Section 11. Identification and Screening of Technologies and Process Options

This section identifies GRAs and evaluates available technologies and process options to address the RAOs for Parcel E-2 discussed in Section 9. The section is organized as follows:

- Section 11.1 presents the selected GRAs for each medium at Parcel E-2, which includes the Landfill Area, Panhandle Area, East Adjacent Area, and Shoreline Area (Figure 1-2).
- Section 11.2 identifies the criteria used to evaluate specific technologies and process options for each GRA.
- Sections 11.3 through 11.6 present the detailed evaluations of each GRA with respect to media at Parcel E-2.
- Section 11.7 summarizes the evaluations.

Some of the GRAs being evaluated in this FS for remediation of wastes have the potential to affect freshwater and tidal wetlands in the Panhandle and Shoreline Areas, south and west of the landfill. Depending on the nature of the remedial alternative selected, wetlands mitigation may be required. Section 11.8 summarizes the available wetland mitigation alternatives discussed in Appendix O.

The GRAs, associated remedial technologies, and process options have been screened to determine which ones most appropriately meet the RAOs. GRAs considered for Parcel E-2 are institutional actions (including monitoring and institutional controls), containment, and removal. These GRAs have been evaluated individually and in combination with others. Within each GRA, remedial technologies, such as containment through capping, are identified to address the media, characteristics, and objectives specific to Parcel E-2. Within each remedial technology, process options are identified. For example, the capping remedial technology includes various process options such as a monolithic soil cover, a multilayer soil cover, or a multilayer soil and geotextile cover.

This RI/FS Report focuses the process option analysis, consistent with the presumptive remedy approach for CERCLA municipal landfills, to a limited set of GRAs and remedial technologies. In addition, the heterogeneous distribution of chemicals in the adjacent areas (the Panhandle Area, East Adjacent Area, and Shoreline Area) limits the types of response actions that are potentially applicable and requires that these response actions be applied throughout Parcel E-2.

The following EPA guidance documents were used in developing the focused approach for this FS:

- "Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites" (EPA, 1991a)
- "Presumptive Remedy for CERCLA Municipal Landfill Sites" (provided in Appendix H to this RI/FS Report)
- Presumptive Remedy: Policy and Procedures (provided in Appendix H to this RI/FS Report)
- Feasibility Study Analysis for CERCLA Municipal Landfill Sites (provided in Appendix H to this RI/FS Report)
- Application of the CERCLA Municipal Presumptive Remedy to Military Landfills (provided in Appendix H to this RI/FS Report)

Also, information from the NCP, 40 CFR § 300.430 (a)(1)(iii)(B), was considered. The NCP states that containment technologies are likely to be appropriate for sites with relatively low-level threats or where treatment is impractical. Containment has been identified in the above listed guidance documents as the most likely response action at municipal and military landfill sites. The following are summaries of the conclusions reached by EPA in some of the guidance documents cited above:

In EPA's guidance document "Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites" (EPA, 1991a), 92 landfill sites were evaluated. EPA found that capping was selected as the primary remedy for soil/landfill contents at 68 sites (74 percent of all sites). EPA also found that additional remedies were implemented at these sites. For soil/hot spots, excavation was selected for 30 sites; onsite disposal was selected for 5 sites; off-site disposal for 13 sites; thermal treatment for 8 sites; and physical treatment for 12 sites. Thus, hot spot excavation and disposal or treatment was a component of remedial actions at a large number of sites. In addition, for groundwater and leachate, groundwater collection and extraction was selected at 43 sites; leachate collection and extraction was selected at 27 sites; and physical treatment was selected at 29 sites. Thus, collection, extraction, and treatment were frequent components of remedial actions targeted for groundwater and leachate. Furthermore, "no action" was selected for only 6 sites.

In the "Presumptive Remedy for CERCLA Municipal Landfill Sites" and the Feasibility Study Analysis for CERCLA Municipal Landfill Sites (provided in Appendix H to this RI/FS Report), analyses of FSs were performed for 30 municipal landfill sites selected at random from the 149 sites (on the NPL list) for which a remedy was selected for at least one operable unit (approximately 20 percent of the sites). Containment (the presumptive remedy) was chosen as the primary component of the selected remedy at all thirty of the sites analyzed. No other technologies or treatments were consistently selected as a remedy or retained for consideration in a remedial alternative. Remedial technologies associated with collection, treatment, and discharge were routinely screened out, primarily because of their difficult implementation and high cost. The remedial technologies that were routinely screened out included excavation and disposal, bioremediation, chemical destruction, thermal treatment, chemical and physical extraction, thermal desorption, and immobilization (EPA, 1994).

In the Application of the CERCLA Municipal Presumptive Remedy to Military Landfills (provided in Appendix H to this RI/FS Report), EPA examined 31 RODs that document the remedial decisions for 51 landfills at military installations (EPA, 1996). Of the 51 landfills, only 41 required remedial action. Of the 41 landfills, containment was the remedy at 23 landfills (56 percent of the sites). At the 18 landfills where other remedies were selected, institutional controls were implemented at 3 sites, excavation and on-site consolidation was selected for 4 sites, and excavation and off-site disposal was selected for 11 sites. The military also reports that, of the 41 landfill sites evaluated, 27 were greater than 1 acre in size and of those 27 sites, containment was recommended for 23 sites (85 percent). This information suggests that the size of the landfill is an important factor in determining whether containment is implemented.

As presented in Section 8.8, the Parcel E-2 Landfill meets all of the criteria specified in EPA guidance (EPA, 1996) for application of the containment presumptive remedy. However, the Navy has agreed to evaluate excavation of the landfill as part of this report to provide information to support the community's review of potential remedial alternatives for Parcel E-2. Therefore, the remedial technologies and process options identified and screened in this section are limited to those related to the containment and removal GRAs.

Evaluation of the containment GRA also includes addressing groundwater in Parcel E-2 and leachate emanating from the Parcel E-2 Landfill. This evaluation is provided for completeness, despite the uncertainty of the risk to humans and wildlife from exposure to groundwater, and as a formal evaluation of the current GES in the southeast portion of Parcel E-2 (that was installed as part of an interim action).

11.1. APPLICABLE GENERAL RESPONSE ACTIONS

This subsection describes the GRAs to be evaluated for achieving the Parcel E-2 RAOs (Section 9). The RAOs were established to address potential exposure pathways that could affect human health and the environment from affected media at Parcel E-2. The GRAs presented on the following page have been selected for Parcel E-2 media.

As shown in the table on the following page, all affected media are evaluated for both the institutional action and containment action GRAs, except for surface water. As discussed in Section 6.2.5, surface water runoff (including runoff from freshwater wetlands located in the Panhandle Area) can be contaminated through surface erosion and could result in unacceptable exposures to aquatic life in the San Francisco Bay. However, this potential exposure can be effectively controlled by management (through implementation of BMPs), and monitoring of surface water runoff should be evaluated as part of any remedial alternative that leaves contaminated soil in place. Therefore, only institutional actions are evaluated for potentially affected surface water at Parcel E-2.

GRA	General Description	Applicable Media
No Action	No-action GRA is required by the NCP; used as a baseline for comparison	Solid waste, soil, sediment, landfill gas, groundwater, and surface water
Institutional Actions	Includes institutional controls, engineering controls, and site monitoring	Solid waste, soil, sediment, landfill gas, groundwater, and surface water
Containment Actions (with or without collection, treatment, and/or disposal)	Includes technologies that isolate media to reduce or eliminate exposure to, and off-site migration of surface and subsurface contaminants	Solid waste, soil, sediment, landfill gas, and groundwater
Removal Actions	Includes removal of contaminated media for treatment and/or disposal on or off site; exposure risk and migration potential are diminished by eliminating or reducing the contaminant source	Solid waste, soil, and sediment

The following subsections describe the GRAs appropriate for addressing contaminated media at Parcel E-2 in more detail.

11.1.1. No Action

Consideration of the no action GRA is required by the NCP and is used as a baseline against which other remedial actions are compared.

11.1.2. Institutional Actions

Actions that can be taken to limit exposure to hazardous chemicals in media at Parcel E-2 include both institutional and engineering controls. In addition, site monitoring can be used to track the effectiveness of the remedy alternative or to verify that hazardous chemicals in media at the site do not migrate and affect human or ecological receptors.

Institutional controls, as defined by the U.S. Department of Defense (DoD) (2001), are nonengineering measures limiting potential exposures to a site or medium of concern or ensuring that engineering measures designed to remediate a site, or limit access to a site, remain in place. Similarly, EPA defines institutional controls as "non-engineering measures designed to prevent or limit exposure to hazardous substances left in place at a site, or assure effectiveness of a selected remedy" (EPA, 2000c).

Engineering controls are implemented technologies that serve to reduce exposure to chemicals in media. Examples of engineering controls include fencing and other physical barriers, which can be effective in limiting access to contaminated media.

Under CERCLA, site monitoring is a required component for any site remedy. Short-term monitoring is conducted to ensure that potential risks to human health and the environment are controlled while a site remedy is being implemented. Long-term monitoring can be used to track site chemicals after an active remedial technology has been used or to ensure that hazardous chemicals are not migrating off site at concentrations that might affect humans or the environment.

11.1.3. Containment Actions (With or Without Collection, Treatment, and Disposal)

Containment actions include technologies that isolate contaminated media from humans and wildlife. For contaminated solid waste, soil, and sediment, containment technologies are meant to minimize disturbance to the surfaces of those media and to reduce or eliminate off-site migration of surface and subsurface chemicals. These actions are effective at preventing direct contact with these media, as well as their migration by surface water, air (wind erosion), subsurface air (landfill gas), or groundwater.

Containment technologies for unlined landfill waste and soil typically include surface controls, such as runoff controls, erosion controls, and capping. Process options include the various types of caps, shoreline protection options, and drainage enhancements.

Containment of landfill gas is typically achieved by collection and treatment of landfill gas through a gas control system, which can minimize or prevent off-site subsurface migration and accumulation of the gas above explosive concentrations. Process options include passive gas venting and active gas collection.

Containment actions for groundwater refer to actions that isolate the chemical source or affected groundwater from downgradient areas to prevent further migration of chemicals. Technologies typically used for groundwater containment include physical barriers (such as sheet pile or slurry walls), hydraulic barriers (groundwater flow diversion structures or such as extraction wells), and reactive walls (such as permeable reactive barriers [PRB]). Depending on the chemical concentrations present, groundwater collected with hydraulic barriers can be disposed of off site, discharged to the surface, discharged to a publicly owned treatment facility for additional treatment, or reinjected into the ground after treatment. Numerous technologies are used for water treatment, most of which are chemical- and site-specific.

11.1.4. Removal Actions

Removal actions refer to removing contaminated media from a site to significantly reduce or eliminate the risk of exposure to humans and wildlife. Removal actions for contaminated solid waste, soil, and sediment would require excavation and disposal at an off-site facility approved to receive the waste, or consolidation with the existing on-site waste.

11.2. EVALUATION CRITERIA FOR TECHNOLOGIES AND PROCESS OPTIONS

Technologies and associated process options selected for this evaluation were screened using the following three criteria:

- Effectiveness: Effectiveness is a judgment regarding the potential for the technology and process options to address the area and volume of contaminated media adequately and reliably. It also identifies any effects to human health and the environment caused by implementation of the technology.
- Implementability: Implementability is an evaluation of the technical appropriateness and the administrative implementability of the technology for the contaminated media.
- Cost: Cost is an approximation of the dollar value of the project; it is neither a bid cost nor an engineer's estimate and, in some cases, is a relative cost (high, medium, or low) rather than a quantified value.

Two issues in evaluating effectiveness and implementability of all of the technologies and process options are future land use and local climate. According to the 2010 amended Redevelopment Plan, most of the planned reuse for Parcel E-2 is open space. A small area (about 0.42 acres) in the East Adjacent Area is designated as part of the Shipyard South Multi-Use District, which includes potential recreational, industrial, and residential reuse (SFRA, 2010).

The following subsections describe remedial technologies and process options under each GRA that are appropriate for addressing solid waste, soil, sediment, landfill gas, groundwater, and surface water at Parcel E-2. The GRAs evaluated are no action (Section 11.3), institutional actions (Section 11.4), containment (with or without collection, treatment, and disposal) (Section 11.5), and removal (Section 11.6). Each process option within the GRA is discussed for each media if applicable. The evaluation of the remedial technologies and process options is presented on Figure 11-1.

11.3. NO ACTION

As discussed above, the NCP requires evaluation of the no action response for all media to provide a baseline for comparison with other response actions. Under this GRA, no additional action would be taken to address:

- Contaminated solid waste and soil in the Landfill Area and isolated solid waste, soil, and sediment in the Panhandle Area, East Adjacent Area, and Shoreline Area (as described in Section 2, a portion of the Landfill Area has been capped with an engineered multilayer cap, and the remainder has been covered with an approximately 2-foot-thick layer of soil)

- Landfill gas
- Groundwater
- Surface water

Under this GRA, engineered systems currently in place (landfill cap and cover, gas control system, and groundwater extraction system) would remain in place, but would not be maintained. In addition, no landfill gas, groundwater, or surface water monitoring would be performed under the no action GRA.

No Action General Screening

- Effectiveness: Low
- Implementability: High
- Cost: No cost
- Retained for Further Analysis: Yes (to provide a baseline for comparison with other response actions for each of the contaminated media at Parcel E-2)

11.4. INSTITUTIONAL ACTIONS

The following subsections address the remedial technologies and process options under the institutional action GRA applicable to contaminated media at Parcel E-2. The three remedial technologies are (1) institutional controls (Section 11.4.1); (2) engineering controls (Section 11.4.2); and (3) site monitoring (Section 11.4.3). The evaluation of the remedial technologies and process options under the institutional action GRA is presented on Figure 11-1.

11.4.1. Institutional Controls

Institutional controls limit potential exposure to hazardous substances by restricting specified land uses and activities on the parcel. This subsection discusses institutional controls that are included in the potential remedial alternatives for Parcel E-2, including institutional controls related to potential radionuclides.

11.4.1.1. Institutional Controls in General

Institutional controls are legal and administrative mechanisms used to implement land use restrictions that are used to limit the exposure of future landowner(s) and user(s) of the property to hazardous substances present on the property and to ensure the integrity of the remedial action. Institutional controls are required on a property where the selected remedial cleanup levels result in contamination remaining at the property above levels that allow for unlimited use and unrestricted exposure. Institutional controls will be maintained until the concentrations of hazardous substances in soil and groundwater are at such levels to allow for unrestricted use and exposure. Implementation of institutional controls includes requirements for monitoring and inspections and reporting to ensure compliance with land use or activity restrictions.

Legal mechanisms include proprietary controls such as restrictive covenants, negative easements, equitable servitudes, and deed notices. Administrative mechanisms include notices, adopted local land use plans and ordinances, construction permitting, or other existing land use management systems that are intended to ensure compliance with land use or activity restrictions. The area requiring institutional controls (ARIC) for CERCLA-regulated hazardous substances, including radionuclides, is presented on Figure 11-2.

Legal Framework

The Navy has determined that 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 "Navy/DTSC MOA"). Appendix N contains the Navy/DTSC MOA.

More specifically, land use and activity restrictions will be incorporated into two separate legal instruments 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 22 CCR § 67391.1.

The "Covenant(s) to Restrict Use of Property" will incorporate the land use and activity restrictions into environmental restrictive covenants that run with the land and that are enforceable by DTSC and any other signatory state entity against future transferees and users. 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.

The activity restrictions in the "Covenant(s) to Restrict Use of Property" and Deed(s) shall be implemented through the Parcel E-2 Risk Management Plan (RMP) to be prepared by the CCSF and approved by the Navy and FFA signatories and/or the Land Use Control remedial design (LUC RD) report that would be reviewed and approved by the FFA signatories. The Parcel E-2 RMP and/or LUC RD report shall be referenced in the applicable Covenant to Restrict Use of Property and Deed. The RMP and/or LUC RD report shall specify soil and groundwater management procedures for compliance with the remedy selected in the Parcel E-2 ROD. The Parcel E-2 RMP and/or LUC RD report shall identify the roles of local, state, and federal government in administering the Parcel E-2 RMP and/or LUC RD report and shall include, but not be limited to, procedures for any necessary sampling and analysis requirements, worker health and safety requirements, and any necessary site-specific construction and/or use approvals that may be required. The Parcel E-2 RMP, which will be approved by the FFA signatories and the California Department of Public Health (CDPH), may set forth certain requirements and protocols that, if followed, will allow certain activities that are otherwise restricted to be performed without additional approval by the FFA signatories and CDPH.

In addition to being set forth in the "Covenant(s) to Restrict Use of Property" and Quitclaim Deed(s) as described above, restrictions applied to specified portions of the property will be described in findings of suitability for transfer and findings of suitability for early transfer. The Navy will also seek to access the portion of the Landfill Area extending onto UCSF property to perform the remedial action pursuant to easements, or another appropriate legal mechanism, entered into with UCSF. For remedial alternatives that leave waste in place, the Navy may also seek to control use, through easements or another appropriate legal mechanism, of the portion of the Landfill Area extending onto UCSF property (as identified on Figure 1-2) to ensure that its future use is compatible with the containment units. Specific requirements for accessing or potentially controlling use of the portion of the Landfill Area extending onto UCSF property will be specified in the LUC RD report.

Access

The Deed and Covenant shall provide that the Navy and FFA signatories, where applicable, and for CDPH in the radiological ARIC (Figure 11-2), and their authorized agents, employees, contractors, and subcontractors shall have the right to enter upon HPS Parcel E-2 to conduct investigations, tests, or surveys; inspect field activities; or construct, operate, and maintain any response or remedial action as required or necessary under the cleanup program, including but not limited to monitoring wells, pumping wells, treatment facilities, and cap containment systems.

Implementation

The Navy will address and describe implementation of institutional controls and maintenance actions, including periodic inspections, and reporting requirements in the preliminary and final RD reports to be developed and submitted to the FFA signatories and CDPH in regard to radionuclides for review and approval pursuant to the FFA (see "Navy Principles and Procedures for Specifying, Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions" attached to January 16, 2004 Department of Defense memorandum titled "Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Record of Decision (ROD) and Post-ROD Policy" [DoD, 2004]). The preliminary and final RD reports are primary documents as provided in Section 7.3 of the FFA.

Although the Navy may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the Navy shall retain ultimate responsibility for remedy integrity.

11.4.1.2. Land Use and Activity Restrictions that Apply Throughout Parcel E-2

The following paragraphs describe the institutional control objectives to be achieved through land use and activity restrictions throughout Parcel E-2 to ensure that any necessary measures to protect human health and the environment and the integrity of the remedy have been undertaken.

Restricted Land Uses

The SFRA has designated most of HPS Parcel E-2 for open space reuse (SFRA, 2010). A small area (about 0.42 acres) in the East Adjacent Area is designated as part of the Shipyard South Multi-Use District, which includes potential recreational, industrial, and residential reuse (SFRA, 2010). Parcel E-2 shall be restricted to open space and recreational uses, unless written approval for other uses is granted by the FFA signatories (and the CDPH within the radiological ARIC). In addition, the following land uses are specifically prohibited in all Parcel E-2 areas, unless written approval for such uses is granted by the FFA signatories and CDPH (e.g., in the small area designated as Shipyard South Multi-Use District), in accordance with the Covenant(s) to Restrict Use of the Property, Quitclaim Deed(s), LUC RD report, and Parcel E-2 RMP, if applicable:

- A residence, including any mobile home or factory built housing, constructed or installed for use as residential human habitation.
- A hospital for humans.
- A school for persons under 21 years of age.
- A daycare facility for children.
- Any permanently occupied human habitation, including those used for commercial or industrial purposes.

Restricted Activities

The following restricted activities throughout HPS Parcel E-2 must be conducted in accordance with the Covenant(s) to Restrict Use of Property, Quitclaim Deed(s), the Operation and Maintenance Plan(s) (OMP), LUC RD report, and the Parcel E-2 RMP and, if required, any other work plan or document approved in accordance with the referenced documents:

- "Land disturbing activity," which includes but is not limited to (1) excavation of soil; (2) construction of roads, utilities, facilities, structures, and appurtenances of any kind; (3) demolition or removal of "hardscape" (for example, concrete roadways, parking lots, foundations, and sidewalks); (4) any other activity that involves movement of soil to the surface from below the surface of the land; and (5) any other activity that causes or facilitates the movement of groundwater known to be contaminated with radioactive or nonradioactive chemicals.

- Alteration, disturbance, or removal of any component of a response or cleanup action (including but not limited to pump-and-treat facilities, revetment walls and shoreline protection, and soil cap containment systems); groundwater extraction, injection, and monitoring wells and associated piping and equipment; or associated utilities.
- Extraction of groundwater and installation of new groundwater wells.
- Removal of or damage to security features (for example, locks on monitoring wells, survey monuments, fencing, signs, or monitoring equipment and associated pipelines and appurtenances).

Prohibited Activities

The following activities are prohibited throughout HPS Parcel E-2:

- Growing vegetables or fruits in native soil for human consumption.
- Use of groundwater.

11.4.1.3. Additional Activity Restrictions Related to Radionuclides at Parcel E-2

Exposure to radioactive chemicals in the radiological ARIC would be prevented by three separate components: (1) an engineered cover, consisting of clean imported fill and (in most areas) a low hydraulic conductivity layer, to provide adequate shielding against residual radioactivity; (2) permeable geosynthetic fabric to serve as a "demarcation layer" between soil cover and underlying soil with residual radioactivity; and (3) institutional controls to implement land use and activity restrictions necessary to limit the exposure to radiological hazardous substances and to ensure the integrity of the remedial action.

In addition to the land use and activity restrictions specified in Section 11.4.1.2, the following activity restriction would apply in the radiological ARIC.

- Land-disturbing activities within the radiological ARIC, as defined above and including installation of water lines, storm drains, or sanitary sewers, below the demarcation layer, are strictly prohibited unless approved in writing by the FFA signatories and the CDPH. Any proposed land-disturbing activity within the ARIC for radionuclides shall be required to be described in a work plan that will include but not be limited to a radiological work plan, the identification of a radiological safety specialist, a soil management plan, soil sampling and analysis requirements, and a plan for off-site disposal of any excavated radionuclides by the transferee in accordance with federal and state law. This work plan must also specify appropriate procedures for the proper identification and handling of MPPEH. This work plan must be submitted to and approved in writing by the FFA signatories and CDPH in accordance with procedures (including dispute resolution procedures) and timeframes that will be set forth in the Parcel E-2 OMP, LUC RD report, or Parcel E-2 RMP, if applicable.

- Following implementation of an approved land-disturbing activity within the radiological ARIC, the integrity of the cover/cap must be restored upon completion of excavation as provided in the Parcel E-2 OMP, LUC RD report, or similar document. A completion report describing the details of the implementation of the work plan, sampling and analysis (if required), off-site disposal (if required), 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 (including dispute resolution procedures) and timeframes that will be set forth in the Parcel E-2 OMP, LUC RD report, or Parcel E-2 RMP, if applicable.
- For land-disturbing activities, as defined above and including installation of water lines, storm drains, or sanitary sewers, above the demarcation layer, the LUC RD report, the OMP, Parcel E-2 RMP, or a project-specific work plan, if applicable, will list the procedures for ensuring that the cover is not disturbed or breeched. The specific design of the cover shall be agreed to in the RD.

At the time of transfer, the areas that require this restriction will be surveyed to define the legal metes and bounds for inclusion in the property transfer documents. No variance or exemption from this restriction shall be allowed unless written approval is provided by the FFA signatories and CDPH in a design and/or work plan, or preapproved in the Parcel E-2 OMP, LUC RD report, and/or the Parcel E-2 RMP, if applicable. The OMP for Parcel E-2 or LUC RD report shall address any necessary additional soil and radiological management requirements; for example, inspections, monitoring, and reporting requirements for portions of Parcel E-2 in the radiological ARIC.

