FINAL

Burn Area Focused Feasibility Study

Installation Restoration IR Site 1
Alameda Point, Alameda, California

Submitted to:
U.S. Department of the Navy
Base Realignment and Closure
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, California 92108-4310
PERMAC Contract No. N62473-08-D-8816
Contract Task Order 0002

Submitted by:
AMEC Environment & Infrastructure, Inc.
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San Diego, California 92123
(858) 300-4300
Document Control No. AMEC-8816-0002-0180

February 2013

DEPARTMENT OF THE NAVY
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
1455 FRAZEE RD, SUITE 900
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SUBJECT: FINAL BURN AREA FOCUSED FEASIBILITY STUDY INSTALLATION RESTORATION SITE 1, ALAMEDA POINT, ALAMEDA, CALIFORNIA.

Dear Federal Facility Agreement Members:

To finalize the *Burn Area Focused Feasibility Study Installation Restoration Site 1, Alameda Point, Alameda, California*, the Navy has enclosed replacement pages and CD for insertion into the Draft Final version sent on January 18, 2013. The Navy appreciates your input and effort in the progress of these sites.

If you have any questions or comments, please call me at (619) 532-0951 or the Remedial Project Manager, Ms. Cecily Sabedra at (619) 532-0972.

Sincerely,

DEREK J. ROBINSON
BRAC Environmental Coordinator
By direction of the Director

Enclosure: Replacement pages and CD for *Final Burn Area Focused Feasibility Study Installation Restoration Site 1, Alameda Point, Alameda, California, February 2013.*

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Prepared for:
U.S. Department of the Navy
Base Realignment and Closure
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, California 92108-4310

Prepared by:
AMEC Environment & Infrastructure, Inc.
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Prepared under:
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Prepared by:	Peter Guerra Task Manager	28 February 2013 Date
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ACRONYMS AND ABBREVIATIONS

AMEC	AMEC Environment & Infrastructure, Inc.
ANSI	American National Standards Institute
APP	Accident Prevention Plan
ARAR	applicable or relevant and appropriate requirements
Army	U.S. Department of the Army
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BaP_{equiv}	benzo(a)pyrene equivalent
bcy	bank cubic yards
BEI	Bechtel Environmental, Inc.
bgs	below ground surface
BSU	Bay Sediment Unit
CalEPA	California Environmental Protection Agency
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDPH	California Department of Public Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	chemical of potential concern
COC	contaminant of concern
CPM	counts per minute
CSM	conceptual site model
CTO	Contract Task Order
CTR	California Toxics Rule
cy	cubic yards
DAF	dilution attenuation factor
DDD	dichlorodiphenyldichloroethane
DDT	dichlorodiphenyltrichloroethane
DOD	U.S. Department of Defense
DoN	U.S. Department of Navy
DTSC	(California) Department of Toxic Substances Control
EDC	Economic Development Conveyance
E&E	Ecology and Environment, Inc.
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency
ESL	environmental screening level
ERA	ecological risk assessment
ERV	ecological reference value

ACRONYMS AND ABBREVIATIONS (Cont.)

^{o}F	degrees Fahrenheit
ft/sec	feet per second
ft/min	feet per minute
ft^2/min	square feet per minute
FS	Feasibility Study
FFA	Federal Facilities Agreement
FFS	Focused Feasibility Study
FW	Foster Wheeler Environmental Corporation
FWBZ	First Water-Bearing Zone
GM	geological model
HHRA	human-health risk assessment
HI	hazard index
IC	Institutional Control
IR	Installation Restoration
K_d	hydraulic distribution coefficient
LDR	land-disposal restriction
L/kg	Liters per kilogram
LUC RD	Land Use Controls Remedial Design
MAH	mononuclear aromatic hydrocarbons
MC	munitions constituents
MCE	maximum credible earthquake
MDL	method detection limit
MEC	munitions and explosives of concern
mg/kg	milligram per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
MOA	memorandum of agreement
MPPEH	material potentially presenting an explosive hazard
MSL	mean sea level
NAS	Naval Air Station
NAVFAC SW	Naval Facilities Engineering Command Southwest
Navy	U.S. Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NERP	Navy Environmental Restoration Program
NRC	Nuclear Regulatory Commission
NTR	National Toxics Rule

O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PAL	project action limit
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PCG 5	Preconditioned Conjugate Gradient Solver package
PCP	phencyclidine
PDP	Preliminary Development Plan
POTW	publicly owned treatment works
PRG	preliminary remediation goal
RA	remedial action
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
RG	remediation goal
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SHE	AMEC Safety, Health, and Environment Program
SOW	scope of work
SPT	submersible pressure transducer
S/S	solidification/stabilization
SSC	sediment screening concentration
STLC	soluble threshold limit concentration
SVOC	semivolatile organic compound
SWAT	solid waste assessment test
SWBZ	Second Water-Bearing Zone
SWRCB	(California) State Water Resources Control Board
TBD	to be determined
TCDD	tetrachlorodibenzodioxin
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TEF	toxic equivalency factor
TEQ	toxicity equivalent
TPH	total petroleum hydrocarbons

ACRONYMS AND ABBREVIATIONS (Cont.)

TSD	treatment, storage, and disposal
TtEMI	Tetra Tech EM Inc.
TtFW	Tetra Tech FW, Inc.
TVD	Total Variation Diminishing (method)
UMTRCA	Uranium Mill Tailings Radiation Control Act
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	United States Code
VOC	volatile organic compound
Water Board	San Francisco Bay Regional Water Quality Control Board
WIB	waste isolation bulkhead

1.0 INTRODUCTION

AMEC Environment & Infrastructure, Inc. (AMEC) has prepared this Focused Feasibility Study (FFS) for services associated with Installation Restoration (IR) IR Site 1, the 1943-1956 former Disposal Area, at Alameda Point in Alameda, California, on behalf of the Department of the Navy (Navy), Naval Facilities Engineering Command Southwest (NAVFAC SW). This FFS was prepared under Navy Contract N62473-08-D-8816, Contract Task Order (CTO) 0002.

1.1 Purpose and Methodology

In September 2009, a Final Record of Decision (ROD) for IR Site 1 was completed and included a remedy for a portion of IR Site 1 called Area 1b, the Burn Area (Chadux Tt 2009). In brief, the remedy for the Burn Area was excavation and disposal of burn waste and impacted soils above and below the burn waste. Data gap characterization in support of the remedial design was conducted in the summer of 2010. Results of this investigation, presented in this report, revealed that the vertical and horizontal extent of the burn layer and impacted materials above and below the Burn Area was significantly different than characterized in the ROD and supporting documents, particularly the Final Feasibility Study (FS) (BEI 2006a).

The purpose of this FFS Report is to develop and evaluate an additional remedial action alternative and to compare the alternate remedy to the selected remedial action for IR Site 1 Area 1b soil in the IR Site 1 ROD (Chadux Tt 2009). Additional data determining the horizontal and vertical extent of the burn layer and surrounding impacted materials has been generated since the ROD was issued. This new data suggests an alternative remedial action to contain the waste inplace with a geotechnical remedy, partially excavate materials, backfill, and place a soil cover over the Burn Area. Considering that the Burn Area waste will remain in place, this FFS report includes an updated risk assessment to evaluate the discharge and mixing of groundwater from the Burn Area to the San Francisco Bay. The results of the updated risk assessment and remedial action alternative evaluation will be considered by the Navy in determining whether or not to select a revised remedial action for the Burn Area at IR Site 1.

The FFS methodology is summarized below and is further detailed in subsequent sections of this report. Methodology created by the United States (U.S.) Environmental Protection Agency (EPA) includes the following steps (U.S. EPA 1988):

1. Review applicable or relevant and appropriate requirements (ARARs).
2. Establish the need for reconsideration of the selected remedy as it pertains to the Burn Area Remedy (Chadux Tt 2009).

3. Define volume and area of environmental media for which remedial response actions may be needed.
4. Identify, on the basis of technical considerations, an alternative remedial technology to the selected remedy.
5. Screen the alternative remedial technology on the basis of effectiveness, implementability, and cost.
6. Evaluate the alternative and selected remedies in detail against the nine criteria specified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) found in the Title 40 Code of Federal Regulations (CFR) § 300.430(e)(9)(iii) as follows:
    i. Overall protection of human health and the environment
    ii. Compliance with ARARs
    iii. Long-term effectiveness and permanence
    iv. Reduction of toxicity, mobility, or volume through treatment
    v. Short-term effectiveness
    vi. Implementability
    vii. Cost
    viii. State acceptance
    ix. Community acceptance
7. Perform a comparative evaluation of the remedial alternative and selected remedy.

This FFS Report does not identify or recommend a preferred remedial alternative. Comments made during public and regulatory agency review of this document will be evaluated and considered during the remedy-selection process. As required by the NCP and U.S. EPA guidance (U.S. EPA 1988), these comments will also be addressed in a Proposed Plan as well as in an Amendment to the ROD. This FFS Report does not evaluate, reevaluate, or otherwise address the soil remedial action for Areas 1a, 2b, 4, 5a, and 5b or the groundwater remedial action addressing the VOC plume, which is not located within the Burn Area, selected in the IR Site 1 ROD.

1.2 Report Organization

The FFS Report is divided into seven main sections and seven appendices.

- Section 1 provides an overview of the CERCLA FFS process and presents the report organization.
- Section 2 presents background information for IR Site 1, specifically the Burn Area, including facility information and significant findings from previous investigations.
- Section 3 summarizes remedial action objectives (RAOs) for IR Site 1 Burn Area.
- Section 4 identifies and screens various remedial technologies and process options for contaminated groundwater and soil at IR Site 1 Burn Area.
- Section 5 presents the development of alternative remedial actions that address soil contamination associated with IR Site 1 Burn Area.
- Section 6 provides a detailed description of each retained remedial alternative and analyzes and compares these alternatives using criteria specified by NCP.
- Section 7 lists the references used throughout this FFS Report.
- Appendix A provides copies of laboratory analytical reports, data validation, and supporting documentation.
- Appendix B provides trench logs from the Burn Area characterization work in 2010.
- Appendix C provides boring logs from the Burn Area characterization work in 2010 and 2011.
- Appendix D presents a detailed description of the reactive transport groundwater/surface water flow model used to predict bay water concentrations from freshwater replenishment flowing through the Burn Area.
- Appendix E presents the remediation goal tables from the Final ROD (Chadux Tt 2009).
- Appendix F presents design basis memos including preliminary engineering analysis for the Open Cell steel sheet pile waste isolation bulkhead (WIB).
- Appendix G presents cost back up information in support of the remedial alternative evaluation.
- Appendix H contains the response to comments from project stakeholders.

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2.0 BACKGROUND

This section summarizes site background information, site history, previous investigations, pre-design characterization, site modeling, and risk assessment activities for IR Site 1 Burn Area.

2.1 Site Description

This section provides site background information, including an overall description for IR Site 1 and a detailed description of the Burn Area.

2.1.1 IR Site 1 Description

IR Site 1 is located within the boundary of Alameda Point, which is on the eastern side of San Francisco Bay and south of Oakland, California (Figure 2-1). IR Site 1 is located in the northwestern tip of Alameda Island, where the Oakland Inner Harbor joins San Francisco Bay (Figure 2-2).

IR Site 1 is approximately 37 acres in size and was historically used to dispose of waste, aircraft parts and petroleum, and as a pistol and skeet range. The site is partially paved and has relatively flat topography, with slight depressions that promote seasonal wetlands. The site presently includes four small, abandoned buildings, a portion of former aircraft runway, a former pistol and skeet range, a former baseball field, a former aircraft engine and part storage area, and an underground storm water collection and conveyance system.

For the purpose of defining select remedial actions for portions of IR Site 1, the site was subdivided into six areas as shown in Figure 2-3. The Burn Area was titled Area 1b and was defined as the location where waste was burned and disposed of at the edge of the shoreline.

2.1.2 Burn Area Description

The Burn Area is a designated area within IR Site 1, delineated for specific consideration because of additional environmental concerns brought on by the burning of industrial waste and onsite disposal of the burn residues. The Navy Public Works Department implemented open-air burning as the primary waste disposal method at the site in the 1950s. Burned residue was subsequently pushed into San Francisco Bay with a bulldozer (E&E 1983). Aerial photographs from 1953 and 1957 show that between these dates the 400-foot shoreline near the Burn Area was extended approximately 130 feet westward into the San Francisco Bay (BEI 2006a). Logs for borings drilled during the solid waste assessment test (SWAT) program indicate that the shoreline was filled with burned and unburned refuse and a thin covering of sand (TtEMI 1999c). The shoreline in this area is now covered with revetment, consisting primarily of concrete-debris riprap. The surface of the Burn Area is covered with a layer of fill material varying in thickness between approximately 0.5-feet and 8-feet thick. This cover material contains detectable levels of chemicals of concern above remediation goals (RGs) identified in the ROD (Chadux Tt 2009) within the first foot of the ground surface.

Offshore sediment samples were collected in 1993, 1994, and 1996 (PRC 1994 and 1996a). The SWAT results indicated that contaminant concentrations in sediment were generally within the range expected for ambient concentrations in the San Francisco Bay and unlikely to pose an increased health risk relative to the rest of the bay (BEI 2006a).

2.2 History of the Burn Area Formation

Prior to the mid-nineteenth century, the area now occupied by Alameda Point and IR Site 1 was open sea. By 1859, a narrow strip of land had been constructed along what is now the southern bank of the Oakland Inner Harbor. This narrow strip of land armored with riprap, termed a mole, extended from the then shoreline of Alameda to what is now the north end of Alameda Point. Railroad track was installed on the mole to facilitate trains reaching deep enough seas to meet ships for cargo loading and unloading. By 1895, the Alameda Mole was expanded to include a building and ferry slip for the daily commute from the Alameda/Oakland area to San Francisco. The Alameda Mole building and ferry slip were located at what is now the northern terminus of the Burn Area. On November 21, 1902, a large fire completely burned the Alameda Mole building and the above water portions of the ferry slip docks. The building and docks were rebuilt and back in operation by 1903. Other small fires and train accidents were recorded between 1903 and 1915. It is presumed that the burn waste and debris from these fires were disposed of at the place of the fire during the rebuilding and restoration process (Ute and Singer 2007). Figure 2-4 shows a 1939 aerial photograph of the Alameda Mole and ferry slip and the current boundary of IR Site 1.

By 1943, Alameda Point was occupied by the U.S. Navy and a large portion of the area now IR Site 1 was land and being used as a landfill for disposal of waste. The Alameda Mole was abandoned (the construction of the Bay Bridge all but ended the use of the Alameda Mole for commuting by ferry). Remnants of the ferry slip extended from the northern end of Alameda Point; however, the Alameda Mole building and railroad tracks were demolished and removed and/or buried. In 1946, the current western shoreline of Alameda Point in the vicinity of the Burn Area was still underwater. Figure 2-5 shows an aerial photograph of Alameda Point in 1946, the 1939 land surface boundary, and the current boundary of IR Site.

By 1952, the runway now present over IR Site 1 had been constructed;, the landfilling disposal operations seen in aerial photographs from 1943, 1946, 1947, and 1949 had stopped; and, open-air burning of waste at the northwest portion of Alameda Point (just south of the former Alameda Mole building) was ongoing. As described above, review of aerial photographs from 1952, 1953, 1957, and 1958 suggest that burnt waste mixed with sandy fill material was bulldozed into the San Francisco Bay; and, by this means, land was extended to the west. Considering the formation of land prior to the start of the Burn Area activities, it is reasonable to assume that the burn waste presumed to be pushed into the bay was limited to the west and north. Figure 2-6 shows the 1958 aerial photograph of Alameda Point as well as the land boundaries from 1939, 1946, and 2010; and, the IR Site 1 boundary. The vertical extent of the burnt waste in this area is presumed to potentially extend to the bay floor since it was cast over the shoreline slope.

Figure 2-7 shows an aerial photograph from 2010 and land surface boundaries from 1939 and 1946. Above water remnants of the former Alameda Mole ferry slip docks are no longer visible in the 2010 aerial photograph. The shoreline in 2010 closely matches the shoreline from 1958. In addition, the horizontal extent of the Burn Area is shown in Figure 2-7. The development of the Burn Area footprint shown in this aerial photograph is described in detail in Section 2.7.2 of this report.

2.3 Previous Burn Area Investigations

Soil samples were collected from the former Burn Area as part of the Remedial Investigation (RI; TtEMI 2001a) to evaluate incineration-related compounds such as polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Specifically, four surface soil samples and 14 subsurface soil samples from four borings advanced up to 30 feet below ground surface (bgs) were collected for PCDD/PCDF, toxicity characteristic leaching procedure (TCLP), and soluble threshold limit concentration (STLC) analyses (BEI 2006a).

PCDDs and PCDFs were reported in all of the soil samples collected from the Burn Area. Additionally, two of the boring logs contained reference to debris. Boring IR1-EAD-SOC13 contained screws, nails, and wood in soil from 0 to 4 feet bgs and a slight creosote odor was noted at 8 to 9 feet bgs. Boring IR1-EAD-SOC15 had metal debris in the soil samples from 0 to 4 feet bgs and minor metal debris at approximately 8 feet bgs (BEI 2006a).

For each of the soil samples collected in the Burn Area, 2,3,7,8-tetrachlorodibenzodioxin (TCDD) toxicity equivalents (TEQs) were calculated. For informational purposes, the TEQs were compared to the residential Preliminary Remediation Goal (PRG) for dioxins. All eight samples collected in the upper 10 feet of the site had a TEQ greater than the residential dioxin PRG for 2,3,7,8-TCDD of 3.9 x 10^{-6} milligrams/kilogram (mg/Kg) (BEI 2006a).

None of the results for the TCLP analyses exceeded the U.S. EPA criteria for classifying waste as hazardous. The concentration of cadmium in one sample and of lead in three samples exceeded or equaled the California criteria for hazardous waste classification (BEI 2006a).

2.4 2010 and 2011 and 2012 Pre-design Characterization

During the summer of 2010, a focused investigation of the Burn Area was conducted to support remedial design. This included advancing five test trenches and 11 soil borings. Soil samples were collected from soil borings and submitted for analyses pursuant to the established chemical and radiological soil RGs(Chadux Tt 2009). As a result of this 2010 Pre-design Characterization effort, the western extent of the Burn Area was defined and appeared to match the history of the Burn Area formation described above (Section 2.2) in that it nearly matched the 1946 land surface boundary. Additionally, analytical results from the soil sampling revealed that the Burn Area waste and surrounding material contained Contaminants of Concern (COCs) above the RGs established in the ROD. However, the 2010 Pre-design Characterization effort did not define the extent of the Burn Area waste impacts to the south and north. Additional investigation carried out in the Fall 2011 and Spring 2012 were required to fully define the nature and extent of the Burn Area impacts and to support the design of a geotechnical remedy as shown in Figure 2-8. Section 2.7.2 below provides a detailed description of the nature and extent of the Burn Area impacts, including the results from the 2010, 2011, and 2012 Pre-design Characterization work.

2.5 Related Investigations

The Offshore Sediment Investigations and Background Chemical Concentration Determination relate to the Burn Area at IR Site 1. These investigations are discussed in the following subsections.

2.5.1 Offshore Sediment Investigations

Offshore sediment samples adjacent to IR Site 1 were collected in 1993, 1994, and 1996 (PRC 1994 and 1996a). Battelle et al. (2000) submitted a draft Data Summary Memorandum that used all the collected data to describe the nature and extent of contaminants and to evaluate the potential risks to human and ecological receptors. The evaluation found that contaminant concentrations in sediment were generally within the range expected for ambient concentrations in the San Francisco Bay and unlikely to pose an increased health risk relative to the rest of the bay. IR Site 29, located just offshore of IR Site 1, has a proposed plan for no further action. Additional offshore sampling adjacent to IR Site 1 was proposed in the 2004 draft Offshore Sediment Core Study Work Plan at Oakland Inner Harbor, Pier Area, Todd Shipyard, and Western Bayside (Battelle et al. 2004). These offshore sediment samples were collected adjacent to the proposed public beach area at IR Site 1 in March 2005. A more detailed discussion of this effort can be found in the 2006 Feasibility Study Report (BEI 2006a).

2.5.2 Background Chemical Concentration Determination

Background concentrations of inorganic chemicals in soil and groundwater at Alameda Point were evaluated to aid in identifying chemicals resulting from historical site activities. Methods and results are described in the 1997 report titled Final Statistical Methodology for Background Comparisons (PRC 1997) and the 2001 report titled Summary of Background Concentrations in Soil and Groundwater (TtEMI 2001b). The methodology used in developing the soil background data set included dividing Alameda Point into areas with geologically similar soils. The Naval Air Station (NAS) Alameda base was constructed using fill material dredged from various locations in the San Francisco Bay over a period of 75 years (1900 to 1975); therefore, the fill material exhibits variations in lithology across the base. From this study, a single background groundwater data set was developed for Alameda Point for shallow groundwater that occurs within the fill material, referred to as the First Water-Bearing Zone (FWBZ). Background soil and groundwater conditions were determined using a series of statistical tests conducted on each medium. Results of the soil and groundwater background evaluations for the far western area of Alameda Point are presented in the 1997 and 2001 reports.

2.6 Burn Area Characteristics

This section provides an overview of the site setting and characteristics, the nature and extent of the contamination, the predicted fate and transport of dissolved contamination, and a summary and updated assessment of the risks stemming from exposure to wastes in the Burn Area.

2.6.1 Setting Characteristics Summary

The climate, topography, land and groundwater use, ecology, geology, surface water hydrology and tides, and hydrogeology at and in the vicinity of IR Site 1 and the Burn Area are summarized in the sections below.

2.6.1.1 Climate

The San Francisco Bay area is characterized by a Mediterranean climate with mild summer and winter temperatures. The mean annual precipitation at Alameda Island is 23 inches, with most of the precipitation occurring from October to April. Mean yearly low and high temperatures are 52 degrees Fahrenheit (^{o}F) and 67 ^{o}F, respectively. The wind direction is predominantly from the west or northwest, with rare occurrences of gale-force or greater winds. Heavy fog that sometimes impairs visibility for navigation occurs an average of 21 days per year (National Weather Service 2001).

2.6.1.2 Topography

Alameda Island lies at the base of a gently westward-sloping plain that extends from the Oakland-Berkeley Hills in the east to the shore of the San Francisco Bay in the west. Alameda Island is characterized by a low topographic profile, with surface elevations varying from mean sea level (MSL) to approximately 30 feet above MSL. Alameda Point is located in the western portion of Alameda Island. IR Site 1 is located in the northwestern portion of Alameda Point and the area is generally flat with slight depressions in the surface. Ground surface elevation at IR Site 1 ranges from approximately 6 to 10 feet above MSL.

2.6.1.3 Land and Groundwater Use

Currently, IR Site 1 is owned by the federal government and under the jurisdiction of the Navy. Much of the site is covered by paved runway surfaces, and the remaining area is primarily covered by nonnative annual grassland, with some seasonal wetlands that occur during rainy winter periods. IR Site 1 is currently fenced and not in use. According to the City of Alameda, Alameda Point General Plan, as amended May 7, 2003, the proposed land use throughout IR Site 1 is recreational (City of Alameda 2003). This land use is shown in the Alameda Point Preliminary Development Plan (PDP) dated February 1, 2006. Therefore, the future land use for IR Site 1 addressed in the ROD is recreational. The reuse parcel number for IR Site 1 is Economic Development Conveyance (EDC) reuse parcel number EDC-13 (City of Alameda 2002).

Groundwater beneath the western portion of Alameda Point (including IR Site 1) is not currently used for drinking water, irrigation, or industrial supply and meets State Water Resources Control Board (SWRCB) exemption criteria to dedesignate the aquifer beneath portions of Alameda Point as having potential beneficial uses as a municipal supply (Water Board 2003). In addition, the U.S. EPA stated that based on the shallow depth of the aquifer in this area, the likelihood of saltwater intrusion (based on groundwater flow directions) if any significant pumping takes place, and the fact that no wells currently exist within or close to this area, it seems unlikely that groundwater in this area will be a potential source of drinking water in the future. As a result, the U.S. EPA concurs with the cleanup level for IR Site 1 such that the threats posed by such exposures as inhalation, dermal contact, and those associated with irrigation use are eliminated, and any significant ongoing degradation of the groundwater from contamination is prevented (U.S. EPA 2000).

As specified in the San Francisco Bay Basin Water Quality Control Plan (Basin Plan; SFBRWQCB 2011), groundwater beneath the western portion of Alameda Point may have potential use for freshwater replenishment; that is, use of water for natural or artificial maintenance of surface water quantity or quality. At IR Site 1, groundwater remedial action objectives (RAOs) and RGs are protective of the freshwater replenishment beneficial use by reducing concentrations of identified chemicals that pose risk to human health and the environment to below RGs for people who fish (ingesting the organism only) and aquatic life.

IR Site 1 does not have any naturally occurring surface streams or ponds. The Oakland Inner Harbor borders the site to the north, and the San Francisco Bay borders the site to the west.

