Table 2-1) will be sampled to horizontally and vertically delineate potential contamination, increase sample size to meet data needs, or to evaluate areas that have not already been sampled. Proposed sampling plans for each area are presented in Section 6 of the Draft RFI/RI Work Plan Part A

(CH2M HILL, 2006a). Figures 2-2 through 2-9 show proposed sampling locations outside the compressor station. The existing and proposed sampling locations for the Former 300B Pipeline Liquids Tank area are shown on Figure 6-25 of the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a), which is provided in Appendix B for the reader's convenience.

2.3.1.2 Part B – Inside the Compressor Station

Proposed sampling plans for areas inside the compressor station are presented in Section 5 of the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d). As described, the 18 AOCs will be sampled to horizontally and vertically delineate potential contamination, increase sample size to meet data needs, or to evaluate areas that have not already been sampled (Table 2-1). Figures 2-10 through 2-19 show proposed sampling locations for areas inside the compressor station. (The exposure pathways to ecological receptors are incomplete for areas inside the compressor station fence line and no ERA will be performed for those areas.) Additional areas may be added depending on the results of the Part B soil sampling investigation (CH2M HILL, 2007d). As of the submittal of this work plan, PG&E is in discussions with the agencies regarding the schedule for phasing the soil sampling work within the compressor station that was identified in the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d). Such phasing may result in portions of the soil characterization within the fence line of the compressor station being performed after PG&E no longer uses the property for utility purposes.

2.3.2 Groundwater and Surface Water

Routine groundwater and surface water monitoring activities were initiated in 1997 as a continuation of the RFI groundwater investigation. The program initially consisted of quarterly sampling of the monitoring wells and surface water stations established during the RFI, as well as periodic sampling of inactive supply wells. Beginning in November 2003, at DTSC's request, the GMP (CH2M HILL, 2005d) was expanded to include additional wells and more frequent sampling at select locations. A general description of the ongoing groundwater investigations, and some additional investigations that were recently requested by DTSC, are provided below.

2.3.2.1 Ongoing Monitoring

Groundwater monitoring data collected between July 1997 and June 2004 are presented in the Draft RFI/RI (CH2M HILL, 2005a). A final RFI/RI Volume 2 (CH2M

HILL, 2008b) was prepared and presents groundwater and surface water monitoring data collected between 1997 and October 2007 from over 100 wells at the site and surface water sampling locations. The final RFI/RI Volume 2 (CH2M HILL, 2008b) was submitted on July 2, 2008. Sampling locations are shown on Figure 2-21.

Before August 2004, parameters analyzed included only COPCs as described in the 1996 CACA (CalEPA, 1996a) (i.e., hexavalent chromium, total dissolved chromium, copper, nickel, zinc, electrical conductivity [also referred to as specific conductance], and pH). As proposed in the July 2004 *Sampling and Analysis Plan* (SAP; CH2M HILL, 2004a) and approved by DTSC, the parameters analyzed beginning September 2004 included the primary site COPCs: hexavalent chromium, total chromium, specific conductance, pH, and the California Code of Regulations Title 22 full list of metals (including copper, nickel, and zinc) at selected groundwater monitoring wells (CH2M HILL, 2007f).

As of December 2007, the GMP consists of sample collection at groundwater monitoring wells and surface water sampling stations according to the following schedule:

- All 100 of the site monitoring wells are sampled during biennial sampling events (once every 2 years).
- 84 are sampled during annual sampling events.
- 54 of the monitoring wells are sampled during semiannual sampling events.
- 30 monitoring wells are sampled during quarterly sampling events; 9 shoreline surface water stations and 9 in-channel surface water stations are sampled quarterly and monthly during low-river stages.
- 5 monitoring wells on the floodplain and 2 active extraction wells are sampled monthly.

2.3.2.2 Additional Monitoring for Metals

In November 2007, DTSC requested that the analyte list for 13 of the existing groundwater monitoring wells be expanded to include the California Code of Regulations Title 22 full list of metals (CalEPA, 2007a). DTSC has requested that the monitoring be conducted on a quarterly basis, for a minimum of one year.

2.3.2.3 Monitoring Data from Arizona Wells

As requested by DTSC additional groundwater investigation and water quality characterization samples have been collected beneath the Colorado River and on the Arizona shoreline. The purpose of these wells was to further define the limits of the plume to the east and south of the California floodplain. Multilevel monitoring wells were installed at three locations in Arizona to provide additional groundwater characterization data for the final RFI/RI. At one of these locations, a slant well was constructed that extends under the Colorado River (CH2M HILL, 2007e). Monthly sampling events will be conducted for six months and as directed by regulatory agencies thereafter.

2.3.2.4 Data for Inside the Compressor Station

Up to three monitoring wells will be installed inside the compressor station as part of the implementation of the Part B soil sampling investigation (CH2M HILL, 2007d). A minimum of one year of groundwater monitoring will be conducted at these three wells. As of the submittal of this work plan, PG&E is in discussions with the agencies regarding the schedule for phasing work within the compressor station that was identified in the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d). Such phasing may result in some or all of the planned monitoring wells within the fence line of the compressor station being installed after PG&E no longer uses the property for utility purposes.

2.3.2.5 Data from East Ravine Groundwater Investigation

The East Ravine is a small ravine located on the southeast side of the compressor station, which drains eastward. Portions of the East Ravine are on PG&E property outside the compressor station fence line and other portions of the ravine are located on property owned by the Havasu National Wildlife Refuge (HNWR) (CH2M HILL, 2008c). Additional site investigation has been requested by DTSC to identify the groundwater pathway at AOC 10 and the adjoining East Ravine area to supplement the final RFI/RI. The primary objectives of the groundwater investigation in the East Ravine area are to:

- Determine whether elevated concentrations of hexavalent chromium and other inorganic constituents are present in groundwater in the bedrock formation(s) beneath the East Ravine area; if elevated concentrations of hexavalent chromium are confirmed in bedrock, evaluate the presence and potential extent of the groundwater impact

- Assess the potential for perched groundwater to occur at the base alluvium/bedrock contact underlying the East Ravine area
- Install permanent monitoring wells at the bedrock formation(s) and at the base alluvium contact to provide ongoing groundwater quality monitoring in the East Ravine area.

Groundwater monitoring from the wells installed in the East Ravine is expected to occur for a minimum of one year.

2.4 Site Physical Characteristics

The site is located in the Mohave Valley, along the California-Arizona border in eastern San Bernardino County, California. The Chemehuevi Mountains are located to the south and the Colorado River is located to the east and north. The site occupies approximately three square miles of the north-sloping piedmont alluvial terrace and floodplain along the northern margin of the mountains. A detailed description of the site geology and hydrogeology can be found in the Draft RFI/RI (CH2M HILL, 2005a). The following sections contain a brief description of the site physical characteristics.

2.4.1 Geology

Alluvial terraces and incised drainage channels characterize the landforms. BCW is a prominent desert wash that crosses the site from south to north. Floodplains lie adjacent on each side of the Colorado River, though they do not flood due to flow regulations of the Davis Dam, approximately 40 miles north of the site. On the study area side, the floodplain is approximately 500 feet in width. Topography ranges from 450 feet above mean sea level to 1,200 feet mean sea level within a mile of the Colorado River (Figure 2-23) (CH2M HILL, 2005a).

The site is in the Basin and Range geomorphic province, with parallel fault-block mountains separated by alluvial valleys (Figure 2-24). The Chemehuevi Mountains are the dominant geologic feature in the site vicinity, a metamorphic and plutonic basement core complex exposed in southeastern California and western Arizona. A prominent geologic structural feature is a Miocene-age, low-angle normal fault that forms the northern boundary of the mountains (CH2M HILL, 2005a). The compressor station lies upon the north-sloping piedmont terrace along the northern margin of the mountains.

In the floodplain area, the unconsolidated alluvial and fluvial deposits are underlain by the Miocene conglomerate and pre-Tertiary metamorphic and igneous bedrock. In the upland area, the subsurface shallow aquifer zone consists of alluvial deposits. These unconsolidated deposits are up to 400 feet thick in the area of the site where wells have been installed. Up to 340 feet of the unit is saturated. Lithologic logs and hydraulic testing suggest that the alluvial materials undergo facies changes across the Topock site. Additionally, some interfingering of coarser material is observed throughout the sediments (CH2M HILL, 2005a).

2.4.2 Hydrology and Hydrogeology

The site is located within the Sonoran Desert region of the Basin and Range geomorphic province and is situated at the southern end of the Mojave groundwater basin (Anderson, 1995; Anderson et al., 1992). The mountains are roughly parallel north/south and separated by alluvial basins. The Colorado River runs north to south through the basin. The site is located at the southern extent of unconsolidated alluvial aquifer material in the Mohave groundwater basin (CH2M HILL, 2005a). A conceptual model of the hydrogeology at the site is shown on Figure 2-25.

Groundwater occurs under unconfined to semi-confined conditions within the alluvial fan and fluvial sediments beneath most of the Topock site. The saturated portion of the alluvial fan and fluvial sediments are collectively referred as the Alluvial Aquifer. In the floodplain area adjacent to the Colorado River, the fluvial deposits interfinger with, and are hydraulically connected to, the alluvial fan deposits. The unconsolidated alluvial and fluvial deposits are underlain by the Miocene Conglomerate and pre-Tertiary metamorphic and igneous bedrock with very low permeability; therefore, groundwater movement occurs primarily in the overlying unconsolidated deposits.

Water chemistry is generally dominated by sodium and chloride, and total dissolved solids vary considerably. Generally, groundwater flow is north to northeasterly, in contrast to the southerly flow of the majority of the Mohave Valley (CH2M HILL, 2005a). Groundwater moving south down Mohave Valley is diverted to an easterly-northeasterly direction by the low-permeability bedrock of the Chemehuevi Mountains. The measured saturated thickness of the alluvial aquifer at the site ranges from as little as 30 feet in the southern floodplain area (at MW-32) to 260 feet in the IM-3 injection area and 340 feet in the northern floodplain area (MW-49) (CH2M HILL, 2005a).

2.5 Ecological Habitat Characteristics

The site is located adjacent to the 37,515-acre HNWR managed by USFWS. The area is characterized by arid conditions and high temperatures and consists of a series of terraces divided by dry desert washes (CH2M HILL, 2005a). The site is located either within the Mojave Desert province of California, the Colorado Desert, or the boundary between these two deserts (CH2M HILL, 2005a). The following sections provide a general overview of the ecological characteristics for upland and riparian habitats (Figure 2-26). This information has been excerpted from the PBA (CH2M HILL, 2007c) and Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a); these documents should be consulted for detailed information.

2.5.1 Uplands

The terrestrial habitats are typical of Mojave Desert uplands, consisting of creosote bush scrub, Mojave wash, desert riparian, and tamarisk thicket. Creosote bush scrub is the dominant upland plant community (CH2M HILL, 2007c). The area is sparsely vegetated with widely distributed creosote bushes (*Larrea tridentata*). The creosote bush and salt bush scrub plant communities comprise approximately 974 acres within the site. Terrestrial wildlife diversity is considered low because of the disturbed nature of the land and the incomplete wildlife corridor (CH2M HILL, 2005a). Representative upland avian, mammalian, and reptilian species are listed in Table 2-2. Representative upland plant species are listed in Table 2-3.

2.5.1.1 Bat Cave Wash

The BCW is an ephemeral drainage that extends from the Chemehuevi Mountains to the Colorado River approximately 3,500 feet north of the compressor station. It is located west of the Colorado River, in the Mojave Wash habitat. This wash may periodically flood during stormwater runoff events, but remains dry throughout most of the year due to arid desert conditions. It is relatively barren of vegetation, consisting of sand, gravel, and cobblestone substrate (CH2M HILL, 2007c).

2.5.2 Riparian Corridor

The Colorado River is the primary aquatic habitat located approximately 1,300 feet east of the compressor station. The river is approximately 700 to 900 feet wide and 8 to 15 feet deep at this location (E&E, 2000). Small patches of emergent vegetation exist along the banks of the Colorado River, with little to no submergent vegetation within the river. The Topock Marsh, extending northeast of the APE within the HNWR, provides important aquatic marsh and riparian habitat in the local vicinity. East of the Colorado River, the APE is a sand and salt cedar environment very similar to that found of the floodplain on the California side. Salt cedar (also referred to as tamarisk) thicket is the dominant plant community along the Colorado River floodplain. This invasive, exotic plant species has displaced native plant species. This plant community consists of dense monotypic stands of salt cedar with an understory of arrowweed (*Pluchea sericea*)*.* The salt cedar and arrowweed plant communities comprise approximately 349 acres within the APE. Various wildlife and plant species are supported by the riparian habitat and representative species lists are presented in Tables 2-4 and 2-5.

2.5.3 Special-Status Species

Several threatened or endangered species (state and federally listed) were identified as having potential to occur in or near the site. These species were evaluated in the PBA (CH2M HILL, 2007c).

Several wildlife species are known to occur or have potential to occur on or near the site. Tables 2-2 and 2-4 provide a representative list of upland and riparian species with relevant habitat, feeding guild, and potential presence or absence based on site conditions.

The five types of plant communities in the vicinity of the project area are Mojave creosote bush scrub, Mojave wash scrub, desert riparian, tamarisk thicket, and freshwater marsh (CH2M HILL, 2005a). Tables 2-3 and 2-5 provide a representative list of upland and riparian species with relevant habitat and potential presence or absence. There are no state or federally listed threatened or endangered plant species potentially present in the riparian areas. In uplands, smoke tree (*Psorothamnus spinosus*) is potentially present and is an Arizona state protected species.

2.6 Land Use

The following sections describe the current uses of the site and the surrounding areas, as well as the reasonably anticipated future land uses.

2.6.1 Current Land Use

The compressor station is located in a sparsely populated, rural area. The surrounding area has important spiritual meaning to the Fort Mojave Indian Tribe (FMIT) and other lower Colorado River Indian tribes. As mentioned earlier, the compressor station occupies approximately 15 acres of a 65-acre parcel of PG&E-owned land. PG&E also owns a 100-acre parcel located about 0.25 miles north of the compressor station, purchased in 2004 to facilitate IMs. In addition to the PG&E 100-acre parcel, the surrounding area includes land owned and/or managed by a number of government agencies, including the USBLM, USBOR, USFWS, San Bernardino County, California Department of Transportation, and BNSF Railroad (Figure 2-27). Industrial or commercial developments within a 1-mile radius include the existing compressor station and IM No. 3 treatment plant facility. The nearest residents are located in Topock, Arizona, a community of about 20 people in a small mobile home park near the Topock Gorge Marina. Most of the residents in Topock are retired senior citizens who live in the area part of the year, typically from late fall through spring. There are also a few permanent homes (i.e., the homes are occupied all year) located on the southern side of I-40, along the shoreline between the pipeline bridge and the I-40.

The largest nearby community is Golden Shores, Arizona (population approximately 3,000), located approximately 8 miles to the northeast and on the opposite side of the Colorado River from the compressor station. The city of Needles, California, with a population of approximately 4,800 is located approximately 15 miles northwest of the facility.

Moabi Regional Park is a recreational facility operated by the San Bernardino County Department of Parks and Recreation. It is located on land leased from USBLM and lies approximately 1 mile northwest of the compressor station on the west shore of the Colorado River. The park encompasses approximately 1,050 acres, includes a boat marina and 105 campsites, and provides access to the river for various sport and recreational activities. The park is located on a side channel of the Colorado River, approximately 1 mile west of the main river channel. The mobile homes are used primarily as weekend residences. As a regional park, it has no full-time residences. There are no year-round residents because campers are limited to 5-month stays. The park does not keep records of residency; therefore, the number of people at the park at any given time is unknown.

The USBLM-managed lands within the area are owned by USBLM, San Bernardino County, and USBOR. These lands are considered public; however, public use is discouraged, as the Topock Maze, a culturally significant area for several Native American tribes is located here.

A major gas utility and transportation corridor is located within the site. This corridor includes PG&E’s two natural gas transmission pipelines, four natural gas transmission pipelines operated by other companies, the BNSF Railway, and the I-40 freeway. Other developed land uses within the site include the National Old Trails Highway, former Route 66, and various unnamed access roads. In addition, numerous groundwater well clusters, related to the ongoing groundwater investigation activities, are located throughout the site.

The HNWR (land that is managed by USFWS) encompasses approximately 37,515 acres along the Colorado River in Mojave and La Paz Counties, Arizona, and in San Bernardino County, California. Most of the HNWR extends from the upper end of the Topock Marsh southward, to the head of Lake Havasu on the Arizona side of the Colorado River. A small portion of the refuge borders the compressor station. Recreational activities at the HNWR include sightseeing, bird watching, fishing, hunting, camping, and canoeing.

Figure 2-27 presents a map depicting the current owners and managers of the land in the area surrounding PG&E’s compressor station.

2.6.2 Future Land Use

PG&E plans to continue owning and operating the compressor station and associated property inside and outside the fence line as an industrial operation for the foreseeable future. Accordingly, the reasonably anticipated future use of the PG&E compressor station is for ongoing industrial operations.

Similarly, it is reasonable to assume that land that is owned by BNSF Railroad, and land that is leased by the California Department of Transportation, will continue in the future to be used for the railroad and interstate highway.

As indicated above, and as depicted in Figure 2-28, a large portion of the land in the vicinity of the compressor station is owned and/or managed by USBLM and the HNWR. Based on information provided by USDOI, current and future land use on national wildlife refuges is guided by the National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (USFWS Organic Act; USDOI, 2007). The USFWS Organic

Act describes the mission of the National Wildlife Refuge System (the System) as the administration of "…a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, an plant resources and their habitats within the United States for the benefit of present and future generations of Americans." In addition to outlining the conservation mission of the System, the USFWS Organic Act details requirements for the management and use of a refuge and has requirements for land-use planning at each refuge, focusing on the preparation of a comprehensive conservation plan for each refuge and detailed compatibility determinations for each refuge.

According to information presented by USDOI, the primary conservation mission of USFWS as it applies to the HNWR, articulated in the USFWS Organic Act, the conservation management plans, and appropriate use and compatibility policies, limits human use of HNWR property and reduces the likelihood of transferring HNWR property out of federal ownership (USDOI, 2007). According to USDOI, this supports that human use of the HNWR property will continue, in the future, to be restricted to recreational uses consistent with these statutory, regulatory, and policy guidelines.

San Bernardino County has requested that USBLM allow them to expand the leased premises into the Topock site, stretching along the floodplain from the currently leased property south to the railroad bridge. The purpose of the proposed expansion included a variety of seasonal residential and recreational uses, including mobile homes, expansion of tent camping and recreational vehicle areas, a hotel, and reconstruction of an old restaurant. According to USDOI, the requested expansion by San Bernardino County would allow for new pull-through recreational vehicle camping sites and tent camping areas. These areas would be located south and east of the BCW, west of the beach area, east of old Route 66, and north of the railroad. It would seem that use of the floodplain area for camping would be considered an undertaking, and would require USBLM to determine whether camping would create any visual impacts to the Topock Maze or other eligible properties, and whether these uses are compatible with the objective of preserving these resources for the future (USDOI, 2007). However, according to USDOI, the continuing development of adjacent property combined with USBLM's broad land management leave open the possibility that USBLM land may be transferred out of federal ownership.

In sum, future use of the USBLM-owned land at the site, as recommended by USDOI, should take into consideration the following three factors: (1) it is reasonably foreseeable that the land may be transferred out of federal ownership; (2) human use of Park Moabi-leased portion will continue to include both seasonal use by the public and year-round residential use by a limited number of San Bernardino county staff; and (3) it is reasonably foreseeable that camping on the floodplain will occur under either San Bernardino’s proposed expansion or USBLM’s future use of non-leased areas.

3. Data Evaluation for Baseline Risk Assessment

This section describes the approach that will be used in evaluating site data for use in the HHRA and ERA. This approach is based on currently available data, additional data that will be collected, and the preliminary CSMs described in Sections 4, 5, and 6. The approach described in this section is likely to be refined during the risk assessments, based on the specific spatial distribution patterns of constituents, location of “hot spots” (i.e., areas with significantly high concentrations of constituents), habitat, and other varying factors. In general, the identification of hot spots will be conducted by evaluating the site data for outliers, which could require additional and/or alternative statistical evaluations for identifying the appropriate EPCs. The methods that will be used to estimate EPCs and the general approach for evaluating hotspots for the risk assessments are presented in Appendix A.

This section provides a summary of the data available for the site and the approach that will be considered in developing representative exposure areas, a summary of the data usability guidance that will be followed, and the methodology for selection of COPCs.

3.1 Data Summary

For estimating exposures to human and ecological receptors, the site media data that will be considered in the risk assessments may include soil, sediment, groundwater, surface water, interstitial water, and air. Data for these exposure media and the recommended areas for estimating exposures are described below.

3.1.1 Soil

As part of the RFI program, more than 300 soil and sediment[1] samples were collected from the site from 1988 to 2003 as presented in the Draft RFI/RI (CH2M HILL, 2005a). Data in the RFI were obtained from the following sources, and were summarized in the Draft RFI/RI (CH2M HILL, 2005a):

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[1] Some of the older reports listed in Section 3.1.1 used the term sediment for samples that fit into the soil category (rather than inundated sediment). Please see Section 3.1.2 for the definition of sediment as it applies to conducting the risk assessments.

- *Bat Cave Wash Soil Investigations, Topock Compressor Station* (Brown and Caldwell, 1988)

- *Phases 1 and 2 Closure Certification Report, Hazardous Waste Management Facilities, Topock Compressor Station* (Mittelhauser Corporation, 1990a)

- *Closure Activity Report, Oil Water Separator System, Topock Compressor Station* (Mittelhauser Corporation, 1990b)

- *Analytical Data Report, Sediment and Sand Samples, Phase 3, Evaporation Ponds, Closure of Hazardous Waste Facilities, Revision 1* (Mittelhauser Corporation, 1992)

- *Report, Site Investigation, Project 62793, PG&E Compressor Facility* (Environmental Profiles, 1993)

- *Evaporation Pond Closure Report, Pacific Gas and Electric Company, Topock Gas Compressor Station* (Allwaste Transportation and Disposal, 1993)

- *Soil Investigation Report, Pacific Gas and Electric Company, Topock Gas Compressor Station* (Alisto Engineering Group, 1994)

- *Scrubber Oil Sump Closure Certification Report, PG&E Topock Gas Compressor Station* (Trident Environmental and Engineering, 1996)

- *RCRA Facility Investigation Report, Bat Cave Wash Area, Pacific Gas and Electric Company, Topock Gas Compressor Station* (E&E, 2004).

Additional soil data are also available in the following sources as summarized in the Draft RFI/RI Work Plan Part A and Part B (CH2M HILL, 2006a; 2007d):

- Confirmation soil data collected from evaluation of spills from the compressor station as presented in the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a)

- Data collected from tank closure activities at the Former 300B Pipeline Liquids Tank as presented in the Former 300B Pipeline Liquids Tank Closure Technical Memorandum (CH2M HILL, 2007h)

- Soil data collected during the RCRA closure process (CH2M HILL, 2007d)

- Samples collected during a recent (March 2007) utility trenching effort at the compressor station (CH2M HILL, 2007d).

Additional soil samples will be collected from the site as described in the Draft RFI/RI Work Plan Part A and Part B (CH2M HILL, 2006a; 2007d).

Data from the sources listed above and additional soil samples to be collected will be included in the datasets that will be relied upon and evaluated in the risk assessments.

All SWMUs and AOCs that have not received regulatory closure will be included in the risk assessment. The closure criteria for those SWMUs/AOCs/Units that have already received regulatory closure were based on background concentrations as described in Section 5 of the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a). Data for these closed areas will be included in the risk assessment if additional sampling indicates chemical concentrations of potential concern in these areas.

3.1.1.1 Exposure Areas

The SWMUs and AOCs that will be evaluated in the risk assessments are shown in Figure 2-1 (As previously mentioned, the Potential Pipeline Disposal Area is not shown on Figure 2-1, but is presented on Figure 6-1 of the Draft RFI/RI Workplan Part A [CH2M HILL, 2006a] and is provided in Appendix B for the reader’s convenience). For the risk assessments, soil data from terrestrial/upland areas will be grouped into exposure areas. Within exposure areas, a receptor is assumed to move at random and contact environmental media generally equally throughout the area. While an individual human or ecological receptor may not actually exhibit random movement across an exposure area, the assumption of equal time spent in different parts of the exposure area is a reasonable simplifying assumption. However, it is acknowledged that ecological receptors tend to inhabit areas or at least forage in areas that provide for better habitat or better access to prey. Human and ecological populations have some common and some different potential movement patterns and considerations for contact. Consequently, the exposure areas are defined differently for humans and ecological receptors as described below.

The exposure areas identified for the HHRA are the following:

- **BCW:** BCW is a drainage feature that includes the former percolation bed (SWMU 1) and the area around the former percolation bed (AOC 1) as shown in Figure 2-2 and also extends past the SWMU 1/AOC 1 areas down to the Colorado River. For purposes of the HHRA, all AOCs outside the compressor station are assumed to be equally accessible for future human use. However, BCW is being considered as a unique exposure area because wastewater was routinely discharged into this area. It is a known source of the groundwater plume and is, therefore, distinct from both a historical use and geographical perspective.

  A description and status of BCW is presented in the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a) and in the Draft RCRA RFI/RI Work Plan Part A (CH2M HILL, 2006a). Site media for BCW will include soil and sediment. The approach that will be used in evaluating soil data is described below. The sediment data from the mouth of the BCW may be considered in the HHRA in detail depending on the results of the Part A soil sampling investigation (CH2M HILL, 2006a), subsequent transport pathway analysis, and sediment screening using California Human Health Screening Levels (CHHSLs) (CalEPA, 2005b), USEPA Residential Preliminary Remediation Goals (PRGs) (USEPA, 2008c), and USEPA Region 9 PRGs (USEPA, 2004a), as appropriate. The approach that will be used in evaluating sediment data is described in Section 3.1.2. The approach that will be used in evaluating groundwater data is described in Section 3.1.3.

- **Outside the Compressor Station:** The description and status of the AOCs outside the compressor station is presented in the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a).

  For purposes of the HHRA, all AOCs outside the compressor station (excluding BCW) will be initially considered as one exposure area because, as mentioned earlier, all areas outside the compressor station are equally accessible for future human use. The exposure area outside the compressor station for human receptors will be evaluated as one exposure area and will include soil data from AOCs 4, 9, 10, 11, 12, and 14, and Potential Pipeline Disposal Area (see Section 4).

  As indicated in Table 2-1, the Former 300B Pipeline Liquids Tank Area outside the compressor station has already been closed (CH2M HILL, 2007h), but DTSC has requested additional investigation (CalEPA, 2007d). If complete pathways are identified based on the results, the Former 300B Pipeline liquids Tank Area will also be included in the HHRA. The approach that will be used in grouping soil data from this exposure area is described in Section 3.1.1.2 below.

- **Inside the Compressor Station:** The description and status of the SWMUs and AOCs inside the compressor station is presented in the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a). The SWMUs and AOCs located inside the compressor station will be assessed for only human health exposure and not for ecological receptors, as all ecological exposure pathways are considered incomplete in this exposure area (Eichelberger, 2006).

  For the HHRA, all SWMUs and AOCs inside the compressor station will be initially considered as one exposure area. The rationale for considering all SWMUs and AOCs in the compressor station as one exposure area is based on common receptors of concern and the anticipated patterns of exposure, as described in Section 4. The exposure area for inside the compressor station consists of AOCs 5, 6, 7, 8, 13, 15, 16, 17, 18, 19, and 20 (Table 2-1). As also indicated on Table 2-1, additional SWMUs/AOCs/Units inside the compressor station have already been closed (i.e., SWMUs 5, 6, 8, and 9; Units 4.3, 4.4, and 4.5; and AOC 18), but DTSC has requested additional investigation. If complete pathways are identified for these previously closed SWMUs/AOCs/Units based on the results of the upcoming soil investigation (CH2M HILL, 2007d), these units will also be included in the HHRA. The approach that will be used in grouping soil data from this exposure area is described in Section 3.1.1.2 below.

As a result of requests by the regulatory agencies, the exposure areas identified for the ERA are defined separately for large home range receptors (e.g., red-tailed hawk) and small home range receptors (e.g., desert shrew). For the site, DTSC and USDOI are requiring that a discrete exposure area be established as a single AOC rather than defining exposure areas based on considering the area most likely to be occupied by the local population of a particular indicator receptor (for small home range receptors). While PG&E’s position is that a population-based exposure area provides a better estimate of exposure for the selected assessment endpoints for the ERA, PG&E has agreed to initially calculate risks on an AOC-by-AOC basis for small home range receptors, as required by DTSC and USDOI. Thus, for the ERA, exposure areas were identified separately for the large home range receptors (e.g. red-tailed hawk) and the small home range receptors (e.g. desert shrew) as described below.

The main exposure areas for the large home range receptors identified for the ERA include the following:

- **BCW and AOC 4:** BCW (AOC 1) and the Debris Ravine (AOC 4) will be considered one exposure area due to the physical nature of these two AOCs. BCW and AOC 4 are geographically and topographically separated from the other AOCs. For the ERA, BCW and AOC 4 are grouped as a unique exposure area, primarily because these two AOCs are in close proximity and, therefore, the same wildlife populations, especially the large home range receptors, can be expected to forage across both AOCs.

- **Outside the Compressor Station:** All AOCs outside the compressor station (excluding BCW and AOC 4) will be initially considered as one exposure area for the large home range receptors. This exposure area will include AOCs 9, 10, 11, 12, and 14, and Potential Pipeline Disposal Area (see Section 6).

In accordance with DTSC and USDOI's requirement, each AOC outside the compressor station will be evaluated as a separate exposure area for ecological risks to small home range receptors. The main exposure areas for the small home range receptors identified for the ERA include the following:

- BCW (AOC 1)
- AOC 4: Debris Ravine
- AOC 9: Southeast Fence Line combined with AOC 10a
- AOC 10: East Ravine (10b, c, and d)
- AOC 11: Topographic Low Areas
- AOC 12: Fill Area
- AOC 14: Railroad Debris Site
- Potential Pipeline Disposal Area (depending on results, could be combined with the AOC 10 Riparian area).

As agreed by DTSC, the SWMUs and AOCs located inside the compressor station will not be assessed for ecological receptors, as all ecological exposure pathways are considered incomplete in this exposure area (Eichelberger, 2006).

In addition to AOC-by-AOC risk evaluations, AOCs may be grouped if the distribution of chemicals detected during the upcoming soil sampling supports larger exposure areas (i.e., if concentrations detected between different AOCs are comparable, it may be reasonable to group AOCs into larger exposure areas). Decisions to group individual AOCs into larger exposure areas for additional ecological risk evaluation will be made in coordination with and after further discussion with the agencies.

As additional soil data become available, it is possible that small exposure areas may be identified for evaluation (i.e., hot spots) in the risk assessments. This approach is consistent with CalEPA guidance on estimating risks, which recommends calculating exposure concentrations based on all data, then calculating a point estimate to evaluate the potential for hot spots (CalEPA, 1999).

More detailed explanation for the proposed exposure areas, particularly with respect to the receptors and potential patterns of exposure, are described in Sections 4 through 7 in conjunction with the descriptions of the preliminary CSMs and receptor populations.

3.1.1.2 Exposure Depths for Soil

For the HHRA, soil data collected from the exposure areas described above will be evaluated by depth, based on the CSMs for the HHRA (Section 4). All relevant depth groupings for a receptor population will be evaluated to determine what EPC will be health protective for the risk characterization. All receptor populations will be evaluated with respect to contact with surface soil. In order to ensure that the implications of averaging concentrations over one depth zone versus another are clearly understood, the HHRA will evaluate representative exposure concentrations for soils within the following depth categories:

- Surface soil (0 to 0.5 foot bgs)
- Shallow soil (0 to 3 feet bgs)
- Subsurface soil I (0 to 6 feet bgs)
- Subsurface soil II (0 to 10 feet bgs).

The surface and shallow soil may be contacted without substantial intrusive activity. However, the soil at the site is loose desert sand and is not compacted or densely vegetated. Wind erosion and surface water runoff may mix the material at the surface more readily than in other areas of California. Access to soil deeper than 3 feet would require intentional intrusive activity. Some human receptors may contact either or all exposure depths of soil as described in Section 4. Figure 3-1 illustrates the proposed depth intervals for human exposure and the corresponding soil sampling depths, as proposed in the upcoming soil sampling plans.

For the ERA, soil data collected from the terrestrial/upland exposure areas for the ecological receptors described above will be evaluated by depth based on the CSMs for the ERA (Section 6). All relevant depth groupings for a receptor population will be evaluated to determine what EPC will be health protective for the risk characterization. Receptor populations will be assumed to contact surface soil. In order to ensure that the implications of averaging concentrations over one depth zone versus another are clearly understood, the ERA will evaluate representative exposure concentration for soils within the following depth categories:

- Surface soil (0 to 0.5 foot bgs)
- Shallow soil (0 to 3 feet bgs)
- Subsurface soil I (0 to 6 feet bgs).

The exposure depths were selected following guidance provided by CalEPA (1998a) based on review of the soil data presented in the Draft RFI/RI (CH2M HILL, 2005a) and in coordination with the regulatory agencies. The maximum detected concentrations of COPCs were found in the upper 6 feet of soil at the AOCs, and elevated concentrations relative to background are also typically found in this depth interval. CalEPA guidance indicates that characterization of soil to 6 feet bgs is sufficient for the majority of ecological receptors (CalEPA, 1998a). Figure 3-1 illustrates the proposed depth intervals for ecological receptors and the corresponding soil sampling depths, as proposed in the upcoming soil sampling plans. Exposure to soils at different depths for ecological receptors is discussed further in Section 6.

3.1.2 Sediment

As part of the RFI program, 17 sediment samples were collected from the site; 6 from the mouth of the BCW (AOC 1), 8 from locations up river, and 3 from locations down river from its confluence with the Colorado River as shown in Figure 2-3. The results from these 17 sediment samples are described in the Draft RFI/RI (CH2M HILL, 2005a). Sediment samples were also collected from locations in the river as shown in

Figure 2-1 of the RFI Volume 2 (CH2M HILL, 2008b), which is provided in Appendix B for the reader's convenience. In this study, 10 sediment samples were collected primarily to assess if the geochemical conditions in shallow sediments below the river favor chromium reduction. The sampling results from these 10 sediment samples are described in the Porewater and Seepage Study (CH2M HILL, 2006c).

Sediment data are defined as sample results collected from areas that are typically inundated with water even in the absence of storm events. For the HHRA and ERA, surface sediment data (0 to 0.5 foot bss) from the mouth of the BCW will be evaluated separately for AOC 1 if the results of the Part A soil sampling investigation (CH2M HILL, 2006a) indicate a complete transport pathway. The transport pathways to sediment from surface soil entrained in runoff are still being evaluated. The last release to BCW occurred more than 40 years ago. It is reasonable to expect that the current pattern of chemical distribution in the soil will not be materially different in the future (e.g., if impacted soil has not yet reached the riparian habitat, it is not likely to in the future). The results of the upcoming soil investigations at AOC 1 (BCW) and AOC 10 (East Ravine) will be evaluated to further define the horizontal extent of contamination in surface soil and, thereby, further define the potential for surface soil entrained in runoff to reach the sediment (and eventually the river). A gradient approach will be used to evaluate the completion of this transport pathway. For this evaluation, starting from the upland locations (AOC 1 and AOC 10) to the riparian area, site soil data will be compared to background soil data. If concentrations of constituents in site soil decrease down slope and become less than or equal to background before reaching the sediment in the riparian area, this pathway will be interpreted to be incomplete. In addition and for confirmation of the pathway analysis, sediment data in the riparian area will be compared to human health and ecological screening benchmarks (CHHSLs [CalEPA, 2005b], USEPA Residential PRGs [USEPA, 2008c], USEPA Region 9 PRGs (USEPA, 2004a), and threshold effects concentrations [TECs; MacDonald et al., 2000]). The results of both the gradient approach and the sediment screening will be evaluated, and the potential pathway for surface soil entrained in runoff to reach the sediment will be determined in the risk assessment. If this pathway is considered complete, it will be quantitatively evaluated in the risk assessments.

3.1.3 Groundwater

As part of the RFI program, from June 1997 through June 2004, 56 groundwater monitoring wells at 32 locations were installed and sampled. Prior to the RFI, 12 groundwater monitoring wells were installed near the old single-lined and new Class II (double-lined) evaporation ponds. Groundwater data were collected from each of the

RFI and evaporation ponds monitoring wells, as well as several production wells (PG-06, PG-07, and the Park Moabi well) as part of the RFI.

Groundwater data collected from June 1997 through June 2004 are presented in the Draft RFI/RI (CH2M HILL, 2005a). As previously described, groundwater samples are still being collected as described in the GMP (CH2M HILL, 2005d). Groundwater and surface water monitoring are ongoing. Further, upcoming groundwater sampling will include additional monitoring data from newly installed wells inside the compressor station and within AOC 10 (East Ravine). The risk assessments will only include groundwater monitoring data collected up until May 2008. This dataset will match the data to be included in the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum. Additional groundwater data collected after May 2008 will be submitted in RFI/RI Volume 3, data summary reports, or monitoring reports, as appropriate, given the nature of the data and the affect on RFI/RI conclusions. If appropriate, a risk assessment addendum will also be submitted to demonstrate the impact of the additional monitoring data on the recommendations and conclusions of the groundwater risk assessments.

For the HHRA, all groundwater data contained in the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum will be included in the risk assessment. The approach for evaluating groundwater for the HHRA is further discussed in Section 5.

For the ERA, ecological receptors are not directly exposed to groundwater. Depending on hydrogeologic conditions and constituent fate and transport, ecological receptors potentially may be exposed to site-related constituents in groundwater discharging to surface water in the river. Therefore, the groundwater data are considered in the context of an ecological scoping assessment (Section 7), which will inform the groundwater CMS/FS. As mentioned earlier in Section 2, reducing conditions limit the potential for hexavalent chromium to move toward the river in the floodplain. Transport of other constituents to the river, and subsequent exposure, may be considered further depending on concentrations present at the floodplain wells in comparison with background and surface water criteria or screening values. A step-wise screening process, described in Section 7, will be used to evaluate whether the discharge of constituents in groundwater to the surface water body is considered a complete and/or significant transport pathway and could, thereby, pose a potential risk to ecological receptors.

3.1.4 Surface Water

As part of the RFI program, from June 1997 to June 2004, surface water samples were collected from up to 18 locations as shown in Figure 2-21. The surface water data collected from the sampling locations in the Colorado River are presented in the Draft RFI/RI (CH2M HILL, 2005a). Additional surface water data have been collected since 2004, and sampling continues in accordance with the GMP (CH2M HILL, 2005d).

The transport pathway to surface water (i.e., the Colorado River) from groundwater is still being evaluated. The groundwater-to-surface water pathway will be evaluated in the risk assessments by comparing the concentrations of COPCs in floodplain wells to surface water criteria or screening values, as described in more detail in Sections 5 and 7. If a potentially complete and significant transport pathway from groundwater to the river is identified, surface water data may need to be quantitatively evaluated in the risk assessment to inform the groundwater CMS/FS.

The approach to surface water data evaluation, if necessary, will include comparison of surface water data from the river that may be impacted by the site activities (i.e., via the groundwater) to surface water data collected from up river. If there is no significant difference between constituent concentrations detected upstream from the site versus those that are detected adjacent to and downstream from the site, surface water data from near the site may not need to be further evaluated in the risk assessments as the exposure pathways will be considered incomplete and/or insignificant. Surface water evaluation for the HHRA is further discussed in Section 5 and for the ERA in Section 7.

3.1.5 Interstitial Water

As part of the RFI program, eight interstitial samples were collected. These samples were collected from within the sediment at approximately 2 to 3 feet bss in the Colorado River. Two of these sample locations were in the Moabi Regional Park slough, one location was at the mouth of the BCW, and several locations were along the Colorado River shoreline near monitoring wells MW-27-20 through MW–29 as shown in Figure 2-21. Interstitial water data are presented in the Draft RFI/RI (CH2M HILL, 2005a,b). Interstitial water samples were also collected from locations in the river as shown in Figure 3-1 of the *Porewater and Seepage Study Report* (CH2M HILL, 2006c). In this study, 64 interstitial water samples were collected along 16 transects in the river primarily to assess chromium concentrations downgradient from the chromium plume in the floodplain and upgradient from BCW (CH2M HILL, 2006c).

For the HHRA, exposure to interstitial water is considered an incomplete exposure pathway and, therefore, will not be evaluated.

For the ERA, the transport pathway to interstitial water from groundwater is still being evaluated. If the groundwater-to-surface water transport pathway is identified as potentially complete and significant (based on comparison of concentrations in floodplain wells with background concentrations and surface water screening values; see Section 5), the concentrations in interstitial water will be evaluated in comparison with surface water criteria or screening values described in more detail in Section 7. If a potentially complete and significant transport pathway to the river is identified, interstitial water data may need to be further evaluated in the risk assessment.

The approach to interstitial water data evaluation, if necessary, will include comparison of interstitial water data from the river that maybe impacted by the site activities (i.e., via the groundwater) to interstitial water data collected from up river. If there is no significant difference between constituent concentrations detected upstream from the site versus those that are detected adjacent to and downstream from the site, interstitial water data from near the site may not need to be further evaluated in the risk assessment as the exposure pathways will be considered incomplete and/or insignificant. Interstitial water evaluation for the ERA is further discussed in Section 7.

3.1.6 Air

As part of the RFI program, air samples were collected during excavation and soil sampling activities in AOC 1 (upland BCW), AOC 13, and AOC 15. A total of ten air particulate samples were collected and analyzed for total chromium, hexavalent chromium, and total dust. Air data from these samples are presented in the Draft RFI/RI (CH2M HILL, 2005a). The air monitoring data will be summarized in the risk assessments, and may be considered, in combination with agency-recommended wind-erosion models, in estimating potential human exposures to particulates and chromium. Given the relatively minimal amount of air monitoring data and the large amount of soil data that will ultimately be collected, using agency-approved wind-erosion models to estimate the concentrations of airborne constituents that could be present at the site may be a more reasonable approach for providing a conservative estimate of future long-term airborne particulate concentrations. The rationale and uncertainty associated with the use of modeled data over monitoring data will be discussed in the risk assessments.

The exposure pathway for volatile organic compounds (VOCs) in ambient and/or indoor air is still being evaluated, as data for VOCs will be collected in specific locations as part of the upcoming soils investigations. If VOCs are detected in groundwater, screening-level evaluations of the data would be conducted using the DTSC-modified version of USEPA's Vapor Intrusion Model Spreadsheets (USEPA Model GW-SCREEN Version 3.0, 04/03, as modified by DTSC) to evaluate the likelihood that the VOCs could pose a potential indoor air risk if a building were to be constructed directly over the area of impact. If the presence of VOCs is indicated in the soil data, soil gas data may need to be collected if vapor intrusion is a potential pathway of concern that needs to be evaluated, as soil matrix data is not typically used to evaluate the potential intrusion of vapors into a building. An evaluation of data for this pathway will be presented in the HHRA and is discussed further in Section 4.

For the ERA, exposure to constituents via inhalation of ambient air is considered complete for wildlife but not significant (USEPA, 2008a) and, therefore, will not be quantitatively evaluated. If complete pathways are identified based on upcoming sampling for VOCs, then the inhalation of burrow air will be evaluated for burrowing receptors. This pathway will be further evaluated and if found to be complete and significant, will be quantitatively evaluated and presented in the ERA.

3.2 Data Usability

The database for the risk assessments will consist of data from several sampling events conducted during the various phases of the RFI program and will also include data from the ongoing groundwater monitoring program and upcoming additional soil sampling program. The database will include soil and groundwater data. Additional sediment samples will also be collected at the regulatory agencies' request for comparison to health and ecological screening benchmarks (CHHSLs [CalEPA 2005], USEPA Residential PRGs [USEPA, 2008c], USEPA Region 9 PRGs (USEPA, 2004a) and TECs [MacDonald et al., 2000]. If complete or potentially complete exposure pathways are identified, the database will also include sediment, surface water, and interstitial water data. To prepare a dataset suitable for quantitative risk assessment purposes, the site-media data will be first evaluated for usability and then processed through several steps. This section discusses the usability of the data with respect to conducting the HHRA and ERA.

The following guidance will be used in evaluating data for the site and determining their suitability for use in the risk assessments:

- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988)
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (RAGS; USEPA, 1989a)
- *Guidance for Data Usability in Risk Assessment (Part A)* (USEPA, 1992a)
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998).

USEPA guidance presents data usability criteria that will be considered in ensuring that the dataset presented in the RFIs are suitable for risk assessment (USEPA, 1992a); these include: (1) data sources ; (2) documentation; (3) analytical methods and detection limits; (4) data review; and (5) data quality indicators. The evaluation of the analytical data with respect to these data usability criteria will be presented in the Final RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum and Volume 3. The following sections contain a brief discussion of the data usability criteria that will be presented in the RFI/RIs and summarized in the quantitative risk assessments. Additionally, project-specific agreements regarding a data usability assessment (DUA) prepared by PG&E in 2008 (CH2M HILL, 2008d) and the specific approaches for the management of non-detect (ND) results, field duplicate samples, multiple analytical methods for a constituent, and treatment of PAHs are also presented below.

3.2.1 Data Sources

The data source review evaluates the analytical methods performed on the sample with respect to site-use information. The objective of the data review is to ensure that the appropriate analytical methods were used to identify all potential COPCs for each environmental media of interest. A review of the historical data sources was presented in the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a) and was a key factor in determining the scope of additional soil sampling that will be conducted as part of the Phase 1 and Phase 2 soil sampling.

3.2.2 Documentation

The documentation review evaluates the manner in which samples were managed by the field sampling teams and receiving laboratories. The objective of this review is to ensure that analytical results can be associated with specific sampling locations and that the appropriate procedures were used to collect the environmental samples. The DUA, described briefly below, evaluated the adequacy of the documentation for the historical soil and sediment samples, culminating in the categorization of the historic sampling data into three different data usability categories. In sum, a review of the documentation of the historical sampling data has been conducted, was presented in the DUA, and has been integral in framing and directing the upcoming soil sampling programs.

3.2.3 Analytical Methods and Detection Limits

For an analytical result to be useable for risk assessment, the sample collection, preparation, and analytical methods should appropriately identify the chemical form or species, and the specified sample detection limit should be at or below a concentration that is associated with toxicologically relevant levels for the receptors and conditions at the site. The adequacy of the analytical detection limits will be discussed in the risk assessment to ensure that the analytical data are of sufficient quality to reach reasonable risk-based conclusions. This will include an evaluation of the adequacy of the detection limits relied upon in determining that a chemical is not present at the site and does not need to be included in the quantitative risk assessment. We note that the adequacy of the analytical detection limits is specifically evaluated in the planning of the upcoming soil sampling activities; that is, the analytical detection limits for the proposed sampling program are compared to conservative human health and ecological comparison values in order to ensure that the proposed analytical methods will achieve the detection limits necessary to make informed risk management decisions.

3.2.4 Data Review

All sample data utilized in the risk assessment will be reviewed and validated. Data validation for the historical soil and sediment data was evaluated and discussed in the DUA and was used in classifying the data into the three different data usability categories (described below in Section 3.2.6). Data collected as part of the upcoming field efforts (e.g., the Draft RFI/RI Work Plan Part A [CH2M HILL, 2006a] will be evaluated following the *Quality Assurance Project Plan, PG&E Topock Program (*QAPP; CH2M HILL, 2004c*),* QAPP Revision 2 (CH2M HILL, 2005c), and the QAPP Addendum (CH2M HILL, 2006b).

3.2.5 Data Quality Indicators-Representativeness, Completeness and Comparability

Data will be evaluated to determine how well the chemicals are characterized. Data representativeness is an evaluation of site characterization (i.e., how well the samples describe investigational unit conditions; for example, are samples appropriately placed to reveal potential releases and have all compounds potentially related to activities at the investigational unit been analyzed). Representativeness will be maximized through the appropriate placement of the sampling locations (as discussed in the Draft RFI/RI Work Plan Part A and Part B soil sampling investigations [CH2M HILL, 2006a; 2007d), and through the data gaps analysis that will occur between Phase 1 and Phase 2 sampling.

Completeness relates to whether enough sample results are retained after validation to adequately characterize the investigational unit. An assessment of the completeness of the data to characterize the exposure areas will be presented in the risk assessments. Additionally, the data will be reviewed to determine if the variability of chemical concentration in time and space are adequately characterized.

Comparability expresses the confidence with which data are considered to be equivalent. Combined datasets are regularly used to develop quantitative estimates of risk. Comparability for sampling primarily involves sampling designs and time periods (e.g., Was the same approach to sampling taken in two sampling designs? Was the sampling performed under similar physical conditions in the individual events? Were samples preserved?). Typical questions to consider in determining analytical comparability include questions regarding the analytical methodologies, detection limits, laboratories, and units of measurement. When precision and accuracy are known, the data sets can be compared with confidence.

A discussion of the representativeness, completeness, and comparability of the various datasets will be included in the quantitative risk assessments in order to communicate the overall strengths and weaknesses of the datasets to support risk-based conclusions and subsequent risk management decisions.

3.2.6 Project-Specific Data Usability Assessment

As discussed above, the DTSC and PG&E have agreed on project-specific requirements for the preparation of a data quality assessment (CH2M HILL, 2008d) following USEPA guidance. The data quality assessment, requested by DTSC, was developed to provide supporting information to the RFI/RI regarding the ability to use the existing soil and sediment data for site evaluation and closure decisions. The data quality assessment was considered best applied as a DUA, resulting in the assignment of usability codes to the analyte results for all soil and sediment data contained in the Draft RFI/RI (CH2M HILL, 2005a). The DUA prepared by PG&E (CH2M HILL, 2008d) is based on generally accepted data quality indicators rather than site-specific data quality objectives. The following general data quality categories are proposed in the DUA:

- Category 1: Sufficient documentation is available to demonstrate that the data meet all probable end-use objectives including risk assessment, site characterization, site closure, and informational purposes. The data may be used with confidence for all purposes.

- Category 2: Incomplete documentation is available. The data may be used for site characterization, screening, or informational purposes; however the quantitative results should not be used for future critical decision-making purposes.

- Category 3: Insufficient documentation is available. The data may be used for screening or informational purposes only (qualitatively); however, the quantitative results should not be used for future critical decision-making purposes.

Specifically, all soils and sediment data presented in the Draft RFI/RI (CH2M HILL, 2005a) will be identified according to the three categories listed above. Quantitative evaluation in the risk assessments will use only Category 1 data, consistent with the DUA. Further, as discussed in the DUA, although not categorized separately, there will be additional data considered not to be acceptable for any project purposes due to significant quality and or/applicability deficiencies. These data will be rejected and removed from further consideration in the RFI/RI and the risk assessments. The descriptions and identification of all data that are considered useable for the quantitative risk assessment will be presented in the upcoming RFI/RI Volume 3.

One of the primary uses of the data will be to determine what constituents are present, where they are located, and at what concentrations. Other considerations will include whether site concentrations are greater than background, whether exposure areas will be adequately characterized, and if there will be adequate data to calculate EPCs for use in the risk assessments. As described in the DUA, and consistent with the guidance documents identified above, the limitations of the data and the uncertainty introduced into the risk assessments based on the particular limitations of the data, will be clearly presented and discussed in the risk assessments. The results of the DUA will be part of the RFI/RI Volume 3 and will be used to evaluate if the minimum requirements have been met and to identify areas of uncertainty that will be considered in the risk assessments.

Data collected as part of the RFI/RI Part A soil sampling investigations will be evaluated following the QAPP (CH2M HILL, 2004c*),* QAPP Revision 2 (CH2M HILL, 2005c), and the QAPP Addendum (CH2M HILL, 2006b).

3.2.7 Management of Non-Detect Data

Environmental investigations, including HHRAs and ERAs, typically implement proxy concentrations equal to half the reporting limit (RL/2) for ND results. Recent USEPA guidance states that the RL/2 method does not provide adequate coverage (for any distribution or sample size) for the population mean, even for censoring levels as low as 10% (USEPA, 2006a). This is contrary to previous conjecture and assertion often made in previously released USEPA guidance documents (e.g., USEPA, 2000a) that the RL/2 method can be used for lower (<20%) censoring levels. USEPA-released statistical software called ProUCL Version 4.0 (ProUCL 4.0) will be used calculate EPCs (USEPA, 2007a,b), which contains statistical methods to evaluate both full environmental datasets without ND values and datasets with ND values (also known as left-censored datasets) without the use of proxy values. Methods of calculating EPCs are presented in Appendix A. If an analyte is detected in one or more samples in a dataset, EPCs for that analyte will be calculated as recommended by USEPA guidance (USEPA, 2006a). However, if an analyte is not detected in any of the samples in a dataset and the reporting limits are below applicable risk-based criteria, that analyte will not be considered a COPC and will not be further evaluated.

3.2.8 Management of Field Duplicate Data and Data from Multiple Analytical Methods

For cases where a field duplicate sample is present or multiple analyses are present for the same constituent in a sample, a single representative concentration for the sample will be selected generally consistent with USEPA's guidance regarding data verification, data validation, and data quality assessment (USEPA, 1992a; 2002a). These procedures will include the following:

1. If there is a detection in both samples, the higher concentration will selected.

2. If there is a detection in one sample but not the other, the detected concentration will be selected.

3. If both samples are ND, the lowest method detection limit will be selected and appropriate techniques for handling ND data will be applied in calculating statistics later in the data evaluation.

3.2.9 Treatment of Polycyclic Aromatic Hydrocarbon Data

PAHs, a class of organic compounds, are present in the environment as a result of many natural and anthropogenic sources. Most notably, combustion of fossil fuels, fires, and various industrial activities form PAHs, as do such processes as wild fires. As a result of these many sources, PAHs are generally ubiquitous in the environment, in both rural and urban areas. Therefore, PAH concentrations at the site will be evaluated relative to ambient soil background conditions as determined by the background sampling being conducted, as described more fully below in Section 3.3.

PAHs occur as mixtures rather than individual constituents in the environment. For human health assessments, PAHs are evaluated for both carcinogenic and noncarcinogenic potential health impacts. For ecological populations, only systemic toxicity is evaluated. The manner in which PAH data will be incorporated into the soil risk assessment calculations is different for human and ecological populations and is discussed under Sections 4 and 6, respectively.

3.3 Selection of Constituents of Potential Concern

Selecting the COPCs to be included in the risk assessments is a sequential process where compounds detected in site media may be eliminated from further consideration based on either concentrations deemed to be consistent with ambient background conditions or their status as an essential nutrient. COPCs will be selected following appropriate guidance (CalEPA, 1997; USEPA, 1989a, 1997a, 2000a), according to the exposure areas previously described above and in greater detail in Sections 4 through 7. Data for each medium will be used in the COPC selection process as described below.

This section describes the general approach that will be used to select COPCs in each site media. For the risk assessments, all current data and all future data that will be collected from the site and meet the data usability criteria described will be combined and evaluated to identify the COPCs to be carried through the risk assessments.

Guidance on data evaluation allows exclusion of compounds from COPCs if they have been determined to be associated with laboratory contamination (USEPA, 1989a;

1992a). Identification of sample results reflecting laboratory contamination will be conducted for all datasets for all media during the data quality evaluation and usability evaluation process.

3.3.1 Soil

Prior to selecting the COPCs in soil, the constituent dataset will be grouped based on depth as appropriate. Soil data will be compared to background concentrations and will be evaluated for essential nutrients as described below.

3.3.1.1 Comparison to Background

Current DTSC guidance (CalEPA, 1997) allows inorganic compounds to be eliminated from a risk assessment if it can be demonstrated that they do not exceed local background levels. Methods comparable to the DTSC guidance (CalEPA, 1997) are commonly used in the risk assessment process to evaluate whether ubiquitous anthropogenic compounds such as PAHs are present at a site at levels that exceed background concentrations. Accordingly, the general methodology recommended by DTSC (CalEPA, 1997) will be used to determine whether inorganic compounds and/or PAHs detected in the soil at the site are present at concentrations that are elevated above naturally occurring background levels. As discussed in Section 2, the combination of existing background samples and those currently proposed to be collected during the RFI/RI Part A sampling (CH2M HILL, 2006a) will result in a total of 87 background soil samples; all proposed background samples will be analyzed for Title 22 metals, and the surface soil samples will also be analyzed for PAHs. The results of the soils background sampling and the statistical analyses describing the characteristics, uses, and limitations of the background soils dataset will be submitted separately from the risk assessments as a Technical Memorandum for review and approval by DTSC and the federal agencies (currently scheduled to be completed in November 2008). As an example, it is anticipated that the Technical Memorandum will provide the technical justification for grouping of the soils background data, and whether looking at the background samples collected from the three different lithologic units (described in the Draft RFI/RI Work Plan Part A [CH2M HILL, 2006a]) as one population is reasonable and appropriate. In the event that the background study identifies separate lithologic units with differing background characteristics, site soil lithologic units will be compared to appropriate background lithologic units, as the data allows.

Using the approved background soils dataset, a series of statistical tests will be conducted to assess whether concentrations of constituents detected in the soil at the various exposures areas are elevated above background. There is no single statistical test that can be used to determine when concentrations in soil are equal to background levels. Rather, there are several tests that may be used to support this determination. To evaluate whether the concentrations of constituents across the exposure area are comparable to background concentrations, the use of both point estimates (e.g., the 95% Upper Tolerance Limit [UTL]) and statistical distributional tests (comparisons of means and medians) may be used to compare the concentrations of constituents detected to background concentrations. Each of these methods is discussed below. We note that the background evaluation process may involve making numerous simultaneous comparisons between constituents in the reference and affected areas. In order to control the overall comparison-wise Type I error rate, the process will be monitored by evaluating individual comparison plausibility values (i.e., p-values). The overall comparison process will be assessed and suitable corrections applied if p-values approaching the rejection criterion are frequently observed.

3.3.1.1.1 Point Estimate Comparisons

First, the maximum concentration of each constituent detected across the exposure area will be compared to a concentration representing the upper range of background concentrations. It is envisioned that the 95% UTL of the background soils dataset will be used as a single point of comparison (the 95% UTLs for each of the constituents in the soils background dataset will be developed and presented in an upcoming Technical Memorandum). The UTL is a USEPA-recommended, accepted statistical method for determining a background value from a set of data; the 95% UTL represents a value that 95% of the background population will fall below with 95 percent confidence. While no value can ensure a background threshold with 100% confidence, the 95% UTL does seek, with 95% confidence, to offer a value that at least 95% of background concentrations would fall below.

Constituents for which the maximum detected concentration is below the 95% UTL of the background dataset may be eliminated from further discussion. Constituents for which the maximum detected concentration exceeds the 95% UTL from the background dataset may either be carried through to the quantitative risk assessments or evaluated further (i.e., distributional comparisons), as discussed below.

3.3.1.1.2 Distributional Comparisons

Consistent with DTSC (CalEPA, 1997) and USEPA (2000a) guidance, statistical tests, in addition to the point-estimate comparison, may be employed to identify and distinguish between constituents that may be site-related versus those that are likely the result of ambient conditions. These statistical tests include distributional comparison tests that compare the concentrations of constituents in soil potentially affected by the site to the background distribution of these constituents to understand whether the measurements from one population tend to be consistently higher (or lower) than the measurements from another population.

The simplest form of a distributional comparison is conducted through a visual inspection of the data and graphical comparisons of the site data to the background dataset. If the two datasets are from the same underlying distribution, distribution plots of the data should look similar. Common plots that may be used include histograms, box and whisker plots, probability plots, and quantile-quantile plots.

In addition to the diagnostic plots described above, and consistent with DTSC guidance (CalEPA, 1997), other statistical tools are available for comparing two distributions. One type of test that would likely be used is a comparison of the central tendency of the populations (i.e., means or medians). Depending on the distribution of the datasets (i.e., normally distributed; lognormally distributed; or another), the tests of central tendencies would either be a two-sample t-test (which is a test of the means, and requires that both datasets are normally or lognormally distributed) or the Mann-Whitney test (which is a test of the medians, and does not require that the datasets fit a standard distribution). As part of the distributional analysis, tests to evaluate if the upper tails of the distributions are comparable, or if one of the populations has a higher proportion of samples in the upper quantile than the other population (USEPA, 2000a), may be used. As recommended by USEPA (2000a), when the Mann-Whitney test and the quantile test are applied together, the combined tests are the most powerful at detecting true differences between two populations.

All of these evaluations (maximum point comparison, graphical plots, distributional comparisons), in addition to overall frequency of detection, will be considered in reaching a conclusion as to whether it is likely that the constituent detected at an exposure area is elevated above naturally occurring background levels. In general, the risk assessment will be based on a conservative approach and will include constituents instead of excluding them.

3.3.1.2 Evaluation of Essential Nutrients

Consistent with USEPA guidance (USEPA, 1989a), essential nutrients are defined as constituents:

> "...that are (1) essential human nutrients; (2) present at low concentrations (i.e., only slightly above naturally occurring levels); and (3) toxic only at very high doses (i.e., much higher than those that could be associated with contact at the site) need not be considered further in the quantitative risk assessment. Examples of such chemicals are calcium, magnesium, potassium, iron, and sodium." (USEPA, 1989a)

Essential nutrients are commonly excluded from quantitative risk assessments (USEPA, 1989a). However, as requested by USDOI, the relationship between the essential dose of these nutrients for different receptors and the "toxic dose" of the nutrient will be evaluated. USDOI will provide PG&E with toxicological information regarding essential nutrient dose and levels that may pose toxic effects for receptors of concern at the site. Based on the information provided, essential nutrients will be evaluated in the COPC selection process accordingly. If these essential nutrients are detected above background but at levels not considered to be toxic (when the dietary dose and exposure dose are considered in combination), they will be eliminated from the list of COPCs and will not be evaluated further in the risk assessments. The rationale and technical justification for excluding any nutrients from the quantitative risk assessment will be presented in the risk assessments and will be consistent with regulatory guidance and additional information provided by USDOI. If essential nutrients are detected above background and at levels considered to be toxic, they will be selected as COPCs and will be evaluated further in the risk assessments.

3.3.2 Sediment

COPCs in sediment will be selected if a complete transport pathway to sediment (i.e., surface soil entrained in runoff to the riparian area) is identified based on the approach described in Section 3.1.2. If a complete transport pathway is identified for constituents, those constituents will be further evaluated in sediment. COPCs will be selected based on the general approach outlined for soil in Section 3.3.1.

3.3.3 Groundwater

For selecting COPCs in groundwater, and consistent with the approach described above for soil, a constituent may be eliminated from further analysis if it is considered an essential nutrient (but present below a potentially toxic dose, when the dietary dose and exposure dose are considered in combination) or a common laboratory contaminant. A constituent may also be eliminated from further analysis if it is shown to be present at or below naturally occurring or background levels. In general, the series of graphical and statistical tests described above for soil will also be used for groundwater to help distinguish the nature and extent of site-related contamination versus naturally occurring levels of inorganic constituents. As described in Section 2.2.3, a comprehensive groundwater background study has already been completed, in accordance with a DTSC-approved work plan (CH2M HILL, 2004b), and approved by DTSC (CalEPA, 2004b). As discussed with DTSC, background groundwater 95% UTL calculated from the current background groundwater study and presented in the *Revised Groundwater Background Study Steps 3 and 4: Final Report of Results* (CH2M HILL, 2008a), will provide one important point of comparison for determining whether levels of constituents measured in groundwater at the site are considered elevated above naturally occurring background concentrations. However, as stated in the groundwater background study, during the preparation of the risk assessments, the use of the background groundwater concentrations determined through calculation of 95% UTLs for the study area as a whole will be evaluated, noting that the calculated 95% UTLs may not be appropriate for all constituents in all portions of the site or at all depths. As mentioned earlier for soil background concentrations, the background evaluation process for groundwater may involve making numerous simultaneous comparisons between constituents in the reference and affected areas. In order to control the overall comparison-wise Type I error rate, the process will be monitored by evaluating individual comparison plausibility values (i.e., p-values). The overall comparison process will be assessed and suitable corrections applied if p-values approaching the rejection criterion are frequently observed. The limitations and caveats for use of the calculated UTLs for specific constituents, wells, or areas will be assessed and acknowledged, as appropriate for each application.