11.4.1.4. Additional Activity Restrictions Related to Subsurface Gas at Parcel E-2

Any proposed construction of enclosed structures must be approved in accordance with the Covenant to Restrict Use of the Property, Quitclaim Deed(s), LUC RD report, and Parcel E-2 RMP prior to conducting such activities within the ARIC (Figure 11-2) to ensure compliance with the substantive provisions of 27 CCR §§ 21190(a), (b), (d), (e), (f) and (g), which require that postclosure land uses be designed and maintained to protect health and safety in areas affected by landfill gas migration. In particular, 27 CCR § 21190(g) specifies design and construction standards for “all on site construction within 1,000 feet of the boundary of any disposal area.” The Navy has determined that the substantive provisions of 27 CCR § 21190(g) are relevant and appropriate for future construction within the Parcel E-2 boundary, including the portion of the Landfill Area that extends onto UCSF property, because Parcel E-2 may be affected by subsurface gas emanating from the Landfill Area. However, these provisions are not relevant and appropriate to future off site construction beyond the Parcel E-2 boundary because these areas are not affected by subsurface gas emanating from the Landfill Area. The interim gas control system and ongoing monitoring program are effectively controlling the migration of hazardous levels of landfill gas beyond the Parcel E-2 boundary. The permanent gas control system contemplated in this report (see Section 11.5.3) would continue to control the migration of hazardous levels of landfill gas beyond the Parcel E-2 boundary.

Human health can be protected through engineered containment systems, such as landfill caps and gas control systems, or other design alternatives that meet the specifications set forth in the ROD, RD reports, LUC RD report, and Parcel E-2 RMP. The ARIC, which will initially include all of HPS Parcel E-2, may be modified by the FFA signatories as soil contamination areas and groundwater contaminant plumes that are producing unacceptable risks to human health are reduced over time; or in response to further soil, vapor, and groundwater sampling and analysis that establishes that areas now included in the ARIC do not pose an unacceptable risk to human health.

11.4.1.5. Overall Evaluation

An evaluation of institutional controls based on effectiveness, implementability, and cost is briefly summarized below.

Effectiveness

Under existing conditions, institutional controls alone would not be effective at controlling risk to humans and wildlife at the site. However institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.

Implementability

Institutional controls would be readily implementable. The Navy, as the current owner of the property, would establish covenants with the DTSC and easements with the UCSF and would include restrictions in the property deed to enforce land use restrictions, as necessary, to control exposure and to ensure the integrity of any final remedy at Parcel E-2. Various policies and procedures would be established to implement the land use restrictions and would require ongoing administration and enforcement to ensure their effectiveness.

Cost

The cost of implementing institutional controls would be low, but would be incurred over a relatively long time period. This time period is assumed for estimating purposes as 30 years to be consistent with the minimum period for postclosure maintenance, as specified in 27 CCR. Institutional controls will be maintained until it is demonstrated the landfill no longer poses a threat to the environment and human health, and when regulatory agency approval has been obtained. Costs would include regular administration and enforcement tasks associated with implementing the soil and groundwater management plan.

Institutional Controls General Screening

- Effectiveness: High (if used to maintain the integrity of a final remedy)
- Implementability: High
- Cost: Low

- Retained for Further Analysis: Yes

11.4.2. Engineering Controls

Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options for engineering controls include warning and no trespassing signs, engineered barriers to vehicular traffic, and perimeter fencing to reduce the potential for direct human contact with contaminated media. Engineering controls may also include BMPs; however, BMPs may be implemented as part of a short- or long-term monitoring program, thus they are discussed under site monitoring (Section 11.4.3). Engineered containment systems, such as landfill caps and gas control systems, are discussed under the containment GRA (Section 11.5) and for the purposes of this report are not considered under the institutional action GRA. An evaluation of engineering controls based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Under existing conditions, engineering controls could assist in meeting the specified RAOs; however, long-term access restrictions would conflict with the planned open space reuse for Parcel E-2. The short-term use of fencing, warning signs, and other access restrictions would be effective during implementation of a remedial alternative (e.g., to restrict access during construction activities). In addition, small-scale use of fencing and warning signs (e.g., to restrict access to treatment equipment) would be effective in minimizing exposure to contaminated media. Therefore, engineering controls are not considered effective as a part of a permanent remedy at Parcel E-2, but could be used during implementation of an active remediation technology.

Implementability

Engineering controls would be readily implementable on a short-term basis and would face no technical or administrative issues associated with implementation. However, implementability would be low in the long term because most engineering controls would restrict site access, thereby conflicting with the planned reuse of Parcel E-2 as open space.

Cost

The cost of implementing engineering controls to prevent access would be low, but would be incurred over a relatively long time period (approximately 30 years). Capital costs would include (but not be limited to) installation, inspection, and maintenance of security fencing (which already exists at Parcel E-2) and installation of warning signs.

Engineering Controls General Screening

- Effectiveness: Low (if used as part of a permanent remedy); High (if used during implementation of an active remediation technology)

- Implementability: Low (if used as part of a permanent remedy); High (if used during implementation of an active remediation technology)
- Cost: Low
- Retained for Further Analysis: No (not effective as part of a permanent remedy because it conflicts with planned open space reuse; may be used in conjunction with active remediation technologies)

11.4.3. Site Monitoring

Short-term and long-term monitoring alone would not achieve RAOs; however, monitoring would be an integral component in any remedial alternative implemented at Parcel E-2. Monitoring would be used to track migration of landfill gas if waste is left in place. It would also be used to inspect and maintain the current interim (and any future permanent) gas collection system. Under the current landfill gas monitoring and control program, monitoring results are effectively tracking potential migration of landfill gas. Monitoring data are evaluated to determine if any response actions are required (such as switching the current gas extraction system from passive to active collection mode).

Long-term groundwater monitoring would provide information on chemical migration within and beyond the Parcel E-2 boundary. For this process option, site-specific data would be evaluated to determine if groundwater contamination migrating from the source area would be attenuated before groundwater reaches the compliance monitoring wells. A conservative aquatic evaluation, including a screening and trigger level evaluation, was performed to compare groundwater data with aquatic criteria, in a manner that accounts for chemical attenuation. The aquatic evaluation results are presented in Appendix M. This conservative evaluation, which does not take into account nearshore mixing process, revealed that several chemicals in groundwater at Parcel E-2 have the potential to discharge to the bay at concentrations that may negatively impact aquatic life. The evaluation methodology and approach have been used to estimate the potential for chemical attenuation at other HPS parcels (Parcel C and Parcel D), and have been agreed to by the Navy and the regulatory agencies. The evaluation recommends additional monitoring and evaluation for several locations of concern, including the shoreline areas at Parcel E-2, and inland locations in the Panhandle and East adjacent Areas. The inland portions of the Landfill Area were not evaluated using the trigger level approach because the evaluation methodology was not developed to account for chemical migration through waste. Through long-term site monitoring, the Navy may be able to develop a more accurate method of estimating attenuation in the migration zones at Parcel E-2, and the nearshore mixing processes that undoubtedly take place in the TMZ. Long-term stormwater and groundwater discharge monitoring (from wells along the bay shoreline) would be used to demonstrate compliance with RAOs designed to prevent unacceptable exposures to aquatic life in San Francisco Bay.

Stormwater and landfill cap inspection is another type of monitoring that would be used to verify the effectiveness of BMPs and the integrity of the containment systems in both the short-term (during remedy implementation) and long-term (following remedy implementation). Regular inspections would identify any potential problems and necessary corrective actions, which would be implemented during regular maintenance activities. Additional short-term monitoring would include outdoor air monitoring during construction activities to monitor dust emissions and provide a mechanism to prompt additional control measures if needed.

The monitoring programs discussed above have been established at Parcel E-2, and their ongoing implementation provides the basis of the following evaluation. An evaluation of site monitoring based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Monitoring alone would not achieve RAOs, but monitoring would be an integral component in any remedial alternative implemented at Parcel E-2. Examples of future monitoring include:

- Future landfill gas monitoring programs would be implemented to monitor potential migration of landfill gas and trigger appropriate response actions for alternatives that leave solid waste in place.
- Long-term groundwater monitoring would be implemented to assess compliance with chemical-specific ARARs at the Parcel E-2 boundary. Additional monitoring wells may be needed to ensure the effective tracking of groundwater contamination within and beyond the Parcel E-2 boundary. A preliminary monitoring plan is presented in Section 12.1.2; this plan will be refined in the RD. If groundwater quality at the point of compliance (the Parcel E-2 boundary) does not meet the existing RAOs, supplementation with another remediation technology (such as containment) would be required along with groundwater monitoring.
- The existing SWDMP would be updated to monitor stormwater discharges and ensure that BMPs prevent discharge of surface runoff at concentrations exceeding applicable water quality criteria. Stormwater monitoring would be combined with regular inspection and maintenance of the cap to ensure its integrity and effectiveness at containing waste material.

Implementability

The existing monitoring programs for landfill gas, groundwater, and stormwater could readily be enhanced and converted into effective and long-term monitoring systems. Ongoing inspection and maintenance programs for stormwater BMPs and the interim landfill cap and gas control systems could be used to develop permanent operation and maintenance programs.

Cost

The cost of implementing monitoring programs for all applicable media would be low, and would be incurred over a relatively long time period. Capital costs would include expansion (as needed) and maintenance of the gas and groundwater monitoring network, as well as stormwater BMPs and cap inspections and maintenance actions. The operational costs would include field sampling, laboratory analysis, data validation and evaluation, and reporting.

Site Monitoring General Screening

- Effectiveness: Low (monitoring alone would not achieve RAOs, but monitoring would be an integral component in any remedial alternative implemented at Parcel E-2)
- Implementability: High
- Cost: Low
- Retained for Further Analysis: Yes

11.5. CONTAINMENT (WITH OR WITHOUT REMOVAL, TREATMENT, AND DISPOSAL)

The process options considered under the containment GRA are divided into three categories based on the medium being addressed. The types of media addressed by containment are (1) solid waste, soil, and sediment; (2) landfill gas; and (3) groundwater. Within each of these media, the process options summarized in the table below were considered.

Applicable Media	Remedial Technology	Process Options Evaluated Under Containment GRA
Solid waste, soil, and sediment	Caps and covers	▪ Low-permeability soil cap ▪ Geosynthetic cap ▪ Multilayer geosynthetic cap ▪ Evapotranspiration cap
	Shoreline protection [a]	▪ Armoring ▪ Beach stabilization structures ▪ Beach nourishment
Landfill gas [b]	Collection	▪ Passive venting ▪ Active collection
	Treatment [c]	▪ Adsorption ▪ Destruction (e.g., combustion)
Groundwater [d]	Physical barrier	▪ Sheet-pile wall ▪ Slurry wall ▪ Grout curtain ▪ Vertical geomembrane
	Hydraulic barrier	▪ Flow diversion and on-site discharge ▪ Extraction from wells and off-site discharge ▪ Phytoremediation
	Reactive barrier	▪ Permeable reactive barrier

Notes:

a Shoreline protection is required to protect containment structures from erosion via tidal or wave action; therefore, shoreline protection options are evaluated in conjunction with containment options.

b Landfill gas collection may be required for any containment option that leaves waste in place; therefore, gas collection options are evaluated in conjunction with the containment GRA.

c Treatment may be required for any landfill gas collected at Parcel E-2; therefore, treatment options are evaluated in conjunction with landfill gas collection options.

d Groundwater containment options are being evaluated for completeness, despite the uncertainty of risk to humans and wildlife from exposure to groundwater, and as a formal evaluation of the current GES in the southeast portion of Parcel E-2

The following subsections address the remedial technologies and process options under the containment GRA applicable to contaminated media at Parcel E-2. The evaluation is divided into five subsections: Section 11.5.1, Solid Waste, Soil, and Sediment Containment; (2) Section 11.5.2, Shoreline Protection; (3) Section 11.5.3, Landfill Gas Collection; (4) Section 11.5.4, Landfill Gas Treatment; and (5) Section 11.5.5, Groundwater Containment and Leachate Collection. The removal GRA, including process options for excavation and disposal of the landfill waste and excavation of hot spots, is evaluated in Section 11.6. The evaluation of the remedial technologies and process options under the containment GRA is presented on Figure 11-1.

11.5.1. Solid Waste, Soil, and Sediment Containment

For solid waste, soil, and sediment in Parcel E-2, capping is the primary proposed containment technology. Capping is the primary containment technology for municipal solid waste according to the EPA guidance (EPA; 1991a, 1993a, 1994, and 1996; also provided in Appendix H to this RI/FS Report); thus, it is the primary technology considered for the Landfill Area. Capping is also considered the primary containment technology for the Panhandle, East Adjacent, and Shoreline Areas because multiple, non-contiguous locations of potentially contaminated waste and soil are present throughout these areas. For this reason, as discussed in Section 8.4.4, capping will be considered for uniform implementation throughout the Panhandle, East Adjacent, and Shoreline Areas.

The following capping and erosion protection process options are evaluated in this subsection:

- Low-Permeability Soil Cap
- Geosynthetic Cap
- Multilayer Geosynthetic Cap
- Evapotranspiration Cap

Table 11-1 summarizes the capping process option evaluations described in the following subsections.

11.5.1.1. Low-Permeability Soil Cap

Figure 11-3 shows a cross section of the low-permeability soil cap (27 CCR cover, prescriptive standard). The low-permeability soil cap system includes a low-permeability soil layer (such as clay) at least 12 inches thick, with a maximum permeability of 1×10^{-6} centimeter per second (cm/sec) or maximum permeability equal to the hydraulic conductivity of the base liner system or of the underlying geologic materials.

Use of a low-permeability soil cap discussed above would involve additional design and use considerations, as follows:

- The low-permeability soil layer would be placed on a minimum 2-foot-thick soil foundation layer, and an additional 1-foot-thick vegetative soil layer would cover the low-permeability soil layer.
- The purpose of the vegetative soil layer would be to protect the low-permeability layer and sustain plant growth to limit future erosion.
- This type of cap would be susceptible to damage by desiccation cracking or by burrowing animals or deep-rooted plants.
- Also, the low-permeability soil cap is generally less effective for minimizing infiltration than a cap containing a geomembrane.

An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

This process option would meet the established RAOs. A low-permeability soil cap would be effective because it would (1) control landfill gas, (2) prevent direct contact of humans and wildlife with waste, and (3) reduce stormwater infiltration.

Cap effectiveness is measured by the predicted quantity of precipitation infiltration allowed through the cap. High volumes of infiltration are not desirable because of the potential leachate generation and negative groundwater effects. The Hydrologic Evaluation of Landfill Performance, Version 3 (HELP-3) computer model has been used to evaluate precipitation infiltration through various cap types. Based on HELP-3 modeling, a low-permeability soil cap would allow an annual average infiltration of 5.7 inches per acre into the subsurface (Appendix P and Table 11-1).

Another measure of effectiveness for a cap is its ability to withstand the design seismic event. To determine that the conceptual cap designs presented for comparison in the FS are technically feasible, the Navy performed a liquefaction study (Appendix C) and a preliminary slope stability analysis (Appendix Q) using available site data and the maximum seismic event predicted to occur at the site. This evaluation indicates that no stability problems should arise under static or seismic conditions for a properly designed slope. If containment is selected as the final remedy, a detailed slope stability analysis will be performed on the final slope design to complement the previously performed analyses. The proper design and maintenance of a cap would minimize erosion, liquefaction, and slope stability concerns.

The potential effects on human health and the environment from implementation of this process option would be short-term. These effects include windblown dust during cap construction and sediment in stormwater runoff; however, soil used for the cap would not be contaminated, and off-site sediment migration could be adequately managed through proper construction techniques. No chemicals from the landfill are likely to be released during construction because minimal, if any, disturbance of the solid waste would occur.

This type of cap is proven and reliable in the climatic conditions present at Parcel E-2. The cap must be properly maintained to ensure the effectiveness of the low-permeability soil layer and to prevent damage from burrowing animals and deep-rooted plants. With proper maintenance, the low-permeability soil cap would be durable and capable of sustaining foot traffic, which is anticipated for the planned open space reuse.

Implementability

Material within each area would be graded for proper drainage prior to capping. Throughout the Shoreline Area, erosion protection measures are required to protect the cap. The shoreline protection technologies are discussed in Section 11.5.2. Implementation of capping and erosion protection technologies may require restrictions on future land use because contaminated solid waste, soil, and sediment would be left in place. Capping and installing erosion protection would require excavation and placement of fill on existing wetlands in the Panhandle and Shoreline Areas. Existing wetlands that may be permanently affected by cap and shoreline protection construction would be mitigated by the construction of wetlands in the Panhandle Area.

Another parameter affecting the implementability and cost of each cap type is the availability of materials. Each type of capping process would require imported soil. The foundation layer soil must be structurally stable, but the requirements for this layer are not as stringent as those for a low-permeability soil layer. The vegetative layer soil must be capable of supporting vegetative growth, but a wide variety of soil is suitable. The low-permeability soil layer generally must consist of a clay material possessing specific properties to provide low permeability after placement.

A low-permeability soil cap could be constructed at Parcel E-2, but a high level of quality control would be required during placement of the low-permeability soil layer. Insufficient compaction or improper moisture conditioning may prevent the permeability requirements from being met. Skilled labor and proper supplies and equipment are required to allow proper implementation of this process option. No known, local source of the low-permeability soil is needed to construct a low-permeability soil cap, and the regional availability of a suitable low-permeability soil material cannot be accurately determined until the timing for construction is known. Off-site quarry testing investigations are generally required to ascertain if suitable low-permeability soil is available. Typically, the foundation layer soil and vegetative layer soil are the most readily available and the low-permeability layer soil is more difficult to obtain.

Cost

The cost of a low-permeability soil cap would be moderately high as compared with other cap designs, because of the need to purchase and import suitable low-permeability soil. Maintenance costs for a low-permeability soil cap are comparable with those associated with other cap alternatives.

Solid Waste, Soil, and Sediment Containment – Low-Permeability Soil Cap General Screening

- Effectiveness: High
- Implementability: Moderate to High (with proper quality assurance and quality control, skilled labor, and appropriate supplies and equipment)
- Cost: Moderate to High (costly to purchase and import suitable low-permeability soil)
- Retained for Further Analysis: Yes (not practical for site-wide implementation, but retained for potential focused application at proposed freshwater wetlands)

11.5.1.2. Geosynthetic Cap

Figure 11-4 shows a cross section through the geosynthetic cap (27 CCR cover, engineered alternative). The geosynthetic cap is considered in this FS primarily to address possible difficulties and costs in obtaining suitable low-permeability soil. The geosynthetic cap system would include an HDPE geomembrane 60-mil thick in place of the low-permeability soil layer (1 mil is equivalent to 0.001 inch). The typical permeability of an HDPE geomembrane is 1×10^{-13} cm/sec. A properly constructed 60-mil HDPE liner provides better performance against infiltration than a 12-inch-thick soil layer with a permeability of 1×10^{-6} cm/sec. Similar to the low-permeability soil layer in a low-permeability soil cap, the geomembrane would be placed on a soil foundation layer. A geocomposite drainage layer would be placed on top of the geomembrane, where necessary, to provide a drainage path for water infiltrating through the vegetative layer. The geocomposite drainage layer typically consists of at least two layers: (1) a geonet comprising two bonded overlapping HDPE strands (typically ranging from 200- to 250-mil-thick) to transmit infiltrated water to drainage features at the top of the cap; and (2) a nonwoven polypropylene geotextile fabric (typically 70- to 90-mil-thick) to prevent soil from clogging the underlying geonet. In some applications, an additional layer of nonwoven polypropylene geotextile fabric is placed under the geonet to cushion the HDPE geomembrane. A vegetative soil layer consisting of at least 18 inches of soil to support plant growth would cover the geomembrane and geocomposite drainage layer.

In addition to its primary function stated above, a geocomposite drainage layer can also deter burrowing animals from penetrating the HDPE geomembrane. The potential for burrowing animals to penetrate a geosynthetic cap is generally considered low by experts in the waste containment industry (Sharma and Lewis, 1992; Karr et al., 1992; Gee and Ward, 1997; Air Force Center for Environmental Excellence[AFCEE], 1999); however, this potential cannot be entirely dismissed and some landfill closures specify a biotic barrier (to supplement postclosure inspection, maintenance, and animal control measures). For example, a geocomposite drainage layer has been specified to serve as a biotic barrier at several San Francisco Bay area landfill sites (TtEMI, 2005d; IT, 2000; U.S. Department of Energy, 1997).

The geosynthetic components of the cap would provide good protection against burrowing animals, deep-rooted plants, and desiccation cracking as compared to a low-permeability soil layer. In addition, the geomembrane would allow much less infiltration than a low-permeability soil layer. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

This process option would meet the established RAOs. A geosynthetic cap would (1) enhance control of landfill gas, (2) prevent direct contact of humans and wildlife with waste, and (3) reduce stormwater infiltration. In addition, proper design and maintenance would minimize erosion and slope stability concerns. The infiltration modeling used to evaluate the effectiveness of each cap type was discussed in Section 11.5.1.1. Based on HELP-3 modeling, a geosynthetic cap would allow an annual average of 0.03 inch per acre of infiltration into the subsurface (Appendix P and Table 11-1). This infiltration rate is based on having a completely intact HDPE liner, free from defects, cracks, tears, or pinholes. If the geomembrane is punctured, the infiltration rate would increase.

Similar to the low-permeability soil cap, potential effects on human health and the environment from implementation of this process option would be short-term and could be managed through proper construction techniques. This type of cap is proven and reliable in the climatic conditions present at Parcel E-2. Proper design and maintenance would minimize erosion, liquefaction, and slope stability concerns. The cap is durable and could handle foot traffic. In addition, this cap would resist damage from burrowing animals, deep-rooted plants, and desiccation cracking more effectively than a low-permeability soil cap. As stated previously, the geocomposite drainage layer would deter burrowing animals from penetrating the HDPE geomembrane.

The Geosynthetic Research Institute (GRI), based at Drexel University, is one of the leading groups researching geosynthetics, including HDPE geomembranes. The GRI has published a white paper addressing the life of geomembranes (GRI, 2005). The life of a geomembrane is dependent on several factors, with temperature probably being the most significant factor. The white paper presents predicted

HDPE geomembrane half-lives (i.e., the time when a 50 percent reduction in a specific design property is reached) based on varying temperatures. Assuming an average temperature of 25°C (77°F), the predicted half-life of a typical HDPE geomembrane is 270 years.

Section 10 of the RI/FS Report identifies several requirements pertinent to the question of post-closure duration, including:

- Post-closure Water Entry: 22 CCR § 66264.310(a)(1). This section requires that the final cover be designed to prevent the downward entry of water into the closed landfill throughout a period of at least 100 years.
- Post-closure Care: 22 CCR § 66264.310(b)(1). This section requires that the integrity and effectiveness of the final cover be maintained throughout the post-closure period. This section also incorporates by reference 22 CCR § 66264.117(b)(2)(B), which requires that the post-closure care period be extended if necessary to protect human health and the environment.
- Post-closure care period: 27 CCR § 20950(a). This section requires that the post-closure maintenance period shall extend as long as the wastes pose a threat to water quality.
- Post-closure Maintenance: 27 CCR § 21180(a). This section requires post-closure maintenance and monitoring of the landfill for no less than 30 years following closure.

Based on the information presented in the GRI White Paper, the predicted half-life of a HDPE geomembrane (270 years) well exceeds the established duration for preventing downward entry of water into the closed landfill.

Implementability

As discussed in Section 11.5.1.1, the availability of materials is a major parameter that affects the implementability of each cap type. For the geosynthetic cap, the material requirements for the foundation and vegetative layer would be similar as for the low-permeability soil cap. The low-permeability layer would consist of a geosynthetic material possessing specific properties to provide low permeability after placement.

A geosynthetic cap would be implementable and would provide performance advantages over a low-permeability soil cap. The advantages are mainly due to the use of geosynthetic materials as the predominant impermeable layer, as opposed to a low-permeability soil. Soil needed for the foundation and vegetative layers is readily available from local sources, and the geosynthetic materials required could be easily obtained. Skilled labor, supplies, and equipment are sufficient to allow proper implementation of this process option. In addition, the geosynthetic materials are manufactured under shop conditions with high-quality control and, assuming that the installation is performed by properly trained personnel and with adequate construction quality control, the resulting quality and performance of the cap is expected to be consistent and predictable, thereby ensuring an effective barrier to infiltration. No administrative issues are associated with the implementation of this process option.