2.6.1.4 Ecology

A large portion of IR Site 1 is covered by paved runway surfaces and the remaining area is primarily covered by nonnative annual grassland. Seasonal wetlands occur at IR Site 1 during winter rainy periods. The wildlife observed within IR Sites 1 includes, but is not limited to, the following: European starlings, red-winged blackbirds, snipes, common sparrows, harriers, black-tailed jackrabbits, California ground squirrels, and feral rabbits (TtFW 2004b).

The following five ecological habitats occur within approximately one mile of the Burn Area:

1. barren habitat;
2. urban habitat;
3. nonnative grassland habitat;
4. wetland habitat; and
5. estuarine habitat.

Barren habitat occurs in the vicinity of the Burn Area as bare soil, paved areas, runways, and buildings. Urban habitat occurs in the vicinity as ornamental shrubs, trees, and once-landscaped areas.

Nonnative grassland habitat occurs at many locations on Alameda Point as well as over the inland portions of the Burn Area. Nonnative grassland habitat offers shelter, forage, and nesting opportunities for a variety of birds and small mammals.

Wetland habitat occurs as saline emergent wetlands at Alameda Point salt marshes (e.g. West Beach Landfill wetland and other small locations) and as seasonal wetlands at grassy meadows that are intermittently flooded during the wet season. The saline emergent wetland habitat supports characteristic vegetation, abundant invertebrates, and various birds and mammals. Several seasonal wetlands were identified at IR Site 1 (TtFW 2004b) and are characterized by hydrophobic vegetation (i.e. plants which have adapted to growing in the low-oxygen [anaerobic] conditions associated with prolonged saturation or flooding). The seasonal wetlands also provide rest, shelter, and forage for Canada geese (*Branta canadensis*) and other migratory waterfowl. Seasonal wetlands are not located within the Burn Area.

Alameda Point is bordered to the north, west, and south by open-water aquatic habitats. The San Francisco Bay and the Oakland Inner Harbor border IR Site 1 to the west and north, respectively. Estuarine habitat occurs as intertidal and subtidal zones of the San Francisco Bay and the Oakland Inner Harbor. The Burn Area, which is located at the western tip of Alameda Point, is bordered to the west and north by the San Francisco Bay. The estuarine habit bordering the Burn Area consists of an open-water and riprap portion.

Phytoplankton (dominated by diatoms and dinoflagellates) and green and blue-green algae are the dominant plants found in the open-water portions of the estuarine habitat of San Francisco Bay. Red algae are the dominant plant in the benthic zone and provide forage for herbivorous invertebrates and fish (Kozloff 1993). Zooplankton, filter-feeding invertebrates, and fish consume the phytoplankton. Dominant zooplankton groups include rotifers and crustaceans, such as cladocera (water fleas), copepods, and opossum shrimp. Dominant filter-feeding invertebrates include mussels, clams, shrimp, scallops, barnacles, hydrozoa, and invertebrate larvae (Carefoot 1977). Dominant benthic herbivorous invertebrates include chitons, limpets, snails, and abalones. Dominant filter-feeding fish species include anchovies, herring, and larval fishes. The dominant small carnivorous fish include gobies, sculpins, and surfperches. The dominant large carnivorous fish include striped bass, halibut, rock fish, and starry flounder (McConnaughey and McConnaughey 1985). The open-water areas also provide habitat for piscivorous birds and shorebirds such as pelicans, herons, and terns and for carnivorous marine mammals such as sea lions and seals. The larger fish and bird species, however, are migratory and have large home ranges.

The riprap habitat lines the shoreline of the Burn Area and forms the breakwater at the turning basin south of Alameda Point. Dominant plant species include fig-marigold, fescue, and ryegrass. Pelicans and double-crested cormorants use the breakwater areas for roosting. Western gulls use the breakwater and the riprap near the wetland habitats for nesting as well. Feral cats have been observed in the riprap near the wetland habitats.

Special-status species are those plant and animal species that are classified as threatened, endangered, or species-of-concern by state or federal agencies, and that are known to occur or have the potential to occur in the terrestrial or aquatic habitats in the vicinity of the Burn Area (CDFG 2002a, b, c, and d). There are no recent records of these species occurring at the Burn Area or IR Site 1 (LSA 2001, WRT 2002, TtFW 2004b). A survey has not been performed to identify special-status species; however, because of historical use and disturbances, the listed species are unlikely to occur at the site.

2.6.1.5 Geology

Alameda Island is located on the east side of the San Francisco Bay. The bay occupies a depression between the Berkeley Hills to the east and the Montara Mountain and other mountains to the west. The depression and hills were formed by two active faults, the San Andreas Fault, west of the San Francisco Bay, and the Hayward Fault, east of the San Francisco Bay. The San Andreas and Hayward Faults are approximately 12 miles west and 5 miles east of the island, respectively. Evidence of liquefaction was observed at IR Site 1 after the Loma Prieta Earthquake in 1989 (Magnitude 7.1 on the Richter Scale) (FW 2002).

Alameda Point Geology

Stratigraphy beneath Alameda Island and San Francisco Bay consists of unconsolidated sediments approximately 400 to 500 feet thick at the eastern margin of the bay. Alameda Island sedimentary deposits consist of five stratigraphic units. From oldest to youngest, they are the Alameda Formation, the lower unit of the San Antonio Formation (Yerba Buena Mud), the upper unit of the San Antonio Formation, the Merritt Sand Formation, and the upper and lower Bay Sediment Unit (BSU) (upper bay sediment also referred to as the Young Bay Mud). These sediments overlie bedrock consisting of metamorphosed sandstone, siltstone, shale, graywacke, and igneous bedrock of Jurassic to Cretaceous age, all of which represent the Franciscan Formation (Rogers and Figuers 1991, Norfleet Consultants 1998).

Most of the sedimentary deposits at Alameda Point are overlain by fill material. The northern portion of Alameda Island was formerly tidelands, marshlands, and sloughs adjacent to the historical San Antonio Channel, now known as the Oakland Inner Harbor. Most of the land that is now Alameda Point was created by filling the natural tidelands, marshlands, and sloughs with dredge spoils from the surrounding San Francisco Bay, Seaplane Lagoon, and Oakland Inner Harbor (TtEMI 2000). The western perimeter of IR Site 1 was partly reclaimed by placing two rows of sunken barges and then adding dredged fill material. The depth of the sunken barges and pontoons is believed to be approximately 20 feet. IR Site 1 is located entirely over this dredged material (FW 2002).

IR Site 1 Geology

Interpretation of the geology at IR Site 1 is based on subsurface environmental and geophysical investigations conducted at the site. Some borings extended to depths greater than 100 feet. The five geologic units identified at IR Site 1 and mentioned above include artificial fill material, BSU, Merritt Sand Formation, Upper San Antonio Formation, and Lower San Antonio Formation (Yerba Buena Mud). TtEMI (1999c) interprets that the subsurface stratigraphy represents a paleochannel that trends from northeast to west across the base and is present beneath IR Site 1. The Merritt Sand and Upper San Antonio Formations are interpreted to be present in the northern portion of IR Site 1 but are not present in the southern portion of the site, where the paleochannel removed the two units. Therefore, the BSU is interpreted as directly overlying the Yerba Buena Mud. Based on their geotechnical investigation, Foster Wheeler (2002) interprets most of the sand units underlying the BSU as the Merritt Sand Formation rather than the bay sediments of the lower BSU. Foster Wheeler depicts the Merritt Sand Formation as continuous beneath IR Site 1. This difference in geologic interpretation does not affect the interpretation of hydrostratigraphic units.

Fill Layer

The fill layer that underlies IR Site 1 is composed of mixtures of sand, silt, and clay, and ranges in thickness from approximately 10 to 30 feet. The fill layer is thinnest in the eastern part of the site. The varying thickness is a result of natural variation on the depth of the estuary before filling (FW 2002). In the western portion of the site (in the former disposal area), refuse has been buried in the fill material (TtEMI 1999c).

Bay Sediment Unit

The BSU is the youngest naturally occurring unit in the site area. The sediments were deposited within the bay and the surrounding estuaries and tidal flats. The BSU at IR Site 1 is generally very dark gray and consists of the upper Young Bay Mud underlain in some areas by coarser bay sediments (TtEMI 1999c). The Young Bay Mud consists of clay and silt containing mixtures of silt and fine-grained sand (FW 2002). The lower, coarser portion of the BSU consists of fine-grained sand (TtEMI 1999c). The BSU is interpreted by TtEMI (1999c) to be up to 67 feet thick beneath the southwestern portion of the site within the interpreted paleochannel. The Young Bay Mud ranges from very thin in the northeastern part of IR Site 1, where it pinches out against the underlying Merritt Sand, to approximately 20 to 25 feet thick in the southern part of the site. The thickness of the Young Bay Mud increases to about 30 feet in borings located immediately offshore, and is about 100 feet thick in areas where the unit is still accumulating in deeper parts of the bay (FW 2002).

Merritt Sand Formation

The Merritt Sand Formation formed as sand dunes when the sea level in the bay was lower than the present levels. The Merritt Sand Formation consists of primarily brown, fine-grained sand to silty sand, and can be differentiated by its color and very dense nature. The thickness of the Merritt Sand Formation varies from approximately 30 to 60 feet, due to natural topographic irregularities and post-depositional erosion (FW 2002).

Upper San Antonio Formation and Lower San Antonio Formation (Yerba Buena Mud)

The Upper San Antonio Formation is composed of coarse-grained sediments, primarily olive gray and gray poorly-graded, fine-grained, dense sand (TtEMI 1999c). The upper San Antonio Formation is reported as a discontinuous layer beneath IR Site 1 that is present in the north portion of the site but absent in the southern portion, where it is interpreted byTtEMI to pinch out along the paleochannel. The depth of the Upper San Antonio Formation at the site is approximately 70 to 80 feet bgs.

The Lower San Antonio Formation (Yerba Buena Mud) is a continuous stratigraphic unit located approximately 80 to 90 feet bgs beneath IR Site 1 (TtEMI 1999c). It is composed primarily of silty clay and clay that are stiff, gray-green, brown-gray, olive-gray, black, and gray.

2.6.1.6 Surface Water Hydrology and Tides

IR Site 1 is bordered by the San Francisco Bay to the west and the Oakland Inner Harbor to the north. The water depth in the eastern part of San Francisco Bay, where IR Site 1 is located, is generally very shallow; at low tide, the muddy bay floor is visible through the shallow water (FW 2002).

The Oakland Inner Harbor is contiguous with the San Francisco Bay. The San Francisco Bay is an estuarine environment in which freshwater from the Sacramento and San Joaquin Rivers mixes with salt water from the Pacific Ocean. The water level in the bay is not affected by seasonal changes, but tidal fluctuations of 3 to 9 feet occur daily (Shaw 2005).

Tidal studies have been performed at IR Site 1 in 1992 (TtEMI 1999c), 2004 (Shaw 2005), and in 2012 in support of this FFS. These studies indicate that significant tidal influence at IR Site 1 occurs in wells located adjacent to San Francisco Bay, and generally diminishes away from the shoreline. Studies indicate that appreciable tidal influence extends between approximately 100 and 200 feet inland on the western side of Alameda Point. Each of the tidal influence studies conducted concluded that tidal fluctuations influenced the magnitude of the FWBZ groundwater gradient, but did not influence the groundwater flow direction, with the exception of FWBZ aquifer in the immediate vicinity of the shoreline. Tidal efficiencies from previous tidal influence studies and the study conducted in support of this FFS are provided on Table 2-1 and shown in Figure 2-9.

2.6.1.7 Hydrogeology

This subsection discusses the regional hydrogeology at Alameda Point and site-specific hydrogeology at IR Site 1.

Regional Hydrogeology

Alameda Island is underlain by two primary aquifers, the shallow Merritt Sand aquifer that yields brackish-to-very-saline water (20,000 to 35,000 milligrams per liter [mg/L] total dissolved solids [TDS]; TtEMI 2000) and the deeper Alameda aquifer that yields freshwater. These aquifers are separated by the regional San Antonio aquitard, which is approximately 55 to 90 feet thick beneath Alameda Point.

The Merritt Sand Formation is a confined or semi-confined aquifer beneath Alameda Island (TtEMI 1999c). Regionally, groundwater recharge to the artificial fill material and Merritt Sand Formation is attributed to vertical infiltration from precipitation, excess landscape irrigation, flow from upland areas, and possibly leaking water-supply and sewer piping (TtEMI 2000). The Merritt Sand Formation is dissected by Oakland Inner Harbor, allowing saltwater to intrude into the formation. There is no hydraulic association between the shallow aquifer systems on Alameda Island and the Oakland mainland because of the barrier created by the Oakland Inner Harbor.

The lower unit of the San Antonio Formation (Yerba Buena Mud) is known to be an effective and regionally continuous aquitard and confining layer above the underlying Alameda Formation, which is the principal regional aquifer. No direct evidence of depositional interconnection between the Merritt Sand Formation and the Alameda Formation has been identified. Borehole lithologic descriptions indicate that 55 to 90 feet of low-permeability material (Yerba Buena Mud) is present (TtEMI 2000). Depth to the top of the Alameda aquifer ranges from 180 feet bgs at Alameda Point to 220 feet beneath the surface of the sediment in the Oakland Inner Harbor. The thickness of the formation is between 230 and 800 feet (Hickenbottom and Muir 1988).

Mean electrical conductivity of groundwater in the FWBZ and SWBZ measured during sampling was contoured (Figure 2-10). Considering the salinity, and, therefore electrical conductivity, seawater is considerably higher than that of freshwater (recharging precipitation). The comparison between the electrical conductivities in the FWBZ and SWBZ provide a line of evidence that freshwater recharge from the FWBZ to the SWBZ is limited. In addition, the distribution of conductivities which in general show that lower electrical conductivities are further inland from the seashore, reveal a gradient of freshwater flow from inland to the bay.

Alameda Point and IR Site 1 Hydrogeology

The shallow hydrostratigraphic units beneath IR Site 1 have been divided into the following four hydrogeologic units:

- FWBZ – artificial fill layer
- Semi-confined aquitard – Young Bay Mud of the BSU

- Second Water Bearing Zone (SWBZ) – lower portion of the BSU, Merritt Sand Formation and Upper San Antonio Formation
- Regional aquitard – Lower San Antonio Formation, including the Yerba Buena Mud

The FWBZ at Alameda Point is unconfined and located in the fill material. This FWBZ in the fill layer is a local feature of Alameda Point and is not present regionally. Depth to groundwater in the FWBZ at IR Site 1 ranges from the ground surface to approximately 8 feet bgs and averages 3 to 5 feet bgs (TtEMI 1999c). Groundwater recharge occurs from infiltrating precipitation in unpaved areas within and outside of the site. Groundwater generally flows toward the shoreline in the FWBZ at IR Site 1 (westerly toward the San Francisco Bay and northerly towards the Oakland Inner Harbor). The Young Bay Mud portion of the upper BSU acts as a semi-permeable aquitard between the FWBZ and the SWBZ. Hydraulic communication between the FWBZ and SWBZ is considered minimal across most of the site, where these hydraulic zones are separated by the Young Bay Mud. Localized hydraulic communication may occur in the northeastern portion of the site, where the Young Bay Mud is not present.

The SWBZ is semi-confined. Coarse-grained sediments of the lower portion of the BSU, the Merritt Sand Formation, and the Upper San Antonio Formation comprise the SWBZ. The proximity of the Merritt Sand Formation to San Francisco Bay contributes to the presence of salt water in the SWBZ. The SWBZ is underlain by the Yerba Buena Mud, which forms a regional aquitard separating saline groundwater in the SWBZ from fresh groundwater in the underlying regional Alameda aquifer (TtEMI 1999c).

Transmissivity values were estimated for the FWBZ at IR Site 1 from aquifer test data conducted in 1996 (PRC 1996b). Calculated transmissivity values ranged from 0.22 to 0.65 square feet per minute (ft^2/min) with an average of 0.34 ft^2/min (PRC 1996b). Calculated storativity values ranged from 0.0013 to 0.0026 with an average of 0.0018, and specific yield was 0.05 (PRC 1996b). Hydraulic parameters were also estimated from IR Site 1 slug tests and geotechnical samples. Results of slug tests indicated a range of hydraulic conductivity values from 0.001 to 0.0037 feet per minute (ft/min) for the FWBZ and 0.0015 to 0.0024 ft/min for the SWBZ (TtEMI 1999c). Results of vertical permeability tests conducted on six geotechnical samples from the BSU ranged from 8.3×10^{-9} to 9.0×10^{-8} ft/min (TtEMI 1999c).

2.6.2 Nature and Extent of Burn Area Contamination

For the purposes of this FFS Report, the discussion of the nature and extent of the Burn Area contamination discussion is divided by media - soil and groundwater. Nature and extent related to soil impacts are described in Section 2.6.2.2; and, nature and extent of groundwater impacts are described in Section 2.6.2.3.

2.6.2.1 Historical Sources of Contaminants

The primary source of contamination in the Burn Area is burnt waste material from industrial waste and construction demolition debris. Little to no evidence of putrifiable municipal-type solid waste was observed in samples collected and examined from the Burn Area. In addition to the primary component of waste, radiological waste is also present in the Burn Area. Analytical results for soil and groundwater samples submitted for laboratory analyses are provided in Appendix A.

2.6.2.2 Soil Results

During the Pre-design Characterization (Section 2.4) conducted at IR Site 1, five test trenches and 15 soil borings were advanced over the limits of the suspect Burn Area boundaries, referred to as Area 1b (Figure 2-3). The 2010 Pre-design Characterization was conducted under the Work Plan for Pre-Design Sampling and Investigation (AMEC 2010). As a result of this investigation it was determined that the Burn Area extended further to the south and north than supposed previously (Chadux Tt 2009). In the Fall 2011, 17 additional soil borings were advanced and 14 new groundwater monitoring wells were installed and sampled to complete the characterization of the Burn Area. The 2011 soil sampling was conducted under an amendment to the Work Plan for Pre-Design Sampling and Investigation (AMEC 2011a). Following completion of the additional Pre-design Characterization, the extent of the burn layer and surrounding geology was mapped sufficiently to implement the selected remedy for the Burn Area as described in the Final ROD (Chadux Tt 2009). Mapping results show that the footprint of the burn layer is approximately 900 feet in length from north to south and extends between 150 and 250 feet inland, towards the east from the mean sea level land surface contour along the shoreline slope. The burn layer varies in thickness from up to 28 feet thick in the northern section to less than 1 foot thick in the southern section. Trench, boring, and monitoring well locations are shown in Figure 2-11. The burn layer footprint, geologic cross sections, and three-dimensional renderings showing the burn layer are shown in Figures 2-12 through 2-16,

Test Trenches:
To aid in determining the nature of the debris in the Burn Area and lateral extent of burn residue in the Burn Area, five trenches were excavated and logged. The designations for trenches in the Burn Area are T-10 through T-14 shown on Figure 2-11. Trench logs are provided in Appendix B.

Trench T-10, oriented approximately north-south, was positioned to delineate the northern limit of the Burn Area. Excavation started on the south and proceeded to the north. Burn waste was excavated at the northern terminus of T-10 suggesting that limit of burned waste extends beyond the north limit of the trench, which coincided with the northern boundary of Area 1b, the supposed northern limit of the Burn Area. Burn debris was encountered in the first half and final segment of the trench at depths ranging from 12 to 30 inches bgs. The debris consisted of wood, lumber, porcelain, rubber tubing, glass, metal, pipe, and pieces of concrete and asphalt in a black ashy matrix layered with ash layers. Between Stations 0+50 and 0+60, large voids between pieces of old wood and lumber were observed and minor caving of the trench walls occurred in this segment. Based on inspection of this material and the proximity of this trench to the former Alameda Mole building and ferry slip, the debris in this area is consistent with the 1902 Alameda Mole fire and subsequent restoration (Section 2.2).

Approximately 0.75 cubic yards (cy) of material excavated from T-10 had observed radiological readings at or above twice the normal background levels, which, over the duration of the characterization fieldwork, averaged 4,335 counts per minute (CPM) at a standard deviation of 654 CPM, and were placed in an intermodal container positioned near the trench. The interval with the elevated radiological instrument readings was between Stations 0+30 and 0+40 at a depth of approximately 24 inches bgs. Instrument readings ranged from 10,000 to 25,000 CPM. Groundwater at Trench T-10 was encountered between 56-72 inches bgs. A Ludlum model 4410 Sodium-Iodide 2X2 Probe with model 2350-1 Data Logger (NaI Detector) was used to scan materials exhumed from the test trenches. Each bucket of exhumed material was scanned using the NaI detector.

Trench T-11, oriented approximately east-west, was positioned to delineate the eastern limit of the Burn Area. Excavation started on the east and proceeded to the west. Debris was encountered in the first segment of the trench at depths ranging from 4 to 24 inches bgs. The debris consisted of minor amounts of wood and metal. A clay pipe was also encountered (Station 0+05). Large pieces of concrete were encountered between Stations 0+62 to 0+76 and the backhoe was not able to dig through this segment. From Station 0+76 to the western terminus of the trench (Station 1+10), construction debris consisting of large pieces of concrete, metal, and metal sheeting was excavated. No burn debris was observed in the trench.

Approximately 0.50 cy of material excavated from T-11 had observed radiological readings at or above twice the normal background levels and were placed in an intermodal container positioned near the trench. The interval with the elevated radiological instrument readings was between Stations 0+02 and 0+15 on the ground surface. Instrument readings ranged from 10,000 to 35,000 CPM. Groundwater at Trench T-11 was encountered between 68 and 72 inches bgs.

Trench T-12, oriented approximately east-west, was positioned to delineate the eastern limit of the Burn Area. Excavation started on the east and proceeded to the west. Only minor amounts of debris consisting of metal and wood were excavated between Stations 0+22 and 0+30 at depths ranging from 40 to 50 inches bgs. Large boulders and pieces of concrete were excavated between Stations 0+30 and 0+55 at depths ranging from 4 to 36 inches bgs. Large concrete pieces were encountered between Station 0+70 and the end of the trench (Station 1+90) and the backhoe was not able to excavate them and refusal was called. No burn debris was observed in the trench, however, materials below 3 feet were not observed past Station 0+70. No elevated radiological readings were detected in this trench. Groundwater at Trench T-12 was encountered between 60 and 68 inches bgs.

Trench T-13, oriented approximately east-west, was positioned to delineate the eastern limit of the Burn Area. Excavation started on the east and proceeded to the west. Debris consisting of metal, wire, glass, pipe, wood, and mechanical parts was excavated between Stations 0+00 and 0+30 located near the surface to 4 feet bgs. Black, stained soil with a strong petroliferous odor and an oily sheen on the groundwater was observed in the lower part of the trench in this same interval. Between Stations 0+30 and 0+80, a few pieces of debris were excavated in primarily clean, sandy fill. Between stations 0+80 and 1+10, debris similar to that described above was encountered. Burn debris was excavated at the end of the trench marking the eastern limit of the Burn Area at approximately Station 1+10. No elevated radiological readings were detected in this trench. Groundwater was encountered at Trench T-13 between 56 and 68 inches bgs.

Trench T-14, oriented approximately north-south, was positioned to delineate the southern limit of the Burn Area. Excavation started on the south and proceeded to the north. Debris consisting of burned waste was excavated at the southern terminus of T-14 suggesting that the limit of burned waste extends beyond the southern Area 1b boundary. Burn debris was encountered throughout the entire length of the trench at approximately 24 inches bgs. The burn debris consisted of wood, lumber, a corroded drum containing a small amount of dark watery liquid (presumed to be groundwater), porcelain, glass, metal, and scrap piping in a black, ashy matrix layered with gray ash layers.

Approximately 5 cy of material excavated from Trench T-14 had observed radiological readings at or above twice the normal background levels and was placed in an intermodal container positioned near the trench. The intervals with the elevated radiological instrument readings were located between Stations 0+00 and 0+15 and 0+40 to 0+70 at a depth of approximately 24 inches. Instrument readings ranged from 10,000 to 35,000 CPM. Groundwater was encountered at Trench T-14 between 64 and 74 inches bgs.

Soil Borings and Sampling:
Thirty-two soil borings were advanced and 14 new monitoring wells were installed in the suspect Burn Area during the 2010 and 2011 Pre-design Characterization fieldwork. Soil boring and monitoring well location are shown in Figure 2-11. Boring logs and well construction diagrams are provided in Appendix C.

Of the 32 borings (11 in 2010 and 17 in 2011), 21 are vertical borings; five of which were completed as dual monitoring wells (FWBZ and SWBZ). The five vertical borings with dual-completed monitoring wells were advanced to a depth of about 60 feet bgs. The remaining 12 vertical borings were completed to a vertical depth of about 30 feet bgs. Eleven of the borings were advanced to a vertical depth of approximately 28 feet bgs at an angle of 33-degrees off horizontal (57-degrees off vertical) with four completed as monitoring wells. The approximate length of each of these sloped borings was 50 feet. All borings not completed as monitoring wells were backfilled with an expansive cement-bentonite grout.

The aerial extent (footprint) and cross sections of the Burn Area, including the demarcation of the burn layer are shown in Figures 2-12 through 2-15. Considerable effort was expended to discern the burn layer across the soil samples examined. Specifically, suspect burn material samples were oven dried and washed over a 200-mesh sieve to remove fines. Debris consisting of wood, metal, and glass was closely examined to distinguish burn waste from biologically reduced media. Color alone could not be used as a defining factor because biologically reduced aquifer media was black in color similar to the burn waste. Burn waste debris, once removed from the sample and examined was melted and stained unlike the debris in media that was simply biologically reduced. Three-dimensional renderings of the burn layer showing elevations relative to mean seal level are shown in Figure 2-16.