As with soil, both point estimates and statistical distributional tests may be used to compare the concentrations of constituents detected in monitoring wells to background concentrations. The groundwater background comparison will generally follow the approach described above in Section 3.3.1. As specifically requested by the USDOI, the selection of COPCs in groundwater will be based on a comparison of the entire groundwater dataset to the entire background dataset.

Additionally, because future hypothetical residential uses and exposures to chemicals in groundwater could occur on a residential-lot scale basis, the background dataset will also be compared to the range of concentrations detected in any individual site monitoring well. The comparisons at a given monitoring well location may include a comparison of groundwater data collected across all depth intervals (upper, middle, and lower aquifer intervals), particularly given the fact that the alluvial and fluvial aquifers are hydraulically connected and that the background wells reflect all depth intervals. However, depending on the observed variability and other factors, these statistical comparisons, if completed, may also need to be conducted on the samples collected from a given depth interval, at least at some locations across the site. The rationale and corresponding limitations regarding the treatment of data from different depth intervals will be provided in the risk assessments, if applicable. All of these evaluations (maximum point comparison, graphical plots, distributional comparisons), in addition to overall frequency of detection (both site-wide and in an individual well), will be considered to determine whether it is likely that the constituent at a given monitoring well location is at a concentration that is elevated above naturally occurring background levels. In general, the risk assessment will be based on a conservative approach and will include constituents instead of excluding them.

3.3.4 Surface Water

COPCs in surface water will be selected if a complete exposure pathway for the groundwater-to-surface water pathway is identified based on the transport analysis approach described in Section 3.1.4. If a completed transport pathway is identified for constituents, those constituents will be further evaluated in surface water. If identified, a potentially site-related constituent in surface water may be eliminated from further analysis if it is considered an essential nutrient and present at levels that would be considered below a toxic dose (when the dietary dose and the exposure dose are considered in combination). If potentially site-related constituents remain, surface water data will be evaluated by comparing upstream sampling results to sampling results from areas potentially influenced by site-related groundwater discharge. Those constituents in surface water that remain (after comparison with upstream sampling results) will be identified as COPCs. These steps are discussed in detail in Section 5 for the HHRA and Section 7 for the ERA.

3.3.5 Interstitial Water

COPCs in interstitial water will be selected if a complete exposure pathway for the groundwater-to-surface water pathway is identified based on the transport analysis approach described in Section 3.1.5. If a completed transport pathway is identified for constituents, those constituents will be further evaluated in interstitial water. If identified, a potentially site-related constituent in interstitial water may be eliminated from further analysis if it is considered an essential nutrient and present at levels that would be considered below a toxic dose (when the dietary dose and the exposure dose are considered in combination). If potentially site-related constituents remain, then interstitial water data will be evaluated by comparing upstream sampling results to sampling results from areas potentially influenced by site-related groundwater discharge. Those constituents in interstitial water that remain (after comparison with upstream sampling results) will be identified as COPCs.

These steps are discussed in detail in Section 7 for the ERA. Interstitial water data will not be evaluated for the HHRA as this is considered an incomplete pathway for humans.

3.3.6 Air

For those exposure pathways considered potentially complete, a quantitative evaluation of COPCs in ambient air, indoor air, and/or burrow air will be estimated using standard regulatory-approved models. These models, described more fully in Section 4 for the HHRA and Section 7 for the ERA, are commonly used to predict the concentrations that could be present in the ambient air based on concentrations present in other site media such as soil.

4. Human Health Risk Assessment Approach for Soil

This section describes the procedures for the HHRA for soils that will be implemented following the completion of the Part A and Part B soil sampling investigations (CH2M HILL, 2006a; 2007d) and the submittal of the RFI/RI Volume 3.

Section 300.430(d) of the NCP (USEPA, 1990) states that as part of an RI, a baseline risk assessment is to be conducted to document the potential adverse effects to human health or the environment, under both current and future land-use conditions, caused by the release of constituents in the absence of actions to control or mitigate the release. As specified by USEPA (1989a), two key objectives of the baseline risk assessment are: (1) to help determine whether additional response actions at a site are necessary; and (2) to provide a basis for determining residual constituent levels that are adequately protective of human health.

In accordance with these objectives, the results of the HHRA for soil will:

- Characterize the potential exposures and associated baseline risks for the site

- Inform the RCRA correction action and CERCLA remedy process and provide a basis for developing site management options

- Convey the magnitude and direction of uncertainty associated with the risk estimates

- Identify preliminary RBRGs for the evaluation of remedial alternatives.

The SWMUs, AOCs, and Units vary in their potential to adversely affect human health. Small AOCs located in the active industrialized areas inside the compressor station may be the greatest concern for the protection of workers, whereas outlying undeveloped areas (wildlife refuge and ravines) may pose less risk to human health due to limited potential for human exposure. The difference in exposure potential leads to differences in the exposure assumptions for the different human receptors that may be exposed to site-related COPCs.

Consistent with USEPA guidance, the baseline risk assessment for soil will address the following components:

- Data evaluation and selection of COPCs

- Exposure assessment
- Toxicity assessment
- Risk characterization
- RBRGs
- Uncertainty analysis.

4.1 Purpose and Objectives

The purpose of the HHRA for soil is to evaluate the likelihood that constituents detected in soils at the various exposure areas of the site could adversely impact human health under the assumed set of current and reasonable future land-use scenarios. The results of the risk assessment provide key information that assists the risk managers in making health-protective site management/remedial decisions.

4.2 Applicable Guidance

The approach described in the HHRA portion of this work plan is based on current USEPA and CalEPA guidance documents and includes, but is not limited to, the following:

- *Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil, January 2005 Revision* (CalEPA, 2005a)
- *Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties, January 2005 Revision* (CalEPA, 2005b)
- *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Interim Final, February 2005 Revision* (CalEPA, 2005c)
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A)* (USEPA, 1989a)

- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual Supplemental Guidance, Default Exposure Factors, Interim Final* (USEPA, 1991a)

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B: Development of Risk-Based Preliminary Remediation Goals)* (USEPA, 1991b)

- *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (USEPA, 1991c)

- *Guidance on Risk Characterization for Risk Managers and Risk Assessors* (USEPA, 1992b)

- *Exposure Factors Handbook, Volume 1: General Factors* (USEPA, 1997b)

- *Region 9 PRG Table* (USEPA, 2004a) and the updated Regional Screening Levels (USEPA, 2008c)

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final* (USEPA, 2004b)

- *ProUCL Version 4.0 Technical Guide* (USEPA, 2007a)

- *ProUCL Version 4.0 User's Guide* (USEPA, 2007b).

4.3 Data Evaluation and Selection of Constituents of Potential Concern

The purpose of the data evaluation section of the soils risk assessment is to provide a comprehensive summary of the analytical soil data that has been collected for each exposure area at the site. As part of the data evaluation step, the risk assessment will present a summary of the soil sampling data and will discuss the overall distribution of the constituents detected. Additionally, the data evaluation step will describe the data usability criteria and the specific methods to identify those COPCs that will be included in the quantitative risk assessment.

The outcome of the data evaluation step is identification of: (1) a set of constituents that are likely to be site related; and (2) concentrations that are of acceptable quality for use in the risk assessment. The details regarding the methods that will be used in completing the data evaluation step of the risk assessment, including the specific data usability criteria and methods for selecting the COPCs, are presented in Section 3. A brief overview of each of these steps is summarized below.

4.3.1 Data Quality and Usability

The analytical data will be compiled by environmental medium (e.g., soil, sediment, groundwater, and surface water). Only constituents identified in one or more samples in a given medium will be evaluated in that medium. Constituents reported as NDs in all samples from a given medium will not be evaluated for that medium in the HHRA. A constituent will be deemed ND if it is not reported above detection limits in any of the samples and the reporting limits are below applicable risk-based criteria (e.g., CHHSLs [CalEPA, 2005b] and/or USEPA PRGs [USEPA, 2008c] for residential soil and California MCLs for groundwater).

The analytical data will be evaluated for acceptability for use in the HHRA as outlined in Section 3 and consistent with the DUA (CH2MHILL, 2008d). Analytical results for constituents will be reported in the RFI/RI Volume 3 using data qualifiers issued by the analytical laboratory or applied during the validation process. As described in Section 3, the data usability evaluation for the soil data for the site will follow federal guidelines (USEPA, 1989a; 1992a) and DTSC guidance (CH2M HILL, 2008). Findings of the data quality/data usability evaluation will be presented in the RFI/RI Volume 3. As required by DTSC and USDOI, the HHRA will rely on only Category 1 data to characterize background and site conditions (Section 3.2.6).

4.3.2 Selecting Constituents of Potential Concern

Selecting COPCs is a sequential process where compounds detected in site media are eliminated from further consideration based on either their concentration consistent with ambient background, status as an essential nutrient, or a laboratory contaminant. The general approach for selecting COPCs for inclusion in the soils HHRA is described in Section 3.3.

4.4 Exposure Assessment

Exposure is the contact of a receptor with a constituent or physical agent. The purpose of the exposure assessment is to describe the populations that may potentially be exposed to constituents present at the site, determine the routes by which these exposures may occur, and estimate the magnitude of exposure between the receptor and the potentially impacted environmental media (USEPA, 1989a). For the soil risk assessment, the exposure assessment includes the following steps as described in the subsections below:

- Development of CSM and identification of exposure pathway
- Estimation of EPC
- Estimation of constituent intake or contact rates (exposure assumptions).

4.4.1 Conceptual Site Model

The CSM is a graphical and narrative summary of site conditions, based on currently available information, that describes: (1) all potential or suspected sources of contamination; (2) release and potential migration mechanisms (transport pathways); and (3) potential exposure points and exposure routes through which receptors may contact COPCs associated with the site. All three of these components, taken together, comprise an exposure pathway.

Figures 4-1 through 4-4 present the preliminary CSMs for the site, based on the current understanding and knowledge of site conditions, and may be refined based on the results of the upcoming soil sampling investigations (CH2M HILL, 2006a; 2007d). Figure 4-1 presents a preliminary CSM for the BCW (i.e., SWMU 1 and AOC 1); Figure 4-2 presents a preliminary CSM for all other AOCs (other than the BCW) located outside the compressor station; Figure 4-3 presents a preliminary CSM for inside the compressor station; and Figure 4-4 presents a preliminary CSM for the hypothetical future resident on USBLM land north of the railroad (BCW).

The symbols used for these CSMs are as follows:

- Soild Arrow – represents transport pathways that are potentially complete and will be included in the quantitative risk assessment.

- Dashed Arrow – represents potentially complete transport pathways that will be further evaluated in the risk assessment based on proposed sampling.

- Asterix (*) – represents a potentially complete exposure route to be further evaluated in the risk assessment.

- X – represents potentially complete exposure routes that will be evaluated quantitatively in the risk assessment.

- Open Box – represents incomplete exposure pathway.

There are a few reasons for presenting a separate CSM for each exposure area. First, the evaluations of risk will be completed separately for areas inside the compressor station versus those that are located outside of the compressor station, as the assumed future use of the compressor station as industrial is different from the surrounding areas. Consequently, a separate CSM for inside the compressor station was deemed appropriate. A separate CSM for the BCW (SWMU 1 and AOC 1) was prepared because this area had received historical discharges of untreated wastewater and is the principal source of the hexavalent chromium detected in soil (and groundwater) at the site. As such, the BCW represents a source area that is unique relative to the rest of the SWMUs/AOCs located outside the compressor station.

This HHRA assumes that there are no institutional or engineering controls present within the compressor station to limit contact with site media. The potential areas of soil available for contact are assumed to be unpaved and unvegetated. The exposure pathways designated as complete will be included in the quantitative risk assessment. The transport pathways designated with dashed arrows will be further evaluated in light of the upcoming soil sampling results both inside and outside the compressor station.

In general, an exposure pathway describes the course a constituent takes from the source to the exposed individual. An exposure pathway analysis links the source, location, and type of environmental release with population location and activity patterns to determine the significant pathways of exposure. An exposure pathway is considered complete only if all four of the following elements are present: (1) a source and mechanism of constituent release to the environment; (2) an environmental retention or transport medium (e.g., soil and surface runoff) for the released constituent (exposure pathway); (3) a point of potential contact with the contaminated medium (exposure point); and (4) an exposure route (e.g., ingestion, inhalation, or dermal contact) at the contact point. The exposure pathway is incomplete if any of these four elements are not present. There is no site-related risk associated with incomplete pathways.

A discussion of the constituent sources, the potential pathways through which the sources can be transported to impact soil, and the corresponding pathways through which human populations could potentially be exposed to constituents in soil is provided below.

4.4.1.1 Sources and Potential Transport Pathways

The CSMs in Figures 4-1 through 4-4 show the types of activities and events inside and outside the compressor station that could be potential sources of site-related compounds in the soil. Most sources for site-related compounds found both inside and outside the compressor station originated inside the compressor station or from associated activities, including incidental spills/releases from the following potential areas: tanks, sumps, and pipelines; sludge drying beds; sandblasting area; auxiliary jacket water cooling pumps; cooling water treatment products; former cooling liquid mixing area; floor drains inside the compressor station; hazardous materials storage building and paint locker; and the septic system. Note that these are just the potential sources; the upcoming investigations will help determine whether there were actual releases from any of these sources that resulted in any material impacts. The primary sources of soil contamination in AOCs outside the compressor station, other than BCW, are disposal of debris, potential leaks from the aboveground tanks, potential leaks from the pipeline disposal area, as well as potential incidental discharges/runoff from the compressor station. The BCW area was the primary receiving area of past discharges of untreated wastewater and cooling water to surface soil. From 1951 to 1964, untreated cooling tower blowdown water containing hexavalent chromium was discharged to the BCW near the compressor station. Treated wastewater was released to BCW from 1964 to 1969. Beginning in May 1970, treated wastewater was also discharged to an injection well (PGE-08) located on PG&E property (Figure 2-1), and discharges to the BCW generally ceased (CH2M HILL, 2007a).

Current data indicate that the primary COPCs for site soils are metals, with the primary compound being hexavalent chromium (CH2M HILL, 2005a). DTSC has recommended the following analyses, at some (although not all) sampling locations proposed as part of the Part A and Part B soil sampling investigations (CH2M HILL, 2006a; 2007d): Title 22 metals, hexavalent chromium, VOCs, PAHs, semivolatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), and pH (CH2M HILL, 2007d).

The following summarizes the primary transport pathways that are considered viable and could conceivably carry a significant flux of constituent away from the constituent source areas. Primary source media for the soil is the surface soil as a result of deposition of site-related compounds.

4.4.1.1.1 Surface Runoff

The topography at the site is highly variable. For example, the compressor station is a high point for the area, with the lower yard below the main level, but still higher than the adjacent BCW (SWMU 1/AOC 1) and the Debris Ravine (AOC 4). The site soil data will be evaluated for constituent concentrations compared to background concentrations, geographic location related to topography, and the potential for contribution to down slope locations via surface runoff during the rainy season. Transport of compounds adsorbed to soil particulate matter that move with surface water runoff and overland flow is a potential migration pathway for constituents detected in surface soil. Runoff eventually discharges into low-lying depositional areas where compounds may be redeposited in the surface soil. This pathway will be evaluated by identifying whether constituents in surface soil are distributed in a pattern that suggests that surface runoff is a pathway that could carry site-related constituents from one geographic area to another. Based on current understanding of the topography, surface runoff from the compressor station does not appear to pass beyond the natural berms at AOC 10 and, therefore, does not reach the river. Similar analyses will be conducted for the soils data collected within the BCW to assess whether surface runoff is a pathway that could carry, or has carried, site-related constituents to the mouth of the BCW. Current data indicate that this transport pathway appears to be incomplete. Additional samples, to be collected during the implementation of the Part A soil sampling investigation (CH2M HILL, 2006a), are planned to verify these interpretations.

Currently, the preliminary CSMs do not show a complete exposure pathway for sediment exposure. If upcoming sampling results indicate that surface runoff could have carried impacted surface soil to the river (the most likely location would be at the mouth of BCW), an evaluation of site media and potentially complete exposure pathways could be expanded to include sediment exposure at the shoreline (inundated wet sediment at river shoreline). Sampling and analysis to be reported in the RFI/RI Volume 3 will be discussed in that document and the nature and extent of contamination will be used as part of the risk assessment pathways evaluation.

4.4.1.1.2 Leaching to Groundwater

Leaching of constituents by infiltrating soil pore waters to deeper levels of the vadose zone and to the groundwater is a potential migration pathway for constituents that may not remain bound to soil. Constituent migration in soil and water is governed not only by the physical attributes of the environment but by compound-specific physical/chemical properties, including solubility and soil adsorbency. The RFI/RI Volume 3 and data summary evaluation to be completed between the Phase I and Phase II Part A sampling (CH2M HILL, 2006a) will address leaching potential, the relationship between soil concentrations and groundwater, and the potential for concentrations in soil to impact groundwater quality. Subsurface soil data being collected to evaluate that pathway will be included in the HHRA for potential exposure considerations if data indicate the presence of compounds above background. Potential groundwater exposures and associated risks are discussed in Section 5.

4.4.1.1.3 Fugitive Dust Emissions

Because of the arid conditions of the site, the potential exists for inorganic compounds and SVOCs, if present, to be adsorbed to soil particulates and those particulate emissions to be released to the surrounding air during wind erosion of soil with no vegetative cover. In addition, particulate emissions may occur if the soil were to be disturbed. Accordingly, exposure to fugitive dusts will be evaluated in the HHRA for COPCs present above background.

4.4.1.1.4 Volatilization to Soil Gas

Upcoming data collection includes analysis for VOCs in soil inside the compressor station and at select locations outside the compressor station. If VOCs are detected in subsurface soil, the potential exists for VOCs to partition into soil vapor. If the soil and/or groundwater data confirm the presence of VOCs in these media, vapor intrusion into existing and hypothetical future buildings maybe evaluated, if appropriate, according to the tiered process provided in DTSC guidance (CalEPA, 2005c). The tiered process includes the use of fate and transport modeling to estimate whether the estimated concentration of VOCs in the indoor air of a current or future building could be problematic. If needed, such fate and transport modeling would be conducted according to CalEPA guidance (2005c). If the presence of VOCs indicate a concern for potential vapor migration into indoor air, soil gas data may need to be collected.

4.4.1.2 Identification of Potentially Exposed Populations and Exposure Pathways

The intent of the exposure assessment is to identify plausible human receptors that may be exposed to site-related constituents in contaminated media under current and future site-use scenarios, and to identify the direct and indirect pathways by which they might be exposed to site-related constituents. The appropriateness of including any given receptor scenario is a site-specific determination and depends on the potentially contaminated media, the extent of contamination, and the plausibility that human receptors would be exposed.

Section 2.6 describes the land use for the site and surrounding areas. Figure 2-28 presents a color-coded depiction of the anticipated future land uses for the various areas of the site. There are three color-coded groupings for land-use patterns associated with the exposure areas depicted on this figure. AOCs are shown for identification purposes because these are where the sampling points are located within the exposure areas. The exposure areas and associated receptor populations are grouped as follows:

- BCW – maintenance worker, recreational user, tribal user, and hypothetical future resident (USBLM land only)

- Area outside the compressor station (except BCW) – maintenance worker, recreational user, and tribal user

- Area inside the compressor station – commercial worker and maintenance worker.

The exposure assessment for the HHRA will focus on the future land use and potential receptors. The current land use is assumed, in this risk assessment, to be the same as the future land uses, except for the potential for a hypothetical residential user on USBLM land as shown on Figure 2-28. Current land use does not include residential use for any part of the site. This baseline risk assessment assumes that contact with soil is not limited by the presence of engineering or institutional controls in the future. Because much of the area inside the compressor station is paved, potential exposure for current commercial and maintenance workers would likely be less than the assumptions for future contact with soil for this receptor population working outside the compressor station. Further, current maintenance worker activities outside the compressor station will be used to estimate anticipated future exposures for the population. Therefore, with the exception of the future residential receptor on the

USBLM land, the risk assessment of the future populations as listed above addresses an upper bound for potential exposures for current receptor populations.

The following describes the receptors that are anticipated to be relevant to either current or anticipated future land uses as shown in the CSMs (Figures 4-1 through 4-4) and Figure 2-28. Soil sampling depths for each receptor were presented in Section 3.1.1.2 and shown in Figure 3-1.

4.4.1.2.1 Commercial Worker

Plausible onsite workers include commercial workers who are incidentally exposed to soil as they perform their duties at the compressor station, as described above. Activities may include, but are not limited to, office work and equipment maintenance and monitoring. Because it is assumed that the site soil is not paved or vegetated, there will also be incidental soil contact for the commercial worker, although they are not anticipated to conduct intrusive work. This scenario captures the upper bound potential exposure for long-term routine contact with surface soil (0 to 3 feet bgs) inside the compressor station. Because the land use of the site inside the compressor station is anticipated to remain industrial, the commercial worker in the risk assessment represents all current and future onsite workers for the compressor station. It is currently anticipated that default exposure assumptions for a commercial worker will be appropriate for this receptor. However, further site-specific information regarding known or anticipated duties and activities for site commercial workers may be provided to ground truth the assumptions used in the default exposure scenario. Potential pathways for commercial worker exposure to soil include incidental ingestion, dermal contact, and inhalation of dust in ambient air; all of which will be quantified. Another potential exposure pathway is inhalation of VOCs that may volatilize from the soil, if they are present. Exposure of a commercial worker to vapors in outdoor and/or indoor air will be evaluated if data indicate the presence of VOCs in soil and/or soil vapor. The commercial worker is evaluated only for the exposure area inside the compressor station. If the presence of VOCs indicate a concern for potential vapor migration into indoor air, soil gas data may need to be collected.

4.4.1.2.2 Maintenance Worker

The maintenance worker will be evaluated as a potential receptor involved in routine maintenance and/or repair of the compressor station equipment. This scenario captures the upper bound potential for intermittent short-term exposure to compounds in soil (0 to 10 feet bgs). Exposure may result from excavation and grading activities associated with utility work or equipment maintenance/repair. There are substantial pipelines on PG&E property, along I-40, and along the railroad that periodically require maintenance. This work may require intrusive activity and direct contact with shallow and subsurface soil. A description of known or anticipated duties and activities for maintenance workers will be obtained to assist with developing specific exposure assumptions for this receptor population. The soil exposure pathways include ingestion and dermal contact with soil, as well as the inhalation of particulates in ambient air. The maintenance worker is included in Figures 4-1 through 4-3 and exposure areas being evaluated for current and potential future land use.

4.4.1.2.3 Recreational Receptor

Much of the site area is open desert land with wide-ranging topography and could lend itself to recreational activity, although access to some areas is limited (i.e., steep ravines). The recreational uses for the area could include a variety of wildlife-dependent recreational activities (such as waterfowl hunting, fishing, and wildlife observation), as well as other activities such as hiking. Adults and youth may gain access to areas of the site for sporadic and short periods of time. The adult and youth receptors will be evaluated for exposure to surface soil under both the recreational site-use scenarios. Potential soil exposure pathways for these receptors include incidental ingestion, dermal contact, and inhalation of dust in ambient air. It is assumed that the recreational user would contact only surface soil (0 to 3 feet bgs) and would not conduct intrusive activity. The recreational user is evaluated for areas outside the compressor station including the BCW and other AOCs for potential future land use.

If upcoming soil sampling data indicate a complete transport and exposure pathway for sediment contact at the river, additional recreational users may be considered. Activities associated with contact with sediment could include, but are not limited to, swimming, boating, wading, and fishing.

4.4.1.2.4 Tribal Use Receptor

The FMIT requested that a tribal use scenario be included in the HHRA for soil. For locations outside the compressor station, PG&E will work with the FMIT as requested to develop a tribal use scenario and to define the specific land-use locations and exposure assumptions that would be representative of the FMIT’s use of the land. This receptor is shown on Figures 4-1 and 4-2 for areas outside the compressor station.

4.4.1.2.5 Hypothetical Future Groundwater User

Discussions for the groundwater portion of the HHRA are presented in Section 5. The hypothetical groundwater user is listed separately from the hypothetical future resident to account for the broader context of groundwater as a potable water resource not limited to areas where residential use may occur. Only a very limited portion of the land in BCW is being evaluated under the assumption that the land is used for residential purposes. In contrast, the groundwater impacts associated with BCW (Figure 4-1), as well as any potential groundwater impacts associated with the other AOCs/SWMUs/Units located either outside the compression station (Figure 4-2) or within the compressor station (Figure 4-3), will be evaluated under the assumption that the groundwater could, in the future, be hypothetically be used as a potable source of water across any site location, even if residential use is not planned for that area. Therefore, the hypothetical future groundwater user is included in the CSM figures (4-1 through 4-3) even though residential use is not planned for those areas.

4.4.1.2.6 Hypothetical Future Residential Receptor

The areas outside the compressor station are expected to remain under the control of the current landowners and lease holders, in particular, BNSF and Caltrans for the railroad and freeway operations, and USBLM and the USFWS for wildlife management and recreational purposes. Nonetheless, USBLM has specifically requested an evaluation of a future residential use on their property (USDOI, 2007). Therefore, although future residential land use is a highly unlikely scenario, a future hypothetical residential land-use scenario will be evaluated for USBLM property (see Figure 4-4). The BCW exposure area is partially located on USBLM property. Potential exposure for the hypothetical residential user on USBLM land will be evaluated using the subset of data from BCW located north of the railroad on USBLM property.

The future hypothetical resident may be exposed to soil via inhalation of particulates entrained in ambient air, incidental ingestion of soil, and dermal contact. Inhalation exposure to VOCs in indoor air from vapor intrusion will be evaluated if VOCs are present in the subsurface on the USBLM property.

USDOI envisions the hypothetical future resident as a rural resident who obtains a significant portion of his/her diet from onsite produced food including vegetables, fruits, and poultry, and that chemicals in the soil and groundwater could partition into the vegetables, fruits, and poultry. Thus, pathways involving these foodstuffs and the potential for exposure to contaminants from soils and groundwater via these exposure media have been included in Figure 4-4. It is likely that uptake of the key inorganic chemicals in soils at the site (i.e., chromium and hexavalent chromium) into fruits and vegetables would be considered insignificant. The uptake of chemicals in soil into poultry and the transfer of chemicals in groundwater into either produce or poultry will also be evaluated, although these are also believed not to be pathways of significance. PG&E will also include a qualitative discussion of these pathways in the uncertainty section of the risk assessment. Depending on the available information, potential uptake for certain pathways and compounds may be presented qualitatively rather than quantitatively.

It is unlikely in the foreseeable future that the land currently occupied by HNWR and owned by the USFWS (see Figure 2-28) will become residential. According to information presented by USDOI, the primary conservation mission of USFWS as it applies to the HNWR, and articulated in the USFWS Organic Act, the conservation management plans, and appropriate use and compatibility policies, limits human use of refuge property and reduces the likelihood of transferring refuge property out of federal ownership (USDOI, 2007). According to USDOI, this supports that human use of the HNWR property will continue, in the future, to be restricted to recreational uses consistent with these statutory, regulatory, and policy guidelines.

Similarly, the areas owned by BNSF and Caltrans for the railroad and interstate highway are anticipated to continue indefinitely under the present use scenarios. Therefore, residential land use for those areas is not considered to be a reasonable future use scenario, and will not be evaluated in the HHRA.

The area of the site inside the compressor station fence line is under the control of PG&E and is expected to remain an operating compressor station indefinitely. Therefore, residential land use will not be evaluated for the compressor station. PG&E plans to continue owning and operating the associated property outside the fence line as supporting areas for the compressor station for the foreseeable future. Accordingly, the reasonably anticipated future use of the PG&E-owned land is for ongoing industrial operations, and it will not be evaluated for future residential use in the risk assessment document. If ever there is a need or desire to change the use of the compressor station, additional evaluations would be conducted at that time to reflect the changes in assumed land use.

4.4.2 Exposure Point Concentrations

The EPC is a conservative estimate of the average chemical concentration in an environmental medium (USEPA, 2002b) to which a receptor may be exposed. The

EPC is constituent-specific and is estimated for each individual exposure area within a site. The exposure areas are discussed in Section 3 and consist of: (1) BCW (which includes SWMU 1/AOC 1 and the portion of the drainage feature extending north to the river); (2) the remaining AOCs, all located outside the compressor station fence line; and (3) the SWMUs/AOCs inside the compressor station. Unless there is site-specific evidence to the contrary, an individual receptor is assumed to be equally exposed to the soils within their relevant portions of the exposure area over the time frame of the risk assessment. Typically, the EPCs for soil COPCs will be the upper confidence limit (UCL) on the arithmetic mean, calculated using ProUCL 4.0 (USEPA, 2007a) as described in Appendix A. Most often, the EPC will be the 95% UCL; however, in some cases, the 99% UCL may be selected. The maximum detected concentration may be selected if the data do not support a valid UCL calculation (Appendix A). Additionally, specific areas of hot spots may warrant specific assessment. In general, the identification of hot spots will be conducted by evaluating the site data for outliers, which could require additional and/or alternative statistical evaluations for identifying the appropriate EPCs. Summary statistics that support the UCL calculation as well as documentation of hot spot areas will be provided in the HHRA.

Once data are available from the upcoming soil sampling activities, additional refinements to the exposure areas may be necessary. The HHRA will rely on the findings of the nature and extent of soil contamination both laterally and vertically as expressed in the RFI/RI Volume 3. For example, if the RFI/RI identifies the perimeter of an impacted area to be adequately defined to background conditions, the risk assessment will assume that areas beyond that boundary are not impacted by historical site operations. Data for exposure areas will be used as described in the next section to estimate the EPCs for the HHRA.

4.4.2.1 Exposure Point Concentrations for Soil

A discussion of the different exposure areas that will be used to evaluate risks for the various human receptors is presented below. Exposure areas are discussed below for the following populations: recreational user; tribal user; maintenance workers engaged in activities outside of the compressor station; future, unrestricted land use on USBLM property; and commercial workers inside the compressor station. Figure 2-28 shows the areas of the site associated with the various land uses described below. The exposure areas were chosen according to the likely future land-use scenarios for the areas, with consideration given to current uses and likely sources of site-related constituents. Each exposure area may include lands belonging to various owners.

4.4.2.1.1 Recreational User: Outside the Compressor Station

The compressor station is owned by PG&E, is fenced, and is planned for continued use as an industrial site for the foreseeable future. This area is not accessible to recreational users. All areas outside of the compressor station fence line are open and accessible to recreational users, who may use the area for a variety of wildlife-dependent recreational activities (e.g., waterfowl hunting, fishing, and wildlife observation), as well as other activities such as hiking. The risks for soil contact for the recreational user will be estimated using two data groups to address complete exposure pathways shown on the CSMs in Figures 4-1 and 4-2.

The first data group is for the recreational receptor in contact with soil in BCW. This area was separated out from the other AOCs and locations outside the compressor station because the BCW is known to have received direct releases of wastewater, is a known source of the groundwater plume, and is believed to have some of the highest concentrations in soil. This information is intended to better inform risk management decisions for potential cleanup needs.

The second data group is for the recreational receptor in contact with soil for areas outside the compressor station, except the BCW. The area bordering the Colorado River represents a distinct and unique recreational area (i.e., different from the rest of the upland areas in the general nearby vicinity of the compressor station) that could arguably be more attractive, and an area where recreational receptors would spend the majority of the time. Currently available soil data indicate that site-related impacts to soil do not extend to this more attractive area. With the exception of the drainage feature called the BCW, all other AOCs outside the compressor station are at least 500 feet from the edge of the river and are relatively comparable with respect to their physical attributes and recreational opportunities.

For direct contact soil pathways (i.e., soil ingestion, dermal contact, and inhalation of particulates), sample data within the top 3 feet of soil will be assumed to be available for contact for the recreational receptor. In order to understand the potential implications of averaging concentrations over one depth zone versus another for the recreational user, the risk assessment will evaluate representative exposure concentration for soils within the following depth categories: surface soil (0 to 0.5 foot bgs) and shallow soil (0 to 3 feet bgs) as shown in Figure 3-1. Receptors are not likely to contact soil at depth without having to penetrate the soil above that depth. For example, the recreational user would not contact soil in the interval from 0.5 to 3 feet bgs without having to go through the material in the 0 to 0.5 foot interval above it. However, they might only go as far as the 0.5 foot depth and not all the way to 3 feet.

Consequently, all relevant depth groupings for this receptor population will be evaluated to determine what EPC will be health protective for the risk characterization. Figure 3-1 identifies the depth intervals that will be evaluated for purposes of estimating a representative EPC for this receptor population.

4.4.2.1.2 Tribal User: Outside the Compressor Station

As previously stated, the compressor station is owned by PG&E, is fenced, and is planned for continued use as an industrial site for the foreseeable future. This area is not accessible to tribal users. All areas outside of the compressor station fence line are open and accessible to tribal users. PG&E will work with FMIT to determine any areas of particular interest and the patterns of activity including soil depth potentially contacted.

The risks for soil contact for the tribal user will be estimated using data relevant for areas of interest for the tribal user. As a preliminary approach, it is assumed that two data groups will be used to address complete exposure pathways shown on the CSMs in Figures 4-1 and 4-2 for the tribal user.

The first data group is for contact with soil in BCW. This area was separated out from the other AOCs and locations outside the compressor station because the BCW is known to have received direct releases of wastewater, is a known source of the groundwater plume, and is believed to have some of the highest concentrations in soil. This information is intended to better inform risk management decisions for potential cleanup needs. The second data group is for contact with soil for areas outside the compressor station, except the BCW.

For direct contact soil pathways (i.e., soil ingestion, dermal contact, and inhalation of particulates), sample data within the top 3 feet of soil will be assumed to be available for contact for the tribal use receptor. This depth for contact is subject to adjustment based on use information to be provided by the tribes. All relevant depth groupings for this receptor population will be evaluated to determine what EPC will be health protective for the risk characterization. Figure 3-1 identifies the depth intervals that will be evaluated for purposes of estimating a representative EPC for this receptor population.

4.4.2.1.3 Maintenance Workers: Inside and Outside the Compressor Station

As described above, underground pipelines exist at numerous locations outside the compressor station. Further, various roads, including I-40, and a railway are located within the site. Based on the presence of subsurface pipelines and roads located throughout the site, subsurface maintenance activities could be conducted anywhere on the site. To address potentially complete exposure pathways shown on the CSMs in Figures 4-1 through 4-3, there are three exposure areas to be evaluated for the maintenance worker. The first data group will include soil data from BCW. The second group will include soil data for all other areas outside the compressor station except BCW, and the third group will include soil data from inside the compressor station. Because activities inside the compressor station are not localized, and there are subsurface features in a variety of areas, it is proposed that the compressor station be evaluated as one exposure area. For more detailed discussion of the data group for inside the compressor station, see Section 4.4.2.1 regarding the commercial worker.

Surface samples (0 to 0.5 foot bgs) as well as a depth-weighted average concentration of samples from deeper subsurface soil I or subsurface soil II (down to 10 feet bgs) will be evaluated for direct contact EPCs for this receptor for each of the three exposure areas. The risk assessment for maintenance workers will evaluate representative exposure concentration for soils within the following depth categories: surface soil (0 to 0.5 foot bgs), shallow soil (0 to 3 feet bgs), subsurface soil I (0 to 6 feet bgs), and subsurface soil II (0 to 10 feet bgs). Receptors are not likely to contact soil at depth without having to penetrate the soil above that depth. For example, the maintenance worker would not contact soil in the interval from 6 to 10 feet bgs without having to go through the material in the 0 to 6 feet above it. However, they might only go as far as the 3 or 6 feet depth and not all the way to 10 feet. Consequently, all relevant depth groupings for this receptor population will be evaluated to determine what EPC will be health protective for the risk characterization. Figure 3-1 identifies the depth intervals that will be evaluated for purposes of estimating a representative EPC for this receptor population.

4.4.2.1.4 Evaluation of Future, Unrestricted Use Scenario: USBLM Land

USBLM, as a land owner, has specifically requested that the exposure scenarios for future use of USBLM land include a future, unrestricted land-use scenario. Accordingly, if the upcoming soil investigation activities indicate that the extent of impact for the site extends on to the USBLM land (i.e., north of the railroad), the data from these impacted areas will be evaluated under the assumption that in the future, residential use of these areas could occur. It should be noted that residential land use is not a current condition for any portion of the site.

Currently, data do not indicate that impacts have reached the USBLM land. However, planned data collection described in the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a) includes samples along the northernmost portion of the BCW between the railroad and the river to further evaluate this migration pathway. Currently there are three proposed sampling locations on the USBLM property north of the railroad. During previous investigations, approximately 19 soil samples (from 8 locations) were collected along the BCW, from areas north of the railroad and on USBLM land (Figure 2-2). One of the primary goals of the Part A sampling is to adequately characterize the COPCs in each of the AOCs to levels that reasonably approach background conditions. As long as the overall objectives of the sampling plan are attained, resulting in a reasonable understanding of the lateral and horizontal extent of impact in the BCW area (a criteria that is not unique to the BCW), additional step-out sampling in the USBLM land would not be necessary to reach conclusions regarding the risks associated with future, unrestricted land use of the USBLM property. Specifically, a conclusion that the characterization activities are adequate in this portion of the BCW would be sufficient to provide the necessary dataset to evaluate potential exposures and risks associated with unrestricted use of this portion of the property.

Per risk assessment guidance, a typical exposure area for a residential lot is approximately 1/8 acre (USEPA, 1989a). Accordingly, data collected from the BCW area, north of the railroad (on USBLM land), will be evaluated under the assumption that a reasonable representative exposure area for a future, unrestricted land-use scenario is 1/8 of an acre. However, the land owner (USBLM) has requested a residential evaluation assuming a rural resident who obtains a significant portion of their diet from onsite produced food including fruits, vegetables, and poultry. Such activities would likely require bigger parcels than 1/8 of an acre.

The approaches for evaluating the USBLM land will depend on the overall distribution of the impacts and the spatial distribution of the impacts. If impacts are relatively evenly and randomly distributed across the sampled area of the USBLM land, the average concentration across the entire area will likely represent a reasonable representation of a smaller (1/8 acre) subarea. If, on the other hand, there appear to be hot spots in areas that could reasonably represent an individual 1/8-acre parcel, the maximum concentrations across an approximate 1/8 acre parcel on the USBLM land may be the more appropriate and conservative measure of estimating future residential exposure concentrations. The rationale for one approach over another will be fully detailed in the risk assessment, and will largely depend on the specific distribution of chemicals in the USBLM land.

Surface soil samples (0 to 0.5 foot bgs) as well as a depth-weighted average concentration of samples down to 10 feet bgs will be evaluated for direct contact EPCs. The risk assessment for the hypothetical future residential user will evaluate representative exposure concentration for soils within the following depth categories: surface soil (0 to 0.5 foot bgs), shallow soil (0 to 3 feet bgs), subsurface soil I (0 to 6 feet bgs), and subsurface soil II (0 to 10 feet bgs). Receptors are not likely to contact soil at depth without having to penetrate the soil above that depth. For example, the future hypothetical resident would not have direct soil contact in the interval from 6 to 10 feet bgs without having to go through the material in the 0 to 6 feet above it. However, they might only go as far as the 3 or 6 feet depth and not all the way to 10 feet. For some of the indirect soil exposure pathways, only some of the depth intervals may be relevant. For example, poultry may only contact soil in the 0 to 0.5 foot interval, while vegetable plants may contact soil down to a depth of 3 feet. Consequently, all relevant depth groupings for this receptor population and associated exposure pathways will be evaluated to determine what EPC will be conservative and health protective for the risk characterization. Figure 3-1 identifies the depth intervals that will be evaluated for purposes of estimating a representative EPC for this receptor population.

4.4.2.1.5 Commercial Workers: Inside the Compressor Station

Commercial workers inside the compressor station have full access to and work in all areas of the station. According to PG&E, there are no specific exposure patterns associated with one particular group of workers being predominantly exposed to one specific area of the compressor station. Therefore, the entire area inside the compressor station will be considered one representative exposure area for the compressor station workers.

As discussed in the RFI/RI Work Plan Part B (CH2M HILL, 2007d), the analytical data for the four RCRA SWMUs (SWMUs 5, 6, 8, and 9); AOC 18; and Units 4.3, 4.4, and 4.5 will be initially evaluated individually because these SWMUs/AOCs/Units may need to be closed individually. As previously discussed, these SWMUs/AOCs have previously been closed, but DTSC has requested that additional characterization be conducted to ensure that all COPCs have been adequately assessed. If data from any of these SWMUs/AOCs/Units indicate that any of these SWMUs/AOCs/Units may require formal RCRA closure (i.e., if other constituents, not previously identified, are detected at levels of potential concern), the affected SWMUs/AOCs/Units may be treated as an individual exposure area.

If needed, the risk assessment for the commercial worker will evaluate representative exposure concentration for soils within the following depth categories: surface soil (0 to 0.5 foot bgs) and shallow soil (0 to 3 feet bgs). Receptors are not likely to contact soil at depth without having to penetrate the soil above that depth. For example, the commercial worker would not contact soil in the interval from 0.5 to 3 feet bgs without having to go through the material in the 0 to 0.5 foot interval above it. However, they might only go as far as the 0.5 foot depth and not all the way to 3 feet. Consequently, all relevant depth groupings for this receptor population will be evaluated to determine what EPC will be health protective for the risk characterization. Figure 3-1 identifies the depth intervals that will be evaluated for purposes of estimating a representative EPC for this receptor population.

4.4.2.2 Exposure Point Concentrations for Air

This section describes the methods that will be used to estimate concentrations of constituents in air as dust and VOCs in ambient air (if data indicate the presence of VOCs). As the existing air monitoring data are of limited value, EPCs in air will be modeled from soil data as described below.

4.4.2.2.1 Dusts

The estimation of EPCs for nonvolatile compounds present in the particulate form (i.e., adsorbed onto soil particulates) requires the determination of the quantitative relationship between constituent concentrations in the soil (in milligrams per kilogram [mg/kg]) and the concentration of respirable particulates (particulate matter of 10 micrometers or less in diameter) in the air due to fugitive dust emissions. Particulate emissions are due to wind erosion and, therefore, depend on the erodibility of the surface material. The particulate emission factor equation presented in the USEPA Soil Screening Guidance (USEPA, 1996) will be used in the risk assessment to quantify this relationship. One input term for the equation is the size of the source area. This input term will likely be adjusted to reflect site-specific conditions, based on the final determination of land-use patterns and data indicating sizes of potential source areas for windblown dust.

Predicted air concentrations of constituents in the particulate phase are estimated by dividing the concentration of each constituent in the soil (in units of mg/kg) by the particulate emission factor (in units of cubic meters of air per kilogram of dust). For maintenance workers who could be exposed to higher levels of dust during the limited subsurface digging/repair activities than dust levels simply from wind-blown erosion, it will be assumed that the average 8-hour respirable dust level to which the worker could be exposed will be equal to the respirable dust level of 1 milligram per cubic meter (mg/m^3), as recommended by DTSC (CalEPA, 2005d). Outdoor air exposure concentrations for each population of concern would then be developed using the 95% UCL concentrations calculated for nonvolatile compounds in soils for each of the representative exposure areas.

4.4.2.2.2 VOCs

The estimation of EPCs for VOCs present in soil requires the determination of the quantitative relationship between chemical concentrations in the soil (in mg/kg) and the concentration of VOCs in air due to VOC emissions from soil. In the event that data show the presence of VOCs in soil, the volatilization factor equation presented in the USEPA Soil Screening Guidance (USEPA, 1996) will be used to estimate outdoor ambient air exposures to VOCs for receptor populations of concern. As per DTSC vapor intrusion guidance, if significant VOCs were detected in soils, a soil gas sampling effort may be required to evaluate the potential for vapor intrusion to be a significant exposure pathway (CalEPA, 2005c). If sufficient soil gas data do get collected, soil gas data will be used instead of soil data to evaluate the potential for exposures to VOCs in outdoor and/or indoor air, as soil gas data are generally considered to be a more relevant representation of constituents present in the vapor phase as compared to soil or groundwater data. If it is determined that vapor intrusion represents a potentially complete pathway, methods recommended by DTSC will be used to evaluate the significance of this exposure pathway (CalEPA, 2005c).

4.4.3 Exposure Assumptions

Constituent intake is the amount of the constituent entering the receptor's body. The risk assessment process follows regulatory guidance for both the calculation methods (e.g., equations used) and input terms used to estimate exposure. The calculation equations and input terms to be used in the soil HHRA are provided in the following guidance documents:

- *Preliminary Endangerment Assessment Guidance Manual* (CalEPA, 1994a)

- *Supplemental Guidance for Human Health Multimedia Risk Assessment of Hazardous Waste Sites and Permitted Facilities* (CalEPA, 1992)

- *Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Military Facilities* (CalEPA, 2005d)

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A), Interim Final* (USEPA, 1989a)

- *Exposure Factors Handbook, Volume I: General Factors* (USEPA, 1997b)

- *Exposure Factors Handbook, Volume III: Activity Factors* (USEPA, 1997c)

- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final* (USEPA, 2004b).

The amount of constituent contacted depends upon activity patterns of the receptor and nature of the environmental media containing the constituent of concern. Key components contributing to intake of site-related compounds include:

CR = contact rate, the amount of environmental medium contacted per unit time or event. There are different units depending on whether exposure occurs via ingestion, dermal contact, or inhalation (e.g., milligrams per day [mg/day] for soil ingestion).

EF = exposure frequency, accounts for how often exposure occurs (days per year).

ED = exposure duration, describes how long exposure occurs (years).

BW = body weight, the average BW of the exposed individual receptor (kg).

AT = averaging time, period over which exposure is averaged (days). This term varies based on whether the compound being evaluated is a carcinogen or noncarcinogen.

The values available for each of the exposure factors can vary according to the type of receptor (e.g., resident vs. commercial worker) and also by age and sex for some components. For this HHRA, default exposure assumptions will be used for both the future hypothetical resident on USBLM land and the commercial worker. Site-specific exposure scenarios will be developed in the HHRA for soil contact for the maintenance worker, recreational user, and tribal user as described below.

Specific exposure parameters that will be selected for each scenario along with the rationale for selection will be described in the HHRA. Consistent with the default exposure assumptions for a future hypothetical resident and commercial worker, exposure scenarios for the recreational user and maintenance worker will be developed based on a reasonable maximum exposure (RME). The intent of the RME approach is to estimate the highest exposure level that could be reasonably expected to occur, but not the worst possible case (USEPA, 1989a; 1991c). In keeping with USEPA guidance, variables chosen for a baseline RME scenario for intake or contact rate, exposure frequency, and exposure duration are generally upper bounds. All exposure scenarios will include evaluation of both cancer and noncancer (systemic) potential health impacts, depending on the toxicity characteristics for each compound and the relevance for the exposure pathway.

- **Commercial Worker:** The commercial worker will utilize standard default assumptions developed by USEPA and adopted by CalEPA as shown on Table 4-1 (USEPA, 2002c; CalEPA, 2005f).

- **Maintenance Worker*:*** The maintenance worker is a plausible receptor under current and future land-use assumptions inside and outside the compressor station. Maintenance projects requiring intrusive work, which may be performed on any part of the site where the installation or repair of underground pipelines or utilities may occur. Site-specific information regarding the type, frequency, and duration of such activities will be obtained for incorporation into the HHRA. The rationale for all exposure terms will be provided in the risk assessment.

- **Recreational:** Recreational land use and associated exposure is expected to occur at areas outside the compressor station. Potential direct pathways for exposure to soil for the recreational adult and youth include incidental ingestion, dermal contact, and inhalation of dust arising from wind erosion. The exposure assumptions for this exposure scenario will be developed using site-specific input from USBLM and USFWS. Parameters will be selected to ensure the assumptions reflect a conservative yet reasonable estimate of exposure. Additional resources may also include USEPA guidance (USEPA, 1997b,c) and guidance and resources from the New Mexico Environment Department website where recreational exposure to canyon land soils is commonly evaluated at remote sites, such as Los Alamos National Laboratory.

- **Tribal User:** Tribal use and associated exposure is expected to occur at areas outside the compressor station. Potential direct pathways for exposure to soil for tribal use include incidental ingestion, dermal contact, and inhalation of dust arising from wind erosion. The exposure assumptions for this exposure scenario will be developed using site-specific input from FMIT. Parameters will be selected to ensure the assumptions reflect a conservative yet reasonable estimate of exposure.

- **Resident:** Residents are not currently present outside the compressor station nor is the compressor station intended for residential use in the future. Furthermore, the areas outside the compressor station are unlikely to be developed for residential land use. However, because the USBLM has specifically requested an evaluation of potential future residential use, that exposure scenario will be evaluated for USBLM land. The residential receptor will utilize standard default assumptions developed by USEPA and adopted by CalEPA as shown on Table 4-2 (USEPA, 2002c; CalEPA, 2005f). In the event that site constituents indicate a potential concern for uptake of site-related lead or other bioaccumulative compounds into poultry and/or produce, site-specific exposure assumptions will be identified for those exposure pathways.

4.5 Toxicity Assessment

The relationship between the magnitude of exposure to a constituent and the potential for adverse effects is characterized in the toxicity assessment portion of the HHRA. More specifically, the toxicity assessment identifies agency-promulgated toxicity values that can be used to estimate the likelihood of adverse effects occurring in humans at different exposure levels. Consistent with regulatory risk assessment policy, adverse health effects resulting from constituent exposures are evaluated in two categories: carcinogenic effects and noncarcinogenic effects. The hierarchy of sources for the toxicity criteria to be used in the risk assessment generally corresponds to the state's guidelines (CalEPA, 1994b), and is discussed in more detail below. Further, consistent with current risk assessment guidance (CalEPA, 1994b), the potential human health implications associated with the presence of TPH will be assessed by evaluating each of the individual constituents detected in the samples.

4.5.1 Toxicity Assessment for Carcinogenic Effects

Current HHRA practice for carcinogens is based on the assumption that, for most substances, there is no threshold dose below which carcinogenic effects do not occur. This current “no-threshold” assumption for carcinogenic effects is based on an assumption that the carcinogenic processes are the same at high and low doses. This approach has generally been adopted by regulatory agencies as a conservative practice to protect public health. The no-threshold assumption will be used in this risk assessment for evaluating carcinogenic effects. Although the magnitude of the risk declines with decreasing exposure, the risk is believed to be zero only at zero exposure.

Cancer slope factors (CSFs) are used to quantify the response potency of a potential carcinogen. The CSF represents the excess lifetime cancer risk due to a continuous, constant lifetime exposure to a specified level of a carcinogen. CSFs are generally reported as excess incremental cancer risk per milligram of constituent per kilogram BW per day ($[\text{mg/kg-bw/day}]^{-1}$). CalEPA and USEPA have published a list of CSFs recommended for use in risk assessments. The CalEPA-recommended CSFs are maintained on the CalEPA Office of Environmental Health Hazard Assessment (OEHHA) online toxicity criteria database (CalEPA, 2007b). The USEPA-recommended CSFs are obtained from the USEPA’s Integrated Risk Information System (IRIS) online database (USEPA, 2007c) or the National Center of Environmental Assessment (NCEA)/Superfund Health Risk Technical Support Center (STSC) (as cited in USEPA, 2004a). Consistent with CalEPA risk assessment guidance, the OEHHA CSFs are used when available, and USEPA CSFs are used when OEHHA CSFs are not available. If CSFs have not been promulgated by either OEHHA or USEPA, the chemical is not evaluated as a carcinogen.

4.5.2 Toxicity Assessment for Noncarcinogenic Effects

The toxicity assessment for noncarcinogenic effects requires the derivation of an exposure level below which no adverse health effects in humans are expected to occur. USEPA refers to these levels as reference doses (RfDs) for oral exposure and reference concentrations (RfCs) for inhalation exposure (USEPA, 1989a).

The noncancer RfD represents a dose, given in mg/kg-bw/day, that would not be expected to cause adverse noncancer health effects in potentially exposed populations. The noncancer RfD, reported in units of mg/kg-bw/day, is often referred to as the “acceptable dose.”

The noncancer RfC represents the airborne concentration (in units of micrograms per cubic meter [µg/m^3]) that would not be expected to cause adverse noncancer health effects in populations exposed through the inhalation pathway. OEHHA refers to these “acceptable air concentrations” as reference exposure levels (RELs).

As the inhalation RfCs/RELs are derived from inhalation toxicity studies, they are used for evaluating inhalation exposures, when available, and are converted to corresponding inhaled doses (inhalation RfDs) using USEPA standard conversion assumptions. As recommended by USEPA, inhalation RfCs/RELs are converted to inhaled doses (inhalation RfDs) by assuming a breathing rate of 20 cubic meters per day (m^3/day), and a BW of 70 kg (i.e., RfC/REL [µg/m^3]×[20 m^3/day]×[1/70 kg]×[1 mg/1000 µg] = RfD [mg/kg-bw/day]). If inhalation RfCs/RELs are not available, RfDs obtained from an oral study (oral RfDs) will be extrapolated and applied to the inhalation route in this evaluation (i.e., the inhalation RfD was assumed to be equivalent to the oral RfD, under the toxicological assumption that the constituent could produce the same type of noncancer effects via the inhalation route as observed through the oral route of exposure).

As recommended by USEPA (2003a), RfDs will be obtained from IRIS (USEPA, 2007c), NCEA/STSC (as cited in USEPA, 2004a), or from the Health Effects Assessment Summary Tables (HEAST; USEPA, 1997d), in that order of preference. As recommended by DTSC, noncancer RELs (in units of µg/m^3), obtained from OEHHA’s list of chronic RELs (CalEPA, 2005e), will be used for evaluating noncancer effects from inhalation exposures, where available. If an OEHHA REL is not available for a constituent, the RfC will be obtained from IRIS (USEPA, 2007c), NCEA/STSC (as cited in USEPA, 2004a), or from HEAST (USEPA, 1997d) in that order of preference. Also, if both a USEPA RfC and an OEHHA REL are available, the more conservative RfC/REL is used (e.g., RfC for naphthalene).

Consistent with CalEPA risk assessment guidance (CalEPA, 1994a), the potential human health implications associated with the presence of TPH will be assessed by evaluating each of the individual constituents detected in the samples.

4.5.3 Toxicity Assessment for Lead

The traditional RfD approach to the evaluation of constituents is not applied to lead because most human health effects data are based on blood-lead concentrations, rather than external dose (CalEPA, 1992). Blood-lead concentration is an integrated measure of internal dose, reflecting total exposure from site-related and background sources. A clear no-observed-effects level has not been established for such lead-related endpoints as birth weight, gestation period, heme synthesis, neurobehavioral development in children and fetuses, and blood pressure in middle-aged men. Dose-response curves for these endpoints appear to extend down to 10 micrograms per deciliter (µg/dL) or less (ATSDR, 1993).

The DTSC has provided a spreadsheet (LEADSPREAD) based on its guidance for evaluating lead toxicity for residential exposure to lead in the environment. The updated spreadsheet model, LEADSPREAD Version 7, will be used in this HHRA for the unrestricted land-use scenario to be conducted on the USBLM property. Further, LEADSPREAD is proposed for use to evaluate lead exposures to children under the recreational land-use scenario. As recommended by the DTSC, the spreadsheet will be used in the unrestricted land-use scenario to estimate the 99th percentile blood-lead concentration in hypothetical future residential populations that would result from multi-pathway exposures to lead, both from the soils at the site and from background sources. As recommended by the DTSC, a predicted total blood-lead concentration of 10 µg/dL will be used as the target concentration of concern.

The USEPA has developed a methodology for evaluating exposure and the potential for adverse health effects resulting from nonresidential exposure to lead in the environment, in *USEPA Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil* (TRW ALM; USEPA, 2003b). The methodology results in a blood-lead concentration of concern for the protection of fetal health (in women of child-bearing age) and presents an algorithm for predicting quasi-steady state blood-lead concentrations among adults who have relatively steady patterns of nonresidential exposure to lead in soil.

USEPA has provided a spreadsheet based on its guidance for evaluating lead toxicity from nonresidential exposure to lead in soil. The USEPA recommends that the estimated 95th percentile blood-lead concentrations for a given exposure scenario in the spreadsheet be used to screen against the target blood-lead concentration of 10 µg/dL. Consistent with current DTSC recommendations, the USEPA TRW ALM model will be used to evaluate all nonresidential adult exposures to lead.

4.5.4 Toxicity Equivalency Factors for Polycyclic Aromatic Hydrocarbons

For human health, PAHs are evaluated for both carcinogenic and noncarcinogenic toxicity endpoints. The compounds with noncancer toxicity values will be addressed in the HHRA as individual compounds. The PAHs designated by the state of California as carcinogenic will be addressed in terms of a benzo(a)pyrene equivalent value (BaP_{Eq}) for each sample. Carcinogenic toxicity values have not been established for each individual carcinogenic PAH (cPAH); rather, the carcinogenic potential of each cPAH has been determined based upon its toxicity compared to benzo(a)pyrene. As a result, OEHHA has assigned a benzo(a)pyrene toxicity equivalency factor (TEF) for each cPAH, which when multiplied by the site concentration, converts the cPAH concentration into a concentration of BaP_{Eq} (CalEPA, 1994b).

For this site, the concentrations of all cPAHs will be converted into BaP_{Eq}, which will be summed for the sample to produce a total BaP_{Eq} concentration for that sample. The total BaP_{Eq} concentration will be included in the final dataset and used for comparison to background BaP_{Eq} characteristics. If any cPAHs are detected in a sample, the BaP_{Eq} will include all seven cPAH constituents using half the detection limit for those constituents not reported above the detection limit. If no cPAHs are reported above detection limits for a sample, then no BaP_{Eq} will be estimated. In this case, the BaP_{Eq} concentration for that sample will be reported as less than the highest detection limit of the individual cPAH compounds.

The TEFs to be used in this HHRA are summarized below.

cPAH	OEHHA TEF
Benzo(a)pyrene	1.0 (index compound)
Benz(a)anthracene	0.1
Benzo(b)Fluoranthene	0.1
Benzo(k)Fluoranthene	0.1
Dibenz(ah)anthracene	0.34
Chrysene	0.01
Indeno(1,2,3-cd)pyrene	0.1

Source: CalEPA, 1994b

4.6 Risk Characterization Based on Soil Exposure

Risk characterization is the combination of the results of the exposure assessment and toxicity assessment to yield a quantitative expression of risk. This quantitative expression is the probability of developing cancer, or a nonprobabilistic comparison of a route-specific dose rate with an RfD as an indicator of the potential for noncancer effects. Quantitative estimates will be developed for individual COPCs and potentially complete exposure pathways for each receptor. The risk characterization step provides the information to guide risk management decisions.

Generally, the risk characterization will follow the methodology prescribed by USEPA documents as listed previously in Sections 4.2 and 4.4.3. USEPA methods are appropriately designed to be health protective, and tend to overestimate rather than underestimate risk. The risk/hazard estimates may exceed the intent of the RME paradigm, because risk characterization involves multiplication of the conservatisms built into each of the steps described above. The use of multiple conservative assumptions can lead to an overestimate of the actual risk. The most probable risk is likely to be much less, perhaps as low as zero (USEPA, 1989b).

Although some constituents induce both cancer and noncancer effects, the risks for each endpoint will be calculated separately.

4.6.1 Cancer Risk

The risk from exposure to potential carcinogens is estimated as the probability of an individual developing cancer over a lifetime and is called the incremental lifetime cancer risk (ILCR). In the low-dose-rate range, which would be expected for most environmental exposures, cancer risk will be estimated from the following linear equation (USEPA, 1989b):

$$ILCR = (CDI)(CSF)$$ Equation 4-1

where:

ILCR = incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, based on the exposures evaluated

CDI = chronic daily intake, averaged over 70 years (mg/kg-bw/day)

CSF = cancer slope factor $(mg/kg\text{-}bw/day)^{-1}$.

The chronic daily intake term in Equation 4-1 is equivalent to the intake estimated as part of the exposure assessment. Default exposure assumptions and intake equations for the Commercial Worker and Hypothetical Future Resident are shown on Tables 4-1 and 4-2, respectively.

The use of Equation 4-1 assumes that chemical carcinogenesis does not exhibit a threshold, and that the dose-response relationship is linear in the low-dose-rate range. Equation 4-1 could generate theoretical cancer risks greater than 1 for high dose rates and is considered to be inaccurate at cancer risks greater than 1×10^{-2}.

As a matter of policy, USEPA (1989b; 2005b) considers the cancer risk for contact with multiple compounds to be additive, regardless of the constituent's mechanisms of toxicity or sites of action (organs of the body). In addition, cancer risk for a given receptor across multiple exposure routes is also considered to be additive. Consequently, cancer risks for each receptor and exposure area will be summed to show a cumulative multi-constituent, multi-pathway risk estimate. For risk management purposes, a total cancer risk of one in a million probability of occurrence (1×10^{-6}) is a point of departure below which cancer risks are considered to be insignificant (USEPA, 1990). Cancer risks between one in a million and one hundred in a million probability of occurrence (1×10^{-6} and 1×10^{-4}) fall within a risk management range. This is generally referred to as the acceptable risk range. Within this estimated cancer risk range, there is flexibility for risk managers in deciding what action, if any, is necessary and appropriate for the protection of human health. Cancer risks above 1×10^{-4} are generally considered to be unacceptable and require action.

4.6.2 Noncancer Effects

The hazards associated with the noncancer effects of constituents are evaluated by comparing a route-specific exposure level or intake with a noncancer reference dose (RfC or RfD). The hazard quotient (HQ) will be estimated as (USEPA, 1989b):

$$HQ = I / RfD \qquad \text{Equation 4-2}$$

where:

HQ = hazard quotient (unitless, calculated)

I = intake rate of constituent averaged over exposure duration (mg/kg-bw/day)

RfD = reference dose (mg/kg-bw/day).

The noncancer intake term in Equation 4-2 is equivalent to the intake estimated as part of the exposure assessment. Default exposure assumptions and intake equations for the Commercial Worker and Hypothetical Future Resident are shown on Tables 4-1 and 4-2, respectively.

The approach for noncancer hazard evaluation is different from the probabilistic approach used to evaluate carcinogenic risks. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates that the estimated intake rate is 100 times lower than the RfD (also known as the dose that is considered “acceptable”). An HQ of one indicates that the estimated intake equals the RfD.

In the case of simultaneous exposure of a receptor to several constituents by a given exposure route, the HQs for each constituent are summed and the total is called the hazard index (HI) for that exposure route.

Similar to the cancer risk estimate, HI values will be summed across exposure routes and media to estimate a total HI for the receptor. If the HI for a given receptor exceeds one, individual HI values may be calculated for each target organ or critical effect.

HI estimates at or below the threshold value of one are interpreted to mean that adverse noncancer effects are unlikely (USEPA, 1989b).

It should be noted that the HQ terms are summed for all exposure routes independent of the target organ which is affected by the constituent. The target organ for dermal exposure is assumed to be the same as for oral exposure; therefore, the HI for a given target organ would include HQs calculated for oral and dermal exposure to the relevant constituents.

4.7 Risk-Based Remediation Goals for Constituents in Soil

Based on the results of the soil HHRA, the COPCs that contribute most significantly to risk and/or that exceed *de minimis* risk levels for soil for the specific receptors being evaluated will be identified. Risk management decisions to be made in the CMS/FS step of the regulatory process will be focused on these COPCs. Currently, there are no promulgated regulatory concentrations for soil (i.e., no chemical-specific ARARs for soil) comparable to MCLs for drinking water (discussed further in Section 5). As stated by USEPA (USEPA, 1991b), when ARARs do not exist, RBRGs are calculated using USEPA health criteria (i.e., RfDs or CSFs) and default or site-specific exposure assumptions. Therefore, consistent with USEPA guidance, a risk-based process will be used to estimate RBRGs for COPCs that drive soil risk concerns above negligible risk thresholds. Negligible or *de minimis* risk levels are defined in accordance with state and federal guidance as one in one million (1×10^{-6}) for compounds identified as carcinogens. This will be the point of departure, recognizing that CalEPA and USEPA ultimately have authority to allow for residual risks to be within the risk management range of 1×10^{-4} to 1×10^{-6}. For noncancer health hazards, a target HI of unity (one) will be used. Individual constituent exposures that yield HIs of less than one are not expected to result in adverse noncancer health effects (USEPA, 1989a). RBRGs will be calculated for all chemicals that are the significant contributors to soil risks that exceed (on a multiple chemical basis) cancer risks of 10^{-6} and an HI of 1. This process will ensure that the potential cumulative effects of multiple chemicals will not be overlooked.