Cost

The cost of a geosynthetic cap would be moderate because it generally costs the same or less to install than a low-permeability soil cap (which depends on the availability of suitable low-permeability soil). A geosynthetic cap would also cost less to install than a multilayer geosynthetic cap. Maintenance costs for a geosynthetic cap are similar to those associated with other cap alternatives.

Solid Waste, Soil and Sediment Containment – Geosynthetic Cap General Screening

- Effectiveness: High
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)
- Cost: Moderate
- Retained for Further Analysis: Yes

11.5.1.3. Multilayer Geosynthetic Cap

Figure 11-5 shows a cross section of a multilayer geosynthetic cap. A multilayer geosynthetic cap has already been installed over a portion of the Landfill Area in response to the August 2000 fire. This type of landfill cap is considered to meet or exceed the established RAOs for solid waste, soil, and sediment.

The multilayer geosynthetic cap includes a composite low-permeability layer consisting of an HDPE geomembrane at least 60-mil thick over a geosynthetic clay liner (GCL). The composite low-permeability layer is placed on a soil foundation layer, and the geomembrane is overlain by a geocomposite drainage layer, where necessary, to provide a drainage path for water infiltrating through the vegetative layer and to deter burrowing animals from penetrating the HDPE geomembrane and GCL. The geomembrane and geocomposite drainage layer is covered by a minimum 18-inch-thick vegetative soil layer capable of supporting plant growth. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

This process option would meet the established RAOs. A multilayer geosynthetic cap would (1) enhance control of landfill gas control, (2) prevent direct contact of humans and wildlife with waste, and (3) reduce stormwater infiltration. In addition, proper design and maintenance would minimize erosion and slope stability concerns. The infiltration modeling used to evaluate the effectiveness of each cap type was discussed in Section 11.5.1.1. The estimated life of HDPE geomembranes was discussed in Section 11.5.1.2. Based on HELP-3 modeling, a multilayer geosynthetic cap would allow an annual average infiltration of 0.03 inches per acre into the subsurface (Appendix P and Table 11-1). The presence of a GCL would provide additional protection against leakage through pinholes or small tears in the geomembrane. The GCL is composed of bentonite sandwiched between two geotextile layers and has a permeability of 5×10^{-9} cm/sec or less. The unique attributes of the bentonite include:

- High swell and water adsorption potential
- Low permeability (lowest of all naturally occurring soil)
- Chemical stability (inert mineral)

One advantage of a GCL in the composite layer system is the swell capability of the bentonite when it becomes hydrated. Bentonite, when hydrated, will swell into the defect in the overlying geomembrane to impede infiltration. The interaction between the two components of the composite cap creates a self-sealing system that is extremely impermeable to infiltration. In addition, the self-sealing properties of the composite cap will limit landfill gas emissions in a variety of site conditions. Because of the higher volume and proportion of putrescible waste in the landfill relative to the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas), the extra protection afforded by the composite cap is important to the control of landfill gas emissions.

Similar to the other capping options, the potential effects on human health and the environment from this process option would be short-term and could be adequately managed through proper construction techniques. This type of cap is proven and reliable in the climatic conditions present at Parcel E-2. Proper design and maintenance would minimize erosion and slope stability concerns. The cap is durable and could handle moderate traffic. In addition, this cap would resist damage from burrowing mammals, desiccation cracking, and deep-rooted plants more effectively than a low-permeability soil cap.

Implementability

As discussed in Section 11.5.1.1, the availability of materials is a major parameter that affects the implementability of each cap type. For the multilayer geosynthetic cap, the material requirements for the foundation and vegetative layer would be similar as for the low-permeability soil cap. The low-permeability layer would consist of two different geosynthetic materials possessing specific properties to provide low permeability after placement.

Similar to the geosynthetic cap, the multilayer geosynthetic cap would be implementable and would provide performance advantages over a low-permeability soil cap. The types of soil and materials needed to construct a multilayer geosynthetic cap are readily available locally, and skilled labor, supplies, and equipment are sufficient to allow proper implementation of this process option. Assuming that the installation is performed by properly trained personnel and with adequate construction quality control, the resulting quality and performance of the cap is expected to be consistent and predictable, thereby ensuring an effective barrier to infiltration. No administrative issues would affect the implementability of a multilayer geosynthetic cap.

Cost

A multilayer geosynthetic cap would cost moderately more than a geosynthetic cap and is comparable in price to a low-permeability soil cap. Maintenance costs for a multilayer geosynthetic cap are similar to the other capping options.

Solid Waste, Soil, and Sediment Containment – Multilayer Geosynthetic Cap General Screening

- Effectiveness: High (most effective of the containment barriers screened for this evaluation)
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)
- Cost: Moderate to High
- Retained for Further Analysis: Yes

11.5.1.4. Evapotranspiration Cap

Figure 11-6 shows a cross section of an evapotranspiration cap. An evapotranspiration cap is typically a 4- to 6-foot-thick soil layer over a soil foundation layer. The evapotranspiration cap acts to store moisture within the cap thickness, while minimizing infiltration, until the moisture is removed through vegetative uptake or evaporation. The soil layer consists of specially selected soil planted with fast-growing trees, shrubs, and grasses. The soil pores hold moisture like a sponge until plant roots can access the water. Plants take up this water for growth and release it into the atmosphere through transpiration. The system would be designed to be thick enough and with enough vegetation to minimize infiltration of the expected precipitation at the landfill.

An evapotranspiration cap is more appropriate for arid and semi-arid climates typical of southern California, and requires a rigorous infiltration analysis and post-construction moisture monitoring. This cap is more susceptible to burrowing animals and may be less effective at minimizing infiltration than cap systems that include a geomembrane layer. This type of cap also requires large volumes of soil material to meet its thickness requirement. In addition, this cap requires the establishment of a robust vegetative growth, which can require several growing seasons to develop. The vegetative growth may also not be compatible with certain types of end uses, and can be susceptible to damage by animals, humans, and climatic changes. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

This technology may meet the established RAOs. An evapotranspiration cap would (1) control landfill gas, (2) prevent direct contact of humans and wildlife with contaminated waste and soil, and (3) reduce stormwater infiltration. In addition, proper design and maintenance would minimize erosion and slope stability concerns. The infiltration modeling used to evaluate the effectiveness of each cap type was discussed in Section 11.5.1.1. However, the HELP-3 model is not appropriate for evaluating the performance of an evapotranspiration cap, and a more extensive modeling would be required if an evapotranspiration cap is considered a viable process option. As discussed below, the evapotranspiration cap is not expected to be effective at this site due to the climatic conditions. Therefore, the more extensive modeling required for an evapotranspiration cap was not performed.

For nonirrigated end uses in arid and semi-arid areas, the performance of an evapotranspiration cap can be comparable to other cap alternatives; however, the more temperate climate in northern California diminishes the effectiveness of this type of cap. This diminished effectiveness is because the rate of evapotranspiration may not adequately eliminate the water percolating through the cap during the wet season. Landfill gas collection, particularly active collection, may also be less effective with this type of cap.

Implementability

As discussed in Section 11.5.1.1, the availability of materials is a major parameter that affects the implementability of each cap type. For the evapotranspiration cap, the material requirements for the foundation and vegetative layer would be similar as for the other cap types. The low-permeability layer from the other cap types would be replaced by a relatively thicker soil cover consisting of a sandy material with sufficient content of fine-grained soil to retain moisture.

In all likelihood, it would not be possible to construct an evapotranspiration cap in the northern part of Parcel E-2 without encroaching on neighboring property to the north. The required soil thickness of 4 or more feet would result in a final cap elevation several feet higher than the surrounding area and, because of the close proximity of waste to the UCSF compound, the resulting transition slope would likely encroach on the UCSF compound. The thickness of this cap would induce heavier loads on the subgrade and might cause additional settlement. In addition, this type of cap would require a significantly higher volume of truck or rail traffic through the local community to deliver the quantity of import soil necessary to construct the cap.

Similar to the other capping options, the potential effects on human health and the environment from implementation of this process option would be short-term and could be adequately managed through proper construction techniques. No administrative issues are associated with the implementation of this process option.

Cost

The cost of constructing an evapotranspiration cap would be moderate to high considering the volume and specialized properties of the required import soil. Because soil for an evapotranspiration cap generally must be a sandy material, but must also contain a sufficient amount of fine-grained soil to retain moisture, mixing of two or more different soil sources may be needed to achieve the required properties, and such a mixing effort would result in higher costs. Maintenance costs for an evapotranspiration cap are similar to those associated with other capping options.

Solid Waste, Soil, and Sediment Containment – Evapotranspiration Cap General Screening

- Effectiveness: Moderate (diminished effectiveness in temperate climates; ideal in arid or semi-arid climates)
- Implementability: Low (would require importation of a significant amount of cover soil and may encroach on neighboring property)
- Cost: Moderate-High
- Retained for Further Analysis: No (diminished effectiveness in temperate climates and implementation issues, including potential encroachment on neighboring property)

11.5.2. Shoreline Protection

Shoreline protection works are used to retain or rebuild natural systems (cliffs, dunes, wetlands, and beaches) or to protect manmade structures (buildings, infrastructure, engineered berms, etc.) landward of the shoreline. In the case of Parcel E-2, shoreline protection is necessary to allow wetlands to be rebuilt and to protect engineered berms needed for a containment action.

The following erosion protection process options are evaluated in this subsection:

- Armoring
- Shoreline Stabilization Structures
- Shoreline Nourishment

Similar to the evaluation of solid waste and soil containment options, the ability of the shoreline containment system to withstand the design seismic event was evaluated (see Section 11.5.1).

11.5.2.1. Armoring

Armoring includes seawalls, bulkheads, and protective revetments. The primary purpose of a seawall is to prevent inland flooding from major storm events accompanied by large, powerful waves. The key functional element in the design of a seawall is the crest elevation to minimize the overtopping from storm surge and wave runup. A seawall is typically a massive concrete structure with its weight providing its stability. Bulkheads are vertical retaining walls to hold or prevent soil from sliding seaward.

Their main purpose is to reduce land erosion and loss to the sea, not to mitigate coastal flooding and wave damage. Bulkheads are either cantilevered or anchored sheet piles or gravity structures, such as rock-filled timber cribs and gabions. Revetments are a cover or facing of erosion resistant material placed directly on a slope, embankment, or dike to protect the area from waves and strong currents. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Armoring would meet the established RAOs. Armoring would (1) protect containment systems in the Landfill Area and adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) from erosion, (2) provide an appropriate termination point for the cap, and (3) allow the establishment of freshwater wetlands in the Panhandle Area. Proper design and maintenance would minimize future erosion and slope stability concerns.

Potential effects on human health and the environment from implementation of this option would be short-term and could be managed through proper construction techniques. Armoring is proven and reliable in applications similar to Parcel E-2.

Implementability

The technical implementability of armoring is high. Armoring would be subject to, and must comply with, various location-specific ARARs regarding work within a coastal zone. The types of materials needed to construct the armoring would be readily available. Skilled labor, supplies, and equipment are sufficient to allow proper implementation of this option.

Cost

The cost of armoring would be high compared with other shoreline protection options. Maintenance costs for armoring would be similar to or less than other shoreline protection options.

Shoreline Protection – Armoring General Screening

- Effectiveness: High
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)
- Cost: High
- Retained for Further Analysis: Yes

11.5.2.2. Shoreline Stabilization

Shoreline stabilization involves the construction of manmade structures or placement of natural material to moderate the coastal sediment transport processes and reduce the local erosion rate. Shoreline stabilization structures include headland and nearshore breakwaters, groins, sills, and reefs. Nonstructural shoreline stabilization involves the planting of upland or submerged aquatic vegetation, or the placement of sand fill or biodegradable organic materials (such as natural fiber logs and matting). Shorelines that are restored using natural material, either alone or in combination with stabilization structures, are referred to as "living shorelines" because they provide living space for aquatic organisms (National Oceanic and Atmospheric Administration [NOAA], 2009). Nonstructural stabilization alone is typically implemented in environments with low wave energy; a hybrid of both nonstructural and structural stabilization is typically implemented in environments with moderate wave energy (NOAA, 2009). An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Shoreline stabilization structures in combination with nonstructural stabilization measures will meet the established RAOs. Nonstructural shoreline stabilization alone may not meet the established RAOs because the moderate wave action offshore of Parcel E-2, which during winter storms is about 1-foot high (Battelle and Woods Hole Group, 2001), could erode nearshore soil and vegetation. In areas planned for tidal wetlands restoration, nonstructural stabilization measures could be combined with low-profile stabilization structures to dissipate wave energy and minimize erosion potential. Proper design and maintenance would minimize, but not eliminate, future erosion and slope stability concerns.

Implementability

The technical implementability of shoreline stabilization varies based on the shoreline slopes because steeper slopes are generally more susceptible to erosion than gradual slopes. Stabilization of shoreline areas with gradual slopes (less than 10 percent) is relatively easy to implement because minimal excavation is required prior to placement of the shoreline protection material. In contrast, stabilization of shoreline areas with steeper slopes is more difficult to implement because significant excavation is required prior to placement of the shoreline protection material. Shoreline stabilization would be subject to, and must comply with, various location-specific ARARs regarding work within a coastal zone. The types of materials needed to construct the shoreline stabilization structures would be readily available. Skilled labor, supplies, and equipment are sufficient to allow proper implementation of this option.

Cost

The cost of shoreline stabilization would be moderate compared with other shoreline protection options. Maintenance costs for shoreline stabilization could be higher than other shoreline protection options due to the need for maintenance following larger than average storms.

Shoreline Protection – Shoreline Stabilization Structures General Screening

- Effectiveness: Moderate (if shoreline stabilization structures are used in combination with nonstructural stabilization measures)
- Implementability: High (in shoreline areas with gradual slopes)
- Cost: Moderate to High
- Retained for Further Analysis: Yes

11.5.2.3. Shoreline Nourishment

The primary function of shoreline nourishment is to provide improved protection to upland structures and infrastructures from the effects of storms. Shoreline nourishment typically involves constructing a wider shoreline and more substantial dune to reduce storm damage relative to the level of damage that would have resulted without shoreline nourishment. Shoreline nourishment can include berms, dunes, feeder beach, nearshore berm, dune stabilization, or structural stabilization. Aspects of shoreline nourishment that can affect the integrity of the dune and berm include periodic renourishment, advance nourishment, and emergency maintenance.

The level of storm protection provided by shoreline nourishment is not an absolute measure due to the uncertainties in the frequency of high intensity storms. Some risk always exists that a storm will cause property damage even with the shoreline nourishment in place. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Shoreline nourishment would not meet the established RAOs because shoreline nourishment is not intended to prevent erosion. Shoreline nourishment would not (1) protect the containment systems in the Landfill Area and adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) from erosion, (2) provide an appropriate termination point for the cap, and (3) allow the establishment of wetlands in the Panhandle Area.

Implementability

Shoreline nourishment requires a sufficiently wide shoreline to allow construction beyond the anticipated erosion zone. Because the Shoreline Area at Parcel E-2 is narrow, there would not be adequate area to create a wider shoreline without substantial excavation. As a result, the technical implementability of shoreline nourishment is low.

Cost

The cost of shoreline nourishment would be moderate compared with other shoreline protection options. Maintenance costs for shoreline nourishment could be higher than other shoreline protection options due to the need for maintenance associated with continued erosion.

Shoreline Protection – Shoreline Nourishment General Screening

- Effectiveness: Low
- Implementability: Low
- Cost: Moderate
- Retained for Further Analysis: No (not implementable within narrow Shoreline Area)

11.5.3. Landfill Gas Collection

Two process options, passive landfill gas venting and active landfill gas collection, are considered for the landfill gas collection technology. Both process options include installation of vertical wells into the landfill that extend through the cap. The landfill gas collection process option evaluations are described in Sections 11.5.3.1 and 11.5.3.2. Both options may also need to be paired with a technology to treat the collected gas. Because treatment may be required for landfill gas collected from Parcel E-2, treatment technologies are evaluated in conjunction with the treatment technologies (Section 11.5.4).

11.5.3.1. Passive Venting

Passive venting technology uses the physical properties of methane to control the migration of landfill gas. Landfill gas is typically composed of approximately 50 percent methane, and the specific gravity of methane is 0.55, or about half that of air at sea level; therefore, landfill gas tends to rise in the presence of air. Also, as landfill gas is generated during waste decomposition, pressure will build within the solid waste mass. Landfill gas will migrate from areas of higher pressure to areas of lower pressure. Landfill gas travels along permeable zones of lower pressure, and these permeable zones are the primary pathways of subsurface migration of landfill gas. A passive landfill gas venting system attempts to provide a preferential pathway for gas to migrate to the surface to prevent pressure buildup and horizontal subsurface gas migration. The system would vent landfill gas from the landfill, thereby controlling off-site migration.

A passive system at Parcel E-2 would include a series of venting wells extending from below the historic low water-table elevation through the cap and discharging to the atmosphere above the surface of the cap. Figure 11-7 shows the conceptual landfill gas vent that would be installed at Parcel E-2. In areas where a new cap is installed, a thin venting layer, such as a geotextile, may be installed. This layer would be connected to vent risers under the cap to prevent landfill gas from building up beneath the cap. The vents would extend high enough above the cap to ensure that the landfill gas being vented would not accumulate at ground level. Each vent may have passive wind-driven turbines on top of the vent to enhance venting and disperse landfill gas at the vent outlet.

Passive gas venting does not require an outside power source to control landfill gas. Barrier walls, gas collection trenches, and gas vents are possible passive gas collection technologies. Passive collection is meant to provide a preferential pathway for gas to escape to the surface, rather than allowing it to migrate laterally underground. Treatment units, such as activated carbon, can be used in combination with passive gas collection. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

This technology is considered moderately effective. Venting is a proven technology for landfills that have a bottom and sidewall liner system or for landfills that have sufficient buffer space between the edge of waste and the compliance points to allow for restriction of subsurface gas flow. If NMOC treatment is required at the discharge points, the required treatment systems could restrict landfill gas venting, rendering this technology less effective. At Parcel E-2, the lack of buffer space at the northern and western boundaries and the difficulties associated with installing an effective landfill gas barrier due to the presence of large debris may limit the effectiveness of a passive venting system in those areas.

Landfill gas that dissipates through the passive vents would vent directly to the atmosphere, in the absence of a control device. Preliminary air modeling conducted during the landfill gas TCRA indicated that landfill gas vented 15 feet above the ground would not present an unacceptable risk to human health; however, this preliminary modeling was based on soil gas data from the northern area of the landfill and may not be representative of the amount and quality of landfill gas to be vented across the entire landfill if a permanent cap is installed. Additional data would be collected to support the final design of a gas control system and determine if treatment is required. Gas treatment process options are evaluated in Section 11.5.4.

Implementability

The technical implementability of the passive gas collection system is high. The labor and materials needed to design and construct a passive gas system are readily available. Any landfill gas collection system installed at Parcel E-2 must comply with the substantive BAAQMD regulations.

Cost

The construction cost for the passive venting technology would be low. Because the system takes advantage of the properties of landfill gas and natural wind currents to vent gases, the operation costs would also be low. This assessment of cost does not consider potential treatment costs, which are discussed further in Section 11.5.4.

Landfill Gas Collection - Passive Venting General Screening

- Effectiveness: Moderate
- Implementability: High
- Cost: Low

- Retained for Further Analysis: Yes

11.5.3.2. Active Collection

Active collection uses vacuum blowers to alter pressure gradients and direct the flow of landfill gas to desired locations, where it is collected through a series of extraction wells or trenches and piped to a centralized location for atmospheric discharge or treatment. The vacuum applied during active collection prevents pressure buildup from landfill gas generation and also creates an inward pressure gradient away from the Parcel E-2 boundaries to prevent outward landfill gas migration. Landfill gas collected in this manner could be discharged directly, treated, or used for a beneficial use such as energy or product generation, depending on the gas composition, flow rates, and whether treatment is needed to achieve the RAOs.

Active collection requires an outside power source to control landfill gas. Adsorption or other treatment technologies can be used in combination with active gas collection. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Active landfill gas collection with treatment generally provides the most effective control of gas. An active system would be less affected by treatment of emissions, gas generation rates, barometric pressure fluctuations, and heterogeneous subsurface conditions than a passive system. This type of system could be designed to collect landfill gas from the entire landfill, thereby reducing or eliminating the potential for off-site migration of landfill gas in all directions. By removing much of the landfill gas as it is generated and reducing pressure in the landfill, active collection could also remove volatile chemicals in the unsaturated zone. Except for the central collection point, this system would be installed primarily underground; this is a favorable scenario because an underground system is less likely to be vandalized. With proper maintenance, system performance would remain very effective; maintenance requirements could be adjusted over time to address varying landfill gas conditions.

Implementability

The technical implementability of the active gas collection system is high. An active gas collection system would be subject to, and must comply with, the substantive BAAQMD regulations. This technology could be used both with the existing cap and a new cap and is effective for both soil and geosynthetic caps. However, it is more effective with geosynthetic caps in shallow landfills, like the Parcel E-2 Landfill, because geosynthetic materials offer a better barrier against vacuum short-circuiting to the surface. The labor and materials needed to design and construct an active gas collection system are readily available. No administrative issues would affect the implementability of active gas collection.

Cost

The overall cost of active gas collection would be moderate. The capital costs for system installation would be higher than for a passive system because more electrical and mechanical systems are involved. Detailed design and construction of a system that can adequately control landfill gas for the entire landfill would require more engineering than other types of systems. Site-specific conditions should be considered in the RD to accommodate Parcel E-2's unique characteristics, such as its proximity to surface water and residential and commercial structures. Because active collection systems are typically more flexible than passive systems, evaluation of landfill gas generation rates and subsurface conditions could be less detailed. The O&M costs are moderate. This assessment of cost does not consider potential treatment costs, which are discussed further in Section 11.5.4.

Landfill Gas Collection - Active Collection General Screening

- Effectiveness: High
- Implementability: High
- Cost: Moderate
- Retained for Further Analysis: Yes

11.5.4. Landfill Gas Treatment

Two process options, adsorption and destruction, are considered for the landfill gas treatment technology. Adsorption consists of passing the collected landfill gas stream through a medium, such as granular activated carbon (GAC), to remove NMOCs prior to discharge. Destruction uses either a combustion device or a noncombustion conversion process to destroy both methane and NMOCs.

For the current interim control system, gas treatment consists of adsorption to remove NMOCs. Methane concentrations are sufficiently low as to not require destruction. However, the existing treatment process may require modification, depending on the collection technology selected to control the landfill gas in the future (if necessary), the anticipated NMOC and methane concentrations, and the total flow of collected landfill gas.

To further evaluate the treatment processes, modeling was performed to predict future landfill gas generation rates, as described in Appendix P. Results indicate that anywhere from 5 to 30 cubic feet per minute of gas may be generated within the landfill. Although this is not a substantial amount as compared to modern active landfills, a landfill gas generation rate of 10 cubic feet per minute would create enough landfill gas to fill all of the void spaces (assuming 25 percent) within the landfill in less than a year. The modeling indicates a slow rate of landfill gas generation at this time. Prior to finalizing the design of a gas control system, a landfill gas generation study is needed to better estimate the gas generation rates from the landfill and to determine the content of the landfill gas. This study may reveal that direct discharge of landfill gas would not meet RAOs, and that treatment of the landfill gas prior to discharge is required.

The following subsections discuss the following treatment process options: Section 11.5.4.1, Adsorption; Section 11.5.4.2, Destruction through Combustion; and Section 11.5.4.3, Destruction through Noncombustion Processes.

11.5.4.1. Adsorption

Adsorption would remove NMOCs from the landfill gas stream. Methane remaining in the gas stream would not be effectively removed through adsorption and would either be discharged directly to the atmosphere or would require destruction. The two adsorbent media considered for landfill gas treatment are GAC and a potassium permanganate-impregnated medium (such as Hydrosil®). The two could be used independently or in combination, depending on the NMOCs in the landfill gas. GAC would remove SVOCs and most VOCs. Potassium permanganate would remove lighter VOCs such as vinyl chloride.