To characterize the horizontal and vertical extent of Burn Area impacts, eight soil samples were collected and analyzed from each of the 32 additional borings (256 soil samples total) as follows:

- Four depth-discrete samples taken from the vadose zone;

- One composite sample from the saturated zone;
- Two samples at the vertical waste limit (one at the vertical limit of visually-identified waste and one from directly below that limit); and
- One sample from 1 foot below the Young Bay Mud / artificial fill interface.

Each Burn Area soil sample was screened for radionuclides in the field, and was submitted for laboratory analyses of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, metals, hexavalent chromium, radium-226, cesium-137, and cobolt-60 to test for soil RGs for human and ecological receptors specified in the Final ROD (Chadux Tt 2009). Soil sample analysis results are summarized on Table 2-2, Table 2-3, and Table 2-4. The distributions of COCs in surface soil (0.0 to 1.0 feet bgs) that exceed RGs are shown in Figure 2-17. The distributions of COCs in the subsurface at the Burn Area are shown in Figures 2-18 through Figure 2-31. The spatial distribution of soil COCs shown in these figures were generated by a three step process as follows:

1. Soil sample depth intervals at each boring were converted to elevation relative to mean sea level and COC concentrations at plotted elevations at borelog locations were calculated using linear interpolation between soil sample results. Non-detect soil sample results were entered as the reporting limit.
2. A model domain extending around the study-area soil boring locations to the east, north and south and to the shoreline slope surface was established for each elevation plotted.
3. The spatial distribution of each COC at each elevation plotted was calculated over a 10-foot x 10-foot grid within the model domain using a Kriging algorithm (Surfer™ software version 9.0).

The near land-surface spatial distribution of concentrations for COCs that had RG exceedances shown in Figure 2-17 was similarly constructed using soil sample results from the 0.0- to 1.0-foot sample interval at each soil boring location.

The trenching, soil boring, and soil sampling results provide a significantly higher resolution representation of the nature and extent of the burn residue and surrounding impacted soil compared with previous investigations. Prior to the 2010 characterization effort, the extent of the Burn Area was primarily based on review of aerial photographs from the 1950s, which showed the Burn Area occupying 3.7 acres at the northwestern end of Alameda Point. Additionally, it was conceived that the burn residue was limited to within the upper 10 feet of the 3.7 acres and did not extend under the shoreline slope. The results from the recent investigations completed in 2010 and 2011 revealed that the burn residues derived from Burn Area activities conducted in the 1950s occupy approximately

4.3 acres, extend beyond the top of the shoreline slope, and up to 28 feet bgs. Additionally, in the northern portion of the Burn Area, burn residues are primarily derived from fires that occurred at the Alameda Mole building and ferry slip at the beginning of the twentieth century prior to Navy presence at Alameda Point.

Results from soil samples collected from the Burn Area show that five of the eight COCs for human receptors, three of the five COCs for ecological receptors, and two of the three primary radiological materials exceed remediation goals pursuant to the ROD (Chadux Tt 2009). The spatial distribution of the chemicals of concern varies. Cadmium, zinc, and lead appear more widespread across the Burn Area compared withPAHs, PCBs, and pesticides; which occur in localized areas and depths.

2.6.2.3 Groundwater Results

Groundwater samples were collected from Burn Area monitoring wells installed as described above. Each groundwater sample collected from both the FWBZ and the SWBZ was submitted for laboratory analysis for the following:

- PCBs (EPA Method 8082),
- Pesticides (EPA Method 8151A),
- Volatile Organic Compounds (VOCs; EPA Method 8260B),
- Semivolatile Organic Compounds (SVOCs; EPA Method 8270C-SIM),
- Dissolved and Total Metals Cal 22 (EPA Methods 6000/7000 series),
- Dioxins / Furans (EPA Method 8290), and
- Radionuclides.

The 2012 groundwater sampling and analysis was conducted pursuant to the Burn Area Groundwater Sampling and Analysis Plan (AMEC 2012).

Groundwater sampling was conducted using dedicated low-flow submersible pumps with Teflon® tubing. If well screens spanned burn debris, the groundwater samples were collected from the midpoint of the intersection of the well screen section and the burn debris interval. Otherwise, groundwater samples were collected from the approximate midpoint of the screen section.

Groundwater sampling was conducted in two events as follows:

- Tidal Influence Biased Groundwater Sampling and Analysis and
- Study-area Groundwater Sampling and Analysis.

Prior to collecting groundwater samples, groundwater and surface water (San Francisco Bay) levels in the FWBZ and SWBZ were monitored by two methods. First, monitoring wells across IR Site 1, including the 14 newly installed wells, were gauged on three occasions: March 26, 2012, May 07, 2012, and May 10, 2012. The results of well gauging, including the date and time of day (hour:minute) of gauging is summarized on Table 2-5. The second method used to monitor groundwater and surface water levels in support of this FFS report was to install submersible pressure transducers (SPTs) with on-board dataloggers in the 14 newly installed wells to monitor the tidally and infiltrating storm-water induced pressure fluctuations at the study-area. Five of the 14 newly installed wells; PMW-9FWBZ, PMW-10FWBZ, PMW-11, PMW-9SWBZ, and PMW-10SWBZ were monitored using SPTs between March 01, 2012, and May 07, 2012. Monitoring wells PMW-5FWBZ, PMW-5SWBZ, PMW-8, and PMW-16FWBZ were monitored using SPTs between May 08, 2012, and May 10, 2012. Monitoring wells PMW-1, PMW-12, PMW-13FWBZ, and PMW-13SWBZ were monitored using SPTs between May 11, 2012, and May 15, 2012. Monitoring well PMW-16SWBZ was monitored using an SPT between May 08, 2012 and May 15, 2012. During the SPT monitoring described above, sea level pressure change (tides) was monitored using an SPT.

Results from pressure monitoring were used to determine the tidal efficiency (ratio of the sea level pressure fluctuation to the corresponding pressure fluctuation in a well) and the lag-time (the time between a tide minimum/maximum and the corresponding minimum/maximum pressure observed in a well). Tidal efficiency values determined from the SPT data are provided on Table 2-1. Lag time values determined from the SPT data are summarized on Table 2-6. In addition, the groundwater gauging and SPT data were used to generate a mean FWBZ water table contour tying into MSL (Serfes 1991). Figure 2-32 shows the mean FWBZ groundwater contours at IR Site 1.

Tidal Influence Biased Groundwater Sampling was conducted using groundwater monitoring wells PMW-9FWBZ, PMW-10FWBZ, PMW-11, PMW-9SWBZ, and PMW-10SWBZ. Samples were collected between 08:35 hours on May 08, 2012, and 04:09 hours on May 09, 2012. Based on the lag-times calculated using SPT data (Table 2-6), samples were collected from wells at corresponding pressures aligning with the cycle of the tides from low tide, through high-high tide, and ending on low-low tide. Five samples were collected from each to correspond with (1) the low tide, (2) the midpoint between the low and high-high tide, (3) the high-high tide, (4) the midpoint between the high-high and low-low tide, and (5) the low-low tide.

Results of the Tidal Influence Biased Groundwater Sampling are summarized in Table 2-7, Table 2-8, and Table 2-9. The primary purpose of this sampling program was to determine if dilution of groundwater contamination by tidal influence was quantifiable. If quantifiable tidal dilution of groundwater contamination was observed then two responses would follow. First, future study-area groundwater contamination would be timed to correspond to the low tide; which would correspond to the highest groundwater contaminations detected. Second, the flow component of the reactive-transport model would be driven by the transient nature of the tides and not the average steady-state, freshwater replenishment flow to the bay. However, correlation with tidal influence dilution was not observable in the analytical results.

Following the Tidal Influence Biased Groundwater Sampling, each of the 14 newly installed groundwater wells and one existing well, M-033A, were sampled. This Study-area Groundwater Sampling event was conducted between May 15, 2012, and May 17, 2012, and samples were collected at low or low-low tide plus lag time (Table 2-6) for each well. This low-tide sampling approach was taken to be conservative, even though the results of the Tidal Influence Biased Groundwater Sampling showed no correlation with tides and groundwater contamination dilution.

Results of the Study-area Groundwater Sampling are summarized in Table 2-10, Table 2-11, and Table 2-12 and show that chemicals and radiological materials of potential concern are contained in the groundwater within the Burn Area. Based on results from previous risk assessments conducted at IR Site 1 (Section 2.7), the remedial action objectives established for IR Site 1 (Chadux Tt 2009) and these recent groundwater sampling results, it was determined that the exposure pathway associated with freshwater replenishment to the San Francisco Bay required additional consideration. Section 2.7.2 details the additional analyses and assessment of this remaining exposure pathway.

2.6.3 Fate and Transport of Contaminants

The fate-and-transport analysis evaluates the potential for site contaminants to migrate through the environment and to persist in the environment. The fate-and-transport analysis is presented in terms of a conceptual site model that includes a description of potential migration pathways and a discussion of natural attenuation processes that describe the fate of contaminants in the subsurface.

2.6.3.1 Burn Area Conceptual Site Model

The IR Site 1 conceptual site model (CSM) presented in Figure 7-1 of the Final ROD (Chadux Tt 2009) was originally presented in the OU-3 RI Report and used to support the risk assessments by identifying the potential receptors and exposure pathways associated with each of the sources of chemicals at IR Site 1. A waste disposal area, burn waste area, former pistol and skeet range (including clay pigeons), and radium-contaminated material in an unlined trench were identified and evaluated (TtEMI 1999c).

The Final FS Report (BEI 2006a) and Final ROD (Chadux Tt 2009) have descriptions of soil remedial alternatives for Soil Area 1, inclusive of the Burn Area. The ROD states that "Area 1, the former waste disposal area, is approximately 25.8 acres in size. Area 1 is divided into Area 1a (the main disposal area) and Area 1b (the former burn area). Area 1a consists of the main disposal area and is approximately 22.1 acres. Area 1b is the former burn area and is approximately 3.7 acres. Components of the soil remedial alternatives for Area 1 include no action, a soil cover, a low-permeability cap, excavation and off-site disposal of soil, a wetlands mitigation plan (WMP), and institutional controls (ICs). Before covering or capping, waste from other areas of Site 1 may be consolidated into the interior of Area 1.

The shoreline portion of Area 1b is addressed under Area 5 (shoreline) alternatives. It is assumed that Area 1 would be developed for recreational purposes after remediation. The subsections below discuss the components associated with each remedial alternative for Area 1."

Comparative analysis of the Area 1 Soil Remedy Alternatives as presented in Section 9 of the ROD states that the alternative which consisted of covering the Burn Area and not excavating the burn waste, S1-2, "was judged to be the most effective in the short-term, most implementable, and least costly among the Area 1 remedial alternatives." The current selected remedy, which includes excavation of the burn waste, Alternative S1-4a, was "rated next highest in satisfying the balancing criteria. It was judged to be slightly less implementable and more costly than Alternative S1-2." It should be noted that implementation of Alternative S1-2 would require a geotechnical remedy for stabilization of the Burn Area since the Burn Area wastes are within the area of shoreline slope anticipated to fail (liquefy/slough) as a result of the maximum credible earthquake.

Additional information in support of the Burn Area CSM follows:

- Blackened waste materials encountered in northern portions of the characterization area (PB-2, PB-3, PB-4, and PMW-5) are outside the footprint of the burn layer and are most likely associated with the former Alameda Mole operations and fire (November 1902).

- A wedge-shaped layer of burnt waste and construction debris adjacent to and extending approximately 500 feet south of the former Alameda Mole building and ferry slip docks is present. This layer of burn material was emplaced by pushing wastes and residues generated by open-air burning into the San Francisco Bay.
- A thin layer of burn waste between 1 and 2 feet thick extends approximately 230 feet south of the southern limits of the area where open-air burning and pushing of waste into the bay occurred. This thin burn layer is encountered at approximately mean sea level. It is presumed that this waste was deposited by longshore currents and was not directly pushed into the bay.
- Between 0.5 feet and 8 feet, an average of approximately 4 feet of soil cover was placed over the burn layer.

Soil sampling conducted in Summer 2010 and Fall 2011 revealed that the soil COC RG exceedances are detected in the burn waste and materials surrounding the burn waste. The largest areal impact of soil RG exceedances were metals - cadmium, zinc, and lead. Pesticides, PAHs, PCBs, hexvalent chromium, cesium-137, cobalt-60, radium-226, strontium-90, and uranium-238 were also detected in isolated pockets above their respective RGs within the burn waste and surrounding materials. Radiological field screening of material from trenchs T-10, T-11, and T-14 (Figure 2-11 and Appendix B) and core retrieved from soil borings SB-12 and PMW-1 (Figure 2-11 and Appendix C) exceeded twice the background radiation.

Soil sampling conducted in March 2005 focused on evaluating dioxins and furans in this area. Results were compared to a Sediment Screening Concentration (SSC) to evaluate potential impacts of this material on the San Francisco Bay. A preliminary sediment screening value of 1.2×10^{-7} mg/kg was used for comparison to 2,3,7,8-TCDD TEQs. All of the samples collected from the Burn Area contained reported concentrations of dioxins/furans in excess of the sediment screening value. Dioxin TEQs were also compared to environmental screening levels (ESLs) prepared by the San Francisco Bay Regional Water Quality Control Board (Water Board) for deeper soils to evaluate potential impacts to the subsurface assuming no contact with soil at the site (as would be the case if the area were capped or covered). One sample had a reported concentration greater than the ESL of 2.4×10^{-4} mg/kg.

The regional direction of groundwater flow is towards the shoreline (Figure 2-32; BEI 2006a). The groundwater flows (a) towards the San Francisco Bay in the southwestern part of the site, and (b) towards the Oakland Inner Harbor in the northeastern part of the site. This indicates the existence of a groundwater divide along the northwestern direction at the site (following the footprint of the paved runway, which bisects the land surface). Tidal influence in the Oakland Inner Harbor and San Francisco Bay, although affecting the magnitude of the regional groundwater gradient, does not affect the direction of groundwater flow.

The hydrological communication between the FWBZ units and SWBZ units is minimal and limited to the northeastern part of the site where the BSU pinches out. The recharge due to rainfall is limited to the unpaved zones of the FWBZ, and any minimal recharge to the SWBZ materials is through the vertical infiltration from the FWBZ materials though the bay sediments, which have very low vertical hydraulic conductivity. Evapotranspiration from the unpaved areas of the FWBZ extracts water from the groundwater flow system.

The site has topological depressions which intersect the groundwater surface (BEI 2006a), mainly in rainy seasons. This has resulted in localized seasonal wetlands south and east of the Burn Area. The wetlands were not instrumented, and therefore, specific surface water elevation measurements for these wetlands do not exist.

Groundwater chemicals of potential concern to freshwater replenishment of the San Francisco Bay detected in the Burn Area samples collected from the FWBZ include the following:

VOCs	SVOCs	Pesticides	Dioxins/Furans
1,2-Dichlorobenzene	2,4-Dimethylphenol	4,4'-DDD	1,2,3,4,7,8-HxCDD
2-Hexanone		4,4'-DDE	1,2,3,6,7,8-HxCDD
Acetone	**PAHs**	beta-BHC	1,2,3,4,6,7,8-HpCDD
Benzene	Acenaphthene		1,2,3,4,6,7,8,9-OCDD
cis-1,2-Dichloroethene	Anthracene	**Metals**	2,3,7,8-TCDF
Ethylbenzene	Benzo(a)anthracene	Barium	1,2,3,7,8-PeCDF
m-Xylene & p-Xylene	Benzo(a)pyrene	Cadmium	2,3,4,7,8-PeCDF
Methylene chloride	Benzo(b)fluoranthene	Chromium	1,2,3,4,7,8-HxCDF
Naphthalene	Benzo(g,h,i)perylene	Cobalt	1,2,3,6,7,8-HxCDF
o-Xylene	Benzo(k)fluoranthene	Copper	2,3,4,6,7,8-HxCDF
Toluene	Chrysene	Lead	1,2,3,7,8,9-HxCDF
trans-1,2-Dichloroethene	Dibenz(a,h)anthracene	Manganese	1,2,3,4,6,7,8-HpCDF
Vinyl chloride	Fluoranthene	Molybdenum	1,2,3,4,7,8,9-HpCDF
1,2,4-Trimethylbenzene	Fluorene	Nickel	1,2,3,4,6,7,8,9-OCDF
1,3,5-Trimethylbenzene	Indeno(1,2,3-cd)pyrene	Silver	
4-Isopropyltoluene	Naphthalene	Thallium	
n-Butylbenzene	Phenanthrene		
n-Propylbenzene	Pyrene		
sec-Butylbenzene			

Groundwater chemicals of potential concern to freshwater replenishment of the San Francisco Bay detected in the Burn Area samples collected from the SWBZ include the following:

VOCs	SVOCs	Metals	Dioxins/Furans
Acetone	2,4-Dimethylphenol	Arsenic	1,2,3,4,7,8-HxCDD
Benzene	bis(2-Ethylhexyl)phthalate	Barium	1,2,3,6,7,8-HxCDD
Ethylbenzene		Chromium	1,2,3,4,6,7,8-HpCDD
Chlorobenzene	**PAHs**	Cobalt	1,2,3,4,6,7,8,9-OCDD
m-Xylene & p-Xylene	Acenaphthene	Copper	1,2,3,7,8-PeCDF
Methyl-tert-butyl ether	Anthracene	Lead	1,2,3,4,7,8-HxCDF
Methylene chloride	Benzo(a)pyrene	Manganese	1,2,3,6,7,8-HxCDF
Naphthalene	Benzo(b)fluoranthene	Molybdenum	2,3,4,6,7,8-HxCDF
o-Xylene	Benzo(g,h,i)perylene	Nickel	1,2,3,7,8,9-HxCDF
Styrene	Benzo(k)fluoranthene	Silver	1,2,3,4,6,7,8-HpCDF
Toluene	Chrysene	Thallium	1,2,3,4,7,8,9-HpCDF
1,2,4-Trimethylbenzene	Dibenz(a,h)anthracene		1,2,3,4,6,7,8,9-OCDF
1,3,5-Trimethylbenzene	Fluoranthene	**Pesticides**	1,2,3,7,8-PeCDD
Isopropylbenzene	Fluorene	beta-BHC	1,2,3,7,8,9-HxCDD
n-Butylbenzene	Indeno(1,2,3-cd)pyrene	delta-BHC	
n-Propylbenzene	Phenanthrene	Heptachlor	
	Pyrene	Methoxychlor	

In addition to these detected chemicals of potential concern listed above, radium-226 and uranium-238 were detected in FWBZ and SWBZ groundwater samples collected from the Burn Area. In addition, strontium-90 was detected in groundwater samples collected from the FWBZ within the Burn Area.

To assess the fate and transport of chemical and radiological material of potential concern associated with exposure derived from the freshwater replenishment pathway, a groundwater/surface water reactive transport model was developed. The conceptual flow model is shown in Figure 2-33. The model was used to predict the maximum bay water concentration from groundwater contamination detected at the Burn Area monitoring wells. These predicted bay water concentrations were then compared with Project Action Limits (PALs) to determine if any of the chemical and radiological material of potential concern in groundwater samples could result in bay water exceedances. The sections below detail the procedures and results of the reactive-transport groundwater/surface water model and risk assessment associated with the freshwater replenishment exposure pathway.

2.6.3.2 Numerical Model Description

The numerical model was developed in five principal steps as follows:

1. Develop a three-dimensional geological model (GM) of the site inclusive of the site topography and bathymetry; wetlands; detailed layering of the Burn Area; surrounding geology; FWBZ, BSU, and SWBZ; and San Francisco Bay;

2. Use the GM and other pertinent data such as groundwater pressure and climate records as the basis to construct and calibrate a groundwater/surface water flow model;
3. Establish the pertinent, relevant, conservative variable(s) and their potential range of values that define and control the fate and transport of chemicals and radiological materials of potential concern;
4. Use the groundwater/surface water flow model to predict the maximum concentration of bay water resulting from chemicals and radiological materials of potential concern detected at Burn Area monitoring wells and defined by the potential range of values; and
5. Calculate a dilution attenuation factor (DAF) for chemicals and radiological materials of potential concern detected at Burn Area monitoring wells.

Based on the regional settings of various geological units as described above (Section 2.6.1.5), borelogs, and site-specific cross section maps, a GM was constructed using a proprietary software package, Leapfrog®. The resultant three-dimensional geological model honors the available Burn Area cross section maps (Figures 2-13, 2-14, and 2-15). For example, Figure 2-34 shows a comparison of the Burn Area cross section map A-A’ (Figure 2-13) and F-F’ (Figure 2-15) to the GM cross sections at the same locations. Whereas Figure 2-34 shows the comparison between only two cross section maps, Figure 2-35 shows each of the cross section maps embedded in the GM. Furthermore, Figure 2-35 also shows the final three-dimensional geological model which was used later to develop the groundwater/surface water flow model.

The groundwater/surface water flow model was first developed by creating a numerical grid that conforms to the conceptualized stratigraphy in the GM and by implementing appropriate material properties for the flow simulations. The flow model was next calibrated in a steady-state mode to averaged observed conditions. The flow model was verified using transient simulations of tidal fluctuations over 77 days against observations at several wells over the same time period. The transport model was then run using the calibrated steady-state flow field to assess the migration and mixing of contaminants from the Burn Area into San Francisco Bay and Oakland Inner Harbor over the next 1,000 years.

Advection, dispersion, adsorption, and diffusion were considered as potentially pertinent and relevant to predicting the fate and transport of chemicals and radiological materials of potential concern in the model. Advection of groundwater species was simulated by the flow model. Advection describes mass transport of contamination due to the bulk flow of groundwater in which the mass is dissolved, or movement of solute as a consequence of groundwater flow. The direction and rate of transport coincides with that of groundwater flow; which is controlled based on hydrogeology, groundwater gradient, and site geometry.

These parameters are independent of the specific chemicals and/or radiological materials of potential concern. In the absence of retardation, mass transport takes place at the average linear velocity of the groundwater. The average linear velocity (average pore velocity) is calculated as the Darcy velocity divided by the effective porosity. The effective porosity is the part of the pore space where water is actually flowing. The effective porosity is smaller than the total porosity, as it only includes that void space that forms part of the interconnected flow paths through the medium and excludes void space in isolated or dead-end pores. Similarly, dispersion variables are independent of the specific chemicals and/or radiological materials of potential concern. The model framework allows the user to simulate two chemical-specific processes with respect to fate and transport: degradation (e.g. biodegradation/radiological decay) and adsorption. With respect to the site model, only adsorption was considered. Chemical decay processes were not considered. Adsorption was defined in the model by the distribution coefficient (K_d); ratio of solid- to liquid-phase concentrations of a solute at equilibrium. For the chemicals and radiological materials of potential concern, K_d was estimated to range between 1 and $3x10^6$ liters/kilogram (L/kg). Nine species, each with a different K_d, were chosen to simulate the fate and transport of chemicals and radiological materials of potential concern.

Between six and nine of the nine species were simulated at a time using the flow model to predict the maximum bay water concentration resulting from chemicals and radiological materials of potential concern detected at Burn Area monitoring wells. The approach consisted of the following steps:

- Initiate the model with the six to nine soluble species contained within a 10-foot diameter cylinder of impacted media and groundwater at equilibrium and surrounding the screen section of each Burn Area monitoring well.
- Simulate the transport of the six to nine soluble species over 1,000 years.
- Process the model results to determine the predicted maximum bay water concentration within 1,000 years of simulation.

DAFs for each well and species were determined as the initial groundwater concentration divided by the predicted maximum bay water concentration. In some instances, because of the distance from the well to the shoreline and/or the K_d value, the maximum predicted bay water concentration for a given species at a specific well location was zero even after 1,000 years of simulation. DAFs for these scenarios were not calculated.

The flow and transport models were developed in accordance with standard practice (Aquaterra Consulting 2000, ASTM D 2002, ASTM 2004). The steady-state groundwater flow model was calibrated to the mean of the observed water level elevations over the period from 1996 to 2004. The model was verified against transient observations of tidal fluctuations over 77 days. Transport of components that originate from the Burn Area were then evaluated over a period of 1,000 years to note the maximum concentration possible in the bay.

The governing equations for groundwater flow and contaminant transport were discretized on a rectangular grid using the block-centered finite difference method. These equations were then numerically solved using a proprietary software package, MODFLOW-SURFACT®. MODFLOW-SURFACT is a highly efficient and versatile software package used to numerically simulate the groundwater flow equation in both saturated and unsaturated domains. Additionally, the software comes with a very robust Preconditioned Conjugate Gradient Solver package (PCG 5). For transport simulations, a fully implicit Total Variation Diminishing (TVD; Sweby 1984, Cox and Nishikawa 1991) method with van Leer (van Leer 1977 and 1979) flux limiting scheme is used. This provides for robust and accurate transport simulations (HydroGeoLogic Inc. 1996). A detailed description of the flow and transport models, including the discretization, layering, and boundary and initial conditions are provided in Appendix D.