RBRGs are concentrations that may remain in place and do not present a threat to human health. The RBRG is a proposed health protective target cleanup concentration that can be used, in combination with other factors such as background concentrations, as a starting point for making risk management decisions. RBRGs will be calculated for compounds where estimated risks or hazards exceed *de minimis* levels. This could occur when either or both of the following conditions is met:

- Total ILCR for a given receptor summed across exposure routes and COPCs exceeds 1×10^{-6}.

- Total target organ HI for a given receptor exceeds the threshold limit of one.

When either of these conditions is present, the compounds contributing to the overall risk estimate and/or HI will be reviewed. RBRGs will be calculated for those compounds driving the risk and/or hazard estimates (USEPA, 1991b) and for any individual constituents that correspond to a cancer risk of greater than 10^{-6} or a noncancer HQ of greater than one. RBRGs are risk-based concentrations that reflect the exposure and toxicity assumptions applied in the HHRA. Consequently, the RBRGs are medium-, receptor-, and constituent-specific.

4.7.1 Estimating Risk-Based Remediation Goals

RBRGs for soil are developed by combining information regarding the level of intake of the constituent, the levels of acceptable risk, and the relationship between the intake of constituent and the incidence of an adverse health effect as a function of human exposure to the constituent. The methodology used to develop the risk-based goals for the COPCs in soil at the site will be based on guidance and the specific equations provided in the guidance documents below:

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A)* (USEPA, 1989a)

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B: Development of Risk-Based Preliminary Remediation Goals)* (USEPA, 1991b)

- *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA, 1992)

- *Preliminary Endangerment Assessment Guidance Manual* (CalEPA, 1994a).

In accordance with the NCP (40 CFR 300.430(e)(2)) (USEPA, 1990), remediation goals will establish acceptable exposure levels that are protective of human health and the environment. The objective of developing RBRGs is to ensure that, following remediation, risks are protective of human health based on the presence of multiple chemicals, via the multiple exposure pathways.

4.8 Uncertainty Analysis

Uncertainty is a factor in each step of the exposure and toxicity assessments described in the preceding sections. As stated by USEPA (1989a), it is important that the risk assessment identify the key site-related variables and assumptions that contribute most to the uncertainty associated with the evaluation. In accordance with USEPA guidance, the risk assessment will identify the key uncertainties associated with each of the major steps of the risk assessment: data evaluation and selection of COPCs, including a discussion of potential data gaps; exposure assessment; toxicity assessment; and risk characterization. The uncertainty section is qualitative in nature and will focus on identifying those assumptions that contribute most to the overall uncertainty in the risk assessment and will be consistent with USEPA guidance (USEPA, 1989a).

Generally, risk assessments are influenced by two types of uncertainty: (1) measurement uncertainty; and (2) uncertainty arising from data gaps. Measurement uncertainty includes the usual variance that accompanies scientific measurements (e.g., instrument uncertainty and variance [accuracy and precision] associated with constituent concentrations and the heterogeneity of the data). A second type of uncertainty stems from data gaps. Models are often used to fill data gaps because they represent a level of understanding to address parameters that are impractical or impossible to measure. Assumptions represent an educated estimate of information that is not available.

The general sources of uncertainty that are common to essentially all risk assessments as well as the bias they impart to the risk assessment (i.e., whether conservatism is increased or decreased) will be discussed in the HHRA to include site-specific sources of uncertainty. The analysis will include, but will not be limited to, the weight-of-evidence supporting the conclusions reached, the degree of success in meeting the objectives of the evaluation, and the degree of confidence in the data used to assess the site and its constituents. Factors contributing to uncertainty in the overall risk assessment will be highlighted, including uncertainties introduced by limitations in site-specific data, toxicity data for the COPCs, and the ability to estimate existing and probable future intakes.

5. Human Health Risk Assessment Approach for Groundwater

This section describes the approach for completing the HHRA for groundwater. Certain portions of the following sections are similar to the steps of the soil HHRA, described in Section 4. Accordingly, this section presents a more streamlined discussion of how the groundwater HHRA will be conducted. The approach for the groundwater risk assessment has been developed in accordance with applicable risk assessment guidance documents published by USEPA and CalEPA (as listed in Section 4). Where appropriate, this section of the work plan cross-references comparable sections presented in more detail in Section 4.

5.1 Purpose and Objectives

As described in Section 4, the general purpose of any human health risk evaluation process is to provide a framework for developing information necessary regarding potential health threats at a site to assist risk management decision making (USEPA, 1989a). Specific objectives within that overall purpose include: (1) helping to determine the need for action at a site; and (2) providing a basis for determining levels of compounds that can remain at the site and still adequately protect public health (USEPA, 1989a).

As described in more detail below, there is currently no evidence of a pathway through which chemicals in the groundwater could reach a receptor. Impacted groundwater is not reaching drinking water wells, and there is no evidence that impacted groundwater is reaching the Colorado River. At DTSC's direction, PG&E has been extracting and treating groundwater at the site since March 2004, due to the presence of hexavalent and total chromium in groundwater at concentrations exceeding the State of California MCLs. The purpose of these IMs is to maintain hydraulic control of the groundwater plume boundaries until a final corrective action is in place at the site. These groundwater IMs were implemented, at the request of DTSC, even though there are no current exposures to plume groundwater. Given the known groundwater impacts, the designated beneficial use of the groundwater as a potential *future* drinking water source and the fact that concentrations of hexavalent and total chromium exceed MCLs, one of the primary objectives of the groundwater risk assessment is to determine the residual levels of all potential site-related constituents that are adequately protective of human health and in compliance with applicable and relevant regulatory criteria. However, DTSC has specifically requested that a baseline risk evaluation of the groundwater be conducted, and thus, the HHRA for groundwater will consist of the following standard baseline risk assessment elements (parallel with those described for the soil HHRA):

- Data evaluation and selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Development of RBRGs/applicable drinking water criteria
- Uncertainty analysis.

As previously described, a significant amount of effort has been focused on obtaining a sufficiently robust background dataset for inorganic compounds in groundwater (CH2M HILL, 2008a). One key objective of the background groundwater investigation is to be able to distinguish the nature and extent of site-related constituents from naturally occurring constituents. The development of background concentrations for all COPCs can then be considered, in conjunction with risk-based criteria and the regulatory-based criteria, in the overall development of a range of remediation goals for the groundwater. The range of remediation goals identified in this HHRA for groundwater will then be used in the CMS/FS to identify and evaluate the effectiveness of various remedial alternatives for managing the environmental conditions at the site.

The following sections describe the methods that will be used to complete the groundwater HHRA.

5.2 Data Evaluation and Selection of Constituents of Potential Concern

The purpose of the data evaluation section of the groundwater risk assessment is to provide a comprehensive summary of the analytical groundwater and relevant surface water monitoring data that have been collected at the site. As part of the data evaluation step, the risk assessment will present a summary of key groundwater and surface water monitoring data and will discuss the overall distribution of the constituents detected. Additionally, the data evaluation step will describe the data usability criteria and the specific methods used to identify those COPCs that will be included in the quantitative risk assessment.

As described in Section 2, there are ongoing groundwater and surface water investigations that are part of the current groundwater and surface water monitoring programs. Further, there are additional groundwater monitoring data that will be collected, as requested by DTSC, as part of the East Ravine groundwater sampling, and sampling on the Arizona side of the Colorado River. Additionally, DTSC has requested comprehensive metals data be collected from a specified number of wells located throughout the site. Consistent with the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum, the cutoff date for all data that are to be included in the groundwater risk assessment is May 2008; data collected after May 2008 will not be included in the risk assessment described in this work plan. However, data collected following the May 2008 cutoff date can be evaluated and assessed in a subsequent addendum to the groundwater risk assessment, if deemed necessary and appropriate.

The goal of the data evaluation step is to: (1) identify a set of constituents that are likely to be site related; and (2) identify a set of data that are of acceptable quality for use in the risk assessment. The details regarding the methods that will be used in completing the data evaluation step of the risk assessment, including the specific data usability criteria and methods for selecting the COPCs, are presented in Section 3. A brief overview of each of these steps is summarized below.

5.2.1 Data Quality and Usability

Groundwater and surface water monitoring data will be evaluated for their acceptability for use in the HHRA, as outlined in Section 3. Analytical results will be reported in the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum using the data qualifiers issued by the analytical lab or applied during the validation process. As described in Section 3, the data usability evaluation for the groundwater and surface water data will follow federal guidance (USEPA 1989a; 1992a; 2002a). Findings of the data quality assessment will be presented in the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum.

5.2.2 Selecting Constituents of Potential Concern

As with soil, the selection of COPCs is a sequential process where compounds detected in site media are eliminated from further consideration if the constituent is consistent with ambient/background conditions, or if the compound is an essential nutrient (and present below a potentially toxic dose, when the dietary dose and the exposure dose are considered in combination) or a common laboratory contaminant.

The general approach for selecting COPCs for inclusion in the groundwater HHRA is described in Section 3.3.

5.3 Exposure Assessment

As described in Section 4, one primary purpose of the exposure assessment step in a risk-based evaluation is to describe the populations that may be potentially exposed to constituents present at the site, determine the routes by which these exposures may occur, and estimate the magnitude of contact between the receptor and the potentially impacted environmental media. The sections that follow describe the process that will be used in reviewing the preliminary CSMs in light of the groundwater dataset (to be reported in the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum) and in determining which transport pathways and exposure routes may be considered complete for the groundwater HHRA.

5.3.1 Conceptual Site Model

As described in Section 4, a CSM is used to show the relationship between constituent sources, exposure pathways, and potential receptors at a site. These source-pathway-receptor relationships provide the basis for the quantitative exposure assessment. Only complete source-pathway-receptor relationships will be carried through in the quantitative portion of the groundwater risk assessment.

Figures 4-1 through 4-4 present the preliminary CSMs for the site, based on our current understanding and knowledge of site conditions. Figure 4-1 presents a preliminary CSM for the BCW (which includes SWMU 1 and AOC 1); Figure 4-2 presents a preliminary CSM for all other AOCs (other than the BCW) located outside the compressor station; Figure 4-3 presents a preliminary CSM for inside the compressor station; and Figure 4-4 presents the CSM for the hypothetical future onsite resident, assumed to be present on USBLM land (BCW, north of the railroad), evaluated specifically at the request of USDOI. As these preliminary CSMs are based on our current understanding of the site and site conditions, they will be refined as the upcoming soil sampling investigations become available (CH2M HILL, 2006a; 2007d). The soil exposure pathways identified on these CSMs are described in more detail in Section 4.4.1.

As previously described, there are a few reasons for presenting the CSMs in four separate figures. First, evaluations of risk will be completed separately for areas inside the compressor station versus those that are located outside of the compressor station, as the assumed future use of the compressor station as industrial is different from the surrounding areas. Consequently, a separate CSM for inside the compressor station was deemed appropriate. A separate CSM for the BCW area (SWMU 1 and AOC 1) was prepared because a portion of this drainage feature received known historical discharges of untreated wastewater and is the principal source of the hexavalent chromium detected in groundwater (and soil) at the site. As such, the BCW represents a source area that is unique relative to the rest of the SWMUs/AOCs located outside the compressor station.

A discussion of the constituent sources, the potential transport pathways through which the sources can be transported into the groundwater, and the corresponding pathways through which human populations could be potentially exposed to constituents in groundwater is provided below.

5.3.1.1 Sources of Groundwater Constituents

The principal constituent in groundwater at the site is hexavalent chromium, which was contained in water treatment products added to the cooling water from 1951 to 1985 to inhibit corrosion, minimize scale formation, and control biological growth. From 1951 to 1964, untreated cooling tower blowdown water containing hexavalent chromium was discharged to the BCW near the compressor station. From 1964 to 1969, PG&E began treating the wastewater by converting the hexavalent chromium to trivalent chromium. In 1969, the process was expanded to two steps that converted hexavalent chromium to trivalent chromium (Step 1) and then removed trivalent chromium via precipitation (Step 2). Beginning in May 1970, discharges to the BCW ceased, and treated wastewater was instead discharged to an injection well (PGE-08) located on PG&E property and lined ponds. In 1973, PG&E discontinued use of injection well PGE-08, and wastewater has since been discharged to lined ponds. PG&E replaced the hexavalent chromium-based cooling water treatment products with non-hazardous phosphate-based products in 1985.

Nearly all of the hexavalent chromium present in groundwater at the site is believed to have been released during the 13-year period when untreated wastewater was discharged to the BCW. From the discharge locations in the BCW, the cooling tower blowdown water infiltrated into the coarse sand and gravel of the wash bed and percolated approximately 75 feet downward through the unsaturated zone to reach groundwater. The depiction of the original release of the untreated wastewater and the resulting percolation and infiltration into the underlying groundwater is shown on Figures 4-1 and 4-4.

Figures 4-2 and 4-3 present a depiction of the potential for other releases, not related to the known discharges at the BCW, to have impacted the underlying groundwater. Specifically, it is theoretically plausible that compounds may have been released to soils through spills and leaks of cooling water and other fluids at the compressor station. Further, it is possible that there could have been releases from other industrial operations occurring inside the compressor station. Also, AOCs outside the compressor station fence line are generally associated with runoff or past disposal of debris and solid wastes; it is at least theoretically possible that surface releases from these sources could have percolated down through the unsaturated soil and could have potentially impacted the groundwater.

Although the historical releases from the BCW are known to have resulted in groundwater impacts, it is not yet clear whether any other releases, such as those identified on Figures 4-2 and 4-3, have impacted the groundwater. As described in Section 2.3, the characterization of soils from areas both within and outside of the compressor station is not yet complete. Additional soil characterization activities are scheduled to begin during the summer of 2008 and should be complete by February 2010. One of the objectives of the additional soil characterization activities, as specified in the Draft RFI/RI Work Plans Part A and Part B (CH2M HILL 2006a; 2007d), is to verify whether there are additional sources, other than those related to the BCW, that are impacting the groundwater. As described in Section 4.4.1, the determination as to whether there are soil sources that either are or have the potential to impact groundwater via leaching will be presented within the RFI/RI Volume 3. Further, additional groundwater monitoring wells will be installed both inside the compressor station and in the East Ravine Area, and groundwater monitoring data will be collected from these wells over the course of the next year. Accordingly, additional data collection efforts, collected over the course of the next year, will assist in determining whether there are other sources, as identified in Figures 4-2 and 4-3, that have impacted groundwater at the site. The preliminary CSMs will be revised as needed based on sampling results.

5.3.1.2 Potential Transport Pathways

Once constituents are in the groundwater, the potential pathways through which the constituents may move from the groundwater to another environmental media include transport and release to the surface water (Colorado River) and volatilization from the groundwater and release into ambient/indoor air. Each of these potential transport pathways is discussed below.

5.3.1.2.1 Groundwater-to-Surface Water Transport Pathway

Once a constituent has reached the groundwater, the pathway of migration at the site is through groundwater transport. The general direction of groundwater flow from the source area in the BCW is toward the north or northeast. Prior to the IM pumping, which began in March of 2004, groundwater could flow toward or away from the river, depending on the river stage (CH2M HILL, 2007a). Since March 2004, a landward groundwater gradient has been maintained in the floodplain.

Strong reducing geochemical conditions are observed in the groundwater in the fluvial deposits along the Colorado River floodplain. Reducing conditions were also observed in the sediments beneath the river during the pore water study (CH2M HILL, 2006c) and the recent slant drilling under the river (CH2M HILL, 2007b). As discussed in many of the previous documents, hexavalent chromium is not stable in reducing conditions and reverts to trivalent chromium, which is strongly sorbed to aquifer materials or forms insoluble precipitates. The reducing conditions in the fluvial sediments provide a natural geochemical barrier that greatly limits or prevents the movement of hexavalent chromium through the fluvial sediments adjacent to and beneath the Colorado River.

Based on the data that have been collected to date, as discussed in the Draft RFI/RI (CH2M HILL, 2005a) and the RFI/RI Volume 2 (CH2M HILL. 2008b), there is currently no evidence of a complete pathway for hexavalent chromium in groundwater to reach the river (CH2M HILL, 2007b). Despite the natural reducing conditions that greatly limit and/or prevent the movement of hexavalent chromium to the river, the groundwater HHRA will comprehensively evaluate the significance of the groundwater-to-surface water pathway for all constituents to address what previous data reports have stated (and what the historical and ongoing surface water monitoring data suggest), specifically, that the groundwater-to-surface water transport is incomplete and/or insignificant. If additional data confirm that the pathways are complete, the CSM will be modified and the complete exposure pathways will be included in the risk characterization steps of the groundwater risk assessment.

All COPCs, including chromium and hexavalent chromium, will be evaluated in the same manner regarding their potential to impact surface water due to groundwater release to the Colorado River. The general proposed approach for assessing the significance of the groundwater-to-surface water transport pathway for purposes of the groundwater HHRA will consist of the following steps:

- **Step 1: Comparison of Floodplain Concentrations to Screening-Level Surface Water Quality Criteria**

  Concentrations of COPCs (selected as described above in Section 3) in the floodplain wells will be compared to surface water criteria or screening values that would be considered protective of the known human uses of the Colorado River. Concentrations of constituents in the floodplain wells will be compared to surface water criteria because the constituents measured in these wells represent the body of groundwater that could be potentially released to the Colorado River.

  The criteria considered applicable for ensuring that the uses of the river are not impacted include drinking water criteria and criteria based on consumption of aquatic organisms that live in the river. For protection of human health based on drinking the water and consumption of aquatic organisms, the criteria used in this screening-level evaluation are from the following sources, in the following order:

  - Water Quality Standards; Establishment of Numeric Criteria for Priority Toxics for the State of California; Rule, Federal Register 40 CFR Part 131 (the California Toxics Rule or "CTR"; USEPA, 2000b)
  - National Recommended Water Quality Criteria (NRWQC; USEPA, 2006b).

  The order of preference for published criteria based on human consumption of aquatic organisms is based on the preference for regulatory criteria (i.e., CTR values) over recommended criteria (i.e., NRWQC). Note that the Basin Plan (CRWQCB, 2005) does not provide criteria based on the human consumption of aquatic organisms pathway. The surface water quality criteria for the protection of human health are presented in Table 5-1.

  As a conservative screening approach, concentrations of COPCs in the floodplain wells will be compared to the human health surface water screening values described above and presented in Table 5-1. As with the discussion regarding the comparison to background concentrations presented in Section 3, there is no one statistical test that will provide the determination as to whether concentrations in the floodplain wells exceed human health screening-level criteria applicable to the river. Rather, there are a series of tests that will be conducted in reaching any such conclusions. These tests will include looking at the averages, UCLs of the average, frequency of detections, as well as maximum detected concentrations and comparing these values to the screening-level surface water criteria. These methods, in combination, will be used to reach an overall conclusion as to how the concentrations detected in the floodplain wells compare to human health screening-level criteria applicable to the river.

Note that such a comparison, specifically comparing concentrations in groundwater in the floodplain wells to criteria applicable to the river is considered extremely conservative, as the surface water criteria are applicable to the surface water body not the groundwater (and aquatic organisms that inhabit the river do not live in the underlying groundwater). Application of surface water criteria to the groundwater does not account for the natural dilution and attenuation that would occur between the groundwater body and the point of release in the surface water body. Most often, some form of dilution attenuation factors (DAFs) are applied to account for the mixing between the groundwater seeping into the river and the water within the river.[2] Nonetheless, as a conservative screening approach used merely to help assess whether the groundwater-to-surface water pathway represents a potentially significant exposure pathway, COPCs in the floodplain wells at levels that exceed human health screening-level surface water criteria will be carried through to Step 2 of the screening evaluation. Constituents detected in the groundwater in the floodplain wells at concentrations that are below screening-level surface water criteria would not be expected to migrate and be released in the river at a level of concern and are, therefore, eliminated from further analysis.

- **Step 2: Comparison of Concentrations of Constituents Measured in Surface Water to Screening-Level Surface Water Criteria**

  If there are compounds in the floodplain wells that are above surface water quality screening levels (Step 1), a final step will be conducted to evaluate the potential for the groundwater-to-surface water exposure pathway to be complete/significant. The final step in assessing whether the migration of constituents in groundwater to the surface water represents a potentially complete migration pathway of significance will involve a comparison of the concentrations of constituents in the surface water to the applicable screening-level surface water criteria. This comparison of measured concentrations in the river to the applicable screening-level surface water criteria will occur for all constituents that remain after completing Step 1. The comparison of surface water data to screening-level

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[2] It is common for DAFs of at least 10 to be used in comparable screening-level evaluations.

surface water criteria will be conducted by comparing the average, UCLs of the average, and the maximum detected concentrations to the applicable criteria to understand the potential significance of any individual exceedances. As in previous steps, other factors, such as detection frequency, will also be considered in reaching conclusions about the significance of levels measured in the river. Constituents that are detected in the surface water during an individual sampling period at concentrations that exceed the screening-level surface water criteria will be further examined to see if concentrations in the upstream portion of the river (upstream of the site) are greater than, equal to, or less than the concentrations detected downstream of the site. Such evaluations will help in determining whether measured values are likely the result of background or could be attributable to discharges from the groundwater to the river.

In general, if the concentrations of constituents detected in the river, particularly in the downstream section of the river, are below the screening-level surface water criteria, then the groundwater-to-surface water pathway will be deemed to be incomplete and/or insignificant and will not be evaluated further. If, however, representative concentrations of constituents are detected in the river at levels that are in excess of screening-level surface water criteria, then the groundwater-to-surface water pathway could be considered complete and will require further evaluation. As described below, this refinement may involve a more detailed identification of actual receptors in the river (recreational; aquatic), identification of applicable site-specific exposure assumptions, and site-specific estimates of risk and/or development of surface water remediation goals. Additionally, if it is determined that this pathway requires further evaluation, it is possible that fate and transport models would need to be applied to quantify the extent of the dilution and attenuation that occurs as the groundwater is released from the river to the surface water. The purpose of the models would be to assist in developing a suitable groundwater remedy.

5.3.1.2.2 Volatilization of Constituents in Groundwater to Ambient/Indoor Air

VOCs, if present in groundwater, may present an exposure concern via vapor migration upward into ambient or indoor air. Based on the groundwater monitoring data presented in the Draft RFI/RI (CH2M HILL, 2005a) and subsequent groundwater monitoring events completed as of the writing of this work plan, the groundwater is not believed to be impacted with VOCs. Specifically, in June 2004, nine groundwater monitoring wells were sampled and analyzed for VOCs. Chloroform, a common laboratory contaminant, was the only VOC detected and was only detected in trace concentrations in four samples (ranging between 0.5 and 1.9 parts per billion [ppb]). Subsequent sampling for VOCs in groundwater, conducted during May 2007, again supported that the groundwater is not impacted with VOCs, as only trace levels of chloroform were detected (detected in two out of eight monitoring wells, at a maximum concentration of 1.3 ppb) (CH2M HILL, 2007g).

Accordingly, based on the groundwater data collected to date, volatilization of constituents in groundwater to either ambient or indoor air is not considered to be a complete pathway. The justification for this conclusion and a complete evaluation of all groundwater monitoring data collected up until May 2008 (the cutoff date for data to be included in the groundwater risk assessment) will be fully presented and discussed in the groundwater HHRA.

During upcoming investigations, DTSC has requested that groundwater monitoring wells to be installed in the East Ravine be sampled for VOCs (CalEPA, 2008a). These sampling data will be included in a data summary report for the East Ravine investigation. In the event that VOCs are detected during the upcoming groundwater sampling events, the CSM will be further refined in an addendum to the groundwater HHRA. The methods for evaluating all potentially complete volatilization pathways will be described in an addendum to the groundwater HHRA.

5.3.1.3 Identification of Current and Future Potentially Exposed Populations and Exposure Pathways

Under current conditions, there are no users of the underlying groundwater affected by the plume. Water for the compressor station is supplied from wells on the Arizona side of the Colorado River (i.e., Topock Wells No. 2a and No. 3). Further, Park Moabi receives water from wells that are located upgradient and outside of the plume and not at risk of being impacted by site-related activities. In sum, the groundwater beneath the site is not currently being used. In the future, however, based on the designated beneficial uses of the groundwater as specified in the Basin Plan (CRWQCB, 2005) it is at least theoretically possible that the groundwater at the site could be extracted and used as a potable source of water. Therefore, the future potentially exposed populations include a future hypothetical groundwater user. The future hypothetical groundwater user could be exposed to constituents in the groundwater through direct ingestion, dermal contact (through bathing/shower use), and potentially through the inhalation of volatiles (e.g., while showering). A preliminary list of the potential exposure pathways associated with the future domestic use of groundwater as a drinking water source is identified on Figure 4-1.

5.3.2 Exposure Point Concentrations

The EPC is a conservative estimate of the average chemical concentration in an environmental medium (USEPA, 2002b) to which a receptor may be exposed, and USEPA (1989a) defines the EPC as “the arithmetic average of the concentration that is contacted over the exposure period.” Accordingly, and consistent with USEPA guidance, representative EPCs for each COPC in groundwater will correspond to the UCL on the arithmetic mean, calculated using ProUCL 4.0 (USEPA, 2007a). In order to understand the range of potential risks across the site associated with a future hypothetical groundwater user, EPCs will be calculated for the following three categories:

- Individual wells
- Site-wide, within the boundary of the hexavalent chromium plume (as defined in the RFI/RI Volume 2 [CH2M HILL, 2008b] by wells with hexavalent chromium concentrations of greater than California’s MCL of 50 µg/L)
- Site-wide, outside the hexavalent chromium plume.

Summary statistics that support the UCL calculation will be provided in the HHRA.

5.3.3 Exposure Assumptions

As described in Section 4.4.3, constituent intake is the amount of the constituent entering the receptor's body. The risk assessment process follows regulatory guidance for both the calculation methods (e.g., equations used) and input terms used to estimate exposure. The calculation equations and input terms to be used in the groundwater HHRA are provided in the following guidance documents:

- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (USEPA, 1989a)
- *DTSC/*Human and Ecological Risk Division *(HERD) Human Health Risk Assessment (HHRA) Note Number 1* (CalEPA, 2005f)
- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final* (USEPA, 2004b).

The amount of constituent in groundwater contacted depends upon activity patterns of the receptor and the concentrations of the constituent in the groundwater. Key components contributing to intake of site-related compounds include:

CR = contact rate, the amount of environmental medium contacted per unit time or event. There are different units depending on whether exposure occurs via ingestion, dermal contact, or inhalation (e.g., mg/day for groundwater ingestion).

EF = exposure frequency, accounts for how often exposure occurs (days per year).

ED = exposure duration, describes how long exposure occurs (years).

BW = body weight, the average BW of the exposed individual receptor (kg).

AT = averaging time, period over which exposure is averaged (days). This term varies based on whether the compound being evaluated is a carcinogen or noncarcinogen.

The values available for each of the exposure factors can vary by type of receptor (e.g., resident vs. commercial worker) and also by age and sex for some components. For this HHRA, default exposure assumptions will be used to evaluate intake for the future hypothetical groundwater user, under the assumption that the groundwater is extracted and used for domestic potable use.

Based on the current CSM, specific exposure parameters that will be used in evaluating chemical intake associated with future hypothetical groundwater use are presented in Table 5-2. Exposure assumptions for the future hypothetical groundwater user are based on a RME. The intent of the RME approach is to estimate the highest exposure level that could be reasonably expected to occur, but not the worst possible case (USEPA, 1989a; 1991c). In keeping with USEPA guidance, variables selected for a baseline RME scenario for intake (or contact rate), exposure frequency, and exposure duration are generally upper bounds. As with the health risk assessment for soil (described in Section 4), the groundwater risk evaluation will include an evaluation of both cancer and noncancer (systemic) potential health impacts, depending on the toxicity characteristics for each constituent and the relevance for the exposure pathway.

The exposure assumptions presented in Table 5-2 are based on our current understanding of the CSM and the exposure pathways that are required to be evaluated when assessing a future hypothetical groundwater user. A refined list of the complete exposure pathways and exposure assumptions will be detailed in the HHRA following the evaluation of all of the analytical data and will be clearly presented in the final CSM. Future refinements may be made to the CSM based on the findings of the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum; and could be refined again based on data collected subsequent to Volume 2 Addendum and information included in RFI/RI Volume 3. The comprehensive identification of all complete exposure pathways will dictate whether expansion of steps in the risk assessment process is warranted, including the need for the identification of additional exposure assumptions, the quantification of risks for additional pathways/receptors, and/or the development of additional remediation goals. If, for example, the groundwater-to-surface water migration pathway is deemed to be a complete exposure pathway requiring further analysis, additional human receptors and exposure pathways, such as recreational users of the river, may need to be identified and evaluated. If standard exposure assumptions are not available for certain pathways that are deemed to be complete, site-specific information will be obtained from site owners/managers, such as USBLM and USFWS, and other entities that may have information and statistics on site-specific use patterns for the recreational activities on the river.

5.4 Toxicity Assessment

As with the soils HHRA (Section 4), the relationship between the magnitude of exposure to a constituent and the potential for adverse effects is characterized in the toxicity assessment portion of the HHRA. More specifically, the toxicity assessment identifies agency-promulgated toxicity values that will be used to develop the risk-based groundwater goals. Consistent with regulatory risk assessment policy, adverse health effects resulting from constituent exposures are evaluated in two categories: carcinogenic effects and noncarcinogenic effects. The hierarchy of sources for the toxicity criteria to be used in the risk assessment generally corresponds to the state's guidelines (CalEPA, 1994b), and is discussed in more detail below. Further, consistent with current risk assessment guidance (CalEPA, 1994b), the potential human health implications associated with the presence of TPH will be assessed by evaluating each of the individual constituents detected in the samples.

5.4.1 Toxicity Assessment for Carcinogenic Effects

Current HHRA practice for carcinogens is based on the assumption that, for most substances, there is no threshold dose below which carcinogenic effects do not occur. This current “no-threshold” assumption for carcinogenic effects is based on an assumption that the carcinogenic processes are the same at high and low doses. This approach has generally been adopted by regulatory agencies as a conservative practice to protect public health. The no-threshold assumption will be used in this risk assessment for evaluating carcinogenic effects. Although the magnitude of the risk declines with decreasing exposure, the risk is believed to be zero only at zero exposure.

CSFs are used to quantify the response potency of a potential carcinogen. The CSF represents the excess lifetime cancer risk due to a continuous, constant lifetime exposure to a specified level of a carcinogen. CSFs are generally reported as excess incremental cancer risk per milligram of constituent per kilogram BW per day ($[mg/kg\text{-}bw/day]^{-1}$). CalEPA and USEPA have published a list of CSFs recommended for use in risk assessments. The CalEPA-recommended CSFs are maintained on the CalEPA’s OEHHA online toxicity criteria database (CalEPA, 2007b). The USEPA-recommended CSFs are obtained from the USEPA’s IRIS online database (USEPA, 2007c) or the NCEA/STSC (as cited in USEPA [2004a]). Consistent with CalEPA risk assessment guidance, the OEHHA CSFs are used when available, and USEPA CSFs are used when OEHHA CSFs are not available. If CSFs have not been promulgated by either OEHHA or USEPA, the chemical is not evaluated as a carcinogen.

5.4.2 Toxicity Assessment for Noncarcinogenic Effects

The toxicity assessment for noncarcinogenic effects requires the derivation of an exposure level below which no adverse health effects in humans are expected to occur. USEPA refers to these levels as RfDs for oral exposure and RfCs for inhalation exposure (USEPA, 1989a).

The noncancer RfD represents a dose, given in mg/kg-bw/day, that would not be expected to cause adverse noncancer health effects in potentially exposed populations. The noncancer RfD, reported in units of mg/kg-bw/day, is often referred to as the “acceptable dose.”

The noncancer RfC represents the airborne concentration (in $\mu g/m^3$) that would not be expected to cause adverse noncancer health effects in populations exposed through the inhalation pathway. OEHHA refers to these “acceptable air concentrations” as RELs.

As the inhalation RfCs/RELs are derived from inhalation toxicity studies, they are used for evaluating inhalation exposures, when available, and are converted to corresponding inhaled doses (inhalation RfDs) using USEPA standard conversion assumptions. As recommended by USEPA, inhalation RfCs/RELs are converted to inhaled doses (inhalation RfDs) by assuming a breathing rate of 20 m^3/day, and a BW of 70 kg (i.e., RfC/REL [µg/m^3]×[20 m^3/day]×[1/70 kg]×[1 mg/1000 µg] = RfD [mg/kg-bw/day]). If inhalation RfCs/RELs are not available, RfDs obtained from an oral study (oral RfDs) will be extrapolated and applied to the inhalation route in this evaluation (i.e., the inhalation RfD was assumed to be equivalent to the oral RfD, under the toxicological assumption that the constituent could produce the same type of noncancer effects via the inhalation route as observed through the oral route of exposure).

As recommended by USEPA (2003a), RfDs will be obtained from IRIS (USEPA, 2007c), NCEA/STSC (as cited in USEPA, 2004a), or from HEAST (USEPA, 1997d), in that order of preference. As recommended by DTSC, noncancer RELs (in units of µg/m^3), obtained from OEHHA’s list of chronic RELs (CalEPA, 2005e), will be used for evaluating noncancer effects from inhalation exposures, where available. If an OEHHA REL is not available for a constituent, the RfC will be obtained from IRIS (USEPA, 2007c), NCEA/STSC (as cited in USEPA, 2004a), or from HEAST (USEPA, 1997d) in that order of preference. Also, if both a USEPA RfC and an OEHHA REL are available, the more conservative RfC/REL is used (e.g., RfC for naphthalene).

5.5 Risk Characterization for Future Hypothetical Groundwater User

Risk characterization is the combination of the results of the exposure assessment and toxicity assessment to yield a quantitative expression of risk. This quantitative expression is the probability of developing cancer, or a nonprobabilistic comparison of a route-specific dose rate with an RfD as an indicator of the potential for noncancer effects. Quantitative estimates will be developed for individual COPCs and potentially complete exposure pathways for the hypothetical future groundwater user. The risk characterization step provides the information to guide risk management decisions.

Generally, the risk characterization will follow the methodology prescribed by USEPA documents as listed previously in Sections 5.2 and 5.4.3. USEPA methods are appropriately designed to be health protective, and tend to overestimate rather than underestimate risk. The risk/hazard estimates may exceed the intent of the RME paradigm, because risk characterization involves multiplication of the conservatisms built into each of the steps described above. The use of multiple conservative assumptions can lead to an overestimate of the actual risk. The most probable risk is likely to be much less, perhaps as low as zero (USEPA, 1989b).

Although some constituents induce both cancer and noncancer effects, the risks for each endpoint will be calculated separately.

5.5.1 Cancer Risk

The risk from exposure to potential carcinogens is estimated as the probability of an individual developing cancer over a lifetime or ILCR. In the low-dose-rate range, which would be expected for most environmental exposures, cancer risk will be estimated from the following linear equation (USEPA, 1989b):

$$ILCR = (CDI)(CSF) \qquad \text{Equation 5-1}$$

where:

ILCR = incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, based on the exposures evaluated

CDI = chronic daily intake, averaged over 70 years (mg/kg-bw/day)

CSF = cancer slope factor (mg/kg-bw/day)$^{-1}$.

The chronic daily intake term in Equation 5-1 is equivalent to the intake estimated as part of the exposure assessment.

The use of Equation 5-1 assumes that chemical carcinogenesis does not exhibit a threshold, and that the dose-response relationship is linear in the low dose-rate range. Equation 5-1 could generate theoretical cancer risks greater than 1 for high dose rates and is considered to be inaccurate at cancer risks greater than 1×10^{-2}.

As a matter of policy, USEPA (1989b; 2005b) considers the cancer risk for contact with multiple compounds to be additive, regardless of the constituent's mechanisms of toxicity or sites (organs of the body) of action. In addition, cancer risk for a given receptor across multiple exposure routes is also considered to be additive.

Consequently, cancer risks for each constituent in groundwater will be summed to show a cumulative multi-constituent risk estimate. For risk management purposes, a total cancer risk of one in a million probability of occurrence (1×10^{-6}) is a point of departure below which cancer risks are considered to be insignificant (USEPA, 1990). Cancer risks between one in a million and one hundred in a million probability of occurrence (1×10^{-6} and 1×10^{-4}) fall within a risk management range. This is generally referred to as the acceptable risk range. Within this estimated cancer risk range, there is flexibility for risk managers in deciding what action, if any, is necessary and appropriate for the protection of human health. Cancer risks above 1×10^{-4} are generally considered to be unacceptable and require action.

5.5.2 Noncancer Effects

The hazards associated with the noncancer effects of constituents are evaluated by comparing a route-specific exposure level or intake with a noncancer reference dose (RfC or RfD). The HQ will be estimated as (USEPA, 1989b):

$$HQ = I \ / \ RfD \qquad \text{Equation 5-2}$$

where:

HQ = hazard quotient (unitless, calculated)

I = intake rate of constituent averaged over exposure duration (mg/kg-bw/day)

RfD = reference dose (mg/kg-bw/day).

The approach for noncancer hazard evaluation is different from the probabilistic approach used to evaluate carcinogenic risks. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates that the estimated intake rate is 100 times lower than the RfD (also known as the dose that is considered “acceptable”). An HQ of one indicates that the estimated intake equals the RfD.

In the case of simultaneous exposure of a receptor to several constituents by a given exposure route, the HQs for each constituent are summed and the total is called the HI for that exposure route. If the HI for a given receptor exceeds one, individual HI values may be calculated for each target organ or critical effect. HI estimates at or below the threshold value of one are interpreted to mean that adverse noncancer effects are unlikely (USEPA, 1989b).

It should be noted that the HQ terms are summed for all chemicals independent of the target organ that affected by the constituent. The target organ for dermal exposure is assumed to be the same as for oral exposure; therefore, the HI for a given target organ would include HQs calculated for oral and dermal exposure to the relevant constituents.

5.6 Development of Risk-Based Remediation Goals/Applicable Drinking Water Criteria for Groundwater

Based on the results of the groundwater HHRA, the COPCs that contribute most significantly to risk and/or that exceed *de minimis* risk levels for groundwater under the assumption of future hypothetical use of the groundwater will be identified. Risk management decisions to be made in the CMS/FS step of the regulatory process will be focused on these COPCs.

The approach to be used in the development of the groundwater remediation goals is consistent with the recommendations and guidance provided by USEPA (1991b). Two fundamental requirements of CERCLA are that selected remedies be protective of human health (and the environment) and comply with ARARs. As specified by USEPA (1991b), development of remediation goals requires the following site-specific data: (1) media of potential concern; 2) COPCs; and 3) probable future land use. Once these factors are known, all potential ARARs must be identified. When ARARs do not exist, RBRGs are calculated using USEPA health criteria (i.e., RfDs or CSFs) and default or site-specific exposure assumptions (USEPA, 1991b).

Drinking water criteria, in compliance with chemical-specific ARARs, will be identified as the relevant remediation goals for all constituents where such criteria are available. Specifically, in accordance with the California Safe Drinking Water Act, California MCLs will be identified as the chemical-specific ARARs for site-related constituents detected in the groundwater (California Code of Regulations, Title 22, Division 4, Chapter 15). These drinking water criteria are presented in the first column of Table 5-1 (the California MCLs). These are the applicable drinking water criteria that will be compared to site data to identify those constituents and geographical areas that may need remedial action.

As stated by USEPA (USEPA, 1991b), when ARARs do not exist (i.e., when MCLs do not exist for a COPC in groundwater), RBRGs are calculated using USEPA health criteria (i.e., RfDs or CSFs) and default or site-specific exposure assumptions. Therefore, consistent with USEPA guidance, a risk-based process will be used to estimate RBRGs for COPCs in groundwater that contribute most significantly to risk and/or that exceed *de minimis* risk levels for groundwater for which ARARs do not exist.

RBRGs will be developed by combining information regarding the level of intake of the constituent, the levels of acceptable risk, and the relationship between the intake of constituent and the incidence of an adverse health effect as a function of human exposure to the constituent. The methodology used to develop RBRGs for the COPCs that do not have applicable drinking water criteria will be based on guidance and the specific equations provided in the guidance documents below:

- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (USEPA, 1989a)
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part B: Development of Risk-Based Preliminary Remediation Goals)* (USEPA, 1991b)
- *Supplemental Guidance for Human Health Multimedia Risk Assessment of Hazardous Waste Sites and Permitted Facilities* (CalEPA, 1992)
- *Preliminary Endangerment Assessment Guidance Manual* (CalEPA, 1994a).

In accordance with the NCP (40 CFR 300.430(e)(2)) (USEPA, 1990), remediation goals shall establish acceptable exposure levels that are protective of human health and the environment and shall be developed considering the following:

(A) “Applicable or relevant and appropriate requirements…and the following factors:
  (1) For systemic toxicants, acceptable exposure levels shall represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety;
  (2) For known or suspected carcinogens, acceptable exposures levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not

> available or are not sufficiently protective because of multiple constituents at a site or multiple pathways of exposure.”

Consistent with USEPA guidance, the target cancer risk that will be used in the development of the RBRGs will be one in one million (1×10^{-6}). This will be the point of departure, recognizing that CalEPA and USEPA ultimately have authority to allow for residual risks to be within the risk management range of 1×10^{-4} to 1×10^{-6}. For noncancer health hazards, a target HI of unity (one) will be used. Individual constituent exposures that yield HIs of less than one are not expected to result in adverse noncancer health effects (USEPA, 1989a).

The applicable drinking water criteria and the RBRGs developed and presented in this section of the groundwater HHRA provide key information, in addition to other factors such as background concentrations, to be used in the CMS/FS in evaluating the feasibility of different remedial options.

5.6.1 Discussion of Uncertainties

As described in the soils HHRA portion of this work plan, an important component of the risk assessment process is a fair and transparent discussion of the uncertainties that are inherent in the risk assessment. As stated by USEPA (1989a), it is important that the risk assessment identify the key site-related variables and assumption that contribute most to the uncertainty associated with the evaluation. In accordance with USEPA guidance, the risk assessment will identify the key uncertainties associated with each of the major steps of the risk assessment: data evaluation and selection of COPCs, including a discussion of potential data gaps; exposure assessment; toxicity assessment; and risk characterization. The uncertainty section will focus on identifying those assumptions that contribute most to the overall uncertainty in the risk assessment and will be consistent with USEPA guidance (USEPA, 1989a).

Generally, risk assessments are influenced by two types of uncertainty: (1) measurement uncertainty; and (2) uncertainty arising from data gaps. Measurement uncertainty includes the usual variance that accompanies scientific measurements (e.g., instrument uncertainty and variance [accuracy and precision] associated with constituent concentrations and the heterogeneity of the data). A second type of uncertainty stems from data gaps. Models are often used to fill data gaps because they represent a level of understanding to address parameters that are impractical or impossible to measure. Assumptions represent an educated estimate of information that is not available.

The general sources of uncertainty that are common to essentially all risk assessments as well as the bias they impart to the risk assessment (i.e., whether conservatism is increased or decreased) will be discussed in the HHRA to include site-specific sources of uncertainty. The analysis will include, but will not be limited to, the weight-of-evidence supporting the conclusions reached, the degree of success in meeting the objectives of the evaluation, and the degree of confidence in the data used to assess the site and its constituents. Factors contributing to uncertainty in the overall risk assessment will be highlighted, including uncertainties introduced by limitations in site-specific data, toxicity data for the COPCs, and the ability to estimate existing and probable future intakes.

6. Ecological Risk Assessment Approach for Soil

This section describes the approach that will be used in conducting an ERA for the site and includes the purpose and objectives of the ERA, a summary of the preliminary scoping assessment for soil data from outside the compressor station, and the approach that will be used in the Phase I Predictive ERA for exposure to soil outside the compressor station.

The scoping assessment was, and the Phase I Predictive ERA for soil will be, prepared in accordance with applicable state and federal regulations and guidance. Regulatory guidance consulted includes:

- *Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities, Parts A and B* (CalEPA, 1996c)
- *HERD Ecological Risk Assessment Note (EcoNote) 1, Depth of Soil Samples for Exposure of Burrowing Animals* (CalEPA, 1998b)
- *HERD EcoNote 2, Calculation of Range of Intakes for Vertebrate Receptors* (CalEPA, 1999)
- *HERD EcoNote 4, Use of USEPA Region 9 Biological Technical Assistance Group (BTAG) Toxicity Reference Values (TRVs) for Ecological Risk Assessment* (CalEPA, 2000)
- *HERD EcoNote 5, Revised USEPA Region 9 BTAG TRV for Lead: Justification and Rationale* (CalEPA, 2002a)
- *Currently Recommended USEPA Region 9 BTAG Mammalian and Avian TRVs* (CalEPA, 2002b)
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997a)
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998)
- *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)* (USEPA, 2005a; 2008a)

- *ECO Update Bulletin Series* (USEPA, various dates)

- *Generic Ecological Assessment Endpoints (GEAE) for Ecological Risk Assessment* (USEPA, 2003c).

The overall goal of the ERA for soil is to identify potential adverse effects of COPCs in soil that could result in adverse effects to ecological receptors and to use the results of the ERA to provide a basis for developing site management options. The specific purpose and objectives of the ERA for soil are described in Section 6.1.

The scoping assessment was conducted with existing data and culminates in a CSM for ecological risks associated with the exposure areas described in Section 3.1.1. For large home range receptors, exposure areas will be the BCW (which includes SWMU 1/AOC1 and AOC 4) the remaining areas outside that includes the five AOCs (AOC 9, 10, 11, 12, and 14), and the Potential Pipeline Disposal Area. For small home range receptors, exposure areas will be each individual AOC outside the compressor station (BCW; AOCs 4; 9 and 10a; 10b, c, and d; 11; 12; 14; and the Potential Pipeline Disposal Area, which could be combined with the riparian area of AOC 10 if the data warrant). All ERA exposure areas are located outside the fence line of the compressor station. The scoping assessment is presented in Section 6.2 and was conducted with existing data. Certain elements of the scoping assessment, principally the COPECs, may be revised when the results of planned or ongoing soil studies become available. Data collected from the site to date are documented in the Draft RFI/RI (CH2M HILL, 2005a), and additional soil sampling that will be conducted is described in the Draft RFI/RI Work Plans Part A and Part B (CH2M HILL, 2006a; 2007d). Sections 2 and 3 provide summaries of the data available for the site.

The scoping assessment was based on information previously provided to the regulatory agencies and is presented in Section 6.2. The Phase I Predictive ERA planning process for soil has already begun and is documented in two Technical Memoranda that were submitted for regulatory review and comment. These memoranda are:

- *Topock Compressor Station – Ecological Conceptual Site Models, Assessment Endpoints, and Receptors of Concern* (ARCADIS BBL, 2007a)

- *Topock Compressor Station – Ecological Exposure Parameters, Bioaccumulation Factors, and Toxicity Reference Values* (ARCADIS BBL, 2007b).

The memoranda were accepted by the DTSC and USFWS with comments (Marr, 2007; Eichelberger, 2007; CalEPA, 2008b; and USDOI, 2008). The components of the ERA that have been previously reviewed and agreed to in the technical memoranda are:

- Preliminary COPECs
- CSMs
- Assessment and measurement endpoints
- Receptors of concern
- Exposure parameters
- Bioaccumulation factors (BAFs)
- TRVs.

However, information presented in the Technical Memoranda were updated since their submission to address DTSC comments, refine exposure areas, and update toxicity values as described in Section 6.3 below.

The agencies have also reviewed and accepted the screening levels that will be used to evaluate potential risk to plant and invertebrate communities. These screening levels were provided as generic ecological comparison values (ECVs) in Appendix D of the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a) and are discussed in Section 6.3.4.1.

The elements of the soil ERA work plan that have not been reviewed in previously submitted documents are the:

- Complete problem statement
- Approach to EPC calculations
- Risk characterization approach

- Uncertainty analysis approach.

The scoping assessment and the Phase I Predictive ERA were initiated April 2007 to support upcoming soil sampling by providing input to data quality objectives for the Part A soil sampling investigation (e.g., assist in evaluation of detection limits). The soil investigation is proceeding to refine the understanding of the nature and extent of contamination. Toward that end, one objective of the investigation is to characterize chemical concentrations toward background. However, as screening-level (generic) ECVs are often below background concentrations, it was determined that site-specific ECVs would help the sampling decisions. It was recognized that the scoping assessment and initial Phase I Predictive ERA activities will provide the necessary information to develop site-specific ECVs. The site-specific ECVs will be used to evaluate the nature and extent characterization being supplemented in the upcoming soil sampling and are used for evaluating adequacy of soil sampling only and will not be used for screening COPECs in the ERA. The site-specific ECVs for the preliminary COPECs were submitted as a Technical Memorandum to DTSC on May 28, 2008: *Technical Memorandum 3: Ecological Comparison Values for Metals and Polycyclic Aromatic Hydrocarbons in Soil for the PG&E Topock Compressor Station* (ARCADIS, 2008). Site-specific ECVs for other COPECs will be presented in a separate Technical Memorandum as data becomes available during the RFI/RI Part A sampling (CH2M HILL, 2006a).

6.1 Purpose and Objectives

The purpose of the ERA is to predict the potential for adverse effects of COPECs on ecological receptors and the objectives are to:

- Inform the RCRA corrective action and CERCLA remedy process by providing risk managers with risk estimates for COPECs detected during the RFI/RI and related investigations

- Provide transparent estimates of potential site-related risks to ecological receptors

- Provide spatial context for the risk estimates

- Convey the magnitude and direction of uncertainty associated with the risk estimates

- Provide information that can be used to develop protective concentrations of site-related constituents in environmental media

- Provide risk-based comparison values that can be used to assist in site characterization (e.g., for establishing reporting limits, and adequacy of sample coverage).

These objectives will be met by conducting a scoping ERA, Phase I Predictive ERA, and developing site-specific ECVs for use in site characterization and other decision-making processes. Additional risk assessment steps may be required depending on the outcome of these preliminary activities. Potential next steps are described in Section 8.

6.2 Scoping Assessment

A scoping assessment was conducted in accordance with CalEPA guidance for ERAs (CalEPA, 1996c). The purpose of the scoping assessment is to develop CSMs that can serve as the basis for problem formulation in the Phase I Predictive ERA. The main elements of the scoping assessment are the identification of COPECs, identification of potentially complete exposure pathways, and selection of representative receptors. These elements are summarized in the CSM presented in Figure 6-1 and discussed below.

6.2.1 Constituents of Potential Ecological Concern

Preliminary COPECs for soil were identified and presented to the regulatory agencies in a Technical Memorandum (ARCADIS BBL, 2007a). The preliminary COPECs have been revised somewhat (based on more current information) and are discussed below. Final COPECs will be identified using additional environmental data and will be presented in the risk assessment. The final COPEC selection process is a step-wise process, generally consisting of elimination of common laboratory contaminants, a comparison to background, and evaluation of essential nutrients, which is described in detail in Section 3.3.1.

6.2.1.1 Soil

As discussed in Section 3.1.1, for the purposes of the risk assessment, soil is defined as solid matrix collected from areas not inundated with water and typically dry in the absence of storm events. This definition varies from the definition used in preparing the

Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a). The soil data that will be used in the ERA are discussed in Section 3.1.1 and will include upland soil data collected from certain locations depicted as "sediment" (i.e., SS-2 through SS-8) on Figure 2-3.

The preliminary COPECs identified for the site are summarized in Table 6-1. The preliminary COPECs for the ERA are based on the COPCs identified in the RFI/RI Volume 1 (CH2M HILL, 2007a). The preliminary COPECs include Title 22 metals, hexavalent chromium, manganese, TPH, and PAHs. The Title 22 metals include antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. The PAHs include total low molecular weight (LMW) PAHs and total high molecular weight (HMW) PAHs In addition, the COPECs may include VOCs and SVOCs other than PAHs.

The preliminary COPECs for soil will be reviewed and potentially revised when new constituent data are available from soil samples collected during the RFI/RI Part A sampling (CH2M HILL, 2006a). Specifically, data for organic constituents collected during the Part A soil sampling investigation will be reviewed and additional COPECs may be identified.

The primary source of contamination for BCW is the discharge of untreated wastewater containing chromium and potentially other COPCs to surface soil (Figure 6-1). The remaining AOCs and Potential Pipeline Disposal Area have potential sources from the discharge/runoff from the compressor station, disposal of waste to surface soil, leaking subsurface piping, and leaking from the aboveground tank (Figure 6-1). Incidental releases inside the compressor station fence line may have been a source of dissolved or suspended constituents to AOCs 4, 9, 10, and 11 via intermittent stormwater runoff. Surface soil is the primary source medium for all seven AOCs.

As described in the RFI/RI Volume 1(CH2M HILL, 2007a), hexavalent chromium and other metals were identified as COPCs for BCW (Table 6-1). At DTSC’s request, additional sampling for other constituents (e.g., VOCs and SVOCs) has been added to the Phase I Part A investigation (see below). The preliminary list of COPECs will be revised as necessary based on the Phase I Part A investigation results. Similarly, the preliminary COPEC list for AOCs 4, 9, 10, 11, 12, and 14 may be expanded based on the results of the Phase I Part A investigation.

The COPCs also include PAHs at AOC 4 (Table 6-1). Sixteen PAHs were detected at AOC 4 at concentrations typically less than 1 mg/kg (CH2M HILL, 2006a). One aspect of the upcoming Phase I Part A investigation is an evaluation of ambient PAH concentrations to distinguish site-related PAH concentrations from ambient anthropogenic PAHs (CH2M HILL, 2006a). Therefore, the selection of PAHs as COPECs will be revisited after the results of the ambient PAH evaluation become available. If PAHs are identified as final COPECs, information regarding PAH data management, bioaccumulation, and toxicity will be presented in a technical memorandum or an addendum to this work plan in accordance with comments received from DTSC on Ecological Exposure Parameters, Bioaccumulation Factors, and Toxicity Reference Values (ARCADIS BBL, 2007b;CalEPA, 2008b).

As described in the RFI/RI Volume 1(CH2M HILL, 2007a), no COPCs (other than potential asbestos in the subsurface associated with the pipe) were identified for the Potential Pipeline Disposal Area. However, DTSC requested soil sampling in addition to the planned geophysical survey. Therefore, COPECs may be identified for the Potential Pipeline Disposal Area based on the Part A investigation results.

As described in the RFI/RI Volume 1 (CH2M HILL, 2007a), the COPCs for the Former 300B Pipeline Liquids Tank Area consist only of TPH. However, soil from the Former 300B Pipeline Liquids Tank area was removed to a depth of 5.5 feet bgs as part of the closure (CH2M HILL, 2007h), residual TPH concentrations were acceptable, and the area was closed. Additional investigation was requested by DTSC after the closure (as an attachment to Aaron Yue/DTSC’s letter dated August 10, 2007 [CalEPA, 2007a]). Therefore, COPECs may be identified for the Former 300B Pipeline Liquids Tank Area based on the Part A investigation results.

Based on agency comments on the original Draft RFI/RI Work Plan Part A (CH2M HILL 2006a), the following analyte groups were added to the investigation at the indicated AOCs:

- AOC-1: pH
- AOC-4: VOCs, SVOCs, and TPH
- AOC9: VOCs, SVOCs, and pH
- AOC10: VOCs, SVOCs, and pH
- AOC11: VOCs, SVOCs, and pH

- AOC14: All samples will be analyzed for Title 22 metals, hexavalent chromium, VOCs, SVOCs, TPH, PAH, and asbestos

- Former 300B Pipeline Liquids Tank: Title 22 metals, hexavalent chromium, VOCs, SVOCs, PAHs, and PCBs

- Potential Pipeline Disposal Area: Title 22 metals, hexavalent chromium, VOCs, SVOCs, TPH, PAHs, asbestos, and pH.

Data from the additional investigation will be evaluated, and will be selected following methods described in Section 3.3.1 and COPECs will be included in the ERA as appropriate.

6.2.1.2   Sediment

As discussed in Section 3.1.2, for the purposes of the risk assessment, sediment is defined as solid matrix collected from areas typically inundated even in the absence of storm events. This definition varies from the definition used in preparing the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a), and the figures cited in this section depict “sediment” samples that are classified as soil for the risk assessment (i.e., SS-2 through SS-8 on Figure 2-3). Sediment data from the mouth of the BCW north of AOC 1, and locations both upriver and downriver from its confluence with the Colorado River, were collected as part of the RFI/RI program (Section 3.1.2). While limited additional sampling is planned for the area north of the railroad tracks (Figure 2-3), existing data from AOC 1 do not indicate the presence of COPECs in the northern reach of the BCW at concentrations that warrant further investigation (CH2M HILL, 2006a).

As described earlier in Section 3.1.2, a gradient and screening approach will be used to evaluate the completion of the transport pathway from upland soil to riparian sediment. Starting from the upland locations (AOC 1 and AOC 10) to the riparian areas, site soil data will be compared to background soil data. If concentrations of constituents in site soil decrease down slope and become less than or equal to background before reaching the sediment in the riparian areas, this pathway will be interpreted to be incomplete. In addition, and for confirmation of the pathway analysis, sediment data in the BCW riparian area will be compared to ecological screening benchmarks (TECs; MacDonald et al., 2000). The results of both the transport analysis, using comparison to background concentrations, and the sediment screening will be evaluated, and the potential pathway for surface soil entrained in runoff to reach the sediment will be determined in the risk assessment. If this pathway is considered complete, it will be quantitatively evaluated in the risk assessments. Additional data may be collected as part of the Phase II Part A investigation (CH2M HILL, 2006a).

6.2.2 Exposure Pathways

Exposure pathways for the soil risk assessment consist of constituent sources, transport mechanisms, and exposure media. The site history and potential constituent sources are described in Section 2 and the preliminary COPECs are described above in Section 6.2.1. The potential ecological exposure pathways are illustrated in Figure 6-1. As mentioned in Section 3.1.1.1, the Former 300B Pipeline Liquids Tank area outside the compressor station has already been closed (CH2M HILL, 2007h), but DTSC has requested additional investigation (CalEPA, 2007d). If complete pathways are identified based on the results, the Former 300B Pipeline Liquids Tank area will also be included in the ERA. For all the exposure areas, the principal exposure pathways for ecological receptors in the terrestrial environment are exposure to constituents in surface soil, shallow soil, and subsurface soil I[3] via direct contact, incidental ingestion, and/or ingestion of chemically affected biota. These and other terrestrial exposure pathways are discussed in Section 6.2.2.1. While the transport of site-related constituents to the riparian area is unconfirmed, a general discussion of potential exposure pathways is provided in Section 6.2.2.2. Additional sampling is planned during the Phase I Part A investigation (CH2M HILL, 2006a) to investigate if the riparian area warrants further evaluation.

6.2.2.1 Terrestrial Exposure Pathways

Wastewater and various other wastes (e.g., discarded debris) may impact surface soil and, via transport mechanisms, may impact terrestrial biota tissue and soil at greater depths (Figure 6-1). Percolation and/or infiltration serve as the primary transport route for constituents in the CSM to reach media in the terrestrial environment other than surface soil. If constituents are present in subsurface soil as a result of percolation or infiltration and they reach groundwater, the potential for discharge to surface water will be examined (see Section 6.2.2.2 and Section 7). Constituents adhering to surface soil, the primary source medium, may be moved laterally via entrainment and surface runoff. However, COPEC transport in the BCW and AOC 10 via surface soil runoff to

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[3] See Figure 3-1 for exposure depth intervals to be considered in the risk assessment.

the riparian area is unconfirmed and will be examined based on the screening approach described in Section 3.1.2.

The following potential exposure pathways will be quantitatively evaluated for terrestrial ecological receptors: (1) direct contact/uptake by plants and terrestrial invertebrates; (2) incidental ingestion of soil by wildlife; and (3) ingestion of terrestrial biota tissue by wildlife.

Exposures to ecological receptors such as soil invertebrates, birds, and non-burrowing mammals generally occur at the surface (0 to 0.5 foot bgs). Plant roots can go down to 6 feet bgs or deeper, and burrowing mammals can also burrow to depths of 6 feet bgs or deeper. Surface soil (defined as 0 to 0.5 foot bgs), shallow soil (defined as 0 to 3 feet bgs), and subsurface soil (defined as 0 to 6 feet bgs) are the primary exposure media of concern for all areas included in the CSM (Figure 6-1). The exposure depths were selected consistent with guidance provided by CalEPA (1998a) for assessing exposure of fossorial vertebrates and based on review of the soil data presented in the Draft RCRA RFI/RI Work Plan Part A (CH2M HILL, 2006a). The maximum detected concentrations of COPCs were found in the upper six feet of soil at the AOCs, and elevated concentrations relative to background are also typically found in this depth interval.

Exposures of terrestrial wildlife receptors are primarily via ingestion of biota tissue (plants and prey items) and incidental soil ingestion, although inhalation of VOCs in burrow air may also be an important pathway and will be evaluated as appropriate. Inhalation of particulates by ecological receptors is an insignificant pathway, contributing less than 1% of the ingestion pathway dose (USEPA, 2008a) and will not be evaluated.

Ingestion of biota tissue generally occurs at the surface, and prey items reside and take up constituents from surface soils. Therefore, surface soil will be used in estimating uptake into biota tissue. Soil ingestion is largely associated with foraging for prey items, although some soil ingestion may occur during grooming/preening that could include soils from deeper burrows. CalEPA guidance indicates that characterization of soil to 6 feet bgs is sufficient for the majority of ecological receptors (CalEPA, 1998a). For the burrowing receptors likely to be onsite, a maximum depth of 6 feet bgs is considered sufficient to capture the range of burrow depths of the majority of small mammals present onsite. Including deeper samples, if they are not as contaminated as surface soils, could potentially decrease the overall exposure estimates. To understand the potential implications of averaging concentrations over one depth interval versus another, the representative EPCs from soils and prey tissue (modeled from soil concentrations) will be evaluated for each receptor as described in detail in Section 6.3.3.1. Figure 3-1 illustrates the proposed depth intervals for ecological receptors and the corresponding soil depths, as proposed in the upcoming soil sampling plans.

6.2.2.2 Riparian Exposure Pathways

Exposure pathways to the riparian area down slope of the site at the mouth of the BCW and along the Colorado River are currently unconfirmed. Two potential transport pathways are of interest in considering exposure pathways to the riparian area. First, entrainment of chemically affected surface soil and subsequent surface runoff may transport constituents down slope of the source areas. Surface runoff, if extensive, may result in constituent deposition in the riparian sediment at the mouth of the BCW or downgradient of AOC 10. Currently, this transport pathway appears to be insignificant; however, it will be evaluated further based on the results of the Part A soil sampling investigation (CH2M HILL, 2006a) and the screening approach described earlier in Section 3.1.2.

A second potential transport pathway is groundwater discharge to surface water. This potential transport pathway is discussed in Section 7.

6.2.3 Representative Receptors

Ecological receptors potentially exposed to chemically affected media include plants, invertebrates, birds, and mammals. Potential exposure routes are evaluated for each category as: “potentially complete exposure pathway” (X), “potentially complete exposure route not evaluated” (O), or “incomplete pathway” (open box) (Figure 6-1). Potential exposure routes to fish and reptiles/amphibians are not confirmed. However, these routes will be evaluated further based on the results of the screening approach described in Section 3.1.2.

Representative receptors were identified for both the terrestrial and riparian areas outside the compressor station based on habitat characteristics and available literature as summarized below. While complete transport pathways to the riparian area are unconfirmed, representative receptors were identified to provide a complete description of the ecological setting for the site.