Adsorption could be used with either a passive venting or active landfill gas collection system. However, treatment units could restrict the airflow of passive venting systems, rendering them less effective. To use adsorption with a passive venting system, small treatment units would be installed at each passive vent that is determined to require treatment. In an area that allows public access, each system would require security to prevent vandalism and potential exposure to NMOCs or explosion hazards. Adsorption on an active collection system could be achieved with one treatment system located at the central landfill gas collection point. This type of system, if designed properly, would not limit the effectiveness of the collection system. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Adsorption would effectively remove and prevent the inhalation of carcinogenic NMOCs. Treatment would be designed so that NMOCs no greater than 5 ppm above background levels would be discharged. Adsorption would not remove methane, which is a nontoxic gas. Methane could possibly be discharged directly to the atmosphere, depending on the concentrations in the landfill gas. The venting system would need to be designed to ensure adequate dispersion of the methane gas; a potential health and safety concern exists from freely venting methane.

Implementability

Adsorption could be readily implemented as part of an active collection system. Implementing adsorption into a passive collection system would be more difficult because of safety concerns that arise when public access is allowed. The labor and materials needed to design, construct, and operate an adsorption treatment system are readily available. Adsorption is currently used as part of the interim gas control system. Implementing an adsorption treatment system is subject to BAAQMD regulations depending on the emissions from the treatment system.

Cost

Design and construction necessary to use adsorption with either a passive or an active landfill gas collection system should require minimal effort and cost, especially if commercially available, premanufactured treatment units and automated controls are used. Based on current (interim) landfill gas mitigation efforts at Parcel E-2, projected O&M costs would be relatively low because the system is not complex and media usage would be low. However, significant costs for operating an adsorption treatment system could be realized with an active collection system after the remainder of the landfill is capped. The flow and concentration of the landfill gas to be treated could increase by more than an order of magnitude above that currently observed in the northern area of the landfill. As such, costs for treatment by adsorption could be limiting for this technology. Additionally, methane, which is not effectively removed by adsorption, could require destruction.

Landfill Gas Treatment – Adsorption General Screening

- Effectiveness: High
- Implementability: High
- Cost: Low (based on low NMOC concentrations from current control system); High (if NMOC concentrations increased significantly following capping of the entire landfill)
- Retained for Further Analysis: Yes

11.5.4.2. Destruction by Combustion

Combustion devices are standard technologies for landfill gas destruction that have been successfully implemented nationwide and worldwide. These devices include open and enclosed flares, internal combustion engines, and boilers. Because of their improved system controls relative to open flares, enclosed flares are routinely used to destroy landfill gas at landfills throughout the San Francisco Bay area. These devices are used at the following facilities:

- Redwood Landfill (Marin County)
- American Canyon Landfill (Napa County)
- Keller Canyon Landfill (Contra Costa County)
- Berkeley, Davis Street, Altamont, Pleasanton, Tri Cities, and Newby Island Landfills (Alameda County)
- Kirby Canyon Landfill (Santa Clara County)

Internal combustion engines and boilers, which use landfill gas to generate power, are used at landfills with a sufficient volume of methane (and resulting power generation) to offset the higher capital costs relative to flares. Based on preliminary gas generation estimates (Appendix P), the volume of gas generated by the Parcel E-2 Landfill is not anticipated to be sufficient to support the cost-effective implementation of internal combustion engines or boilers. Therefore, an enclosed flare is considered the only viable process option for destruction by combustion.

Figure 11-8 shows a typical enclosed flare. A typical flare may pose aesthetic concerns to future site occupants because the stack of a typical flare extends 15 to 20 above the ground surface. Figure 11-9 shows an enclosed burner, which may be considered as an alternative to a typical flare because of its low profile design. A flare destroys landfill gas, including NMOCs and methane, through combustion. The primary chemical byproducts from flares are carbon dioxide and nitrogen oxide compounds. These byproducts are managed by controlling flare combustion temperatures. Further, management of these byproducts is achieved through flare designs that maximize air dispersion to reduce potential effects. A flare can only be used in conjunction with an active collection system and is most cost-effective when landfill gas concentrations are sufficient to facilitate combustion. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

If the volume and concentration of landfill gas collected is sufficient to support combustion (after the landfill is fully capped), a flare would effectively destroy landfill gas when a proper operating temperature is maintained. It could be designed to treat all of the landfill gas extracted by an active collection system. The destruction efficiencies of properly designed and operated ground flares are typically 99 percent or better for NMOCs and methane. EPA recognizes this treatment technology as the best demonstrated available technology for landfill gas (EPA, 1999b), and the technology has been approved by the BAAQMD, as shown by the implementation of flares at many San Francisco Bay area municipal landfills.

Implementability

There are no technical barriers to implementing a flare. This technology has been successfully implemented at many landfills. As with any treatment unit, a flare would require security to restrict public access for safety reasons. The labor and materials needed to install, operate, and maintain a flare are readily available. Administratively, several regulatory agencies have expressed concern about the potential creation of dioxins as a byproduct of flare combustion, and this concern would need to be evaluated if a flare is to be implemented. The conditions required to allow for the possible creation of dioxin are controlled in an enclosed flare so as to not promote the creation of dioxins. For example, dioxins require organics, temperatures in the 400 to 800ºF range, and a minimal combustion duration. Enclosed flares use automated controls to maintain temperatures in the 1,400 to 1,800ºF range over an extended residence time. These operating conditions reduce the possibility of dioxin formation by (1) promoting the destruction of organics, (2) operating at temperatures above those that would allow dioxin formation followed by rapid quenching to temperatures below 400ºF, and (3) extending the combustion residence time to further deter the formation of dioxins. Operating a flare would be subject to the substantive BAAQMD regulations.

Cost

Capital costs for flares would be low to moderate and would depend on the complexity of the control system required. Flare operation is relatively cost-effective when methane concentrations in the landfill gas stream are sufficient to facilitate combustion; however, operation costs would increase if methane concentrations become too low to maintain proper operating temperature. Supplemental fuel may be required to maintain the proper operating temperature, and costs could be moderately high, depending on the size of the flare and the amount of supplemental fuel required. Alternatively, the flare could be operated intermittently and shut off when methane concentrations are sufficiently low as to not support combustion, provided that NMOC concentrations are sufficiently low as to not pose a risk to human health.

Landfill Gas Treatment – Destruction by Combustion (Enclosed Flare) General Screening

- Effectiveness: High
- Implementability: Moderate to High (public and regulatory agency concerns about flare combustion process by products)
- Cost: Low to Moderate (depending on type of flare used and landfill gas properties; costs could increase if supplemental fuel is required to support combustion)
- Retained for Further Analysis: Yes

11.5.4.3. Destruction by Noncombustion Processes

Noncombustion conversion processes are alternative technologies for the management, treatment, and use of landfill gas. Alternative technologies are those new or innovative technologies that have not been commonly used at a commercial scale to manage landfill gas. An evaluation of each alternative technology is not presented in this evaluation because it is unknown, based on the uncertainties related to gas volume and composition, which technologies would be implementable at the site. Instead, the technologies are evaluated collectively. Results of a landfill gas generation study will help support the final selection of a landfill gas treatment alternative (if necessary) and may reveal that an innovative, emerging technology may be well suited for landfill gas treatment at Parcel E-2.

Most modern landfills use a landfill gas management system that includes enclosed flares, which destroy a significant proportion of the methane and NMOCs within landfill gas. Research and development in the field of landfill gas management have led to the design of noncombustion technologies that typically offer higher gas treatment efficiencies and allow for gas conversion to energy. These innovative technologies could be used to manage landfill gas at Parcel E-2, if the appropriate gas characteristics exist.

The following paragraphs discuss several emerging noncombustion treatment and destruction technologies that potentially could be implemented at Parcel E-2; these technologies fall under two general categories: energy recovery and gas-to-product conversion.

Energy recovery technologies use landfill gas to produce energy directly using a fuel cell. The phosphoric acid fuel cell is the most commercially available noncombustion energy recovery technology, although other viable fuel cell technologies exist (e.g., molten carbonate, solid oxide, and solid polymer). Several chemical reactions occur within this system to create water, electricity, and heat.

Gas-to-product conversion technologies focus on converting landfill gas into commercial products, such as compressed natural gas, methanol, purified carbon dioxide and methane, or liquefied natural gas. The chemical processes required to produce each of these vary, but each includes landfill gas collection, pretreatment, and chemical reactions and purification techniques.

An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Under proper operating conditions, energy recovery or gas-to-product systems can be highly effective in destroying methane and NMOCs in landfill gas. However, the effectiveness of energy recovery and gas-to-product systems incorporated into a Parcel E-2 gas management system is likely to be low due to the gas generation rates at the landfill, which are expected to be insufficient to support an energy recovery or gas-to-product system. If gas conditions at Parcel E-2 allow for implementation of such a system, the effectiveness of the system is presumed to be moderate to high.

Implementability

Energy recovery and gas-to-product systems have been implemented at other sites, but the specialized equipment and skilled operators needed are not as widely available compared to more common technologies such as adsorption and flares. The implementability of an energy recovery or gas-to-product systems at Parcel E-2 is likely to be low due to gas generation rates at the landfill, which are expected to be insufficient to support an energy recovery system or gas-to-product system. Better definition of the site-specific conditions at Parcel E-2 (through a gas generation study) would be required to evaluate implementability. In addition, implementation of an alternative technology would require review and approval by the BAAQMD to ensure that it would meet the substantive BAAQMD regulations.

Cost

Because equipment for energy recovery or gas-to-product systems is specialized and not widely available as compared to more common technologies, the capital cost of implementing such a system is assumed to be moderate to high. However if gas conditions at Parcel E-2 allow for implementation of such a system, the moderate to high capital costs could be offset by the value of the energy or product generated by the respective processes.

Landfill Gas Treatment – Destruction by Noncombustion Processes General Screening

- Effectiveness: Likely low (assumed moderate to high, if implementable at Parcel E-2)
- Implementability: Likely low (site-specific conditions need to be better defined)
- Cost: High (could be offset by the value of the energy or product generated)
- Retained for Further Analysis: Yes (for consideration following collection of additional data regarding gas volume and composition)

11.5.5. Groundwater Containment and Leachate Collection (With or Without Treatment and Discharge)

Groundwater containment and leachate collection and treatment are considered components of the presumptive remedy for CERCLA municipal landfills (EPA, 1993a). Because solid waste in the Parcel E-2 Landfill is submerged in the A-aquifer, groundwater containment (adjacent to the landfill) and leachate collection and treatment are functionally the same actions and are evaluated together in this subsection. A final cap over the landfill source area would reduce infiltration and associated leachate generation in the unsubmerged portion of the waste. As discussed in Section 8.5.2.3, groundwater conditions along the Parcel E-2 shoreline may pose a risk to aquatic life in San Francisco Bay. This evaluation of groundwater containment and leachate collection was focused by using the engineering evaluation/cost analysis (EE/CA) previously prepared for the existing GES (PRC, 1996e). Consistent with the EE/CA, both physical barriers and hydraulic containment were evaluated as possible remedial technologies for containing leachate and contaminated groundwater if containment is required.

Physical barriers are subsurface obstructions used to contain contaminated groundwater or divert it, to ensure no migration to uncontaminated areas. They can also be used to divert uncontaminated groundwater so it does not contact subsurface sources of contamination. Physical barriers are often used in landfill remediation situations when a waste mass is difficult to treat or remove, and where soluble and mobile chemicals pose an imminent threat to a downgradient source of drinking water or wildlife. The process options for this remedial technology are (1) slurry wall, (2) grout curtains, (3) vertical geomembrane, and (4) sheet-pile wall. The evaluation of the physical barrier process options was focused in Section 11.5.5.1 because the previous EE/CA evaluated these options individually and concluded that a sheet-pile wall was the most viable process option (PRC, 1996e).

Hydraulic barriers aim to stop contaminated groundwater from flowing beyond a specified boundary. This stoppage is achieved by installing a groundwater flow diversion drain, a series of groundwater extraction wells, a vegetated area that allows for groundwater uptake by plants (phytoremediation), or a PRB that passively reduces chemical concentrations in groundwater passing through it.

Groundwater flow diversion is a passive method for controlling groundwater flow and accumulation (mounding) by diverting water away from one on-site area to another via a highly conductive conduit, such as a drain pipe. Flow diversion structures typically route flow to on-site temporary storage areas, such as depressions or ponds, where water can evaporate or percolate. Flow diversion is typically used to route excess uncontaminated water to an area with adequate capacity to accommodate it.

In the case of conventional extraction, an active groundwater control method, wells are used to remove water from the subsurface. Active groundwater extraction is typically used when contamination is present. The intercepted water typically is stored, tested, and treated (if necessary) before it is reinjected at another location, discharged to a reservoir, surface water body, or sewer system, or transported off site for treatment and disposal. Extraction wells can be used to reduce mounding behind a physical barrier, or to extract contaminated groundwater (such as leachate).

Phytoremediation is a passive groundwater control process by which plants uptake water (including dissolved chemicals in water). Much of the water is then released to the atmosphere through transpiration. The three process options for hydraulic barriers are evaluated in Sections 11.5.5.2, 11.5.5.3 and 11.5.5.4.

Treatment by PRB is a passive method for treating groundwater contamination that uses granular reactive fill materials specifically selected to break down plume contaminants as groundwater flows through the wall. Water treated through PRBs is typically discharged to the subsurface immediately after passing through the wall. Treatment by PRB is evaluated in Section 11.5.5.5.

11.5.5.1. Physical Barrier

This option would involve installing a physical barrier, such as a slurry wall, grout curtain, vertical geomembrane, or sheet-pile wall, to cut off and redirect groundwater flow. A physical barrier would generally extend from the ground surface down to an aquitard to prevent groundwater flow under the barrier. As discussed above, the evaluation of physical barriers is focused on slurry walls and sheet-pile walls. An evaluation of slurry walls and sheet-pile walls based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Physical containment technologies, specifically a slurry wall or sheet-pile wall, which has been used previously at HPS, would likely be moderately to highly effective in preventing off-site migration of groundwater contamination from the landfill, or to prevent uncontaminated groundwater (originating upgradient of the landfill) from flowing through the landfill waste. The long-term effectiveness of a sheet-pile wall would be limited by corrosion; however, the corrosion potential could be mitigated by use of a cathodic protection system (one was installed as part of the existing GES) or by use of alternative materials (such as PVC). A slurry wall would not be as susceptible to a decrease in long-term effectiveness. Use of these technologies may require augmentation with flow diversion structures, extraction wells, or phytoremediation techniques to prevent excessive groundwater mounding behind the barrier.

Implementability

Installation of a physical barrier would require trenching 10 to 15 feet below the groundwater table to key the barrier into the Bay Mud aquitard. The site conditions generally preclude installation of a grout curtain or vertical geomembrane because these process options must be installed within a stable, open trench. Shoring and dewatering to facilitate open trench construction is not feasible at Parcel E-2 because of the saturated conditions resulting from the proximity to San Francisco Bay. As a result, physical barriers that can be installed in saturated conditions (such as slurry walls or sheet-pile walls) are the only viable process options at Parcel E-2. Installation of slurry walls or sheet-pile walls would be affected by site conditions identified during previous interim actions, including the presence of large debris (which would make excavation difficult) and the presence of irregular subsurface voids (which could result in slurry loss during construction). However, site conditions would not preclude construction of a slurry wall or sheet-pile wall and could be mitigated by removing the large debris or realigning the wall. Such techniques were previously used at Parcel E-2 during the construction of the GES and the interim gas control system. If realignment of the wall was required because of the presence of large debris, adjustment of the slurry wall would be relatively easier to implement than adjusting the sheet-pile wall.

Cost

The cost of installing a slurry wall or sheet-pile wall at Parcel E-2 would vary from moderate to high depending on the length of upgradient area or shoreline requiring containment (not known at this time). If upgradient groundwater flow containment were required, the installation costs for a sheet-pile wall or a slurry wall along the western boundary of the landfill (approximately 700 feet long) to limit horizontal groundwater migration through the waste would be moderate. If downgradient containment were required, the existing sheet-pile wall could be extended along the shoreline where the landfill solid waste is located within 50 to 100 feet, and the installation costs would be moderate. However, the costs would be high if containment were required along the entire shoreline (2,500 to 3,000 feet long). Costs would also be higher if obstructions that required realignment or redesign of the sheet-pile wall were encountered.

Groundwater Containment – Physical Barrier General Screening

- Effectiveness: Moderate to High (for slurry wall); Moderate (for sheet-pile wall)
- Implementability: Moderate to High (for slurry wall); Moderate (for sheet-pile wall)
- Cost: Moderate to High

- Retained for Further Analysis: Yes (for slurry wall); No (for sheet-pile wall)

11.5.5.2. Hydraulic Containment by Flow Diversion Drain

Hydraulic containment could be accomplished by minimizing the volume of groundwater flowing through the waste from the upgradient side of the landfill. To reduce groundwater flow through the waste, a flow diversion drain coupled with a physical barrier (such as a slurry wall) could be installed along the western boundary of the Landfill Area, the predominant upgradient source of groundwater entering the landfill. The purpose of the flow diversion drain would be to relieve the groundwater mounding created behind (upgradient of) the physical barrier. The drain would consist of a passive (gravity driven) French drain system that would route flow to an on-site storage location. Stored water would be re-infiltrated and evaporated, as it would not have been contaminated through contact with the waste. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Hydraulic containment through flow diversion would be moderately effective in reducing the volume of groundwater migrating through the waste, and thus would reduce off-site migration of contaminated groundwater from Parcel E-2. The effectiveness of the hydraulic containment is constrained by two factors: (1) the depth at which the flow diversion drain could be placed to intercept shallow groundwater and drain to an on-site retention area; and (2) the degree to which groundwater would mound behind a slurry wall installed along the western boundary of the Landfill Area (where there is no Bay Mud aquitard or shallow bedrock in which to embed the slurry wall). Groundwater modeling would be required to estimate the level of containment that could be achieved through flow diversion, and to estimate the extent of the groundwater mound that would need to be reduced by the flow diversion drain. Hydrogeologic and hydrologic modeling outputs would provide the information required for sizing the diversion structure and assessing the capacity for the on-site retention area (such as a retention pond or wetland). Results of preliminary groundwater modeling provided in Appendix P indicate that (1) a flow diversion drain placed along the western boundary of the Landfill Area (at a depth of at least 6 feet msl) could reduce groundwater levels within the Landfill Area, and (2) a flow diversion drain could discharge into an on-site freshwater wetland downgradient of the Landfill Area. The preliminary groundwater modeling is adequate to evaluate the potential effectiveness of the flow diversion drain; however, the groundwater modeling does not account for the dynamic hydrologic conditions that would be present at the on-site retention area. Therefore, this preliminary modeling would be refined in the RD to detail the anticipated hydrogeologic and hydrologic response in this area.

Implementability

Hydraulic containment using a flow diversion drain is a proven method for reducing and redirecting groundwater flow through landfills or other contaminated soil. Flow diversion drains are simple to design and construct. Because they are passive in nature, and require only gravity flow to convey water, they are easy to implement and maintain. Flow diversion structures can be designed to accommodate any amount of flow, with the only constraints being the available space to construct the drain, and the available capacity of the retention structure receiving the flow.

Cost

Installation and operation costs of a hydraulic containment system using a flow diversion structure would be low. This is because there are no operating costs and minimal maintenance costs associated with this type of passive structure. Construction costs for the flow diversion drain would include the cost of excavating the trench for the drain, installing a drain pipe in the trench to convey the flow, and backfilling the trench with a hydraulically conductive material (such as gravel), which would be low to moderate. Long term costs for ongoing O&M would be low, including periodic inspections and maintenance on the drain system.

Groundwater Containment – Hydraulic Containment by Flow Diversion Drain General Screening

- Effectiveness: Moderate to High
- Implementability: High
- Cost: Low
- Retained for Further Analysis: Yes

11.5.5.3. Hydraulic Containment by Well Extraction

Hydraulic containment could be accomplished through groundwater extraction using strategically placed pumping wells along the Parcel E-2 shoreline. Extracted groundwater could be discharged to the sanitary sewer system (without treatment based on the operation of the current GES), treated and reinjected, or treated and discharged to San Francisco Bay. Based on the evaluation conducted in the EE/CA (PRC, 1996e), discharge to the sanitary sewer system is considered the most viable process option because it presents the fewest technical and administrative issues. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Hydraulic containment through pumping has been previously used at HPS and likely would be effective in preventing off-site migration of groundwater contamination from Parcel E-2. Groundwater modeling would be required to optimize extraction well placement and pumping rates and to minimize the volume of water pumped from the Parcel E-2 aquifers.

Implementability

The implementability of hydraulic containment through pumping has already been demonstrated at Parcel E-2. The current GES was successfully installed along a section of the Parcel E-2 shoreline and was successfully operated from 1998 to 2005 (when implementation of the removal action at the PCB Hot Spot Area required its decommissioning). Operation of the GES required regular monitoring of the extracted groundwater and coordination with the CCSF to facilitate discharge to the sanitary sewer system.

Cost

Installation and operation costs of a hydraulic containment system using pumping would be moderate to high, depending on the length of time the extraction system would require operation. Construction costs for the system would include costs of the wells and pumping systems, which would be moderate. If required, construction and operation of any associated treatment technology would result in higher costs. Costs for ongoing O&M would be moderate if the system could be operated for a relatively short period of time (approximately 5 to 10 years) and the long-term containment could be achieved through an alternate method (such as, phytoremediation). However, if containment through pumping is required for a longer period of time (e.g., more than 20 years), the overall costs would be high.

Groundwater Containment – Hydraulic Containment by Well Extraction General Screening

- Effectiveness: Moderate to High
- Implementability: High
- Cost: Moderate to High
- Retained for Further Analysis: Yes

11.5.5.4. Hydraulic Containment through Phytoremediation

Hydraulic containment could be accomplished through application of phytoremediation techniques, in particular phytohydraulics, strategically implemented along the Parcel E-2 shoreline. Phytohydraulics is the use of plants to control rainfall infiltration and groundwater levels and movement. In this type of application, plants are used to remove water through evapotranspiration. Deep rooting, fast growing trees and shrubs may be most effective in providing hydraulic control of groundwater flow. Trees generally have a greater rooting depth than grasses and take up large amounts of water. The high evapotranspiration rate of trees will help dewater surface soil during the rainy season, and their roots will seek groundwater for use when rainfall is limited. In addition to hydraulic control, phytoremediation could potentially help reduce chemical concentrations in subsurface soil and groundwater. Many plants, including hybrid poplar and eucalyptus, have been shown to tolerate and take up chlorinated solvents and other VOCs. Further, trees and other plants can enhance biodegradation in soil and groundwater by creating an environment favorable for bacterial and fungal activity in the root zone (rhizosphere). An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Hydraulic containment through phytohydraulics has not been previously used at HPS but could be moderately to highly effective in preventing off-site migration of groundwater contamination from Parcel E-2. Further groundwater and evapotranspiration modeling would be required to optimize the application of phytohydraulics, in particular taking into consideration the remedial technology selected for the other contaminated media, as well as selection of the plant species to use. In addition, the need to collect and dispose of the plant material would require further evaluation.

Implementability

Phytohydraulics has been successfully implemented at other sites in the U.S., but may be limited in their use at Parcel E-2 depending on the remedial technology selected for the other contaminated media. If containment of solid waste, soil, and sediment is selected for the Panhandle, East Adjacent, and Shoreline Areas (where phytohydraulics would potentially be implemented), then the design objective of creating a continuous low-permeability layer would be incompatible with phytohydraulics. An area of sufficient size for planting would need to be identified where a continuous low-permeability layer was not required to prevent exposure to humans or wildlife, then the cap design would need to be altered to allow phytohydraulics to be implemented. Further studies would be required to: (1) identify appropriate plant species that could tolerate the brackish groundwater at Parcel E-2 and remove an adequate volume of groundwater; (2) determine the size of the required planting area, and (3) determine the required planting density. It is likely that one or more of these parameters would be incompatible with the site conditions at Parcel E-2, particularly for remedial alternatives involving on-site containment. For example, the required planting area may be greater than the area at Parcel E-2 that is readily available for planting without additional, large-scale removal. Although the PCB Hot Spot Area was remediated to depths greater than 10 feet bgs and might be an acceptable location for phytohydraulics, its overall size and location may not be adequate to control groundwater along the Parcel E-2 without some other form of groundwater containment and diversion. If groundwater from behind a sheet-pile wall could be diverted (by either gravity drain or mechanical pumping) to these locations, then phytohydraulics may be a feasible alternative to extraction from wells and off-site discharge. The implementability of phytohydraulics as a stand-alone containment option is low. If used in combination with other containment options, this implementability rating is low to moderate and is contingent upon the findings of further studies as discussed above. No administrative issues would affect the implementability of phytohydraulics.