2.6.3.3 Numerical Model Assumptions

The primary assumptions concerning the flow model are as follows:

- Density effects between sea and fresh water can be neglected because the error associated with neglecting density effects is approximately 2.5%. This error is based on the difference between the average density of fresh and sea water at approximately 1 and 1.025 kilograms per liter (NOAA-NODC 2005), respectively.
- The initial hydrological properties of the burn and waste materials were considered equal to the hydrological properties of silty sand. These properties were then varied during the model calibration and verification process to better match observed and simulated head and groundwater fluctuations at the target location. The calibration and verification processes are discussed below in Section 2.6.3.4.
- Flow and transport in the San Francisco Bay is simulated by the groundwater flow equations using a high value for hydraulic conductivity and a specific yield of unity. This high value was limited to 10,000 feet/day (similar to equivalent hydraulic conductivity values of karst aquifers) to provide conservative estimates of flow and mixing in the bay.

The primary assumptions concerning fate and transport of chemicals and radiological materials of potential concern are as follows:

- The effective porosity is equal to the specific yield.

- The transport models represent “single-domain” conditions.
- The decay of chemicals and radiological materials of potential concern, such as radioactive half-life or biodegradation or any other form of abiotic degradation was neglected.
- Linear adsorption was applicable for all contaminants.
- The mass diffusion coefficient was uniform across all layers.
- Longitudinal, transverse, and vertical dispersivity values were uniform across all layers representing the subsurface.
- Transport simulations were conducted under steady-state flow conditions. Preliminary simulations indicated that travel times from well locations are on the order of hundreds of years for maximum conditions to occur in the bay and average conditions over tidal or seasonal fluctuations will be applicable for continuous discharge over the much larger time scales.

The model time of simulation was set at 1,000 years. The decision to terminate the model run at 1,000 years was based on the travel time from well locations to the bay for a large portion of the chemicals and radiological materials of potential concern exceeding 200 years.

2.6.3.4 Numerical Model Results

The results of model calibration and verification and groundwater/surface water interactions are discussed in this section. In addition, sensitivity of the model DAF estimates to hydrodynamic dispersivity terms is also discussed.

Model Calibration and Verification

Steady-State Calibration

The developed groundwater flow model was calibrated to the observed heads for the steady-state scenario. The calibrated steady-state flow model was then verified against transient conditions for observed water level fluctuations at monitoring wells within the Burn Area. This section briefly describes the steady-state groundwater flow model calibration first, and then the transient flow model verification.

To calibrate the flow model to the steady-state flow conditions, observed heads from groundwater level maps (BEI 2006a, BEI 2006b) for various dates over several years were evaluated along with recent data from the three 2012 groundwater gauging events at the 14 Burn Area wells (nine wells screened in the FWBZ and five wells screened in the SWBZ) and 10 historic IR Site 1 wells screened in the FWBZ. Groundwater level data were compared with precipitation and tidal efficiency to assess if relationships exist. Sixteen years (1994 through 2010) of groundwater gauging data were analyzed from ten FWBZ monitoring wells at IR Site 1; M031-A, M030-A, M034-A, M003-A, M035-A, M028-A, M033-A, M001-A, M029-A, and M002-A. Mean monthly groundwater elevations at each of the ten wells were compared with mean monthly precipitation (Figure 2-36). This comparison revealed that groundwater levels at IR Site 1 were highest and lowest near ends of the wet and dry seasons, respectively. Also, the magnitude of groundwater elevation fluctuations between wet and dry season were greatest at wells further inland as compared with wells near the shoreline. The relationship between the standard deviation of the 16 years of groundwater elevation data at each of the ten wells was compared to their distance from the shoreline and is shown in Figure 2-37. Groundwater elevation fluctuations in the FWBZ vary greatest at locations furthest inland from the shoreline. The standard deviation of groundwater elevations measured at the furthest inland wells was approximately 1.5 feet while the standard deviation of the well closest to the shoreline was approximately 0.27 feet. This observation reveals that net groundwater recharge over the course an average year has a significantly greater effect on the general water level gradients in the Burn Area FWBZ than tidal influence.

A simulation of steady-state groundwater flow showed modeled heads at most of the measurement locations within one standard deviation of the observed mean head values. Figure 2-38 shows the modeled heads compared to observed heads at 22 FWBZ well locations. Groundwater heads in the model are representative of observed and conceptual site conditions; flow progressing from a regional hydraulic divide located approximately under the middle of Runway 13, which bisects Alameda Point, to the San Francisco Bay and Oakland Inner Harbor. Close examination of the comparison between modeled and observed heads west of the groundwater divide and within the Burn Area are shown in Figure 2-39. Eighteen years of gauging data from 1994 to 2012 were available from six of the 15 wells shown in Figure 2-39. Comparison between the mean of all of the gauging data and gauging data from March through May revealed that annual mean groundwater elevations were between 0.52 feet and 1.72 feet lower than mean elevations observed between March and May over the 18 years of gauging data. Based on these observations and the relationship between groundwater levels and distance from the shoreline, the annual mean FWBZ groundwater elevations at the Burn Area FFS monitoring wells (PMW-1, PMW-5FWBZ, PMW-8, PMW-9FWBZ, PMW-10FWBZ, PMW-11, PMW-12, PMW-13FWBZ, and PMW-16FWBZ) were estimated based on the gauging conducted at these wells between March and May 2012. These annual mean groundwater elevation estimates at the Burn Area FFS wells are shown in Figure 2-39. Modeled heads were within one standard deviation of the FWBZ observed or estimated mean of observed heads at 19 of 22 wells. Figure 2-40 shows a comparison between modeled and observed conditions for the mean groundwater elevation contours within the FWBZ. Observed and simulated gradients are noted to be similar.

Figure 2-41 shows the modeled heads compared to observed heads at the eight SWBZ well locations. Modeled heads were within one standard deviation of the SWBZ observed at six of eight wells. Figure 2-42 shows a comparison between modeled and observed conditions for mean groundwater elevation contours within the SWBZ. Groundwater heads in the model are representative of observed and conceptual site conditions; flow progressing towards the west-northwest in the SWBZ.

The north to south longshore current along the western shoreline of Alameda Point was also represented by the model. Based on a review of a United States Geological Survey study of circulation and mixing processes of San Francisco Bay waters (Walters et al. 1985), the yearly tidally-driven longshore current velocity along the western shoreline of Alameda Point ranges between zero and 0.3 feet per second (ft/sec). The average longshore current velocity is approximately 0.1 ft/sec. The longshore current velocity simulated in our model was significantly lower at approximately 3 x 10^{-5} ft/sec. Thus, the present flow model results in conservative values for maximum current speed in the bay water, in terms of dilution of contaminants entering the bay.

The simulated flow is consistent with the observed flow direction towards the shoreline; towards the Oakland Inner Harbor in the northeast portion of the site and towards the San Francisco Bay in the western portion of the site, with a north to south longshore current within the bay.

Transient Verification

After calibrating the flow model for the steady-state conditions, the flow model was verified against transient flow conditions. For this simulation, using SPT data, the calculated hourly bay water level fluctuation time series from the sample mean was applied as a prescribed head to all offshore cells. Given these applied water level fluctuations, the groundwater level fluctuations were then numerically monitored at the 14 Burn Area wells (nine FWBZ wells and five SWBZ wells). The transient verification simulation was run for a period of 77 days from February 29, 2012, to May 15, 2012, to evaluate recent water level elevation monitoring conducted at several of the wells at the site. Figures 2-38 through 2-45 show a comparison of observed versus modeled groundwater level fluctuations at all burn site wells.

Dilution Attenuation Factor Estimates

As discussed above, DAFs for each well and for the six to nine species simulated (K_d values) were estimated as the ratio of the initial groundwater concentration to the maximum bay water concentration. Well-specific DAF estimates ranged between approximately 1.3 x 10^3 and 2.8 x 10^7 across the nine FWBZ wells analyzed. The maximum bay water concentrations estimated by the model for chemicals and radiological materials of potential concern at the five Burn Area wells in the SWBZ were all zero. The DAF estimates for the FWBZ wells indicate a second-order polynomial relationship between K_d and DAF. In this, DAF values generally decreases as K_d increases until the maximum bay water concentration occurs sometime beyond the 1,000 year simulation at which point the relationship between DAF and K_d flips. Well-specific DAF estimates as a function of K_d and polynomial functions for the matching curve are shown for the nine FWBZ wells in Figure 2-46.

For conservativeness, two rules were applied for the use of the well-specific DAF estimates for comparison of predicted bay water concentrations to PALs as follows:

- K_d values for chemicals and radiological materials of potential concern were limited to a maximum of 5,000 L/kg for calculating well-specific DAF estimates. The maximum K_d value was constrained at 5,000 L/kg because the contaminants having K_d higher than 5,000 L/kg are not quantifiable in the bay water within the 1,000-year model run.
- Well-specific DAF estimates for FWBZ wells were applied to complementary SWBZ monitoring wells. This approach was taken because the contaminants released in the SWBZ are not quantifiable in the bay within the 1,000-year model run, because of the presence of low permeability bay sediments. Therefore, based on model results, DAFs for contaminants in the SWBZ are infinite within the 1,000-year model run. However, as a conservative approach, the FWBZ well DAFs were applied to the SWBZ wells, which essentially occupy the same horizontal location as the complementary FWBZ well.

By the first rule, where K_d is limited to 5,000 L/kg, the DAF estimate for chemicals and radiological materials of potential concern with higher affinity to the solid phase is lower than estimated by the model. And by the second rule, where DAF estimates for accompanying FWBZ wells are applied to their respective SWBZ wells, the bay water estimate is greater than zero.

Sensitivity of DAF Estimates to Hydrodynamic Dispersion

To gauge the sensitivity of hydrodynamic dispersion on DAF estimates, additional model runs were performed for a single well, PMW-5FWBZ, as described earlier (Section 2.6.3.2). For this case, the initial groundwater concentration of a tracer species at the well location was established at 1 mg/L with initial solid-phase concentrations based on equilibrium with K_d fixed at 0.1 L/kg. The K_d was fixed at 0.1 L/kg so that maximum bay water concentrations could be predicted within the 1,000-year model run.

Two model sensitivities to dispersivity were tested. For the first sensitivity test, each of the three dispersivity variables; the horizontal longitudinal, the horizontal transverse, and the vertical dispersivity values were varied holding the dispersivity ratios (horizontal longitudinal : horizontal transverse : vertical transverse) constant at 1 : 0.1 : 0.01. For the second sensitivity test, only the horizontal traverse dispersivity value was varied. Figure 2-47 shows the sensitivity of horizontal and transverse dispersivities on the DAF estimates. From Figure 2-47, an inverse relationship is noted between dispersivities and DAF values. Moreover, the sensitivity results for realistic horizontal transverse dispersivity values, which are less than or equal to horizontal longitudinal dispersivity, show that the model is not sensitive at all. Based on the dispersivity sensitivity analysis results, the use of the model to simulate a partitioning tracer test for predicting a maximum bay water concentration is valid as an appropriate approach for estimating well-specific DAFs.

2.7 Burn Area Risk Assessment Activities

This section summarizes human-health risk assessments (HHRAs) and ecological risk assessments (ERAs) performed as part of the RI (TtEMI 1999c and 2002) for IR Site 1 as well as recent surface water risk calculations to support this FFS Report.

2.7.1 Previous Related Risk Assessments

This section summarizes human-health risk evaluations conducted as part of the RI and RI Addendum (Tt EMI 1999c) and FS Report (BEI 2006a) as well as results from the screening-level ERA performed as part of the RI.

2.7.1.1 Human-Health Risk Assessments

A baseline HHRA was conducted for IR Site 1 as part of the RI Report using data collected during investigations from 1990 to 1997 (Tt EMI 1999c). In response to regulatory agency comments, three addendums to the RI Report were prepared. The first addendum summarized the results from requested data gap sampling (Tt EMI 2001); the second addendum presented the total risks to human health from chemical and radiological exposures, which were originally reported in the OU-3 RI Report (Tt EMI 2002); and the third addendum presented the results of the geotechnical and seismic evaluations of IR Site 1 to identify associated hazards for the FS Report (FW 2002). To support the FS Report, additional risk calculations using data collected in 2005 were performed to update the HHRA (BEI 2006a).

The waste disposal area, burn waste area, former pistol and skeet range (including clay pigeons), and radium-contaminated material in an unlined trench were identified and evaluated in the HHRA (Tt EMI 1999c). Based on data quality objectives, the pistol and skeet range area was not included in the baseline HHRA.

The future occupational worker and recreational user were evaluated as exposure pathways in the risk assessment. Residential and construction worker exposures were not considered compatible with remedy and closure of the former disposal area. A detailed description of the approach and results of the IR Site 1 HHRA is presented in the Final OU-3 RI Report (Tt EMI 1999c), with updated calculations presented in the Final OU-3 RI Report Addendum, Volume II (Tt EMI 2002) and Final IR Site 1 FS Report (BEI 2006a). The objective of the risk assessments was to estimate the risks to human and ecological receptors from exposure to chemicals in soil and groundwater at the site. They provide the basis for taking action and identify the chemicals of concern and exposure pathways that need to be addressed by the remedial action.

The cumulative HHRA (TtEMI 2002) presented a refined list of COCs with risk values of 1×10^{-6} or greater (or COCs that represented most of the hazard index [HI] value). Calculated risks were presented in the RI Addendum as reasonable maximum exposure results. Total radiological and chemical cancer risk values and non-cancer HIs are summarized below; underlying cancer risks for the occupational and recreational receptors vary by media and can be found in Table 2-22 of the FS (BEI 2006a).

Occupational receptor:

- Cancer risk: 1 x 10^{-4} (U.S. EPA) or 3.6 x 10^{-4} (Cal/EPA)
  - Contribution from radionuclides: 3.7 x 10^{-5} (U.S. EPA and Cal/EPA), approximately 34 percent (U.S. EPA) or 11 percent (Cal/EPA)
  - Contribution from chemical COCs: 6.6 x 10^{-5} or approximately 66 percent (U.S. EPA); 3.6 x 10^{-4} or approximately 89 percent (Cal/EPA)
- Noncancer HI: 0.1 (U.S. EPA) or 0.2 (Cal/EPA); related entirely to chemical COCs

Recreational receptor:

- Cancer risk: 1 x 10^{-4} (U.S. EPA) or 5.5 x 10^{-4} (Cal/EPA)
  - Contribution from radionuclides: 2.0 x 10^{-5} (U.S. EPA and Cal/EPA), which is approximately 16 percent (U.S. EPA) or 4 percent (Cal/EPA)
  - Contribution from chemical COCs: 8.4 x 10^{-5} or approximately 84 percent (U.S. EPA), 5.3 x 10^{-4} or approximately 96 percent (Cal/EPA)
- Noncancer HI: 0.1 (U.S. EPA) or 0.4 (Cal/EPA); related entirely to chemical COCs

2.7.1.2 Ecological Risk Assessments

The RI assumed a presumptive remedy of capping for the IR Site 1 (CalEPA 1996); therefore completed exposure pathways for terrestrial ecological receptors were not identified. The conclusion of the scoping assessment completed for terrestrial receptors during the RI can be found in Sections 5 and 6 of the OU-3 RI Report (TtEMI 1999c). Additionally, and as stated in the Final ROD (Chadux Tt 2009), the shoreline portion of Area 1b is addressed under the Area 5 (shoreline) alternatives.

A screening-level ERA was conducted in the RI to evaluate potential risk to aquatic ecological receptors from contaminants in shallow groundwater that could migrate to San Francisco Bay. This ERA involved developing screening-level ecological risk values for groundwater at IR Site 1 using a two-step process. First, the most appropriate ecological reference value (ERV) was determined from the literature. Second, a screening value was developed based on the corresponding ERV. Groundwater concentrations were compared to the screening ecological values. Results from these comparisons indicated that concentrations of 2,4-dimethylphenol; 2-methylphenol; 1,2-dichloroethene; toluene; and xylene present in samples from monitoring wells M028-A, M028-E, and M034-A (identified as the groundwater hot spot) could adversely impact aquatic receptors. The evaluation indicated that potential ecological risks would not exceed applicable criteria outside the hot spot (TtEMI 2001a).

2.7.1.3 Groundwater Quality Evaluation from 2006 Feasibility Study

As part of the FS Report (BEI 2006a), a Groundwater Quality Evaluation was conducted. Results of the Groundwater Quality Evaluation suggested that no significant source of contamination at IR Site 1 is contributing to groundwater contamination outside the VOC plume area. In general, for groundwater outside the VOC plume area, reported California Toxic Rule (CTR) exceedances are isolated both spatially and temporally. Based on the groundwater quality evaluation, groundwater in the FWBZ outside the VOC plume area and groundwater in the SWBZ area do not appear to warrant active remediation. Attenuated values that exceed the comparison criteria were generally close to the comparison criteria; these values could be indicative of background, and do not appear to be significant enough to result in exceedances of the CTR criteria in the San Francisco Bay or the Oakland Inner Harbor as a result of discharge from IR Site 1. The attenuated shoreline concentrations do not reflect the tidal mixing process, which would result in additional dilution and dispersion of the contaminant concentrations prior to coming in contact with the ambient receiving water.

The Groundwater Evaluation (Appendix F of the FS Report [BEI 2006b]) does not offer a written explanation of the conclusion that exceedances are isolated both spatially and temporally. To examine this conclusion, groundwater metal detections at IR Site 1 were compared to their mean groundwater concentrations, which were determined using detected metal analysis results from dissolved analysis. Based on this approach, it ws determined that metals in the FWBZ at IR Site 1 are spatially isolated. Examples include the following: (1) manganese concentrations detected in samples collected from monitoring wells PMW-12 and PMW-13FWBZ, which are less than 20 feet apart, are an approximate order of magnitude different; (2) barium detected in groundwater samples from M001-A, M029-A, and PMW-9FWBZ are close to or just below the mean, whereas at nearby wells PMW-10FWBZ and PMW-11, the barium concentration is approximately three times the mean; and (3) selenium is approximately three times greater than its mean at M033-A, whereas at nearby well PMW-16FWBZ, selenium is less than the mean. Similar evidence of spatial isolation was observed by comparison with the mean in the SWBZ. Examples include the following: (1) antimony, copper, and nickel were detected above their mean values in only one of the eight SWBZ monitoring wells at IR Site 1; and (2) arsenic was detected above its mean in only two of the eight SWBZ monitoring wells. Temporal isolations were also observed in the groundwater metal analysis results. For example, barium and manganese show temporal spikes, oscillating above and below their mean values in samples collected between 1991 and 2012 from six FWBZ and three SWBZ monitoring wells.

Correlations between metal concentrations and oxidation reduction potential (ORP), pH, and specific conductance was examined using the groundwater sample analysis and field screening results from IR Site 1 collected between 1991 and 2012. Of the 14 dissolved metal analytes, six had sufficient data to analyze for correlation to ORP, pH, and specific conductance in the FWBZ. Data were considered significant if (1) three or more data pairs were available and (2) the dissolved metal analysis results in the data pairs were a detection or estimated detection. The six dissolved metals with significant data for correlation analyses were cadmium, zinc, nickel, arsenic, barium, and manganese. The remaining eight metals are chromium, copper, mercury, silver, antimony, selenium, lead, and thallium.

Dissolved nickel and zinc concentrations correlated well with pH and specific conductance, respectively. The correlation coefficient with specific conductance was 0.98 for the five nickel detections. The correlation coefficient with pH was -0.92 for the four dissolved zinc detections. The correlation coefficients between the six metals with significant data for analysis with ORP were all less than 0.11 (average less than 0.05). Dissolved nickel, arsenic, barium, and manganese showed weak correlation with pH (correlation coefficients between -0.2 and -0.5). Dissolved cadmium and zinc showed weak correlation to specific conductance with correlation coefficients between 0.15 and 0.22. Dissolved arsenic, barium, and manganese detections did not correlate with specific conductance (correlation coefficients less than 0.012).

2.7.2 Evaluation of Potential Risks from Exposure to Surface Water in San Francisco Bay

The purpose of this FFS evaluation is to establish if chemicals or radiological materials of potential concern dissolved in the Burn Area groundwater that have discharged to the San Francisco Bay are below surface water criteria. As stated in the Final ROD (Chadux Tt 2009), the shoreline portion of Area 1b is addressed under the Area 5 (shoreline) alternatives. This FFS evaluation was performed as part of the Pre-design Characterization work conducted during 2010, 2011, and 2012.

The evaluation of potential risks to human and ecological receptors from exposure via surface water (i.e. bay water) consists of a screening level assessment to select appropriate risk-based screening values and compare estimated surface water concentrations to those screening values to identify compounds that could potentially contribute to unacceptable risk. The receptors evaluated are saltwater aquatic life that reside in San Francisco Bay (a wide range of aquatic receptors, including benthic receptors, are considered through the screening levels employed) and humans that may consume this saltwater aquatic life. Food chain modeling was not conducted because it was outside the scope of this FFS. The prior risk assessments did not fully evaluate these exposure pathways for chemicals and radiological materials of potential concern because the remedy envisioned was capping or isolation of the buried wastes, which eliminated the complete exposure pathway. Screening value selection was conducted to identify the most protective value for the two receptor groups being evaluated using the applicable screening criteria for IR Site 1. The California Toxics Rule (65 FR 31682) was the primary source of the water criteria used as screening values. These criteria are based on the Clean Water Act section 304(a) methodology and therefore " … might be thought of as an estimate of the highest concentration of a substance in water which does not present a significant risk to the aquatic organism in the water and their uses." (45 FR 79341). The CRT criteria account for a minimum of eight families of organisms to minimize the potential for criteria to over-protect or under-protect. The data used in this evaluation include groundwater results from the tidal-bias monitoring event and the study-area groundwater monitoring event, each conducted in May 2012.

The evaluation of potential risks consisted of the following steps:

1. Establish Project Action Limits (PALs) – Verify the PALs provided in Worksheet 15 of the SAP (AMEC 2012) and identify PALs for compounds that were analyzed but that did not have a PAL established in the SAP.
2. Determine if chemicals or radiological materials of potential concern exist based on groundwater results – Compare concentrations in groundwater to PALs to determine which compounds should be evaluated further as a potential COC.

3. Evaluate potential risk from exposure to estimated bay water concentrations – Compare estimated bay water concentrations to PALs to determine which compounds may contribute to unacceptable risk; and, therefore are identified as chemicals and/or radiological materials of concern.

2.7.2.1 Project Action Limit Selection

The PALs used in this risk evaluation are provided in Table 2-13. PALs were selected from the chemical-specific ARARs established in the FS (BEI 2006a) and the ROD (Chadux Tt 2009) and from the sources used to identify PALs in the SAP (AMEC 2012). PALs previously established in the SAP or ROD were verified against the sources referenced in the SAP or the ROD, and corrected or updated, if needed. PALs for compounds without previously established values were selected by reviewing the applicable criteria for each receptor group using the hierarchy of sources provided below. The receptor group associated with the selected PAL is identified in Table 2-13. The sources used to establish PALs are described below and are presented in the order of their use:

1. **California Toxic Rule (CTR) Criteria –** The ARAR evaluation presented in the FS and incorporated into the ROD identifies the CTR as applicable to the site (EPA 2000). CTR criteria were established as the PAL for compounds with published values. The most conservative applicable value to a marine or estuarine water body was selected when more than one value was published. An inland surface water value was selected if no marine or estuarine water body value was published.
2. **Basin Plan Criteria –** The ARAR evaluation presented in the FS and incorporated into the ROD identifies the toxicity water quality objectives provided in the Basin Plan as applicable to the Site (SFBRWQCB 2011). The numerical water quality objectives for toxic pollutants in marine surface waters are presented in Table 3-3 of the Basin Plan. The Basin Plan criteria were selected as the PAL when CTR criteria were not published, or when the Basin Plan indicated its value should take precedent over the CTR criteria.
3. **Assessment Threshold Table –** This table is prepared by the State Water Resources Control Board (SWRCB) using information presented in an April 2011 staff report titled, "A Compilation of Water Quality Goals" (SWRCB 2011). The April 2011 compilation report supersedes all prior versions. The table presents a compilation of published assessment thresholds that are recommended to protect the beneficial uses of groundwater and surface water in the state of California. A recommended assessment threshold is indicated for each compound listed in the table for each type of water body and associated beneficial use. A PAL was selected from this source when a CTR criterion or a Basin Plan criterion was not

published for that compound. The value recommended for “aquatic life & consumption” for a “bay or estuary” was selected as the PAL.

4. **Use of Surrogates –** Not all compounds were listed on one of the above sources of screening levels, so a suitable surrogate compound was identified for each of these compounds. Surrogate compounds were selected because they were structurally similar or because they provide a conservative evaluation of potential effects based on toxicity where a structurally similar compound with a published screening level is not available. Surrogate compounds are identified on Table 2-13. The PAL for surrogate compounds was selected using the sources and hierarchy described above. A more detailed discussion of the use of surrogates for evaluating mononuclear aromatic hydrocarbons (MAHs), cumulative risk from carcinogenic PAHs, and for dioxins/furans is presented below.