6.2.3.1 Terrestrial Receptors

Representative terrestrial species include species confirmed present or potentially present in the upland areas on or adjacent to the exposure areas outside the compressor station (listed in Table 2-1). The upland animal species, based on habitat type (i.e., Mojave Desert scrub) and the location of the site, and the species present or potentially present in the vicinity of the site are identified in Table 2-2. Representative animal receptors include birds such as raptors, songbirds, ground-nesting birds, and species tolerant of human disturbance (e.g., dove and raven). Snakes, lizards, small mammals, and larger carnivorous mammals such as the desert kit fox are also present. Representative terrestrial plant species include creosote bush and associated species such as spineflower (*Chorizanthe brevicornu*) and cheesebush (*Hymenoclea salsola*) (Table 2-3).

6.2.3.2 Riparian Receptors

Completed transport pathways to the riparian area are unconfirmed. However, representative receptors were identified to provide a complete description of the ecological setting for the site. Potential ecological receptors include species present or potentially present in the riparian areas of the APE described in the PBA (CH2M HILL, 2007c) (Tables 2-4 and 2-5). Animal species in the riparian area include snakes, water birds, wading birds, songbirds, and perching birds. Small mammals, including the cave myotis (*Myotis velifer*), beaver (*Castor canadesis*), bobcat (*Lynx rufus*), and raccoon (*Procyon lotor*) are also present in the area. The bonytail chub (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*), both special status fish species, are potentially present in the Colorado River reach near the site. Plant species in the riparian area include salt cedar (*Tamarix* sp.), palo verde (*Cericidum* sp.), and mesquite (*Prosopis* sp.), as well as wetland plants (e.g., cattails [*Typha* sp.], sedge [*Carex* sp.], reeds [*Phragmites communis*]).

6.2.4 Summary of Conceptual Site Models

The CSM is the basis for the Phase I Predictive ERA that will be conducted and summarizes the results of the scoping assessment. The CSM is the framework for relating potential receptors to chemically affected media and evaluating the degree of completion of exposure pathways. A CSM was developed for all the AOCs including BCW; AOCs 4, 9, 10, 11, 12, and 14; and the Potential Pipeline Disposal Area (Figure 6-1). In the Technical Memorandum (ARCADIS BBL, 2007a), BCW was evaluated separately from the rest of the AOCs outside the compressor station. However, based on further understanding of the exposure areas and the ecological receptors that occupy the site, for large home range receptors, the BCW is combined with AOC 4 and will be evaluated as one exposure area as described earlier in Section 3.1.1.1. BCW and AOC 4 are in close proximity and are physically and topographically separated from the other AOCs, and populations of wildlife receptors foraging in the BCW and AOC 4 are expected to be different from the wildlife populations foraging in the rest of the AOCs outside the compressor station. For small home range receptors, as requested by DTSC and USDOI, individual AOCs outside the compressor station, as described previously, will be evaluated as separate exposure areas. No ecological exposures are anticipated inside the fence line of the compressor station and, therefore, an ERA is not planned for those AOCs (Table 2-1).

As shown in Figure 6-1, the primary exposure pathways are direct contact or incidental ingestion of surface soil (0 to 0.5 foot bgs), shallow soil (0 to 3 feet bgs), and subsurface soil I (0 to 6 feet bgs)[4], and uptake and subsequent ingestion of constituents in biota. Receptors that will be evaluated include plants, terrestrial invertebrates, birds, and mammals. Reptiles, while common in the Mojave Desert, will not be evaluated quantitatively in the ERA because, as USEPA noted in the Eco-SSL Guidance (USEPA, 2008a), toxicity data for amphibians and reptiles are insufficient to support establishing risk-based thresholds. Reptiles will be addressed qualitatively in the uncertainty analysis.

The CSM (Figure 6-1) also illustrates that the exposure pathway to the riparian area along the Colorado River and the river itself is potentially incomplete. This potential pathway is the subject of ongoing evaluation as described earlier in Section 6.2.2.2.

6.3 Phase I Predictive Ecological Risk Assessment Work Plan

Elements of the Phase I Predictive ERA work plan were initiated and documented in the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a) and Technical Memoranda submitted for regulatory review (ARCADIS BBL, 2007a,b). The Phase I Predictive ERA will consist of:

- Problem statement

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[4] Subsurface soil exposure intervals are defined as subsurface soil I (0 to 6 feet bgs) and subsurface soil II (0 to 10 feet bgs). Subsurface soil II is considered in the human health risk assessment only.

- Assessment and measurement endpoints
- Exposure assessment
- Effects assessment
- Risk characterization
- Uncertainty analysis.

A preliminary problem statement and assessment and measurement endpoints have already been developed and documented (ARCADIS BBL, 2007a). Elements of the exposure assessment, as well as the preliminary effects assessment, have already been completed and documented (CH2M HILL, 2005a; ARCADIS BBL, 2007b). Previously documented information with updated exposure and/or effects parameters based on DTSC comments and current values from updated literature sources are also included herein. This work plan presents the approach that will be used in risk characterization and uncertainty analysis of the Predictive Phase I ERA.

6.3.1 Problem Statement

The problem statement is the outcome of the problem formulation process. Briefly, problem formulation includes identifying societal or regulatory goals and assessment endpoints, preparing a conceptual model, and developing an analysis plan using data collected specifically to support the ERA and/or data available from previous studies. The problem statement consists of the CSM (discussed in Section 6.2 and depicted on Figure 6-1) and the selection of assessment and measurement endpoints (Section 6.3.2). The analysis plan relies on chemical and spatial data collected in previous and ongoing studies and is provided in Sections 6.3.3 through 6.3.6.

In short, constituent discharges to areas near the compressor station (most notably, but not exclusively, wastewater containing hexavalent chromium) may have resulted in potential risk to ecological receptors; however, the potential risks are undefined. The complete and significant exposure pathways were identified in the CSM and include direct contact or incidental ingestion of surface soil and shallow soil, and uptake and subsequent ingestion of constituents in biota. Development of the problem statement is an iterative process. When data become available from the ongoing soil and groundwater investigations, the CSM, including COPECs and exposure pathways, will be reviewed and potentially revised. Similarly, the endpoints and analysis plan may be adjusted based on additional understanding of the nature and extent of contamination developed during ongoing investigations.

6.3.2 Assessment and Measurement Endpoints

An assessment endpoint is an explicit expression of the environmental value (species, ecological resource, or habitat type) that is to be protected (USEPA, 1997a). Assessment endpoints relate to statutory mandates (protection of the environment) but must be specific enough to guide the development of the risk assessment study design at a particular site (USEPA, 1997a; 1998). Selecting appropriate assessment endpoints is an important step in developing an ERA that is useful to risk managers in the decision-making process (USEPA, 2003c). Useful assessment endpoints define both the valued ecological resource (i.e., ecological entity) and a characteristic of the resource to protect (i.e., attributes) (USEPA, 1997a; 1998; and 2003c).

Assessment and measurement endpoints, as well as indicator receptors, are presented in Table 6-2. Ecological assessment endpoints are explicit expressions of environmental values that are to be protected and involve multiple species that are likely to be exposed to differing degrees and respond differently to the same constituent (USEPA, 1997a). Assessment endpoints for ERAs should be selected based on the ecosystems, communities, and species potentially present at the site and depend on:

- Constituents present and their concentrations
- Mechanisms of toxicity of the constituents to different groups of organisms
- Ecologically relevant receptor groups that are potentially sensitive or highly exposed to the constituents
- Potentially complete exposure pathways.

In accordance with the USEPA (1997a) guidance, the following assessment endpoints were developed to identify the ecological values at the project site:

- Sufficient rates of survival, growth, and reproduction to sustain plant populations (e.g., creosote bush scrub)

- Sufficient rates of survival, growth, and reproduction to sustain invertebrate populations

- Sufficient rates of survival, growth, and reproduction to sustain avian populations

- Sufficient rates of survival, growth, and reproduction to sustain mammalian populations.

In addition to the above assessment endpoints, sufficient rates of survival, growth, and reproduction to sustain reptile populations were identified as an important environmental value. However, toxicity data for reptiles are insufficient to support quantitative evaluation of effects.

Measurement endpoints are measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint (USEPA, 1997a). The selected measurement endpoints for each assessment endpoint are provided in Table 6-2. Measurement endpoints to evaluate protection of ecological communities (i.e., plant and invertebrate communities) are a comparison of constituent concentrations in soil to direct screening values. Measurement endpoints to evaluate protection of avian and mammalian receptors are a comparison of estimated exposure doses with TRVs (i.e., literature-derived RfDs).

6.3.3 Exposure Assessment

The outcome of the exposure assessment will be estimates of exposure concentrations or doses for comparison with reference toxicity data. EPCs will be developed to estimate direct exposure and provide the basis for estimating bioaccumulation and subsequent exposure of upper trophic-level receptors.

6.3.3.1 Exposure Point Concentrations

The EPC is the representative concentration of a constituent in an environmental medium that is potentially contacted by the receptor (USEPA, 1997a), and USEPA (1989a) defines the EPC as “the arithmetic average of the concentration that is contacted over the exposure period.” The EPC is constituent-specific and is estimated for each individual exposure area within a site. The exposure areas were discussed in Section 3.1.1.1 and for the large home range receptors, the exposure areas include the BCW and AOC 4 as one exposure area, and the remaining AOCs (9, 10, 11, 12, and 14) and Potential Pipeline Disposal Area as another exposure area. For the small home range receptors, in accordance with DTSC and USDOI's request, the ERA will include each individual AOC outside the compressor station as a separate exposure area (BCW; AOCs 4; 9 and 10a; 10b, c, and d; 11; 12; and 14; and the Potential Pipeline Disposal Area).

Unless there is site-specific evidence to the contrary, a receptor population is assumed to be equally exposed to media within all portions of the exposure area over the time frame of the risk assessment. Typically, the EPCs for soil COPECs will be the UCL on the arithmetic mean, calculated using ProUCL 4.0 as described in Appendix A. The maximum detected concentration may be selected if the data do not support a valid UCL calculation (Appendix A). Consistent with DTSC guidance (CalEPA, 1996c), soil concentrations will be estimated using both the maximum detected concentration and the 95% UCL for each COPEC identified in soil. Additionally, specific areas of hot spots (generally defined as areas that have individual concentrations significantly higher than the overall EPC) may warrant specific assessment. The general approach that will be used to evaluate hot spots is described in Appendix A. Summary statistics that support the UCL calculation as well as documentation of hot spot areas will be provided in the ERA. As mentioned in Section 3.1.1.1, once data are available from the upcoming soils sampling activities, additional refinements to the exposure areas may be necessary.

If a potentially complete pathway from soil to burrow air for VOCs is identified based on the Part A investigation results (CH2M HILL, 2006a), the Johnson and Ettinger model will be used to estimate burrow air concentrations. The Johnson and Ettinger model is a screening-level model that incorporates both convective and diffusive mechanisms for estimating the transport of constituent vapors emanating from either subsurface soils or groundwater into indoor spaces located directly above the source of contamination (Johnson and Ettinger, 1991). In the ERA, the Johnson and Ettinger model will be used in an initial evaluation to estimate burrow air concentrations for burrowing ecological receptors. In the event that VOCs are detected in areas outside the compressor station fence line, additional investigation may be planned to support the risk assessment. Transport modeling, active soil gas sampling and analysis, and sampling and analyzing burrow air are all alternatives that could be considered if VOCs are detected. Passive soil gas sampling is not recommended because it would only yield qualitative results. The refined approach to the exposure assessment for burrowing mammals will be developed in consultation with the agencies after review of the Part A soil sampling investigation results.

6.3.3.2 Direct Exposure

Soil EPCs will be used to provide an average concentration term for direct exposure assessment. To understand the potential implications of averaging concentrations over one depth interval versus another, the risk assessment will evaluate representative EPCs from soils within the following depth categories for each of the AOCs and undesignated areas except BCW (explained below):

- Plants: soil uptake based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs
- Soil invertebrates: soil uptake based on the EPCs from 0 to 0.5 foot bgs
- Granivorous birds (non-burrowing): soil EPCs from 0 to 0.5 foot bgs for incidental ingestion of soil
- Insectivorous birds (non-burrowing): soil EPCs from 0 to 0.5 foot bgs for incidental ingestion of soil
- Carnivorous birds (non-burrowing): soil EPCs from 0 to 0.5 foot bgs for incidental ingestion of soil
- Granivorous mammals (burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs for incidental ingestion of soil
- Insectivorous mammals (non-burrowing): soil EPCs from 0 to 0.5 foot bgs for incidental ingestion of soil
- Carnivorous mammals (burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs for incidental ingestion of soil.

For BCW, substantial soil scouring and deposition has been observed as a result of heavy rain events. However, this is unique to BCW and soil scouring to this extent has not been observed at other AOCs or undesignated areas. Therefore, it is considered possible that non-burrowing wildlife (i.e., all the birds and the insectivorous mammal) could be exposed to surface/shallow soil via incidental soil ingestion and prey (i.e., invertebrates) uptake at BCW. However, following CalEPA guidance (CalEPA, 1998), exposure depths for plants and burrowing mammals will be evaluated as described above; but for BCW, the risk assessment will evaluate representative EPCs from soils within the following depth categories:

- Plants: soil uptake based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs
- Soil invertebrates: soil uptake based on the highest EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs
- Granivorous birds (non-burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs for incidental ingestion of soil
- Insectivorous birds (non-burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs for incidental ingestion of soil
- Carnivorous birds (non-burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs for incidental ingestion of soil
- Granivorous mammals (burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs for incidental ingestion of soil
- Insectivorous mammals (non-burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs for incidental ingestion of soil
- Carnivorous mammals (burrowing): soil EPCs based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs for incidental ingestion of soil.

Figure 3-1 presents a schematic of proposed sampling intervals, and Table 6-3 provides an evaluation of exposure depth intervals and estimation of EPCs.

Consistent with DTSC guidance (CalEPA, 1996c), direct exposure will be estimated using both the maximum detected concentration and the 95% UCL for each COPEC identified in soil.

6.3.3.3 Exposure Modeling

Exposure modeling will be used to estimate exposure doses from soil-to-biota for upper trophic-level (i.e., wildlife [birds and mammals]) receptors. To calculate exposures to wildlife receptors, soil data and receptor-specific parameters will be used in the dose equation listed below.

$ADD_t = ADD_f + ADD_s$ Equation 6-1

where:

ADD_t = total average daily dose in milligrams per kilogram BW per day (mg/kg-bw/day)

ADDf = average daily dose resulting from food (mg/kg-bw/day)

ADDs = average daily dose resulting from soil (mg/kg-bw/day).

To understand the potential implications of averaging concentrations over one depth interval versus another, the risk assessment will evaluate representative EPCs from prey tissue (modeled from soil concentrations) within the following depth categories for each of the AOCs and undesignated areas except BCW (explained below):

- Plant tissue as food: soil uptake based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs
- Soil invertebrates tissue as prey: soil uptake based on the EPCs from 0 to 0.5 foot bgs
- Granivorous birds: plant tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs
- Insectivorous birds: prey tissue EPCs modeled on soil EPCs from 0 to 0.5 foot bgs
- Carnivorous birds: prey tissue EPCs modeled on soil EPCs from 0 to 0.5 foot bgs
- Granivorous mammals: plant tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs
- Insectivorous mammals: prey tissue EPCs modeled on soil EPCs from 0 to 0.5 foot bgs

- Carnivorous mammals: prey tissue EPCs modeled on soil EPCs from 0 to 0.5 foot bgs.

While certain invertebrates (e.g., scorpions and ants) may burrow to depths greater than 0.5 foot, the 0 to 0.5 foot bgs interval is judged to best represent exposure for this very diverse group that also includes flying insects that invertivorous birds and mammals may ingest in the exposure dose models. In the ERA, the uncertainty in characterizing exposure intervals for such a diverse group will be discussed.

For BCW, as mentioned earlier, substantial soil scouring and deposition has been observed as a result of heavy rain events, prey (not plants) maybe exposed to surface/shallow soil. Therefore, the risk assessment will evaluate representative EPCs from prey tissue (modeled from soil concentrations) within the following depth categories for BCW:

- Plant tissue as food: soil uptake based on the highest EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs

- Soil invertebrates tissue as prey: soil uptake based on the highest EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs

- Granivorous birds: plant tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs

- Insectivorous birds: prey tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs

- Carnivorous birds: prey tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs

- Granivorous mammals: plant tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs

- Insectivorous mammals: prey tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs

- Carnivorous mammals: prey tissue EPCs modeled on the highest soil EPCs from 0 to 0.5 foot bgs and 0 to 3 feet bgs.

Figure 3-1 presents a schematic of proposed sampling intervals, and Table 6-3 provides an evaluation of exposure depth intervals and estimation of EPCs.

Consistent with DTSC guidance (CalEPA, 1996c), modeled exposure will be estimated using both the maximum detected concentration and the 95% UCL for each COPEC in soil. For example, for the granivorous mammal (a burrower), the following EPCs will be estimated for each COPEC:

- Incidental ingestion of soil based on the highest maximum detected concentration from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs; prey tissue concentration modeled based on the highest maximum detected concentration from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs

- Incidental ingestion of soil based on the highest 95% UCL from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs; prey tissue concentration modeled based on the highest 95% UCL from 0 to 0.5 foot bgs, 0 to 3 feet bgs, and 0 to 6 feet bgs.

For exposure modeling, a subset of indicator receptors was selected from the list of species potentially present at the site. These receptors were selected to represent a cross-section of feeding guilds for each assessment endpoint so that sufficient rates of survival, growth, and reproduction for their representative populations could be evaluated.

The following criteria were considered in selecting potential indicator species for the site (USEPA, 1997a):

- Species has been observed at the site

- Upper trophic-level predator

- Important prey species

- Important to structure or function of the ecosystem

- Potential for exposure to constituents

- Susceptible to bioaccumulation of constituents

- Toxicological literature available

- Likely to exhibit toxic effects
- Species of special conservation concern or similar species.

The indicator receptors chosen are as follows:

- Granivorous bird: Gambel's quail (*Callipepla gambelii*)
- Insectivorous bird: cactus wren (*Campylorhynchus brunneicapillus*)
- Carnivorous bird: red-tailed hawk (*Buteo jamaicensis*)
- Insectivorous mammal: desert shrew (*Notiosorex crawfordi*)
- Carnivorous mammal: desert kit fox (*Vulpes macrotis*)
- Granivorous mammal: Merriam's kangaroo rat (*Dipodomys merriami*).

Each of the selected indicator species was identified by the biological assessment as being potentially present in the project area. The receptors were selected to represent avian and mammalian populations that reside or forage in the upland creosote bush scrub and the BCW near the compressor station.

In addition to the above indicator receptors, the coachwhip (*Masticophis flagellum*), a carnivorous reptile, was also considered for assessment. However, as USEPA noted in the Eco-SSL Guidance (USEPA, 2008a), toxicity data for amphibians and reptiles are insufficient to support establishing risk-based thresholds and, therefore, risk to these receptors will not be quantitatively evaluated.

6.3.3.3.1 Selection of Granivorous Avian Receptor

Gambel's quail is a common resident of the Mojave Desert and occurs at the HNWR. It is a granivorous bird that forages on the ground in open habitats. Succulent forbs and grasses are preferred when available, but forb, shrub, and grass seeds are the primary adult diet (CDFG, 2005a). Escape cover provided by trees or shrubs is a habitat requirement. Gambel's quail are most commonly seen near water and Miller and Stebbins (1964; as cited in CDFG, 2005a) did not observe a covey more than 1.5 miles from water. The home range for the Gambel's quail is approximately 35.7 acres (CDFG, 2005a).

Gambel's quail was selected to represent granivorous birds for the following reasons:

- It is an abundant, year-round resident of HNWR, and suitable habitat is available at the site
- It feeds on seeds that it gleans from the ground resulting in a relatively high incidental soil ingestion rate, a potential route of exposure to COPECs
- COPEC bioaccumulation data are available for plants
- It is similar to the California quail, for which exposure parameters are readily available
- TRVs are available for birds.

6.3.3.3.2 Selection of Insectivorous Avian Receptor

The cactus wren is an insectivorous bird that forages on the ground in low vegetation for insects, spiders, other small invertebrates, cactus fruits, other fruits, nectar, and seeds (Bent, 1948 and Anderson and Anderson, 1973; both cited in CDFG, 2005a). Vegetation is used for cover, and nests are also used for roosting. Nesting is usually in cactus or other thorny shrub. The cactus wren territory averages 4.8 acres and the home range may be the same as the territory (CDFG, 2005a).

There are other insectivorous birds associated with the site, but the cactus wren was selected for the following reasons:

- It is listed as uncommon but occurring year-round in HNWR, and suitable habitat is available at the site
- It preys on insects that may accumulate COPECs
- COPEC bioaccumulation data are available for invertebrates;

- It forages on the ground, during which the intake of COPECs could occur through incidental soil ingestion

- It is similar to the marsh wren, for which exposure parameters are readily available

- TRVs are available for small birds

- It is a suitable indicator receptor for potential effects on the insectivorous bird feeding guild including the southwestern willow flycatcher (*Epidonax tailli extimus*).

6.3.3.3.3 Selection of Carnivorous Bird Receptor

Red-tailed hawks are moderately large soaring birds that inhabit open or semi-open areas. They prey on ground-dwelling vertebrates such as hares, mice, small birds, amphibians, and reptiles. They may be exposed to COPECs through bioaccumulation in prey that forage on the ground and ingest soil incidentally through food. Red-tailed hawks lay one clutch per year with one to three eggs. Most red-tailed hawks attempt to breed at two years. They are territorial throughout the year and have a home range size that can vary from less than 1 to over 10 square kilometers (km^2 or 247 to 2,470 acres) (CDFG, 2005a).

A number of birds are known to be at the site, but the red-tailed hawk was selected for the following reasons:

- It is listed as common and nesting by HNWR, and suitable habitat exists near the site

- It preys on ground mammals in which bioaccumulation of COPECs may occur

- A substantial amount of literature for exposure parameters and TRVS for birds are available.

6.3.3.3.4 Selection of Insectivorous Mammalian Receptor

The desert shrew is insectivorous, foraging on the ground. There is little data on food preferences in the wild, but in the laboratory food consumed included worms, grasshoppers, cockroaches, and other invertebrates (Hoffmeister and Goodpaster, 1962, as cited in CDFG, 2005a). The desert shrew will drink water when available, but otherwise obtains water from food. This species occupies a wide variety of habitats, including desert wash, desert scrub, desert riparian, mixed chaparral, and pinyon-juniper habitats. Home range data are limited for shrews and are not available for the desert shrew; however, the home range of the dusky shrew, a similar species, averages 0.1 acre (CDFG, 2005a).

The desert shrew was selected for the following reasons:

- It is listed in HNWR surveys as being present in the area
- It may be exposed to COPECs via incidental ingestion of soil while foraging on the ground
- Exposure parameters are available or can be estimated from the available data from species with similar feeding habits
- TRVs for small mammals can be used.

6.3.3.3.5 Selection of Carnivorous Mammal Receptor

The desert kit fox is carnivorous, preying on black-tailed hares, desert cottontails, rodents, birds, and reptiles. They are residents of arid regions and live in annual grasslands or grassy open stages of vegetation dominated by scattered brush, shrubs, and scrub. They dig dens in open, level areas of sandy soil to obtain cover. Home range size has been reported as approximately 9.8 km^2 (2,420 acres) and 12.3 km^2 (3,038 acres), for females and males, respectively (Zoellick and Smith, 1992). Pups are born February through April with an average of four per litter.

The desert kit fox was chosen as a receptor for the following reasons:

- It is a state-protected, fur-bearing mammal and is listed on HNWR mammalian surveys
- It may be exposed to COPECs via the food chain
- It plays an important role in providing cover for other species by its burrowing activity
- It is similar to the red fox for which exposure parameters are readily available

- TRVs are available for larger mammals (i.e., dogs).

6.3.3.3.6 Selection of Granivorous Mammal Receptor

The kangaroo rat is granivorous but may also feed on leafy vegetation and arthropods seasonally. It is found in desert scrub and alkali desert scrub, sagebrush, Joshua tree, and pinyon-juniper habitats. They are solitary animals and receive cover by burrows they dig in sandy soil. Kangaroo rats may breed several times per year, but once is normal. They normally have a litter size of four young. Home range size has been reported of 13 to 19 per hectare (or 32 to 47 acres) in creosote scrub populations (CDFG, 2005a).

The kangaroo rat was chosen as a receptor for the following reasons:

- It is listed by HNWR as being present in the area
- It forages on the ground where intake of COPECs in the soil may occur
- It is an important prey species for desert consumers
- Its burrows provide important cover for other animals
- Exposure parameters and toxicity information for small mammals are available.

The parameters described below will be used to assess survival, growth, and reproduction endpoints. Exposure parameters were selected from the available literature. Species-specific values are proposed for the following exposure parameters and are presented in Table 6-4.

6.3.3.3.7 Body Weights

Total BWs (in kg) were selected for the red-tailed hawk and desert shrew based on data from the *Wildlife Exposure Factors Handbook* (USEPA,1993b) using an average of adult male and female BWs. For the desert kit fox, the BW was selected from O’Farrell and Gilbertson (1986; as cited in CalEPA, 2007c), using an average of adult male and female BWs. BWs for Gambel’s quail and the cactus wren were selected from sources cited in Birds of North America (2005). Gorsuch (1934) provided an average BW for adult males and females for Gambel’s quail, and Anderson and Anderson (1973) provided an average BW of adult males and females for the cactus wren. A BW for Merriam’s kangaroo rat was obtained from Nagy et al. (1999; as cited in Nagy, 2001).

6.3.3.3.8 Diet Composition

The diet type for each receptor was assumed using information from CDFG (2005a). While dietary composition is likely more complex, following USEPA guidance (USEPA, 1997a), it will be conservatively assumed that the diet of each receptor will consist of 100% of the most contaminated food item as follows:

- Gambel’s quail: 100% plants
- Cactus wren: 100% invertebrates
- Red-tailed hawk: 100% mammals
- Desert shrew: 100% invertebrates
- Desert kit fox: 100% mammals
- Merriam’s kangaroo rat: 100% plants.

6.3.3.3.9 Food Ingestion Rates

Total daily food ingestion rates in kg/day were estimated using allometric equations from Nagy (2001). Rates are presented in dry weight and based on body mass, metabolic rates, and dietary habits. Specific equations were available for Gambel’s quail, desert kit fox, and Merriam’s kangaroo rat. General equations were used for the remaining receptors as indicated in Table 6-4.

6.3.3.3.10 Incidental Soil Ingestion Rates

The incidental soil ingestion rate in kg/day for each receptor is based on the food ingestion rates multiplied by the percentage of soil in the total daily diet. These values were obtained from data from Beyer et al. (1994), based on the diet type and feeding habits of each receptor. If soil ingestion data were not available for a specific receptor, surrogate and representative species were used based on similar feeding habits. Soil ingestion data were not available for the indicator receptors and, therefore, soil ingestion data for surrogate species were used based on the best available/conservative feeding habits. The following surrogates were used for the indicator receptors:

- Gambel's quail: American woodcock
- Cactus wren: wild turkey
- Red-tail hawk: soil ingestion data were not available for carnivorous birds (raptors), and therefore, the red fox, a carnivorous mammal was selected. However, feeding habits of raptors are different from carnivorous mammals. Raptors tend to catch prey (small birds) during migration, by pouncing from low quartering flights, and even when hovering on winds and air current (CDFG, 2005a). Raptors can consume prey (insects) in mid-air or carry them to perching locations before consuming prey. Whereas, carnivorous mammals tend to hunt for and consume prey closer to the ground (CDFG, 2005a), and thus, generally consume prey on the ground. Therefore, it was assumed that the percent intake of soil by carnivorous birds would not be any greater than one-half the intake by carnivorous mammals.
- Desert shrew: white-footed mouse
- Desert kit fox: red fox
- Merriam's kangaroo rat: meadow vole.

Surrogates and assumptions are noted in Table 6-4.

6.3.3.3.11 Home Ranges

Home ranges (acres) are representative of the average area in which receptors normally confine their activity over a specific time period. The size of a home range can be used to determine the proportion of time that an individual is expected to contact contaminated environmental media. Home range for the desert kit fox was selected from Zoellick and Smith (1992), and for the rest of the receptors from CDFG (2005b).

6.3.3.3.12 Site-Use Factor

The site-use factor (SUF; unitless) represents the area used by an individual on the site. If the home range of a receptor species is larger than the site acreage, the following equation will be applied:

SUF = site acreage / home range of species Equation 6-2

For the initial phases of the ERA, an SUF of one will be assumed for all species. Site- or area-specific SUFs may be used in latter phases of the ERA.

6.3.3.3.13 Bioaccumulation Factors

Bioaccumulation in animal tissue or uptake in plants is the process where COPECs in the surrounding media are accumulated within the tissues of ecological receptors, especially to concentrations higher than in the surrounding media. Any COPEC that is excreted or metabolized at a slower rate than its uptake through absorption and ingestion will increase in tissues over time, resulting in bioaccumulation. Constituents with high octanol-water partitioning coefficient (log K_{ow}) are more likely to bioaccumulate in tissues of prey (plants, invertebrates, and mammals) due to their lipophilic nature (USEPA, 2000c). Additionally, some metals that are not readily excreted are also known to bioaccumulate (e.g., lead). COPECs that bioaccumulate have the potential to be passed up the food chain.

BAFs are multipliers that are used to estimate concentrations of constituents that can accumulate in tissues through any route of exposure (USEPA, 2000c). For plants, the BAF is sometimes referred to as a plant uptake factor. In this work plan, BAFs were used to estimate concentrations of COPECs in biota and food item tissue (i.e., prey) from site media.

Literature-derived uptake factors or equations and site-specific soil EPCs that will be provided following soil sampling activities will be used to estimate BAFs. Table 6-5 presents the BAFs for the preliminary COPECs listed in Table 6-1 including metals and PAHs; BAFs were not available for TPH. All BAFs are from sources as cited in USEPA (2008a), unless otherwise noted. BAFs will be used in conjunction with soil EPCs to estimate biota EPCs. All values presented in Table 6-5 are on a dry-weight basis.

Soil-to-biota BAFs for plants, invertebrates, and mammals are developed as either uptake factors or regression equations. A BAF is the ratio of biota constituent concentration to soil concentration and is expressed as follows:

$BAF = C_b / C_s$ Equation 6-3

where:

BAF = soil-to-biota bioaccumulation factor (kg soil/kg tissue)

C_b = constituent concentration in biota tissue (mg constituent/kg tissue)

C_s = constituent concentration in soil (mg constituent/kg soil).

Regression equations are expressed as follows:

$\ln(C_b) = M*\ln(C_s)+ I$ Equation 6-4

where:

Cb = constituent concentration in biota tissue (mg of constituent/kg of tissue)

M = slope of regression line

C_s = constituent concentration in soil (mg constituent/kg soil)

I = y-intercept of regression line (unitless).

6.3.3.3.13.1 Soil-to-Plant Uptake

Uptake relationships for plants were available for all metals and PAHs and are presented in Table 6-5. Regression equations were available for antimony, beryllium, cadmium, copper, lead, mercury, nickel, selenium, zinc, and PAHs. The remaining metals have a calculated BAF based on empirical data. A BAF was not available for hexavalent chromium and, therefore, the BAF for total chromium was used as a surrogate consistent with the approach taken by USEPA in deriving Eco-SSLs for hexavalent chromium (USEPA, 2008a).

6.3.3.3.13.2 Soil-to-Invertebrate Uptake

Uptake relationships for invertebrates were available for all metals and PAHs. Regression equations were available for arsenic, cadmium, lead, mercury, selenium, and zinc. BAFs were not available for molybdenum and thallium. However, based on a similar approach described by the USEPA Region 6 ERA guidance (USEPA, 1999a), BAFs for molybdenum and thallium were estimated by calculating the mean of the available empirical invertebrate BAFs for metals. The remaining metals and PAHs have a calculated BAF based on empirical data. A BAF was not available for hexavalent chromium, and therefore, the BAF for total chromium was used as a surrogate consistent with the approach taken by USEPA in deriving Eco-SSLs for hexavalent chromium (USEPA, 2008a).

6.3.3.3.13.3 Soil-to-Mammal Uptake

Uptake relationships for mammals were available for all metals. Regression equations were available for arsenic, cadmium, chromium, cobalt, copper, lead, nickel, selenium, and zinc. The remaining metals have a calculated BAF based on empirical data. A BAF was not available for hexavalent chromium and, therefore, the uptake regression for total chromium was used as a surrogate consistent with the approach taken by USEPA in deriving Eco-SSLs for hexavalent chromium (USEPA, 2008a).

According to USEPA Eco-SSL Guidance (USEPA, 2008a), SVOCs, including PAHs, tend to metabolize rapidly in birds and mammals, and therefore, uptake of these constituents from soil-to-mammal were assumed to be zero (USEPA, 2008a).

6.3.4 Effects Assessment

The effects assessment has been initiated for the Phase I ERA and documented in Appendix D of the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a) and in the second ERA Technical Memorandum (ARCADIS BBL, 2007b). Based on the preliminary COPECs list, screening values (CH2M HILL, 2005a) and TRVs were selected with review and/or input from the DTSC and USFWS. These screening values and TRVs were updated with current values since the submission of second ERA Technical Memorandum (ARCADIS BBL, 2007b) and are discussed below. If additional COPECs are identified based on the Part A soil sampling investigation (CH2M HILL, 2006a), additional TRVs may be selected and presented in an addendum to this work plan. Additionally, further literature searches could be conducted in latter phases of the ERA to further refine the toxicity assessment.

6.3.4.1 Screening Values

Although more than one exposure pathway is considered potentially complete for plants and soil invertebrates, generally route-specific doses are not quantified for ecological communities such as plants and soil invertebrates. Exposures of ecological communities to site media are expressed as concentrations (i.e., mg/kg in soil), rather than doses, and generally encompass all potential exposure pathways. The screening values, or ecological benchmarks, for estimating risk to plants and soil invertebrates were developed for the preliminary COPECs listed in Table 6-1 including metals and PAHs; screening values were not available for TPH. The plant and soil invertebrate screening values are presented in Table 6-6. Sources of screening values for plants and soil invertebrates are listed in order of preference:

- *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)* (USEPA, 2008a)
- Oak Ridge National Laboratory (ORNL) documents (Efroymson et al., 1997a,b)
- Other published sources.

Confidence in certain screening values presented in the ORNL documents is low, as indicated in Table 6-6. Confidence in plant screening values for antimony, barium, beryllium, hexavalent chromium, mercury, molybdenum, thallium, and vanadium is low due to the low number of studies on which the screening values are based or other factors (Efroymson et al., 1997a). The soil type and test species (typically agricultural) may also vary significantly from site-specific conditions, or the toxic effects may be unspecified in the source study. There may be significant variability in the toxic responses noted. Similarly, confidence in the invertebrate screening values is low for arsenic, hexavalent chromium, and mercury because of the low number of studies on which they are based or other factors (Efroymson et al., 1997b).

Plant screening values are not readily available for PAHs from literature sources, except for acenaphthene (Efroymson et al., 1997a), a LMW PAH, and benzo(a)pyrene (USEPA, 1999a), a HMW PAH. Empirical toxicity data for naphthalene, another LMW PAH, are available in the USEPA ECOTOX database (USEPA, 2008b). A study reporting ecologically relevant adverse effects at the lowest concentration was used to develop plant screening values for naphthalene. Hulzebos et al. (1993) reported a 7-day EC50 of 100 mg/kg for reduced biomass in lettuce. This study tested nearly 40 organic contaminants in both soil and a nutrient solution to determine the relationship between toxicity thresholds in both matrices. In this study, an EC50 (i.e., concentration of a chemical causing an effect to 50 percent of the population) of 100 mg/kg was conservatively assumed to be equivalent to a lowest-observed adverse effects concentration (LOAEC) for more serious adverse effects. Following CalEPA DTSC guidance (CalEPA, 1996c), an uncertainty factor (UF) of 10 was applied to extrapolate to a no-observed adverse effects concentration (NOAEC) resulting in a value of 10 mg/kg, which was used as the plant screening value for naphthalene.

As naphthalene is a more common LMW PAH than acenaphthene, the comparison value for total LMW PAHs for protection of plants was based on the NOAEC-based screening value of 10 mg/kg for naphthalene, and the comparison value for total HMW PAHs was based on the screening value of 1.2 mg/kg for benzo(a)pyrene (USEPA, 1999a).

If the inhalation pathway for burrowing receptors is identified as complete and significant, potential risk to burrowing receptors will be evaluated using literature-derived burrow air screening values. Burrow air inhalation toxicity RfCs are defined as the constituent-specific concentration in mg/m^3 at which ecologically relevant effects might occur.

6.3.4.2 Toxicity Reference Values

The toxicity of a constituent to wildlife is assessed by identifying a TRV specific to the constituent and receptor being evaluated. TRVs are conservative, literature-derived toxicity values and are established based on toxicity studies with individuals, whereas ERAs are generally designed to protect species at the population level of ecological organization. Therefore, estimated exposure doses exceeding TRVs do not necessarily indicate adverse effects to populations of receptor species at the site.

Daily dose TRVs will be used to evaluate risk to avian and mammalian species via the ingestion pathway. TRVs are expressed in mg/kg-bw/day and represent a dose associated with no-effect (no-observed-adverse-effect-level [NOAEL]) or effect threshold (lowest-observable-adverse-effects-level [LOAEL]).

Wildlife TRVs were developed for the preliminary COPECs listed in Table 6-1 including metals and PAHs; wildlife TRVs were not available for TPH. Following USEPA guidance (USEPA, 1997a), wildlife TRVs were developed based on population-level assessment endpoints such as survival, reproductive, development, and growth for wildlife. TRVs were developed for the protection of birds and mammals following appropriate guidance (USEPA, 1999b; 2005a; 2008a). TRV selection included a review of toxicity studies from standard sources with appropriate endpoints. Following CalEPA guidance (1996b, 2000), TRVs were adjusted when the differences in BW between the site-specific wildlife receptor and the laboratory animals used in the studies to develop the TRVs were significant (i.e., greater than two orders of magnitude). Thus, literature-derived mammalian TRVs for arsenic, copper, and silver were allometrically adjusted for the desert shrew and Merriam's kangaroo rat using the allometric equation from Sample and Arenal (1999):

$$Aw = At * (BWt/BWw)^{1-b} \qquad \text{Equation 6-5}$$

where:

Aw = TRV of wildlife species (mg/kg-bw/day)

At = TRV of test species (mg/kg-bw/day)

BWt = body weight of test species (kg)

BWw = body weight of wildlife species (kg)

b = allometric scaling factor (1.2 for birds, 0.94 for mammals).

The literature sources used to identify and develop TRVs for the avian and mammalian receptors included the following, in order of preference:

- USEPA Eco-SSL Guidance (USEPA, 2008a)
- *Revised USEPA Region 9 BTAG Mammalian TRVs for Lead: Justification and Rationale, EcoNote 5* (CalEPA, 2002c)
- ORNL: Toxicological Benchmarks for Wildlife (Sample et al., 1996)
- Other guidance (e.g., USEPA Region 6 ERA Guidance [USEPA, 1999a]).
- Other published sources: appropriate avian TRVs were not available for PAHs from the sources listed above; published toxicity studies were reviewed and TRVs were developed based on the most appropriate studies.

The proposed TRVs and respective references are presented in Table 6-7. Allometric conversions for appropriate proposed TRVs and representative receptors are presented in Table 6-8. In response to verbal comments from the DTSC on August 17, 2007 (Eichelberger, 2007), DTSC-recommended TRVs (Table 6-9) and corresponding allometric conversions (Table 6-10) will also be used to estimate risks. The DTSC-recommended TRVs are preferably based on the BTAG TRVs. The following section discusses the proposed TRVs developed for use in the Predictive Phase I ERA (Tables 6-7 and 6-8), but risks will be calculated using both proposed TRVs (Tables 6-7 and 6-8) and DTSC-recommended TRVs (Tables 6-9 and 6-10).

A range of TRVs were developed to estimate a range of risks. Low TRVs were preferably based on chronic NOAELs, with an emphasis on studies that measured effects on survival, reproduction, development, and growth endpoints, applicable to the protection of wildlife populations. A NOAEL is defined as the highest level (or dose) at which no adverse effects are observed. Some of the low TRVs from USEPA Eco-SSL Guidance (USEPA, 2008a) are based on geometric means of multiple NOAELs for growth and reproductive study endpoints. High TRVs are preferably based on LOAELs with an emphasis on studies that measured effects on survival, reproduction, development, and growth endpoints, applicable to the protection of wildlife populations. A LOAEL is defined as the lowest level (or dose) at which adverse effects are observed. In the case of DTSC-recommended TRVs, the low BTAG TRVs are NOAEL-based and the high BTAG TRVs are based on a midpoint of a variety of adverse effects and are not necessarily LOAEL-based (CalEPA, 2002c).

Some sources, such as the USEPA Eco-SSL Guidance (USEPA, 2008a), provide only NOAEL-based TRVs. Therefore, LOAEL-based TRVs were developed for birds and mammals as follows:

- If a bounded NOAEL-based TRV was recommended, the LOAEL from the same study and endpoint was selected. For birds this is the case for copper, lead, selenium, and vanadium. For mammals this is the case for antimony, arsenic, cadmium, hexavalent chromium, copper, lead, nickel, selenium, vanadium, total LMW PAHs, and total HMW PAHs.

- If the recommended NOAEL-based TRV was unbounded, the lowest reproduction, growth, and survival LOAEL greater than the NOAEL-based TRV was selected. For birds this is the case for arsenic; for mammals this is the case for beryllium.

- If the recommended NOAEL-based TRV was a geometric mean of the reproduction and growth NOAELs, the geometric mean of the reproduction and growth LOAELs was selected. For birds this is the case for cadmium, chromium, cobalt, nickel, and zinc. For mammals this is the case for barium, cobalt, hexavalent chromium, and zinc.

- The mammalian NOAEL-based TRV for chromium is the geometric mean of the reproduction and growth NOAELs. However, no bounded NOAELs or LOAELs were contained in the dataset. Therefore, the lowest reproduction and growth LOAEL greater than mammalian low TRV for chromium was conservatively selected as the LOAEL-based TRV.

- If the recommended NOAEL-based TRV was derived from a LOAEL with a UF applied, the LOAEL-based TRV was selected by removing the UF. For birds and mammals, this was the case for silver.

For high TRVs not based on the Eco-SSLs (USEPA, 2008a), the following approach was used:

- If a LOAEL was reported for the study used to derive the NOAEL-based TRV, that LOAEL value was used. For birds, this was the case for molybdenum, mercury, and PAHs. For mammals, this was the case for molybdenum and mercury.

- If there was no paired LOAEL, a UF of 10 was applied to the NOAEL to estimate a LOAEL. This was the case for thallium for birds, where no chronic toxicity data were available. However, an acute study on starlings was reported (USEPA, 1999a) that extrapolated a NOAEL-based TRV using a UF of 100 and a LOAEL-based TRV using a UF of 10.

6.3.4.2.1 Antimony

Avian TRVs could not be derived for antimony due to a lack of available data.

The mammalian NOAEL TRV of 0.059 mg/kg-bw/day was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The NOAEL TRV was selected from a study examining reproductive effects on rats and is the highest bounded[5] NOAEL lower than the lowest bounded LOAEL for all relevant endpoints (reproduction, growth, and survival) based on a study by Rossi et al. (1987*)*. The LOAEL TRV was the bounded value of 0.59 mg/kg-bw/day from the same study.

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[5] Bounded refers to NOAEL values that have a corresponding LOAEL value from the same ecological endpoint of a study.

6.3.4.2.2 Arsenic

The NOAEL TRV of 2.24 mg/kg-bw/day for arsenic for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV for arsenic could not be derived by calculating a geometric mean of NOAELs; therefore, the lowest NOAEL value for growth and reproduction was selected based on a study by Holcman and Stibiju (1997) examining reproductive, growth, and survival effects on chickens. The LOAEL TRV of 3.55 mg/kg-bw/day was the lowest bounded LOAEL greater than the selected NOAEL for reproduction and growth, based on a study by Howell and Hill (1978) examining growth effects on the chicken.

The NOAEL TRV of 1.04 mg/kg-bw/day for arsenic for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was selected from a study examining growth effects on dogs and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints based on a study by Neiger and Osweiler (1989). The LOAEL TRV of 1.66 mg/kg-bw/day was the bounded value from the same study. The BW of the test species was 10.1 kg, which is significantly greater than the BWs of the desert shrew (0.0168 kg) and Merriam’s kangaroo rat (0.0343 kg); therefore, the mammalian TRVs for arsenic will require allometric conversions using Equation 6-5. Allometrically adjusted TRVs are presented in Table 6-8.

6.3.4.2.3 Barium

Avian TRVs for barium could not be derived due to a lack of available data.

The NOAEL TRV of 51.8 mg/kg-bw/day for barium for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A mammalian LOAEL TRV of 82.6 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

6.3.4.2.4 Beryllium

Avian TRVs for beryllium could not be derived due to a lack of available data.

The NOAEL TRV of 0.532 mg/kg-bw/day for beryllium for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). Because a sufficient number of NOAEL values for reproduction and growth endpoints were not available to calculate a geometric mean, the mammalian NOAEL TRV of 0.532 mg/kg-bw/day was selected from a study by Schroeder and Mitchener (1975), examining survival effects on rats and is the lowest NOAEL for reproduction, growth, and survival endpoints. There were no bounded LOAELs for comparison; therefore, a LOAEL TRV of 0.63 mg/kg-bw/day was selected from the same study examining growth effects and is the lowest LOAEL greater than the selected NOAEL for growth, reproduction, and survival endpoints.

6.3.4.2.5 Cadmium

The NOAEL TRV of 1.47 mg/kg-bw/day for cadmium for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV for cadmium was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 6.35 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 0.77 mg/kg-bw/day for cadmium for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was selected from a study by Yuhas et al. (1979), examining the growth effects on rats and is the highest bounded NOAEL lower than the lowest bounded LOAEL. The LOAEL TRV of 7.7 mg/kg-bw/day is the bounded value from the same study.

6.3.4.2.6 Chromium

The NOAEL TRV of 2.66 mg/kg-bw/day for chromium for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV for chromium (based on trivalent chromium) was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. The LOAEL TRV of 15.6 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 2.4 mg/kg-bw/day for chromium for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). A mammalian NOAEL TRV for chromium was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. As mentioned earlier, the LOAEL TRV of 9.62 mg/kg-bw/day was selected using a conservative value of the lowest LOAEL for reproduction and growth, because no bounded NOAELs were available for comparison. The LOAEL TRV was selected from a study by Zahid et al. (1990), examining reproductive effects on mice.

6.3.4.2.7 Hexavalent Chromium

Avian TRVs could not be calculated for hexavalent chromium due to a lack of available data. There are TRVs for birds for trivalent chromium (see above) but not for hexavalent chromium. In response to verbal comments (Eichelberger, 2007) on a Technical Memorandum presenting TRVs (ARCADIS BBL, 2007b), hexavalent chromium literature for birds that was referenced in the USEPA Eco-SSL Guidance (USEPA, 2008a) was reviewed (Asmatullah et. al., 1999; Jensen and Maurice, 1980; Rao et. al., 1983; and Romoser et. al., 1961). Only one paper identified a LOAEL, although unbounded, for an appropriate effect endpoint (reproduction or growth) (Asmatullah et. al., 1999). A single study does not provide a good basis for development of a TRV. Therefore, based on the available literature, there is insufficient toxicity data to support establishing hexavalent chromium TRVs for avian receptors.

The NOAEL TRV of 9.24 mg/kg-bw/day for hexavalent chromium for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). A mammalian NOAEL TRV for hexavalent chromium was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 38.8 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

6.3.4.2.8 Cobalt

The NOAEL TRV of 7.61 mg/kg-bw/day for cobalt for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 18.3 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 7.33 mg/kg-bw/day for cobalt for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 18.8 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

6.3.4.2.9 Copper

The NOAEL TRV of 4.05 mg/kg-bw/day for copper for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV was selected for copper from a study by Ankari et al. (1998), examining reproductive effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 12.1 mg/kg-bw/day was the bounded value from the same study.

The NOAEL TRV of 5.6 mg/kg-bw/day for copper for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was selected from a study by Allcroft et al. (1961), examining growth and survival effects on pigs and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 9.34 mg/kg-bw/day is the bounded value from the same study. The test species had a BW of 100 kg, which is significantly greater than the BWs of the desert shrew (0.0168 kg) and Merriam’s kangaroo rat (0.0343 kg); therefore, the mammalian TRVs for copper will require allometric conversions using Equation 6-5. Allometrically adjusted TRVs are presented in Table 6-8.

6.3.4.2.10 Lead

The NOAEL TRV of 1.63 mg/kg-bw/day for lead for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV was selected from a study by Edens and Garlich (1983), examining the reproductive effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The selected LOAEL TRV of 3.26 mg/kg-bw/day was the bounded value from the same study.

The NOAEL TRV of 4.7 mg/kg-bw/day for lead for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was selected from a study by Kimmel et al. (1980), examining growth effects on rats and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 8.9 mg/kg-bw/day was the bounded value from the same study.

6.3.4.2.11 Mercury

Avian TRVs could not be derived for mercury from USEPA Eco-SSL Guidance (USEPA, 2008a); therefore BTAG values (CalEPA, 2002c) were used. The avian

NOAEL TRV of 0.039 mg/kg-bw/day was obtained from a study examining reproductive effects on mallards by USEPA Great Lakes (USEPA, 1995). The avian LOAEL TRV of 0.18 mg/kg-bw/day was obtained from a study examining mortality and neurological effects on mallards by USEPA Great Lakes (USEPA, 1995).

Similarly, BTAG values (CalEPA, 2002c) for mercury were used for mammalian TRVs. A mammalian NOAEL TRV of 0.25 mg/kg-bw/day and LOAEL TRV of 4.0 mg/kg-bw/day based on reproductive effects on mice were obtained from a study by USEPA Great Lakes (USEPA, 1995).

6.3.4.2.12 Molybdenum

Avian TRVs could not be derived for molybdenum from USEPA Eco-SSL Guidance (USEPA, 2008a) nor from CalEPA (2002c), due to a lack of available data. Therefore, avian NOAEL TRV of 3.5 mg/kg-bw/day and LOAEL TRV of 35.3 mg/kg-bw/day based on reproductive effects on chickens were obtained from a study by Lepore and Miller (1965), presented in Sample et al. (1996).

Similarly, mammalian NOAEL TRV of 0.26 mg/kg-bw/day and LOAEL TRV of 2.6 mg/kg-bw/day based on reproductive effects on mice were obtained from a study by Schroeder and Mitchener (1971), presented in Sample et al. (1996).

6.3.4.2.13 Nickel

The NOAEL TRV of 6.71 mg/kg-bw/day for nickel for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 18.6 mg/kg-bw/day was also derived by calculating a geometric mean for LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 1.7 mg/kg-bw/day for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was selected from a study by Pandey and Srivastava (2000), examining reproductive effects on mice and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth and survival endpoints. The LOAEL TRV of 3.4 mg/kg-bw/day was the bounded value from the same study.

6.3.4.2.14 Selenium

The NOAEL TRV of 0.29 mg/kg-bw/day for selenium for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV was selected for selenium from a study by El-Begearmi and Combs (1982), examining survival effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 0.579 mg/kg-bw/day was the bounded value from the same study.

The NOAEL TRV of 0.143 mg/kg-bw/day for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was selected from a study by Mahan and Moxon (1984), examining behavioral effects on pigs and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and behavioral endpoints. The LOAEL TRV of 0.215 mg/kg-bw/day was the bounded value from the same study.

6.3.4.2.15 Silver

The low TRV of 2.02 mg/kg-bw/day for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). There was insufficient NOAEL data for silver; therefore, a low TRV value was extrapolated from the lowest LOAEL of 20.2 mg/kg-bw/day for reproduction and growth endpoints using a UF of 10. This low TRV was selected from a study by Jensen et al. (1974), examining the reproductive effects on turkeys.

The low TRV of 6.02 mg/kg-bw/day for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). There was insufficient NOAEL data for reproduction or growth endpoints; therefore, a low TRV value was extrapolated from the lowest LOAEL of 60.2 mg/kg-bw/day for reproduction and growth endpoints using a UF of 10. This low TRV was selected from a study by Van Fleet (1976), examining the growth effects on pigs. The test species had a BW of 8.86 kg, which is significantly greater than the BWs of the desert shrew (0.0168 kg) and Merriam’s kangaroo rat (0.0343 kg); therefore, the mammalian TRVs for silver will require allometric conversions using Equation 6-5. Allometrically adjusted TRVs are presented in Table 6-10.

6.3.4.2.16 Thallium

Avian TRVs could not be derived for thallium from USEPA Eco-SSL Guidance (USEPA, 2008a), CalEPA (2002c), nor from Sample et al. (1996), due to a lack of available data. However, a NOAEL-based TRV of was available in USEPA Region 6 ERA guidance (USEPA, 1999a). This TRV was derived from an acute study on starlings by Schafer (1972), where a UF of 100 was applied to the acute dose of 35 mg/kg-bw/day to extrapolate to a NOAEL-based low TRV of 0.35 mg/kg-bw/day. As no LOAELs were reported, a UF of 10 was applied to the acute dose of 35 mg/kg-bw/day to extrapolate to a LOAEL-based high TRV of 3.5 mg/kg-bw/day.

Mammalian TRVs could not be derived for thallium from USEPA Eco-SSL Guidance (USEPA, 2008a); therefore, CalEPA (2002c) BTAG values were used. Mammalian NOAEL TRV of 0.48 mg/kg-bw/day and LOAEL TRV of 1.43 mg/kg-bw/day based on hair loss effects on rats were obtained from a study by Downs et al. (1960).

6.3.4.2.17 Vanadium

The NOAEL TRV of 0.344 mg/kg-bw/day for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV for vanadium was selected from a study by Hill (1979), examining the growth effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 0.688 mg/kg-bw/day is the bounded value from the same study.

The NOAEL TRV of 4.16 mg/kg-bw/day for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). A mammalian NOAEL TRV was selected from a study by Sanchez et al. (1991), examining the reproductive, growth, and survival effects on mice and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 8.31 mg/kg-bw/day is the bounded value from the same study.

6.3.4.2.18 Zinc

The NOAEL TRV of 66.1 mg/kg-bw/day for zinc for avian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The avian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 171 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 75.4 mg/kg-bw/day for zinc for mammalian species was recommended by USEPA Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 298 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

6.3.4.2.19 Polycyclic Aromatic Hydrocarbons

For birds, there are no TRVs for PAHs reported in the Eco-SSL Guidance (USEPA, 2008a). Published TRVs are available in USEPA Region 6 ERA Guidance (USEPA, 1999a). However, the study (Brunstrom et al., 1991) was based on egg injection tests that are not considered appropriate for developing TRVs (USEPA, 2008a). Several studies were reviewed, and the most appropriate study was selected to develop avian TRVs for PAHs.

For LMW PAHs, Patton and Dieter's study (1980) evaluating the effect of PAH mixtures on hepatic function in mallard duck livers using a mixture of paraffins and aromatic hydrocarbons was selected. There were visible signs of toxicity, indicated by significant increase in liver weight for the group that were administered 4,000 mg/kg PAH mixture, but livers appeared normal in texture and color. No effects were observed for the 400 mg/kg treatment group. Therefore, 400 mg/kg was selected as the NOAEC and the 4,000 mg/kg was selected as the LOAEC. The NOAEC and the LOAEC were then converted to a NOAEL-based TRV and a LOAEL-based TRV, respectively, using the standard dose equations shown below:

$$TRV_{NOAEL} = \frac{NOAEC \times IR}{bw} = \frac{400\ \ mg/kg \times 0.059\, kg/day}{1.04\, kg\ bw} = 22.8\, mg/kg - bw/day$$

Equation 6-6

$$TRV_{LOAEL} = \frac{LOAEC \times IR}{bw} = \frac{4000\, mg/kg \times 0.059\, kg/day}{1.04\, kg\ \ bw} = 228\, mg/kg - bw/day$$

Equation 6-7

Where:

TRV_{NOAEL} = no-observed adverse effects level based toxicity reference value (mg/kg-bw/day)

TRV_{LOAEL} = lowest-observed adverse effects level based toxicity reference value (mg/kg-bw/day)

IR = ingestion rate (kilogram soil per day [kg soil/day]); calculated from allometric equation for food ingestion rate in dry weight for all birds (USEPA,1993b)

BW = body weight of receptor (kilograms [kg bw]); assuming approximately 1.04 kg for the mallard ducks (from USEPA, 1993b)

For HMW PAHs, a study by Trust et al. (1994) reporting a NOAEL of 10 mg/kg-bw/day and a LOAEL of 100 mg/kg-bw/day for overt signs of toxicity, such as decreased body mass in European starlings exposed to 7,12-dimethylbenz(a)anthracene, was selected to develop TRVs. Immunosuppression was observed at higher doses. The exposures were via oral gavage, and the study was conducted on nestlings, a sensitive life-stage. No UFs were applied, and therefore, an avian low TRV of 10 mg/kg-bw/day and an avian high TRV of 100 mg/kg-bw/day were used for HMW PAHs (Table 6-7).

There are no BTAG PAH TRVs for bird, and therefore, there are no separate DTSC-recommended PAH TRVs for birds.

Mammalian TRVs for PAHs are available in the Eco-SSL Guidance (USEPA, 2008a). The mammalian NOAEL TRV of 65.6 mg/kg bw-day for LMW PAHs was selected from a study by Verschuuren et al. (1976), examining the growth effects on rats and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 328 mg/kg bw-day is the bounded value from the same study. The mammalian NOAEL TRV of 0.6 mg/kg bw-day for HMW PAHs was selected from a study by Culp et al. (1998), examining the survival effects on mice and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 3.07 mg/kg-bw/day is the bounded value from the same study (Table 6-7). No allomteric adjustments were required for these TRVs.

BTAG TRVs are available for mammals (CalEPA, 2002c). The BTAG TRVs for naphthalene was used for LMW PAHs and the BTAG TRVs for benzo(a)pyrene was used for HMW PAHs as the DTSC-recommended TRVs (Table 6-8). No allomteric adjustments were required for these TRVs.

6.3.5 Risk Characterization

The purpose of the ERA will be to focus on identifying unacceptable risks to local terrestrial populations and evaluating the potential for a completed transport pathway to the Colorado River where special status species may occur. This is consistent with CalEPA and USEPA guidance for conducting an ERA (CalEPA, 1996b; USEPA, 1999a), which focus on protecting local populations, communities, and habitats, as well as special status species. For example, in the CalEPA guidance (1996b), DTSC HERD notes that the assessment endpoints should be selected to assess risk to the biological community or population.

The risk characterization integrates the results of the exposure assessment and toxicity assessment and is subject to uncertainties in both those efforts, as well as uncertainties in the problem formulation step. Risk characterization includes two major components: risk estimation and risk description. Risk estimation involves integrating exposure profiles with the exposure-effects information and summarizing the associated uncertainties. Risk estimates may be quantitative or qualitative. Risk descriptions provide information important for interpreting the risk results and identify a threshold for adverse effects on the assessment endpoints. Risk descriptions may include lines of evidence, such as spatial considerations.

6.3.5.1 Risk Estimation

Risk estimates for soil invertebrates and plants will be conducted by comparing soil EPCs for each COPEC to screening values and calculating an HQ. If a complete pathway is identified, risk estimates for mammals potentially exposed to VOCs via inhalation in burrows will be based on quantitative comparison of the modeled burrow air EPCs to literature-derived burrow air screening values that will be provided in an addendum to this work plan.

Risk estimates for avian and mammal receptors will be conducted by comparing modeled exposure doses to TRVs and calculating HQs. HQs are an expression of the ratio of an exposure estimated dose (ADD_t) to an effects dose (i.e., TRV). ADD_t for indicator species presented in Section 6.3.3.3 will be compared to the NOAEL-based (low) and LOAEL-based (high) TRVs presented in Section 6.3.4.2. The exposure models estimate exposure to an individual. Therefore, HQs represent potential risk to individual receptors and potential risk to populations must be extrapolated from these HQ values.

The following standard HQ equation (USEPA [1997a] will be used to estimate risks to wildlife:

$$HQ = \frac{Dose}{TRV} = \frac{(C_{soil} \times SIR) + (C_{tissue} \times FIR) \times SUF}{TRV \times BW} = \frac{(C_{soil} \times SIR\ ) + (C_{soil}\ \times BAF \times FIR) \times SUF}{TRV \times BW} = 1$$

Equation 6-8

Where:

HQ = hazard quotient (unitless)

Dose = exposure dose (mg/kg bw-day)

TRV = toxicity reference value (mg/kg bw-day])

C_{soil} = concentration of constituent in soil (mg/kg soil)

SIR = soil ingestion rate (kg soil/day)

C_{tissue} = concentration of constituent in biota or tissue (mg/kg tissue)

FIR = food or biota ingestion rate (kg tissue/day)

SUF = site-use factor (unitless); an adjustment factor used when the foraging range of a receptor is larger than the potentially contaminated area; calculated by dividing the potentially contaminated area by the home or foraging range of the receptor

BW = body weight of receptor (kg bw)

BAF = bioaccumulation factor or regression for media-to-biota uptake (kg soil/kg tissue).

If PAHs are detected in site media, HQs will be estimated for individual PAHs. However, as PAH toxicity is additive, risk from total LMW PAHs will be estimated by summing the HQs for the individual LMW PAHs, thereby estimating an HI. LMW PAHs are defined as PAHs with less than or equal to three rings and with molecular weight less than or equal to 192 atomic mass units (NOAA, 2000). Parent LMW PAHs include naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, and phenanthrene. Similarly, for HMW PAHs, HQs of individual HMW PAHs will be summed to estimate an HI. HMW PAHs are defined as PAHs with greater than or equal to four rings and with molecular weight greater than or equal to 202 atomic mass units (NOAA, 2000). Parent HMW PAHs include pyrene, fluoranthene, benz(a)anthracene, chrysene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene.

6.3.5.2 Risk Description and Lines of Evidence

Risk description will interpret and provide context for the risk estimates. Because risk estimates are based on potential risk to individual receptors, but assessment endpoints focus on protection of populations, there are several possible interpretations for an HQ value. For this ERA, the following will be assumed:

- Adverse effects are unlikely to occur in individuals or populations with estimated exposures resulting in HQs less than one based on the NOAEL or low TRV.

- Adverse effects are possible but unlikely for individuals with estimated exposures resulting in HQs greater than one based on the NOAEL or low TRV, but less than one based on the LOAEL or high TRV. TRVs are thresholds with an interval that is an artifact of the dosing regime used in the toxicity study. Therefore, the nature and magnitude of effects, if any, that may occur at exposures between these values is unknown.

- There is potential for adverse ecological effects for individuals with estimated exposures resulting in HQs greater than one based on the LOAEL or high TRV. However, the magnitude of such effects is uncertain. Therefore, risk managers should consider multiple lines of evidence, the level of conservatism and uncertainty in the assessment, and sensitivity of receptor populations when making risk management decisions.

In addition to the above assumptions, the risk estimates may be refined by altering the exposure areas proposed in Section 3.1.1.1, evaluating for hot spots, and/or area-weighting exposure. Spatial estimates of risk, if developed, will be estimated using the Theissen polygon approach described in Appendix A. Other lines of evidence that may be considered, in addition to the risk estimates and spatial distribution of risks, include direct field observations (i.e., evidence of stressed vegetation), and literature-derived information on the bioavailability of specific metals.

Those COPECs for which potential risk is identified, may warrant further investigation or refinement of risk estimates (see Section 8). The likelihood of adverse effects on ecological receptors from exposure to COPECs, for which HQs cannot be estimated due to lack of toxicity values, will be discussed in the uncertainty analysis.

6.3.6 Uncertainty Analysis

A qualitative uncertainty analysis will be conducted to convey the magnitude and direction of uncertainty in the risk estimates. There are many sources of uncertainty that influence risk characterization. These include uncertainties in the analytical results, data evaluation, CSM, exposure assessment, effects assessment, and interpretation of the risk estimates. The major sources of uncertainty associated with each phase of the risk assessment will be identified in the uncertainty analysis. The potential direction of bias in the resulting risk estimates will be identified where practical.