Cost

Installation and operation costs of a phytohydraulic containment system would be low to moderate. Construction costs for the system would include costs of the plants (trees and shrubs), installation of the plants, cultivation (i.e. watering and fertilizing), and the replacement of trees that do not survive. Long-term costs, once the plant roots have reached the groundwater table costs would be very low.

Groundwater Containment – Hydraulic Containment through Phytoremediation General Screening

- Effectiveness: Moderate to High
- Implementability: Low (may increase if used with other containment technologies)
- Cost: Low to Moderate
- Retained for Further Analysis: No (issues regarding implementability at Parcel E-2)

11.5.5.5. Hydraulic Containment through Permeable Reactive Barrier

This option would involve installing a PRB along part or all of the Parcel E-2 shoreline to break down contaminants in groundwater. The PRB would generally extend from the ground surface down to an aquitard to allow the entire vertical groundwater profile to flow through the barrier. The width of the PRB is generally determined by the width of the groundwater contaminant plume to be treated. The PRB is typically keyed into a low permeability layer at the bottom of the contaminated water-bearing zone (or aquifer). Slurry walls are often installed at either end of the PRB to funnel groundwater flow through the PRB, often referred to as “funnel and gate” construction.

PRB technology is an EPA-recognized technology that has been used successfully to remove contaminants from groundwater. The advantage of this technology is that it is a passive technology requiring no operation and infrequent maintenance after installation. The PRB is typically installed in a trench that is excavated perpendicular to the prevailing groundwater flow direction along the entire width of a groundwater contaminant plume. The PRB contains granular reactive fill materials specifically selected to break down the plume contaminants as groundwater flows through the PRB. The most common reactive material is zero-valent iron (ZVI), which may be mixed with silica sand. PRBs have been used with success to treat groundwater plumes containing a wide range of organic and inorganic contaminants. An excellent source of information on PRB applications is the EPA’s report entitled, “Permeable Reactive Barrier Technologies for Contaminant Remediation” dated September 1998 (EPA/600/R-98/125).

The complete breakdown of contaminants is based on residence time within the PRB. The grain size of the reactive fill is selected based on the grain size distribution of the native soil outside the PRB. The width of the PRB is selected to allow for the proper residence time based on groundwater flow velocity and contaminant concentrations. Bench scale testing, that incorporates site-specific materials, should be used to assist in determining the proper reactive fill mixture and PRB width to obtain the optimum residence time.

D. Jun, et al., in the article "Laboratory Study on Sequenced Permeable Reactive Barrier Remediation for Landfill Leachate Contaminated Groundwater" (in press Journal of Hazardous Materials, 2008) evaluated the use of PRBs in breaking down several landfill leachate compounds including ammonium ion (NH^{4+}). The bench scale experiment used both ZVI and a ZVI/zeolite mixture. According to Jun, et al., ZVI alone "is not effective for longevity, after a short time, the concentration of the ammonium and N increased gradually, which indicated that ZVI could remove ammonium and N effectively, in turn ammonium and N could accelerate corrosion of the ZVI." Based on this study, the removal ratio for ammonium in the ZVI/zeolite PRB was 97.4%. However, the author also stated that there have been problems with loss of PRB porosity due to clogging by precipitates and biofouling, and that this requires further study.

While the above study indicates that PRBs may be effective in reducing leachate concentrations in groundwater at the bench-scale level, there is little to no published documentation of pilot- or full-scale studies where the technology has been applied to treat ammonia in groundwater. This, coupled with the author's stated problems with reduced permeability, indicates that the technology will require further study before being implemented at a pilot-scale or full-scale level.

Effectiveness

As discussed in the study above, PRB technology has been shown to be over 97 percent effective in initially removing ammonium from groundwater. However, the effectiveness may diminish over time due to corrosion of the ZVI and bacterial fouling of the reactive media. The loss of effectiveness may be mitigated by reintroducing reactive fill materials into the substrate, but such actions could substantially decrease implementability and increase cost. Another factor that may affect the effectiveness of this technology is associated with the fact that implementation at Parcel E-2 would require that the PRB be installed in a tidal environment. Because PRB performance is a function of residence time and water chemistry, it is likely that the variable gradients and fluctuating salinity due to tidal fluctuations could potentially reduce the performance of a PRB. Based on the limited performance data available in the published literature, further study and extensive laboratory and field experimentation would be needed to assess the effectiveness of this technology, if it is to be implemented at Parcel E-2 at the full scale level. Because of these issues, effectiveness of this technology is undetermined in the short-term, and considered to be low in the long term.

Implementability

The PRB technology has been implemented at many sites in the United States for a variety of contaminants. However, the use of PRB technology for landfill leachate with elevated concentrations of ammonia has not been proven in full scale implementation. To implement this technology would require additional bench scale studies to prove effectiveness for the specific site chemical suite over an extended time period. If proven effective in the bench scale, then pilot and full-scale studies would be required to further prove the technology. While regulatory agencies have accepted the use of PRBs for other contaminants, the technology has not been accepted for leachate with elevated concentrations of ammonia, and therefore regulatory acceptance is not assured for this technology. Based on these factors, implementability of this technology is considered low.

Cost

PRB technology is a passive technology, so future operation and maintenance costs would be minimal, unless reactive fill materials require periodic reintroduction into the substrate because of declining effectiveness over time. Initial installation requires trenching to encompass the entire downgradient edge of the groundwater plume to the depth of a competent aquitard. The exact width of the trench and the mixture of the reactive fill material cannot be determined until bench and pilot scale studies have been completed. Further, the installation of slurry walls oriented parallel to the groundwater flow direction may be required at each end of the PRB trench to force contaminated groundwater through the PRB and prevent it from flowing around the sides. Based on the anticipated cost of laboratory bench and pilot scale studies, and the installation cost for the PRB and slurry walls (if necessary), the cost of this technology is considered to be high.

Groundwater Containment – Contaminant Containment through Permeable Reactive Barrier

- Effectiveness: Undetermined in the short term; low in the long term
- Implementability: Low
- Cost: High
- Retained for Further Analysis: No (issues with effectiveness, implementability, and cost)

11.6. REMOVAL BY EXCAVATION (WITH OFF-SITE DISPOSAL OR ON-SITE CONSOLIDATION)

The process options considered under the removal by excavation/disposal GRA are: (1) excavation and off-site disposal of all solid waste and contaminated soil in the Landfill Area, and contaminated soil/sediment in Panhandle, East Adjacent, and Shoreline Areas that may pose a risk to human health and the environment; (2) excavation and off-site disposal of hot spots in Panhandle, East Adjacent, and Shoreline Areas (including LLRW encountered during hot spot excavation activities); (3) excavation of hot spots in Panhandle, East Adjacent, and Shoreline Areas with off-site disposal of LLRW and on-site consolidation of non-radiological hot spot material; and (4) excavation of solid waste and contaminated soil/sediment in Panhandle, East Adjacent, and Shoreline Areas, as needed to meet design requirements of a containment process option (for example, stable slopes along shoreline and altered topography to support wetlands restoration), with off-site disposal of LLRW and on-site consolidation of non-radiological material. These removal process options are evaluated in Sections 11.6.1, 11.6.2, 11.6.3, and 11.6.4.

11.6.1. Excavation with Off-Site Disposal of Solid Waste, Soil, and Sediment throughout Parcel E-2

This process option includes excavation and off-site disposal of all solid waste and contaminated soil in the Landfill Area and contaminated soil and sediment in the Panhandle, East Adjacent, and Shoreline Ares that may pose a risk to humans or wildlife. This material includes construction debris, industrial and municipal-type waste, contaminated soil, existing multilayer geosynthetic cap, and existing soil cover. Excavated areas would require backfilling with clean imported fill to provide proper drainage of surface water runoff. The depth of excavation required in the adjacent areas would be initially estimated based on the results of the risk assessment and the specified RAOs, and confirmation sampling would be used to evaluate post-excavation conditions. All excavated material, estimated at over 1 million cubic yards, would be disposed of at a licensed off-site facility authorized to accept wastes from a CERCLA site (per 40 CFR § 300.440, also referred to as the “CERCLA Off-Site Rule”). Because large excavation volumes are anticipated under this process option, transportation of excavated material by rail may be a cost-effective alternative to truck transport and would also minimize vehicle traffic through the local community.

An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Excavation and off-site disposal is a proven and reliable process option capable of addressing solid waste, soil, and sediment at Parcel E-2. Excavation and off-site disposal would meet the RAOs by (1) eliminating risk to humans and wildlife from exposure to contaminated solid waste, soil, and sediment; (2) eliminating leachate generation and subsequent effects to groundwater and surface water; and (3) eliminating generation of on-site landfill gas from waste decomposition. The potential human health and environmental effects that may be caused by implementation of this technology would be short-term and could be effectively managed by appropriate health and safety, dust control, and stormwater management procedures. These effects include windblown dust during excavation, sediment in stormwater runoff, and inhalation of volatile chemicals, such as VOCs. Dust would be controlled through regular spraying with water, and off-site sediment and volatile chemical migration would be controlled through proper construction techniques and BMPs and verified by site monitoring.

Implementability

Excavation is possible but may be very difficult to implement because of the depth of waste at the landfill, the proximity to surface water (the bay), and the proximity to adjacent non-Navy property. Difficulties associated with the removal of solid waste and soil from the landfill include:

- Slope stability during excavation
- Surface water control to prevent inundation resulting from tides or stormwater
- Groundwater inflow control for excavation below the water table
- Moisture content control and ease of dewatering of waste and soil prior to transportation and off-site disposal
- Dewatering of the subsurface during excavation and prior to backfilling
- Handling, disposal, and on-site treatment of contaminated water removed from open excavations or from excavated material (as it is dewatered prior to transportation)
- Radiological screening, characterization, and confirmation sampling of all soil and debris transported from the site (for disposal and treatment) and to the site (for backfill and restoration)
- Segregation and handling of a variety of waste types, including crushing or shredding large construction debris and segregating small radioluminescent devices from the surrounding soil and large debris
- Location of multiple, large-volume sources of backfill material that are free of contamination and do not contain metals concentrations in excess of existing ambient levels
- Import, placement, and compaction of the large volume of imported fill required for backfill to provide positive drainage
- Quantification of contaminated soil currently underlying the waste to be removed because of limited characterization data within the landfill
- Control of potential releases of chemicals from waste and soil during removal and transport through the surrounding neighborhood

Overcoming the technical difficulties identified above is possible, but will require a large expenditure of human and material resources. This process option would use proven techniques for which both skilled labor and appropriate equipment are readily available; however, the large volume of material contemplated for excavation would require a large number of labor hours and pieces of equipment that could exceed the available resources from the local area.

Excavations deeper than 3 feet bgs may require dewatering prior to and during excavation. This water must be managed by pumping and storage. Disposal or on-site treatment of any contaminated groundwater encountered is typically very expensive, so this option would require careful dewatering and excavation management to minimize costs. Sheet-pile walls or shoring would be required around the excavation to provide stable slopes for the deep excavations and to provide groundwater control for excavation below the water table. Installation of the sheet pile walls may not be possible at all locations because of large pieces of construction debris intermingled with the soil. Well-point dewatering systems could be installed if sheet-pile walls are not feasible at certain locations.

Backfilling the excavated areas would be required to restore Parcel E-2 for future open space use, including recreation areas and restored wetlands, as outlined in the 2010 amended Redevelopment Plan (SFRA, 2010). The backfilling plan, accounting for final elevations substantially lower than the pre-excavation elevations, would involve importing nearly 700,000 cubic yards of material that is free of contamination and does not contain metals concentrations in excess of existing ambient levels. The magnitude of this backfilling effort poses numerous technical difficulties including: (1) identifying acceptable sources of backfill material in the local area, in order to minimize transportation; (2) coordinating transportation of the material to the site (by truck, rail, or barge); (3) staging the large volume of material on-site while minimizing the impact to ongoing remediation efforts and reuse of other portions of HPS; and (4) managing the backfilling activities in conjunction with ongoing excavation and disposal activities.

Implementation of this process option would significantly affect the local community. There may also be effects on the neighboring communities located along the materials disposal and importation transportation route. These effects could include potential exposure to accidental releases of contaminated materials and nuisance effects, such as increased vehicle noise (from trucks and rail cars), vehicle congestion (from trucks), and odor issues (from exposed putrefiable waste). Foul odor complaints are likely to be the most prevalent of all nuisance complaints. This disturbance would be minimized with the use of a railroad-based transportation system for hauling the waste to disposal facilities, but this process option undoubtedly would take longer to implement and be more disruptive to the surrounding community during implementation than the technologies and process options considered under the containment GRA.

The administrative implementability of this process option is moderate. Excavation would result in removal of a considerable area (more than 3 acres) covered by wetlands and surface drainage routes. The excavation and restoration plan would incorporate avoidance and mitigation measures to minimize and compensate for such losses to adequately restore mudflat and wetland acreage.

Cost

The technical issues that make implementation of this process option difficult and require a large expenditure of human and material resources directly correspond to the high projected costs. The primary factors that result in the high costs of excavation and disposal are:

- Large volume of solid waste, soil, and sediment to be excavated and disposed of off site
- Large volume of solid waste, soil, and sediment to be screened for radiological contamination, sampled for characterization, and transported and treated or disposed of off site
- Extensive controls required to minimize, manage, treat (if necessary), and dispose of contaminated water during excavation and waste segregation processes
- Large volume of imported clean fill required for backfill to restore the site

Excavation of the solid waste throughout the Landfill Area would be much more costly than a containment action. Cost and implementation issues for this process option do not offset the long-term effectiveness of such an action, particularly considering the short-term risks associated with such a large-scale removal action.

For these reasons, removal actions for CERCLA landfills are routinely screened out in evaluations similar to the one performed in this subsection (EPA, 1994) and form the basis of the containment presumptive remedy. As presented in Section 8.2.3.4, the Parcel E-2 Landfill meets all of the criteria specified in EPA guidance for application of the containment presumptive remedy (see Appendix H). However, the Navy has agreed to fully evaluate excavation of the landfill as part of this report to provide information to support the community's review of potential remedial alternatives for Parcel E-2. Therefore, excavation and off-site disposal of all solid waste and contaminated soil in the Landfill Area will be retained as a potentially viable process option.

EPA guidance for military landfills (EPA, 1996) advises that the presumptive remedy should not be used where excavation is considered; however, the Navy believes that, based on site-specific considerations, excavation should also be evaluated to address community concerns although this goes beyond the requirements of the presumptive remedy policy. This approach is consistent with EPA's directive titled "Presumptive Remedies: Policy and Procedures" (pp. 1-2, EPA 1993b), which states that "there may be unusual circumstances (such as, complex contaminant mixtures, soil conditions, or extraordinary State and community concerns) that may require the site manager to look beyond the presumptive remedies for additional (perhaps more innovative) technologies or remedial approaches." In addition, this approach was applied in the Remedial Action Plan and ROD prepared for the landfill within Investigation Area H1 at the former Mare Island Naval Shipyard (Weston Solutions, Inc, 2006).

Although the containment presumptive remedy does not apply to the Panhandle Area, East Adjacent Area, and Shoreline Area, the Navy recognizes that site conditions at these areas and their proximity to the Landfill Area present opportunities to streamline the remedy evaluation process by focusing on remediation technologies that can be closely aligned with actions at the Landfill Area. This type of focused remedy evaluation process for the Panhandle Area, East Adjacent Area, and Shoreline Area is consistent with the streamlining approach outlined in pages 8704-8705 of the 1990 NCP Preamble

(55 Federal Register 8704-8705, March 8, 1990) and in Section 4.1.3.1 of EPA's RI/FS guidance (EPA, 1988a).

In accordance with the streamlining approach outlined in the NCP, excavation and off-site disposal will be retained as a process option for the contaminated soil and sediment in the Panhandle, East Adjacent, and Shoreline Areas that may pose a risk to humans or wildlife. Shallow excavation throughout these areas (to depths between 2.5 and 3 feet bgs) could be aligned with the excavation of all solid waste and contaminated soil in the Landfill Area.

Excavation and Off-Site Disposal of Solid Waste, Soil, and Sediment throughout Parcel E-2 – General Screening

- Effectiveness: Moderate to High (short-term risks associated with removal of landfill wastes)
- Implementability: Low-Moderate (multiple issues associated with excavation, transport, and disposal of the large anticipated volume of landfill solid waste and soil)
- Cost: Very High (most costly option screened for this evaluation)
- Retained for Further Analysis: Yes (to support the community's review of potential remedial alternatives for Parcel E-2)

11.6.2. Excavation and Off-Site Disposal of Hot Spots in the Panhandle, East Adjacent, and Shoreline Areas

This process option includes excavation and off-site disposal of hot spots in the Panhandle, East Adjacent, and Shoreline Areas. EPA guidance and the NCP provide the following information regarding definition of hot spots and evaluation of their removal and treatment:

- Hot spots consist of highly toxic and highly mobile material and present a potential principal threat to human health or the environment (EPA, 1991a).
- Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur (EPA, 1991b).
- Treatment of the principal threats posed by a site, with priority placed on treating waste that is liquid, highly toxic, or highly mobile, will be combined with engineering controls (such as containment) and institutional controls, as appropriate, for treatment residuals and untreated waste (55 Federal Register 8846, March 8, 1990).

As discussed in Section 8.2.3.4, the potential hot spots in the Landfill Area are not principal threat wastes; however, several locations in the East Adjacent Area, most notably the western and southwestern sidewall of the PCB Hot Spot Area excavation, contain liquid and highly toxic wastes that may be considered principal threats. In addition to evaluating removal of these potential principal threats, the Navy assessed the benefit of expanded hot spot removal (to enhance the performance of a remedial alternative relative to the RAOs) based on the following factors:

- The potential for the soil hot spots to be a continuing source to groundwater contamination (for example, chemicals that were identified in both soil and groundwater at concentrations exceeding RIECs)
- The magnitude of soil concentrations relative to RIECs (or alternative ecological risk-based criteria)
- The proximity of the potential hot spot relative to San Francisco Bay (which increases the likelihood of its affect on aquatic wildlife)

Additional hot spots identified using these criteria include soil in the Metal Slag Area and soil from various inland locations in the Panhandle and East Adjacent Areas. If implemented in conjunction with a containment process option in the Landfill Area, the removal of hot spots and associated backfilling activities could be integrated with the larger-scale grading required for landfill cap construction. Based on the criteria outlined above, the hot spot excavation volume is anticipated to be lower than the substantial volume of material removed to date at the PCB Hot Spot Area and Metal Slag Area (52,700 cubic yards).

Similar to the procedures used during the previous removal actions, all excavated material would be screened to segregate any radiologically impacted material. All excavated hot spot material, as well as LLRW encountered during excavation activities, would be transported by truck and disposed of at a licensed off-site facility authorized to accept wastes from a CERCLA site (per 40 CFR § 300.440, also referred to as the "CERCLA Off-Site Rule"). Highly toxic or mobile wastes would be treated prior to disposal, if deemed necessary following waste characterization. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Excavation and off-site disposal is a proven and reliable process option capable of addressing hot spot material at Parcel E-2. Hot spot excavation would (1) prevent exposure to potential principal threat wastes, and (2) reduce the potential for hot spots to serve as a source to groundwater contamination. Off-site disposal of the hot spot material would involve placement at a licensed disposal facility with engineered containment systems, and may also include additional treatment. The potential human health and environmental effects that may be caused by implementation of this technology would be short-term and could be effectively managed by appropriate health and safety, dust control, and stormwater management procedures. These effects include windblown dust during excavation, sediment in stormwater runoff, and inhalation of volatile chemicals, such as VOCs. Dust would be controlled through regular spraying with water, and off-site sediment and volatile chemical migration would be controlled through proper construction techniques and BMPs and verified by site monitoring.

Implementability

Excavation of hot spots has been successfully implemented in the past at Parcel E-2. Excavation near the shoreline poses several technical challenges, but these can be overcome with proper excavation techniques, control of groundwater and surface water inflow, and dewatering.

Off-site transportation of excavated waste would affect the local community but would be similar to the disturbance encountered during previous removal actions. The administrative implementability of this process option is high, as it has been accepted and implemented at this site in the past.

Cost

Based on the moderate excavation volume for this process option (less than the volume removed during interim actions at Parcel E-2), the cost of hot spot excavation and off-site disposal is considered moderate to high. Although the anticipated excavated volume is not large, radiological screening, excavation dewatering, and off-site disposal adds significant cost. As such, expansion of the hot spot volume based on unanticipated site conditions could substantially increase the cost of this process option.

Excavation and Off-Site Disposal of Hot Spots in the Panhandle, East Adjacent, and Shoreline Areas – General Screening

- Effectiveness: High
- Implementability: High
- Cost: Moderate to High
- Retained for Further Analysis: Yes

11.6.3. Excavation of Hot Spots in the Panhandle, East Adjacent, and Shoreline Areas with On-Site Consolidation and Off-Site Disposal

This process option includes excavation of hot spots in the Panhandle, East Adjacent, and Shoreline Areas with off-site disposal of LLRW and on-site consolidation of nonradiological hot spot material. This process option is identical to the option evaluated in Section 11.6.2 with the exception of nonradiological hot spot material being consolidated on site in conjunction with a containment process option.

An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Excavation and on-site consolidation of hot spot material would (1) prevent exposure to potential principal threat wastes and (2) reduce the potential for hot spots to serve as a source to groundwater contamination. The hot spot material would be placed under an engineered cap and the disposal unit would be subject to leachate collection and treatment requirements. The potential principal threat wastes at the PCB Hot Spot Area are not highly mobile, and the planned leachate collection system is considered adequate to protect human health and the environment. However, the on-site containment system would not be as robust as those at licensed disposal facilities.

The potential human health and environmental effects that may be caused by implementation of this technology would be short-term and could be effectively managed by appropriate health and safety, dust control, and stormwater management procedures. These effects include windblown dust during excavation, sediment in stormwater runoff, and inhalation of volatile chemicals, such as VOCs. Dust would be controlled through regular spraying with water, and off-site sediment and volatile chemical migration would be controlled through proper construction techniques and BMPs and verified by site monitoring.

Implementability

Excavation of hot spots has been successfully implemented in the past at Parcel E-2. Excavation near the shoreline poses several technical challenges, but these can be overcome with proper excavation techniques, control of groundwater and surface water inflow, and dewatering.

Implementation of this process option would negligibly affect the local community, as the excavated volume anticipated to be transported off site as LLRW is low and would create minimal disturbance. The administrative implementability of this process option is moderate because on-site consolidation of hot spot material may not be viewed by the regulatory agencies as favorably as off-site disposal.

Cost

The cost associated with this process option is considered moderate. Costs are controlled by limiting the volume of material requiring off-site disposal; however, costs for radiological screening, excavation dewatering, and off-site disposal are significant.

Excavation of Hot Spots in the Panhandle, East Adjacent, and Shoreline Areas with Off-Site Disposal and On-Site Consolidation – General Screening

- Effectiveness: Moderate
- Implementability: Moderate
- Cost: Moderate
- Retained for Further Analysis: No (potential issues with administrative implementability)

11.6.4. Excavation of Solid Waste, Soil, and Sediment in the Panhandle, East Adjacent, and Shoreline Areas with On-Site Consolidation and Off-Site Disposal

This process option includes excavation of solid waste and contaminated soil and sediment in the Panhandle, East Adjacent, and Shoreline Areas to meet design requirements of a containment process option (e.g., stable slopes along shoreline and altered topography to support wetlands restoration). This process option would be implemented in conjunction with a hot spot removal and disposal process option, and would include off-site disposal of LLRW and on-site consolidation of nonradiological wastes. Additional industrial debris (such as drums and associated liquid wastes) and MDAS (such as empty shell casings) would be disposed of off site with any potential LLRW.