   MAH PAL – Screening levels are not available in the above sources for several MAHs. These compounds are listed below:

   - o-Xylene, m-xylene, and p-xylene
   - n-Butylbenzene, sec-butylbenzene, and tert-butylbenzene
   - Isopropylbenzene and n-propylbenzene
   - 4-Isopropyltoluene
   - 1,2,4-Trimethylbenzene and 1,3,5-trimethylbenzene
   - Styrene

   Screening levels are, however, available for three MAHs: benzene, toluene, and ethylbenzene. Of these, benzene has the lowest screening level (71 µg/L versus 200,000 and 29,000 µg/L for toluene and ethylbenzene, respectively). For this reason, benzene was used as the toxicological surrogate for the MAHs lacking published screening values. Because the PAL for benzene is orders of magnitude lower than both toluene and ethylbenzene, which have hydrocarbon substitutions on the benzene ring, it is assumed that the use of benzene as the surrogate for the other MAHs that also have single or multiple hydrocarbon substitutions will be conservative in the prediction of potential risk. However, as discussed below, the modeled bay water concentrations for these constituents are well below the conservative screening level concentration for benzene; therefore, the application of this highly conservative approach does not adversely affect project objectives.

   Carcinogenic PAH PAL – For completeness, carcinogenic PAHs were evaluated cumulatively by comparing a benzo(a)pyrene equivalent (BaP_{equiv}) concentration to the BaP PAL. The BaP_{equiv} concentration is calculated in two steps. In the first step, each carcinogenic PAH concentration is multiplied by its relative potency factor (RPF; U.S. EPA 1993e) to calculate an adjusted concentration. One-half the method detection limit is used if a PAH is not detected. In the second step, the adjusted concentrations are added to calculate a BaP_{equiv} concentration. The BaP_{equiv} bay water estimated concentrations are compared to the BaP PAL. BaP_{equiv} bay water estimated concentrations that are less than the published BaP PAL can be inferred not to contribute to unacceptable risk.

Dioxin/furan PAL – Dioxins and furans were evaluated by calculating a TEQ for each groundwater sample to normalize the congener concentrations relative to the most toxic congener (2,3,7,8-TCDD). The TEQ is the calculated in two steps. In the first step, each congener concentration is multiplied by its toxic equivalency factor (TEF; Van der berg et al. 1998 and Van der berg et al. 2006) to calculate an adjusted congener concentration. One-half of the method detection limit is used if a congener is not detected. In the second step, the adjusted congener concentrations are added to calculate the TEQ. Two TEQs are calculated for each sample to evaluate the exposure pathways for saltwater aquatic life and for humans potentially consuming that saltwater aquatic life because the TEFs for each congener are different for human receptors and aquatic receptors. The TEQs for each sample are compared to the PAL for 2,3,7,8-TCDD. TEQs that are less than the published 2,3,7,8-TCDD PAL can be inferred not to contribute to unacceptable risk.

Verification of PALs identified two incorrect values that appear to be entry errors in the SAP (AMEC 2012). The PCB PAL was presented in Worksheet 15 as 0.00075 µg/L and was corrected to be 0.00017 µg/L in this risk assessment. The PAL for dibromochloromethane was presented in Worksheet 15 as 46 µg/L and was corrected to be 34 µg/L in this risk assessment. All other values provided in Worksheet 15 reflect the currently published value.

No published screening value or suitable surrogate compound was identified for carbon disulfide, four ketones (acetone, 2-butanone, 2-hexanone, and 4-methyl-2-pentanone), and three metals (beryllium, cobalt, and molybdenum). These chemicals will be discussed qualitatively in the evaluation of bay water concentrations.

No published screening values were identified for radionuclides. The PAL for each radionuclide was set equal to the lowest minimum detected concentration from the tidal bias sampling and the study-area groundwater monitoring event.

2.7.2.2 Chemicals and Radiological Materials of Potential Concern Based on Groundwater Results

Surface water chemicals and radiological materials of potential concern were identified by comparing groundwater results from the tidal sampling and study-area groundwater monitoring events to the PALs. A compound was identified as a surface water chemical of potential concern if it was detected in a groundwater sample at a concentration above the PAL or if the compound was not detected but had a method detection limit above the PAL. All radionuclides were conservatively considered radiological materials of potential concern because there is no risk-based screening level available. A list of chemicals and radiological materials of potential concern is provided in Table 2-14. The screening process is illustrated on Tables 2-15a through 2-15j for the tidally-biased groundwater sampling event and Tables 2-16a through 2-16h for the study-area groundwater sampling event. The calculated BaP_{equiv} concentration for each sample is shown on Tables 2-15c and 2-15d for the tidally-biased groundwater sampling event and on Tables 2-16c and 2-16d for the study-area groundwater sampling event. The TEQ calculations for each sample are shown on Tables 2-15e through 2-15h for the tidally-biased groundwater sampling event and on Tables 2-16e through 2-16h for the study-area groundwater sampling event.

Compounds that were detected at concentrations below the PAL or that were not detected but had method detection limits below the PAL were not considered to pose unacceptable risk and therefore were not evaluated further.

2.7.2.3 Potential Risks from Exposure to Estimated Bay Water Concentrations

Chemicals and radiological materials of potential concern were further evaluated by calculating an estimated bay water concentration based on the groundwater result and the well-specific DAF estimated using the groundwater reactive-transport model (Section 2.7.3.4).

For the chemicals and radiological materials of potential concern that required further evaluation following the screening comparison of groundwater results to PALs, bay water concentrations were calculated using DAF estimates. The first step to calculating bay water concentrations was to determine a K_d for each of the chemicals and radiological materials of potential concern that required further evaluation. Determination of K_d estimates for chemicals and radiological materials of potential concern was accomplished as follows:

- If a chemical or radiological material of potential concern was detected in soil and groundwater samples from corresponding locations and depths, then the K_d was calculated as the ratio of soil to groundwater detections. If multiple detections of both solid- and liquid-phases were available for a specific chemical or radiological material of potential concern at a single location (one boring/well) then the values were averaged to determine K_d. For cases where multiple detections of both solid- and liquid-phases were available at multiple locations (two or more borings/wells) then the lowest value was selected to determine K_d for these chemicals or radiological materials of potential concern.

- If a chemical or radiological material of potential concern was detected in either soil or groundwater samples, but not both from corresponding locations and depths, then the K_d was calculated as greater than or equal to the ratio of soil analysis method detection limit (MDL) or detection to the groundwater analysis MDL or detection.
- If a chemical or radiological material of potential concern was not detected in either a soil or groundwater, then the K_d was determined based on literature research.

Table 2-17 summarizes the K_d and corresponding well-specific DAF for each of the chemicals and radiological materials of potential concern that required further evaluation. Two rules were applied for the use of the well-specific DAF estimates for comparison of predicted bay water concentrations to PALs to provide for a reasonably conservative evaluation as follows:

- K_d values for chemicals and radiological material of potential concern were limited to a maximum of 5,000 L/kg for calculating well-specific DAF estimates.
- Well-specific DAF estimates for FWBZ wells were applied to complementary SWBZ monitoring wells.

Estimated bay water concentrations for organic and inorganic compounds were calculated by dividing the measured groundwater concentration by the DAF, or by dividing one-half of the method detection limit by the DAF if that compound was not detected. For radionuclides, a conservative groundwater concentration was calculated based on the reported activity, minimum detected concentration, and error delta for each sample using one of the following three approaches:

1. If the radionuclide was not detected and the activity was less than the minimum detectable concentration (MDC) for that sample, the groundwater concentration is the sum of the MDC and error delta.
2. If the radionuclide was not detected and the activity was greater than the MDC for that sample, the groundwater concentration is the sum the activity and error delta.
3. If the radionuclide was detected, the groundwater concentration is the sum of the activity and error delta.

Each approach provides a conservative estimate of the radionuclide concentration in groundwater for the purpose of evaluating the potential migration into to bay water.

The DAF and estimated bay water concentration and PAL for each compound are presented on Tables 2-15A through 2-15H for the tidally-biased groundwater sampling event and Tables 2-16A through 2-16H for the study-area groundwater sampling event. Estimated bay water concentrations were compared to the PAL for each compound to determine the potential for that compound to contribute to unacceptable risk to aquatic receptors or to humans consuming aquatic receptors. No estimated bay water concentration exceeded its respective PAL.

Eight chemicals did not have PALs established because no screening values were available in the sources used for this evaluation and suitable surrogate compounds were not identified. Carbon disulfide is not considered to contribute significantly to unacceptable risk because it was not detected in either the tidal sampling event or in the study-area groundwater monitoring event. Its method detection limit is well below 1 µg/L and an estimated bay water concentration would likely be much lower. Similarly, 2-butanone and 4-methyl-2-pentanone were not detected in either the tidal sampling event or in the study-area groundwater monitoring event. Although the highest method detection limit for these two compounds reached 2.59 µg/L, neither is likely to result in unacceptable risk in bay water due to attenuation and dilution.

Acetone and 2-hexanone were each detected at least once. The single detection of 2-hexanone was at a concentration of 0.234 µg/L. The highest detection limit for 2-hexanone was 1.12 µg/L. Estimated bay water concentrations based on these values would be substantially lower and thus 2-hexanone is not likely to contribute significantly to unacceptable risk. Acetone was detected six times, with concentrations ranging between 2.91 µg/L and 8.89 µg/L (estimated). Acetone detection limits were as high 5.92 µg/L. Estimated bay water concentrations based on these values would be substantially lower and therefore would be unlikely to contribute significantly to unacceptable risk. These conclusions are further supported by the physical and chemical properties of acetone (ATSDR 1994) and 2-hexanone (ATSDR 1992), which indicate they will attenuate in water through biodegradation, though dilution also can be expected to occur because of the high solubility of each compound. The detections of acetone and 2-hexanone also are below other publically-available and conservative screening criteria, including the EPA Regional Screening Level values for tap water consumption (U.S. EPA 2003b), and ecological screening levels from Los Alamos National Laboratory (LANL) ECORISK Database, Release 3.1 (LANL 2012). These criteria are not directly applicable to the exposure pathways evaluated in this FFS, but they provide quantitative evidence that exposure through similar pathways at the levels detected at the site are not likely to contribute to unacceptable risk.

Examination of the laboratory report demonstrates that detections of acetone in these samples were false positives related to field or laboratory contamination. More than 50% of the acetone results were qualified during validation due to the presence of acetone in laboratory blanks. In addition, acetone was detected in the majority of the method blanks associated with project samples at concentrations as high as 1.6 µg/L, and reported acetone concentrations in the field samples fell in the range of 1.15 to 8.89 µg/L.

Only six reported acetone results were not qualified during validation due to blank contamination, and most of these appear to be only slightly above 5x the associated blank concentration. Only one field sample (02-1530) had a reported acetone result greater than 10x the concentration in the associated laboratory blank, and the concentration in this sample was less than 11x the associated blank concentration. Based on this evaluation, all results should have arguably been U-qualified, and the acetone results are clearly related to analytical artifacts.

Of the metals, beryllium was not detected in either the tidal sampling event or in the study-area groundwater monitoring event as either total or dissolved beryllium. Although cobalt and molybdenum were detected in multiple samples as a total metal, neither was detected in dissolved form, which would be the form associated with potential transport to the bay. Therefore, none of these three metals are likely to contribute to unacceptable risk in the bay water.

Based on these results, no chemicals or radiological materials are considered to pose unacceptable risk from exposure to bay water. No new COCs related to the freshwater replenishment pathway at the Burn Area were identified.

2.7.2.4 Conclusions of Burn Area Evaluation of Potential Risks from Exposure to Surface Water in San Francisco Bay

The results of the risk evaluation indicate that no chemicals or radiological materials in groundwater that replenishes bay water are considered to pose unacceptable risk to saltwater aquatic life or to humans consuming that saltwater aquatic life from exposure to bay water. No new COCs related to the freshwater replenishment pathway at the Burn Area are identified.

2.8 Review of Considerations for Site-Wide Remedy Selection and Remedial Design

Section 7 of the FS Report (BEI 2006a) compiled the IR Site 1 area-specific alternatives into seven site-wide alternatives to represent the range of remedial actions and costs for IR Site 1. The sections below provide a review of this section of the FS Report (BEI 2006a), specifically as they pertain to the Burn Area.

2.8.1 Potential Site-Wide Alternatives

The seven site-wide remedial alternatives assessed in the FS Report (BEI 2006a) ranged from no action to complete removal of waste from IR Site 1. With respect to the Burn Area, the five alternatives between Alternative 1 and Alternative 7 considered two approaches, removal of the burn waste (excavation and disposal) or covering the burn waste. Alternative remedies for the Burn Area that considered covering/containment of the waste included a requirement that the cover maintain integrity during and following the maximum credible earthquake (MCE) (California Code of Regulations [CCR] title 22 subsection 66.264.310(a)(5) is an action-specific ARAR). However, the Burn Area cover alternatives assessed in the FS did not fully consider the specifics or costs for a geotechnical remedy for stabilization of the shoreline slope and cover.

2.8.2 Geotechnical and Seismic Considerations

Potential geotechnical and seismic hazards identified in the Geotechnical Characterization Report (FW 2002) were addressed in the Geotechnical and Seismic Feasibility Study, Volume II (FW 2003). The RAO of the geotechnical and seismic FS was to prevent release of waste to the San Francisco Bay. In the Geotechnical Characterization Report for IR Site 1 (FW 2002), an analysis of seismic hazards was performed using the MCE as the design earthquake. The MCE was considered to be a magnitude of 7.9 on the San Andreas Fault or a magnitude of 7.1 on the Hayward Fault (FW 2003).

Seismic hazards identified at IR Site 1 included liquefaction potential and seismic slope instability that could result in settlement and permanent lateral spreading/deformation. Using empirical methods, total seismically-induced settlements in the fill layer were estimated to be up to 18 inches. Predicted lateral deformations of the site from the MCE were estimated to be up to 19 feet, and liquefaction-induced lateral spreading was estimated to be greater than 20 feet (and much higher in some areas).

The inland distance from the shoreline to the edge of waste can be considered analogous to freeboard in an engineered dam. A primary consideration in design of an earthen-dam considers the settlement and lateral spreading of a dam during and following an earthquake by adding freeboard (dam height above the water level). Likewise, lateral spreading and strain induced by liquefaction and slope failure of the shoreline resulting in the exposure of waste to the bay is a primary consideration of the containment remedies selected for IR Site 1. The Burn Area, by its formation, represents the largest volume of waste in close proximity to the shoreline; furthermore, by the analogy presented above, represents the least “freeboard” to waste exposure to bay waters.

2.8.2.1 Geotechnical and Seismic FS Summary

The geotechnical and seismic FS evaluated options for improving slope stability and reducing potential lateral deformations. Possible methods and technologies available to mitigate the geotechnical and seismic hazards were classified under two types of general approaches or response actions. Response actions included performing soil improvement and/or installing physical buttresses along the shoreline perimeter of the site, as well as excavation of the waste from the shoreline and relocation inland were considered.

A total of 20 remedial alternatives were considered by those conducting the geotechnical and seismic feasibility study.

A final comparative analysis using the nine EPA evaluation criteria was performed on nine of the 20 alternatives that passed initial screening. Based on the comparative analysis, Alternative 5, soil cement gravity wall and stone columns, was determined to be the most feasible. This alternative was selected because of the overall safety and reliability of the soil cement gravity wall compared to the methods proposed in the other eight alternatives.

Alternative 5 involved the construction of a 24-foot-wide soil cement gravity wall in the Young Bay Mud layer with a thickness varying from 15 to 35 feet along the shoreline perimeter of the site. It also included the installation of stone columns in the fill layer (from the ground surface to the top of the Young Bay Mud layer) to reduce liquefaction potential by consolidating the liquefiable fill material. The possible increase in mobility and volume of impacted media through application of Alternative 5 was not considered significant in the comparative analysis of the geotechnical alternatives.

Most importantly to this FFS, the Geotechnical FS (FW 2003) stated that if additional information gathered or evaluations performed during the detailed design state demonstrate viability of other remedial actions (components) over the preferred alternative (Alternative 5), then the preferred remedy should be altered.

2.8.2.2 Open Cell Waste Isolation Bulkhead

Alternative 3: Steel Sheet Pile technology was considered in the Geotechnical FS (FW 2003). However, the traditional steel sheet pile applications analyzed were not considered technically feasible. An alternative application of steel sheet piles not considered in the

Geotechnical FS (FW 2003) was the Open Cell® steel sheet pile technology. An Open Cell steel sheet pile bulkhead could be used to buttress the shoreline slope and isolate waste from potential receptors. The benefits of employing an Open Cell WIB for stabilization and fortification of the shoreline compared with the preferred alternative stemming from the 2003 Geotechnical FS include the following:

- Extend the remedy beyond the top of the shoreline;
- Eliminate the spreading of chemical and radioactive contamination into deeper geological units; and
- Reduce groundwater flow along the WIB into the bay.

Unlike traditional steel sheet pile applications, Open Cell structures rely primarily on the tensile strength and not the bending strength of the steel members. Open Cell structures are flexible steel sheet pile membranes supported by soil contact with embedded sheet pile tail anchor walls. This concept creates an integral reinforced soil system. The result is a structure that can withstand large settlement and support a variety of loads. In effect, viewed from above, the structure becomes a series of U-shaped horizontal membranes that require no toe embedment for stability (Figure 2-8). This aspect makes the technology particularly amenable to IR Site 1 because the anthropogenic fill material provides little strength for toe embedment or tie backs, which was identified as an issue with traditional steel sheet pile applications assessed in the Geotechnical FS (FW 2003).

The Open Cell WIB proposed is constructed of only three components including flat sheet piles, fabricated connector wyes, and anchor piles. Compared to alternative structures, several cost savings are realized including reduced sheet pile area, greater construction tolerances, minimal pile penetration, and reduced backfilling procedures. In addition, the installation of the WIB along the IR Site 1 boundary within the Burn Area will facilitate the addition of approximately one acre of relatively flat land over the current shoreline slope.

2.8.3 Conclusions

Based on the improved, current understanding of the nature and extent of the Burn Area contamination; and, in light of the previous Geotechnical FS; the application of a geotechnical remedy such as the steel sheet pile bulkhead to reinforce the shoreline slope and contain wastes in place meets RAOs established in the ROD. Furthermore, site-worker exposure to buried waste will be reduced by limiting the volume and extent of excavation and onsite or offsite disposal.

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3.0 REMEDIAL ACTION OBJECTIVES

This section summarizes the RAOs identified for the Burn Area based on the future site use and the results of risk assessments. RAOs provide the foundation used to develop the remedial alternatives. An RAO is a statement that contains an objective for the protection of one or more specific receptors from exposure to one or more specific chemicals in a specific medium (such as soil, groundwater, or air) at a site. Reasonably anticipated future use of the site is an important consideration in selecting the RAOs and, thus, the remedy for the site. The following sections summarize the RAOs that have been developed for soil, groundwater, and radiologically-contaminated materials at IR Site 1 based on the identified COCs, potential receptors and exposure pathways, ARARs, and remediation goals.

3.1 Affected Media and Chemicals of Concern

This subsection identifies COCs for the affected media in the Burn Area.

According to the U.S. EPA (U.S. EPA 1988b), COCs may be selected because of their toxicological properties, because they are present in large quantities, or because they are presently in or potentially may move into critical exposure pathways (e.g. the drinking water supply). According to the U.S. EPA, it may be useful to select “indicator chemicals” to represent the most toxic, persistent, and/or mobile substances among those identified as likely to contribute significantly to the overall risk posed by the site. The use of indicator chemicals serves to focus the assessment on those chemicals that are likely to be of greatest concern.

This subsection identifies COCs for the affected media in the Burn Area.

3.1.1 Soil

This FFS Report considers soil in the Burn Area from the ground surface to 1 foot below the Bay Mud. A summary of offshore sediment investigations can be found in Section 2.5.1. Offshore sediments are being addressed by the regional sediment work group and are, therefore, not addressed in this FFS Report for IR Site 1.

3.1.1.1 Soil Media of Interest

The primary media of interest at the Burn Area consists of burnt waste and residues mixed with fill material. This media is derived from open-air burning activities conducted by the Navy in the 1950s. The water table aquifer material and impacted soils within and around the burnt waste and residues are also considered media of interest.

3.1.1.2 Soil Chemicals and Radiological Materials of Concern

The chemicals of concern for soil, determined and specificed in the ROD (Chadux Tt 2009), identified in the Burn Area, are consistent with the remainder of IR Site 1 and include the following:

- PAHs: benzo(a)anthracene, benzo(b)fluorathene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and dibenzo(a,h)anthracene;
- PCBs: aroclor-1254 and aroclor-1260;
- Metals: hexavalent chromium, cadmium, lead, and zinc; and
- Pesticides: 4-4'-dichlorodiphenyldichloroethane and 4-4'-dichlorodipheny-ltrichloroethane.

These COCs were determined and specified in the ROD (Chadux Tt 2009).

A 2004 radiological survey confirmed that radium-226 is the radiological COC at IR Site 1 (TtFW 2005). For purposes of this FFS Report, radium-impacted waste in the Burn Area is defined as discarded and burnt scraping solids, rags, and used paint brushes from manufacturing and refurbishing aircraft dials and gauges, as well as any fill material which has become impacted by contact with these materials. Radium-impacted waste in the Burn Area is addressed separately from other soil and groundwater contaminants due to the unique issues associated with this type of waste (e.g. identification, management and disposal, and potential ARARs).

3.1.2 Groundwater and Surface Water

CERCLA remedial actions for contaminated groundwater are driven by the expectation that aquifers will be returned to beneficial uses wherever practicable (Title 40 CFR § 300.430 [a][1][iii][F]). Groundwater beneath IR Site 1 does not have a beneficial use as a source of drinking water. As described in Section 2.6.1.3, in a letter dated July 21, 2003, the Navy received concurrence from the Water Board that groundwater meets the municipal and domestic water supply designation exemption criteria in SWRCB Res. 88-63, "Sources of Drinking Water" (SWRCB 1988), and Water Board Res. 89-39 for groundwater west of Saratoga Street at Alameda Point (Water Board 2003). The Water Board's concurrence included groundwater beneath IR Site 1. In a letter dated January 3, 2000, EPA concurred that the groundwater at IR Site 1 was unlikely to be used as a drinking water source.

Freshwater replenishment, the discharge of groundwater to surface water, is a potential beneficial use of the groundwater at IR Site 1. Potential risks to human health and the environment are posed by the discharge of groundwater to surface water within the VOC plume south of the Burn Area. The Navy developed RAOs and PRGs in the FS to address these risks (BEI 2006a). The CTR (at 40 CFR § 131.38), National Toxics Rule (NTR; at 40 CFR § 131.36), and the surface water quality criteria in the Basin Plan were identified as potential chemical-specific ARARs for surface water where groundwater discharges to surface water to be used as the basis for identifying preliminary remediation goals protective of the recreational fisherman pathway (ingesting the organism only; not ingesting the surface water and the organism) and aquatic receptors in surface water. Therefore, VOC concentrations in the CTR and NTR are identified as surface water remediation goals. These criteria function as remediation goals for surface water where groundwater discharges to surface water.

The risk assessment presented in Section 2.7 demonstrates that freshwater replenishment at the boundary of the Burn Area and San Francisco Bay does not result in exceedances to NTR/CTR and the Basin Plan. This risk assessment considered both human health and ecological risks.

3.1.2.1 Groundwater and Surface Water Media of Interest

Four distinct areas of concern for groundwater and surface water have been identified based on the distribution of chemicals in groundwater and the geology at IR Site 1:

- VOC plume area;
- FWBZ outside the VOC plume area;
- SWBZ area;
- San Francisco Bay adjacent to the Burn Area shoreline.

VOC Plume Area

The VOC plume is located south and outside the limits of the Burn Area. The VOC plume extents were refined during the 2010 Pre-design Characterization. The VOC plume remedial action is addressed in the Work Plan for Groundwater *In-situ* Chemical Oxidation (AMEC 2011b).

FWBZ Outside the VOC Plume Area

This area consists of the groundwater in the present FWBZ within the IR Site 1 boundaries that lies outside the VOC plume area, including the Burn Area. The FWBZ is defined generally as being above the BSU and is unconfined. Groundwater samples from this area typically have isolated reported concentrations of VOC and SVOC analytes and relatively low metals concentrations.

SWBZ Area

This area consists of the SWBZ within the IR Site 1 boundaries. The SWBZ is confined and composed of the lower portion of the BSU, the Merritt Sand Formation, and the upper unit of the San Antonio Formation. This groundwater area can be characterized as containing isolated occurrences of VOC and SVOC analytes and relatively low metals concentrations.

San Francisco Bay Adjacent to the Burn Area Shoreline

This area consists of the surface waters of the San Francisco Bay adjacent to, flowing past, and mixing with the groundwater discharged from the FWBZ and SWBZ within and below the Burn Area.

The areas of concern regarding groundwater applicable to this FFS are the FWBZ outside the VOC Plume Area, the SWBZ Area, and the San Francisco Bay Adjacent to the Burn Area Shoreline. The VOC Plume Area is not considered in this FFS Report.