7. Ecological Risk Assessment Approach for Evaluating Groundwater-to-Surface Water Pathway

This section describes the purpose and objectives of the ERA and the approach to evaluating the groundwater-to-surface water pathway. The scoping ERA for the groundwater-to-surface water pathway will be used to support development of the groundwater CMS/FS. Certain portions of the following sections are similar to the steps of the soil and groundwater HHRA, described in Sections 4 and 5. Accordingly, this section presents a more streamlined discussion of how the surface water scoping assessment will be conducted. Please see Section 6 for general guidance consulted during the development of the ERA approach for the potential groundwater-to-surface water pathway. Where appropriate, this section of the work plan cross-references comparable sections presented in more detail in Section 6.

7.1 Purpose and Background

The purpose of the ERA for surface water is to predict the potential for adverse effects to ecological receptors potentially exposed to chemicals transported to surface water via groundwater. DTSC has specifically requested that a baseline risk evaluation of the groundwater be conducted. For baseline ERA, the first step is the scoping assessment (CalEPA, 1996a). The scoping assessment will be conducted to evaluate the completeness of the groundwater-to-surface water transport pathway. The outcome of scoping assessment is a CSM documenting the complete and significant exposure pathways.

As discussed in Section 6, completion of groundwater-to-surface water transport pathway (i.e., transport of chemicals in groundwater to the Colorado River) is unconfirmed (Figure 6-1). Therefore, the scoping assessment will focus on evaluation of this pathway. An IM is operating to provide hydraulic control of the hexavalent chromium plume and treat extracted groundwater (Section 5). The potential for hexavalent chromium to enter the Colorado River via groundwater discharge was addressed in the Draft RFI/RI (CH2M HILL, 2005a). As described in the RFI/RI Volume 2 (CH2M HILL, 2008b) and earlier in Section 2, at the northern and eastern limits of the chromium groundwater plume, geochemical reducing conditions are observed in groundwater in the fluvial deposits in the floodplain. Hexavalent chromium is not stable in reducing conditions and reverts to trivalent chromium, which is strongly sorbed to aquifer materials or forms insoluble precipitates. The reducing conditions in the fluvial sediments form a natural geochemical barrier that greatly limits the movement of hexavalent chromium from groundwater to surface water. Copper, nickel, and zinc were also identified as additional COPECs in the CACA (CalEPA, 1996a). These metals were either infrequently detected in groundwater or detected at very low concentrations relative to drinking water MCLs.

Despite the natural reducing conditions that greatly limit and/or prevent the movement of hexavalent chromium to the river, the scoping assessment will evaluate the significance of the groundwater-to-surface water pathway for all constituents, to confirm the findings of previous reports and, if necessary, independently evaluate the historical and ongoing surface water monitoring data. Specifically, the scoping assessment will confirm or refute that the groundwater-to-surface water transport is incomplete and/or insignificant. The approach to conducting the scoping assessment and evaluating the groundwater-to-surface water pathway for the ERA is described below.

7.2 Scoping Assessment Approach

A scoping assessment will be conducted in accordance with California guidance for ERAs (CalEPA, 1996c). The purpose of the scoping assessment is to develop a CSM that can serve as the basis for problem formulation in the Phase I Predictive ERA, if one is deemed necessary. The main elements of the scoping assessment are the identification of COPECs, potentially complete exposure pathways, and representative receptors. These elements are summarized in the CSM presented in Figure 6-1 and discussed below.

7.2.1 Constituents of Potential Ecological Concern

The first step in preparing the scoping assessment is to identify COPECs and potentially completed pathways. Although there is no direct exposure of ecological receptors to groundwater, groundwater data will be reviewed to assess the potential for a complete transport pathway to the river. Specific COPECs will not be identified for groundwater, but groundwater exceedances of background and surface water screening values (Table 7-1) will be identified to assess the transport pathway to surface water. The approach to comparison with background concentrations and surface water screening values is described in detail in Section 3.3.3. If the transport pathway is identified as potentially complete and significant, the surface water data from sampling locations adjacent to, or downstream of, the area potentially affected by the site will be evaluated in comparison with upstream sampling results.

7.2.1.1 Groundwater

As previously described, a significant amount of effort has been focused on obtaining a sufficiently robust background dataset for inorganic compounds in groundwater (CH2M HILL, 2008a). One key objective of the background investigation is to be able to distinguish the nature and extent of site-related constituents from naturally occurring constituents. The development of background concentrations for all detected inorganic compounds can then be considered, in conjunction with surface water screening values, for protection of ecological receptors in surface water to assess the transport pathway to the river.

The purpose of the data evaluation in the groundwater scoping assessment is to provide a comprehensive summary of the groundwater data collected to date. As part of the data evaluation step, the scoping assessment will present a summary of relevant groundwater data. To identify relevant data, the groundwater monitoring wells at the site will be reviewed, and floodplain wells between the site and the river will be selected for the dataset. The groundwater data from the floodplain wells will be summarized and descriptive statistics will be calculated.

As described in Section 2, there are ongoing groundwater investigations. Consistent with the RFI/RI Volume 2 Addendum, the cutoff date for all data to be in the scoping assessment is May 2008; data collected after May 2008 will not be included in the scoping assessment described in this work plan. However, data collected following the May 2008 cutoff date can be evaluated and assessed in a subsequent addendum to the scoping assessment, if deemed necessary and appropriate.

As discussed in Section 5, the outcome of the data evaluation step is: (1) the identification of a set of constituents that are likely to be site related; and (2) reported concentrations that are of acceptable quality for use in the risk assessment. Additional details regarding the methods that will be used in completing the data evaluation step of the risk assessment, including the specific data usability criteria and methods for selecting the site-related constituents, are presented in Sections 3 and 5.

7.2.1.2 Surface Water

If the transport pathway to surface water is found to be potentially complete and significant, available surface water data will be summarized, and COPECs will be identified as described in Section 3.3.4. Also as described earlier in Section 3.1.4, the approach to surface water data evaluation, if necessary, will include comparison of surface water data from the river that may be impacted by the site activities (i.e., via the groundwater) to surface water data collected from up river. If there is no significant difference between constituent concentrations detected upstream from the site versus those that are detected adjacent to and downstream from the site, surface water data from near the site may not need to be further evaluated in the risk assessments as the exposure pathways will be considered incomplete and/or insignificant.

7.2.1.3 Interstitial Water

If transport pathways from groundwater to surface water are found to be potentially complete and significant, based on comparison of concentrations of COPECs in floodplain wells with surface water screening levels, available interstitial water data will be summarized and COPECs will be identified as described in Section 3.3.5. The approach to interstitial water data evaluation, if necessary, will include comparison of interstitial water data from locations adjacent to the site that may be impacted by the site activities (i.e., via the groundwater) to interstitial water data collected from up river that are not potentially impacted by site activities. If there is no significant difference between constituent concentrations detected upstream from the site versus those that are detected adjacent to and downstream from the site, interstitial water data from near the site may not need to be further evaluated in the ERA as the exposure pathways will be considered incomplete and/or insignificant.

7.2.2 Exposure Pathways

There are two main transport pathways that may carry site-related constituents to the riparian area where aquatic receptors could be exposed. One is the sediment (via the surface soil runoff) to surface water pathway, and the other is the groundwater transport of site-related constituents to surface water.

Surface water runoff to the Colorado River is expected to be an insignificant transport pathway due to the infrequent nature of storm events and the short-term discharge of surface water runoff to the water column. The potential for a completed transport pathway from surface water runoff depositing chemically affected particles in riparian sediment is also unconfirmed. However, this transport pathway, if found complete, could result in a potentially significant exposure over time. This transport pathway will be evaluated in the soil risk assessment as discussed in Sections 3.1.2 and 6.

Once a constituent has reached the groundwater, the pathway of migration at the site is through groundwater transport. The general direction of groundwater flow from the source area in the BCW is toward the north or northeast. Additional information on groundwater gradient and flow direction is provided in the RFI/RI Volume 2 (CH2M HILL, 2008b).

As discussed above, strong reducing geochemical conditions are observed in the groundwater in the fluvial deposits along the Colorado River floodplain. The reducing conditions in the fluvial sediments provide a natural geochemical barrier that greatly limits or prevents the movement of hexavalent chromium through the fluvial sediments adjacent to and beneath the Colorado River. The scoping assessment will evaluate the groundwater-to-surface water pathway for all constituents, to confirm what previous data reports have stated (and what the historical and ongoing surface water monitoring data suggest); specifically, that the groundwater-to-surface water transport is incomplete and/or insignificant. If additional data confirm that the pathway is complete, the CSM will be modified and the complete exposure pathway will be included in the scoping assessment. The general proposed approach for assessing the significance of the groundwater-to-surface water transport pathway will consist of the following steps, which are similar to those described in detail in Section 5 for the HHRA.

- **Step 1: Comparison of Floodplain Concentrations to Screening-Level Surface Water Quality Criteria**

  In this step, constituents that are detected in the floodplain will be compared to screening-level water quality criteria or screening values that would be considered protective of aquatic receptors (Table 7-1).

  For the protection of aquatic organisms, the criteria used in this screening-level criteria are from the following sources, in order of preference, and are presented in Table 7-1:

  - CTR freshwater Criterion Continuous Concentration (CCC, or the highest concentration in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect)
  - National ambient water quality criteria (NAWQC) freshwater CCC
  - Tier II secondary chronic values, which should be considered screening values only and are more uncertain than the two sources of criteria listed above[6] and are derived by dividing the secondary acute value by the secondary acute-chronic ratio.

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[6] Tier II values were developed so that benchmarks could be established with fewer data than required for the NAWQC. Tier II values were obtained from Suter and Tsao (1996).

Comparison of groundwater concentrations to surface water screening criteria or screening values is considered extremely conservative, as the surface water criteria or screening values are applicable to surface water and not groundwater. Application of surface water criteria or screening values to the groundwater does not account for the natural dilution and attenuation that would occur between the groundwater and the point of release into surface water. Most often, DAFs are applied to account for the mixing between the groundwater seeping into the river and the water within the river.[7] Nonetheless, as a conservative screening approach to assess whether the groundwater-to-surface water pathway represents a potentially significant exposure pathway, potentially site-related constituents that are detected in the floodplain wells at levels that exceed corresponding surface water criteria or screening value, will be carried through to Step 2 of the transport pathway evaluation. Constituents detected in the groundwater in the floodplain wells, at concentrations that are below corresponding surface water criteria or screening values, indicate migration and release to the river is not at a level of concern and, therefore, will be eliminated from further analysis.

- **Step 2: Comparison of Concentrations of Constituents Measured in Surface Water to Screening-Level Surface Water Criteria**

  For this step, an approach similar to that described in Section 5 will be used. If there are potentially site-related constituents in floodplain groundwater that are present at concentrations exceeding surface water criteria or screening values (Step 1), the potential for the complete groundwater-to-surface water exposure pathway will be evaluated. Step 2 will involve comparing constituent concentrations in surface water to ecological surface water criteria. The comparison of surface water data to surface water criteria will be conducted by comparing the 95% UCL and the maximum detected concentrations in surface water to the applicable criteria. Other factors, such as frequency of detection, will also be considered in reaching conclusions about the significance of levels measured in the river. As mentioned earlier in Section 7.2.1.2, constituents that are detected in the surface water during an individual sampling period at concentrations that exceed the surface water criteria or screening values will be examined further to determine if surface water data collected from up river are

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[7] It is common for DAFs of at least 10 to be used in comparable screening-level evaluations.

significantly different from those collected from the river adjacent to or downriver from the site.

In general, if the concentrations of constituents detected in the river, particularly down river, are below the surface water criteria or screening values, the groundwater-to-surface water pathway will be deemed to be incomplete and/or insignificant and will not be evaluated further. If, however, concentrations of constituents are detected in the river at levels that are in excess of surface water criteria or screening values, the groundwater-to-surface water pathway could be considered complete and will require further evaluation. As described below, this refinement may involve a more detailed identification of representative receptors in the river, identification of applicable site-specific exposure assumptions, and site-specific estimates of risk and/or development of groundwater remediation goals for protection of surface water quality. Additionally, if it is determined that this pathway requires further evaluation, fate and transport models may be applied to estimate the dilution and attenuation that occurs as the groundwater is released to the surface water.

7.2.3 Representative Receptors

The aquatic habitat of the Colorado River supports several game fish species including striped bass (*Morone saxatillis*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), white crappie (*Pomoxis annularis*), flathead catfish (*Pylodictis olivaris*), and channel catfish (*Ictalurus punctatus*) (CH2M HILL, 2004a; 2005a,b,c,d; 2006a,b; E&E, 2000). The river, particularly bank areas with lower flow velocity and clearer water, also provides habitat for aquatic invertebrates, such as Asiatic clams (*Corbicula fluminea*), chironomids, and oligochaetes (Andrews et. al., 1997; USFWS, 1997).

Avian species commonly associated with the river include American coot (*Fulica americana*), mallard (*Anas platyrhynchos*), pied-billed grebe (*Podilymbus podiceps*), great egret (*Casmerodius albus*), great blue heron (*Ardea herodias*), northern rough-winged swallow (*Stegidopteryx serripennis*), and belted kingfisher (*Ceryle alcyon*).

The riparian area also supports several special status species as presented in Table 2-4.

7.2.4 Summary of Conceptual Site Model

The current CSM is provided in Figure 6-1. The transport pathway to surface water will be evaluated as described in Section 7.2.2 above. If the results of the transport pathway evaluation indicate the potential for complete and significant exposure pathways to aquatic receptors, the CSM will be revised to reflect this and a Phase I Predictive ERA will be planned. Details of the approach to the Phase I Predictive ERA for surface water (e.g., indicator receptors, exposure parameters, and toxicity values) will be developed and submitted in an addendum to this work plan.

8. Reporting and Next Steps

This section describes the format and approximate schedule and sequencing for the risk assessment reports. Additionally, a short summary of additional steps that could occur in the risk assessment process is included.

8.1 Reporting

The current project schedule (as of August 2008) lists the risk evaluations as components of the CMS/FS process. Based on that schedule, the following overall schedule and sequence of submittals is contemplated:

- Final Risk Assessment Work Plan (this document): submit to agencies on August 27, 2008, and receive approval in early September 2008.

- Groundwater Risk Assessment: begin work in early September 2008 and submit to agencies in early December 2008; receive approval (currently scheduled for April 2009) following acceptance by the agencies of the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum. Completion on this schedule requires:
  - Completion of the groundwater background study and approval by DTSC and USDOI (currently scheduled for August 2008).
  - Submittal to DTSC and USDOI of the RFI/RI Volume 2 (CH2M HILL, 2008b; submitted in early July 2008) and forthcoming Volume 2 Addendum (currently scheduled for submittal in early December 2008). The groundwater risk assessment can begin as scheduled in September 2008, concurrent with the agency review of the draft RFI/RI Volume 2 (CH2M HILL, 2008b; submitted in early July 2008), but cannot be submitted for agency review until the RFI/RI Volume 2 Addendum is submitted to DTSC and USDOI).
  - Approval of the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum prior to approval of the groundwater risk assessment.

- Soil Risk Assessment: begin work following completion of RFI/RI Volume 3 soil datasets, data validation, and submit to agencies; receive approval following acceptance by the agencies of the RFI/RI Volume 3. Completion on this schedule requires:
  - Approval of a background soils dataset before beginning the soil risk assessment.
  - Submittal of the RFI/RI Volume 3 for agency review before beginning soil risk calculations.
  - Approval of RFI/RI Volume 3 prior to acceptance of the soil risk assessment.

8.2 Next Steps

As described in Section 1 and listed above, the groundwater and soil risk assessments will be implemented separately, each risk assessment covering both human and ecological receptors.

8.2.1 Human Health Risk Assessment

It is anticipated that during the course of implementing the work described in this work plan, a variety of preliminary Technical Memoranda may be developed at key points during the process. The objectives of these memoranda are: (1) to identify various input terms for the soil and groundwater risk assessments; and (2) to receive feedback from DTSC regarding such information prior to incorporation into the formal risk assessment documents. The content, schedule, and need for such interim documents will be identified in coordination with the agency following agency review of this risk assessment work plan. For example, it is likely that such a process will be useful for achieving agreement on the exposure parameters for the receptors being evaluated in the soil risk assessment.

Following acceptance of this work plan, efforts will proceed for the HHRAs according to the following activities:

- Relying upon the data presented in the RFI/RI Volume 2 (CH2M HILL, 2008b) and forthcoming Volume 2 Addendum, COPCs will be identified for groundwater, and the groundwater risk assessment begins.

- Once Part A Phase I soil sampling activities have been completed and data are available, risk assessment input will be provided regarding adequacy of site characterization and data quality for risk assessment. Recommendations will be made regarding additional data needs to be filled during Phase II soil sampling.

- Following completion of Part B soil sampling investigation inside the compressor station and completion of the dataset, risk assessment input will be provided regarding adequacy of site characterization and data quality for risk assessment. Recommendations will be made regarding additional data gaps that may need to be filled. As of the submittal of this work plan, PG&E is in discussions with the agencies regarding the schedule for phasing the soil sampling work within the compressor station that was identified in the Draft RFI/RI Work Plan Part B (CH2M HILL, 2007d). Such phasing may result in portions of the soil characterization within the fence line of the compressor station being performed after PG&E no longer uses the property for utility purposes. These discussions may effect the timing of components of the HHRA (e.g., worker exposure to soils within the compressor station).

- Concurrent with soil sampling activities, work will begin on identifying appropriate input terms for the soil risk assessment that can be prepared in advance of the data being complete. Such activities may include, but are not limited to: identifying receptor-specific exposure parameters and assumptions and selection of and input terms for dust air estimates.

- Following completion of the groundwater and soil risk assessments, input will be provided for the CMS/FS efforts for each media as needed and appropriate.

8.2.2 Ecological Risk Assessment

The assumptions and inputs used in the Phase I Predictive ERA will be used to develop site-specific ECVs for soil. These values are a refinement of generic soil ECVs developed in the Draft RFI/RI Work Plan Part A (CH2M HILL, 2006a). The site-specific ECVs will be completed to support the Phase II Part A soil sampling investigation planning. Applications of these values may include setting reporting limits for analytical data and evaluating the adequacy of historical sampling to characterize the nature and extent of contamination. The site-specific ECVs will not be used to eliminate COPECs from the ERA. These values for metals and PAHs were submitted in a Technical Memorandum to the agencies on May 28, 2008. The ECVs for other constituents will be developed as data becomes available and will be submitted to the agencies as a separate Technical Memoranda before the Phase II investigation work plan.

Following completion of the Phase I Predictive ERA, the risk characterization results will be evaluated and the need for completion of a Phase II Validation Study and a Phase III Impact Assessment will be assessed. A validation study and an impact assessment are used to refine modeled factors or default/literature-based assumptions, such as BAFs, exposure assumptions, or toxicity assessments. If deemed necessary, these steps will include:

- A refined CSM identifying pathways and receptors requiring further evaluation

- A list of COPECs requiring further evaluation

- An outline of additional data needs (e.g., site-specific tissue data, toxicity tests, and surveys)

- A sampling and analysis plan, as appropriate, for collecting any additional samples.

Alternately, the next phases of assessment could focus on defining remediation goals (i.e., cleanup levels/scenarios) where risks are high enough to warrant immediate consideration of remedial alternatives.

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Appendix A

Methods for Calculating Exposure
Point Concentrations

ARCADIS

Appendix B

Figures Prepared by Others

Tables

Table 2-1
SWMUs, AOCs, and Other Undesignated Areas
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

SWMU/AOC/Undesignated Area	Location Inside or Outside Developed Areas of Topock Compressor Station	Risk Assessment Activities
Soil		
SWMU 5 - Former Sludge Drying Beds[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
SWMU 6 - Former Chromate Reduction Tank[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
SWMU 8 - Former Process Pump Tank[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
SWMU 9 - Former Transfer Sump[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
Unit 4.3 - Oil/Water Holding Tank[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
Unit 4.4 - Former Oil/Water Separator[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
Unit 4.5 - Former Portable Waste Oil Storage Tank[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
SWMU 1/AOC 1 - Former Percolation Bed	Outside	HHRA and ERA
AOC 4 - Debris Ravine	Outside	HHRA and ERA
AOC 5 - Cooling Tower A	Inside	HHRA
AOC 6 - Cooling Tower B	Inside	HHRA
AOC 7 - Hazardous Material Storage Area	Inside	HHRA
AOC 8 – Paint Lockers	Inside	HHRA
AOC 9 - Southeast Fence Line (Outside Visitor Parking Area)	Outside	HHRA and ERA
AOC 10 - East Ravine	Outside	HHRA and ERA
AOC 11 - Topographic Low Areas	Outside	HHRA and ERA
AOC 12 - Fill Area	Outside	HHRA and ERA
AOC 13 - Unpaved Areas within the Compressor Station	Inside	HHRA
AOC 14 - Railroad Debris Site	Outside	HHRA and ERA

Table 2-1
SWMUs, AOCs, and Other Undesignated Areas
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

SWMU/AOC/Undesignated Area	**Location Inside or Outside Developed Areas of Topock Compressor Station**	**Risk Assessment Activities**
AOC 15 - Auxiliary Jacket Water Cooling Pumps	Inside	HHRA
AOC 16 - Sand Blast Shelter	Inside	HHRA
AOC 17 - Onsite Septic System	Inside	HHRA
AOC 18 - Combined Wastewater Transference Pipelines[a]	Inside	No HHRA Activities Planned; Pending Results from Part B Work Plan Investigation
AOC 19 - Former Cooling Liquid Mixing Area	Inside	HHRA
AOC 20 - Industrial Floor Drains	Inside	HHRA
Potential Pipe Disposal Area	Outside	HHRA and ERA
Former 300B Pipeline Liquids Tank[a]	Outside	No HHRA or ERA Activities Planned; Pending Results from Part A Work Plan Investigation
Groundwater		
SWMU 1- Former Percolation Bed	Outside	HHRA and ERA
SWMU 2 - Inactive Injection Well (PGE-08)	Inside	HHRA and ERA

Notes:

[a] These units have been previously closed but additional investigation has been requested by the California Department of Toxic Substances Control (DTSC).

AOC = Area of Concern
ERA = Ecological Risk Assessment
HHRA = Human Health Risk Assessment
SWMU = Solid Waste Management Unit

Part A Work Plan = *Draft RCRA Facility Investigation/Remedial Investigation Soil Investigation Work Plan Part A* (CH2M HILL, 2006)
Part B Work Plan = *Draft RCRA Facility Investigation/Remedial Investigation Soil Investigation Work Plan Part B* (CH2M HILL, 2007)

Table 2-2
Representative Upland Animal Species
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	**Scientific Name**	**Conservation Status**	**Habitat**	**Feeding Guild**	**Confirmed Present**	**Potentially Present**	**Comments**
Birds							
Bald eagle	*Haliaeetus*	State endangered	Large trees and/or cliffs	Raptor	No	No	
Brewer's blackbird	*Euphagus*	No status	Open trees and shrubs	Insectivore,	Yes	Yes	
Cactus wren	*Campylorhyncus brunneicapillus*	No status	Desert succulent shrub, desert wash, and Joshua tree habitats	Invertivore, frugivore	Yes	Yes	Included in Havasu species list; uncommon.
California condor	*Gymnogyps californianus*	State and federally endangered	High desert canyon lands and plateau; caves, ledges, or large trees necessary for nesting; high perches necessary for roosting	Carnivore; carrion	No	No	No suitable habitat. Site is not within reintroduction areas.
Canyon wren	*Catherpes mexicanus*	No status	Canyons and cliffs	Insectivore	Yes	Yes	
Common raven	*Corvus corax*	No status	Open terrain with cliffs	Omnivore	Yes	Yes	
Gambel's quail	*Callipepla gambelii*	No status	Desert habitats	Herbivore	Yes	Yes	Common and nesting in Havasu.
Greater roadrunner	*Geococcyx californianus*	No status	Trees and arid open land	Carnivore	Yes	Yes	Common and nesting in Havasu.
Mourning dove	*Zenaida macroura*	No status	Open woodland or desert	Herbivore	Yes	Yes	Common and nesting in Havasu.
Red-tailed hawk	*Buteo jamencensis*	No status	Adaptable	Carnivore	Yes	Yes	Common and nesting in Havasu.
Rock dove	*Clumba livia*	No status	Urban areas, adaptable	Omnivore	No	No	
Turkey vulture	*Cathartes aura*	No status	Open with large tree and cliffs	Carnivore; carrion	Yes	Yes	
Reptiles							
California kingsnake	*Lampropeltis getulus california*	No status	All habitats except mountain	Carnivore	Yes	Yes	Included in Havasu species list.
Chuckwalla	*Sauromalus obesus*	No status	Rocky outcrops and rocky hillsides	Herbivore	Yes	Yes	Included in Havasu species list.
Coachwhip	*Masticophis flagellum*	No status	Wide range of habitats: desert, prairie, scrubland, juniper-grassland, woodland, thornforest, farmland, creek valleys, and swamps; usually in dry open terrain	Carnivore	Yes	Yes	
Desert horned lizard	*Phynosoma platyrhinos*	No status	All desert scrub types and grass/forb stages of pine/juniper woodlands	Invertivore, herbivore	Yes	Yes	Included in Havasu species list.
Desert iguana	*Dipsosaurus dorsalis*	No status	Creosote scrub, sandy creosote flats	Herbivore	Yes	Yes	
Desert tortoise	*Gopherus agassizii*	State and federally threatened	Mohave Desert scrub	Herbivore	No	No	No suitable habitat or foraging vegetation (PG&E, 2006).
Ground snake	*Sonora semiannulata*	No status	Hillsides or flats with or without rocks, usually where there is fine wind-blown sand	Invertivore	Yes	Yes	Included in Havasu species list.
Mohave rattlesnake	*Crotalus scutulatus*	No status	Desert, grassland/herbaceous, shrubland/chaparral, woodland/conifer, woodland/hardwood, woodland/mixed	Carnivore	No	No	
Pine-gopher snake	*Pituophis melanoleucus*	No status	All habitats; absent from densely forested areas	Carnivore	Yes	Yes	Included in Havasu species list.
Side-blotched lizard	*Uta stansburiana*	No status	Desert scrub, desert wash, creosote	Invertivore	Yes	Yes	Included in Havasu species list.

Table 2-2
Representative Upland Animal Species
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	Scientific Name	Conservation Status	Habitat	Feeding Guild	Confirmed Present	Potentially Present	Comments
Sidewinder	*Crotalus cerastes*	No status	Wide variety of habitats most frequently desert washes and flats with scrub cover and windblown sand	Carnivore	Yes	Yes	Included in Havasu species list.
Speckled rattlesnake	*Crotalus mitchellii*	No status	Rocky areas and slopes in desert and chaparral habitats; occasionally in pine-juniper and woodland habitat	Carnivore	Yes	Yes	Included in Havasu species list.
Spotted leaf-nosed snake	*Phyllorynchus decurtatus*	No status	Rocky and sandy flats and slopes to 3000 feet; most abundant in areas of mixed sandy and rocky soil with some brush cover	Carnivore	Yes	Yes	Included in Havasu species list.
Western blind snake	*Leptotyphlops humilis*	No status	Wide variety of habitats at low elevations	Insectivore	Yes	Yes	Included in Havasu species list.
Western diamondback rattlesnake	*Crotalus atrox*	No status	Flats and foothills, prefers brushy areas, riparian habitats	Carnivore	Yes	Yes	
Western long-nosed snake	*Rhinocheilus lecontei lecontei*	No status	Grasslands, arid brushlands	Carnivore	Yes	Yes	Included in Havasu species list.
Western whiptail lizard	*Cnemidorphorus tigris*	No status	Valley foothills (hardwoods, mixed conifer, pine-	Invertivore	Yes	Yes	
Zebra-tailed lizard	*Callisaurus draconoides*	No status	Sandy and gravelly desert flats, creosote scrub	Invertivore	Yes	Yes	
Mammals							
American badger	*Taxidea taxus*	No status	Drier open stages of most shrub, forest, and herbacious habitat	Carnivore	Yes	Yes	
Black-tailed hare	*Lepus californicus*	No status	Cropland/hedgerow, desert, grassland/herbaceous, savanna	Herbivore	Yes	Yes	
Bobcat	*Lynx rufus*	No status	Brushy stages of low/mid elevation conifer, oak, riparian	Carnivore	Yes	Yes	
California ground squirrel	*Spermophilus beecheyi*	No status	Found in a wide variety of habitats; usually in open areas in many plant communities	Herbivore	No	No	
California myotis	*Myotis californicus*	No status	Desert, chaparral, woodland, and forest from sea level up to ponderosa pine, mixed conifer, and Jeffery pine	Invertivore	Yes	Yes	Included in Havasu species list.
Cave myotis	*Myotis velifer*	CSC; no federal status	Desert scrub, desert wash, desert succulent scrub, and desert riparian	Insectivore	Yes	Yes	Included in Havasu species list.
Coyote	*Canis latrans*	No status	Open brush, scrub, herbaceous habitats	Carnivore	Yes	Yes	
Deer mouse	*Peromyscus maniculatus*	No status	All habitats	Herbivore,	Yes	Yes	
Desert cottontail	*Sylvilagus audubonii*	No status	Grasslands, open forests, desert shrub	Herbivore, granivore	Yes	Yes	
Desert kit fox	*Vulpes macrotis*	State status: protected furbearing mammal	Annual grasslands or grassy open stages of vegetation w/scattered brush	Carnivore	Yes	Yes	
Desert shrew	*Notiosorex crawfordi*	No status	Desert wash, desert scrub, desert riparian, mixed chaparral, and pinyon/juniper habitats	Invertivore	No	Yes	
Desert woodrat	*Neotoma lepida*	No status	Joshua tree, pinyon-juniper, most desert habitats	Herbivore, granivore	Yes	Yes	
Marriam kangaroo rat	*Dipodomys merriami*	No status	Desert scrub and alkali desert shrub, sagebrush, Joshua tree, prefers sparse habitat	Granivore	Yes	Yes	

Table 2-2
Representative Upland Animal Species

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	**Scientific Name**	**Conservation Status**	**Habitat**	**Feeding Guild**	**Confirmed Present**	**Potentially Present**	**Comments**
Nelson’s bighorn sheep	*Ovis canadesis nelsoni*	USBLM: sensitive FS: sensitive	Desert mountain ranges, alpine dwarf shrub, low sage, desert shrub	Herbivore	Yes	Yes	
Pallid bat	*Antrozous pallidus*	CSC; no federal status	Common in open dry habitats with rocky areas for roosting	Invertivore	Yes	Yes	Included in Havasu species list.
Raccoon	*Procyon lotor*	No status	All habitats except alpine and desert w/out water	Carnivore, frugivore, granivore, invertivore,	Yes	Yes	
Stripped skunk	*Mephitis mephitis*	No status	Earlier successional stages of conifer and dec. forest, intermediate canopy	Carnivore, frugivore, invertivore	Yes	Yes	
Whitetail antelope squirrel	*Ammospermophilus leucurus*	No status	Desert scrub	Omnivore	Yes	Yes	
Yuma myotis	*Myotis yumanensis*	Federal species of concern	Wide variety of habitats, optimally open forest and woodlands with a source of water over which to feed	Insectivore	Yes	Yes	Included in Havasu species list.

Notes:
CSC = Department of Fish and Game California special concern species; possibly vulnerable to extinction (have declining populations)
FS = federal status
USBLM = Bureau of Land Management

Source:
PG&E. 2006. Desert Tortoise Presence/Absence Surveys for the PG&E Topock Compressor Station Expanded Groundwater Extraction and Treatment System. July.

Table 2-3
Representative Upland Plant Species
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	**Scientific Name**	**Family**	**Conservation Status**	**Habitat**	**Confirmed Present**	**Potentially Present**
Catclaw acacia	*Acacia greggii*	Fabaceae	No status	Wash	Yes	Yes
White burrobush	*Ambrosia dumosa*	Asteraceae	No status	Creosote bush scrub	No	No
Cushenbury milk-vetch	*Astragalus albens*	Fabaceae	Federally endangered	Rocky areas; elevation range 3600 to 5400 feet	No	No
Lane mountain milk-vetch	*Astragalus jaegerianus*	Fabaceae	Federally endangered	Shrub association	No	No
Cattle-spinach (also known as allscale)	*Atriplex polycarpa*	Chenopodiaceae	No status	Creosote bush scrub	Yes	Yes
Sweetbush	*Bebbia juncea aspera*	Asteraceae	No status	Creosote bush scrub	Yes	Yes
Foothills palo verde	*Cercidium microphylla*	Fabaceae	No status	Wash	Yes	Yes
Straw-bed pincushion	*Chaenactis carphoclinia*	Asteraceae	No status	Wash annuals	Yes	Yes
Brittle spiny flower (also known as spineflower)	*Chorizanthe brevicornu*	Polygonaceae	No status	Creosote bush scrub	Yes	Yes
Soft-prairie clover (also known as dalea)	*Dalea mollissima*	Fabaceae	No status	Creosote bush scrub	No	No
Barnaby smokethorn	*Dalea spinosa*	Fabaceae	No status	Wash	No	No
White brittlebush	*Encelia farinosa*	Asteraceae	No status	Creosote bush scrub	Yes	Yes
Parish’s daisy	*Erigeron parishii*	Asteraceae	Federally threatened	Limestone substrate; rocky slopes	No	No
Skeleton weed	*Eriogonum deflexum*	Polygonaceae	No status	Wash annuals	Yes	Yes
Trumpet buckwheat (also known as desert trumpet)	*Eriogonum inflatum*	Polygonaceae	No status	Creosote bush scrub	Yes	Yes
Cushenbury buckwheat	*Eriogonum ovalifolium var. Vineum*	Polygonaceae	Federally endangered	Limestone areas, elevation range 4500 to 6300 feet	No	No
Barrel cactus	*Ferocactus cylindraceus*	Cactaceae	No status	Creosote bush scrub	Yes	Yes
White cheesebush	*Hymenoclea salsola*	Asteraceae	No status	Creosote bush scrub	Yes	Yes
Desert-lavender	*Hyptis emoryi*	Lamiaceae	No status	Wash	No	No
Small flower ratany	*Krameria erecta*	Kramerianceae	No status	Creosote bush scrub	No	No
Bristley langloisia	*Langloisia setosissma*	Polemoniaceae	No status	Wash annuals	No	No
Creosote bushes	*Larrea tridentata*	Zygophyllaceae	No status	Dry hills and well-drained areas	Yes	Yes
Pepper grass	*Lepidium densiflorum*	Brassicaceae	No status	Wash annuals	Yes	Yes
Arizona lupine	*Lupinus arizonicus*	Fabaceae	No status	Wash annuals	Yes	Yes
Beavertail cactus	*Opuntia basilaris*	Cactaceae	No status	Creosote bush scrub	Yes	Yes

Table 2-3
Representative Upland Plant Species

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	**Scientific Name**	**Family**	**Conservation Status**	**Habitat**	**Confirmed Present**	**Potentially Present**
Straw-top cholla (also known as golden cholla)	*Opuntia echinocarpa*	Cactaceae	Vulnerable	Creosote bush scrub	Yes	Yes
Cushenbury oxytheca	*Oxytheca parishii Var. Goodmaniana*	Polygonaceae	Federally endangered	Limestone talus, 1300 to 2000 meters	No	No
Smoke tree	*Psorothamnus spinosus*	Fabaceae	Arizona state protected status: salvage assessed	Wash	Yes	Yes
Notch-leafed phacelia	*Phacelia crenulata*	Hydrophyllaceae	No status	Wash	Yes	Yes
Honey mesquite	*Prosopis glandulosa*	Fabaceae	No status	Wash	Yes	Yes
Common Mediteranean grass (also known as split grass)	*Schismus barbatas*	Poaceae	No status	Wash annuals	No	No
Brown-plume wire-lettuce	*Stephanomeria*	Asteraceae	No status	Wash	Yes	Yes

Table 2-4
Representative Riparian Animal Species
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	Scientific Name	Conservation Status	Habitat	Feeding Guild	Confirmed Present	Potentially Present	Comments
Birds							
American coot	*Fulica americana*	No status	Dense emergent aquatic vegetation	Omnivore	Yes	Yes	
Arizona Bell's vireo	*Vireo bellii arisonae*	State endangered	Dense vegetation	Insectivore	Yes	Yes	
Belted kingfisher	*Ceryle alcyon*	No status	Riparian or aquatic	Carnivore	Yes	Yes	
Brown-crested flycatcher	*Yiarchus tryannulus*	LC; DFG-CSC	Riparian thicket	Insectivore	Yes	Yes	Nests locally according to Havasu.
California brown pelican	*Pelecanus occidentalis californicus*	State and federally endangered	Uncommon transient at many Arizona lakes and rivers	Piscivore	No	Yes	
Crissal thrasher	*Toxostoma crissale*	LC, DFG-CSC, USFWS-BCC	Dense thickets	Omnivore	Yes	Yes	Common and nesting in Havasu.
Gambel's quail	*Callipepla gambelii*	No status	Desert habitats	Herbivore	Yes	Yes	Common and nesting in Havasu.
Gila woodpecker	*Melanerpes uropygailis*	State endangered	Riparian trees	Insectivore, herbivore	Yes	Yes	Common and nesting in Havasu.
Great blue heron	*Ardea herodias*	LC, CDF sensitive	Requires trees for nesting	Carnivore	Yes	Yes	Common and nesting in Havasu.
Great egret	*Casmerodius albus*	LC, CDF sensitive	Requires trees for nesting	Carnivore, insectivore	Yes	Yes	Common and nesting in Havasu.
Great-tailed grackle	*Quiscalus mexicanus*	No status	Open near water	Omnivore	Yes	Yes	Common and nesting in Havasu.
Least Bell's vireo	*Vireo bellii pusillus*	State and federally endangered	Dense vegetation	Insectivore	Yes	Yes	Common and nesting in Havasu.
Lesser nighthawk	*Chordeiles acutipennis*	No status	Riparian and open low lands	Insectivore	Yes	Yes	Common and nesting in Havasu.
Mallard	*Anas platyrhynchos*	No status	River, riparian vegetation	90% herbivore, 10% insectivore	Yes	Yes	Common and nesting in Havasu.
Northern rough-winged swallow	*Stegidopteryx serripennis*	No status	Trees or cliffs	Insectivore	Yes	Yes	Common and nesting in Havasu.

Table 2-4
Representative Riparian Animal Species
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	**Scientific Name**	**Conservation Status**	**Habitat**	**Feeding Guild**	**Confirmed Present**	**Potentially Present**	**Comments**
Pied-billed grebe	*Podilymbus podiceps*	No status	Open water and vegetation	Omnivore	Yes	Yes	Common and nesting in Havasu.
Song sparrow	*Melospiza melodia*	LC in Alameda and San Pablo counties	Riparian	Herbivore, carnivore	Yes	Yes	Common and nesting in Havasu.
Sonoran yellow warbler	*Dendroica petechia sonorana*	LC; DFG-CSC, USFWS-BCC	Riparian woodlands, coastal/desert lowlands	Insectivore, herbivore	No	No	
Southwestern willow flycatcher	*Epidonax tailli extimus*	Federally endangered	Dense riparian vegetation	Insectivore	Yes	Yes	Listed as nesting locally in Havasu, but uncommon.
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	State endangered	Densely foliated deciduous trees esp. willows; large blocks of Riparian woodland	Insectivore	Yes	Yes	
Yellow-breasted chat	*Icteria virens*	LC, DFG-CSC	Riparian thickets	Insectivore, herbivore	Yes	Yes	Listed as nesting locally in Havasu, and common
Yuma clapper rail	*Rallus longirostris yumanensis*	State and federally endangered	Fresh water and brackish marshes	Insectivore	Yes	Yes	Listed as nesting locally in Havasu, but uncommon.
Reptiles							
Pine-gopher snake	*Pituophis melanoleucus*	No status	All habitats; absent from densely forested areas	Carnivore	Yes	Yes	Included in Havasu species list.
Western diamondback rattlesnake	*Crotalus atrox*	No status	Flats and foot hills, prefers brushy areas, riparian habitats	Carnivore	Yes	Yes	Included in Havasu species list.
Amphibians							
Arroyo toad	*Bufo microscaphus californicus*	Federally endangered	Desert riparian	Insectivore	No	No	

Table 2-4
Representative Riparian Animal Species

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	Scientific Name	Conservation Status	Habitat	Feeding Guild	Confirmed Present	Potentially Present	Comments
Fish							
Bonytail chub	*Gila elegans*	State and federally endangered	Warm, swift, turbid mainstem rivers of the Colorado River basin	Omnivore	No	Yes	
Razorback sucker	*Xyrauchen texanus*	State and federally endangered	Riverine and lacustrine areas; generally not in fast-moving waters and may use backwaters	Benthic invertebrates	No	Yes	
Colorado pikeminnow	*Ptychocheilus lucius*	State and federally endangered	Colorado River	Carnivore	No	No	This species extirpated from the lower Colorado River basin.
Mammals							
Beaver	*Castor canadesis*	No status	Riparian	Herbivore	Yes	Yes	
Bobcat	*Lynx rufus*	No status	Brushy stages of low/mid elevation conifer, oak, riparian	Carnivore	Yes	Yes	
Cave myotis	*Myotis velifer*	CSC; no federal status	Desert scrub, desert wash, desert succulent scrub, and desert riparian	Insectivore	Yes	Yes	Included in Havasu species list.
Deer mouse	*Peromyscus maniculatus*	No status	All habitats	Herbivore, invertivore	Yes	Yes	
Desert shrew	*Notiosorex crawfordi*	No status	Desert wash, desert scrub, desert riparian, mixed chaparral, and pinyon/juniper habitats	Invertivore	No	Yes	

Table 2-4

Representative Riparian Animal Species

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	**Scientific Name**	**Conservation Status**	**Habitat**	**Feeding Guild**	**Confirmed Present**	**Potentially Present**	**Comments**
Raccoon	*Procyon lotor*	No status	All habitats except alpine and desert w/out water	Carnivore, frugivore, granivore, invertivore, piscivore	Yes	Yes	

Notes:
LC = Least Concern
CDF = California Department of Forestry and Fire Protection: Sensitive
DFG-CSC = Department of Fish and Game - California Special Concern Species
USFWS-BCC = U.S. Fish and Wildlife Service: Birds of Conservation Concern

Table 2-5
Representative Riparian Plant Species

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Common Name	Scientific Name	Family	Conservation Status	Habitat	Confirmed Present	Potentially Present
Sedge	*Carex* sp.	Cyperaceae	No status	Wetland	Yes	Yes
Palo verde	*Cericidum* sp.	Fabaceae	No status	Desert riparian	Yes	Yes
Arrowweed	*Pluchea sericea*	Asteraceae	No status	Desert scrub, desert wash, desert riparian	Yes	Yes
Common reed	*Phragmites communis*	Poaceae	No status	Wetland	Yes	Yes
Mesquite	*Prosopis* sp.	Fabaceae	No status	Desert riparian, desert wash	Yes	Yes
Bulrush	*Scirpus* sp.	Cyperaceae	No status	Wetland	Yes	Yes
Tamarisk (also known as salt cedar)	*Tamarix* sp.	Tamaraceae	No status	Desert riparian, desert wash	Yes	Yes
Cattail	*Typha* sp.	Typhaceae	No status	Wetland	Yes	Yes

Table 4-1
Exposure Formulas and Factors for Commercial Worker Exposure to Soil
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Dermal Exposure

$$CDI = EPC * \frac{FC * ABS_D * AF * SA * FE * EF * ED}{BW * AT_{carc}} \qquad I = EPC * \frac{FC * ABS_D * AF * SA * FE * EF * ED}{BW * AT_{noncarc}}$$

Inhalation Exposure (Ambient Air)

$$CDI = EPC * \frac{IRa * \left(\frac{1}{VF} \; or \; \frac{1}{PEF}\right) * EF * ED}{BW * AT_{carc}} \qquad I = EPC * \frac{IRa * \left(\frac{1}{VF} \; or \; \frac{1}{PEF}\right) * EF * ED}{BW * AT_{noncarc}}$$

Oral Exposure

$$CDI = EPC * \frac{FC * IRs * FE * EF * ED}{BW * AT_{carc}} \qquad I = EPC * \frac{FC * IRs * FE * EF * ED}{BW * AT_{noncarc}}$$

Parameter		Value		Source / Comment [a]
ABS_D	Dermal absorption factor	--	(unitless)	COPC-specific values
AF	Soil-to-skin adherence factor	0.2	mg/cm^2	Default value for an adult worker
AT_{carc}	Period of time over which exposure is averaged for potential carcinogenic effects	25,550	days	70 years * 365 days/year
$AT_{noncarc}$	Period of time over which exposure is averaged for potential noncarcinogenic effects	9,125	days	ED (years) * 365 days/year
BW	Body weight	70	kg	Default adult body weight
CDI	Chronic daily intake (carcinogenic)	--	(unitless)	COPC-specific values
ED	Exposure duration	25	years	National 95th percentile time at one workplace
EF	Exposure frequency	250	days/year	Default value for the amount of time spent at work

Table 4-1
Exposure Formulas and Factors for Commercial Worker Exposure to Soil

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Parameter		Value		Source / Comment [a]
EPC	Exposure point concentration	--	mg/kg	COPC-specific values.
FC	Units conversion factor for soil	1E-6	kg/mg	--
FE	Fraction of total soil contacted that is from contaminated source	1.00	(unitless)	Conservative assumption that all soil contacted during site activities is contaminated
I	Intake (noncarcinogenic)	--	(unitless)	COPC-specific values
IRa	Inhalation rate	20	m^3/day	Default industrial inhalation rate
IRs	Soil ingestion rate	100	mg/day	Default industrial soil ingestion rate
PEF	Particulate emission factor	1.316E+9	m^3/kg	Default value for worker inhalation
SA	Skin surface area available for contact with soil	5,700	cm^2/day	Default value for worker exposure
VF	Soil-to-ambient air volatilization factor	--	m^3/kg	COPC-specific values for volatile organics based on equations from USEPA, 2002

Notes:

a. All factors from DTSC/HERD, 10/27/2005, unless otherwise specified.

Notes:

DTSC/HERD. 2005. Human Health Risk Assessment (HHRA) Note 1.
USEPA. 2002. SSL.

Table 4-2
Exposure Formulas and Assumptions for Hypothetical Future Residential Exposure to Soil
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Dermal Exposure

$$CDI = EPC * \frac{FC * ABS_D * SFS_{adj} * FE * EF}{AT_{carc}} \qquad I = EPC * \frac{FC * ABS_D * AF * SA * FE * EF * ED}{BW * AT_{noncarc}}$$

Inhalation Exposure (Ambient Air)

$$CDI = EPC * \frac{InhF_{adj} * \left(\frac{1}{VF} \; or \; \frac{1}{PEF}\right) * EF}{AT_{carc}} \qquad I = EPC * \frac{IRa * \left(\frac{1}{VF} \; or \; \frac{1}{PEF}\right) * EF * ED}{BW * AT_{noncarc}}$$

Oral Exposure

$$CDI = EPC * \frac{FC * IFS_{adj} * FE * EF}{AT_{carc}} \qquad I = EPC * \frac{FC * IRs * FE * EF * ED}{BW * AT_{noncarc}}$$

Parameter		Value		Source / Comment [a]
ABS_D	Dermal absorption factor	--	(unitless)	COPC-specific values
AF	Soil-to-skin adherence factor	0.07	mg/cm^2	Default value for residential adult soil exposure
		0.2	mg/cm^2	Default value for child soil exposure
AT_{carc}	Period of time over which exposure is averaged for potential carcinogenic	25,550	days	70 years * 365 days/year
$AT_{noncarc}$	Period of time over which exposure is averaged for potential noncarcinogenic effects	8,760	days	Adult ED (years) * 365 days/year
		2,190	days	Child ED (years) * 365 days/year
BW	Body weight	70	kg	Default adult body weight
		15	kg	Default child (age = 1 to 6 years, inclusive) body weight
CDI	Chronic daily intake (carcinogenic)	--	(unitless)	COPC-specific values

Table 4-2

Exposure Formulas and Assumptions for Hypothetical Future Residential Exposure to Soil

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Parameter		Value	Source / Comment [a]
ED	Exposure duration	24 years	National 95th percentile time at one residence for an adult
		6 years	Value for young children aged 1 to 6 years, inclusive
EF	Exposure frequency	350 days/year	Default residential exposure
EPC	Exposure point concentration	-- mg/kg	COPC-specific values
FC	Units conversion factor for soil	1E-6 kg/mg	--
FE	Fraction of total soil contacted that is from contaminated source	1 (unitless)	Conservative assumption that all soil contacted during site activities is contaminated
I	Intake (noncarcinogenic)	-- (unitless)	COPC-specific values
IFS_{adj}	Time-weighted ingestion factor for soil	114 mg-year/kg-day	$\left(\frac{IRs_{child} * ED_{child}}{BW_{child}}\right) + \left(\frac{IRs_{adult} * ED_{adult}}{BW_{adult}}\right)$
$InhF_{adj}$	Time-weighted inhalation factor for air	11 m^3-year/kg-day	$\left(\frac{IRa_{child} * ED_{child}}{BW_{child}}\right) + \left(\frac{IRa_{adult} * ED_{adult}}{BW_{adult}}\right)$
IRa	Inhalation rate	20 m^3/day	Default adult inhalation rate
		10 m^3/day	Default child inhalation rate
IRs	Soil ingestion rate	100 mg/day	Default value for adult residential soil ingestion
		200 mg/day	Default value for child residential soil ingestion
PEF	Particulate emission factor	1.316E+9 m^3/kg	Default value for residential particulate inhalation
SA	Skin surface area available for contact with soil	5,700 cm^2/day	Default value for residential adult soil exposure
		2,900 cm^2/day	Default value for child soil exposure

Table 4-2

Exposure Formulas and Assumptions for Hypothetical Future Residential Exposure to Soil

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Parameter		Value		Source / Comment [a]
SFS_{adj}	Time-weighted dermal exposure factor for soil	369	mg-year/kg-day	$\left(\frac{AF_{child} * SA_{child} * ED_{child}}{BW_{child}}\right) + \left(\frac{AF_{adult} * SA_{adult} * ED_{adult}}{BW_{adult}}\right)$
VF	Soil-to-ambient air volatilization factor	--	m^3/kg	COPC-specific values for volatile organics based on equations from USEPA, 2002.

Notes:
a. All factors from DTSC/HERD, 10/27/2005, unless otherwise specified.

Notes:
DTSC/HERD. 2005. Human Health Risk Assessment (HHRA) Note 1.
USEPA. 2002. SSL.

Table 5-1
Human Health Surface Water Screening Values

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

California Code of Regulations Title 22 Metals	California Primary Maximum Contaminant Level	California Toxic Rule Criteria		National Ambient Water Quality Criteria				Chosen Criteria[a]
		Inland Surface Waters		For Human Health and Welfare Protection				
		Human Health (30-day average)		Noncancer Health Effects		One-in-a-Million Cancer Risk Estimate		
		Drinking Water Sources (consumption of water and aquatic organisms)	Other Waters (consumption of aquatic organisms only)	Drinking Water Sources (consumption of water and aquatic organisms)	Other Waters (consumption of aquatic organisms only)	Drinking Water Sources (consumption of water and aquatic organisms)	Other Waters (consumption of aquatic organisms only)	
Aluminum	1000	NA	NA	NA	NA	NA	NA	1000
Antimony	6	14	4300	5.6	640	NA	NA	6
Arsenic	10	NA	NA	NA	NA	0.018	0.14	10 [b]
Barium	1000	NA	NA	1000	NA	NA	NA	1000
Beryllium	4	NA	NA	NA	NA	NA	NA	4
Cadmium	5	NA	NA	NA	NA	NA	NA	5
Chromium, hexavalent	NA	NA	NA	NA	NA	NA	NA	NA
Chromium, total	50	NA	NA	NA	NA	NA	NA	50
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA
Copper	1000 [c]	1300	NA	1300	NA	NA	NA	1000
Lead	15 [d]	NA	NA	NA	NA	NA	NA	15
Manganese	50 [c]	NA	NA	50	100	NA	NA	50
Mercury	2	0.05	0.051	NA	NA	NA	NA	0.05
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	100	610	4600	610	4600	NA	NA	100
Selenium	50	NA	NA	170	4200	NA	NA	50
Silver	100 [c]	NA	NA	NA	NA	NA	NA	100
Thallium	2	1.7	6.3	0.24	0.47	NA	NA	1.7
Vanadium	50 [e]	NA	NA	NA	NA	NA	NA	50
Zinc	5000 [c]	NA	NA	7400	26000	NA	NA	5000

Notes:
Values in units of micrograms per liter (µg/L).

a. The selection of surface water criteria is the lowest value of either the maximum contaminant level (MCL), or the California Toxic Rule (CTR) Criteria. If a CTR criteria doesn't exist, the chosen critieria is the lower of either the MCL or the National Ambient Water Quality Criteria (NAWQC). This hierarchy places preference on regulatory criteria (MCLs or CTR criteria) over recommended criteria (NAWQC).

b. For arsenic, although the NAWQC based on drinking water source is the lowest value, this value is not chosen because as indicated in the U.S. Environmental Protection Agency (USEPA) CTR, the USEPA is specifically not promulgating human health criteria for arsenic due to uncertainties associated with the health effects of arsenic.

c. California Secondary MCL provided when Primary MCL not promulgated.

d. California Action Level for lead provided in CCR Title 22, Division 4, Chapter 17.5, Article 3, Section 64678.

e. California Department of Public Health Drinking Water Notification Level provided when neither California Primary or Secondary MCL are promulgated.

NA = Not applicable or not available.
T = Total Recoverable.

Sources:

USEPA. 2000. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule. 40 CFR 131. U.S. Environmental Protection Agency. May. Available at: http://www.epa.gov/waterscience/standards/ctr/toxic.pdf

USEPA. 2002. National Recommended Water Quality Criteria. EPA 822-R-02-047. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. November. Available at: http://www.epa.gov/waterscience/criteria/wqcriteria.html

Table 5-2

Exposure Formulas and Assumptions for Hypothetical Future Residential Exposure to Groundwater

PG&E Topock

Needles, California

Human Health and Ecological Risk Assessment Work Plan

Dermal Contact

Noncancer

$$CDI_{\text{derm, child}} = \frac{C_w * SA_{child} * PC * ET_{child} * EF * ED_{child} * CF}{BW_{child} * AT_{nc,child}} \qquad CDI_{\text{ing, adult}} = \frac{C_w * SA_{adult} * PC * ET_{adult} * EF * ED_{adult} * CF}{BW_{adult} * AT_{nc,adult}}$$

Cancer

$$CDI_{\text{derm, age-adjusted}} \frac{C_w * SA_{child} * PC * ET_{child} * EF * ED_{child} * CF}{BW_{child} * AT_c} + CDI_{\text{ing, age-adjusted}} \frac{C_w * SA_{adult} * PC * ET_{adult} * EF * ED_{\text{age-adjusted}} * CF}{BW_{adult} * AT_c}$$

Ingestion

Noncancer

$$CDI_{\text{ing, child}} = \frac{C_w * IR_{child} * EF * ED_{child}}{BW_{child} * AT_{nc,child}} \qquad CDI_{\text{ing, adult}} = \frac{C_w * IR_{adult} * EF * ED_{adult}}{BW_{adult} * AT_{nc,adult}}$$

Cancer

$$CDI_{\text{ing, age-adjusted}} = \frac{C_w * IR_{child} * EF * ED_{child}}{BW_{child} * AT_c} + \frac{C_w * IR_{adult} * EF * ED_{\text{age-adjusted}}}{BW_{adult} * AT_c}$$

Parameter		Value	Source / Comment †
AT_c	Period of time over which exposure is averaged for potential carcinogenic	25,550 days	70 years * 365 days/year
AT_{nc}	Period of time over which exposure is averaged for potential noncarcinogenic effects	10,950 days	Adult ED (years) * 365 days/year
		2,190 days	Child ED (years) * 365 days/year
BW_{adult}	Body weight	70 kg	Default adult body weight
BW_{child}		15 kg	Default child (age = 1 to 6 years, inclusive) body weight
CF	Conversion factor	0.001 liter/cm^3	Volumetric conversion factor for water
ED_{adult}	Exposure duration	30	Adult
ED_{child}		6	Child
$ED_{\text{age-adjusted}}$		24	Age-adjusted
EF	Exposure frequency	350	Default residential exposure frequency

Table 5-2
Exposure Formulas and Assumptions for Hypothetical Future Residential Exposure to Groundwater

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Parameter		Value	Source / Comment [†]
ET	Exposure time	0.58 hour/day	Amount of time spent by adult showering\bathing in hours/da
		1 hour/day	Amount of time spent by child showering\bathing in hours/da
IR	Ingestion rate	2 liter/day	Default ingestion rate of drinking water by adult in
		1 liter/day	Default ingestion rate of drinking water by child in liters/day
PC	Dermal Permeability Coefficient from Wa	cm/hour	Chemical-specific values
SA	Skin surface area	18,000 cm^2	Surface area available while showering/bathing for adult
		6,600 cm^2	Surface area available while showering/bathing for child

Notes:

[†] All factors from DTSC/HERD, 10/27/2005, unless otherwise specified.

Table 6-1
Preliminary COPECs for Soil
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Area of Concern	Constituents of Potential Concern[a]												
	Total Chromium	**Hexavalent Chromium**	**Copper**	**Lead**	**Mercury**	**Molybdenum**	**Nickel**	**Zinc**	**Title 22 Metals**	**VOCs**	**SVOCs**	**TPH**	**PAHs**
Bat Cave Wash (SWMU 1/AOC1)	X	X	X	X	X		X	X	X	X	X	X	X
AOC 4		X							X	X	X	X	X
AOC 9	X	X	X	X		X	X	X	X	X	X	X	X
AOC 10	X	X	X	X		X	X	X	X	X	X	X	X
AOC 11	X	X	X	X			X	X	X	X	X	X	X
AOC 12		X (subarea 12a)							X	X		X	X
AOC 14									X	X	X	X	X
Potential Pipeline Disposal Area													
Former 300B Pipeline Liquids Tank[b]												X	

Notes:

a. Constituents of potential concern (COPCs) were discussed in the Revised Final RFI/RI Volume 1 (CH2M HILL, 2007a). The COPCs referenced in this table are the COPCs identified in the text of the Revised Final RFI/RI Volume 1 with the exception of asbestos, electrical conductivity, and pH which will not be chemicals of potential concern for the ecological risk assessment.

b. The Former 300B Pipeline Liquids Tank area has already been closed (CH2M HILL, 2007b), but DTSC has requested additional investigation (CalEPA, 2007). If complete pathways are identified based on the results, the Former 300B Pipeline Liquids Tank area will be included in the ERA.

PAHs = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons
VOCs = volatile organic chemicals
SVOCs = semivolatile organic chemicals

Sources:

CalEPA. 2007. Letter “Comments and Conditional Approval of the RCRA Facility Investigation/Remedial Investigation Soil Investigation Work Plan, Pacific Gas and Electric (PG&E) Topock Compressor Station, Needles, California."

CH2M HILL. 2007a. Revised Final RCRA Facility Investigation/Remedial Investigation Report, Volume 1 - Site Background and History, PG&E Topock Compressor Station, Needles, California. August 10.

CH2M HILL. 2007b. 300B Pipeline Liquids Tank Closure, PG&E Topock Compressor Station, Needles, California. Technical Memorandum. April 26.

Table 6-2
Summary of Assessment Endpoints, Measurement Endpoints, and Representative Receptors
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Assessment Endpoint	Corresponding Measurement Endpoint	Representative Receptor
Sufficient rates of survival, growth, and reproduction to sustain plant populations (e.g., creosote bush scrub)	Comparison of contaminant concentrations in soil with relevant plant toxicity data obtained from the literature	Plant communities
Sufficient rates of survival, growth, and reproduction to sustain invertebrate populations	Comparison of contaminant concentrations in soil with relevant invertebrate toxicity data obtained from the literature	Invertebrates
Sufficient rates of survival, growth, and reproduction to sustain avian populations	Calculated hazard quotients (HQs) for selected indicator receptors; HQs will be based on estimated exposure doses	Gambel's quail
		Cactus wren
		Red-tailed hawk
Sufficient rates of survival, growth, and reproduction to sustain mammalian populations	Calculated HQs for selected indicator receptors; HQs will be based on estimated exposure doses compared with toxicity	Desert shrew
		Desert kit fox
		Merriam's kangaroo rat

Table 6-3
Exposure Depth Intervals for Ecological Receptors for Calculating of Exposure Point Concentrations

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

				Exposure Depth Intervals for Calculation of EPCs[a]			
		Type of Prey		Soil EPCs for Uptake/Incidental Ingestion of Soil		Prey Tissue EPCs (modeled from soil EPCs)	
Ecological Receptor	**Plant/Burrowing Receptor?**	**All AOCs except BCW**	**BCW**	**All AOCs except BCW**	**BCW**	**All AOCs except BCW**	**BCW**
Plants	Yes	NA	NA	Highest EPCs from the three depth intervals[b]	Highest EPCs from the three depth intervals[b]	NA	NA
Soil Invertebrates	No	NA	NA	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs	NA	NA
Granivorous bird (Gambel's quail)	No	Plants (with roots in all 3 depth intervals)	Plants (with roots in all 3 depth intervals)	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs	Highest EPCs from the three depth intervals[b]	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs
Insectivorous bird (cactus wren)	No	Insects (from surface soil)	Insects (from surface soil and shallow soil)	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs
Carnivorous bird (red-tailed hawk)	No	Insectivorous mammals (from surface soil)	Insectivorous mammals (from surface soil and shallow soil)	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs
Granivorous mammal (kangaroo rat)	Yes	Plants (with roots in all 3 depth intervals)	Plants (with roots in all 3 depth intervals)	Highest EPCs from the three depth intervals[b]	Highest EPCs from the three depth intervals[b]	Highest EPCs from the three depth intervals[b]	Highest EPCs from the three depth intervals[b]
Insectivorous mammal (desert shrew)	No	Insects (from surface soil)	Insects (from surface soil and shallow soil)	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs
Carnivorous mammal (desert kit fox)	Yes	Insectivorous mammals (from surface soil)	Insectivorous mammals (from surface soil and shallow soil)	Highest EPCs from the three depth intervals[b]	Highest EPCs from the three depth intervals[b]	EPCs from 0-0.5 feet bgs	Highest EPCs from 0-0.5 feet bgs and 0-3 feet bgs

Notes:
EPCs: expousure point concentrations.

a. Exposure point concentrations for ecological receptors will be represented by both the maximum detected concentation and the 95 percent upper confidence limit on the mean.
b. Depth intervals for ecological receptors include:
Surface Soil = 0 - 0.5 feet below ground surface (bgs).
Shallow Soil = 0 - 3 feet bgs.
Subsurface Soil I = 0 - 6 feet bgs.