All excavated material would be screened to determine if it is radiologically impacted. Based on data from the removal actions at the Metal Slag Area and PCB Hot Spot Area, potential LLRW encountered during hot spot removal would be low compared to the overall excavation volume. Therefore, transportation of excavated material to an off-site disposal location by truck would be very limited, resulting in minimal impact on the local community. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

If combined with a containment process option, excavation and on-site consolidation of non-radiological wastes would be effective, consistent with the rationale provided in Section 11.5.1, by (1) reducing risk to humans and wildlife from exposure to contaminated solid waste, soil, and sediment; and (2) reducing leachate generation and subsequent effects to groundwater and surface water. The lower level contamination associated with the excavated material, as compared to hot spot material, could be reliably contained by the planned on-site control system. In addition, contaminated material located near the shoreline would be relocated to an upland location prior to capping, thereby further reducing the potential impact to aquatic life in San Francisco Bay.

The potential human health and environmental effects that may be caused by implementation of this technology would be short-term and could be effectively managed by appropriate health and safety, dust control, and stormwater management procedures. These effects include windblown dust during excavation, sediment in stormwater runoff, and inhalation of volatile chemicals, such as VOCs. Dust would be controlled through regular spraying with water, and off-site sediment and volatile chemical migration would be controlled through proper construction techniques and BMPs and verified by site monitoring.

Implementability

Excavation near the shoreline poses several technical challenges, but these can be overcome with proper excavation techniques, control of groundwater and surface water inflow, and dewatering. Implementation of this process option would negligibly affect the local community, as the excavated volume anticipated to be transported off site as LLRW is low and would create minimal disturbance. The administrative implementability of this process option is high, because the material to be consolidated on-site is not highly toxic or highly mobile.

Cost

The costs associated with this process option are considered moderate. Although the anticipated volume of LLRW requiring off-site disposal is not large, radiological screening, excavation dewatering, and off-site disposal adds significant cost.

Excavation of Solid Waste, Soil, and Sediment in the Panhandle, East Adjacent, and Shoreline Areas with Off-Site Disposal and On-Site Consolidation – General Screening

- Effectiveness: High
- Implementability: High
- Cost: Moderate
- Retained for Further Analysis: Yes

11.7. SUMMARY OF SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

The remedial technologies and process options evaluated in the previous subsections are summarized in a flow chart (Figure 11-1). Included in the flow chart are brief descriptions of the evaluated technologies and process options, the results of their evaluation with respect to the three criteria (effectiveness, implementability, and cost), and the determination of whether or not they have been retained for consideration as a remedial alternative.

As discussed in Section 11.6, the decision to retain excavation and off-site disposal as a potentially viable process option for the Landfill Area was made despite the implementation difficulties and very high costs (which, as previously determined by EPA, typically result in the elimination of such an option from consideration [EPA, 1994]). In light of feedback from members of the local community, the Navy has decided to fully evaluate excavation and off-site disposal as a remedial alternative to support the community's review of potential remedial alternatives for Parcel E-2. Also, excavation and off-site disposal will be retained as a process option for the contaminated soil and sediment in the Panhandle, East Adjacent, and Shoreline Areas because shallow excavation throughout these areas (to depths between 2.5 and 3 feet bgs) could be aligned with the excavation of all solid waste and contaminated soil in the Landfill Area.

The containment process options retained for the Landfill Area can be closely aligned with the response action for the contaminated soil and sediment in the Panhandle, East Adjacent, and Shoreline Areas. In particular, a combination of containment and hot spot removal for these areas can be integrated with the larger-scale grading required for landfill cap construction. Two removal process options will be retained and integrated with containment process options: (1) off-site disposal of hot spot material and LLRW encountered during site excavation; and (2) on-site consolidation of other contaminated material excavated to meet design requirements of a containment process option.

As discussed in Section 11.5.4, two process options for landfill gas treatment were retained (1) treatment by adsorption, and (2) destruction by combustion. In addition, destruction by noncombustion processes was retained as a viable option that may be appropriate to implement in the future; however, this option was not included in any of the proposed remedial alternatives (presented in Section 12) because the need for its implementation cannot be supported by existing data. Additional studies would be needed to identify the volume and concentrations of gas within the landfill to determine the appropriate treatment or destruction type; this study will be scoped, performed, and summarized as part of the RD process.

11.8. WETLANDS MITIGATION ALTERNATIVES

Implementation of any containment or removal action that would alter existing site conditions will affect Parcel E-2 wetlands. Compliance with regulations for wetlands protection (in accordance with the Clean Water Act § 404 and the San Francisco Bay Plan [14 CCR, §§ 10110 through 11990]) will require that such effects be addressed through the established wetlands mitigation process. The mitigation process options and the alternatives available for wetlands mitigation are detailed in Appendix O and briefly summarized in this subsection.

Under the above-listed regulations, the major approaches to addressing wetlands effects (in order of preference) are avoidance, minimization, and compensation. Due to overlapping distributions of wastes in the Landfill Area and adjacent areas with wetlands (Panhandle and Shoreline Areas), avoidance is not feasible with any of the engineering approaches to site remediation. Minimization of effects is an approach that will be used and would be part of designing and planning the engineering of excavation or containment of the landfill and adjacent areas. Wetlands mitigation likely will be needed to compensate for the loss of wetlands. The following mitigation approaches have been identified:

- Wetlands mitigation banking
- Wetlands restoration within HPS at areas not affected by COCs and COECs; this could be an area outside of Parcel E-2 or within Parcel E-2 following excavation; this option could be assembled into an alternative with excavation of the Landfill Area and the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas)
- Wetlands restoration in Parcel E-2 on top of a prepared subgrade with hydric soil cover and constructed cap; this option could be assembled into an alternative involving containment of the Landfill Area and the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas)

Each mitigation approach is discussed and evaluated in detail in Appendix O.

Figures

Medium: Solid Waste and Soil in Landfill, Panhandle, and East Adjacent Areas; Sediment in Shoreline Area

General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
No Action	None	None	No additional action would be taken to address solid waste and soil in the Landfill Area, Panhandle Area or East Adjacent Area, or sediment in the Shoreline Area.	Required by the NCP and is used as a baseline against which other response actions are compared - would not meet RAOs.	Low	High	No Cost	Yes
Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications); Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Restrict the use of the parcel to open space • Require maintenance of control systems • Maintain the integrity of covers (or access restrictions where covers are not present) • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as, subsurface construction)	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
	Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing); Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
	Site Monitoring	Short-Term Monitoring; Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction that may disturb contaminated solid waste, soil, or sediment. Long-term monitoring includes operation and maintenance of control systems (such as, inspection and maintenance of caps/covers).	Although monitoring alone would not achieve RAOs, short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	Low	High	Low	Yes
Containment	Caps/Covers	Low-Permeability Soil Cap	The low-permeability soil cap system (Title 27 cover, prescriptive standard) includes a low-permeability soil layer (such as clay) at least 12 inches thick with a maximum permeability of $1x10^{-6}$ cm/sec or equal to the hydraulic conductivity of the base liner system.	Limited local sources of low-permeability soil; costly to purchase and import large volumes of suitable low-permeability soils.	High	Moderate-High	Moderate-High	Yes (for potential focused application at freshwater wetlands)
		Geosynthetic Cap	The geosynthetic cap system (Title 27 cover, engineered alternative) would include a 60-mil-thick HDPE geomembrane in place of the low-permeability soil layer (typical permeability is $1x10^{-13}$ cm/sec)	Highly effective and implementable with proper QA/QC, skilled labor, and appropriate supplies and equipment.	High	High	Moderate	Yes
		Multilayer Geosynthetic Cap	The multilayer geosynthetic cap system includes a composite low-permeability layer consisting of an HDPE geomembrane at least 60 mils thick over a GCL (typical permeability of GCL is $5x10^{-9}$ cm/sec)	Already installed over a portion of the waste area; highly effective and implementable with proper QA/QC, skilled labor, and appropriate supplies and equipment.	High	High	Moderate-High	Yes
		Evapotranspiration Cap	An evapotranspiration cap is typically a 4- to 6-foot-thick soil layer over a soil foundation layer; it acts to store moisture within the cap thickness, while minimizing infiltration, until the moisture is removed through vegetative uptake or evaporation.	Diminished effectiveness in temperate climates; ideal in arid or semi-arid climates; would require importation of a significant amount of cover soil and may encroach on neighboring property.	Moderate	Low	Moderate to High	No (not implementable given limited space and temperate climate)
	Shoreline Protection*	Armoring	Armoring includes seawalls, bulkheads, and protective revetments.	Armoring would protect the containment systems from erosion, and allow freshwater wetlands to be established in the Panhandle Area.	High	High	High	Yes
		Shoreline Stabilization	Shoreline stabilization includes man-made structures (such as nearshore breakwaters and reefs) or natural material (such as vegetation or sand fill) used to moderate the coastal sediment transport processes and reduce the local erosion rate.	Shoreline stabilization would be effective In areas planned for tidal wetlands restoration.	Moderate	High	Moderate to High	Yes
		Shoreline Nourishment	Shoreline nourishment can include berms, dunes, feeder beach, nearshore berm, dune stabilization, or structural stabilization.	Inadequate area for proper implementation; would not prevent erosion.	Low	Low	Moderate	No (not implementable within narrow Shoreline Area)
Removal	Excavation	Excavation/Off-Site Disposal 1. Landfill Area 2. Soil in adjacent areas	Excavation and off-site disposal of all solid waste and contaminated soil in the Landfill Area, and contaminated soil/sediment in Panhandle, East Adjacent, and Shoreline Areas that may pose a risk to human health and the environment	Multiple issues associated with excavation and transport of such a large volume of landfill solid waste and soil.	Moderate-High	Low-Moderate	Very High	Yes (to support community review of potential remedies)
		Excavation/Off-Site Disposal 1. Hot spots in adjacent areas 2. Incidental LLRW	Excavation and off-site disposal of hot spots in Panhandle, East Adjacent, and Shoreline Areas (including LLRW encountered during hot spot excavation activities)	Primary hot spots consist of liquid and highly toxic wastes in the PCB Hot Spot shoreline; additional removal at other locations in the Panhandle and East Adjacent Areas to enhance performance of remedy..	High	High	Moderate to High	Yes
		Excavation/On-Site Consolidation of hot spots in adjacent areas (with off-site disposal of incidental LLRW)	Excavation of hot spots in Panhandle, East Adjacent, and Shoreline Areas with off-site disposal of LLRW and on-site consolidation of non-radiological hot spot material	Hot spots are not mobile and planned leachate collection/treatment system is considered adequate but not as robust as off-site disposal facilities	Moderate	Moderate	Moderate	No (potential issues with administrative implementability)
		Excavation/On-Site Consolidation of contaminated material in adjacent areas (with off-site disposal of incidental LLRW)	Excavation of solid waste and contaminated soil/sediment in Panhandle, East Adjacent, and Shoreline Areas, as needed to meet design requirements of a containment process option (for example, stable slopes along shoreline and altered topography to support wetlands restoration), with off-site disposal of LLRW and on-site consolidation of non-radiological material	Specific hot spot removal areas include surface soils in the Metal Slag Area, soils along the PCB Hot Spot shoreline, soils along the Landfill Area Shoreline, and soils from various inland locations in the Panhandle and East Adjacent Areas.	High	High	Moderate	Yes

Legend

- Retained for use in Remedial Alternatives (green)
- Retained for possible future incorporation (based on future site data) (yellow)
- Eliminated from consideration (orange)

Notes:
* Required in Shoreline Area
Acronyms defined on page 4

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FIGURE 11-1
Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

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Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Landfill Gas in Parcel E-2	No Action	None	None	No additional action would be taken to remove or treat landfill gas.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Require maintenance of control systems • Ensure compliance with 27 CCR requirements for construction within 1,000 feet of a landfill, such as the requirement for gas control systems on any installed subsurface structures or other areas in which landfill gas may accumulate	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing) Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction that may affect landfill gas migration. Long-term monitoring includes monitoring of gas monitoring probes, subsurface structures, and site structures; also includes operation and maintenance of gas control systems.	Although monitoring alone would not achieve RAOs, short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	Low	High	Low	Yes
	Containment	Landfill Gas Collection	Passive Venting	A passive system at Parcel E-2 would include a series of venting wells extending from below the historic low water table elevation through the cap and discharging to the atmosphere above the surface of the cap.	Diminished effectiveness at landfills with no bottom and sidewall liner system, or landfills with insufficient buffer space between the edge of waste and the compliance points; if NMOC treatment is required at the discharge points, the required treatment systems could restrict landfill gas venting, rendering venting less effective.	Moderate	High	Low	Yes
			Active Collection	Active landfill gas collection uses vacuum blowers to extract landfill gas through vertical extraction wells installed and plumbed together; gases are drawn to a central collection point to create an inward pressure gradient to prevent outward landfill gas migration.	More effective with geosynthetic caps in shallow landfills because geosynthetic materials offer a better barrier against vacuum short-circuiting to the surface.	High	High	Moderate	Yes
	Treatment (gas treatment and/or destruction) *	Adsorption (via GAC and Hydrosil®)	GAC Hydrosil® (permanganate-impregnated zeolite medium)	GAC would remove SVOCs and most VOCs; could be used with either passive or active collection systems. Hydrosil® would remove lighter VOCs such as vinyl chloride; could be used with either passive or active collection systems.	Treatment units could restrict the airflow of passive venting systems, rendering them less effective.	High	High	Low (if NMOC concentrations are low) High (if NMOC concentrations are high, following capping of the entire landfill)	Yes
		Destruction (via combustion)	Enclosed Flare	An enclosed flare would destroy landfill gas, including NMOCs and methane, through combustion; primary chemical by-products from flares are carbon dioxide and nitrogen oxide compounds.	Operating conditions would reduce the possibility of dioxin formation by promoting the destruction of organics, operating at temperatures above those that would allow dioxin formation followed by rapid quenching, and extending the combustion residence time.	High	Moderate to High	Low to Moderate	Yes
			Open Flare	Eliminated from consideration due to poor system controls (relative to enclosed flares).		N/A	N/A	N/A	N/A
			Internal Combustion Engine	Eliminated from consideration because volume of gas generated by the Parcel E-2 Landfill is not anticipated to be sufficient to support the cost-effective implementation of internal combustion engines.		N/A	N/A	N/A	N/A
		Destruction (via non-combustion processes)	Energy Recovery Gas-to-Product	Energy recovery technologies, such as fuel cells, use landfill gas to produce energy directly. Gas-to-product conversion technologies focus on converting landfill gas into commercial products, such as compressed natural gas, methanol, purified carbon dioxide and methane, or liquefied natural gas.	Effectiveness of energy recovery and gas-to-product systems at Parcel E-2 is unknown due to the lack of information on gas concentration generation rates (assumed moderate to high, depending on implementability).	Likely Low (assumed moderate to high, if implementable at Parcel E-2)	Likely Low (site-specific conditions need to be better defined)	High	Yes

Legend

- Retained for use in Remedial Alternatives (green)
- Retained for possible future incorporation (based on future site data) (yellow)
- Eliminated from consideration (orange)

Notes:
* Additional data are needed to determine the type(s) of treatment required for landfill gas at Parcel E-2.
Acronyms defined on page 4

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FIGURE 11-1 (cont.)
Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

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Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Groundwater in Parcel E-2	No Action	None	None	No action would be taken to remove, contain or treat groundwater; no institutional controls would be established to prevent exposure, and no monitoring would be required.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as subsurface construction • Restrict the use of groundwater within the Parcel E-2 boundaries • Prohibit the installation of wells that have the potential to affect the migration of contaminated groundwater within Parcel E-2.	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and would be required to prevent exposure to groundwater within the Parcel E-2 boundaries.	High	High	Low	Yes
		Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing) Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction of groundwater control systems. Long-term monitoring includes groundwater monitoring and operation and maintenance of groundwater control systems.	Although monitoring alone would not achieve RAOs, short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	Low	High	Low	Yes
	Containment	Physical Barrier	Slurry Wall	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Physical barrier may need to be complemented with hydraulic barrier to prevent excessive groundwater mounding.	Moderate to High	Moderate to High	Moderate to High	Yes
			Grout Curtain Vertical Geomembrane	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Site-specific conditions limit the implementability of these options.	Moderate to High	Low to Moderate	Moderate to High	No (not implementable given site-specific conditions)
			Sheet Pile Wall	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Physical barrier may need to be complemented with a hydraulic barrier to prevent excessive groundwater mounding. Corrosion potential limits effectiveness and presence of large debris limits implementability.	Moderate	Moderate	Moderate to High	No (issues regarding effectiveness and implementability)
		Hydraulic Barrier	Flow Diversion Drain	Flow diversion drain coupled with a physical barrier would be installed on the upgradient side of the landfill to reduce groundwater flow through the waste. Drain would divert flow to reduce groundwater mounding behind the physical barrier.	Flow diversion drain is a passive technology requiring no operation, and minimal maintenance after installation.	Moderate to High	High	Low	Yes
			Extraction from Wells & Off-Site Discharge	System would extract groundwater through pumping wells to contain groundwater and achieve RAOs at compliance points; extracted groundwater could be discharged to the sanitary sewer system, treated and reinjected, or treated and discharged to the Bay.	Groundwater modeling would be required to optimize extraction well placement and pumping rates, and to minimize the volume of water pumped from the Parcel E-2 aquifers; the required level of treatment would greatly influence cost.	Moderate to High	High	High	Yes
			Phytoremediation / Phytohydraulics	Phytohydraulics would use of plants to control rainfall infiltration and groundwater levels and movement; plants would remove water through evapotranspiration. In addition to hydraulic control, phytoremediation could potentially help reduce chemical concentrations in subsurface soils and groundwater.	Further studies would be required to identify plant species that could tolerate brackish groundwater, determine required planting area size and plant density. Space requirements may be incompatible with site conditions.	Moderate to High	Low	Low to Moderate	No (issues regarding implementability)
	Treatment	Reactive Barrier	Permeable Reactive Barrier	Permeable reactive barrier would be installed along the shoreline to breakdown contaminants in groundwater flowing off site.	Permeable reactive barrier is a passive technology that may require periodic reinjection of reagent to maintain effectiveness. Technology is unproven for treatment of landfill leachate in a tidal environment.	Undetermined in the short term; Low in the long term	Low	High	No (issues regarding effectiveness, implementability, and cost)

Legend

- Retained for use in Remedial Alternatives
- Retained for possible future incorporation (based on future site data)
- Eliminated from consideration

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FIGURE 11-1 (cont.)
Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

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Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Surface Water in Parcel E-2	No Action	None	None	No action would be taken to monitor or manage stormwater runoff and groundwater discharges to wetlands and the Bay at Parcel E-2; no institutional controls would be established to prevent exposure to surface water.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Restrict the use of the parcel to open space • Require maintenance of stormwater BMPs • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as, subsurface construction)	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing) Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring Stormwater BMPs	Short-term monitoring involves stormwater monitoring during construction. Long-term monitoring includes surface water monitoring and inspection and maintenance of stormwater BMPs. Monitoring of surface water is used to demonstrate compliance with RAOs designed to prevent unacceptable exposures to aquatic receptors in the bay.	Although monitoring alone would not achieve RAOs, a stormwater monitoring program, including stormwater BMPs, would be implemented in conjunction with an inspection and maintenance for any containment systems.	Low	High	Low	Yes

Legend

- Retained for use in Remedial Alternatives
- Retained for possible future incorporation (based on future site data)
- Eliminated from consideration

Acronyms

BMP	best management practice
CCR	California Code of Regulations
cm/sec	centimeters per second
GAC	granular activated carbon
GCL	geosynthetic clay liner
GRA	general response action
HDPE	high-density polyethylene
LLRW	low-level radioactive waste
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NMOC	nonmethane organic compound
PCB	polychlorinated biphenyl
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
QA	quality assurance
QC	quality control
SVOC	semivolatile organic compound
VOC	volatile organic compound

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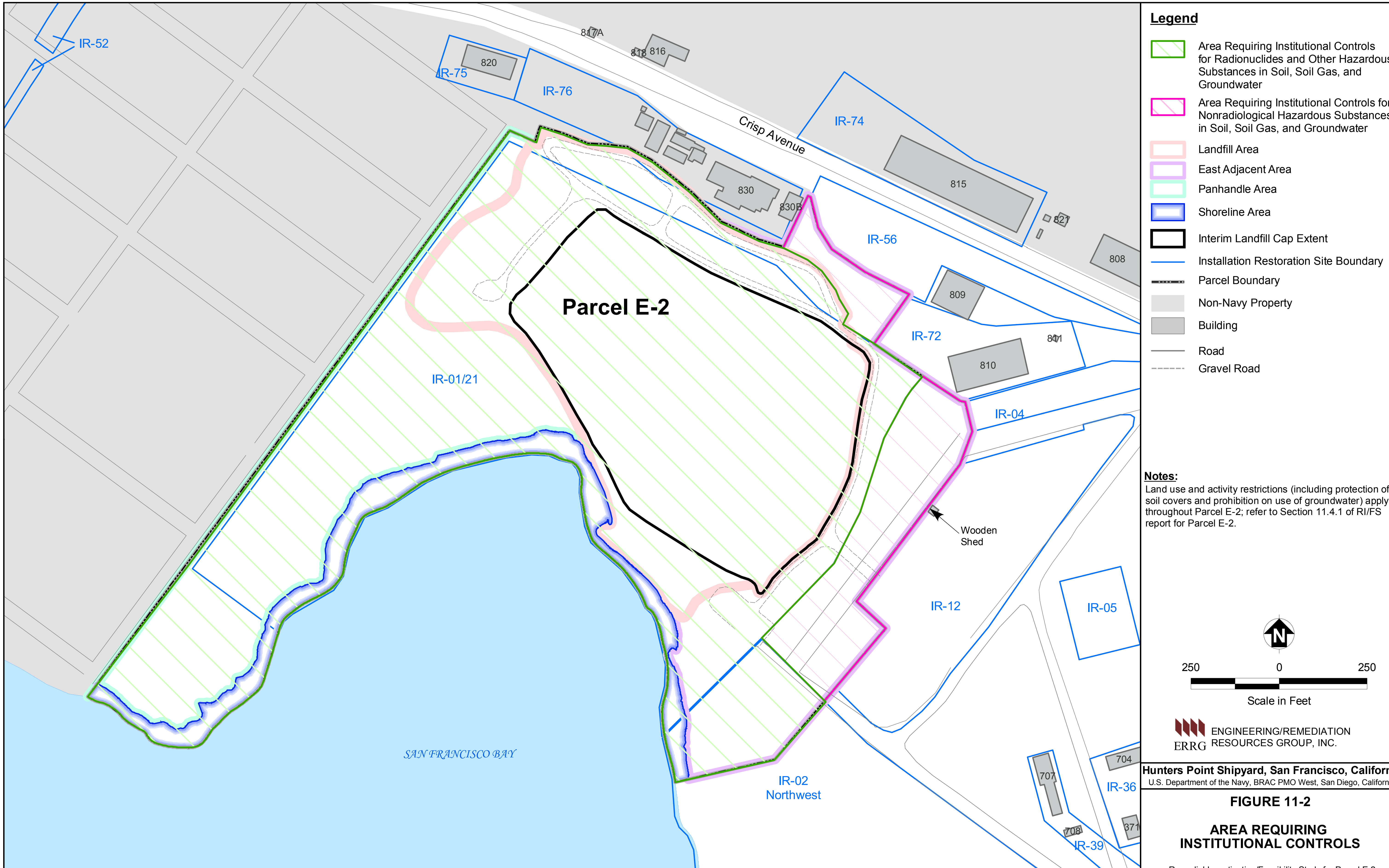
FIGURE 11-1 (cont.)
Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

N:\projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\Graphics\Remedial Technology Screening Table_03-25-10.vsd



Notes:
Land use and activity restrictions (including protection of soil covers and prohibition on use of groundwater) apply throughout Parcel E-2; refer to Section 11.4.1 of RI/FS report for Parcel E-2.