3.1.2.2 Groundwater and Surface Water Chemicals of Concern

There are no chemicals of concern in the groundwater and adjacent bay waters consistent with the ROD (Chadux Tt 2009) concerning groundwater and freshwater replenishment outside of the VOC Plume. This conclusion is supported by the risk assessment presented in Section 2.7, which demonstrates that freshwater replenishment at the boundary of the Burn Area and San Francisco Bay does not result in exceedances to NTR/CTR and the Basin Plan. This risk assessment considered both human health and ecological risks.

3.2 Applicable or Relevant and Appropriate Requirements

Section 121(d)(1) of CERCLA (42 USC § 9621[d]) states that remedial actions on CERCLA sites must attain (or the decision document must justify) the waiver of any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. The chemical-, location-, and action-specific ARARs for soil and groundwater remedies at IR Site 1 are discussed below.

3.2.1 Chemical-Specific ARARs

Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Chemical-specific ARARs for the alternatives assessed in this FFS are described below by medium.

3.2.1.1 Soil

Federal

Chemical Contamination

Performance of the components of the selected and alternative remedies will include excavation and will generate waste that the Navy will dispose of on and/or offsite. The Navy has identified substantive provisions of the following regulations as federal ARARs that require the characterization of waste for proper offsite disposal:

- Resource Conservation and Recovery Act (RCRA) regulations defining a hazardous waste at CCR title 22, §§ 66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100

For PCB-contaminated soil, the Navy has identified substantive provisions of 40 CFR § 761.61(c) of the Toxic Substances Control Act's PCB remediation waste requirements as federal ARARs.

Radiological Contamination

The Navy has identified the substantive provisions of the following regulations as federal ARARs for radiological contamination remaining onsite at IR Site 1:

- Uranium Mill Tailings Radiation Control Act (UMTRCA) standards for occupied or habitable buildings at 40 CFR §§ 192.12(b)(1) and (b)(2) and 192.41(b)
- Nuclear Regulatory Commission (NRC) requirements for land disposal of radioactive waste at 10 CFR § 61.41
- NRC requirements for license termination, including requirements for closure of waste disposal sites at 10 CFR § 20.1301

State

Chemical Contamination

The Navy has accepted the substantive provisions of the following regulations as state ARARs for the characterization of waste for proper offsite disposal:

- State of California regulations defining designated waste, nonhazardous solid waste, and inert waste at CCR title 27, §§ 20210, 20220, 20230

- Non-RCRA state-regulated hazardous waste determinations at CCR title 22 § 66261.3(a)(2)(C) or (F), 66261.22(a)(3) and (4), 66261.24(a)(2) to (a)(8), 66261.101(a)(1) and (a)(2)

If the Navy determines that excavated soil meets the regulatory definition of any of the following regulated wastes: (1) RCRA hazardous waste, (2) designated waste, or (3) nonhazardous solid waste - and that it will need to be disposed of offsite, the Navy will dispose of it in classified waste management units and will comply with all legally applicable requirements for proper off-site disposal, such as packaging, labeling, and placarding. Placement of waste that is consolidated within the "Area of Contamination" for IR Site 1 will not be subject to the land disposal restrictions set forth at 40 CFR Part 268 and as described in "Land Disposal Restrictions: Summary of Requirements" (EPA 2001).

3.2.1.2 Groundwater

Groundwater beneath the central portions of Alameda Point (including IR Site 1) is not currently used for drinking water, irrigation, or industrial supply. Because the groundwater is unlikely to be used as drinking water, federal maximum contaminant levels are not ARARs for groundwater.

Federal

The substantive provisions of the following requirements are federal chemical-specific ARARs for remediation of groundwater at IR Site 1:

- RCRA groundwater protection standards in CCR title 22, § 66264.94(a)(1), (a)(3), (b), (c), and (e)

State

The substantive provisions of the following requirements are state chemical-specific ARARs for remediation of groundwater at IR Site 1:

- Chapters 2 and 3 of the Basin Plan, except for the municipal beneficial use designation (Cal. Water Code, Division 7, §§ 13240, 13241, 13243, 13263(a), 13269, and 13360)
- SWRCB Res. 88-63

The SWRCB Res. 68-16 (Statement of Policy With Respect to Maintaining High Quality of Waters in California) and 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Cal. Water Code § 13304) do not constitute chemical-specific ARARs for this response action because they are state requirements and are not more stringent than federal ARAR provisions of CCR title 22, § 66264.94.

3.2.1.3 Surface Water

Federal

The Navy has identified the substantive provisions of CTR and the NTR at 40 CFR § 131.38 and 40 CFR § 131.36(b), respectively, as ARARs for surface water to be met in surface water at the interface of groundwater and surface water.

The Navy has identified the effluent limitations of 33 United States Code (USC) § 1311(b)(2) as ARARs for the point source discharge of groundwater to surface water associated with dewatering excavations.

State

The substantive provisions of the following requirements are state chemical-specific ARARs for surface water at IR Site 1. They will be met at the interface of the groundwater and surface water:

- Chapters 2 and 3 of the Basin Plan, except for the municipal beneficial use designation (Cal. Water Code, Division 7, §§ 13240, 13241, 13243, 13263(a), 13269, and 13360)
- SWRCB Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California

3.2.2 Location-Specific ARARs

Location-specific ARARs are restrictions on the concentrations of hazardous substances or on conducting activities solely because they are in specific locations. Specific locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. The selected remedies can be implemented to comply with location-specific ARARs. The substantive provisions of the following requirements are the most stringent of the potential federal and state location-specific ARARs for remedial action at the Burn Area:

- Clean Water Act § 404 (33 USC § 1344) governs the discharge of dredged and fill material into waters of the United States, including adjacent wetlands.
- Migratory Bird Treaty Act of 1978 at 16 USC § 703 protecting almost all species of native migratory birds in the United States from unregulated takings, which can include poisoning at hazardous waste sites. The substantive provisions of the Migratory Bird Treaty Act cited above are ARARs because migratory birds are

present on Alameda Point and may use the IR Site 1 wetlands for nesting or pass through the site.

- Coastal Zone Management Act at 16 USC § 1456(c) and 15 CFR § 930 requiring activities that affect the coastal zone be conducted in a manner consistent with approved state management programs, including the San Francisco Bay Plan (see state location-specific ARARs below).
- Endangered Species Act at 16 USC § 1536(a) and (h)(1)(B) and 16 USC § 1538(a)(1)(B) and (G) requiring federal agency actions not jeopardize the continued existence of any threatened or endangered species or its critical habitat and allowing an exemption from this requirement when reasonable mitigation and enhancement measures are established (Navy and Tt 1997). The California clapper rail is a federal endangered species and is potentially present on IR Site 1.

The state location-specific ARARs are the relevant and appropriate substantive provisions of the following:

- Cal. Fish and Game Code § 2080: This section prohibits the taking of any state threatened or endangered species. The Navy accepts this section as an ARAR for the threatened or endangered species present on IR Site 1 that are not protected under the Federal Endangered Species Act. The California black rail is a state threatened species that is not protected under the Federal Endangered Species Act and is potentially present on IR Site 1.
- Cal. Fish and Game Code § 5650(a), (b), and (f): This section prohibits depositing or placing where it can pass into waters of the state any petroleum products, factory refuse, sawdust, shavings, slabs or edgings and any substance deleterious to fish, plant life or bird life.
- Cal. Fish and Game Code § 3511: This section provides that it is unlawful to take or possess listed fully protected birds. The Navy accepts this section as an ARAR for the fully protected birds present on IR Site 1 that are not protected under the Federal Endangered Species Act. The American peregrine falcon and the California black rail are fully protected birds that are not protected under the Federal Endangered Species Act. The American peregrine falcon and the California black rail are potentially present on IR Site 1.
- McAteer-Petris Act and the San Francisco Bay Plan: The Coastal Zone Management Act was evaluated and certain substantive provisions were determined to be relevant and appropriate federal requirements because the remedy selected in the ROD (Chadux Tt 2009) contemplates activity within the coastal zone. Coastal Zone Management Act § 1456(c)(1)(A) requires each federal agency activity within or outside the coastal zone that affects any land or water use or natural resource to

conduct its activities in a manner that is consistent to the maximum extent practicable with enforceable policies of approved state management policies. The State of California's approved coastal management program includes the McAteer-Petris Act developed by the Bay Conservation and Development Commission. Substantive provisions of this statute and plan are state ARARs. The remedial actions selected in the ROD (Chadux Tt 2009) are in compliance with the purposes of the San Francisco Bay Plan.

3.2.3 Action-Specific ARARs

Action-specific ARARs are technology- or activity-based requirements or limitations for remedial activities. These requirements are triggered by the particular remedial activities conducted at the site. The substantive provisions of the following requirements are the most stringent of the potential federal and state action-specific ARARs for remedial action at the Burn Area.

3.2.3.1 Excavation and Offsite Disposal

For excavation and offsite disposal, substantive provisions of the following requirements are federal ARARs.

- RCRA onsite waste generation, CCR title 22 §§ 66262.10(a), 66262.11 (Person who generates waste shall determine if that waste is a hazardous waste.)
- RCRA onsite waste generation, CCR title 22 §§ 66264.13(a) and (b) (Requirements for analyzing waste for determining whether waste is hazardous.)
- RCRA hazardous waste container storage regulations, CCR title 22, §§ 66264.171–173, 66264.174, 66264.175(a) and (b), 66264.177, 66264.178
- RCRA temporary units and waste pile requirements, CCR title 22, §§ 66264.553(b), (d), (e) and (f); 66264.258(a) and (b) and 40 CFR §§ 264.554(d)(1)(i-ii) and (d)(2), (e), (f), (h), (i), (j), and (k)
- Standards applicable to the transportation, storage, and treatment and disposal of solid waste military munitions, 40 CFR §§ 266.203, 266.205, and 266.206
- Clean Water Act storm water discharge requirements 40 CFR §§ 122.44(k)(2) and (4)
- Clean Air Act provisions of state implementation plan, 40 USC § 7410; Bay Area Air Quality Management District Regulation 6, Rules 6-301 and 6-302

No state ARARs for excavation and offsite disposal are identified.

3.2.3.2 Soil Cover and Waste Isolation

The substantive provisions of the following requirements are federal ARARs for waste isolation remedies.

- RCRA site closure at CCR title 22, §§ 66264.111(a) and (b), 66264.114
- RCRA final cover requirements at CCR title 22, § 66264.310(a)(2) through (5)
- RCRA requirement to maintain the cover, CCR title 22, § 66264.310(b)(1)
- RCRA site security requirements, CCR title 22 § 66264.14(a)
- Clean Water Act Storm water discharge requirements 40 CFR §§ 122.44(k)(2) and (4)

The substantive provisions of the following requirements are state ARARs for the soil cover.

- Landfill gas control, CCR title 27, § 20921(a)(1)-(3)
- Erosion control, CCR title 27, §§ 20365(c) and (d) and 21090(c)(4) and 21150
- Engineered alternatives to final cover, CCR title 27, §§ 20080(b) and (c) and 21090(a)
- Vegetative layer, CCR title 27, § 21090(a)(3)
- Final Grading, CCR title 27, § 21090(b)(1)

3.2.3.3 Radiological Screening

The Navy has identified the substantive provisions of the following requirements as federal action-specific ARARs for the temporary storage of radiologically impacted soil (soil with radiological contamination at or above the radiological remediation goals) prior to offsite disposal:

- Nuclear Regulatory Commission radiological materials storage requirements at 10 CFR § 20.1801
- Nuclear Regulatory Commission radiological requirements for controlling and maintaining constant surveillance at 10 CFR § 20.1802

3.2.3.4 Institutional Controls

There are no federal ARARs for the implementation of ICs.

The substantive provisions of the following state statutes have been accepted by the Navy as state ARARs for implementing ICs and entering into a Covenant to Restrict Use of Property with the California Department of Toxic Substance Control (DTSC):

- Cal. Civil Code § 1471, environmental restrictions
- Cal. Health and Safety Code Land Use Controls §§ 25202.5, 25222.1, 25232(b)(1)(A)-(E), 25233(c), 25234, and 25355.5(a)(1)(C).

DTSC promulgated a regulation on April 19, 2003, regarding "Requirements for Land-Use Covenants" at CCR title 22, § 67391.1. The substantive provisions of this regulation have been determined to be "relevant and appropriate" state ARARs by the Navy.

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

The substantive provision of Cal. Health and Safety Code § 25202.5 is the general narrative standard to restrict "present and future uses of all or part of the land on which the … facility … is located …." This substantive provision will be implemented by incorporation of restrictive environmental covenants in the Covenant to Restrict Use of Property at the time of transfer for purposes of protecting present and future public health and safety.

Cal. Health and Safety Code §§ 25222.1 and Cal. Health and Safety Code § 25355.5(a)(1)(C) provide the authority for the state to enter into voluntary agreements to establish land-use covenants with the owner of property. The substantive requirements of the following Cal. Health and Safety Code § 25222.1 provisions are "relevant and appropriate": (1) the general narrative standard: "restricting specified uses of the property, …" and (2) "… the agreement is irrevocable, and shall be recorded by the owner, … as a hazardous waste easement, covenant, restriction or servitude, or any combination thereof, as appropriate, upon the present and future uses of the land." The substantive requirements of the following Cal. Health and Safety Code § 25355.5(a)(1)(C) provisions are "relevant and appropriate": "… execution and recording of a written instrument that imposes an easement, covenant, restriction, or servitude, or combination thereof, as appropriate, upon the present and future uses of the land."

The Navy will comply with the substantive requirements of Cal. Health and Safety Code §§ 25222.1 and 25355.5 (a)(1)(C) by incorporating CERCLA use restrictions into the Navy's deed of conveyance in the form of restrictive covenants under the authority of Cal. Civil Code § 1471. The substantive provisions of Cal. Health and Safety Code §§ 25222.1 and 25355.5 (a)(1)(C) may be interpreted in a manner that is consistent with the substantive provisions of Cal. Civil Code § 1471. The covenants shall be recorded with the deed and run with the land.

Cal. Health and Safety Code § 25233(c) sets forth "relevant and appropriate" substantive criteria for granting variances from restrictions on prohibited uses set forth in Cal. Health and Safety Code § 25232(b)(1)(A)-(E) based upon specified environmental and health criteria. Cal. Health and Safety Code § 25234 sets forth the following "relevant and appropriate" substantive criteria for the removal of a land-use restriction on the grounds that "… the waste no longer creates a significant existing or potential hazard to present or future public health or safety."

In addition to being implemented through the Covenant to Restrict Use of Property between the Navy and DTSC, the appropriate and relevant portions of Cal. Health and Safety Code §§ 25202.5, 25222.1, 25232(b), 25233(c), 25234, and 25355.5(a)(1)(C) and Cal. Civil Code § 1471 shall also be implemented through the deed between the Navy and the transferee.

3.3 Remedial Action Objectives

RAOs typically involve preserving or restoring a resource (e.g. groundwater or surface soil); therefore, they are expressed in terms of the medium of interest and target cleanup levels whenever possible. RAOs were identified as the result of the risk assessment (TtEMI 1999c and 2002), the potential beneficial uses of groundwater, the ARARs analysis, and site-specific evaluations.

3.3.1 Soil

RAOs for soil are presented for nonradiological contaminants and for radiological anomalies.

3.3.1.1 Nonradiological Soil Contaminants

The RAOs for chemical contamination are to:

- Protect future recreational visitors from exposure to hexavalent chromium, PAHs, and PCBs at concentrations above human health remediation goals; and

- Protect terrestrial ecological receptors from cadmium, lead, zinc, 4,4’-dichlorodiphenyldichloroethane (DDD), and 4,4’-dichlorodiphenyltrichloroethane (DDT) at concentrations above ecological remediation goals.

Soil remediation goals for chemical contamination protective of human and ecological receptors are listed in Table 8-1 and Table 8-2, respectively, of the ROD (Chadux Tt 2009), and are provided in Appendix E.

3.3.1.2 Radiological-Impacted Waste

The RAO for radiological contamination in soil is to:

- Prevent exposure to radionuclides of concern (radium-226, cesium-137, strontium-90, depleted uranium, uranium oxide, thorium-232, and cobalt-60) that exceed remediation goals.

Soil remediation goals for radiological materials of concern protective of human receptors are presented in Table 8-3 of the ROD (Chadux Tt. 2009), and are provided in Appendix E.

3.3.2 Groundwater and Surface Water

The RAOs for groundwater and surface water are to:

- Prevent human exposure to VOCs in outdoor air by reducing VOC concentrations in groundwater to risk-based remediation goals;
- Prevent ingestion of VOCs and SVOCs by people who fish recreationally (ingesting the organism only) by ensuring that groundwater discharges to surface water do not cause concentrations in the surface water above CTR and NTR criteria for surface water; and
- Prevent ingestion of arsenic by aquatic receptors by ensuring that groundwater discharges to surface water do not cause concentrations in the surface water above the CTR, NTR, and Basin Plan criteria, for the aquatic life remediation goal for surface water.

Groundwater and surface water remediation goals protective of human and ecological receptors are listed in Tables 8-1 and 8-2, respectively, in the ROD (Chadux Tt 2009), and are provided in Appendix E.

The risk assessment presented in Section 2.7 demonstrates that freshwater replenishment at the boundary of the Burn Area and San Francisco Bay does not result in exceedances to

NTR/CTR and the Basin Plan. This risk assessment considered both human health and ecological risks.

3.3.3 Remedial Action Objectives Conclusions

The RAOs and associated remediation goals presented above are taken from the Final ROD (Chadux Tt 2009). Additional risk assessments conducted to assess the exposure of chemicals and radiological materials of potential concern by freshwater replenishment of the San Francisco Bay from groundwater in the Burn Area was conducted. Groundwater/surface water COCs in addition to those presented in the Final ROD (Chadux Tt 2009) were not determined as a result of this additional risk assessment.

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This section discusses general response actions, process options, and associated technologies potentially capable of addressing contaminated groundwater and soil at the IR Site 1 Burn Area. The remedial technologies have been screened for effectiveness, implementability, and relative cost (U.S. EPA 1988) in the Final FS (BEI 2006a).

4.1 Burn Area Remedial Technology Process Options

The process-option screening criteria (effectiveness, implementability, and cost) were applied on the basis of their relative importance to the FS process (U.S. EPA 1988). The criterion of effectiveness was given the most weight, followed by implementability, and then by cost. When two or more process options yielded comparable results, cost determined the most effective option.

4.1.1 Effectiveness

The following criteria were considered when options were screened for effectiveness (U.S. EPA 1998a).

- **Ability to achieve RAOs for the protection of human health and the environment.** Technologies incapable of attaining chemical-specific ARARs or health-based cleanup goals or those that would not effectively contribute to the protection of public health or the environment were not considered further.
- **Permanent reduction in toxicity, mobility, or volume of affected groundwater and soil.** Technologies that permanently reduce contaminant toxicity, mobility, or volume were preferred.
- **Long-term risks of treatment residuals or containment systems.** Technologies with significantly lower long-term risks were preferred.
- **Risks to the public, workers, or the environment during technology implementation.** Technologies posing less risk during implementation were preferred.

4.1.2 Implementability

The following criteria were considered when options were screened for implementability (U.S. EPA 1998a).

- **Site characteristics limiting the construction or effective functioning of a technology.** Technologies limited by site conditions were eliminated.

- **Waste or media characteristics that limit the use or effective functioning of a technology.** Technologies limited by waste or media characteristics were eliminated.
- **Availability of equipment needed to implement a technology and the capacity of required offsite treatment or disposal facilities.** Commercially developed technologies that are readily available or innovative technologies that have been pilot tested were preferred.
- **Administrative feasibility of obtaining permits and approvals from regulatory agencies and other offices.** Administrative feasibility is an important component of implementability because a technically feasible option may be difficult or impossible to permit (or to comply with the substantive requirements of the permit process). Technologies were eliminated if the permitting process was judged to be prohibitively difficult.

4.1.3 Cost

Criteria used to screen remedial technologies were qualitative and based on engineering judgment unless otherwise noted. The relative magnitude of costs as well as operation and maintenance (O&M) costs were considered when process options within a technology were compared. Process options with lower costs were preferred if the effectiveness and other implementability criteria were comparable.

4.1.4 Identification of Burn Area Remedial Technologies

Review of the Final FS (BEI 2006a) (including the Geotechnical and Seismic FS Report [FW 2003]) and Final ROD (Chadux Tt 2009) facilitated identification of Burn Area remedial alternatives. The Burn Area remedial technologies identified for screening include as follows:

Groundwater:

- ICs
- Long-term groundwater monitoring
- Source removal and disposal associated with excavation dewatering

The process options listed above were considered in the development of alternatives for the Burn Area remedy.

Soil:

- ICs
- Capping with a soil cover
- Partial containment with an Open Cell steel sheet pile WIB
- Relocation of contaminated soil and debris from the Burn Area to inland portions of the former disposal area (Area 1a)
- Complete removal of waste material
- Offsite disposal of waste material

The process options listed above were considered in the development of alternatives for the Burn Area remedy.

4.2 Screening Results of Burn Area Remedial Technologies for Groundwater

The following subsections discuss screening results for groundwater technologies. Results for process options are grouped by general response action and technology.

Chemicals and radiological materials of potential concern in groundwater within the Burn Area that exceed RGs were not identified. Considering the freshwater replenishment pathway (discharge of groundwater to the ambient receiving waters of the San Francisco Bay), chemicals and radiological materials of potential concern in groundwater within the Burn Area that result in surface water that exceed PALs based on DAF analysis were not identified.

4.2.1 Institutional Controls

ICs for groundwater pertinent to the Burn Area would be implemented in accordance with the procedures and requirements outlined in Section 12.2.1.1 of the final ROD (Chadux Tt 2009). Based on contamination in the groundwater, the following activities would be considered prohibited unless conducted in accordance with the “Covenant(s) to Restrict Use of Property,” Quitclaim Deed(s), or otherwise approved by the Federal Facilities Agreement (FFA) Signatories:

a. Any surface or subsurface activity that causes or could cause the preferential movement of contaminated groundwater
b. Extraction of groundwater and installation of new groundwater wells

c. Alteration, disturbance, or removal of any component of the groundwater response or cleanup action, including groundwater monitoring wells, groundwater extraction wells, treatment facilities, and associated equipment

d. Removal of or damage to security features (e.g. locks on monitoring wells, survey monuments, fencing, signs, or monitoring equipment and associated pipelines and appurtenances)

ICs would be maintained until the concentrations of hazardous substances in the groundwater are at such levels to allow for unrestricted use and exposure.

Effectiveness

ICs would not be effective in the active treatment of groundwater contamination. However, implementation of ICs can prevent exposure of the general public to groundwater contaminants through acceptable land-use practices. Implementation of ICs may also be effective as an interim strategy, in conjunction with other remedial process options, to protect human health and the environment by preventing extraction of impacted groundwater and construction of buildings on the site until unrestricted use is possible, and by protecting remediation and/or monitoring equipment.

Implementability

ICs are implementable at IR Site 1.

Cost

Potential costs associated with the ICs at IR Site 1 are low compared to other groundwater options.

Conclusion

Implementation of ICs to restrict construction of buildings and protect groundwater remediation and/or groundwater monitoring equipment will be retained as a process option for IR Site 1 groundwater. By preventing exposure to the IR Site 1 groundwater contaminants, the protection of human health and the environment can be achieved at a nominal cost.

4.2.2 Long-term Groundwater Monitoring

The monitoring process involves regular site inspections, groundwater monitoring, and compliance reporting. One process option, long-term groundwater sampling and analysis, was evaluated. Groundwater would be periodically sampled and analyzed to monitor aquifer hydraulics and variations in contaminants and aquifer chemistry.

Effectiveness

Groundwater sampling and analysis as a stand-alone action is not effective at reducing the mass, volume, or toxicity of groundwater contamination. It is effective as a means of monitoring the selected groundwater remedy and therefore included in this FFS.

Implementability

Groundwater sampling and analysis is implementable at the Burn Area as demonstrated by previous investigations and the current base-wide groundwater monitoring program.

Cost

Groundwater sampling and analysis can be a cost-effective process option if it is planned and executed effectively and if it is fixed in duration.

Conclusion

Long-term groundwater monitoring is a practical method of measuring the effectiveness of groundwater remediation technologies and is a means to identify changes in groundwater quality that may be indicative of a chemical release. This process option is, therefore, retained as an effective support technology for all groundwater remediation alternatives and as a stand-alone technology for groundwater in the Burn Area.

4.2.3 Source Removal and Disposal Associated with Excavation Dewatering

Groundwater extraction and *ex-situ* treatment was eliminated for the FWBZ and the SWBZ within the Burn Area. Groundwater extraction and *ex-situ* treatment do not appear necessary to meet the RAOs in the ambient receiving water of San Francisco Bay. However, partial extraction and disposal of groundwater accumulated in open excavations may be required to effectively implement soil remedies.

Effectiveness

Use of extraction wells for pump-and-treat operations is applicable to most dissolved phase contaminants. The primary factors affecting the applicability of this technology are site geology and hydrogeology. Use of wells for pump-and-treat operations is expected to be partially effective for mass removal of dissolved-phase contaminants. Hydraulic conductivities are likely amenable to pump-and-treat operations. Although the contaminant mass may be reduced using extraction methods, this technology has been shown to be an inefficient and high-cost method for removing contaminants to low levels (API 1993, Bartow and Davenport 1992, Doty and Travis 1991, MacDonald and Kavanaugh 1994, Mackay and Cherry 1989, NRC 1994, U.S. EPA 1993b).