AOC = includes areas of concern and undesignated areas outside the compressor station
BCW = Bat Cave Wash
bgs = below ground surface
EPC = exposure point concentration
NA = not applicable

Table 6-4
Ecological Exposure Parameters
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Parameter	Symbol	(units)	Gambel's Quail	Source	Cactus Wren	Source	Red-Tailed Hawk	Source	Desert Shrew	Source	Desert Kit Fox	Source	Merriam's Kangaroo Rat	Source
Diet														
Proportion of diet containing plants	pla	(proportion)	1	CDFG (CalEPA, 2005)	--		--	--	--	--	--	--	1	CDFG (CalEPA, 2005)
Proportion of diet containing invertebrates	inv	(proportion)	--	--	1	CDFG (CalEPA, 2005)	--	--	1	CDFG (CalEPA, 2005)	--	--	--	--
Proportion of diet containing mammals	mam	(proportion)	--	--	--	--	1	CDFG (CalEPA, 2005)	--	--	1	Assumed based on information presented for the kit fox in CDFG, (CalEPA, 2005)	--	--
Ingestion rate of food	IR	(kg/day)	0.00649 (dry	Nagy, 2001; Table 1: Species-specific feeding rates.	0.00713	Nagy, 2001; ingestion equation for insectivorous birds	0.0899 (dry	Nagy, 2001; ingestion equation for carnivorous birds	0.001015 (dry	Nagy, 2001; ingestion equation for insectivores	0.0702 (dry	Nagy, 2001; Table 1: Species-specific feeding rates	0.00282 (dry	Nagy, 2001; Table 1: Species-specific feeding rates
Body Weight	bw	(kg)	0.1693	Based on average weight for M/F adults from Gorsuch (1934); cited in Birds of North America, 2004-2005	0.0389	Based on average weight for M/F adults from Anderson and Anderson (1973); cited in Birds of North America, 2004-2005	1.134	Based on average weight for M/F adults (USEPA, 1993)	0.005	Based on average weight for M/F adults for desert shrew (Silva and Downing, 1995)	1.985	Based on the average weight for M/F adults; O'Farrell et al. (1986) cited in Cal/Ecotox (CalEPA, 2007)	0.0343	Nagy (1999) cited in Nagy (2001)
Media Uptake														
Percent soil in diet			10.4	Based on American Woodcock (Beyer et al., 1994)	9.3	Based on wild turkey (Beyer et al., 1994)	1.4	Assumed to be no greater than 1/2 soil intake of red fox (Beyer et. al., 1994)	2	Based on white-footed mouse (Beyer et al., 1994)	2.8	Based on the red fox (Beyer et al., 1994)	2.4	Based on the meadow vole (Beyer et al., 1994)
Incidental soil ingestion rate	SIR	(kg/day)	0.000675	Calculated: % soil * IR	0.000663	Calculated: % soil * IR	0.00126	Calculated: % soil * IR	2.03E-05	Calculated: % soil * IR	0.00197	Calculated: % soil * IR	0.0000677	Calculated: % soil * IR
Site Usage														
Site use factor (assumed)	SUF	(unitless)	1		1		1		1		1		1	
Home range[a]	HR	acres	35.7	Gullion (1962); cited in CDFG (CalEPA, 2005)	4.8	Anderson and Anderson (1973); cited in CDFG (CalEPA, 2005)	2471	CDFG, 2005	0.1	Based on dusky shrew; Hawes (1977); cited in CDFG (CalEPA, 2005)	3039	Zoellick, 1992	0.13	Based on 7.6 individuals per acre; Soholt (1973); cited in CDFG (CalEPA, 2005)

Notes:
a. Home ranges were converted to acres if presented in units other than acres in respective sources.

CalEPA = California Environmental Protection Agency
CDFG = California Department of Fish and Game
kg = kilogram(s)
M/F = male/female
USEPA = U.S. Environmental Protection Agency

Sources:
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Beyer, W. N., E. Connor, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. Journal of Wildlife Management 58:375-382.
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USEPA. 1993. Wildlife Exposure Factors Handbook. U.S. Environmental Protection Agency. EPA/600/R-93/187a. Washington, DC.
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Table 6-5
Bioaccumulation Factors
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Constituent	**Soil-to-Biota Bioaccumulation Factors**[a]		
	BAF_{plant} (dw) (kg soil/kg tissue)	**BAF_{invert} (dw) (kg soil/kg tissue)**	**BAF_{mammal} (dw) (kg soil/kg tissue)**
Antimony	$\ln(C_p) = 0.938 \times \ln(C_s) - 3.233$	1.00	$0.05 \times C_d$
Arsenic	0.03752	$\ln(C_i) = 0.706 \times \ln(C_s) - 1.421$	$\ln(C_m) = 0.8188 \times \ln(C_s) -4.8471$
Barium	0.156	0.091	$0.0075 \times C_d$
Beryllium	$\ln(C_p) = 0.7345 \times \ln(C_s) - 0.5361$	0.045	$0.05 \times C_d$
Cadmium	$\ln(C_p) = 0.546 \times \ln(C_s) - 0.475$	$\ln(C_i) = 0.795 \times \ln(C_s) + 2.114$	$\ln(C_m) = 0.4723 \times \ln(C_s) - 1.2571$
Chromium, total	0.041	0.306	$\ln(C_m) = 0.7338 \times \ln(C_s) - 1.4599$
Chromium, hexavalent	0.041	0.306	$\ln(C_m) = 0.7338 \times \ln(C_s) - 1.4599$
Cobalt	0.0075	0.122	$\ln(C_m) = 1.307 \times \ln(C_s) - 4.4669$
Copper	$\ln(C_p) = 0.394 \times \ln(C_s) + 0.668$	0.515	$\ln(C_m) = 0.1444 \times \ln(C_s) + 2.042$
Lead	$\ln(C_p) = 0.561 \times \ln(C_s) - 1.328$	$\ln(C_i) = 0.807 \times \ln(C_s) - 0.218$	$\ln(C_m) = 0.4422 \times \ln(C_s) + 0.0761$
Mercury	$\ln(C_p) = 0.544 \times \ln(C_s) - 0.996$[b]	$\ln(C_i) = 0.3369 \times \ln(C_s) - 0.078$[c]	0.192[d]
Molybdenum	0.25[e]	0.55[f]	$\ln(C_m) = 0.006 \times 50 \times C_d$[e]
Nickel	$\ln(C_p) = 0.748 \times \ln(C_s) - 2.223$	1.059	$\ln(C_m) = 0.4658 \times \ln(C_s) - 0.2462$
Selenium	$\ln(C_p) = 1.104 \times \ln(C_s) - 0.677$	$\ln(C_i) = 0.733 \times \ln(C_s) - 0.075$	$\ln(C_m) = 0.3764 \times \ln(C_s) - 0.4158$
Silver	0.014	2.045	0.004
Thallium	0.004[e]	0.55[f]	0.112[d]
Vanadium	0.00485	0.042	0.0123
Zinc	$\ln(C_p) = 0.554 \times \ln(C_s) + 1.575$	$\ln(C_i) = 0.328 \times \ln(C_s) + 4.449$	$\ln(C_m) = 0.0706 \times \ln(C_s) + 4.3632$
Total LMW PAH	1.3205	3.04	0.0
Total HMW PAH	1.7026	2.6	0.0

Notes:

a. All BAFs from Eco-SSL Guidance (USEPA, 2008a), except as otherwise noted. Ecological Soil Screening Levels. March. http://www.epa.gov/ecotox/ecossl/

b. Bechtel Jacobs Company LLC. 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Bechtel Jacobs Company LLC, Oak Ridge, Tennessee. BJC/OR-133.

c. Sample, B., J.J. Beauchamp, R. Efroymson, G.W. Suter, II, and T. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory. ES/ER/TM-220. Sample et al, 1998b.

d. Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998. Development and Validation of Bioaccumulation Models for Small Mammals. February. Prepared for the U.S. Department of Energy. ES/ER/TM-219.

e. Baes, C.F., R. Sharp, A. Sjoreen and R. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for U.S. Dept. of Energy. 150 pp.

f. Mean of available metal BAFs (invertebrates only). This follows approach in USEPA (1999a).

BAF = bioaccumulation factor
BAF_{invert} = soil-to-invertebrate uptake bioaccumulation factor (kilogram soil/kilogram tissue)
BAF_{plant} = soil-to-plant uptake bioaccumulation factor (kilogram soil/kilogram tissue)
C_d = concentration in diet
C_i = constituent concentration in invertebrates
C_m = constituent concentration in mammals
C_p = constituent concentration in plants
C_s = constituent concentration in soil
dw = dry weight
HMW PAHs - high molecular weight polycyclic aromatic hydrocarbons

Table 6-6
Screening Values for Surface Soil

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Analytes	Plant (mg/kg)	Invertebrate (mg/kg)
Antimony	5*	78
Arsenic	18	60**
Barium	500*	330
Beryllium	10*	40
Cadmium	32	140
Chromium, trivalent	NA	NA
Chromium, hexavalent	1*	0.4**
Chromium, total	NA	NA
Cobalt	13	NA
Copper	70	80
Lead	120	1700
Manganese	220	450
Mercury	0.3*	0.1**
Molybdenum	2*	NA
Nickel	38	280
Selenium	0.52	4.1
Silver	560	NA
Thallium	1*	NA
Vanadium	2*	NA
Zinc	160	120
LMW PAHs	10	29
HMW PAHs	1.2	18

Notes:

*Confidence in this benchmark is low due to the low number of studies on which it is based or other factors. The soil type and test species (typically agricultural) may also vary significantly from site-specific conditions or the toxic effects may be unspecified in the source study. There may be significant variability in the toxic responses noted.

**Confidence in this benchmark is low due to the low number of studies on which it is based or other factors. The tests were conducted with earthworms.

kg = kilogram(s)

🟥 Indicates USEPA Eco-SSL
🟨 Indicates ORNL Screening Benchmark
🟩 Primary sources (see Section 6).

Sources:

USEPA. 2008. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER Directive 9285.7-55. United States Environmental Protection Agency Office of Solid Waste and Emergency Response. Washington, DC. November 2003, revised March, 2005. http://www.epa.gov/ecotox/ecossl/

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Prepared for the Oak Ridge Laboratory. November.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Prepared for the Oak Ridge Laboratory. November.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp. ES/ER/TM-86/R3.

Table 6-7
Toxicity Reference Values
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Constituent	Wildlife TRVs (mg/kg-bw/day)							
	Birds				Mammals			
	Low TRV (NOAEL)	Source	High TRV (LOAEL)	Source	Low TRV (NOAEL)	Source	High TRV (LOAEL)	Source
Antimony	NA	--	NA	--	0.059	USEPA, 2005	0.59	USEPA, 2005
Arsenic	2.24	USEPA, 2005	3.55	USEPA, 2005	1.04	USEPA, 2005	1.66	USEPA, 2005
Barium	NA	--	NA	--	51.8	USEPA, 2005	82.6	USEPA, 2005
Beryllium	NA	--	NA	--	0.532	USEPA, 2005	0.630	USEPA, 2005
Cadmium	1.47	USEPA, 2005	6.35	USEPA, 2005	0.770	USEPA, 2005	7.7	USEPA, 2005
Chromium	2.66	USEPA, 2005	15.6	USEPA, 2005	2.40	USEPA, 2005	9.62	USEPA, 2005
Hexavalent Chromium	NA	--	NA	--	9.24	USEPA, 2008	38.4	USEPA, 2008
Cobalt	7.61	USEPA, 2005	18.3	USEPA, 2005	7.33	USEPA, 2005	18.8	USEPA, 2005
Copper	4.05	USEPA, 2007	12.1	USEPA, 2007	5.60	USEPA, 2007	9.34	USEPA, 2007
Lead	1.63	USEPA, 2005	3.26	USEPA, 2005	4.70	USEPA, 2005	8.90	USEPA, 2005
Mercury	0.039	CalEPA BTAG (2002)	0.2	CalEPA BTAG (2002)	0.25	CalEPA BTAG, 2002	4	CalEPA BTAG, 2002
Molybdenum	3.5	Sample et al., 1996	35.3	Sample et al., 1996	0.26	Sample et al., 1996	2.6	Sample et al., 1996
Nickel	6.71	USEPA, 2007	18.6	USEPA, 2007	1.70	USEPA, 2007	3.40	USEPA, 2007
Selenium	0.290	USEPA, 2007	0.579	USEPA, 2007	0.143	USEPA, 2007	0.215	USEPA, 2007
Silver	2.02	USEPA, 2006	20.2	USEPA, 2006	6.02	USEPA, 2006	60.2	USEPA, 2006
Thallium	0.35	USEPA, 1999	3.5	USEPA, 1999	0.48	CalEPA BTAG, 2002	1.43	CalEPA BTAG, 2002
Vanadium	0.344	USEPA, 2005	0.688	USEPA, 2005	4.16	USEPA, 2005	8.31	USEPA, 2005
Zinc	66.1	USEPA, 2007	171	USEPA, 2007	75.4	USEPA, 2007	298	USEPA, 2007
Total LMW PAHs	22.8	Patton and Dieter, 1980	228	Patton and Dieter, 1980	65.6	USEPA, 2007	328	USEPA, 2007
Total HMW PAHs	10	Trust et al., 1994	100	Trust et al., 1994	0.6	USEPA, 2007	3	USEPA, 2007

Notes:

-- = not applicable

LOAEL = lowest observed adverse effects level

mg/kg-bw/day = milligrams per kilogram of body weight per day

NA = not available

NOAEL = no observed adverse effects level

TRV = toxicity reference value

Sources:

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp. ES/ER/TM-86/R3.

CalEPA. 2002. Currently Recommended U.S. Environmental Protection Agency Region 9 Biological Technical Assistance Group (BTAG) Mammalian and Avian Toxicity Reference Values (TRVs). Department of Toxic Substances Control: Human and Ecological Risk Division.

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Trust, K.A., A. Fairbrother, and M.J. Hooper. 1994. Effects of 7,12-dimethylbenz(a)anthracene on immune function and missed-function oxygenase activity in the European starling. Environ. Toxicol. Chem. 13(5): 821-830.

USEPA 1999. Region 6 Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities: Appendix E Toxicity Reference Values. August.

USEPA 2005-2008. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER Directive 9285.7-55. United States Environmental Protection Agency Office of Solid Waste and Emergency Response. Washington, DC. November 2003, revised March, 2005. http://www.epa.gov/ecotox/ecossl/

Table 6-8
Allometrically Converted TRVs for Representative Receptors

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Constituent	Wildlife Receptors			
	Desert Shrew		Merriam's Kangaroo Rat	
	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	1.53	2.44	1.46	2.33
Copper	9.43	15.73	9.04	15.07
Selenium	0.23	0.35	0.21	0.31
Silver	8.77	87.68	8.40	84.01

Notes:
LOAEL = lowest observed adverse effects level
NOAEL = no observed adverse effects level

Equation used: Aw = At ´ (BWt/BWw)^1-b

where:

Aw =toxicity value of wildlife species
At =toxicity value of test species (TRV)
BWt =body weight of test species
BWw =body weight of wildlife species
b =allometric scaling factor (1.2 for birds, 0.94 for mammals)

Source:

Sample, B.E. and C.A. Arenal. 1999. Allometric Models for Interspecies Extrapolation of Wildlife Toxicity Data. Bull. Environ. Contam. Toxicol. (1999) 62: 653-663.

Table 6-9
DTSC-Recommended TRVs

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

	Wildlife TRVs (mg/kg-bw/day)							
	Birds				Mammals			
Constituent	Low TRV (NOAEL)	Source	High TRV (LOAEL)	Source	Low TRV (NOAEL)	Source	High TRV (LOAEL)	Source
Antimony	NA	--	NA	--	0.059	USEPA, 2005	0.59	USEPA, 2005
Arsenic	5.5	CalEPA BTAG, 2002	22.0	CalEPA BTAG, 2002	0.32	CalEPA BTAG, 2002	4.7	CalEPA BTAG, 2002
Barium	NA	--	NA	--	51.8	USEPA, 2005	82.6	USEPA, 2005
Beryllium	NA	--	NA	--	0.532	USEPA, 2005	0.630	USEPA, 2005
Cadmium	0.08	CalEPA BTAG, 2002	10.4	CalEPA BTAG, 2002	0.060	CalEPA BTAG, 2002	2.64	CalEPA BTAG, 2002
Chromium	2.66	USEPA, 2005	15.6	USEPA, 2005	2.40	USEPA, 2005	9.62	USEPA, 2005
Hexavalent Chromium	NA	--	NA	--	9.24	USEPA, 2008	38.4	USEPA, 2008
Cobalt	7.61	USEPA, 2005	18.3	USEPA, 2005	1.2	CalEPA BTAG, 2002	20	CalEPA BTAG, 2002
Copper	2.30	CalEPA BTAG, 2002	52.3	CalEPA BTAG, 2002	2.67	CalEPA BTAG, 2002	632	CalEPA BTAG, 2002
Lead	0.014	CalEPA BTAG, 2002	8.75	CalEPA BTAG, 2002	1.0	CalEPA BTAG, 2002	241	CalEPA BTAG, 2002
Mercury	0.039	CalEPA BTAG, 2002	0.18	CalEPA BTAG, 2002	0.25	CalEPA BTAG, 2002	4	CalEPA BTAG, 2002
Molybdenum	3.5	Sample et al., 1996	35.3	Sample et al., 1996	0.26	Sample et al., 1996	2.6	Sample et al., 1996
Nickel	1.38	CalEPA BTAG, 2002	56.3	CalEPA BTAG, 2002	0.133	CalEPA BTAG, 2002	31.6	CalEPA BTAG, 2002
Selenium	0.23	CalEPA BTAG, 2002	0.93	CalEPA BTAG, 2002	0.05	CalEPA BTAG, 2002	1.21	CalEPA BTAG, 2002
Silver	2.02	USEPA, 2006	20.2	USEPA, 2006	6.02	USEPA, 2006	60.2	USEPA, 2006
Thallium	0.35	USEPA, 1999b	3.5	USEPA, 1999b	0.48	CalEPA BTAG, 2002	1.43	CalEPA BTAG, 2002
Vanadium	0.344	USEPA, 2005	0.688	USEPA, 2005	4.16	USEPA, 2005	8.31	USEPA, 2005
Zinc	17.2	CalEPA BTAG, 2002	172	CalEPA BTAG, 2002	9.60	CalEPA BTAG, 2002	411	CalEPA BTAG, 2002
LMW PAHs	NA	--	NA	--	50	CalEPA BTAG, 2002	150	CalEPA BTAG,
HMW PAHs	NA	--	NA	--	1.31	CalEPA BTAG, 2002	32.8	CalEPA BTAG,

Notes:
DTSC = Department of Toxic Substances Control
kg = kilograms
mg/kg-bw/day = milligram(s) per kilogram body weight per day
NA = not available
LOAEL = lowest observable adverse effects level
NOAEL = no observable adverse effects level
TRV = toxicity reference value
UF = uncertainty factor
-- = not applicable

Sources:

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp. ES/ER/TM-86/R3.

CalEPA 2002. Currently Recommended U.S. Environmental Protection Agency Region 9 Biological Technical Assistance Group (BTAG) Mammalian and Avian Toxicity Reference Values (TRVs). Department of Toxic Substances Control: Human and Ecological Risk Division.

USEPA 1999. Region 6 Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities: Appendix E Toxicity Reference Values. August.

USEPA 2005 - 2008. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER Directive 9285.7-55. United States Environmental Protection Agency Office of Solid Waste and Emergency Response. Washington, DC. November 2003, revised March, 200

Table 6-10
Allometrically Converted DTSC-Recommended TRVs for Representative Receptors

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

	Wildlife Receptors			
	Desert Shrew		Merriam's Kangaroo Rat	
Constituent	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Silver	8.77	87.68	8.40	84.01

Notes:
"--" = not applicable

Equation used: Aw = At * (BWt/BWw)^1-b

Where:

Aw =toxicity value of wildlife species
At =toxicity value of test species (TRV)
BWt =body weight of test species
BWw =body weight of wildlife species
b =allometric scaling factor (1.2 for birds, 0.94 for mammals)

Source:

Sample, B.E. and C.A. Arenal. 1999. Allometric Models for Interspecies Extrapolation of Wildlife Toxicity Data. Bull. Environ. Contam. Toxicol. (1999) 62: 653-663.

Table 7-1
Ecological Surface Water Screening Values

PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Analytes	CTR Criteria (µg/L)	NAWQC Freshwater CCC (µg/L)	Tier II SCV (µg/L)	Chosen Criteria (µg/L)	Hardness Adjusted Criteria (µg/L)	Source	Comments
Antimony	NA	NA	30	30	NA	Tier II SCV	USEPA (1988) FCV as cited in Suter and Tsao (1996).
Arsenic	150	150	3.1	150	NA	CTR/NAWQC	
Barium	NA	NA	4.0	4.0	NA	Tier II SCV	
Beryllium	NA	NA	0.66	0.66	NA	Tier II SCV	
Cadmium	2.2	0.25	NR	2.2	5.0	CTR	Adjusted for hardness of 300 mg/L.
Chromium, hexavalent	11	11	NR	11	NA	CTR/NAWQC	
Chromium, total dissolved[a]	180	74	NR	180	438	CTR	Adjusted for hardness of 300 mg/L.
Cobalt	NA	NA	23	23	NA	Tier II SCV	
Copper	9.0	9.0	NR	9.0	23	CTR/NAWQC	Adjusted for hardness of 300 mg/L. Also, when concentration of dissolved organic carbon is elevated, copper is substantially less toxic and use of Water-Effect Ratios might be appropriate (USEPA, 2002).
Lead	2.5	2.5	NR	2.5	8	CTR/NAWQC	Adjusted for hardness of 300 mg/L. USEPA is actively working on this criteria and so this recommended water quality criteria may change substantially in the near future (USEPA, 2002).
Manganese	NA	NA	120	120	NA	Tier II SCV	
Mercury	NA	0.77	1.30	0.77	NA	NAWQC	
Molybdenum	NA	NA	370	370	NA	Tier II SCV	
Nickel	52	52	NR	52	132	CTR/NAWQC	Adjusted for hardness of 300 mg/L.
Selenium	5.0	5.0	NA	5.0	NA	CTR/NAWQC	
Silver	NA	NA	0.36	0.36	NA	Tier II SCV	The SCV was estimated from the FAV and acute-chronic ratios for three species.

Table 7-1
Ecological Surface Water Screening Values
PG&E Topock
Needles, California
Human Health and Ecological Risk Assessment Work Plan

Analytes	CTR Criteria (µg/L)	NAWQC Freshwater CCC (µg/L)	Tier II SCV (µg/L)	Chose n Criteria (µg/L)	Hardness Adjusted Criteria (µg/L)	Source	Comments
Thallium	NA	NA	12	12	NA	Tier II SCV	
Vanadium	NA	NA	20	20	NA	Tier II SCV	
Zinc	120	120	NR	120	300	CTR/NAWQC	Adjusted for hardness of 300 mg/L.

Notes:

The screening levels were selected from available water quality criteria using the following order of preference: CTR freshwater CCC, NAWQC freshwater CCC, Tier II SCVs. Tier II values were developed so that benchmarks could be established with fewer data than required for the NAWQC. Tier II values were obtained from Suter and Tsao (1996).

a. A total chromium value was not available, therefore the NAWQC value for trivalent chromium was used.

CCC = Criterion Continuous Concentration; highest concentration in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.
CTR = California Toxics Rule
FAV = Final Acute Value
FCV = Final Chronic Value
NA = not available
NR = Not required and not calculated in the source document; NAWQC Freshwater CCC are available.
SCV = Secondary Chronic Value; derived by dividing the secondary acute value by the secondary acute-chronic ratio.
µg/L = microgram(s) per liter
USEPA = U.S. Environmental Protection Agency

Sources:

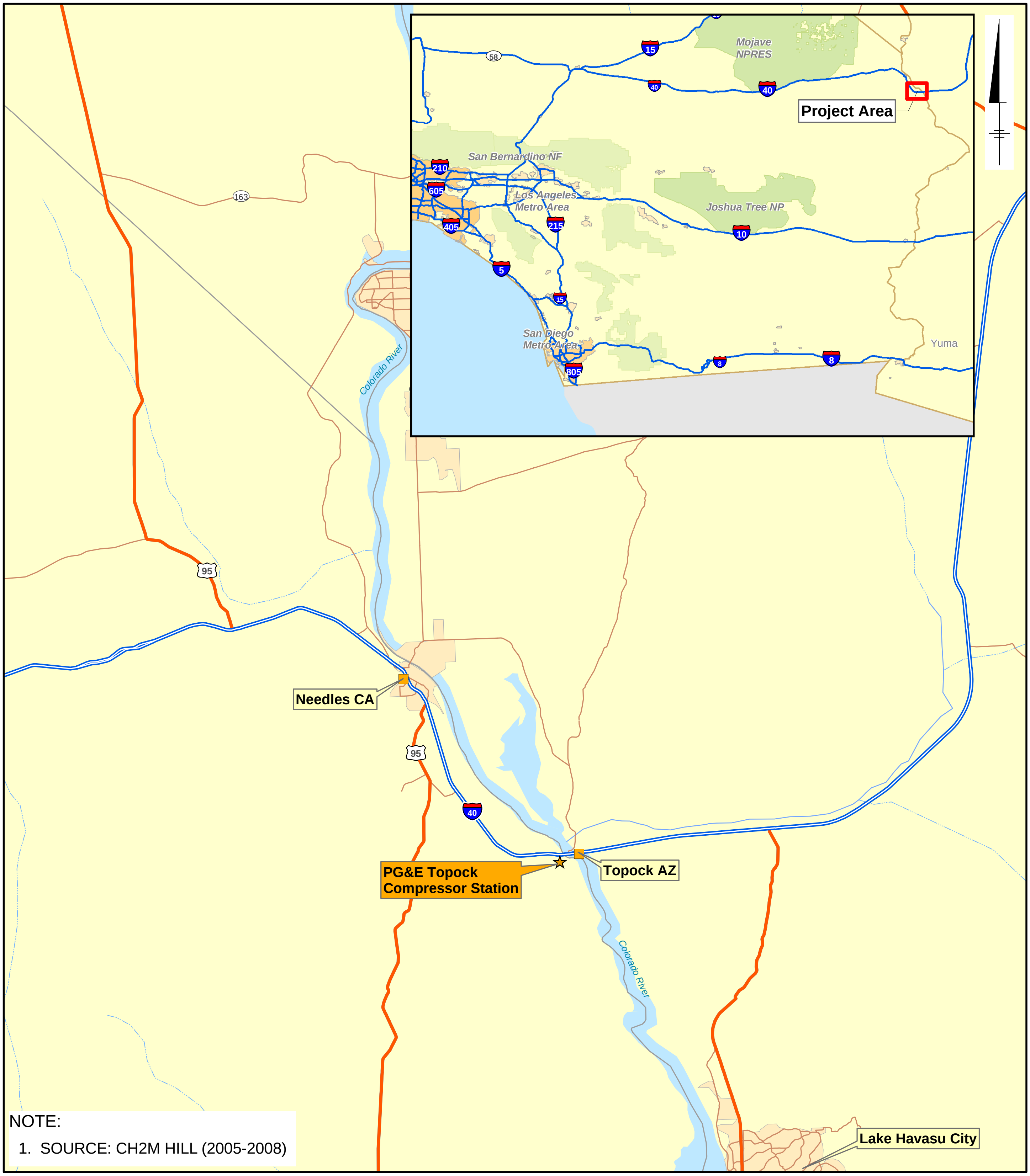
USEPA. 1988. Ambient Water Quality Criteria for Antimony (III). Draft. August. U.S. Environmental Protection Agency. As cited in Suter and Tsao, 1996.

USEPA. 2000. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule. 40 CFR 131. May. U.S. Environmental Protection Agency. Available at: http://www.epa.gov/waterscience/standards/ctr/toxic.pdf

USEPA. 2002. National Recommended Water Quality Criteria. EPA 822-R-02-047. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. November. Available at: http://www.epa.gov/waterscience/criteria/wqcriteria.html

Suter, G.W. , II, and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp. ES/ER/TM-96/R2

Figures



NOTE:

1. SOURCE: CH2M HILL (2005-2008)

LEGEND:

═ LIMITED ACCESS

━ HIGHWAY

— MAJOR ROAD

— LOCAL ROAD

— STREAM

▨ LAKE

0 50 100 Miles

GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

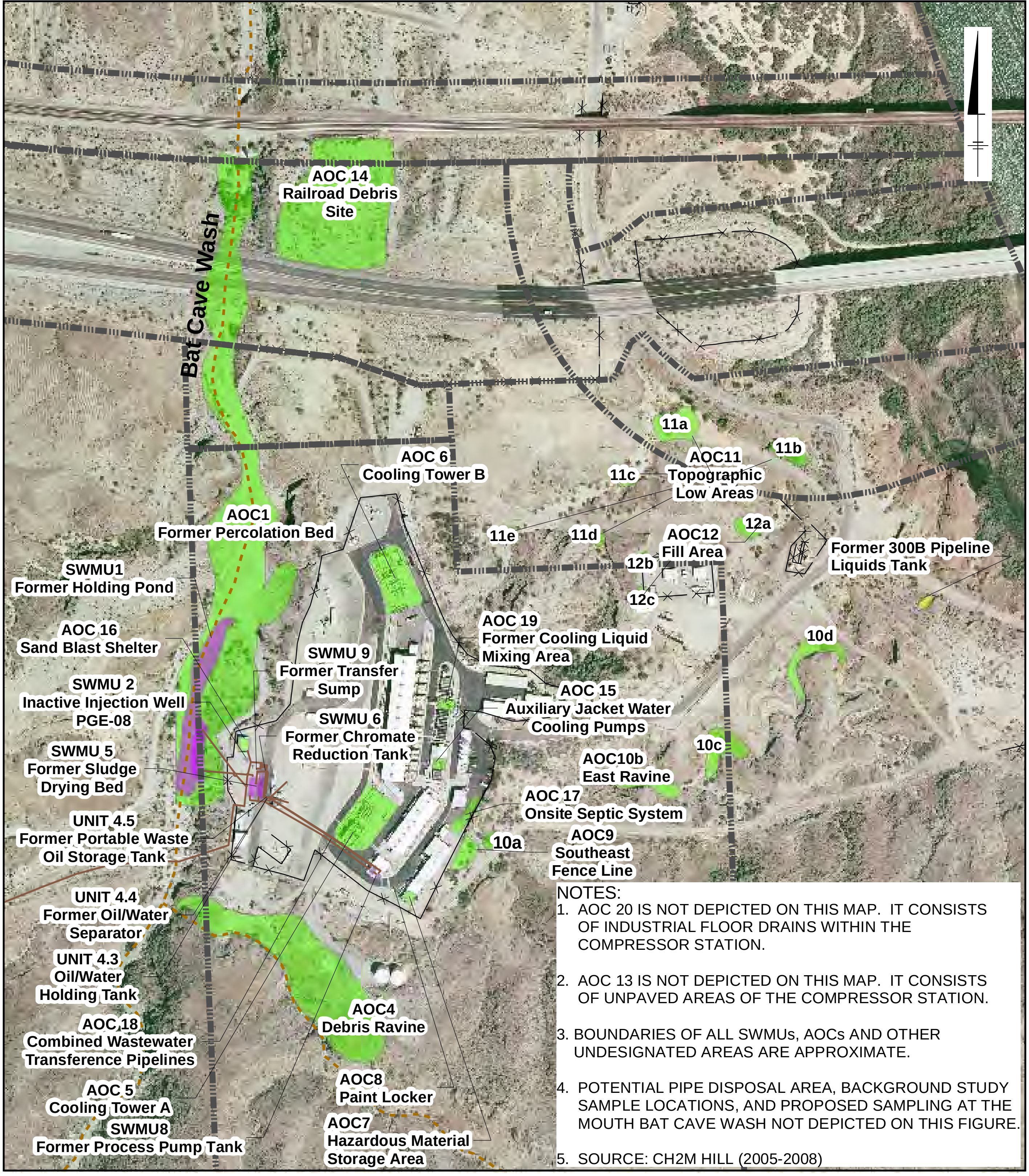
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SITE VICINITY MAP

ARCADIS

FIGURE
1-1

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 1-1 Site Location Map.mxd - 1/23/2008 @ 12:26:26 PM



NOTES:

1. AOC 20 IS NOT DEPICTED ON THIS MAP. IT CONSISTS OF INDUSTRIAL FLOOR DRAINS WITHIN THE COMPRESSOR STATION.
2. AOC 13 IS NOT DEPICTED ON THIS MAP. IT CONSISTS OF UNPAVED AREAS OF THE COMPRESSOR STATION.
3. BOUNDARIES OF ALL SWMUs, AOCs AND OTHER UNDESIGNATED AREAS ARE APPROXIMATE.
4. POTENTIAL PIPE DISPOSAL AREA, BACKGROUND STUDY SAMPLE LOCATIONS, AND PROPOSED SAMPLING AT THE MOUTH BAT CAVE WASH NOT DEPICTED ON THIS FIGURE.
5. SOURCE: CH2M HILL (2005-2008)

LEGEND

🟩	AREAS OF CONCERN (AOC)
🟪	SOLID WASTE MANAGEMENT UNITS (SWMU)
🟨	OTHER (UNDESIGNATED AREA)
――――	TRANSFER PIPING
—✕—	FENCE WALL
— · · —	PROPERTY BOUNDARIES
- - -	RAVINE

0 200 400 Feet

GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SWMUs, AOCs, AND OTHER UNDESIGNATED AREAS

ARCADIS

FIGURE
2-1

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-1 SWMUs_AOCs_Undesignated Areas.mxd - 7/16/2008 @ 10:47:34 AM

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-2 Soil Sample Locs_SWMU 1_AOC 1_v2.mxd - 8/20/2008 @ 12:09:07 PM

LEGEND

- ● PROPOSED SOIL SAMPLE LOCATION
- ● EXISTING SOIL SAMPLE LOCATION
- PROPERTY LINE
- NATURAL GAS PIPELINE *
- 🟩 AOC 1 BOUNDARY
- 🟧 SWMU 1 BOUNDARY
- RAVINE

NOTES:

1. THE LOCATIONS FOR SAMPLES WP-1 THROUGH WP-6, T-1 THROUGH T-3, P-1, P-2, WP-BANK1, WP-BANK2, BANK-B, AND BANK-WP ARE APPROXIMATE.
2. * PIPELINE LOCATIONS AND ACCESS ROUTES ARE APPROXIMATE.
3. SOURCE: CH2M HILL (2005-2008)

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SOIL SAMPLE LOCATIONS
SWMU 1/AOC 1
FORMER PERCOLATION BED

ARCADIS

FIGURE
2-2

LEGEND:

● EXISTING SEDIMENT SAMPLE LOCATION

RAVINE

NOTES:

1. SOURCE: CH2M HILL (2005-2008)

2. FOR THE RISK ASSESSMENT, SEDIMENT DATA ARE DEFINED AS SAMPLE RESULTS COLLECTED FROM AREAS THAT ARE TYPICALLY INUNDATED WITH WATER EVEN IN THE ABSENCE OF STORM EVENTS. SAMPLES SS-2 THROUGH SS-8 ARE NOT CONSIDERED SEDIMENT FOR PURPOSES OF THE RISK ASSESSMENT.

0 400 800
Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SEDIMENT SAMPLE LOCATIONS
SWMU 1/AOC 1

ARCADIS

FIGURE
2-3

LEGEND

- 🟡 PROPOSED SAMPLE LOCATION
- 🟢 EXISTING SOIL SAMPLE LOCATION
- 🟩 AOC 4 BOUNDARY
- ▪·▪·▪ PROPERTY LINE
- — NATURAL GAS PIPELINE *
- — TRENCH LOCATIONS

NOTES:

1. * PIPELINE LOCATIONS ARE APPROXIMATE.
2. SOURCE: CH2M HILL (2005-2008)

0 50 100 Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 4 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-4

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-4 AOC 4 Soil Sample Locs.mxd - 7/15/2008 @ 3:39:41 PM

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-5 AOC 9 Soil Sample Locs.mxd - 7/15/2008 @ 4:19:05 PM

LEGEND:

🟡 PROPOSED SAMPLE LOCATION

🟢 EXISTING SOIL SAMPLE LOCATION

— NATURAL GAS PIPELINE *

▭ AOC 9 BOUNDARY

NOTES:

1. * PIPELINE LOCATIONS ARE APPROXIMATE

2. SOURCE: CH2M HILL (2005-2008)

0 40 80 Feet

GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

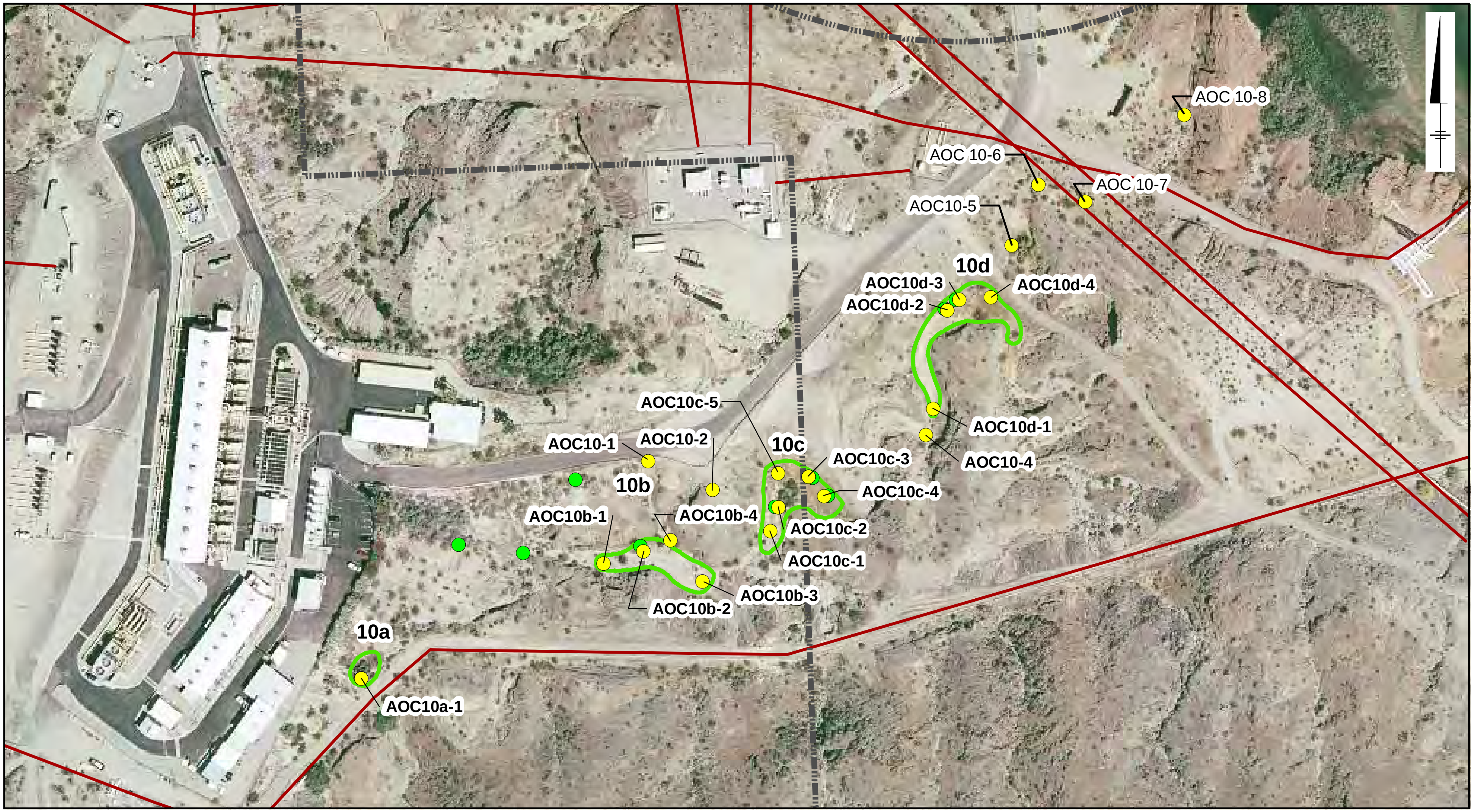
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 9 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-5

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-6 AOC 10 Soil Sample Locs.mxd



LEGEND

● PROPOSED SAMPLE LOCATION

● EXISTING SOIL SAMPLE LOCATION

▬ ▪ ▪ ▬ PROPERTY LINE

▬ NATURAL GAS PIPELINE *

▭ AOC 10 BOUNDARY

NOTES:

1. * PIPELINE LOCATIONS ARE APPROXIMATE

2. SOURCE: CH2M HILL (2005-2008)

0 100 200 Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

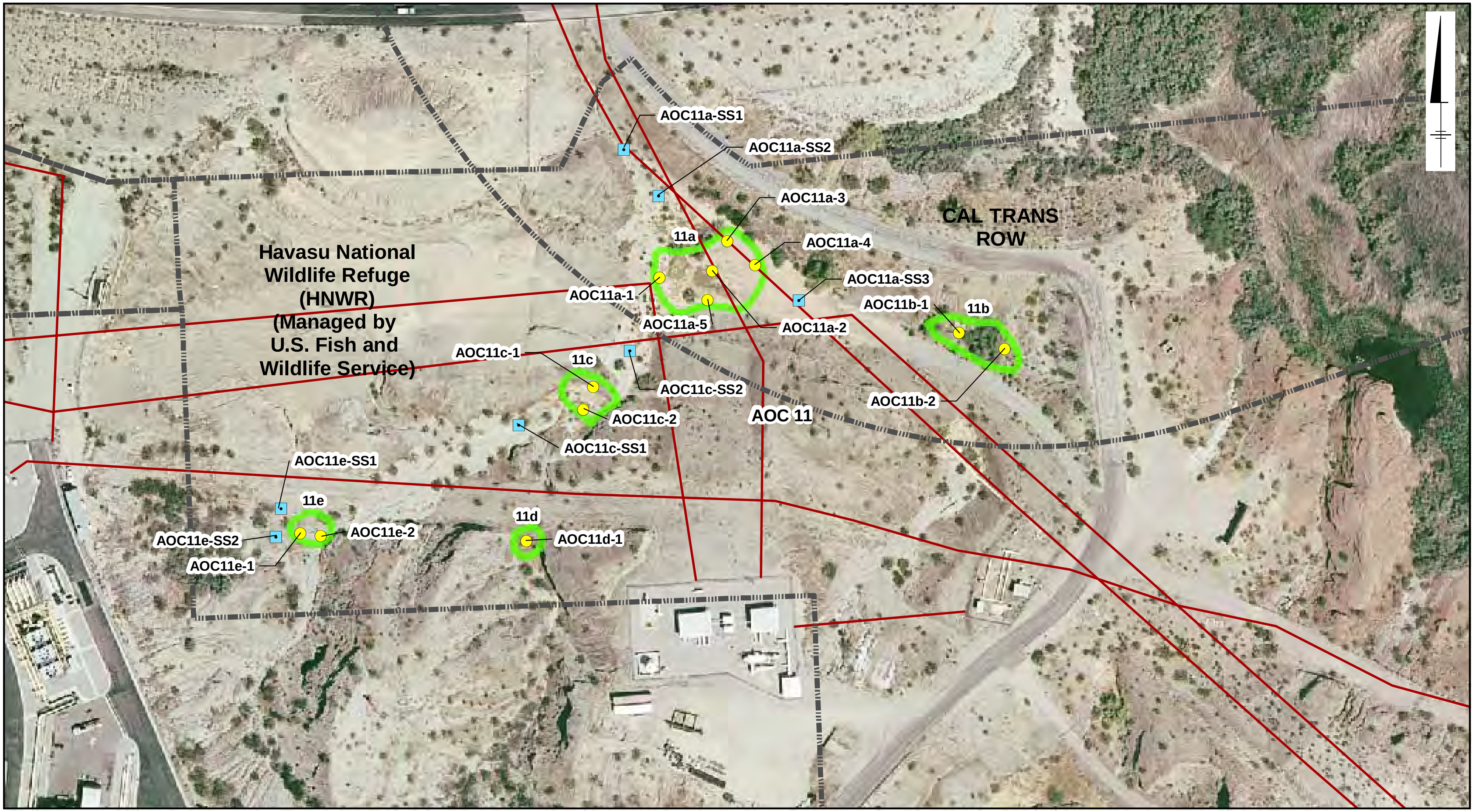
**HUMAN HEALTH AND ECOLOGICAL
RISK ASSESSMENT WORK PLAN**

AOC 10 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-6

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-7 AOC 11 Soil Sample Locs.mxd



LEGEND

- 🟡 PROPOSED SAMPLE LOCATION
- 🟢 EXISTING SOIL SAMPLE LOCATION
- 🟦 SECONDARY PROPOSED SAMPLE LOCATION *
- 🟩 AOC 11 BOUNDARY
- ▬ ▪ ▪ ▬ PROPERTY LINE
- ▬ NATURAL GAS PIPELINE **

NOTES:

1. * SOIL SAMPLES FROM THESE LOCATIONS ARE SECONDARY SAMPLES TO BE HELD FOR ANALYSIS AND ANALYZED CONTINGENT UPON RESULTS OF PRIMARY SAMPLES.

2. ** PIPELINE LOCATIONS ARE APPROXIMATE.

3. SOURCE: CH2M HILL (2005-2008)

0 100 200 Feet

GRAPHIC SCALE

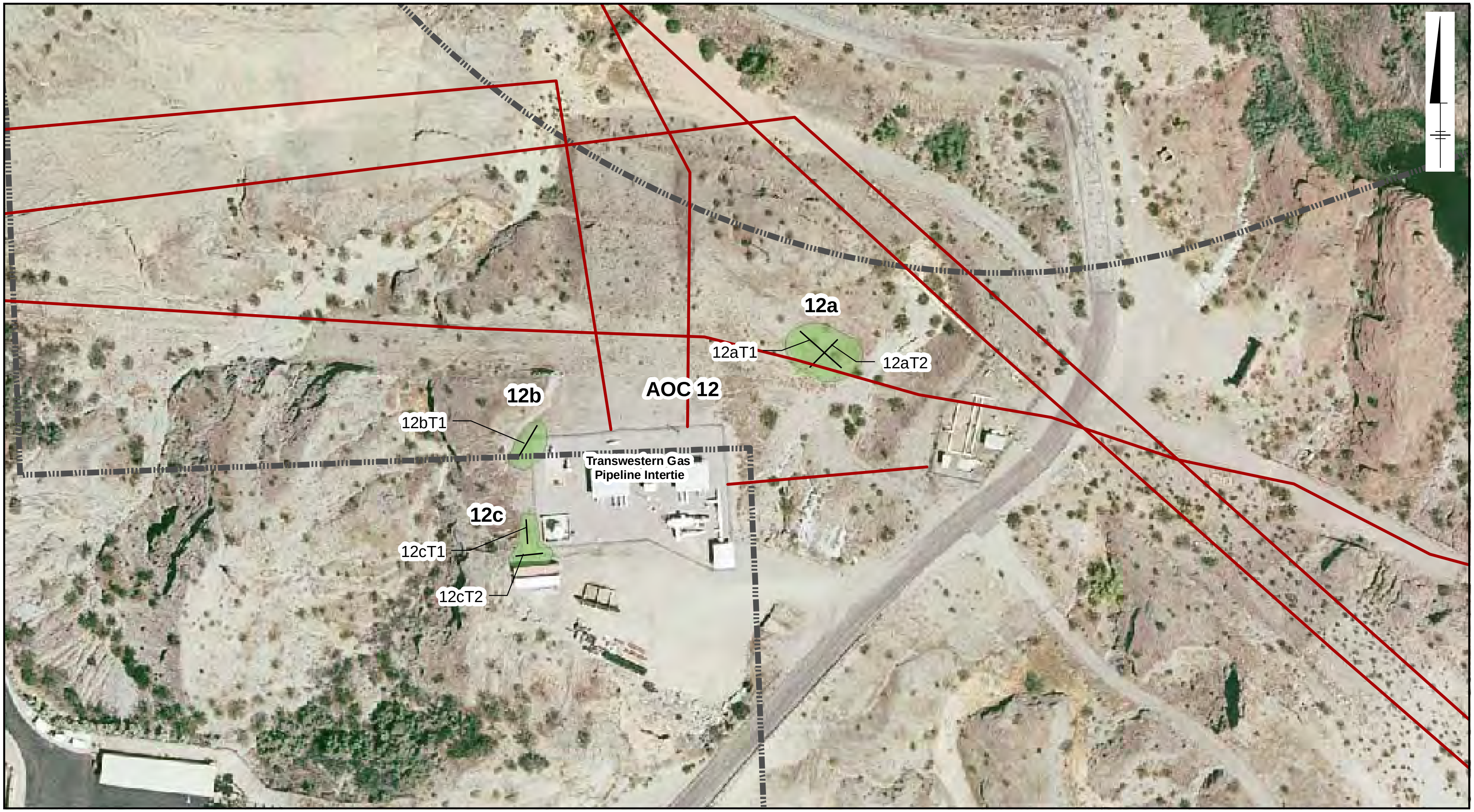
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 11 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-7



LEGEND

▪▪▪▪ PROPERTY LINE

▬ NATURAL GAS PIPELINE *

— PROPOSED TRENCH LOCATION

🟩 AOC 12

NOTES:

1. * PIPELINE LOCATIONS AND ACCESS ROUTES ARE APPROXIMATE.

2. SOURCE: CH2M HILL (2005-2008)

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

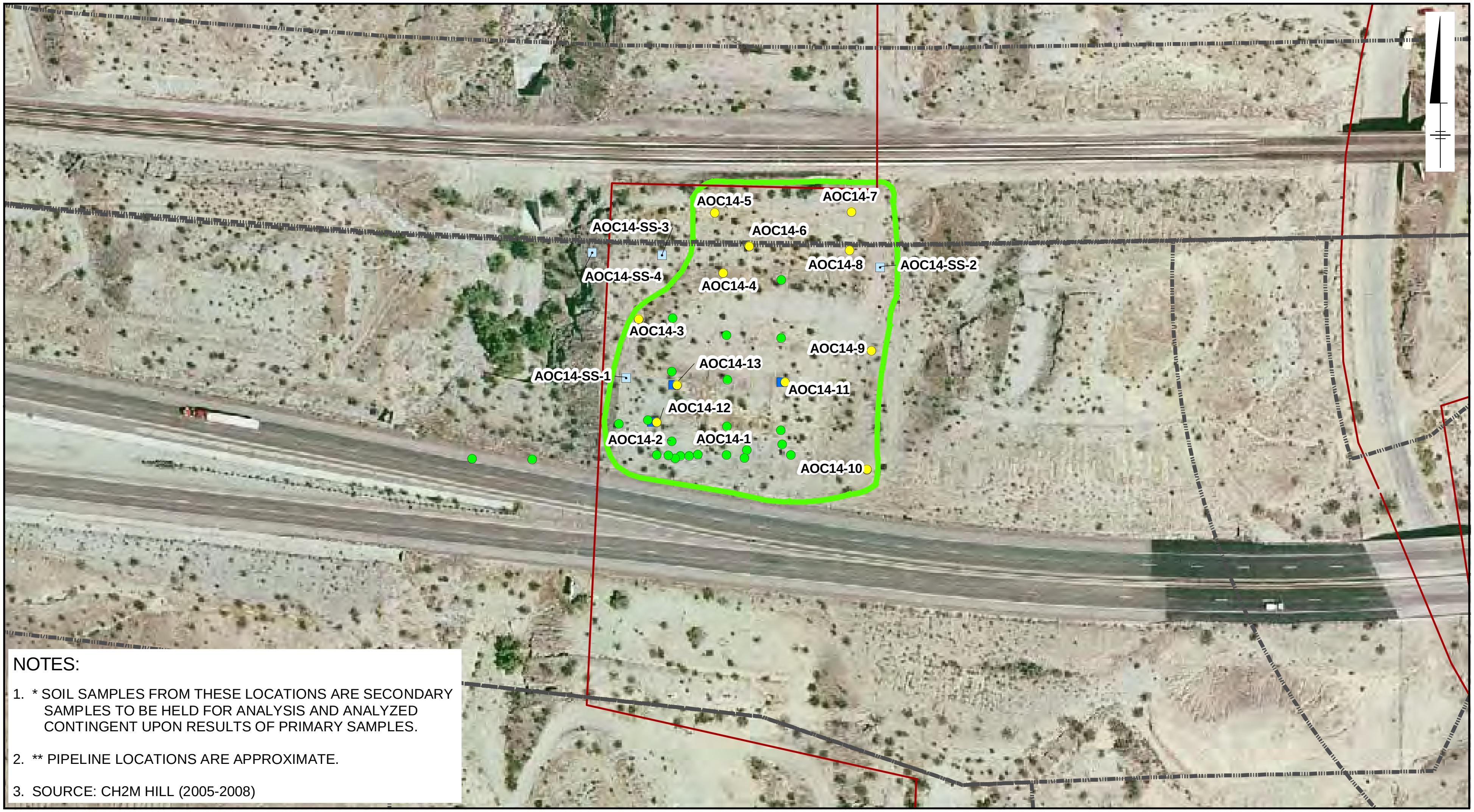
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 12 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-8

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-9 AOC 14 Soil Sample Locs.mxd - 7/15/2008 @ 5:10:32 PM



NOTES:

1. * SOIL SAMPLES FROM THESE LOCATIONS ARE SECONDARY SAMPLES TO BE HELD FOR ANALYSIS AND ANALYZED CONTINGENT UPON RESULTS OF PRIMARY SAMPLES.

2. ** PIPELINE LOCATIONS ARE APPROXIMATE.

3. SOURCE: CH2M HILL (2005-2008)

LEGEND

● PROPOSED SAMPLE LOCATION

● EXISTING SOIL SAMPLE LOCATION

■ EXISTING DEBRIS SAMPLE LOCATION

▣ SUPPLEMENTAL PROPOSED SAMPLE LOCATIONS *

▬ ▪ ▪ ▬ PROPERTY LINE

— NATURAL GAS PIPELINE **

🟩 RAILROAD DEBRIS SITE BOUNDARY

0 100 200 Feet

GRAPHIC SCALE

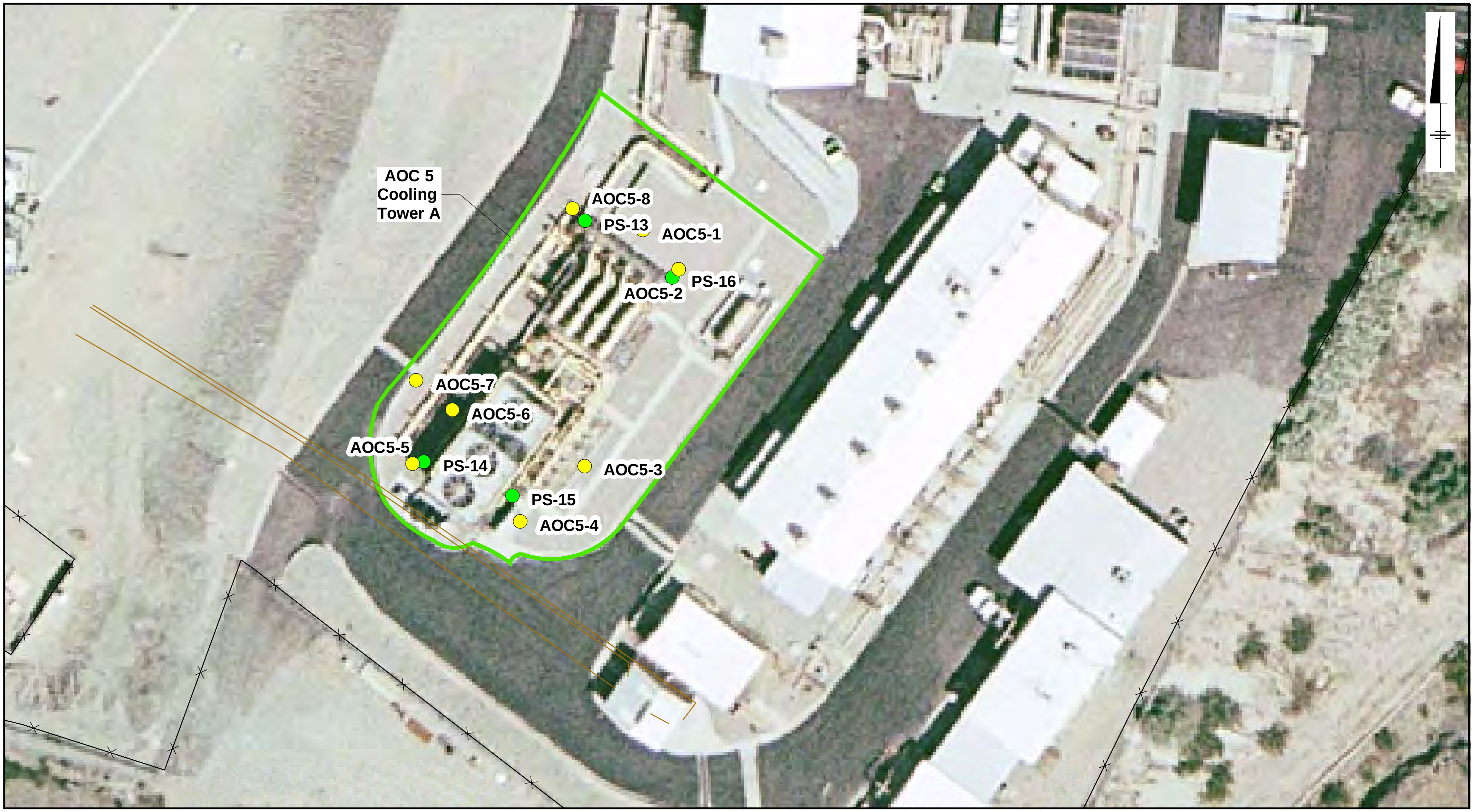
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 14 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE 2-9

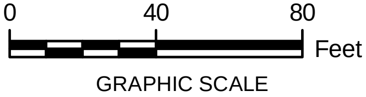


LEGEND:

- 🟡 PROPOSED SAMPLE LOCATION
- 🟢 EXISTING SOIL SAMPLE LOCATION
- —×— SITE FENCE BOUNDARY
- —— TRANSFER PIPING
- 🟩 AOC 5 BOUNDARY

NOTE:

1. SOURCE: CH2M HILL (2005-2008)



PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 5 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-10

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-11 AOC 6 Soil Sample Locs.mxd - 7/21/2008 @ 3:31:36 PM

LEGEND:

- 🟡 PROPOSED SAMPLE LOCATION
- 🟢 EXISTING SOIL SAMPLE LOCATION
- —×— SITE FENCE BOUNDARY
- ▭ AOC BOUNDARY

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 40 80
Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 6 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-11

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
O:\PGE\Topock\HHERA\Mxd\Figure 2-12 AOC 7 Soil Sample Locs.mxd - 1/25/2008 @ 12:04:42 PM

LEGEND:

● PROPOSED SAMPLE LOCATION
—×— SITE FENCE BOUNDARY
—— TRANSFER PIPING
▭ AOC BOUNDARY

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 50 100 Feet
GRAPHIC SCALE

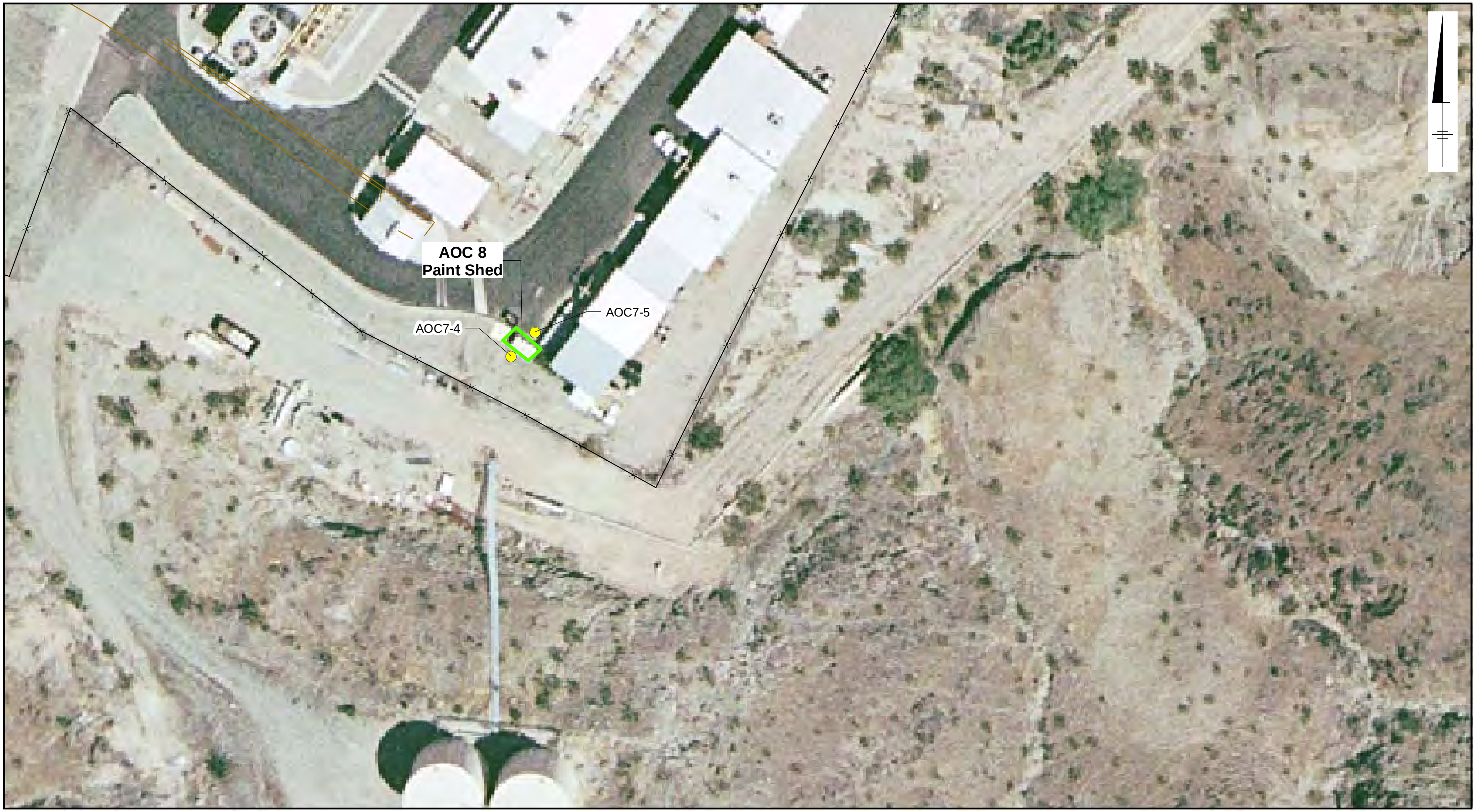
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 7 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-12

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-13 AOC 8 Soil Sample Locs.mxd - 1/25/2008 @ 12:38:19 PM



LEGEND:

● PROPOSED SAMPLE LOCATION

—×— SITE FENCE BOUNDARY

—— TRANSFER PIPING

▭ AOC BOUNDARY

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 50 100 Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 8 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-13

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-14 AOC 13 Soil Sample Locs.mxd - 2/13/2008 @ 3:42:50 PM

LEGEND:

🟢	EXISTING SOIL SAMPLE LOCATION
🟡	PROPOSED SAMPLE LOCATION

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 50 100 Feet
GRAPHIC SCALE

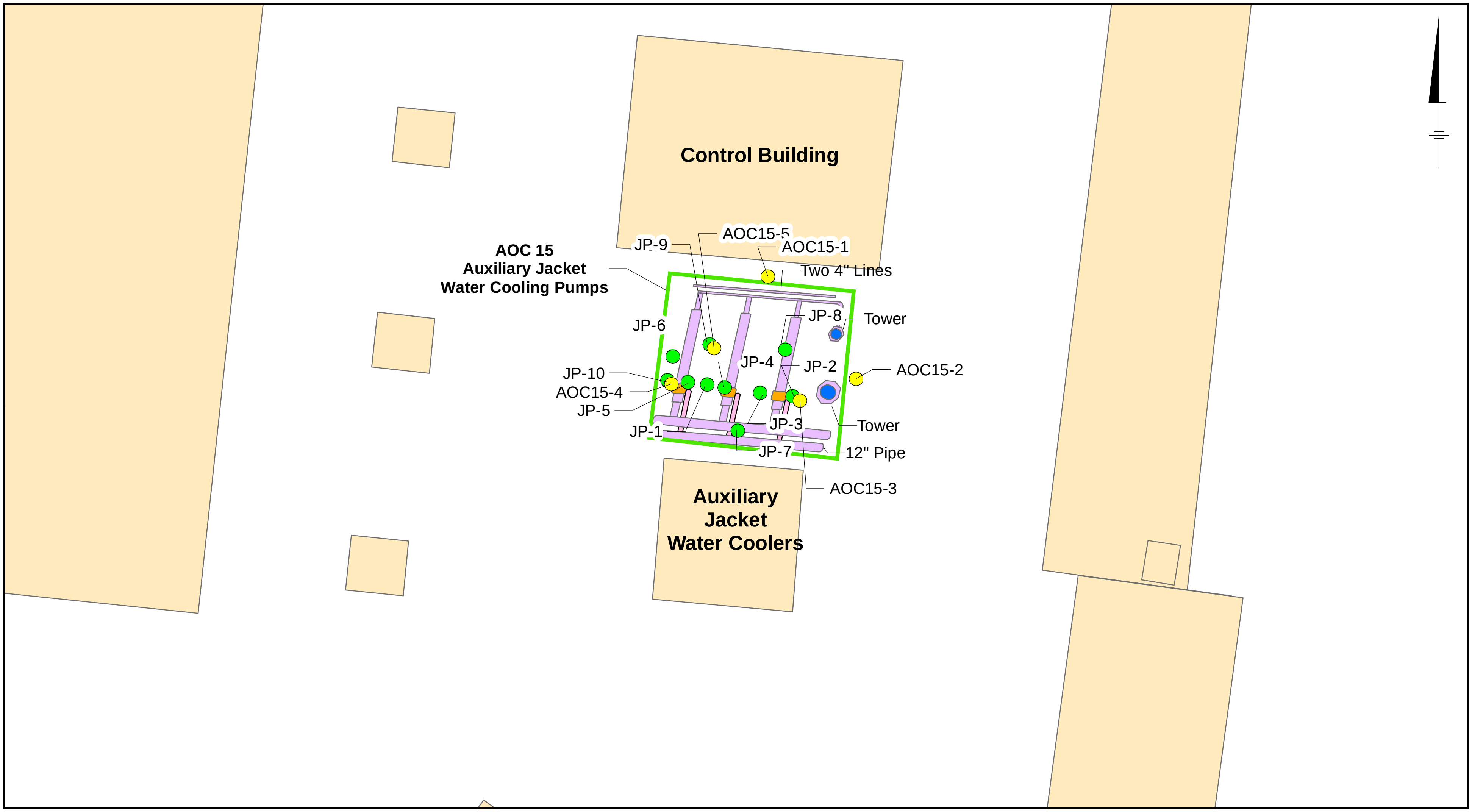
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 13 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-14

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-15 AOC 15 Soil Sample Locs.mxd - 1/25/2008 @ 12:06:43 PM



LEGEND

- 🟡 PROPOSED SOIL SAMPLE LOCATION
- 🟢 EXISTING SOIL SAMPLE LOCATION
- 🟩 AOC 15 BOUNDARY
- 🟧 BUILDINGS

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 10 20 Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 15 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-15

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-16 AOC 16 Soil Sample Locs.mxd - 1/29/2008 @ 12:04:26 PM

LEGEND:

- 🟡 PROPOSED SOIL SAMPLE LOCATION
- 🟢 EXISTING SOIL SAMPLE LOCATION
- —×— SITE FENCE BOUNDARY
- —— TRANSFER PIPING
- 🟩 AOC 16 BOUNDARY

NOTES:

1. THE EXISTING SOIL SAMPLING DATA WERE COLLECTED AT AOC 2. DUE TO THE CLOSE PROXIMITY OF THE AOC 2 DATA TO AOC 16 THE DATA ARE REPRESENTATIVE OF AOC 16.