ENGINEERING/REMEDIATION RESOURCES GROUP, INC.
ERRG

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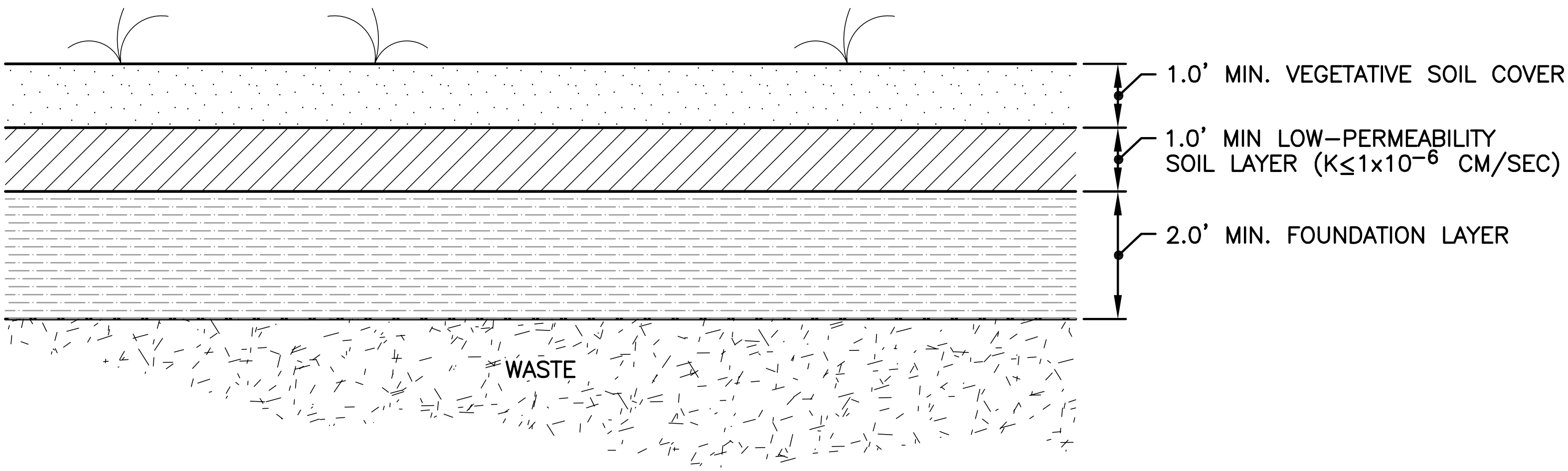
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 11-2

AREA REQUIRING INSTITUTIONAL CONTROLS

Remedial Investigation/Feasibility Study for Parcel E-2

N:\projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\IC_for_Radionuclides.mxd



LOW-PERMEABILITY SOIL CAP

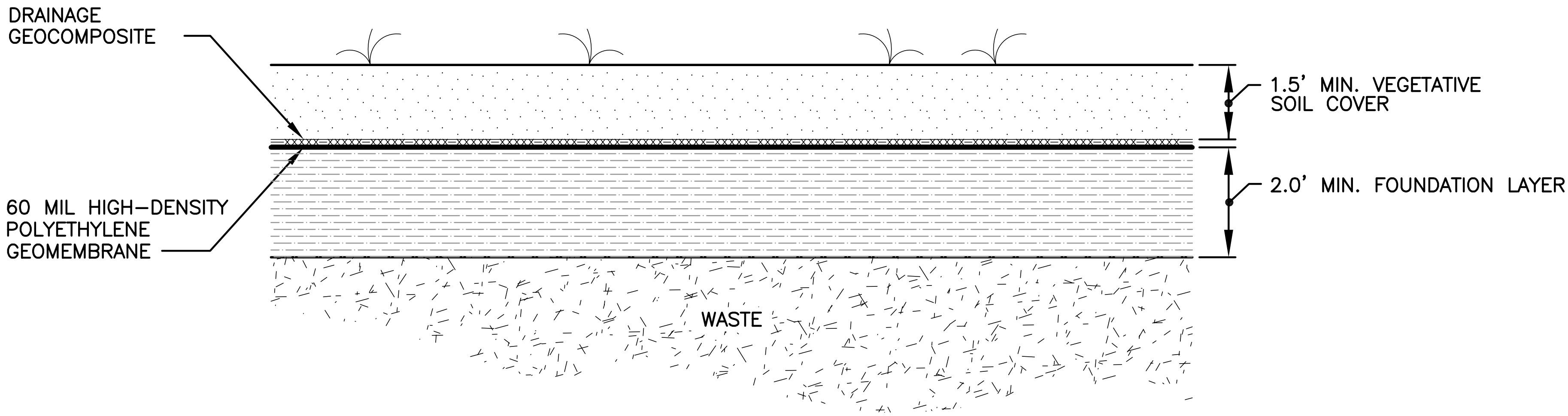
SHAW Environmental, Inc.

Hunters Point Shipyard, San Francisco, California

Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-3
LOW-PERMEABILITY
SOIL CAP

Remedial Investigation/Feasibility Study for Parcel E-2



GEOSYNTHETIC CAP

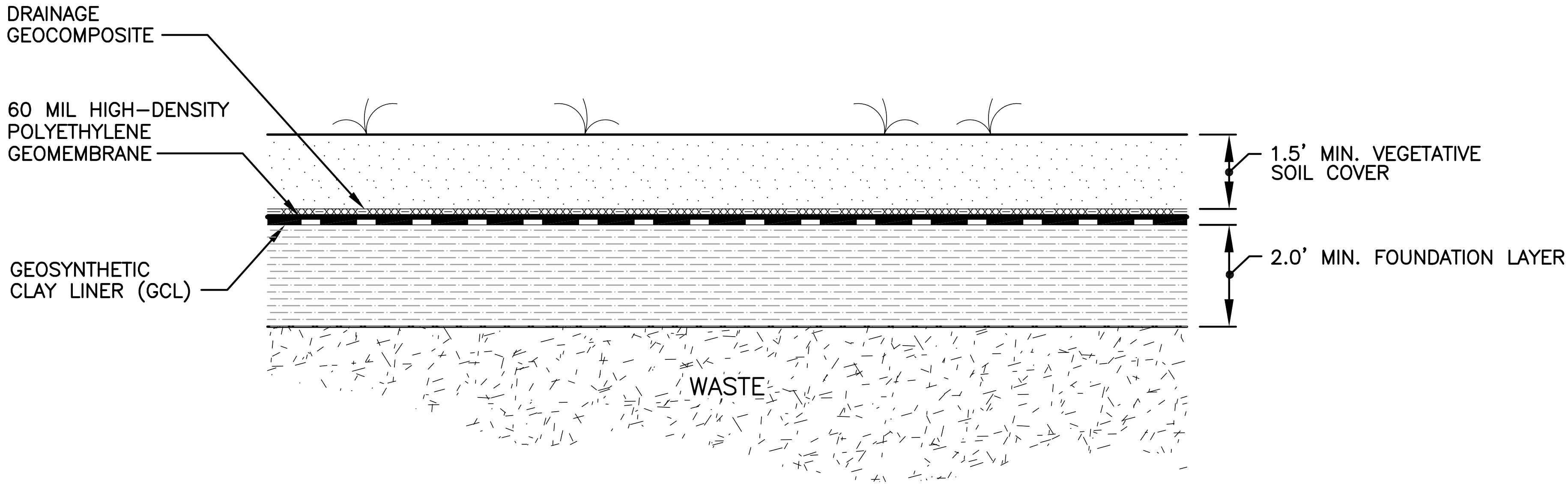
SHAW Environmental, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-4
GEOSYNTHETIC CAP

Remedial Investigation/Feasibility Study for Parcel E-2

XREF Files: IMAGE Files:
File: N:\cad\DWG\HuntersPoint\FINAL FIGURES\SJHP-FIG11-5.dwg Layout: 7-2005 User: kathy.troyer Jan 16, 2007 - 10:54am



MULTILAYER GEOSYNTHETIC CAP

Shaw®

SHAW Environmental, Inc.

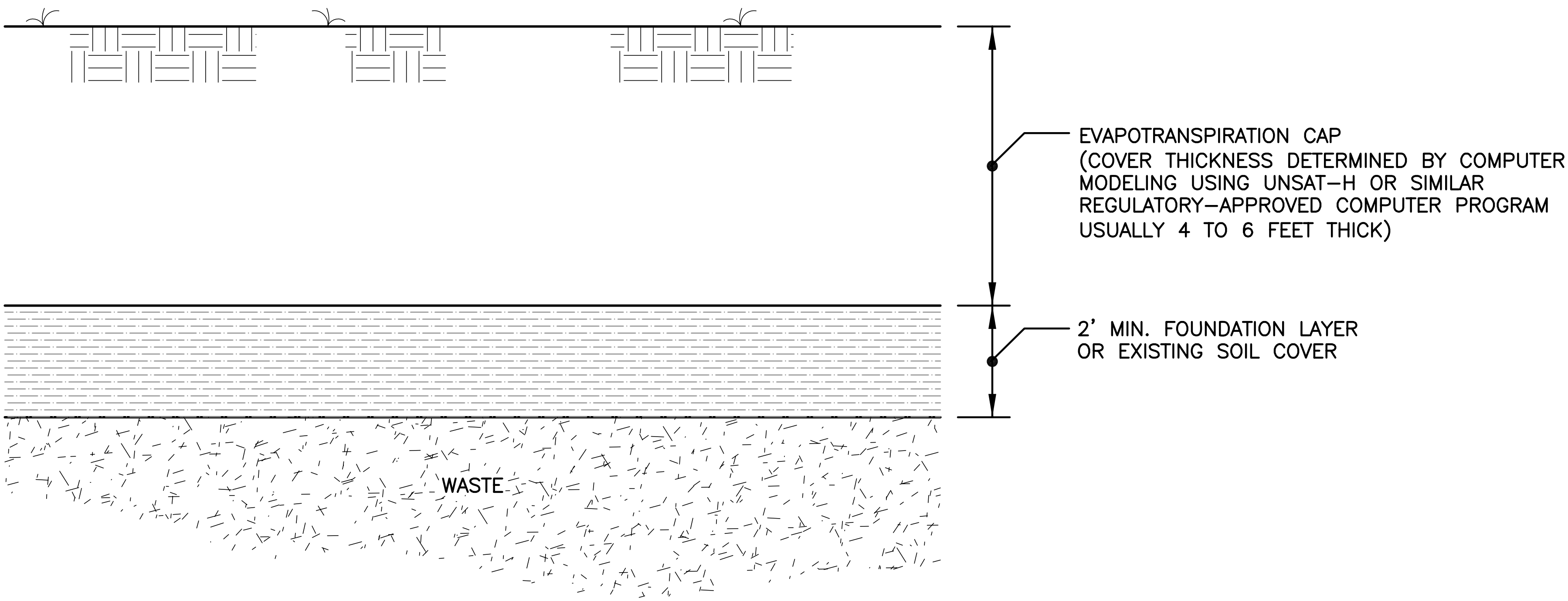
Hunters Point Shipyard, San Francisco, California

Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-5
MULTILAYER
GEOSYNTHETIC CAP

Remedial Investigation/Feasibility Study for Parcel E-2

XREF Files: IMAGE Files:
File: N:\cad\DWG\HuntersPoint\FINAL FIGURES\SJHP-FIG11-6.dwg Layout: 7-2005 User: kathy.troyer Jan 16, 2007 - 10:59am



EVAPOTRANSPIRATION CAP

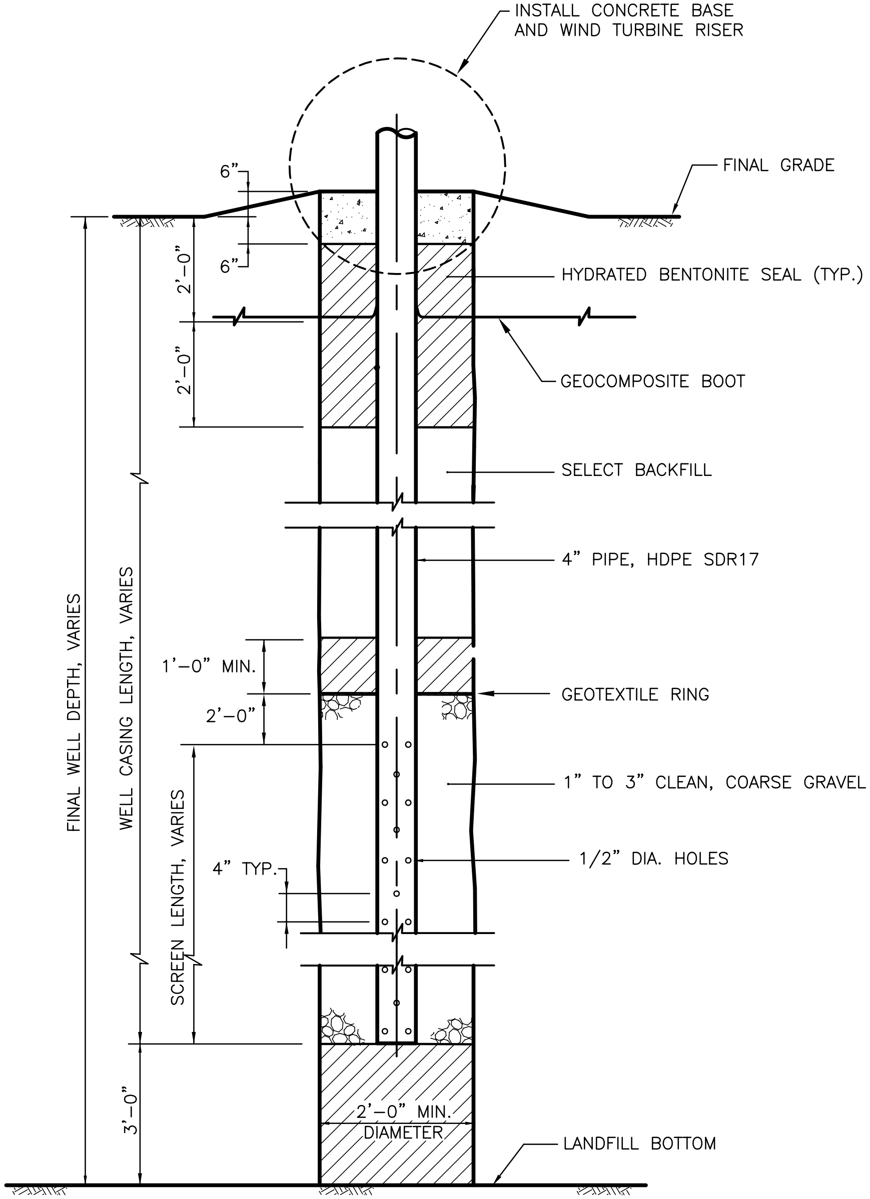
SHAW Environmental, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-6
EVAPOTRANSPIRATION CAP

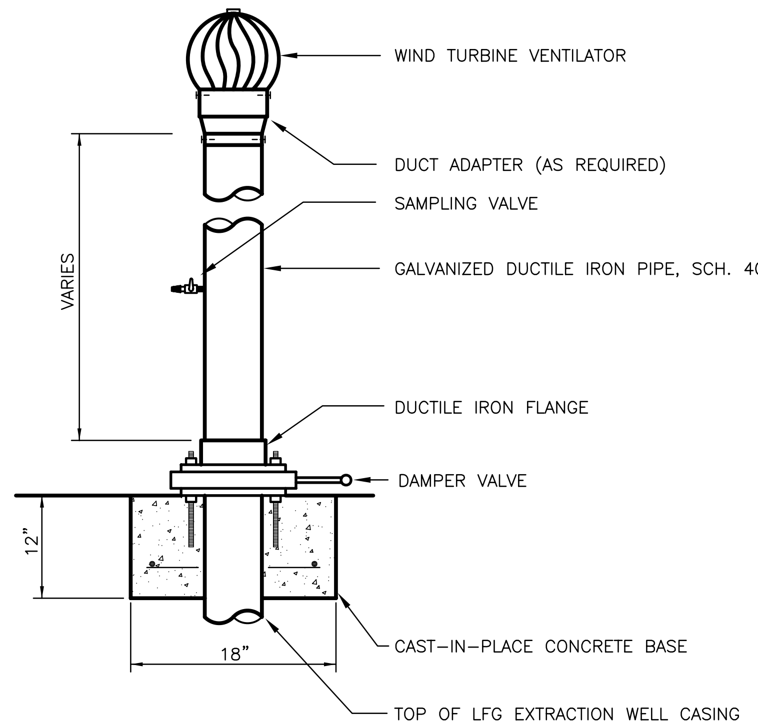
Remedial Investigation/Feasibility Study for Parcel E-2

XREF Files: IMAGE Files:
File: N:\cad\DWG\HuntersPoint\FINAL FIGURES\SJHP-FIG11-7.dwg Layout: 7-2005 User: kathy.troyer Jan 16, 2007 - 11:05am



LFG EXTRACTION WELL

NOT TO SCALE



CONCRETE BASE AND WIND TURBINE RISER

NOT TO SCALE

Shaw®

SHAW Environmental, Inc.

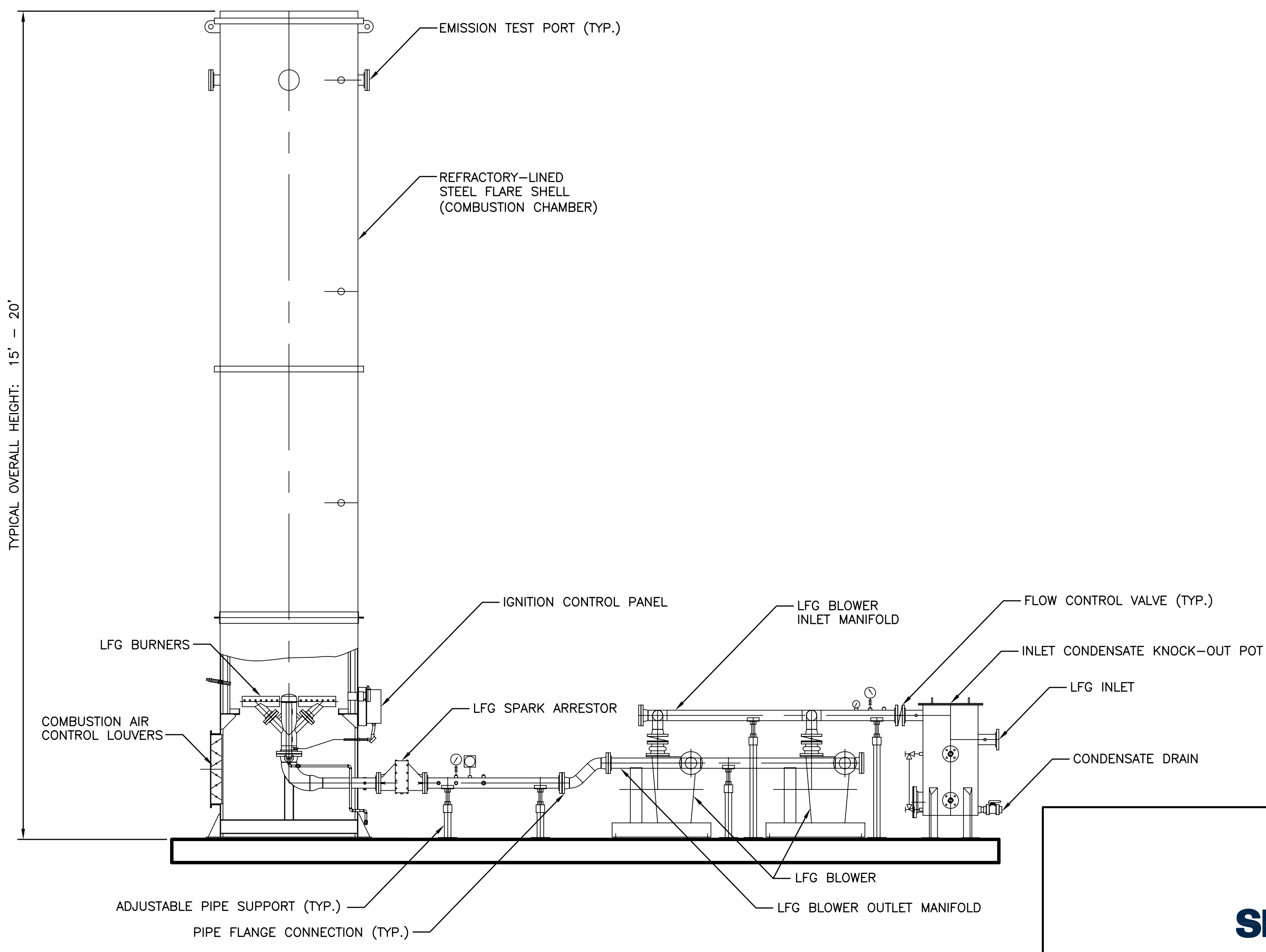
Hunters Point Shipyard, San Francisco, California

Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-7
CONCEPTUAL LANDFILL GAS VENT,
EXTRACTION WELL AND WIND TURBINE

Remedial Investigation/Feasibility Study for Parcel E-2

XREF Files: IMAGE Files:
File: N:\cad\DWG\HuntersPoint\FINAL FIGURES\SJHP-FIG11-8.dwg Layout: 7-2005 User: kathy.troyer Jan 16, 2007 - 11:09am



CONCEPTUAL LANDFILL GAS FLARE

SHAW Environmental, Inc.

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Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-8
CONCEPTUAL LANDFILL GAS FLARE

Remedial Investigation/Feasibility Study for Parcel E-2

XREF Files: IMAGE Files: ALT-FLARE.jpg
File: N:\cad\DWG\HuntersPoint\FINAL FIGURES\SJHP-FIG11-9.dwg Layout: 7-2005 User: kathy.troyer Jan 16, 2007 - 11:17am

SOURCE: Bekaert CEB Technologies BV

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FIGURE 11-9
ALTERNATE FLARE

Remedial Investigation/Feasibility Study for Parcel E-2

Tables

Table 11-1. Containment Technology Evaluation
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

	Evaluation Criteria				
Containment Technology	Proposed End Use	Climate	Performance[1]	Availability of Materials	Cost[2]
Low-Permeability Soil Cap (Title 27 Cover, Prescriptive Standard)	Not Suitable for Irrigated End Use	Suitable	5.70	Availability of Soil Unknown until Construction Occurs	$4.50
Geosynthetic Cap (Title 27 Cover, Engineered Alternative)	Suitable for Irrigated End Use	Suitable	0.03	Availability of Soil Unknown until Construction Occurs; Geosynthetic Components Readily Available	$5.00
Multilayer Geosynthetic Cap	Suitable for Irrigated End Use	Suitable	0.03	Availability of Soil Unknown until Construction Occurs; Geosynthetic Components Readily Available	$5.60
Evapotranspiration Cap	Not Suitable for Irrigated End Use	Not Suitable	Not Suitable	Not Suitable	Not Suitable

Notes:

1 Inches of infiltration through the cover based on HELP (Hydrogeologic Evaluation of Landfill Performance) modeling.

2 Typical unit cost per square foot of cover.

Section 12. Development of Remedial Alternatives

This section describes remedial alternatives for Parcel E-2 developed from the technologies and process options retained in Section 11. The technologies and process options have been combined into four remedial alternatives, and are presented with a fifth "no action" alternative, for a total of five alternatives. These alternatives have been paired with an appropriate wetlands mitigation strategy (as outlined in Appendix O). The five remedial alternatives developed for Parcel E-2 are:

- **Alternative 1 – No Action:** For this alternative, no remedial action would take place. Solid waste, soil, sediment, surface water, and groundwater would be left in place without any response actions (e.g., monitoring, institutional controls, containment, removal, and treatment). The no action alternative is retained throughout the FS process as required by the NCP to provide a baseline for comparison with and evaluation of other alternatives.
- **Alternative 2 – Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, institutional controls, and unlined freshwater wetlands):** This alternative would involve excavation and off-site disposal of all solid waste, debris, and soil in the Landfill Area. Isolated solid waste locations, soil, and sediment in the adjacent areas (which consist of the Panhandle Area, East Adjacent Area, and Shoreline Area) would also be excavated and disposed of off site. The proposed excavation in the Panhandle Area, East Adjacent Area, and Shoreline Area would eliminate exposure to radioactive and nonradioactive contamination, in accordance with the exposure depths in the risk assessments, and would extend deeper in areas with known hot spots of nonradioactive chemicals. Groundwater monitoring would be included under this alternative to evaluate chemical concentrations in groundwater while the aquifers naturally recover. Additionally, groundwater monitoring would be used to confirm site conditions and to ensure that, over time, the potential exposure pathways would remain incomplete. This alternative would also include institutional controls (consisting of land use and activity restrictions) that would be implemented across the entire parcel to prevent exposure to COCs and COECs in soil and groundwater. Wetlands disturbed during excavation activities would be restored on top of the clean fill in the Panhandle Area.
- **Alternative 3 – Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands):** This alternative would involve (1) excavation and off-site disposal of all radiological surface anomalies and Tier 1 and Tier 2 hot spots in the Panhandle Area, East Adjacent Area, and Shoreline Area (see Section 12.1.6); and (2) excavation and on-site consolidation of soil in portions of the Panhandle Area planned for wetlands restoration (both tidal and freshwater) and sediment throughout the Shoreline Area. Excavation activities would be followed by containment of solid waste and soil in the Landfill, Panhandle, East Adjacent, and Shoreline Areas. The portions of the Landfill Area not already covered by the existing multilayer cap would be covered with a similarly designed

multilayer cap. The isolated solid waste locations and soil in the East Adjacent Area, as well as portions of the Panhandle and Shoreline Areas not planned for tidal and freshwater wetlands restoration, would be covered with a geosynthetic cap. A conceptual grading plan is shown on Figure 12-1. The cap termination within the Shoreline Area would be protected with a shoreline protection system (see Section 12.1.3) and, where the Landfill Area abuts the Shoreline Area, would also be underlain by a subsurface drainage system (in the event that groundwater monitoring results prompt extraction and treatment of leachate and contaminated groundwater). In addition, this alternative would include (1) construction of a groundwater diversion system (consisting of an upgradient slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation; (2) installation, operation, and maintenance of an active landfill gas control system; (3) monitoring of landfill gas, stormwater, and groundwater; and (4) institutional controls (consisting of land use and activity restrictions) that would be implemented across the entire parcel to prevent exposure to COCs and COECs in soil, landfill gas, and groundwater. Also, freshwater wetlands disturbed during construction of the containment systems would be restored on top of a low-permeability compacted clay liner in the Panhandle Area, while tidal wetlands disturbed during construction would be restored without a liner.