Implementability

Limited extraction of groundwater from open excavations in the Burn Area is implementable. A National Pollutant Discharge Elimination System permit may be obtained from the Water Board to discharge treated water to the San Francisco Bay; however, the presence of radiological materials in extracted groundwater may preclude discharge of treated effluent to the bay.

Ex-situ treatment of the dioxins/furans and metals-based chemicals and radiological materials of potential concern would be difficult to implement. Constructed wetlands would require a significant amount of property, which could hinder plans for site reuse. Precipitation requires pH adjustment, typically requiring hazardous reagents, and the process generates sludge that must be tested, transported through the community, and disposed. Adsorption/absorption would be implementable, although frequent change out of sorbent material could be required. Ion exchange is a capital-intensive technology that produces sidestream wastes; however, it would be implementable.

Cost

Costs for dewatering and *ex-situ* treatment systems are difficult to predict, primarily due to the uncertain endpoint of the remedy. Factors affecting cost include the time required for extraction and the *ex-situ* treatment chain alternatives. Also, the cost of addressing the substantive requirements of permitting, procuring, and operating treatment systems is high.

Conclusion

Long-term groundwater extraction and *ex-situ* treatment were eliminated from further consideration due to the high cost, long duration, and limited implementability associated with pump-and-treat systems. However, *ex-situ* treatment using either adsorption/absorption or stripping processes was retained for consideration for treatment of groundwater extracted during dewatering processes.

4.3 Screening Results of Burn Area Remedial Technologies for Soil

The following subsections discuss screening results for soil technologies. Results for process options are grouped by general response action and technology. Technologies are initially screened for their applicability to the Burn Area.

4.3.1 Institutional Controls

The Navy has determined that when the property is transferred to a non-federal entity it will rely upon proprietary controls in the form of environmental restrictive covenants as provided in the “Memorandum of Agreement Between the United States Department of the Navy and the California Department of Toxic Substances Control” and attached covenant models (Navy and DTSC 2000; hereinafter referred to as the “Navy/DTSC memorandum of agreement [MOA]”). More specifically, land use and activity restrictions will be incorporated into two separate legal IC instruments at the time of transfer as provided in the Navy/DTSC MOA:

- Restrictive covenants included in one or more Quitclaim Deeds from the Navy to the property recipient;
- Restrictive covenants included in one or more “Covenant to Restrict Use of Property” entered into by the Navy and DTSC as provided in the Navy/DTSC MOA and consistent with the substantive provisions of CCR title 22, § 67391.1.

The “Covenant to Restrict Use of Property” will incorporate the ICs into environmental restrictive covenants that run with the land and that are enforceable by DTSC and any other signatory state entity against future transferees. The Quitclaim Deed(s) will include the identical land use and activity restrictions in environmental restrictive covenants that run with the land and that will be enforceable by the Navy against future transferees.

ICs will be applied to the Burn Area and included in findings of suitability to transfer, findings of suitability for early transfer, “Covenant to Restrict Use of Property” (“the Covenant(s)”) between the Navy and DTSC, and any Quitclaim Deeds (“the Deed(s)”) conveying real property containing the Burn Area.

The following sections describe the IC objectives to be achieved through land use and activity restrictions including the Burn Area.

Land Use Restrictions

IR Site 1 shall be restricted to open space and recreational uses. In addition, the following land uses are specifically prohibited within the Burn Area:

a. A residence, including any mobile home or factory built housing, constructed or installed for use as human habitation,

b. A hospital for humans,

c. A school for persons under 21 years of age,

d. A day care facility for children, or

e. Any permanently occupied human habitation including those used for commercial or industrial purposes.

Activity Restrictions

The following activities are restricted within the Burn Area and must be approved by the Navy and FFA Signatories and California Department of Public Health (CDPH) prior to conducting them:

a. Land disturbing activity is prohibited unless conducted pursuant to an approved soil management plan. “Land disturbing activity” includes but is not limited to:

    1. Excavation of soil and disturbance of the soil cover;

    2. Construction of roads, utilities, permanently occupied buildings, facilities, structures, and appurtenances of any kind;

    3. Demolition or removal of paved areas;

    4. Actions that may impair the soil cover or other exposure prevention barriers;

    5. Excavation and/or disturbance of soil or riprap areas; and

    6. Any other activity that involves movement of soil to the surface from below the surface of the land.

b. Alteration, disturbance, or removal of any component of a response or cleanup action.

c. Extraction of groundwater and installation of new groundwater wells.

d. Removal of or damage to security features (e.g. locks on monitoring wells, survey monuments, fencing, signs, or monitoring equipment and associated pipelines and appurtenances).

ICs will be maintained until the concentrations of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and exposure.

Additional Land Use Restrictions Related to Radionuclides at IR Site 1
Excavation within the Burn Area is strictly prohibited unless approved in writing by the FFA signatories and CDPH. Any proposed excavation below a depth of 2 feet shall be required to be described in a soil management plan that will include but not be limited to a radiological work plan, the identification of a radiological safety specialist, soil sampling and analysis requirements, and a plan for offsite disposal of any excavated radionuclides by the transferee in accordance with federal and state law. This work plan must be submitted to and approved in writing by the FFA signatories and CDPH in accordance with procedures that will be set forth in the Covenant(s), the Deed(s), IR Site 1 O&M Plan, and/or Land Use Controls Remedial Design (LUC RD) report. The integrity of the cover/cap must be restored upon completion of excavation as provided in the IR Site 1 O&M Plan, LUC RD report, or similar document. A completion report describing the details of the implementation of the soil management plan, the sampling and analysis, the off-site disposal, and the restoration of the integrity of the cover/cap must be submitted to and approved in writing by the FFA signatories and CDPH in accordance with procedures and timeframes that will be set forth in the Covenant(s), the Deed(s), the IR Site 1 O&M Plan, and/or LUC RD.

Effectiveness

ICs are effective, not through actively treating contamination, but through prevention of human exposure to contaminants through the use of acceptable land-use practices. ICs should be effective in preventing or limiting access or exposure to contaminated soil. ICs may also be effective as an interim strategy with other remedial process options by preventing exposure to or removal of impacted soil until a permanent remedy is implemented. ICs alone are unlikely to be effective in protecting ecological receptors.

Implementability

ICs are readily implementable at IR Site 1. There is precedent for the use of ICs at Alameda Point. Construction and/or maintenance of fencing and signage are implementable at IR Site 1. Access to IR Site 1 currently is controlled with fencing and signage.

Cost

ICs are expected to be low in cost compared to other process options.

Conclusion

ICs are effective, implementable, and low in cost. Therefore they are retained for consideration. Fencing and signage are retained for consideration as a temporary measure until a permanent remedy is implemented. Governmental controls (e.g. zoning and land-use restrictions) are retained for consideration. Proprietary controls are retained for consideration. Enforcement tools (e.g. administrative orders, consent decrees) are eliminated from consideration. Informational tools (e.g. deed notices, advisories) are retained for consideration as a secondary layer of public health protection.

4.3.2 Containment

Containment involves isolating contaminated soil and buried debris from potential receptors. Generally, contaminated soil is contained using some type of cap or shield. Capping is among the more common response actions employed for soils because it is generally less expensive than other technologies and effectively manages the human and ecological risks associated with a remediation site.

Two types of capping are being considered for use at the Burn Area: soil cover and an Open Cell WIB. These two capping options are briefly described as follows.

- **Soil Cover.** Soil covers consist of a single layer of compacted soil to act as a physical barrier. When designed to be of a suitable thickness, a soil cover also acts as an effective shield against underlying radiological anomalies. Soil covers do not prevent infiltration of precipitation.
- **Open Cell Steel Sheet Pile WIB.** An Open Cell steel sheet pile WIB placed along the shoreline acts as a buttress to support and isolate the waste under and behind the shoreline slope. When designed to be of suitable strength, the WIB will maintain the integrity of the shoreline slope during and following the design earthquake; thereby preventing the release of waste into ambient surface waters. Additionally, the WIB serves to limit the rate of freshwater replenishment along its alignment.

Screening results for these soil containment process options are summarized below.

Effectiveness

Capping prevents exposure of humans, animals, or plants to hazardous materials. Capping does not lessen toxicity, mobility, or volume of hazardous wastes. The most appropriate process option for a cap depends on the objectives of the cap.

- **Soil Cover.** A soil cover of suitable thickness would be effective to shield a recreational visitor or site worker from radiological anomalies and underlying buried debris. A soil cover would not prevent infiltration of precipitation to groundwater. A soil cover is considered to be effective, provided that it is implemented with ICs to prohibit actions that could reduce the effectiveness of the cover, and assuming that groundwater protection is not required.
- **Open Cell Steel Sheet Pile WIB.** Steel sheet pile bulkheads are commonly used to stabilize and fortify shorelines for multiple applications. The Open Cell technology, as it applies to steel sheet pile bulkheads, is a proven technology for shoreline bulkheads in soft soils and under heavy seismic loads. Limited data exists on the permeability of steel sheet pile bulkheads to water. However, it is presumed that a WIB installed along the shoreline at the Burn Area would result in reduced rate of groundwater discharge to the bay along its alignment. Increased rates of groundwater discharge to the bay would be realized at the WIB ends.

Implementability

The implementation of soil covers and WIBs are different. Soil covers are considered easy to install and implement. Steel sheet pile installation requires specialized equipment and training beyond what is considered ordinary.

- **Soil cover.** Soil covers are relatively easy to install but require strict quality control inspection during installation. The primary limitations of capping are the need for long-term maintenance and uncertain design life. In addition, existing roads, site features, and underground utilities at IR Site 1 would have to be taken into consideration during cap construction. The technology required for a soil cover is readily available. A soil cover is readily implementable at IR Site 1.
- **Open Cell Steel Sheet Pile WIB.** Application of the Open Cell technology is more complex than standard steel sheet pile installation, which in itself requires specialized equipment and training beyond what is considered ordinary. In addition, the concrete-debris revetment along the shoreline alignment further complicates the installation of the WIB. Integral cathodic protection can be added to enhance the lifespan of the WIB.

Cost

Costs for each containment technology are discussed below.

- **Soil cover.** Installation of a soil cover at the Burn Area would be very cost-effective if affordable fill material can be used as the soil cover. Soil cover maintenance costs are also considered low.
- **Open Cell Steel Sheet Pile WIB.** The capital costs associated with the installation of an Open Cell WIB for containment of the wastes in the Burn Area are considered moderate to high. The procurement of the steel and galvanization is dependent on commodity markets for the raw materials; and, to some degree, the cost of shipping the relatively heavy products to the site. Installation requires specialized heavy equipment and operators/laborers which are locally available. In addition, the concrete-debris revetment currently armoring the shoreline will need to be managed (and possibly removed) to install the sheet pile along its desired alignment at the IR Site 1 boundary. WIB maintenance costs are considered low.

Conclusion

Each containment option is potentially effective at the Burn Area. Therefore, soil cover and Open Cell steel sheet pile WIB options are retained for further consideration at the Burn Area on the basis of their effectiveness, implementability, and cost. These options should meet the RAOs of preventing exposure to contaminated soils. Containment would likely be combined with other remedial process options such as ICs.

4.3.3 Excavation and Removal

Excavation or removal technologies would remove contaminants from the medium of concern, which is contaminated soil and burn residue at the Burn Area. Mechanical excavation was evaluated as specific process options.

Soil excavation entails removing contaminated material with heavy equipment. Excavated material from the Burn Area could be relocated to the interior of IR Site 1 prior to construction of a soil cover for that area. Excavated soil from the Burn Area could also be stockpiled onsite for treatment, or transported to permitted offsite treatment and disposal facilities. If offsite disposal is considered, some pretreatment may be required in order to meet land-disposal restrictions (LDRs). Excavations typically are backfilled with clean and/or remediated soil.

Excavation of the Burn Area material would require the installation of bracing to support the excavation and prevent the invasion of seawater at the shoreline limits of the dig. An Open Cell steel sheet pile bulkhead similar to the WIB discussed above without the galvanization would serve as effective bracing to support the excavation. Because of the wastes encountered, the steel sheet pile bulkhead would remain in place following backfill of the excavation.

Effectiveness

Excavation and offsite disposal comprise a process option that is applicable to the complete range of contaminant groups, with no particular target group. Relocation of excavated soil from the Burn Area to the inland portions of IR Site 1 to be contained under a cap is an effective means of preventing human and ecological exposure without transporting waste through the local community. Excavation and offsite disposal are also considered effective and potentially applicable. Excavation allows relocation of the waste to a different (and presumably safer) location where future contact or exposure onsite would be prevented.

Implementability

Factors that may limit implementability of this process option include: (1) generation of fugitive emissions during operations, and (2) the depth and composition of the media requiring excavation.

Cost

Disposal costs for excavated soil and debris can be high, depending on volume. One must consider the costs of excavation and removal, equipment maintenance, transportation, and disposal at a RCRA-permitted facility. Additional cost of treatment at a disposal facility may also be required. Excavation and offsite disposal is a labor-intensive practice. Additional costs may include soil characterization and treatment to meet LDRs. Capital and O&M costs are considered to be medium and low, respectively.

Conclusion

Soil excavation at the Burn Area could be applied to two scenarios: (1) excavation of small volumes of contaminated soil (hot spots), or (2) complete excavation. In some cases, excavation of small volumes of highly contaminated soil is more cost-effective than the design and construction of an onsite remediation process. Excavation could also be employed for a complete removal alternative in the Burn Area. Soil excavation was retained for further consideration on the basis of its effectiveness and implementability under both scenarios.

4.3.4 Disposal

Process options for disposal of untreated or treated material and radiologically-impacted waste are screened in this section. Several technologies are evaluated below.

OnSite Disposal
A possible soil-disposal scenario in which soil is kept on IR Site 1 is consolidation of the excavated material into the inland portions of the former disposal area (Area 1a) prior to containment by capping. The U.S. EPA's Area of Contamination policy can be applied to this CERCLA remedial action. The Area of Contamination policy allows consolidation of waste (e.g. contaminated soil) from areas of contaminated soil into a single location (U.S. EPA 1996a). After consolidation, Area 1 would be graded and capped with a soil cover or engineered alternative cap, as described in Section 4.3.2. Excavated soil from IR Site 1 areas (Figure 2-3) only would be considered for relocation under the Area of Contamination policy. Soil from other sites on Alameda Point would not be allowed to be placed in Area 1 under the Area of Contamination policy.

Effectiveness

Relocation of contaminated soil from the Burn Area into the inland portions of the former disposal area (Area 1a) prior to capping would be effective in protecting human health and the environment, provided that the cap is designed, constructed and maintained appropriately.

Implementability

This process option is considered easily implementable. Approval of Area 1 as an area of contamination would be required from U.S. EPA and DTSC.

Cost

The cost for this process option is considered low.

Conclusion

This process option is retained for further consideration.

OffSite Disposal

This process option involves collecting and transporting soil to a RCRA-permitted treatment, storage, and disposal (TSD) facility. Disposal of soil would involve constructing onsite storage facilities from which soil would be transferred to trucks and transported to an offsite treatment or disposal facility. Contaminated soil that is not radiologically contaminated would be disposed offsite at a California Class I, II, or III facility, depending on its characteristics. It is assumed that the radiologically-impacted waste would be disposed offsite under the Navy's Low-Level Radioactive Waste program at a disposal facility licensed by the NRC under 10 CFR § 61, Licensing Requirements for Land Disposal of Radioactive Waste.

Effectiveness

This process option would comply with ARARs. Excavation and offsite disposal comprise a process option that is applicable to the complete range of contaminant groups with no particular target group. The effectiveness is considered medium since there may be future liability for disposed untreated waste.

Implementability

This option is easily implemented at IR Site 1 for small quantities of soil or radiologically-impacted waste. For larger quantities (e.g. complete removal of debris in Area 1), implementability is moderate. Transportation of large volumes of soil or radiologically-impacted waste through populated areas may affect community acceptability. "Cradle-to-grave" liability would remain with the Navy. The soil must be staged and profiled according to disposal facility requirements.

Several Class I hazardous waste landfills in the state of California are potentially capable of accepting soil from IR Site 1. At the time of publication of this FFS Report, there was at least one facility in California with available capacity to accept the wastes.

Cost

Costs for offsite disposal could range from medium to very high, depending upon the volume of soil required for disposal and its characteristics. For smaller volumes, it tends to be a relatively cost-effective option when compared to *in-situ* or onsite treatment options. For larger volumes, offsite disposal can often be among the more expensive options. If the soil exceeds LDRs and therefore requires pretreatment, costs can be prohibitively high.

Conclusion

Soil and radiologically-impacted waste disposal offsite was retained on the basis of its effectiveness. Offsite disposal could be used for two scenarios: (1) disposal of small volumes of process residuals or (2) complete removal of the Burn Area wastes.

4.4 Summary of Burn Area Process Options

The Burn Area because of its close proximity to the shoreline and extent below the water table represents an area of IR Site 1 which presents the greatest risk of exposure of wastes to the ambient receiving surface water of the San Francisco Bay. The risk of exposure of contamination to the bay waters by freshwater replenishment (groundwater discharge to the bay) was studied and determined to be at such a rate that the resulting concentrations in the bay waters of chemicals and radiological materials of potential concern was acceptable. Therefore, the most likely candidate for process options concerning groundwater/surface water contamination is ICs and monitoring.

As identified and presented in the ROD (Chadux Tt 2009) the risk of exposure to soil contamination located in the Burn Area by humans and terrestrial and aquatic organisms is unacceptable. Therefore, the “no action” alternative is not considered a viable process option for soil remedy of the Burn Area to meet RAOs. The active remediation process options that remain for the Burn Area soil are containment and excavation, along with supporting technologies including excavation dewatering and *ex-situ* treatment and on and/or offsite disposal. The excavation option is the primary component of the Burn Area remedy selected in the ROD. The excavation process would likely also include a combination of relocation of material inland on IR Site 1 and offsite disposal of excavated waste. Each soil option; containment and excavation, would also include ICs.

5.0 DEVELOPMENT AND SCREENING OF BURN AREA REMOVAL ALTERNATIVES

The technologies and associated process options retained after the screening evaluation were assembled into remedial alternatives to address the soil contamination at the Burn Area. Section 5.1 describes the development of the Burn Area remedial alternatives for soil, Section 5.2 presents the Burn Area remedial alternatives, and Section 5.3 discusses the screening of the alternatives.

5.1 Development of Burn Area Remedial Alternatives for Soil

The remedial alternatives for soil at the Burn Area were developed on the basis of the RAOs summarized in Section 3, requirements of CERCLA and the NCP, and, to the extent practicable, applicable U.S. EPA technical guidance (U.S. EPA 1988). CERCLA Section 121(b) identifies the following statutory preferences for remedial actions.

- Preferred remedial actions are those involving treatment that permanently and significantly reduce the volume, toxicity, or mobility of site-related contaminants.
- The least favored remedial action is offsite transport and disposal of hazardous substances or contaminated materials without treatment when practical treatment technologies are available.
- Remedial actions using permanent solutions, alternative treatment technologies, or resource recovery technologies should be assessed.

The NCP states that, in the FS process, a range of remedial alternatives should be developed (40 CFR 300.430[e]). These alternatives may vary in the degree of treatment employed (i.e. in the quantity of material treated or the percent reduction of contaminant concentrations) as well as in the types and quantities of residuals and untreated material remaining onsite and requiring long-term management. For groundwater response actions, alternatives that attain RAOs in varying lengths of time using one or more different technologies may also be considered.

Also considered were the criteria regarding eventual selection of a preferred remedial action (U.S. EPA 1988). The preferred remedial action(s) will be presented in the proposed plan. According to U.S. EPA technical guidance, the preferred remedial action should:

- Protect human health and the environment,
- Meet contaminant-specific ARARs and be consistent with location- and action-specific ARARs,
- Be cost-effective,

- Use permanent solutions and alternative treatment technologies to the maximum extent practicable, and
- Satisfy the preference for treatment as a principal element of the remedial action to reduce the toxicity, mobility, or volume of contaminants.

This FFS also includes an alternative that does not involve treatment. In this case, human health and the environment would be protected by using engineering controls to prevent or control exposure to site contaminants. As necessary, ICs (i.e. governmental controls, proprietary controls, and informational devices) would be included as part of a comprehensive remedial alternative to assure the continued effectiveness of engineering controls and other aspects of the response action.

Because this FFS postdates the ROD (Chadux Tt 2009), the selected remedy for the Burn Area is included as an alternative.

5.2 Burn Area Remedial Alternatives

This section presents the soil remedial alternatives for the Burn Area.

5.2.1 Selected Remedy – Alternative S1-4a: Removal of Waste from Area 1b, Soil Cover for Remainder of Area 1, and ICs

Alternative S1-4a from the Final ROD (Chadux Tt 2009) includes excavation, placement of a soil cover, radiological screening, a sweep for materials potentially presenting an explosive hazard (MPPEH), wetlands mitigation, and ICs. Alternative S1-4a addresses the main disposal area, which includes the Burn Area. Therefore, components of Alternative S1-4a that are not related directly to the Burn Area remedy are not applicable to this FFS. The parts of Alternative S1-4a, which are not applicable to the Burn Area remedy include radiological screening, a sweep for MPPEH, and wetlands mitigation. These non-applicable aspects of Alternative S1-4a would remain unchanged (Chadux Tt 2009). The portions of Alternative S1-4a applicable to the remedy of the Burn Area are described below.

Excavation

Alternative S1-4a for Area 1 includes excavation to remove the burn layer in Area 1b. The Area1b would be excavated laterally to remove the visible burn layer. In areas where visible burn waste is removed, excavations would continue vertically to meet the remediation goals, even if the contamination extends below the water table. If the lateral extent of the visible burn layer is less than the approximate 3.7-acre boundary defined by historical photos, confirmation samples would be taken throughout the remaining area of Area 1b to evaluate whether chemicals or radionuclides that exceed remediation goals are present in the soils above the water table. If sampling results indicate that concentrations in soils above the water table are above remediation goals, the Area 1b excavation would continue but would not extend below the water table. No excavations would extend past the 3.7-acre Area 1b boundary as shown in Figure 2-3. Excavated waste and soil that exceeds chemical or radiological remediation goals or contains MPPEH would be disposed of offsite. Excavated soil that is free of MPPEH and is below chemical or radiological remediation goals may be placed back into the Area 1b excavation if it meets design requirements or may be used as foundation material for the cover. If additional soil is needed to fill the excavations, the Navy would import clean backfill. The surface of Area 1b would be graded to match the surrounding Area 1a cover.

The ROD did not specify all means and methods for advancement of the excavation. Following Pre-design Characterization and during development of the initial remedial design for the Burn Area excavation, it was determined that advancement of the excavation to the limits of Area 1b along the shoreline would require the installation of bracing. In lieu of a full coffer dam, an Open Cell steel sheet pile bulkhead could be used for bracing along the Area 1b (IR Site 1) boundary at the shoreline slope at mean sea level. Once installed material could be excavated and backfilled within each of the sheet pile cells sequentially. Once this process is complete, the remainder of the excavation and backfilling activities behind the bulkhead could be completed. The steel bulkhead could remain and not be removed because of the cost associated with removal, decontamination, and confirmatory sampling of the steel sheets.

Soil Cover

The seismically-stable soil cover would be placed over the waste in Area 1a (Figure 2-3) to prevent exposure to contaminants above remediation goals. This cover would likely extend into other areas of IR Site 1 to accommodate appropriate design requirements, seismic considerations, appropriate setback distances, and ARAR requirements. The Navy would determine the exact location of the cover in the remedial design. The soil cover would be seeded with indigenous plant species as an erosion control measure.

Alternative S1-4a assumes that all waste in the 3.7-acre Area 1b would be excavated, removed, and disposed on and offsite. Area 1b would then be backfilled to restore the existing grade. The soil cover would be constructed over the remainder of Area 1.

ICs would prohibit residential use of the Burn Area and the remainder of IR Site 1 and actions that could damage or otherwise reduce the effectiveness of the remedies (Section 3.2.3). No fencing or signage would be included.

5.2.2 Alternative BA-1: Stabilization and Containment of Burn Waste with Open Cell Steel Sheet Pile Waste Isolation Bulkhead, Select Excavation, Soil Cover, and ICs

Alternative BA-1 includes the installation of an Open Cell steel sheet pile WIB along the shoreline boundary of the thickest portions of the Burn Area, select excavation of burn waste and relocation of the excavated waste to above the thickest portion of the burn layer, installation of a soil cover over the main disposal area (Area 1a) and the Burn Area, tying the cover into the WIB, radiological screening, a sweep for MPPEH, wetlands mitigation, and ICs. The inclusion of Alternative BA-1 would change the selected remedy Alternative S1-4a. The portions of Alternative S1-4a applicable to the Burn Area remedy (Section 5.2.1) would be substituted with Alternative BA-1.