2. SOURCE: CH2M HILL (2005-2008).

0 50 100 Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 16 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-16

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-17 AOC 17 Soil Sample Locs.mxd - 1/23/2008 @ 12:38:07 PM

LEGEND:

● PROPOSED SOIL SAMPLE LOCATION

—×— SITE FENCE BOUNDARY

🟩 AOC 17 BOUNDARY

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 50 100 Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 17 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-17

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-18 AOC 19 Soil Sample Locs.mxd - 1/23/2008 @ 10:05:15 AM

LEGEND:

- 🟡 PROPOSED SOIL SAMPLE LOCATION
- 🟢 EXISTING SOIL SAMPLE LOCATION
- —×— SITE FENCE BOUNDARY
- ▭ AOC 19 BOUNDARY

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 50 100 Feet

GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 19 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-18

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
O:\PGE\Topock\HHERA\Mxd\Figure 2-19 AOC 20 Soil Sample Locs.mxd - 2/12/2008 @ 10:47:08 AM

NOTE:
1. SOURCE: CH2M HILL (2005-2008)

LEGEND:

- ● PROPOSED SOIL SAMPLE LOCATION
- ⊕ WELL LOCATION
- ● INDUSTRIAL FLOOR DRAIN
- ■ PIPE TRENCH SUMP
- - - - DIRT ROAD
- —×— FENCE WALL
- — BUILDINGS LINE
- — CURRENT UNDERGROUND PIPING
- — CURRENT ABOVE GROUND PIPING
- — ABANDONED LINE
- — HISTORIC PIPING
- ☐ CURRENT STRUCTURES
- ▨ HISTORIC STRUCTURES

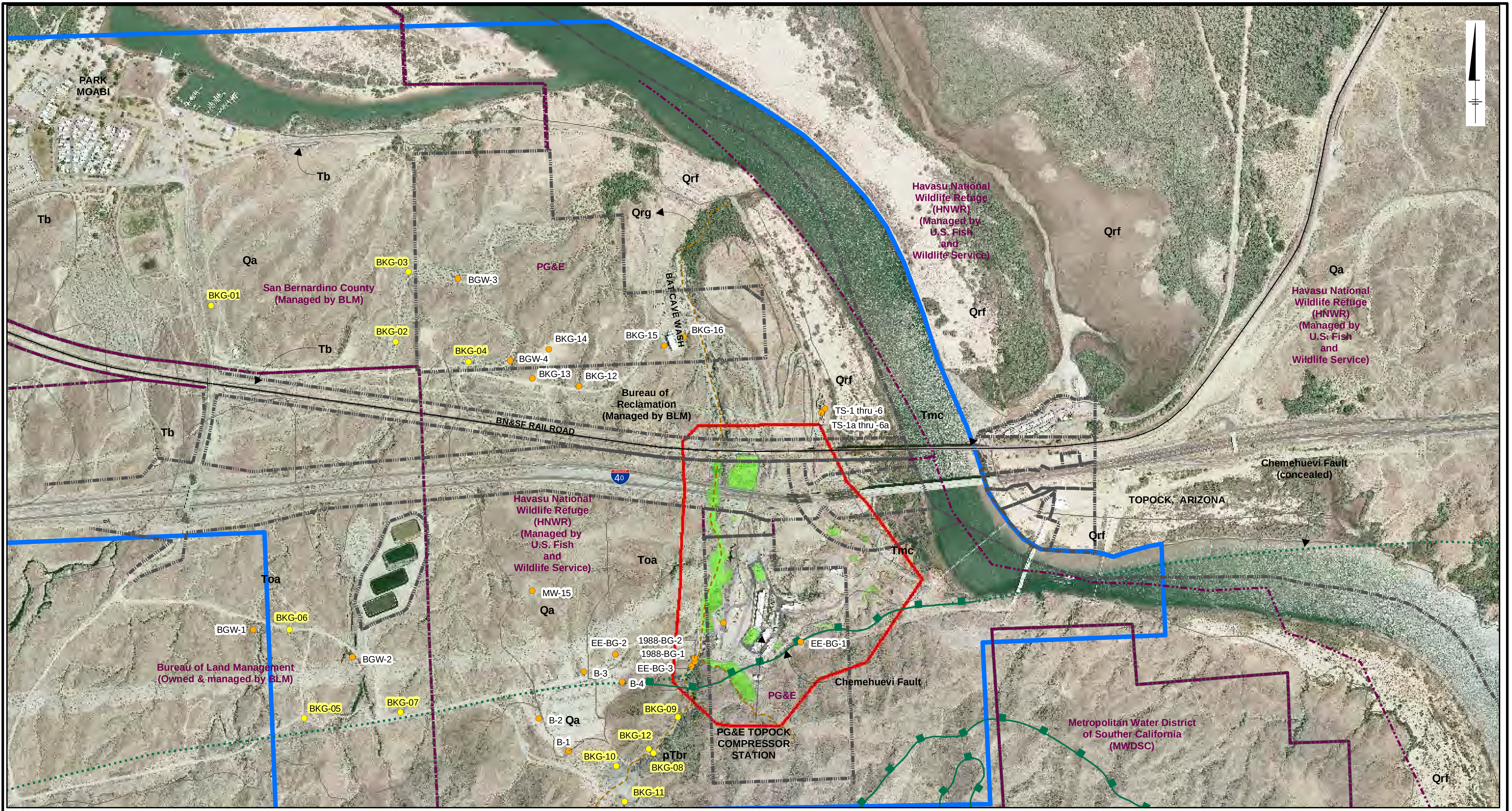
0 100 200
Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

AOC 20 SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-19



LEGEND:

DETACHMENT FAULT BARBS ON DOWNTHROWN SIDE

DETACHMENT FAULT CONCEALED

● PROPOSED SAMPLE LOCATIONS

● EXISTING BACKGROUND SOIL SAMPLE LOCATIONS

AREA OF POTENTIAL EFFECTS

PG&E COMPRESSOR STATION BOUNDARY LINE

🟩 AREA OF CONCERN (AOC)

🟪 SOLID WASTE MANAGEMENT UNIT (SWMU)

NOTES:

0 500 1,000 Feet

GRAPHIC SCALE

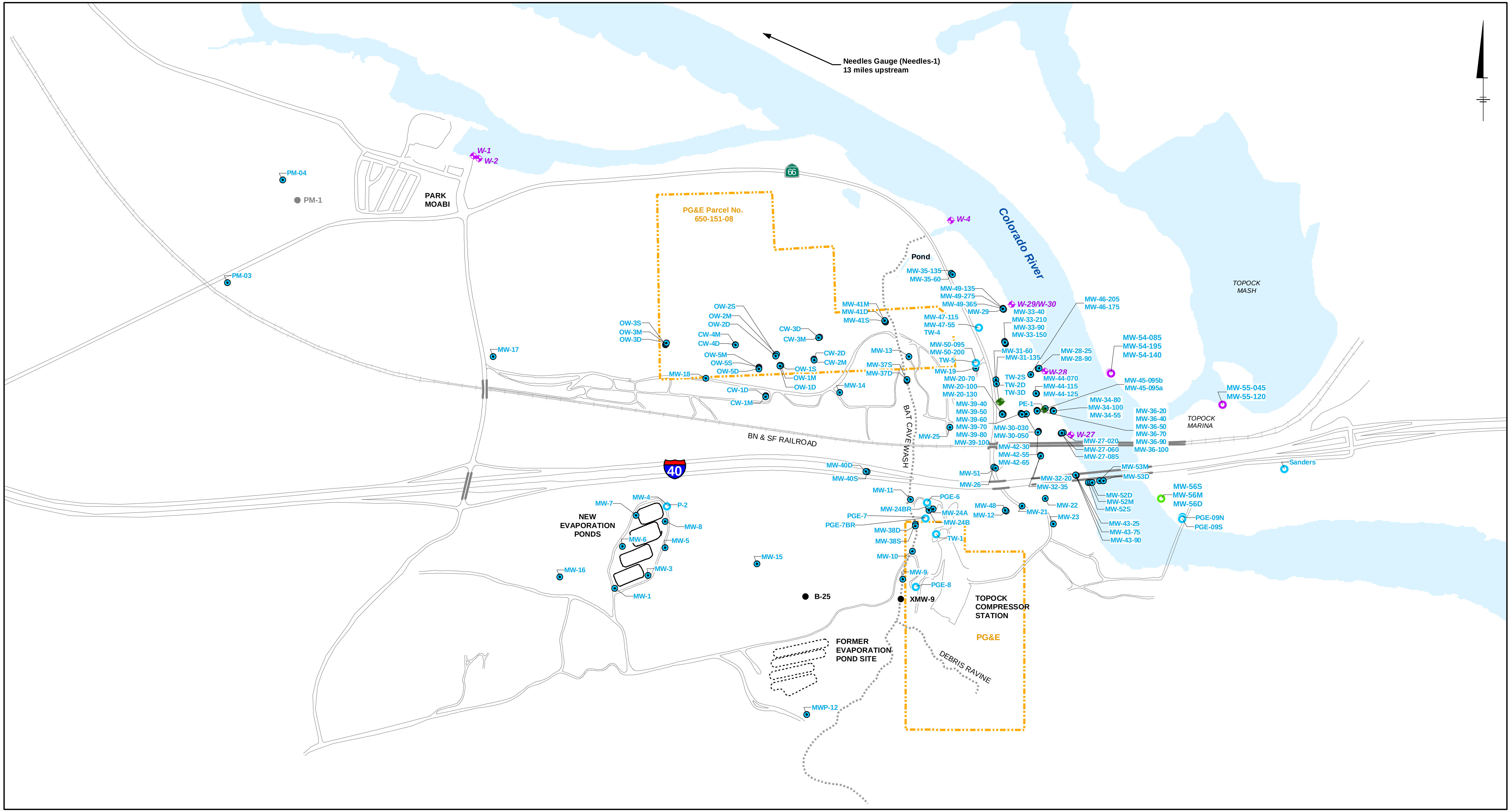
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

BACKGROUND SOIL SAMPLE LOCATIONS

ARCADIS

FIGURE
2-20

[CITY-DIV MTK TBR EAB KEW EGH PGL] SYR-85 MTK TBR EAB KEW EGH PGL
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-20 Background Soil Sample Locs.mxd - 8/19/2008 @ 2:36:15 PM



LEGEND

●	ABANDONED WATER SUPPLY WELL
⊕	INTERSTITIAL WATER SAMPLING LOCATION
●	EXPLORATION BORING
◉	GROUNDWATER MONITORING WELLS
○	WATER SUPPLY AND TEST WELLS
⊕	EXTRACTION WELL
○	NEW VERTICAL MONITORING WELL
○	NEW SLANT MULTI-LEVEL MONITORING WELL
⬚	FORMER EVAPORATION POND
☐	NEW EVAPORATION POND
-·-·-	PG&E PROPERTY LINE
—+—	RAILROAD
——	ROAD
······	RAVINE

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 800 1,600 Feet

GRAPHIC SCALE

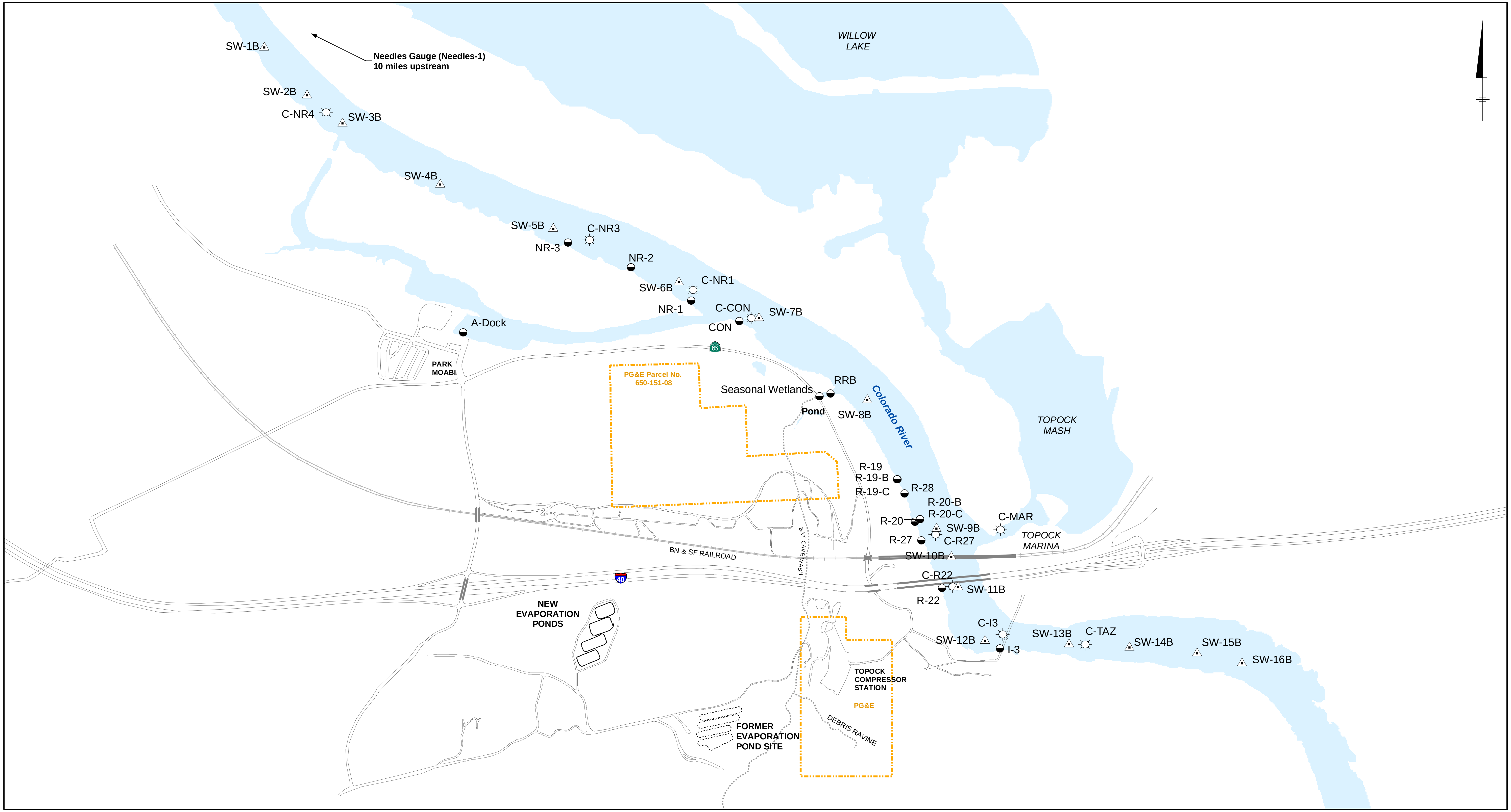
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL
RISK ASSESSMENT WORK PLAN

GROUNDWATER SAMPLE LOCATIONS

ARCADIS

FIGURE
2-21a

[MC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-21a GW Sample Locs.mxd - 8/21/2008 @ 4:46:24 PM



LEGEND

◒ SHORELINE SURFACE WATER SAMPLING LOCATION

☼ RIVER CHANNEL SURFACE WATER SAMPLING LOCATION

△ Pore Water Study Surface Water Sampling Location

PG&E PROPERTY LINE

RAILROAD

ROAD

RAVINE

FORMER EVAPORATION POND

NEW EVAPORATION POND

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 800 1,600
Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL
RISK ASSESSMENT WORK PLAN

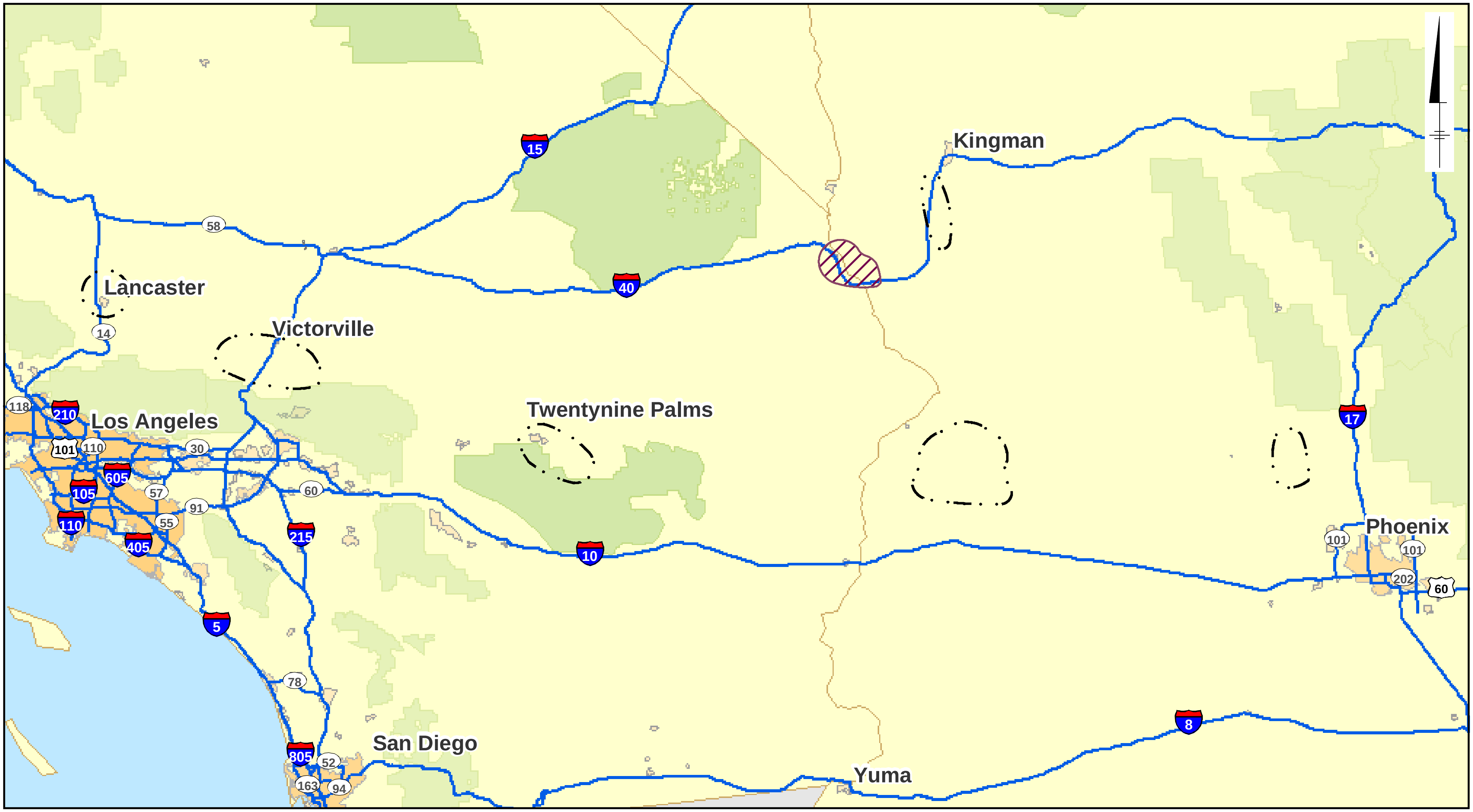
SURFACE WATER SAMPLE LOCATIONS

ARCADIS

FIGURE
2-21b

[MC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
O:\PGE\Topock\HHERA\Mxd\Figure 2-21b GW and SW Sample Locs.mxd - 8/21/2008 @ 4:48:39 PM

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-22 Background GW Study Locs.mxd - 1/23/2008 @ 10:38:20 AM

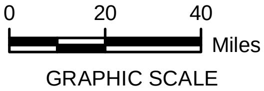


LEGEND:

- GENERAL AREA OF PUBLISHED BACKGROUND CHROMIUM SAMPLING
- ▨ GENERAL AREA OF PROPOSED TOPOCK BACKGROUND CHROMIUM STUDY

NOTE:

1. SOURCE: CH2M HILL (2005-2008)



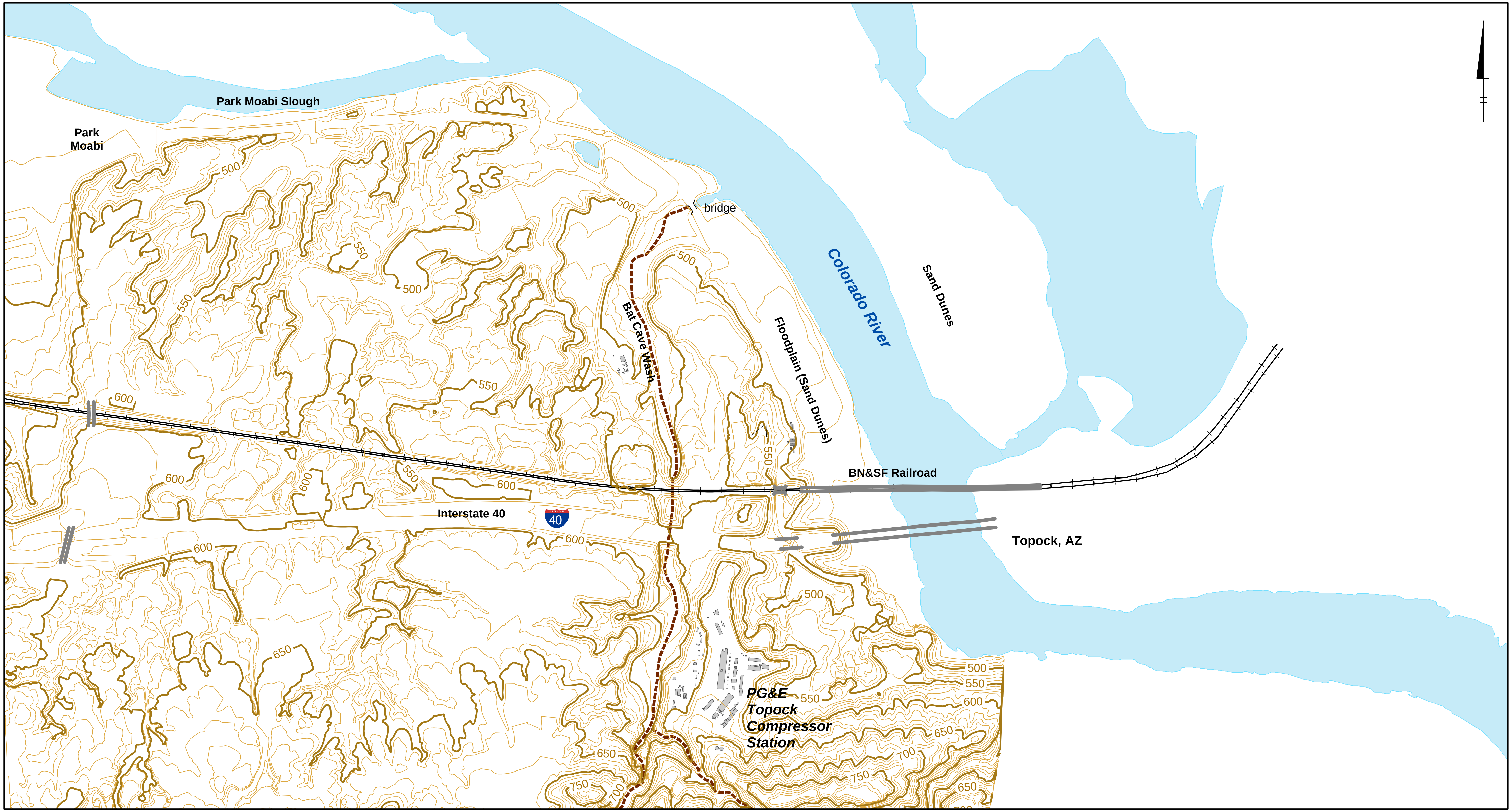
PACIFIC GAS AND ELECTRIC COMPANY,
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

BACKGROUND GROUNDWATER STUDY LOCATIONS

ARCADIS

FIGURE
2-22



LEGEND

- CONTOUR 50 FT
- CONTOUR 10 FT
- RAILROAD
- BAT CAVE WASH
- GRAVEL
- PAVED
- HIGHWAY
- BRIDGES
- ▨ BUILDING
- 🟦 WATER

NOTES:

1. SOURCE: TOPOGRAPHIC DATA FROM E & E, INC., 1994, WITH ADDITIONAL AERIAL TOPOGRAPHIC MAPPING FLOWN APRIL, 2004 (CH2M HILL).

2. CALIFORNIA STATE PLANE, NAD 83, ZONE 5, US FEET CONTOUR INTERVAL IS 10 FEET, WITH INDICES AT 50 FEET.

3. SOURCE: CH2M HILL (2005-2008)

0 700 1,400 Feet

GRAPHIC SCALE

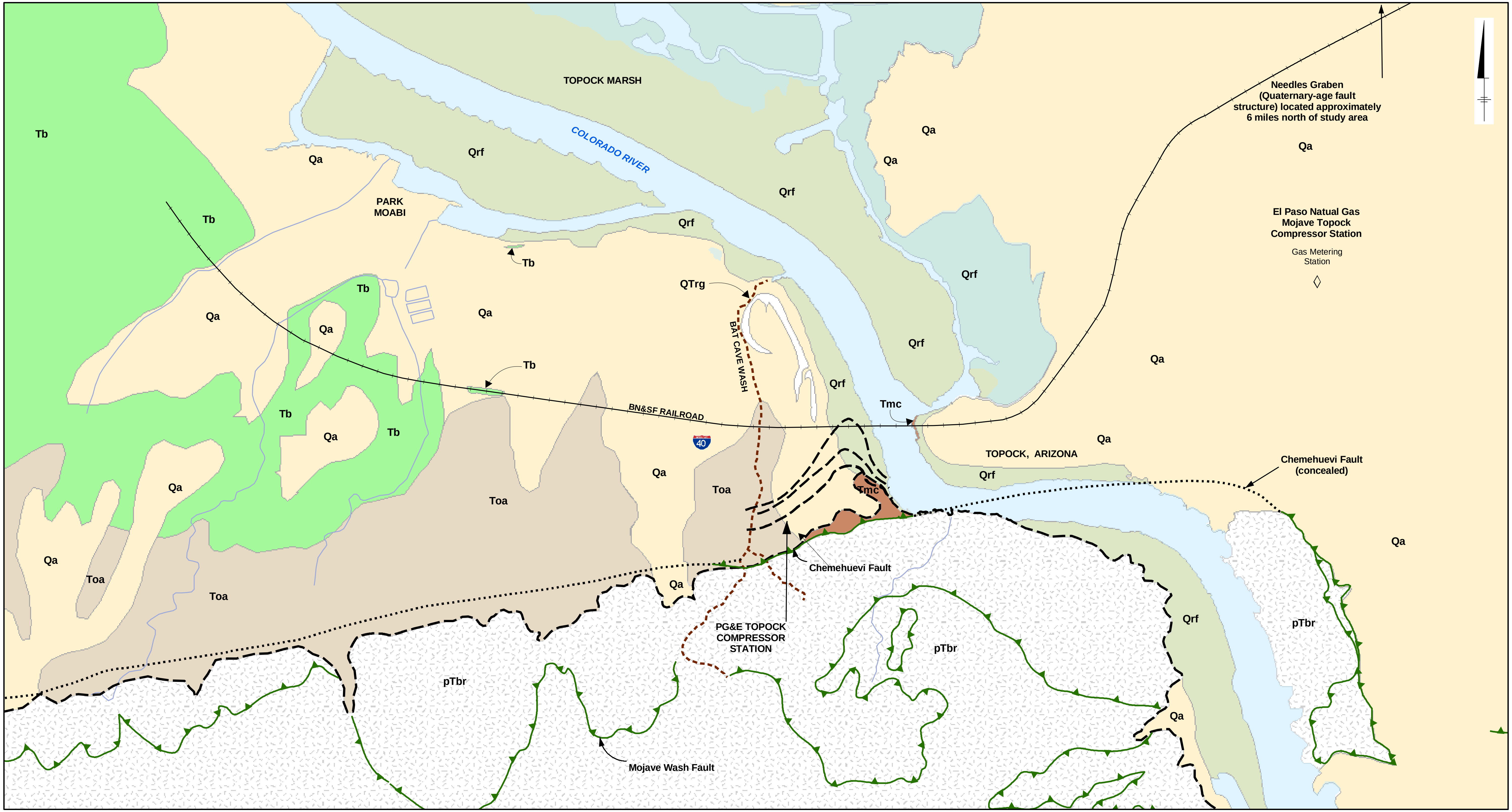
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SITE TOPOGRAPHY

ARCADIS

FIGURE
2-23

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-23 Site Topography.mxd - 1/25/2008 @ 12:39:34 PM



LEGEND

- DETACHMENT FAULT
- DETACHMENT FAULT CONCEALED
- BEDROCK CONTACT
- RAVINE
- STREAMS
- SURFACE WATER

- QRF = QUATERNARY COLORADO RIVER AND RECENT FLOODPLAIN DEPOSITS
- Qa = QUATERNARY ALLUVIUM AND SURFICIAL DEPOSITS, UNDIFFERENTIATED
- Tb = BOUSE FORMATION
- Toa = OLDEST ALLUVIUM (UNDEFORMED FANGLOMERATE)
- pTbr = PRE-TERTIARY BEDROCK (METADIORITE, GNEISS, GRANITIC ROCKS)

NOTES:

1. GENERALIZED SURFACE GEOLOGIC MAP COMPILED FROM METZGER AND LOELTZ (1973), JOHN (1987), HOWARD AND OTHERS (1997) AND PG&E TECHNICAL REPORTS.
2. SOURCE: CH2M HILL (2005-2008)

0 1,000 2,000
Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

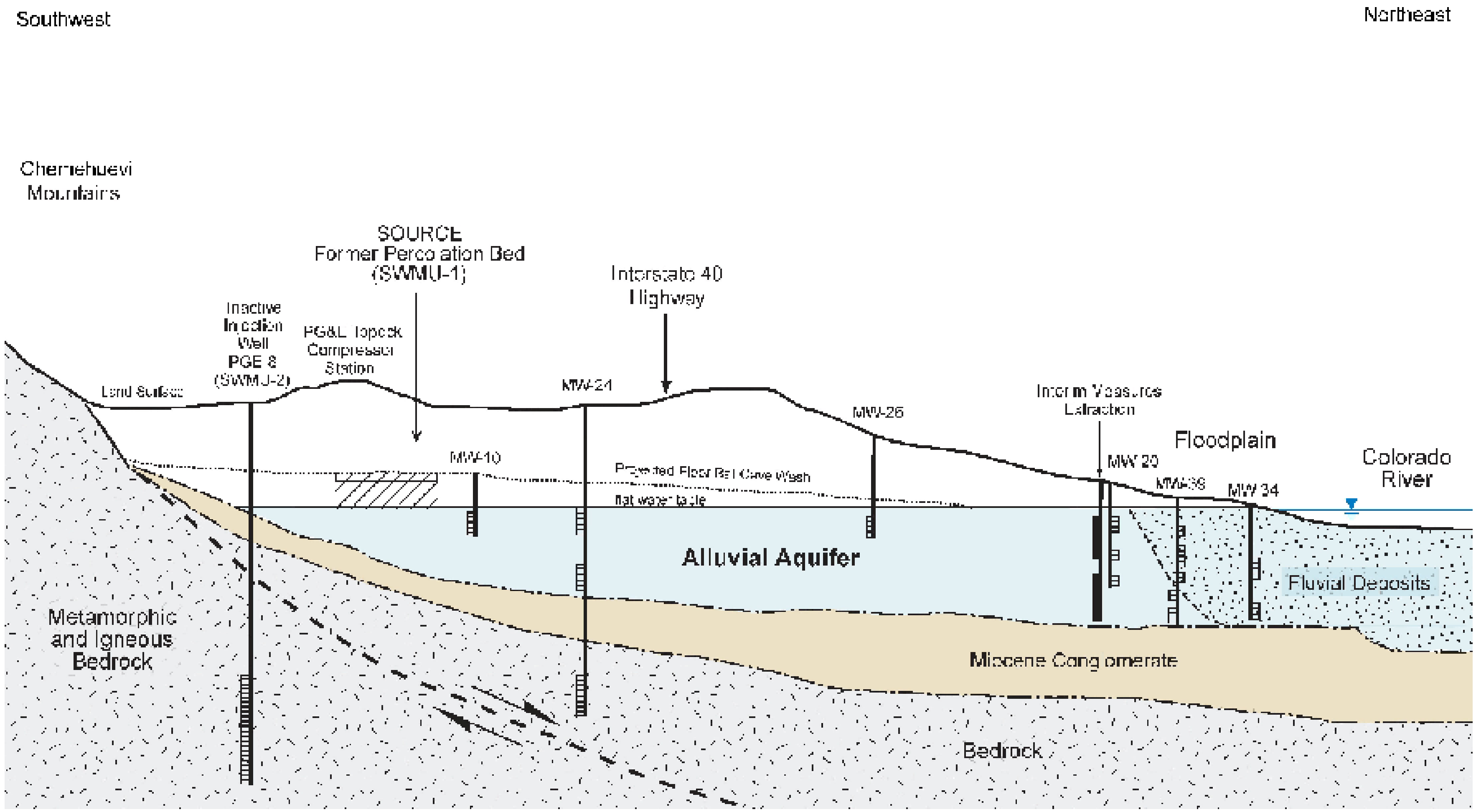
SITE GEOLOGY

ARCADIS

FIGURE
2-24

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
O:\PGE\Topock\HHERA\Mxd\Figure 2-24 Site Geology.mxd - 1/29/2008 @ 12:23:38 PM

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-25 Hydro Cross Section.mxd



NOTE:

1. SOURCE: CH2M HILL (2005-2008)

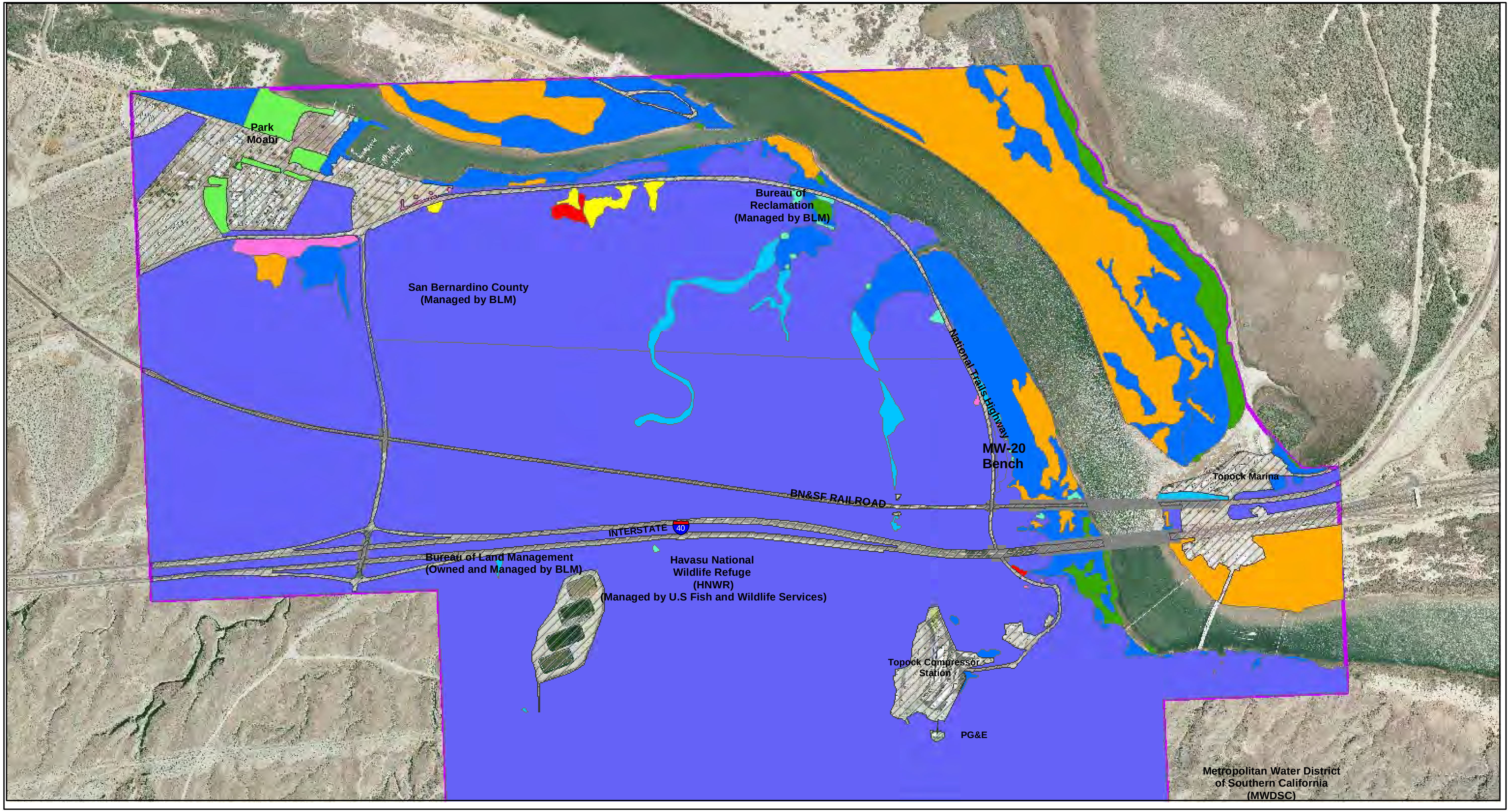
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

PRELIMINARY HUMAN HEALTH CONCEPTUAL MODEL FOR GROUNDWATER

ARCADIS

FIGURE
2-25



LEGEND

▬ BRIDGE

☐ AREA OF POTENTIAL EFFECTS

🟧 ARROWWEED

🟪 CREOSOTE BUSH SCRUB

🟩 LANDSCAPED

🟩 MESQUITE

🟦 MESQUITE/PALO VERDE

🟪 PALO VERDE

🟥 SALT BUSH

🟦 SALT CEDAR

🟨 SALT CEDAR/MESQUITE

🟩 WETLAND/MARSH

NOTE:

1. SOURCE: CH2M HILL (2005-2008)

0 900 1,800 Feet

GRAPHIC SCALE

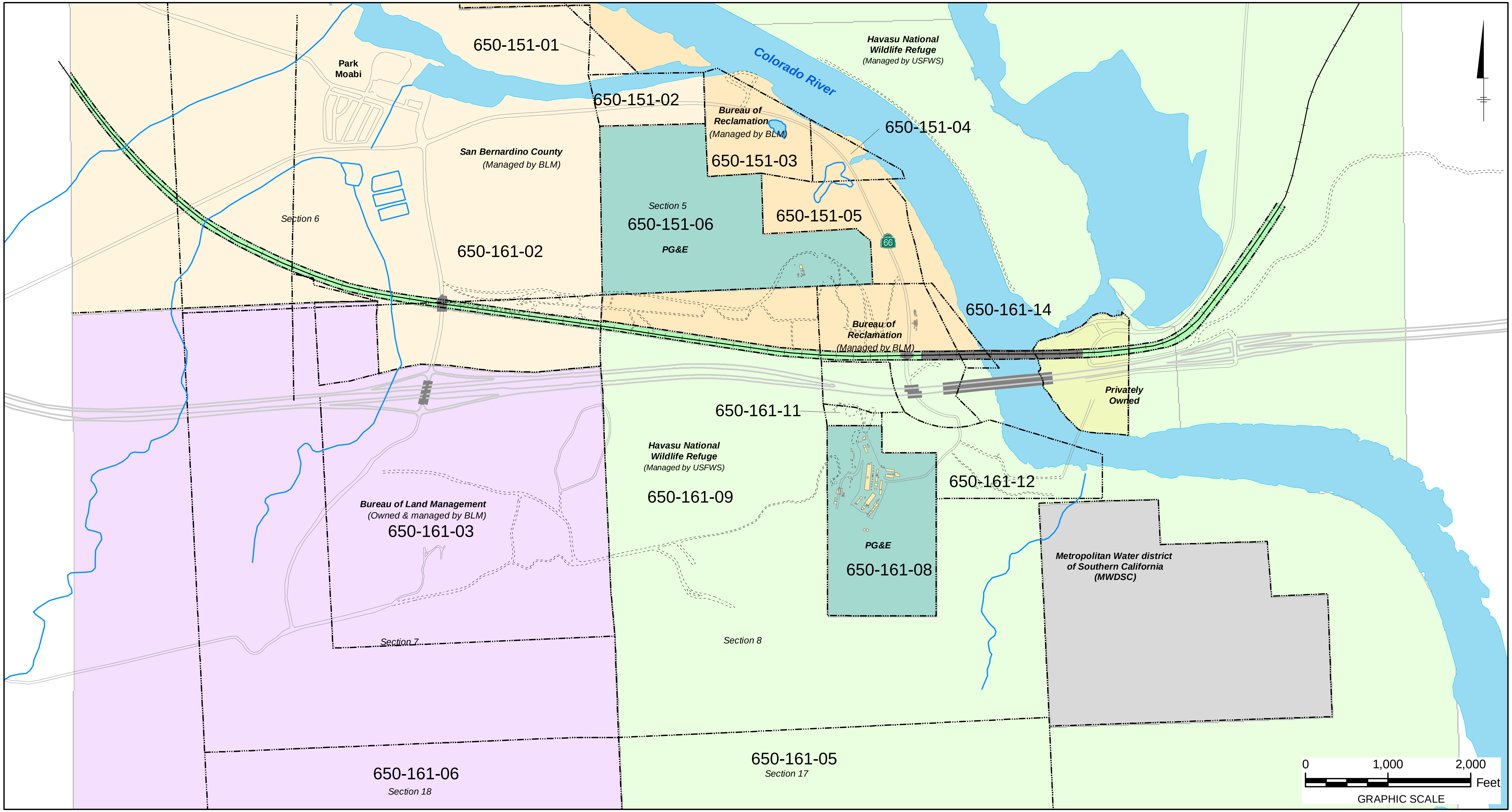
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

VEGETATION COMMUNITIES

ARCADIS

FIGURE
2-26

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-26 Vegetation Communities.mxd - 1/25/2008 @ 12:36:28 PM



LEGEND:

-··-··-	PARCEL BOUNDARY
—	STREAM
▬	BRIDGE
—	PAVED ROAD
– –	DIRT OR GRAVEL ROAD
┼─┼	RAILROAD
🟦	WATER
🟩	BN & SF RAILROAD
🟪	BUREAU OF LAND MANAGEMENT (OWNED AND MANAGED BY BLM)
🟧	BUREAU OF RECLAMATION (MANAGED BY BLM)
🟩	HAVASU NATIONAL WILDLIFE REFUGE (HNWR)
⬛	METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (MWDSC)
🟨	BUILDING
🟩	PG&E
🟨	PRIVATELY OWNED
🟨	SAN BERNARDINO COUNTY (MANAGED BY BLM)

NOTES:

1. THE BOUNDARY LINES SHOWN ARE APPROXIMATE AND FOR REFERENCE ONLY.
2. SOURCE: SAN BERNARDINO COUNTY ASSESSOR, PARCEL QUEST, STATE BOARD OF EQUALIZATION, PACIFIC GAS AND ELECTRIC COMPANY, ECOLOGY AND ENVIRONMENT AND PLAT MAPS PROVIDED BY BLM.
3. SOURCE: CH2M HILL (2005-2008)

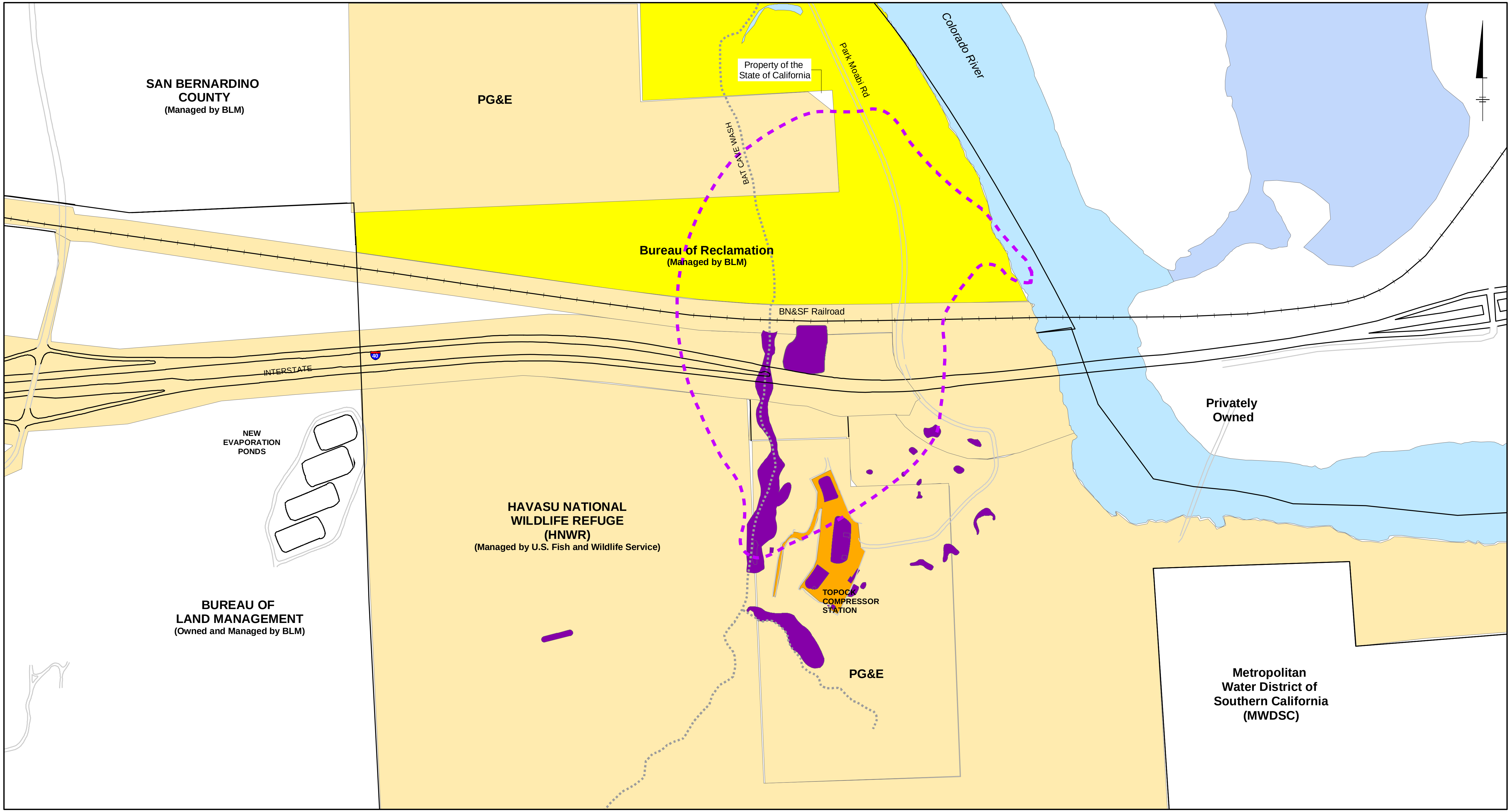
PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SURROUNDING PROPERTIES

ARCADIS

FIGURE
2-27

[MC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
Q:\PGE\Topock\HHERA\Mxd\Figure 2-27 Surrounding Properties.mxd - 1/25/2008 @ 12:39:16 PM



LEGEND:

— PAVED ROAD

— HIGHWAY

- - - ESTIMATED GROUNDWATER CRVI PLUME

┈ RAVINE

┼ RAILROAD

🟪 AOC/SWMU AREA

🟦 COLORADO RIVER

☐ PROPERTY BOUNDARY

🟧 INDUSTRIAL USE

▨ RECREATIONAL, TRIBAL, AND PIPELINE MAINTENANCE USES

🟨 RECREATIONAL, TRIBAL, PIPELINE MAINTENANCE, AND UNRESTRICTED USES

NOTES:

1. SOURCE: CH2M HILL (2005-2008)

0 500 1,000 Feet
GRAPHIC SCALE

PACIFIC GAS AND ELECTRIC COMPANY
NEEDLES, CALIFORNIA
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

ANTICIPATED FUTURE LAND USE

ARCADIS

FIGURE
2-28

[WC-85 VJR] SANF-85 EGH
Project (RC000689.0002 Task 2)
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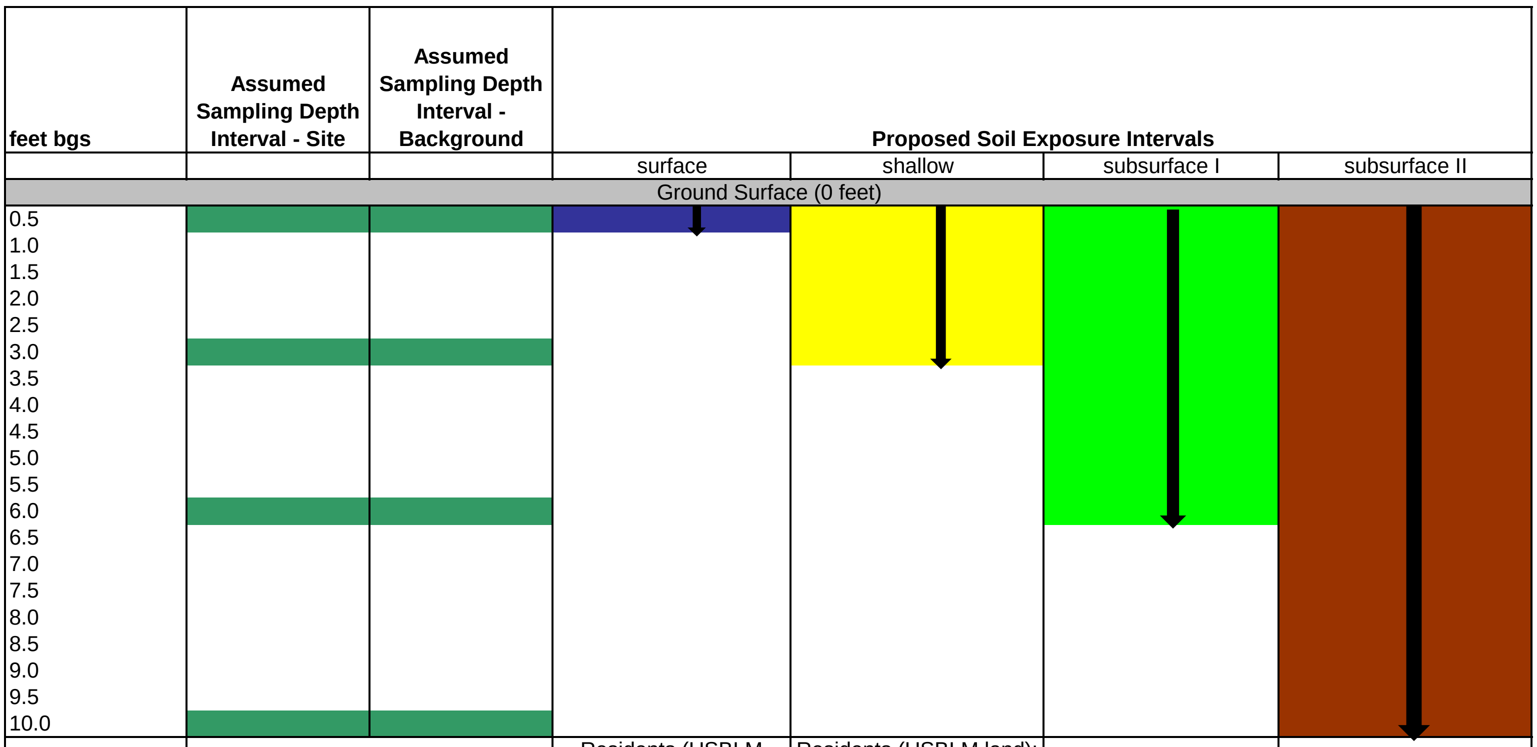
Figure 3-1
Sampling and Exposure Depth Interval for Soil
PG&E Topock, Needles, California
Human Health and Ecological Risk Assessment Work Plan

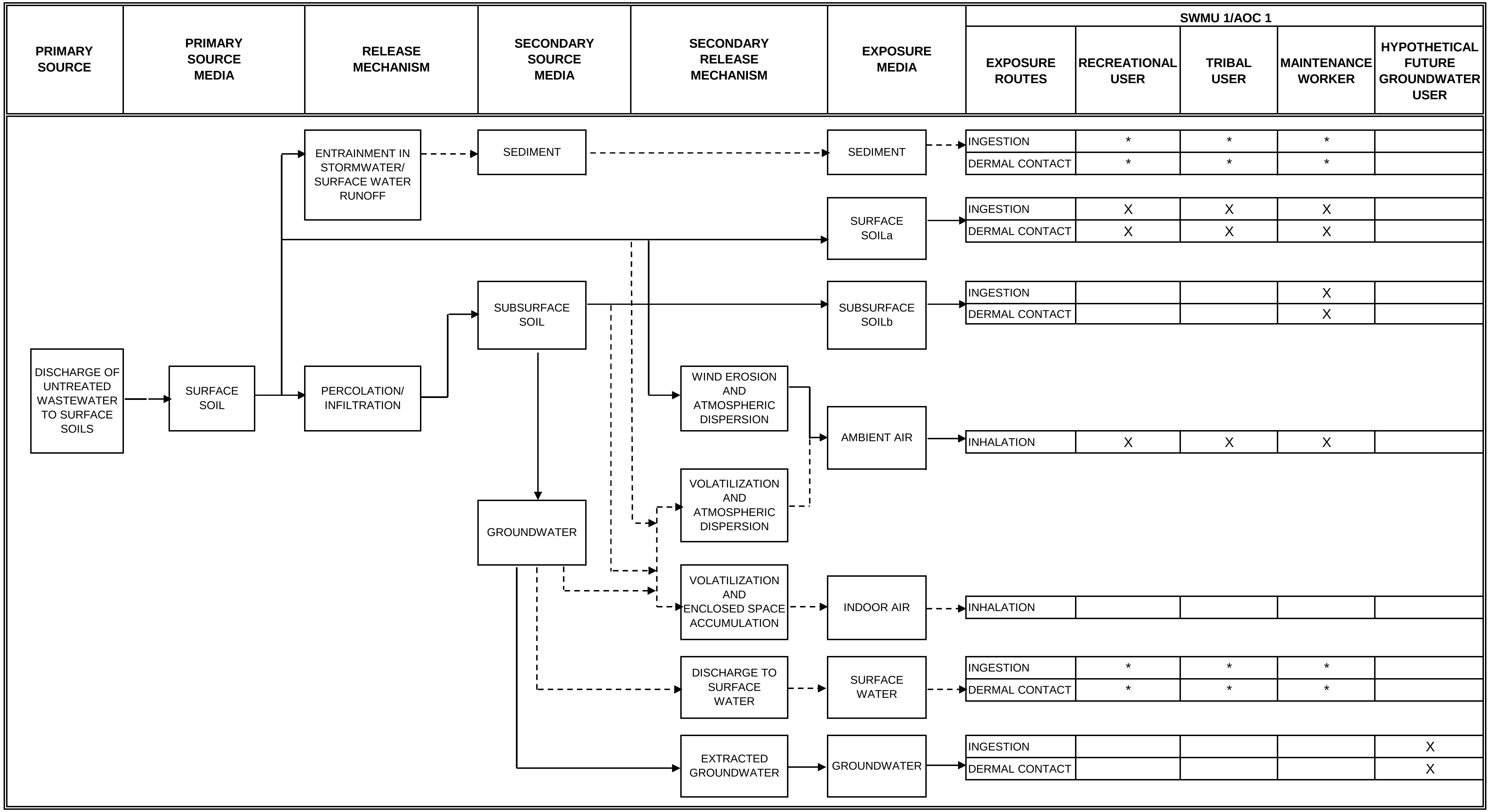


Applicable Receptor Group	Human Receptors-outside the compressor station		Residents (USBLM land); recreational users; maintenance workers; tribal users	Residents (USBLM land); recreational users; maintenance workers; tribal users	Residents (USBLM land); maintenance workers	Residents (USBLM land); maintenance workers
	Human Receptors-inside the compressor station		commercial workers; maintenance workers	commercial workers; maintenance workers	maintenance workers	maintenance workers
	Ecological Receptors-outside the compressor station[a,b]		Plant Uptake = highest EPC from the three depth intervals[c] for all AOCs including BCW.			NA
			Soil Invertebrate Uptake = 0-0.5 foot bgs all AOCs except BCW	NA	NA	NA
			Soil Invertebrates Uptake = highest EPC from the 0-0.5 foot bgs and 0-3 feet bgs for BCW only		NA	
			Granivorous Bird (Gambel's quail): (i) incidental ingestion of soil = 0-0.5 feet bgs for all AOCs except BCW; for BCW, highest EPC from 0-0.5 foot bgs and 0-3 feet bgs (ii) plant (food) concentration (soil-to-plants) = highest EPC from the three depth intervals[c] for all AOCs including BCW			NA
			Insectivorous Bird (cactus wren): (i) incidental ingestion of soil = 0-0.5 feet bgs for all AOCs except BCW; for BCW, highest EPC from 0-0.5 foot bgs and 0-3 feet bgs (ii) prey concentration (soil-to-prey) = 0-0.5 feet bgs for all AOCs except BCW; for BCW, highest EPC from the 0-0.5 foot bgs and 0-3 feet bgs.		NA	NA
			Carnivorous Bird (red-tailed hawk): (i) incidental soil ingestion = 0-0.5 feet bgs for all AOCs except BCW; for BCW, highest EPC from 0-0.5 foot bgs and 0-3 feet bgs (ii) prey concentration (soil-to-prey) = 0-0.5 feet bgs for all AOCs except BCW; for BCW, highest EPC from 0-0.5 foot bgs and 0-3 feet bgs		NA	NA
			Granivorous Mammal (kangaroo rat): (i) incidental soil ingestion = highest EPC from the three depth intervals[c] for all AOCs including BCW (ii) prey (food) concentration (soil-to-plants) = highest EPC from the three depth intervals[c]			NA
			Insectivorous Mammal (desert shrew): (i) incidental soil ingestion = 0-0.5 feet bgs for all AOCs except BCW; for BCW, highest EPC from 0-0.5 foot bgs and 0-3 feet bgs interval (ii) prey concentration (soil-to-prey) = 0-0.5 feet bgs for all AOCs except BCW; for BCW highest EPC from 0-0.5 foot bgs and 0-3 feet bgs interval		NA	NA
			Carnivorous Mammal (desert kit fox): (i) incidental soil ingestion = highest concentration from the three depth intervals[c] for all AOCs including BCW (ii) prey concentration (soil-to-prey) = 0-0.5 feet bgs for all AOCs except BCW; for BCW, highest EPC from 0-0.5 foot bgs and 0-3 feet bgs interval			NA
	Ecological Receptors-inside the compressor station		NA	NA	NA	NA

Notes:
a. See Table 6-3 for details.
b. Exposure point concentrations for ecological receptors will be represented by both the maximum detected concentation and the 95 percent upper confidence limit on the mean.
c. The 3 depth intervals for ecological receptors include:
Surface Soil = 0 - 0.5 feet below ground surface (bgs).
Shallow Soil = 0 - 3 feet bgs.
Subsurface Soil I = 0 - 6 feet bgs.

AOC = includes areas of concern and undesignated areas
bgs = below ground surface
BCW = Bat Cave Wash
NA = not applicable
USBLM = U.S. Bureau of Land Management

FIGURE 4-1
PRELIMINARY HUMAN HEALTH CSM FOR BAT CAVE WASH: RECREATIONAL, TRIBAL, AND WORKER USES
PACIFIC GAS AND ELECTRIC COMPANY
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN



EXPOSURE MEDIA		SWMU 1/AOC 1			
	EXPOSURE ROUTES	RECREATIONAL USER	TRIBAL USER	MAINTENANCE WORKER	HYPOTHETICAL FUTURE GROUNDWATER USER
SEDIMENT	INGESTION	*	*	*	
	DERMAL CONTACT	*	*	*	
SURFACE SOIL[a]	INGESTION	X	X	X	
	DERMAL CONTACT	X	X	X	
SUBSURFACE SOIL[b]	INGESTION			X	
	DERMAL CONTACT			X	
AMBIENT AIR	INHALATION	X	X	X	
INDOOR AIR	INHALATION				
SURFACE WATER	INGESTION	*	*	*	
	DERMAL CONTACT	*	*	*	
GROUNDWATER	INGESTION				X
	DERMAL CONTACT				X

NOTES:

[a] Defined as soils collected at depths between 0 and 3 feet below ground surface (bgs). A subset of this depth interval is near surface soil collected from 0 to 0.5 feet bgs.

[b] Defined as soils collected at depths between 3 and 10 feet bgs.

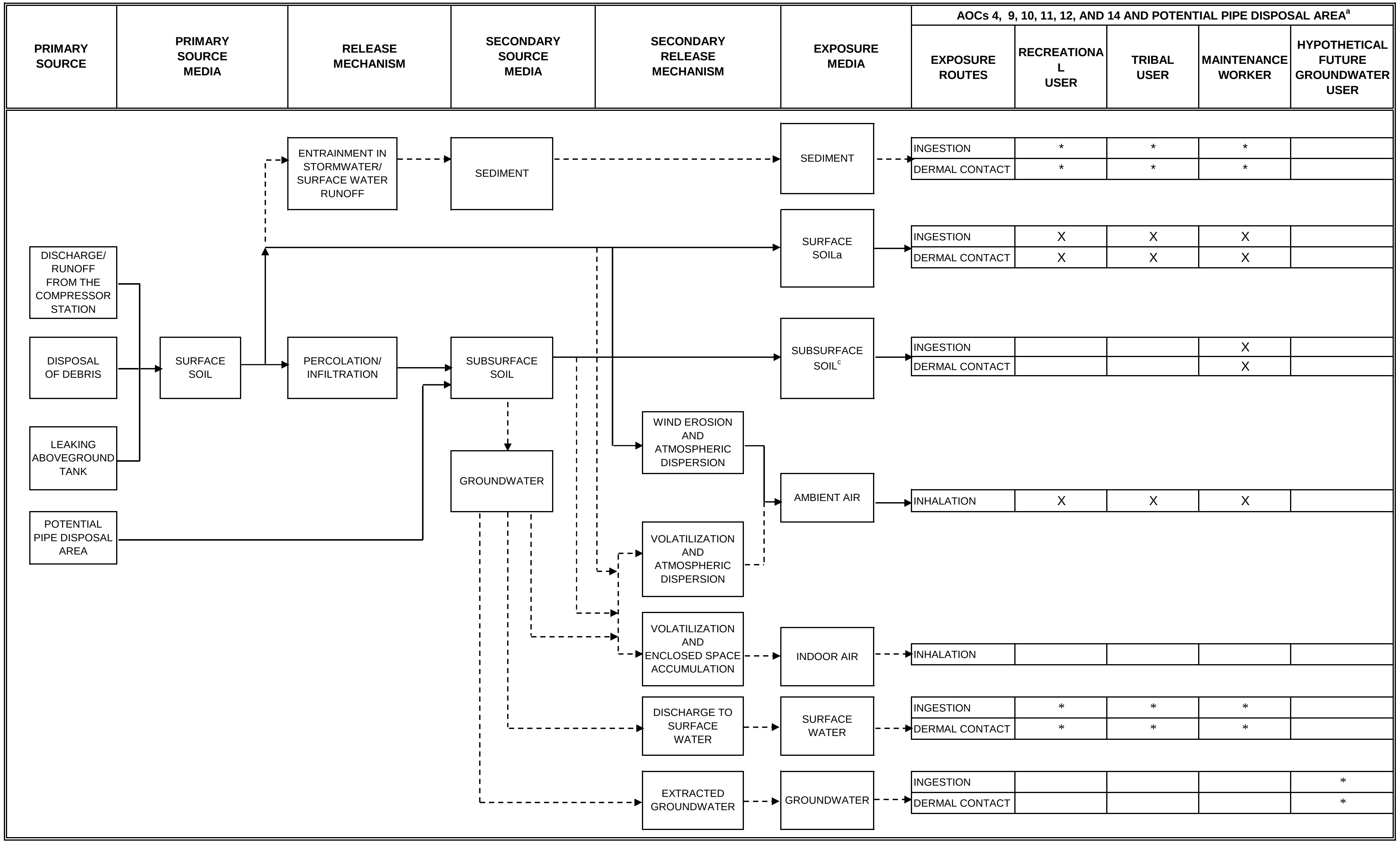
⟶ Potentially complete transport pathway to be included in the quantitative risk assessment.

- - -▸ Potentially complete transport pathway to be further evaluated in the risk assessment.

X Potentially complete exposure route to be included in the quantitative risk assessment.

* Potentially complete exposure route to be further evaluated in the risk assessment.

FIGURE 4-2
PRELIMINARY HUMAN HEALTH CSM FOR AOCS 4, 9, 10, 11, 12, 14, and POTENTIAL PIPELINE DISPOSAL AREA (OUTSIDE THE COMPRESSOR STATION) [a]
PACIFIC GAS AND ELECTRIC COMPANY
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN



EXPOSURE MEDIA	EXPOSURE ROUTES	RECREATIONAL USER	TRIBAL USER	MAINTENANCE WORKER	HYPOTHETICAL FUTURE GROUNDWATER USER
SEDIMENT	INGESTION	*	*	*	
	DERMAL CONTACT	*	*	*	
SURFACE SOILa	INGESTION	X	X	X	
	DERMAL CONTACT	X	X	X	
SUBSURFACE SOIL[c]	INGESTION			X	
	DERMAL CONTACT			X	
AMBIENT AIR	INHALATION	X	X	X	
INDOOR AIR	INHALATION				
SURFACE WATER	INGESTION	*	*	*	
	DERMAL CONTACT	*	*	*	
GROUNDWATER	INGESTION				*
	DERMAL CONTACT				*

NOTES:

[a] The Former 300B Pipeline Liquids Tank Area outside the compressor station has already been closed (CH2MHILL, 2007i), but DTSC has requested additional investigation (CalEPA, 2007d). If complete pathways are identified based on the results, the Former 300B Pipeline Liquids Tank Area will also be included in the HHRA.

[b] Defined as soils collected at depths between 0 and 3 feet below ground surface (bgs). A subset of this depth interval is near surface soil collected from 0 to 0.5 feet bgs.

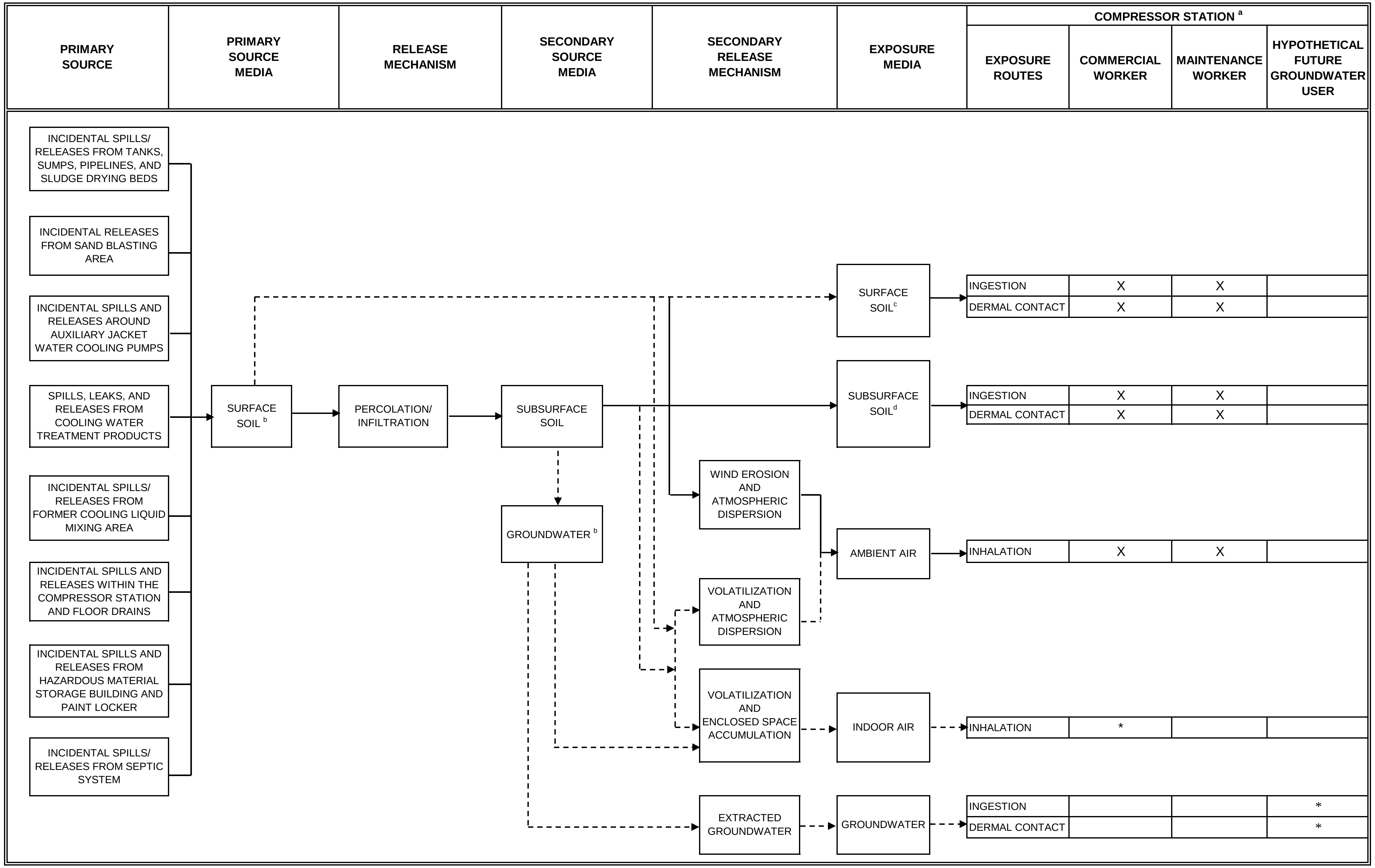
[c] Defined as soils collected at depths between 3 and 10 feet bgs.

⟶	Potentially complete transport pathway to be included in the quantitative risk assessment.
- - -▸	Potentially complete transport pathway to be further evaluated in the risk assessment.
X	Potentially complete exposure route to be included in the quantitative risk assessment.
*	Potentially complete exposure route to be further evaluated in the risk assessment.

FIGURE 4-3

PRELIMINARY HUMAN HEALTH CSM FOR INSIDE THE COMPRESSOR STATION

PACIFIC GAS AND ELECTRIC COMPANY
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

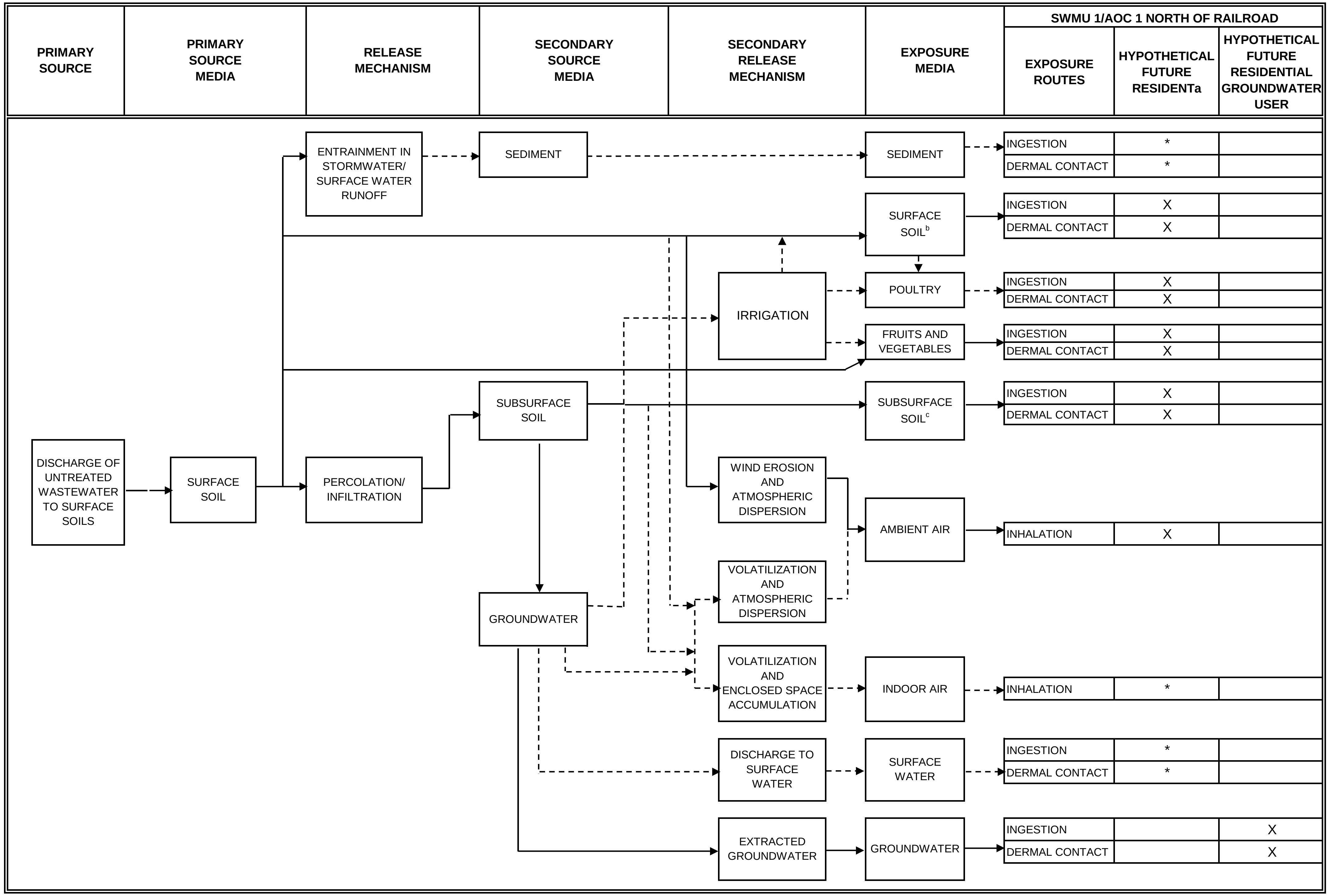


EXPOSURE MEDIA	COMPRESSOR STATION [a]			
	EXPOSURE ROUTES	COMMERCIAL WORKER	MAINTENANCE WORKER	HYPOTHETICAL FUTURE GROUNDWATER USER
SURFACE SOIL[c]	INGESTION	X	X	
	DERMAL CONTACT	X	X	
SUBSURFACE SOIL[d]	INGESTION	X	X	
	DERMAL CONTACT	X	X	
AMBIENT AIR	INHALATION	X	X	
INDOOR AIR	INHALATION	*		
GROUNDWATER	INGESTION			*
	DERMAL CONTACT			*

NOTES:

a	The former sludge drying beds, chromate reduction tank, process pump tank, transfer sump, oil holding water tank, oil water separator, and wastewater transference pipelines inside the compressor station have already been closed (CH2MHILL, 2007i), but DTSC has requested additional investigation (CalEPA, 2007d). If complete pathways are identified based on the results, any of these areas will also be included in the HHRA.
b	Potentially complete transport pathway from primary and secondary source media within the compressor station to exposure media outside of the compressor station and potentially complete exposure pathways will be further evaluated in the risk assessment in the context of areas outside of the compressor station (See Figures 4-1 and 4-2).
c	Defined as soils collected at depths between 0 and 3 feet below ground surface (bgs).
d	Defined as soils collected at depths between 3 and 10 feet bgs. A subset of this depth interval is near surface soil collected from 0 to 0.5 feet bgs.
———▶	Potentially complete transport pathway to be included in the quantitative risk assessment.
- - - -▶	Potentially complete transport pathway to be further evaluated in the risk assessment.
X	Potentially complete exposure route to be included in the quantitative risk assessment.
*	Potentially complete exposure route to be further evaluated in the risk assessment.

FIGURE 4-4
PRELIMINARY HUMAN HEALTH CSM FOR BAT CAVE WASH: HYPOTHETICAL FUTURE RESIDENTIAL USE NORTH OF RAILROAD
PACIFIC GAS AND ELECTRIC COMPANY
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN



	SWMU 1/AOC 1 NORTH OF RAILROAD		
EXPOSURE MEDIA	EXPOSURE ROUTES	HYPOTHETICAL FUTURE RESIDENTa	HYPOTHETICAL FUTURE RESIDENTIAL GROUNDWATER USER
SEDIMENT	INGESTION	*	
	DERMAL CONTACT	*	
SURFACE SOIL[b]	INGESTION	X	
	DERMAL CONTACT	X	
POULTRY	INGESTION	X	
	DERMAL CONTACT	X	
FRUITS AND VEGETABLES	INGESTION	X	
	DERMAL CONTACT	X	
SUBSURFACE SOIL[c]	INGESTION	X	
	DERMAL CONTACT	X	
AMBIENT AIR	INHALATION	X	
INDOOR AIR	INHALATION	*	
SURFACE WATER	INGESTION	*	
	DERMAL CONTACT	*	
GROUNDWATER	INGESTION		X
	DERMAL CONTACT		X

NOTES:

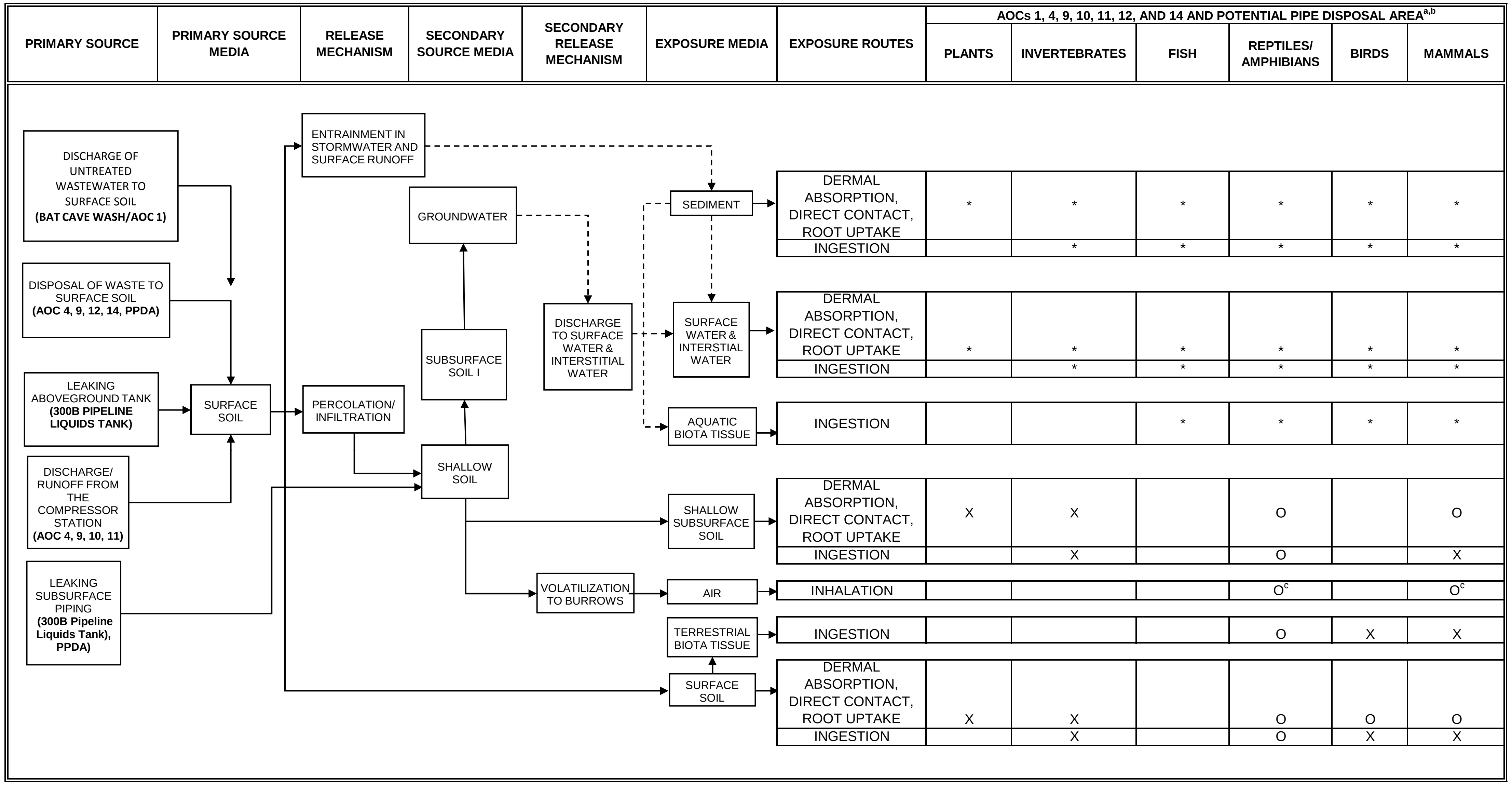
[a] As described in the text, the U.S. Bureau of Land Management (USBLM) has requested that the risk assessment assume future unrestricted use of their property. Accordingly, a future hypothetical residential scenario for contact with soils will be evaluated for property owned by USBLM.

[b] Defined as soils collected at depths between 0 and 3 feet below ground surface (bgs). A subset of this depth interval is near surface soil collected from 0 to 0.5 feet bgs.

[c] Defined as soils collected at depths between 3 and 10 feet bgs.

→ Potentially complete transport pathway to be included in the quantitative risk assessment.
⇢ Potentially complete transport pathway to be evaluated qualitatively in the risk assessment.
X Potentially complete exposure route to be included in the quantitative risk assessment.
* Potentially complete exposure route to be further evaluated in the risk assessment.

FIGURE 6-1
ECOLOGICAL CONCEPTUAL SITE MODEL
PACIFIC GAS AND ELECTRIC COMPANY
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN



EXPOSURE MEDIA	EXPOSURE ROUTES	AOCs 1, 4, 9, 10, 11, 12, AND 14 AND POTENTIAL PIPE DISPOSAL AREA[a,b]					
		PLANTS	INVERTEBRATES	FISH	REPTILES/ AMPHIBIANS	BIRDS	MAMMALS
SEDIMENT	DERMAL ABSORPTION, DIRECT CONTACT, ROOT UPTAKE	*	*	*	*	*	*
	INGESTION		*	*	*	*	*
SURFACE WATER & INTERSTIAL WATER	DERMAL ABSORPTION, DIRECT CONTACT, ROOT UPTAKE	*	*	*	*	*	*
	INGESTION		*	*	*	*	*
AQUATIC BIOTA TISSUE	INGESTION			*	*	*	*
SHALLOW SUBSURFACE SOIL	DERMAL ABSORPTION, DIRECT CONTACT, ROOT UPTAKE	X	X		O		O
	INGESTION		X		O		X
AIR	INHALATION				O[c]		O[c]
TERRESTRIAL BIOTA TISSUE	INGESTION				O	X	X
SURFACE SOIL	DERMAL ABSORPTION, DIRECT CONTACT, ROOT UPTAKE	X	X		O	O	O
	INGESTION		X		O	X	X

NOTES:

——▶	Potentially complete exposure pathway
- - -▶	Potential pathway under evaluation (separate assessment)
*	Exposure route under evaluation (separate assessment)
X	Potentially complete exposure route
O	Potentially complete exposure route not significant or not directly assessed
AOC	Area of concern
PPDA	Potential Pipeline Disposal Area

a. The Former 300B Pipeline Liquids Tank area has already been closed (CH2M HILL, 2007i), but DTSC has requested additional investigation (CalEPA, 2007d). If complete pathways are identified based on the results, the Former 300B Pipeline Liquids Tank area will be included in the ERA.

b. For the large home range ecological receptors, two exposure areas will be evaluated: (i)BCW (AOC 1) and AOC 4 and (ii) all other remaining AOCs outside the compressor station (AOCs 9, 10, 11, 12, 14, Potential Pipeline Disposal Area). For small home range ecological receptors, the Potential Pipeline Disposal Area and each AOC outside the comoressor station (AOCs 4, 9, 10, 11, 12, 14) will be evaluated as separate exposure areas (See Section 3). All exposure pathways inside the compressor station are considered incomplete and will not be evaluated for ecological receptors.

c. Potential inhalation exposure in burrows was included for the Former 300B Pipeline Liquids Tank area only based on the potential presence of volatile organic compounds (VOCs).

Surface Soil:	0-0.5 feet below ground surface
Shallow Soil:	0-3 feet below ground surface
Subsurface Soil I:	0-6 feet below ground surface

Appendix A

Methods for Calculating Exposure Point Concentrations

ARCADIS
Infrastructure, environment, facilities

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Pacific Gas and Electric Company

Appendix A: Methods for Calculating Exposure Point Concentrations

Topock Compressor Station
Needles, California

August 2008

Appendix A: Methods for Calculating Exposure Point Concentrations

Topock Compressor Station
Needles, California

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Our Ref.:
RC000689.0002.00002

Date:
August 2008

Acronyms and Abbreviations

AOC	area of concern
BCW	Bat Cave Wash
bgs	below ground surface
CalEPA	California Environmental Protection Agency
COPC	constituent of potential concern
CSM	conceptual site model
DTSC	Department of Toxic Substances Control
EPC	exposure point concentration
ERA	ecological risk assessment
HHRA	human health risk assessment
ND	non-detect
RAWP	*Human Health and Ecological Risk Assessment Work Plan*
RPD	relative percent difference
(the) site	Pacific Gas and Electric Company (PG&E) Topock Compressor Station
UCL	upper confidence level
USEPA	U.S. Environmental Protection Agency

1. Introduction

This appendix to the *Human Health and Ecological Risk Assessment Work Plan* (RAWP) describes the methods that will be used in calculating exposure point concentrations (EPCs) for use in the human health risk assessment (HHRA) and ecological risk assessment (ERA) for the Pacific Gas and Electric Topock Compressor Gas Station located in San Bernardino County, 15 miles south of Needles, California (the site; RAWP Figure 1-1).

An EPC is the representative concentration of a constituent in an environmental medium that is potentially contacted by the receptor (USEPA, 1989; 1997). For all terms and procedures, standard U.S. Environmental Protection Agency (USEPA) and/or California Environmental Protection Agency (CalEPA) procedures listed as best practices or best current practices will be used in estimating and defining the EPCs that will be used in the risk assessments. USEPA (1989) defines the EPC as "the arithmetic average of the concentration that is contacted over the exposure period." The CalEPA (1996) and USEPA (1989; 1992) recommend using the 95% upper confidence limit (95% UCL) representing the mean as an estimate for the EPC so that the estimate of the average (or mean) is conservative and will not be underestimated. Following CalEPA guidance (1992; 1996), risks will be estimated using the EPCs (i.e., 95% UCL in most cases; however, the 99% UCL may also be selected) on the mean for each constituent of potential concern (COPC) in each environmental medium associated with complete or potentially complete and significant exposure pathways identified in the conceptual site models (CSMs; RAWP Figures 4-1, 4-2, 4-3, 4-4, and 6-1) for the HHRA and the ERA. Additionally, for the ERA only and following CalEPA guidance (1996), risks will be estimated using maximum detected concentrations for each COPC in each of the environmental medium associated with complete or potentially complete and significant exposure pathways. The media that will be evaluated in the HHRA and ERA include:

- Soil for HHRA:
    - Surface Soil (0 to 0.5 foot below ground surface [bgs])
    - Shallow Soil (0 to 3 feet bgs)
    - Subsurface Soil I (0 to 6 feet bgs)
    - Subsurface Soil II (0 to 10 feet bgs)
- Soil for ERA:
    - Surface Soil (0 to 0.5 foot bgs)

  - Shallow Soil (0 to 3 feet bgs)
  - Subsurface Soil I (0 to 6 feet bgs).
- Groundwater (for HHRA and ERA):
  - Groundwater data from all monitoring wells and floodplain wells (i.e., to evaluate groundwater potentially discharging to surface water).

As described in Section 3 of the RAWP, other site media may be evaluated in the risk assessment depending on the results of the upcoming transport pathway analysis. The potential for transport of chemically affected surface soil entrained in surface runoff will be evaluated using a gradient approach to determine the completion of this transport pathway as described in Section 3.1.2 of the main text. In addition and for confirmation of the pathway analysis, sediment data in the riparian area will be compared to human health and ecological screening benchmarks (California Human Health Screening Levels [CalEPA, 2005], USEPA Residential Preliminary Remediation Goals [USEPA, 2008], and threshold effects concentrations [MacDonald et al., 2000]). The results of both the gradient approach and the sediment screening will be evaluated, and the potential pathway for surface soil entrained in runoff to reach the sediment will be determined in the risk assessment. If this pathway is considered complete, it will be quantitatively evaluated in the risk assessments.

The potential for transport and discharge of chemically affected groundwater to surface water will be evaluated based on groundwater background values and surface water criteria or screening values as described in Sections 5 and 7 of the RAWP.

If these transport pathways are identified as complete or potentially complete and significant, the additional media that will be evaluated include:

- Sediment (0 to 0.5 foot below sediment surface) for HHRA and ERA
- Surface water for HHRA and ERA
- Interstitial water for ERA only.

2. Exposure Area Definition

A consideration in developing the EPCs is the definition of the “exposure area” the EPC will represent. The exposure area can be defined as the minimum area that will sustain an assumed exposure. All of the data within an exposure area will be considered in the EPC calculation.

The study areas (RAWP Figure 2-1) will include the areas of concern (AOCs) discussed in the RAWP. For the HHRA, three main exposure areas were identified for the site:

- Inside the Compressor Station
- Bat Cave Wash (BCW)
- Outside the Compressor Station (excluding BCW).

For the ERA, two main exposure areas were identified for large home range receptors at the site:

- BCW (AOC 1) and Debris Ravine (AOC 4)
- All other AOCs outside the Compressor Station (excluding BCW and AOC 4).

For small home range receptors, in accordance with the Department of Toxic Substances Control (DTSC) and U.S. Department of the Interior’s requirement, each AOC outside the compressor station will be evaluated as a separate exposure area. The main exposure areas for the small home range receptors identified for the ERA include the following:

- BCW (AOC 1)
- AOC 4: Debris Ravine
- AOC 9: Southeast Fence Line
- AOC 10: East Ravine

- AOC 11: Topographic Low Areas
- AOC 12: Fill Area
- AOC 14: Railroad Debris Site; and
- Potential Pipeline Disposal Area.

The AOCs included in these exposure areas are discussed in Section 2 and presented in Table 2-1 of the RAWP. The EPCs for the risk assessments will be calculated based on the exposure areas defined in Section 3 of the RAWP and the CSMs (RAWP Figures 4-1, 4-2, 4-3, 4-4, and 6-1).

3. Derivation of Exposure Point Concentrations

Site media data for COPCs will be evaluated by exposure area as described above and in Section 3 of the RAWP prior to calculation of the EPCs. For all exposure areas, EPCs will be derived as point estimates, represented by the 95% UCL and/or maximum detected concentration, using USEPA's ProUCL version 4.0 and the methodology outlined in the USEPA guidance for calculating EPCs (USEPA 2006; 2007a,b). Based on the needs of the risk assessments and to allow better predictions of potential risk to receptors, a "hot spot" evaluation maybe conducted, and/or an area-weighted or spatial approach may be used to develop alternate EPCs (for terrestrial/upland areas only). These methods are described below.

For the ERA, consistent with DTSC guidance (CalEPA, 1996), exposures will be estimated using both the maximum detected concentration and the 95% UCL for each COPC identified in site media.

3.1 Exposure Point Concentrations Derived using ProUCL

USEPA released statistical software called ProUCL Version 4.0 (ProUCL 4.0) to facilitate calculations of 95% UCLs (USEPA, 2007a,b). ProUCL 4.0 is an upgrade of ProUCL Version 3.0 and contains statistical methods to evaluate both full environmental datasets without non-detect (ND) values and datasets with ND values (also known as left-censored datasets). Data distributions for site media will be determined using USEPA's ProUCL 4.0 (e.g., normal, lognormal, or other non-parametric distributions), and the 95% UCL will be calculated based on the distribution. Where possible, the 95% UCL will be selected over the maximum detected concentration per USEPA guidance because the EPC term represents the average exposure contracted by an individual over an exposure area during a long period of time. The maximum concentration is less appropriate because it is unlikely that an individual will visit the location of the maximum detected value all of the time. Prior to calculating 95% UCLs for each COPC and exposure area with ProUCL 4.0, the data will be screened with respect to sample size and number of detects as follows:

- If an analyte is not detected in any sample for a given media and the reporting limits are below applicable risk-based criteria, it will be assumed to not be present in that media, therefore, an EPC will not be calculated.

- If an analyte is detected in one or more samples in a dataset, EPCs for that analyte will be calculated as recommended by USEPA guidance (USEPA, 2006).

- If the number of samples in an exposure area is less than eight, the maximum detected concentration will be used as the EPC.

- If the number of detects is less than five, the maximum detected concentration will be used as the EPC.

If a sufficient number of samples and detections are present for a chemical, ProUCL 4.0 will be used to calculate the 95% UCL. ProUCL 4.0 can calculate UCLs using up to 15 different parametric and nonparametric statistical methods. Some of the methods (e.g., Kaplan-Meier method, regression on order methods) are applicable to left-censored datasets having multiple detection limits. The optimal method(s) for a particular dataset are identified by the software based on USEPA's numerical experiments with hypothetical datasets with a wide range of statistical properties, such as distribution shape, sample size, percent NDs, and skewness (USEPA, 2006). If multiple UCLs are identified as being equally plausible, the relative percent difference (RPD) in 95% UCLs will be evaluated. If the RPD is less than 5%, the EPC will be determined by the method that yields the highest value. If the RPD is greater than 5%, professional judgment will be used to select the method that generally exhibits the most consistent performance according to USEPA guidance (USEPA, 2007a). The ProUCL selection method used to calculate the 95% UCL and the data distribution will be presented in detail in the risk assessment report.

3.2 Hot Spot Evaluation

Based on the needs of the risk assessments and to allow better predictions of potential risk to receptors, a hot spot evaluation maybe conducted. In general, the identification of hot spots maybe conducted by evaluating the site data for outliers, and then identifying the spatial distribution of the statistical outliers. Statistical outliers that are clustered together could indicate the presence of a hot spot, which could require additional and/or alternative statistical evaluations for identifying the appropriate EPCs. The methods used to evaluate hot spots will be described in the risk assessment report.

3.3 Exposure Point Concentrations Derived using Spatial Analysis

Alternate EPCs may be calculated for COPCs in soil based on an area-weighted or spatial approach. USEPA's guidance on probabilistic risk assessment (USEPA, 2001) discusses the importance of accounting for spatial autocorrelation in environmental data. The main benefit of applying spatial statistics is that a more explicit consideration of spatial relationships may lead to a more accurate estimate of the confidence limits for the arithmetic mean concentration (USEPA, 2001). Thiessen polygons will be applied to decluster the samples that may be grouped in close proximity. The size and shape of each polygon will be determined by an algorithm based on the spatial arrangement of sample locations. Each polygon defines the area closer to the corresponding sample point than any other sample point. The size of the polygon divided by the size of the exposure area will determine the probability weighting factor for each observation. Thiessen polygons require minimal assumptions, are intuitive, are relatively straightforward to implement, and can accommodate left-censored data. USEPA's ProUCL 4.0 will be used to calculate a unique 95% UCL for each COPC according to USEPA guidance (USEPA, 2006). An unbiased estimate of the EPC will be determined by the arithmetic mean of the 95% UCLs. The methods used to calculate the spatial EPCs will be described in detail in the risk assessment report.

4. References

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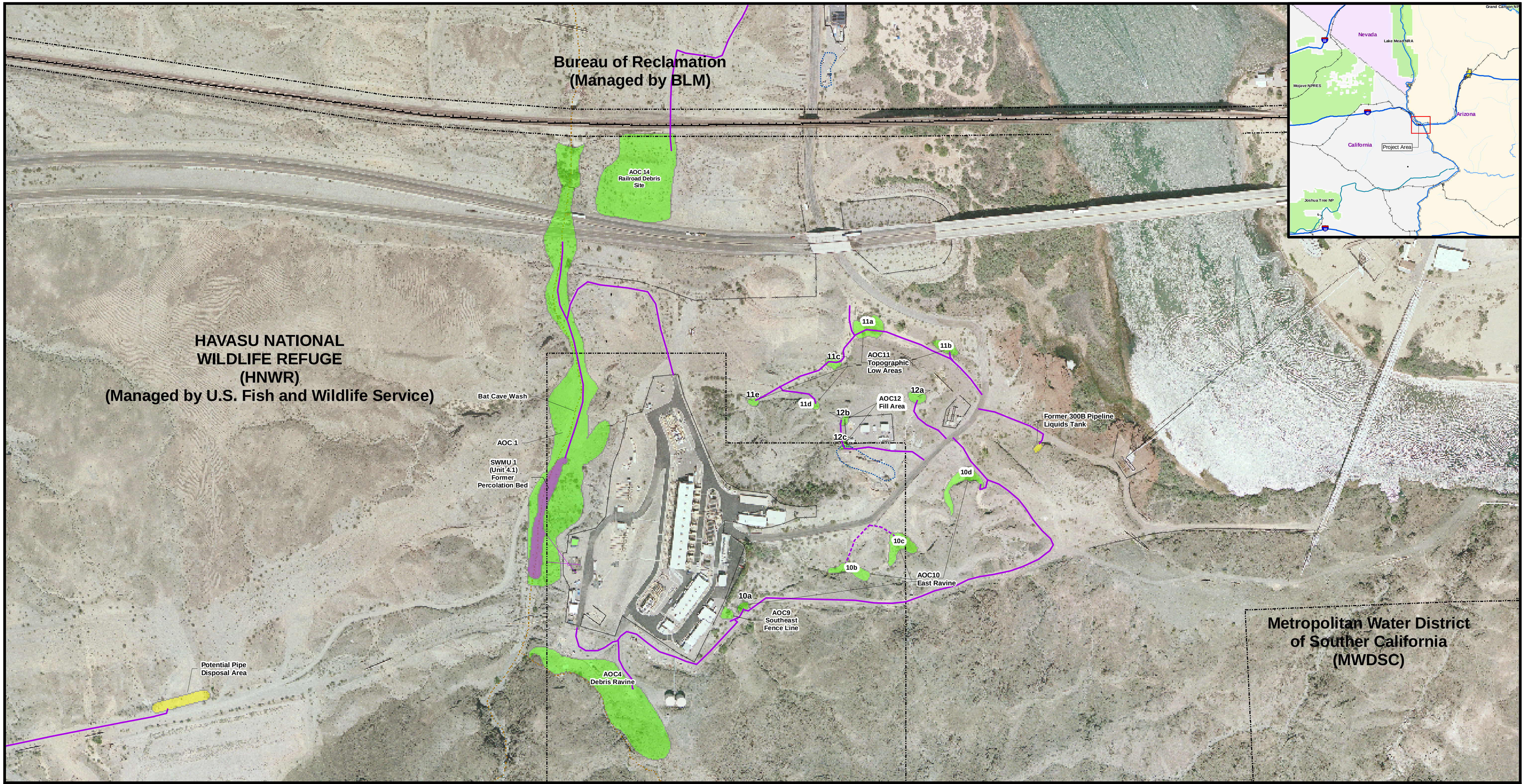
ARCADIS

Appendix B

Figures Prepared by Others



Legend

- Vehicle Access Route *
- Lift by Crane *
- Solid Waste Management Unit (SWMU)
- 🟩 Area of Concern (AOC)
- 🟨 Other Undesignated Areas
- Staging Area

* All access routes are approximate

N

0 350 700 Feet

1 inch equals 350 feet

FIGURE 6-1
SWMUS, AOCS, AND
OTHER UNDESIGNATED AREAS
PROPOSED ACCESS ROUTES

RFI/RI SOIL INVESTIGATION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

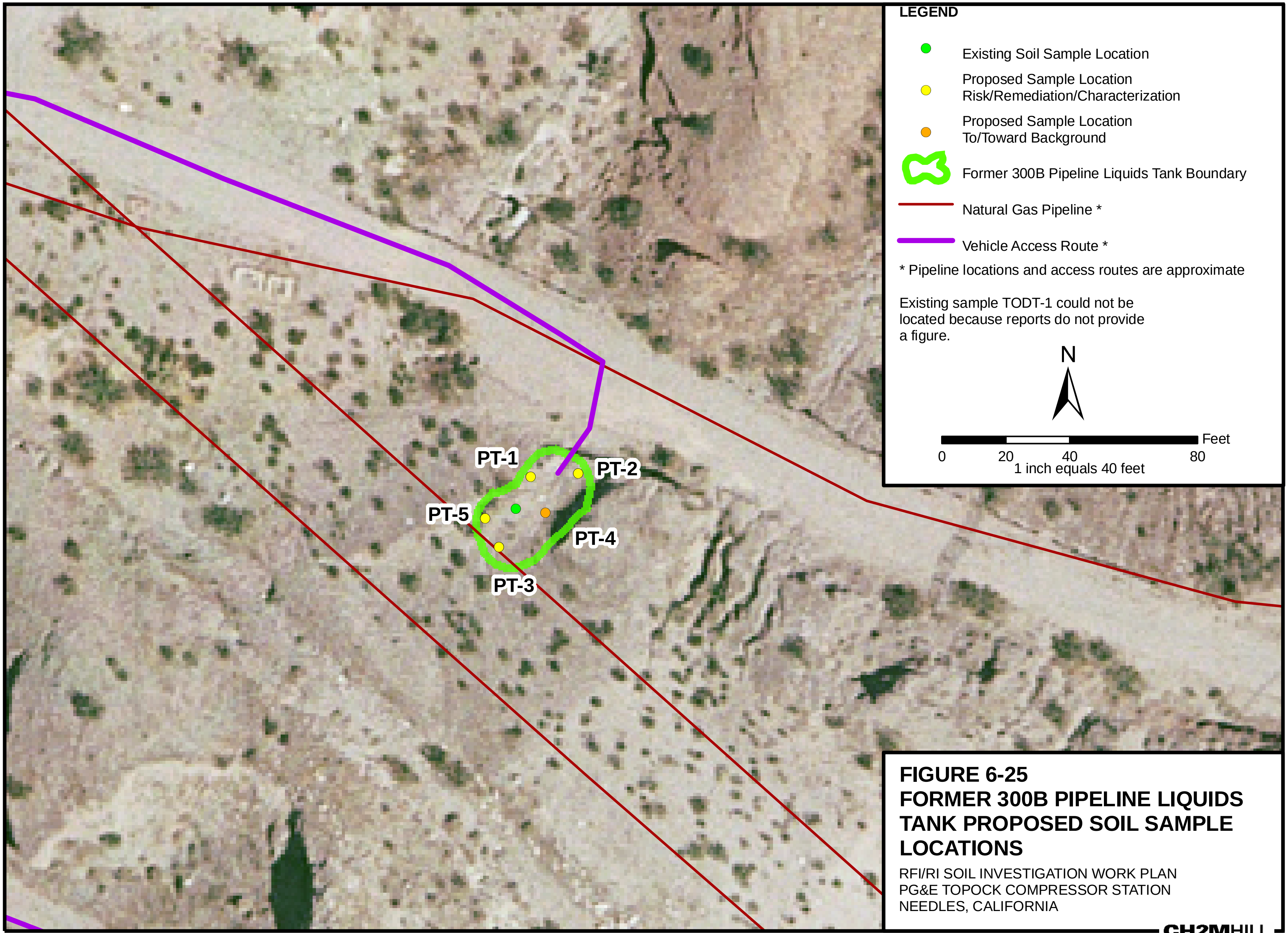
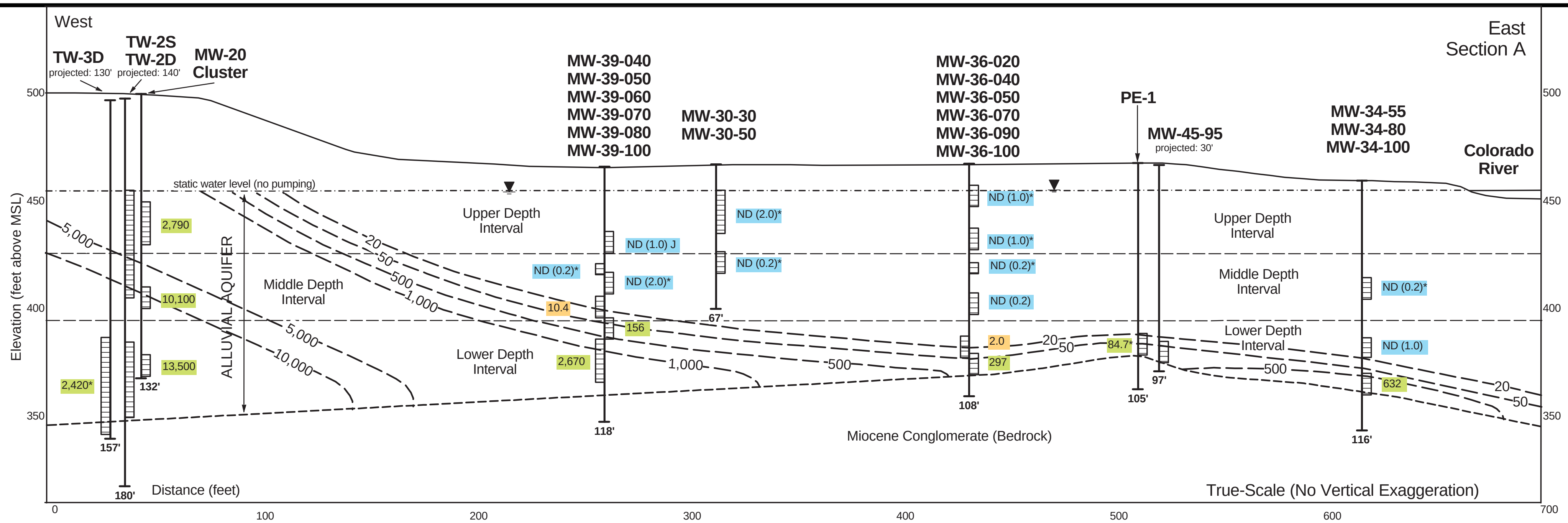


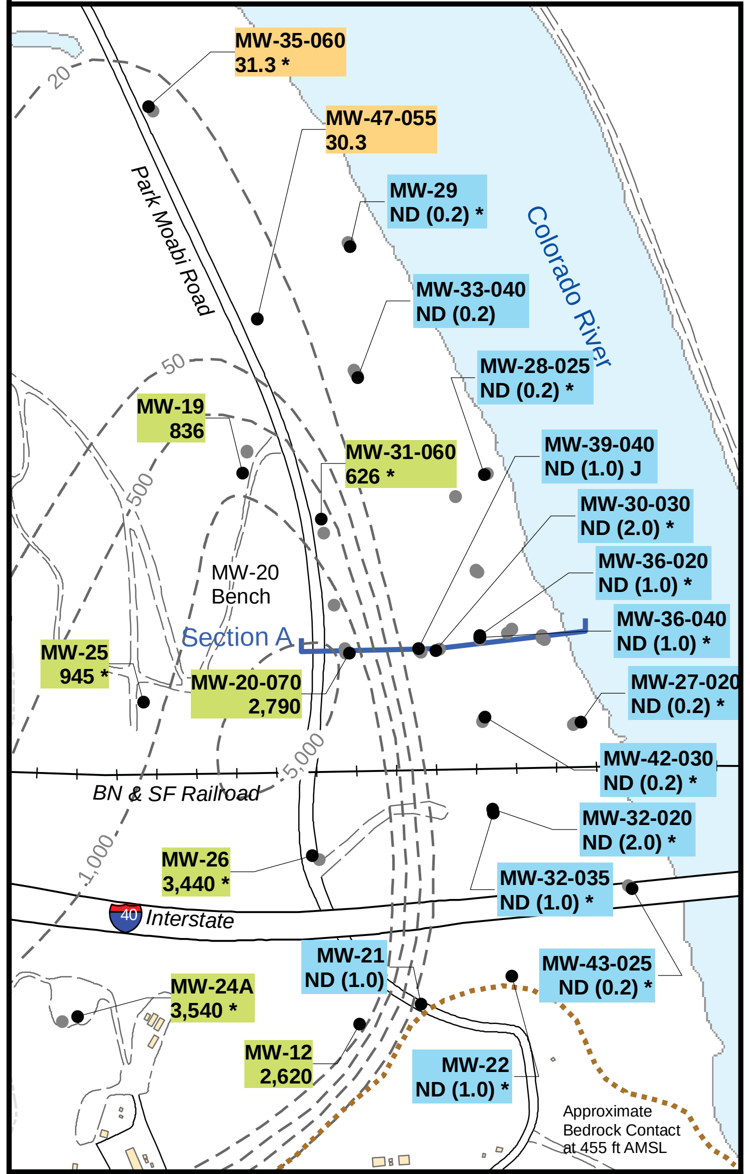
FIGURE 6-25
FORMER 300B PIPELINE LIQUIDS TANK PROPOSED SOIL SAMPLE LOCATIONS

RFI/RI SOIL INVESTIGATION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

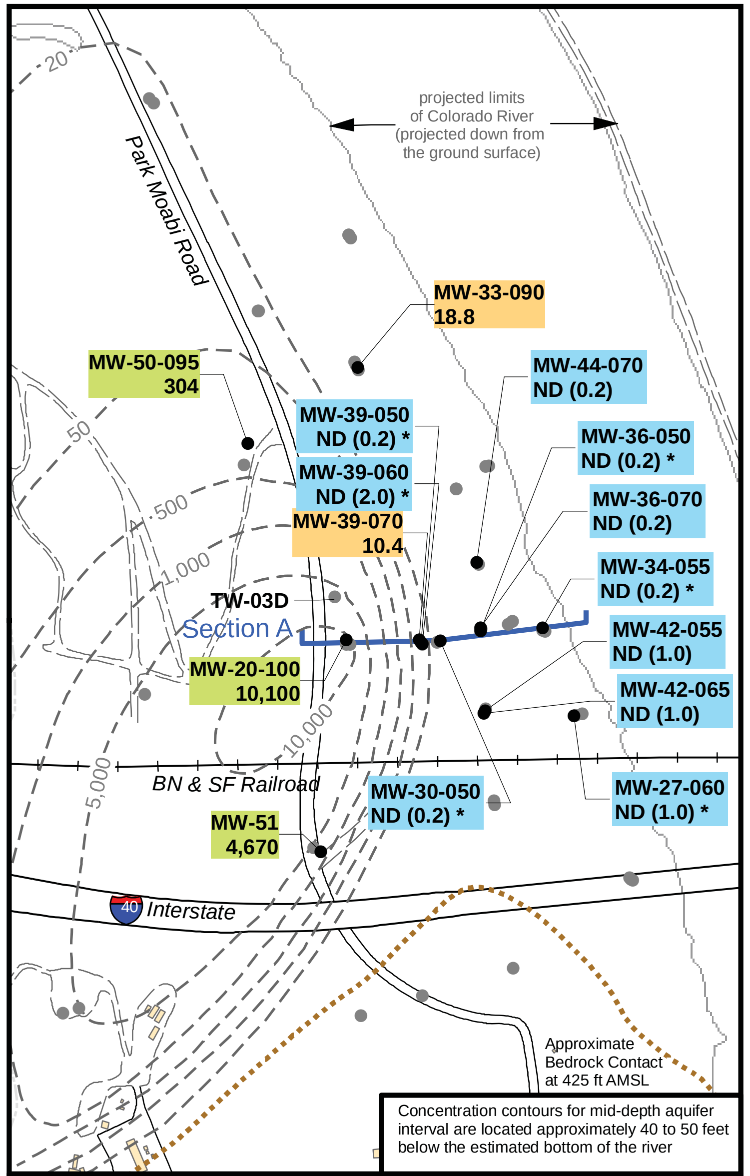
CH2MHILL

BAO \\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MXD\2006\SOILWORKPLAN\SWP_PIPE_LIQUID_TANK_PROPOSED.MXD FIG_6_25_SWP_PIPE_LIQUID_TANK_PROPOSED.PDF 11/14/2006 14:13:54



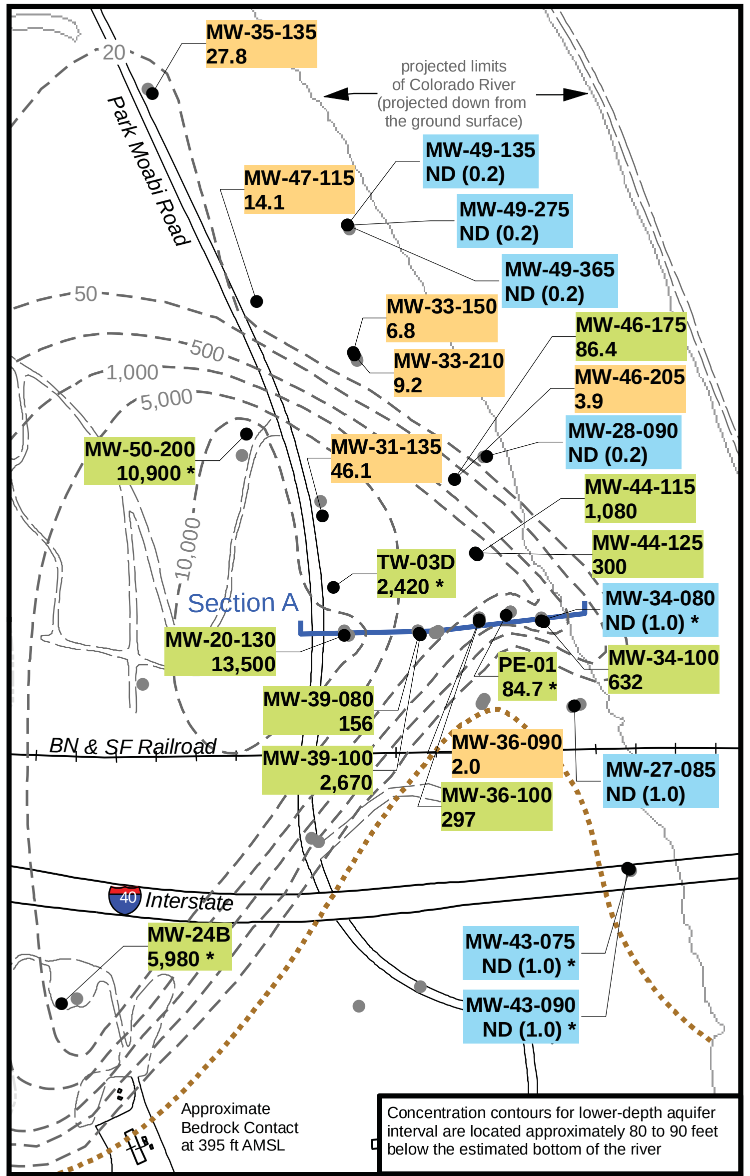


Shallow Wells (Upper Depth Interval)



Concentration contours for mid-depth aquifer interval are located approximately 40 to 50 feet below the estimated bottom of the river

Intermediate Wells (Middle Depth Interval)



Concentration contours for lower-depth aquifer interval are located approximately 80 to 90 feet below the estimated bottom of the river

Deep Wells (Lower Depth Interval)

LEGEND

Maximum Hexavalent Chromium [Cr(VI)] Concentrations in Groundwater, May 2007 Monitoring

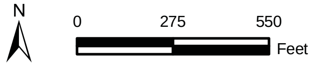
Concentrations in micrograms per liter (µg/L) equivalent to parts per billion (ppb)

ND = Not detected at listed reporting limit
J = Concentration estimated by laboratory or data validation

Well MW-39-70 Cr(VI) results for May 2007 were rejected due to exceedence of laboratory holding time. As a result, the Cr(T) result from this event is posted. This well was resampled on June 12, 2007.

* Indicates samples from March and April 2007 or October 2006 sampling.
All other results are from the May 2007 quarterly sampling event.

Results posted are maximum concentrations from primary and duplicate samples.
See Tables B-1 and B-2 for sampling data and other results.



ND (1)	Not detected at listed reporting limit (ppb)
41	Less than 50 ppb
3,810	Greater than 50 ppb
– – 50 – –	Inferred Cr(VI) concentration contour within aquifer depth interval
	Contours incorporate the maximum concentration from wells within each depth interval
╲	Hydrogeologic Section A (true-scale) showing aquifer depth intervals, well screens, and Cr(VI) sampling results.

NOTES ON CONTOUR MAPS

1. The Cr(VI) contour maps for 2006-2007 performance monitoring incorporate data from new wells and water quality data trends for the floodplain area. The contour maps provide additional interpretation of plume limits and do not reflect plume migration during performance monitoring

2. The locations of the Cr(VI) contours shown for depths 80-90 feet below the Colorado River (east and southeast of well clusters MW-34) are estimated based on hydrogeologic and geochemical conditions documented in site investigations 2004-2006. The actual locations of contours beyond well control points in these areas are not certain, but are inferred using available site investigation and monitoring data (bedrock structure, hydraulic gradients, observed distribution of geochemically reducing conditions and Cr(VI) concentration gradients). There are no data confirming the existence of Cr(VI) under the Colorado River.

FIGURE 2-2
MAXIMUM CR(VI) CONCENTRATIONS IN ALLUVIAL AQUIFER, MAY 2007

CORRECTIVE MEASURES/FEASIBILITY STUDY WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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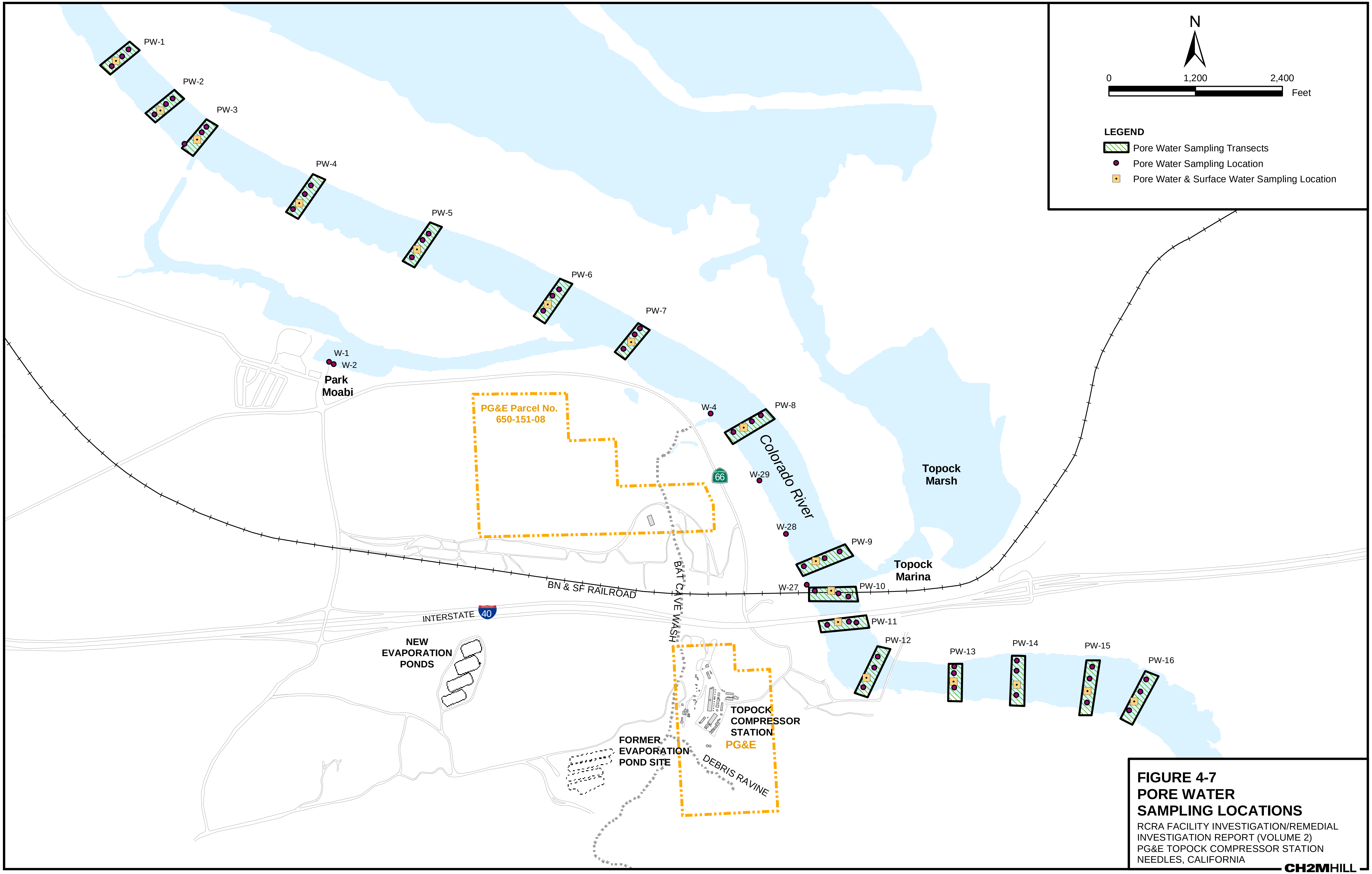

FIGURE 4-7
PORE WATER SAMPLING LOCATIONS

RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION REPORT (VOLUME 2)
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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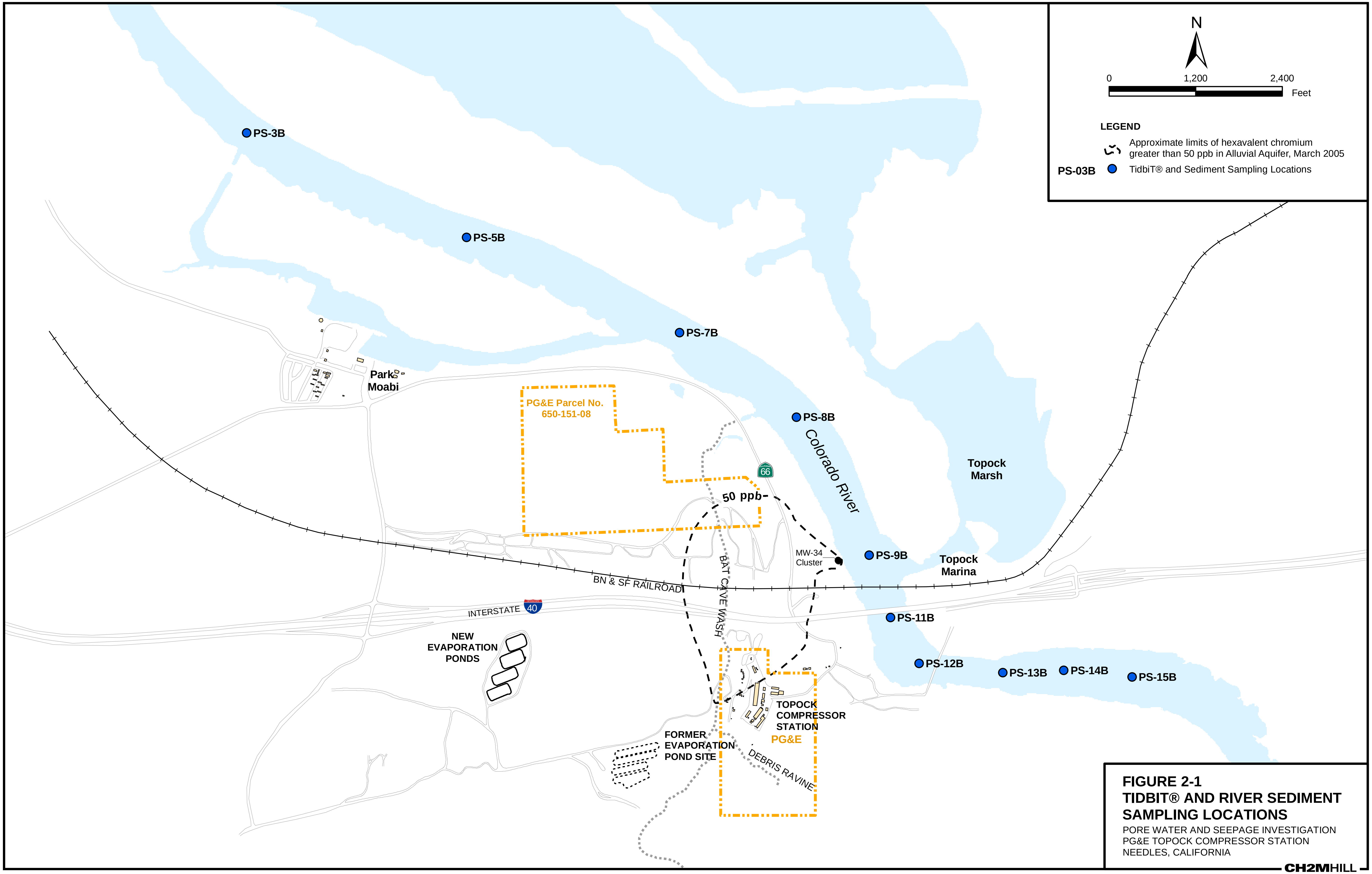

FIGURE 2-1
TIDBIT® AND RIVER SEDIMENT SAMPLING LOCATIONS

PORE WATER AND SEEPAGE INVESTIGATION
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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