Open Cell Steel Sheet Pile WIB

Alternative BA-1 includes the installation of an Open Cell steel sheet pile WIB along the thickest portions of the burn layer and impacted materials adjacent to the IR Site 1 shoreline. Figure 5-1 shows the alignment of the WIB. Details on the installation of the WIB are provided in Figure 2-8. The WIB would be installed by first installing a robust silt curtain and sediment control system along the shoreline and to the bay floor and then removing concrete-debris revetment within the first portion of the sheet pile alignment to be installed. Once an area is clear for sheet pile installation, the WIB steel sheet piles (face sheets first then tail wall sheets) would be installed. By this progress, the amount of unarmored shoreline would be limited during the installation of the WIB. Completed cells of the WIB would be backfilled with clean general fill material during the installation of the WIB. The final elevation of the WIB would be approximately 10 feet above mean sea level providing a relatively flat land surface extending from the current top of the shoreline slope.

Select Excavation

The southern portion of the burn layer is thin in profile (1 to 3 feet thick) and is presumed to have arrived at its current location by littoral drift via longshore currents moving against the burnt wastes bulldozed into the bay to the north. This relatively thin layer of burn waste is located at the approximate mean sea level elevation. The total volume of burn layer material within this thin southern tail of the Burn Area is approximately 2,000 bank cubic yards (bcy). Excavation of this thin layer and relocation of the burn residues to above the thicker burn layer is more economical than installation of WIB in this portion of the Burn Area. The areal extent of the select excavation is shown in Figure 5-1.

Excavation to the burn layer in this area would consist of removing the upper 5 to 6 feet of overburden to expose the surface of the burn residues. Removed overburden would be relocated to inland portions of Area 1a and reused as foundation layer for the soil cover. Burn residues would then be excavated and relocated above the thicker portions of the burn layer stabilized and contained by the WIB. The resulting excavation would be backfilled with clean imported material.

Soil Cover

The seismically-stable soil cover would be placed over the waste in Area 1a (Figure 2-3) and over the Burn Area extending and tying into the clean backfill within the WIB to prevent exposure to contaminants above remediation goals. This cover would likely extend into other areas of IR Site 1 to accommodate appropriate design requirements, seismic considerations, appropriate setback distances, and ARAR requirements. The Navy would determine the exact location of the cover in the remedial design. The soil cover would be seeded with indigenous plant species as an erosion control measure.

ICs would prohibit residential use of the Burn Area and the remainder of IR Site 1 and actions that could damage or otherwise reduce the effectiveness of the remedies (Section 3.2.3). No fencing or signage would be included.

5.3 Screening of Burn Area Remedial Alternatives

When multiple viable remedial alternatives exist, they may have to be refined and screened to reduce the number of alternatives to be analyzed in detail (U.S. EPA 1988). This screening aids in streamlining the FS process while assuring that the most promising alternatives are being considered.

In accordance with U.S. EPA criteria, information available at the time of screening will be used primarily to identify and distinguish differences among the various alternatives and to evaluate each alternative’s effectiveness, implementability, and cost. Only the alternatives judged to be the best or most promising on the basis of these evaluation factors will be retained for further consideration unless additional information becomes available that indicates further evaluation is warranted (U.S. EPA 1988).

Since only two alternatives are considered in this FFS, both will be considered. Additionally, since the primary alternative for groundwater is no action, based on the results of previous risk assessments and the detailed groundwater/surface water Burn Area risk assessment presented in Section 2.7.2, which revealed that unacceptable risks related to groundwater and surface water do not exist at the Burn Area, groundwater remedial alternatives were not considered in the FFS.

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6.0 DETAILED ANALYSIS OF BURN AREA REMEDIAL ALTERNATIVES

This section provides a description and detailed analysis of each of the remedial alternatives for the Burn Area that have been retained following the initial screening in Section 5.

6.1 Review of CERCLA Criteria

The following nine criteria are stipulated in the NCP at 40 CFR § 300.430(e)(9)(iii) for the evaluation of each of the groundwater and soil remedial alternatives under CERCLA.

Threshold criteria:

1. Overall protection of human health and the environment
2. Compliance with ARARs

Primary balancing criteria:

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying criteria:

8. State acceptance
9. Community acceptance

The NCP divides these criteria into three categories: threshold, primary balancing, and modifying criteria. Criteria 1 and 2 are considered threshold criteria. CERCLA Section 121(d) and the NCP at 40 CFR § 300.430(f)(1)(ii) require that a CERCLA remedial action must protect human health and the environment and comply with ARARs unless justification to waive a specific ARAR is provided in the ROD. In other words, both threshold criteria must be satisfied for a remedial alternative to be eligible for selection unless an ARAR waiver applies.

Criteria 3 through 7 from the list above are considered primary balancing criteria. The remedial alternatives do not have to meet all five balancing criteria, although it is preferred.

The last two criteria from the list above are considered modifying criteria. Evaluation against modifying criteria is the final test in determining whether the state and the community find the alternative acceptable.

The nine NCP criteria are further defined by subcriteria and other factors (U.S. EPA 1988). The following subsections explain the nine NCP criteria and summarize relevant subcriteria and other factors.

6.2 Remedial Alternatives for Burn Area

This subsection provides a description and detailed analysis of retained remedial alternatives for the Burn Area.

The Burn Area is located on fill soil that might be subject to liquefaction and lateral spreading in a seismic event. Potential geotechnical remedies for IR Site 1 have been evaluated in this FFS.

6.2.1 ROD Selected Remedy – Alternative S1-4a: Removal of Waste from Area 1b, Soil Cover for Remainder of Area 1, and ICs

This section provides a description and detailed analysis of the ROD selected remedial alternative, Alternative S1-4a, removal of waste from the Area 1b and a soil cover over the remainder of Area 1 at IR Site 1.

Alternative S1-4a assumes that the 3.7-acre Burn Area within Area 1 would be excavated, and all waste in this area would be removed and disposed offsite. A soil cover would be installed over the remaining area within Area 1 and ICs would be implemented for the soil cover area.

This alternative would be implemented in conjunction with a groundwater alternative that includes the design and implementation of a long-term groundwater monitoring program for all of Area 1.

6.2.1.1 Remedial Design

Design activities for the removal of waste in Area 1b and the soil cover would be performed. These activities would include interpretation of waste delineation results, design of the excavation and backfill including the excavation shoring, establishing final slopes and grades of the backfilled area and soil cover, locating underground utilities, planting vegetation, and wetlands mitigation activities.

6.2.1.2 Excavation of Waste from Area 1b

Following completion of waste delineation activities, soil and debris in Area 1b would be excavated, stockpiled, and characterized. Large debris items such as timber, concrete, or scrap metal would be segregated during excavation and recycled, or disposed of separately. The volume of burn layer and materials exceeding remediation goals requiring excavation in Area 1b is estimated to be 75,000 bcy of material. This estimate is based on 3.7 acres of excavation from above the water table to an average depth of 5.5 feet and an additional 42,000 bcy of burn residue and material exceeding the remediation goals below the burn residue footprint below the water table. Pursuant to the ROD (Chadux Tt 2009), the excavation would be limited to the 3.7-acre Area 1b boundary (Figure 2-3) and would leave behind burn residue to the north and south of this boundary.

Advancement of the excavation to the limits of Area 1b along the shoreline would require the installation of bracing. In lieu of a full coffer dam, an Open Cell steel sheet pile bulkhead would be installed along the Area 1b (IR Site 1) boundary at the shoreline slope at mean sea level. Once installed, material would be excavated and backfilled within each of the sheet pile cells sequentially. Once this process is complete, the remainder of the excavation and backfilling activities behind the bulkhead could be completed. The shoreline slope with revetment will be returned to its angle and condition prior to excavation. The steel sheet pile extending above the restored slope will be cut off at ground surface following the restoration of the shoreline slope. The subsurface steel sheet pile will remain in place.

Assuming that 2 percent of the excavated soil in Area 1b is radiologically-impacted, management and disposal of 1,500 bcy of radiologically-impacted soil would be included in this alternative. Above the water table, after each foot in excavation depth, radiological and MPPEH surveys would be conducted. Any radiological sources would then be segregated and disposed of separately from excavated soil. Approximately 150 intermodal containers and associated truck trips would be required to haul this radiologically-impacted material offsite.

Excavation activities are assumed to extend into groundwater, requiring a program to handle free-draining exhumed materials, above ground scanning and segregation of radiologically-impacted and MPPEH-containing materials, and backfill below the water line without dewatering. Dewatering was not considered a viable process option because of the excessive cost of treatment and disposal associated with radiological materials dissolved and suspended in extracted groundwater. Additionally, because of the soft sediments and depth of the excavation, dewatering of the excavation would result in an unstable excavation floor prone to heave and failure.

For costing purposes, it is assumed that 48 percent of the total excavated material (approximately 36,000 bcy) is nonhazardous debris. This material would be placed under the soil cover within inland portions of IR Site 1 and above the former disposal area (Area 1a). Another 30 percent of the excavated debris (22,500 bcy) is assumed to be classified as California-hazardous waste. The last 20 percent of the excavated debris (15,000 bcy) is assumed to be classified as RCRA characteristic hazardous waste. The RCRA waste is assumed to require stabilization at the disposal facility to meet land-disposal requirements. Approximately 3,700 truck trips would be required to off-haul the 37,500 bcy of materials requiring offsite disposal.

To reduce the chance of excavation wall and floor failure and to facilitate access to deeper central portions of the excavation, excavation progress would require a subdivision approach. This would consist of a section of the total excavation to be excavated and backfilled prior to advancing the dig. Therefore, confirmation sampling would have to occur in segments of excavation so that excavated area could be backfilled with clean, imported fill soil as the next section of excavation progressed. It is assumed that 75,000 bcy of clean fill would be required. An estimated 60 percent of backfilling would be accomplished with clean, washed gravel placed below the water table. Remaining backfill would be performed with clean soil from a local source. After emplacement of the clean fill soil, the entire excavation area would be seeded with a native seed mix as an erosion-control measure.

6.2.1.3 Institutional Controls

ICs would prohibit residential use of IR Site 1 and actions that might damage or otherwise reduce the effectiveness of the soil cover in Area 1. Penetration of the soil cover would not be allowed without concurrence from the lead regulatory agency.

6.2.1.4 Reviews and Reporting

A remedial action closeout report would be prepared following completion of removal activities in Area 1b.

An annual report documenting the results of the post-construction inspection program and any follow-on maintenance activities would be submitted to the regulatory agencies. Five-year reviews would be performed.

6.2.1.5 Evaluation by CERCLA Threshold Criteria

Evaluation of Alternative S1-4a Burn Area remedy components relative to the primary balancing criteria is presented and is discussed below. A cost estimate summary is included in Table 6-1.

Overall Protection of Human Health and the Environment

Under Alternative S1-4a, all buried burn residues and materials that exceed remediation goals in Area 1b would be excavated and disposed on and offsite. The materials disposed of onsite would be placed under the soil cover. Clean backfill and cover soil in Area 1 would be expected to protect future recreational visitors to the site from exposure to underlying contaminated soil. This alternative is therefore considered to be protective of human health and the environment. However, strictly adhering to the selected remedy description in the ROD (Chadux Tt 2009), burn residues and materials exceeding remediation goals extending to the north and south of the 3.7-acre Area 1b boundary would not be excavated.

Compliance with Applicable or Relevant and Appropriate Requirements

ARARs associated with the excavation, soil cover, and ICs would be the same as those provided in Table 13-1, Table 13-2, and Table 13-3 from the ROD (Chadux Tt 2009; copies provided in Appendix E). Alternative S1-4a complies with the ARARs presented in the IR Site 1 Final ROD (Chadux Tt 2009).

Long-term Effectiveness and Permanence

Considering the removal action conducted within the footprint of Area 1b, excavation and disposal of wastes exceeding remediation goals offsite represents a permanent solution. However, as stated above, the burn residues and materials exceeding remediation goals outside Area 1b would remain in place and persist in the environment.

6.2.2 Alternative BA-1: Stabilization and Containment of Burn Waste with Open Cell Steel Sheet Pile Waste Isolation Bulkhead, Select Excavation, Soil Cover, and ICs

This section provides a description and detailed analysis of remedial alternative, Alternative BA-1, Stabilization and Containment of Burn Waste with Open Cell Steel Sheet Pile Waste Isolation Bulkhead, Select Excavation, Soil Cover, and ICs.

Alternative BA-1 assumes that the thickest portions of the burn layer and surrounding material exceeding remediation goals would be contained and stabilized by the construction of an Open Cell steel sheet pile bulkhead or WIB. The southern portion of the burn layer, which is thin and relatively shallow (located at approximately mean sea level), would be excavated and placed over the thicker burn layer contained by the WIB. A soil cover would be installed over all of Area 1 and tie into the WIB. ICs would be implemented for the soil cover area.

Section 12.2.1.5 of the final ROD (Chadux Tt 2009), which describes the selected remedy for site-wide radiologically-impacted soil, stated that at Area 1a, Area 2b, Area 4, and the inland areas of Area 5, the Navy will scan the surface using gamma radiation field screening instruments. Radiological hot spots will be identified and removed to a depth of one foot prior to placing the soil cover. The surface scan will be conducted using field screening instruments. For the purpose of this remedial action, the Navy will identify hot spots as material exhibiting gamma radiation readings approximately 2 times background. Area 1b, the Burn Area, was excluded from the selected remedy description because it was to be excavated. Since Alternative BA-1 contains the burn layer in place and extends the soil cover over the Burn Area, Area 1b will be included in the selected remedy for site-wide radiologically-impacted soil.

6.2.2.1 Remedial Design

Design activities for the construction of the WIB, select excavation, and soil cover would be performed. These activities would include interpretation of waste delineation results, design of the WIB, excavation of the southern portion of the burn layer, establishing final slopes and grades of the backfilled area and soil cover, locating underground utilities, planting vegetation, and wetlands mitigation activities.

Preliminary design-basis seismic analysis of the WIB has been performed in a fashion similar the 2003 Geotechnical FS (FW 2003) and in support of this FFS. The seismic stability and liquefaction analysis results have not changed substantially since the 2002 analysis (FW 2002). The key finding is that some displacement may occur during the MCE and/or liquefaction event. The exact amount of movement is difficult to predict. However, the initial computations indicate the WIB will remain intact and prevent the release of contaminated sediments into the waters of San Francisco Bay. Details of the preliminary seismic analysis are provided in Appendix F.

Preliminary corrosion protection design for the WIB has also been conducted in support of this FFS. Key findings for corrosion protection stemming from the preliminary design are as follows:

1. A coating system of hot dip galvanizing should be considered. This system should be applied to the top 20 feet of all face sheets to protect the steel on both sides. Uncoated, bare steel sheets are not recommended.
2. The buried portion of the wall may be subject to corrosive elements, but the effect in this zone is not anticipated to be large enough to warrant application of protection in this zone. There are no high bending stresses in an Open Cell structure, so the acceptable corrosion near the mudline is higher than would be expected in a tied-back or heavy section z-sheet wall.
3. Aluminum anodes should be added to the submerged portion of the wall to add protection, particularly at the scour zone, after coating distress becomes evident. These anodes will provide protection for the entire submerged portion of the sheets during high tides and at the scour zone during low tides.
4. Annual inspection and maintenance of the corrosion protection system should be done. This would include inspection of the coatings in the atmospheric and splash zones for material loss. Maintenance would include coating repairs, replacement of anodes, and possibly welding of steel patches to retain soil in the event of any local anomalies causing holes in the wall. It is important to note that an Open Cell structure does not need to resist bending forces like a typical bulkhead, with all loads being in hoop tension. As a result, corrosion allowances are much greater and corrosion concerns much less critical than a tie-back or combi-wall bulkhead.
5. With proper maintenance and inspection of the corrosion protection system, a steel structure can have an indefinite design life. A steel bulkhead, with an appropriate coating system, inspection, and maintenance program, can meet or exceed a 100-year design life for the project.

6.2.2.2 Installation of WIB and Select Excavation

Alternative BA-1 includes the installation of an Open Cell steel sheet pile WIB along the thickest portions of the burn layer and impacted materials adjacent to the IR Site 1 shoreline and select excavation of the thinner burn layer deposits in the southern portion of the Burn Area. Figure 5-1 shows the alignment of the WIB and select excavation area. Details on the installation of the WIB are provided in Figure 2-8. The WIB would be installed by first installing a robust silt curtain and sediment control system along the shoreline and to the bay floor and then removing concrete-debris revetment within the first portion of the sheet pile alignment to be installed. Once an area is clear for sheet pile installation, the WIB steel sheet piles (face sheets first then tail wall sheets) would be installed. By this progress the amount of unarmored shoreline would be limited during the installation of the WIB. Completed cells of the WIB would be backfilled with clean general fill material during the installation of the WIB. The final elevation of the WIB would be approximately 10 feet above MSL providing a relatively flat land surface extending from the current top of the shoreline slope. Select excavation of the thinner burn layer, presumed to be deposited by littoral drift, and relocation of this burn residue above the thicker burn layer, is more economical than installation of WIB in this portion of the Burn Area. The areal extent of the select excavation is shown in Figure 5-1.

6.2.2.3 Soil Cover over Burn Area

The soil cover would be placed over the waste in Area 1a (Figure 2-3) and over the Burn Area extending and tying into the clean backfill within the WIB to prevent exposure to contaminants above remediation goals. This cover would likely extend into other areas of IR Site 1 to accommodate appropriate design requirements, seismic considerations, appropriate setback distances, and ARAR requirements. The Navy would determine the exact location of the cover in the remedial design. The soil cover would be seeded with indigenous plant species as an erosion-control measure.

Since the soil cover would be extended over the Burn Area, the soil-cover foundation surface would be scanned using gamma radiation field screening instruments. Radiological hot spots would be identified and removed to a depth of one foot prior to placing the soil cover. The surface scan would be conducted using field screening instruments and hot spots would be identified as material exhibiting gamma radiation readings approximately 2 times background.

6.2.2.4 Institutional Controls

ICs would prohibit residential use of the Burn Area and the remainder of IR Site 1 and actions that could damage or otherwise reduce the effectiveness of the remedies. No fencing or signage would be included.

6.2.2.5 Reviews and Reporting

A remedial action closeout report would be prepared following completion of the soil remedies at IR Site 1 inclusive of Alternative BA-1.

An annual report documenting the results of the post-construction inspection program and any follow-on maintenance activities would be submitted to the regulatory agencies. Five-year reviews would be performed.

6.2.2.6 Evaluation by CERCLA Threshold Criteria

This section provides a discussion of Alternative BA-1 relative to the threshold criteria. Evaluation of Alternative BA-1 remedy components relative to the primary balancing criteria is discussed below. A cost estimate summary is included in Table 6-2.

Overall Protection of Human Health and the Environment

Under Alternative BA-1, the thickest portion of the burn residues and materials containing soil remediation goal exceedances would be contained and stabilized against slope failure under design-level earthquake forces. A select portion of buried burn residues would be excavated and disposed onsite, behind the WIB. The materials disposed of onsite would be placed above the thickest burn residues, behind the WIB, and under the soil cover. The WIB, clean backfill, and cover soil would be expected to protect future recreational visitors and ecological receptors from exposure to underlying contaminated soil. This alternative is therefore considered to be protective of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements

ARARs associated with the excavation, soil cover, and ICs would be the same as those provided in Table 13-1, Table 13-2, and Table 13-3 from the ROD (Chadux Tt 2009; copies provided in Appendix E). A portion of the ARARs applicable to the soil cover will also be applied to the WIB. The soil cover action-specific ARAR, which includes the substantive provisions of CCR title 22 § 66.264.310(a)(5) which requires that the cover maintain integrity during and following the maximum credible earthquake will apply to the design and performance of the WIB. Alternative BA-1 complies with the ARARs presented in the IR Site 1 Final ROD (Chadux Tt 2009).

6.3 Comparative Analysis of Remedial Alternatives

This section presents a comparative analysis of the soil remedial alternatives for the Burn Area, analyzed in Section 6.2.

6.3.1 Overall Protection of Human Health and the Environment

Alternatives S1-4a and BA-1 would meet the threshold criterion for overall protection of human health and the environment. The restriction of limiting the excavation in Alternative S1-4a to the boundary of Area 1b would leave burn residue in place at IR Site 1. However, the soil cover remedy associated with the main disposal area and the ARAR to maintain cover integrity under seismic loading (CCR title 22 subsection 66.264.310(a)(5)) would contain the remaining burn residues.

6.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternatives S1-4a and BA-1 meet the threshold criteria of compliance with ARARs. The soil cover action-specific ARAR, which includes the substantive provisions of CCR title 22 subsection 66.264.310(a)(5) which requires that the cover maintain integrity during and following the maximum credible earthquake will apply to the design and performance of the WIB.

6.3.3 Long-Term Effectiveness and Permanence

The Burn Area remedy portion of Alternative S1-4a rates high in long-term effectiveness and permanence considering the area within the Area 1b boundary. The burn residue remaining outside the limits of Area 1b would be contained by the soil cover and would rate medium in long-term effectiveness and permanence.

Alternative BA-1 rates medium high in long-term effectiveness and permanence. Each of these alternatives requires ICs and long-term management of contaminants; however, Alternative S1-4a has fewer components that would require replacement and fewer continuing repair and maintenance needs than BA-1.

A ranking of medium high for the long-term effectiveness and permanence of Alternative BA-1 was selected considering the ranking of medium assessed in the Final FS Report (BEI 2006a) to this alternative without the explicit addition of the WIB, and the adequacy and reliability of the WIB for the containment of the residual wastes. The WIB has a certain lifespan and will require periodic inspection, and potentially maintenance and replacement. However, compared with other geotechnical remedies for stabilization of the shoreline slope, inspection and maintenance for general wearing of the WIB is easily performed with readily available resources (steel sheet pile bulkheads are located very nearby the site) and at the prescribed review periods for other IR Site 1 remedies (e.g. soil cover). In the event that the WIB is damaged during seismic loading (earthquake event), the damages will be readily observable compared to geotechnical remedies located in the inland subsurface portions of the site. Furthermore, the WIB can be placed at the furthest extent of the site and wastes opposed to inland geotechnical remedies that would leave portions of the shoreline slope unprotected.

6.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S1-4a rated low in reduction of toxicity, mobility, or volume through treatment. Some of the excavated waste would likely be treated offsite, which would necessitate time-consuming onsite staging and segregation of the wastes and conservative engineering controls. However, the majority of waste would not receive treatment and would be disposed of as-is either onsite or offsite. Nonhazardous wastes would not be treated and would be disposed of onsite under the soil cover and over inland portions of the former disposal area (Area 1a).

Alternative BA-1 rated low in reduction of toxicity, mobility, or volume through treatment, since the large majority of the Burn Area waste would be contained. A small fraction of radiologically-impacted material segregated from the select excavation would be disposed offsite.

6.3.5 Short-Term Effectiveness

Alternative BA-1 rated high in short-term effectiveness because installation of the WIB and select excavation are relatively quick to implement compared with mass excavation and the associated *ex-situ* treatment and/or waste segregation.

Burn Area aspects of Alternative S1-4a rated medium in short-term effectiveness because the excavation of Area 1b requires the installation of a bulkhead similar to the WIB for shoring and the quantity of material to be removed would result in a significant number of truck trips through the community. Worker safety is of concern due to the unknown contents of the buried waste; and Alternative S1-4a could take a significant amount of time to implement.

6.3.6 Implementability

Burn Area aspects of Alternative S1-4a rated low in implementability. The source removal component would involve large-scale excavation and shoring and segregation of exhumed waste streams.

Alternative BA-1 rated medium in implementability. The installation of the WIB would require specialized labor and equipment. The select excavation would rate high in implementability; however, select excavation accounts for a smaller portion of the Burn Area.

6.3.7 Cost

The Burn Area aspects of Alternatives S1-4a rated low in the cost comparison, as the remedy includes most of the costs associated with Alternative BA-1 plus mass excavation and waste stream segregation. A cost estimate summary for the Burn Area aspects of Alternative S1-4a is included in Table 6-1.

Alternative BA-1 rated medium in the cost comparison. A cost estimate summary for Alternative BA-1 is included in Table 6-2. Cost backup for the summaries provided in Table 6-1 and Table 6-2 is provided in Appendix G.

6.3.8 State Acceptance

Alternative S1-4a is the selected remedy presented in the Final ROD (Chadux Tt 2009). Therefore Alternative S1-4a has State acceptance.

Agency comments on this revised draft FFS Report will be addressed and included in the final FFS Report (Appendix H).

6.3.9 Community Acceptance

Alternative S1-4a is the selected remedy presented in the Final ROD (Chadux Tt 2009). Therefore Alternative S1-4a has community acceptance.

Comments received from the community on the draft FFS Report will be addressed and included in the Final FFS Report (Appendix H).

6.3.10 Comparative Analysis of Remedial Alternatives for the Burn Area

Alternative BA-1 rated highest overall in satisfying the balancing criteria. Alternative BA-1 was judged to be the most effective in the short-term effectiveness, most implementable, and less costly, compared with the selected remedy, Alternative S1-4a. Burn Area aspects of Alternative S1-4a rated slightly higher than Alternative BA-1 in long-term effectiveness and permanence (high versus medium high). Each alternative rated low in reduction of toxicity, mobility, or volume through treatment.