- **Alternative 4 – Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands):** This alternative would have the same components as Alternative 3, but would include (1) excavation and off-site disposal of Tier 3, 4, and 5 hot spots (in addition to Tier 1 and 2 hot spots; see Section 12.1.6); (2) containment of contaminated groundwater with a slurry wall in the nearshore areas where landfill waste is within 100 feet of San Francisco Bay (referred to as the "nearshore slurry wall"); and (3) a contingency to extend the nearshore slurry wall south into the PCB Hot Spot Area. The need to extend the nearshore slurry wall will be assessed in the RD using updated groundwater monitoring data from wells in and around the excavated portion of the PCB Hot Spot Area, which are currently being collected under the BGMP. The groundwater diversion system along the west side of the landfill, as proposed under Alternative 3, would minimize hydraulic head buildup behind the nearshore slurry wall.
- **Alternative 5 – Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and unlined freshwater wetlands):** This alternative would have the same components as Alternative 4, but would include restoration of freshwater wetlands without a liner. Alternative 5 was developed to evaluate the relative advantages of unlined freshwater wetlands compared with the lined freshwater wetlands proposed under Alternatives 3 and 4.

The purpose of this section is to describe, in detail, the remedial alternatives developed for Parcel E-2. The alternatives address the general RAOs and the nine evaluation criteria established in the NCP to varying degrees. The analysis of each alternative relative to the RAOs and NCP evaluation criteria is presented in Section 13. Section 12.1 discusses the common components of Alternatives 2, 3, 4, and 5, and Section 12.2 describes each of the remedial alternatives developed for Parcel E-2.

For Alternatives 3 and 4, a geosynthetic liner underlying the proposed freshwater wetlands was previously proposed in the Draft Final RI/FS Report. The regulatory agencies raised two key technical concerns regarding the geosynthetic liner in their comments on the Draft Final RI/FS Report: (1) the potential reduced effectiveness of a geosynthetic liner underlying the freshwater wetlands, and (2) the potential reduced ecological function of freshwater wetlands that does not allow surface water to percolate into shallow groundwater. To address the concern regarding the effectiveness of the geosynthetic cap, the Navy revised Alternatives 3 and 4 to include a 1-foot-thick compacted clay liner underlying the proposed freshwater wetlands in place of the geosynthetic cap. To address the concern regarding the ecological function of the freshwater wetlands, the Navy developed Alternative 5, which does not include the compacted clay liner underlying the freshwater wetlands. The conceptual wetlands design for Alternatives 3 and 4 is presented in Section 12.2.3.11. The conceptual wetlands design for Alternative 5 is presented in Section 12.2.5.

12.1. COMMON COMPONENTS FOR REMEDIAL ALTERNATIVES 2, 3, 4, AND 5

This subsection discusses components that are included in Alternatives 2, 3, 4, and 5. These component descriptions are not repeated in the individual alternative descriptions in Section 12.2. The common components include:

- Institutional controls (Section 12.1.1)
- Groundwater monitoring (Section 12.1.2)
- Completion of the shoreline protection (Section 12.1.3)
- Stormwater discharge management and monitoring (Section 12.1.4)
- Integration with ongoing wetlands restoration and offshore FS (Section 12.1.5)
- Removal of hot spots in the Panhandle, East Adjacent, and Shoreline Areas (Section 12.1.6)

Table 12-1 summarizes the major components of the remedial alternatives presented in this RI/FS Report.

12.1.1. Institutional Controls

Alternatives 2, 3, 4, and 5 would use institutional controls to restrict use of and activities within the property to prevent unacceptable exposure to solid waste, soil, sediment, landfill gas, and groundwater. As discussed in Section 11.4.1, a combination of legal and administrative mechanisms would be used to enforce a variety of land use and activity restrictions for Parcel E-2.

The institutional controls would be applied throughout Parcel E-2 under Alternatives 2, 3, 4, and 5. Exceptions include restrictions specific to landfill containment and control systems, which would not apply within the Landfill Area under Alternative 2 because complete excavation of the Parcel E-2 Landfill is being considered under this alternative. Additionally under Alternative 2, restrictions on

B-aquifer groundwater use may be removed once chemical concentrations have attenuated to less than the remediation goals. Implementation, monitoring, and enforcement of the institutional controls are expected to be required for a minimum period of 30 years, or until it can be demonstrated that waste materials no longer pose a threat to human health or the environment.

The RD would identify the specific implementation actions necessary to ensure compliance with all institutional controls, and would identify the roles and responsibilities for implementing, monitoring, and enforcing the institutional controls. The RD would be provided to the FFA signatories and the transferee for review and concurrence.

12.1.2. Groundwater Monitoring

Groundwater at Parcel E-2 is subject to regulations designed to ensure protection of human health and the environment. The RAOs were developed based on these requirements and require that the final remedy prevent unacceptable risk to human health or the environment. Long-term groundwater monitoring will be performed for Alternatives 2, 3, 4, and 5 to verify that chemical concentrations in groundwater do not exceed concentrations designated by the RAOs at the compliance boundary. Selection of the compliance boundary for both A-aquifer and B-aquifer groundwater at Parcel E-2 is discussed in Appendix N (Section N2.1.1).

A final plan for long-term groundwater monitoring will be developed during the RD as part of the closure plan for Parcel E-2. Prior to publishing the final monitoring plan, groundwater monitoring will continue to be performed under the existing groundwater monitoring plan, which will be modified as appropriate to address the data gaps discussed in Section 8.5.1.

Groundwater elevations will continue to be monitored under the existing plan to assess flow patterns in the A- and B-aquifers. Horizontal groundwater flow patterns in the A-aquifer may change as the storm drain and sanitary sewer lines are removed throughout HPS (as part of a basewide removal action). Many of these lines are submerged below the water table and likely acting as preferential pathways for groundwater flow. The placement of the monitoring well network may be adjusted, if necessary, based on any changes in groundwater flow patterns; however, it is expected that changes in A-aquifer flow patterns will result in more uniform flow toward the Parcel E-2 shoreline, where a well network will already be in place.

The monitoring frequency and specific suite of monitoring parameters will be developed during the RD phase in consultation with the regulatory agencies and will use ongoing monitoring results. Monitoring results will be reported on a regular basis and will be evaluated on an annual basis. The groundwater monitoring plan will also be subject to CERCLA 5-year reviews. During the post-closure period (anticipated to be at least 30 years), the frequency of monitoring may decrease to one event per year, if chemical concentrations remain stable or decrease over time. Changes to the monitoring frequency or the suite of monitoring parameters will be made in consultation with the regulatory agencies during either the annual evaluations or the CERCLA 5-year reviews.

For the purposes of costing and evaluating alternatives in this FS, it is assumed that 13 A-aquifer and 3 B-aquifer monitoring wells located in and around the Landfill Area will require long-term monitoring and will be sampled for the same parameters as specified in the current monitoring plan. In addition, it is assumed that 22 A-aquifer and 7 B-aquifer wells in the adjacent areas will require long-term monitoring, and will be sampled for analysis of chemical parameters specific to the area of concern (e.g., metals, PCBs, SVOCs, and TPH). For evaluation purposes, the monitoring frequency is assumed as semiannually for 5 years and annually for 25 years; this assumption would allow for changes to the monitoring frequency to be integrated with the CERCLA 5-year reviews. The 30-year monitoring period was selected based on the assumed post-closure monitoring period; however, this monitoring period may be adjusted, as appropriate, to account for pre-closure monitoring. In addition, groundwater monitoring results for the PCB Hot Spot Area will be evaluated in the RD to determine if the groundwater containment structure needs to be extended south to prevent discharge to the bay.

12.1.3. Completion of the Shoreline Protection (with Removal of Solid Waste, Soil, and Sediment)

Shoreline protection will be required under Alternatives 2, 3, 4, and 5 to control erosion from tidal and wave action from San Francisco Bay. In areas proposed for tidal wetlands restoration (under Alternatives 2, 3, 4, and 5), shoreline protection would consist of a combination of wetland vegetation and low-profile rock structures with the objective of maintaining the integrity of the restored surfaces following remediation. For Alternative 2, which involves extensive excavation throughout Parcel E-2, these shoreline protection measures would be implemented along the entire Shoreline Area. For Alternatives 3, 4, and 5, these shoreline protection measures would be implemented at the southern portion of the Panhandle Area (and adjoining portions of the Shoreline Area), where expanded excavation would be performed to facilitate construction of tidal wetlands.

In areas not proposed for tidal wetlands restoration, Alternatives 3, 4, and 5 include a more extensive shoreline protection system, consisting of rock revetment underlain by compacted soil and a geosynthetic cap, to maintain the integrity of the containment systems (see Figure 12-1). Also, existing solid waste, soil, and sediment along the shoreline would be removed and consolidated on site prior to construction of the shoreline protection system or, in the case of the southern portion of the Panhandle Area, prior to construction of the tidal wetlands. The excavation depths along the shoreline would vary between approximately 2 and 5 feet, as shown on Figures 12-2 and 12-3.

At the southeastern portion of the Landfill Area, solid waste along the shoreline would be removed and consolidated on site prior to construction of the shoreline protection system. The geosynthetic cap underlying the rock revetment and soil would be tied into the geosynthetic cap to be installed in the Landfill Area, East Adjacent Area, and the portions of the Panhandle Area outside of the tidal wetlands. Figure 12-4 depicts the tie-in of the multilayer geosynthetic cap in the Landfill Area with the shoreline protection system. Figure 12-2 depicts the tie-in of the geosynthetic cap in the Panhandle Area and East Adjacent Area with the shoreline protection system. The toe of the new landfill slope would generally be inward of the existing slope to allow placement of the shoreline protection and minimize filling of the bay. The landfill slope would be reconstructed at a 3:1 (horizontal:vertical) slope extending upward to where it intersects a future perimeter road (Figure 12-1). A 12- to 15-foot-wide bench would be provided for the future perimeter road that will dually serve as a maintenance access road and pedestrian walkway as a connection to the Bay Trail from the adjacent Yosemite Slough Restoration Project. South of the future perimeter road, the slope would be constructed to a 3:1 slope down to existing ground along the bay shoreline in that portion of Parcel E-2. Excavated material from this area would be placed at the northern portion of the landfill before a multilayer cap is installed.

Shoreline protection for Alternatives 3, 4, and 5 would include compacted soil and rock revetment, on the outer face of the soil, to an elevation above the highest observed water level in the bay (approximately 8.16 feet above the mean lower low water; 5.04 feet above msl). As shown on Figure 12-2, the top elevation of the shoreline protection system is approximately 15 feet above msl, or about 12 feet above the mean high tide level. This design provides an adequate level of shoreline protection, which based on the most recent estimates from the Intergovernmental Panel on Climate Change (IPCC) can reasonably accommodate rising sea levels over the next 100 years. The following excerpt from Church et al. (2008) summarizes the most recent IPCC estimates of global sea level rise: "The IPCC provides the most authoritative information on projected sea-level change. The IPCC Third Assessment Report of 2001 (Church et al., 2001) projected a global-averaged sea-level rise of between 20 and 70 centimeters (cm) between 1990 and 2100 using the full range of IPCC greenhouse gas scenarios and a range of climate models. When an additional uncertainty for land-ice changes was included, the full range of projected sea-level rise was 9–88 cm. For the IPCC's Fourth Assessment Report (Meehl et al., 2007), the range of sea-level projections, using a larger range of models, is 18–59 cm (90% confidence limits) over the period from 1980–1999 to 2090–2099 (Meehl et al., 2007)." Based on the IPCC estimates, the estimated maximum sea level rise in 2100 (88 centimeters or 2.9 feet) is much lower than the 11 to 12 vertical feet of shoreline protection provided in the preliminary FS design. The shoreline protection system will be further evaluated in the RD relative to several factors including, but not limited to, potential rise in sea level.

The toe of the shoreline protection system would generally match the existing toe to minimize filling of the bay. The design would also include sufficient soil fill to provide buttress support to the solid waste along the perimeter. The shoreline protection would be designed for stability under static loading conditions and during earthquakes. Seismic design considerations for Alternatives 3 and 4 are discussed in Section 12.2.3.1.

12.1.4. Stormwater Discharge Management and Monitoring

Existing stormwater discharge from Parcel E-2 is subject to the requirements of the SWDMP (MARRS and MACTEC, 2009b). This plan specifies implementation of BMPs and monitoring to ensure that surface water discharges from the Parcel E-2 Landfill do not pose an unacceptable risk to aquatic life in San Francisco Bay. The SWDMP is updated annually based on site inspection and monitoring results. Under Alternatives 2, 3, 4, and 5, this process is anticipated to continue through remedial action implementation and long-term operation and maintenance.

Additional short-term considerations would be required during the construction phase of Alternatives 2, 3, 4, and 5, in accordance with the substantive provisions of SWRCB Order 99-08 entitled "Stormwater Discharge Associated with Construction Activities" (SWRCB, 1999). These provisions include implementation of BMPs to prevent stormwater from contacting construction pollutants and prevent erosion products from migrating off site. The BMPs likely to be used during construction include minimization of bare soil areas; use of topsoil conservation; placement of straw bale and straw waddle; mulching; seeding; slope cultivation; stabilization of construction entrances; and use of temporary crushed rock roads, temporary berms, filter screens, and sedimentation basins. The specific measures to be used will be determined as part of the RD and associated planning documents (e.g., a stormwater pollution prevention plan).

For Alternative 2, erosion protection in the Shoreline Area was described in Section 12.1.3. Erosion protection and stormwater controls in the Landfill, Panhandle, and East Adjacent Areas include vegetative cover and mats to maintain the integrity of the restored surfaces following remediation. These controls are considered adequate because the final slopes for Alternative 2 would be designed to eliminate areas with steep slopes, thereby minimizing erosion potential.

For Alternatives 3, 4, and 5, stormwater and erosion controls are required for the closed landfill under 27 CCR § 20365(c) and (d), which requires that diversion and drainage facilities be designed, constructed, and maintained to accommodate the anticipated volume of precipitation and peak flows. Solid waste would not be exposed to stormwater in capped areas, and erosion controls would be used to maintain the integrity of the containment structures and prevent sediment discharge above allowable limits. These goals would primarily be accomplished through vegetation and site grading to control stormwater overland flow velocities (slower flow velocities generally have less erosion potential). The final Parcel E-2 grades would be designed to prevent stormwater run-on onto the cap from surrounding areas and to prevent ponding (except in wetland areas) and erosion in other areas. Drainage from capped areas would be directed to designated locations that discharge into the newly constructed freshwater wetlands, existing drainage facilities, or San Francisco Bay. Stormwater from Parcel E-2 is not expected to require treatment prior to discharge. Long-term erosion protection and stormwater controls associated with Alternatives 3. 4, and 5 include the following (shown on Figures 12-1, 12-3, 12-4, 12-5, and 12-6):

- Vegetative cover on shallow slopes and flatter areas
- Concrete- or riprap-lined ditches in high-velocity flow areas
- Shallow ditch side slopes and flow lines
- Concrete inlets and drop structures for significant grade changes
- Vegetative mats to establish growth in concentrated flow areas

12.1.5. Integration with Ongoing Wetlands Restoration, Property Development, and Offshore Feasibility Study

Alternatives 2, 3, 4, and 5 were developed to be consistent, to the maximum extent practical, with other ongoing efforts that are affected by the CERCLA cleanup at Parcel E-2. The conceptual designs and implementation processes for these alternatives, as presented in this section, are expected to be refined in the RD to integrate the cleanup approach with the surrounding environment and the planned reuse of Parcel E-2. The following sections briefly discuss how the remedial alternatives were developed to be consistent with (1) wetlands restoration efforts, (2) property development, and (3) the offshore FS.

12.1.5.1. Wetlands Restoration

Alternatives 2, 3, 4, and 5 were integrated with the wetlands mitigation and monitoring plan (WMMP) for HPS Parcels B, E, and E-2 (Shaw, 2009b). The WMMP was developed to reflect ecological continuity with the tidal wetlands being restored at the adjacent property (Yosemite Slough restoration project). These components include restoration of tidal and freshwater wetlands in the Panhandle Area and planting of submerged aquatic vegetation, which will provide erosion protection for the outboard edge of the restored wetlands. The planned restoration is anticipated to provide adequate acreage to restore wetlands damaged or destroyed at Parcel E-2 (and other HPS parcels) during past and future response actions. The wetlands restoration design will be refined, as appropriate, in the RD to align with the final restoration plans with the Yosemite Slough project. Potential refinements include specification of appropriate measures to minimize human disturbance in ecological restoration areas, such as maintaining minimum setback distances and posting signs.

12.1.5.2. Property Development

SFRA has designated most of HPS Parcel E-2 for open space reuse (SFRA, 2010). A small area (about 0.42 acres) in the East Adjacent Area is designated as part of the Shipyard South Multi-Use District, which includes potential recreational, industrial, and residential reuse (SFRA, 2010). As discussed in Section 1.8 and documented in the previous versions of the RI/FS Report published in 2007 and 2009, land uses other than open space were not anticipated prior to publication of the 2010 amended Redevelopment Plan. Accordingly, the remedial alternatives presented in this RI/FS Report are based on the assumption of open space reuse throughout Parcel E-2. While preparing this Final RI/FS Report, the Navy evaluated potential modifications to the remedial alternatives based on the planned land use in the 0.42-acre area in the East Adjacent Area designated as part of the Shipyard South Multi-Use District.

The following elements of the containment systems proposed for Alternatives 3, 4, and 5 may be adjusted to better integrate the Parcel E-2 cleanup approach with the planned reuse of the Shipyard South Multi-Use District:

- Cover type: The proposed cover in the East Adjacent Area consists of a 2-foot-thick vegetative soil layer underlain by a geosynthetic cap (geocomposite drainage layer and a 60-mil thick HDPE geomembrane, see Section 11.5.1.2). For the area designated as Shipyard South Multi-Use District within Parcel E-2, the 2-foot-thick soil cover is needed to protect human health and the environment because of chemicals detected in shallow soil. However, the geosynthetic cap is not needed in this area because, based on available soil and groundwater data indicating no localized source of groundwater contamination, there is no need to control infiltration. Similar to portions of the Panhandle Area where a soil cover is proposed without a geosynthetic cap, this proposed adjustment to the conceptual design would comply with the ARARs identified in Section 10.
- Landfill Gas Control: Although landfill gas is not expected to be generated in the East Adjacent Area to a degree that requires collection, an investigation will be conducted during the RD to more thoroughly evaluate soil gas and determine if gas collection and control (such as passive subsurface venting) is required. If gas collection and control is required in the East Adjacent Area, then vents and monitoring probes will be located and designed to ensure that landfill gas is controlled within the Parcel E-2 boundary. As discussed in Section 11.4.1.4, proposed construction of enclosed structures within Parcel E-2 must comply with the substantive provisions of 27 CCR §§ 21190(a), (b), (d), (e), (f) and (g), which require that postclosure land uses be designed and maintained to protect health and safety in areas affected by landfill gas migration.
- Site Grading and Surface Water Drainage: The conceptual design for the cover in the East Adjacent Area includes gradual slopes that direct surface water runoff into a drainage channel along the eastern boundary of Parcel E-2. The site grading and drainage channel may require adjustment to align with the proposed redevelopment at the adjoining portions of Parcel E. Such adjustments are considered minor, so long as they do not conflict with other elements of the containment system.

The potential adjustments identified above may be made as the CERCLA process progresses, and can be performed in a manner that (1) ensures the protection of human health and the environment, (2) complies with ARARs, and (3) is generally consistent with the conceptual designs and analyses of the proposed remedial alternatives.

The CCSF proposed, as part of the environmental impact report for the Phase II development at HPS and Candlestick Point, building a roadway along the western portion of Parcel E-2 (SFRA, 2009). The footprint of the proposed roadway is adjacent to the proposed wetlands restoration areas, as shown on Figures 12-1 and 12-12. The proposed roadway is designated as a “local street” in the SFRA’s 2010 amended Redevelopment Plan and is subject to adjustment based on detailed engineering studies prior to actual physical development (SFRA, 2010). Based upon the available information, the Navy does not believe that the proposed roadway is fundamentally incompatible with the excavation or restoration plans for this portion of Parcel E-2. As a result, the Navy has not adjusted the proposed excavation or restoration plans in this portion of Parcel E-2. The Navy recognizes that pertinent elements of the RD (such as surface water drainage) will need to be integrated with future infrastructure along the western property boundary; however, the Navy anticipates that this design integration process would only result in minor refinements of the conceptual designs presented on Figures 12-1 and 12-12 and would not alter the fundamental components of the remedial action.

12.1.5.3. Offshore Feasibility Study

An FS was prepared for Parcel F to evaluate remediation alternatives for the contaminated sediment offshore of Parcel E-2 (Barajas & Associates, Inc., 2008a). As described in the Parcel F FS Report, the remedial alternatives evaluated for Parcel E-2 constitute source control measures for offshore contamination at Areas IX and X because contaminated sediment along the Parcel E-2 shoreline has been a source of contamination to the offshore Areas IX and X. In addition, the Parcel F FS Report notes that source control measures at Parcel E-2 should be completed before or simultaneously with any remediation work at Areas IX and X, which are located offshore of Parcel E-2 (Barajas & Associates, Inc., 2008a). During the RD, the selected shoreline remediation approach for Parcel E-2 will be refined, as needed, to integrate with the remediation approach for Parcel F and the overall site restoration plans. For example, the current alignment of the shoreline protection system for Alternatives 3, 4, and 5 (Figure 12-1) does not contain all contaminated sediment within the Shoreline Area. This alignment was selected to follow the existing shoreline and minimize filling of the bay. Alternatives 3, 4 and 5 assume that the remediation approach selected for the Parcel F FS will be used in the Shoreline Area not currently covered by the shoreline protection system.

12.1.6. Hot Spot Removal in the Panhandle, East Adjacent, and Shoreline Areas

Alternatives 2, 3, 4, and 5 would involve, to varying degrees, removal of identified hot spots in the Panhandle, East Adjacent, and Shoreline Areas. Although hot spot removal is not required to achieve the RAOs for soil, sediment, and solid waste, it constitutes removal of known or likely sources to groundwater contamination; therefore, it contributes to the remedial performance relative to the RAOs for groundwater. Hot spots were identified using existing soil and groundwater data (evaluated in Sections 4 and 5), as well as field observations from recent removal actions (for example, exploratory potholes excavated between the PCB Hot Spot Area excavation and the bay identified oil staining and free-phase product). Based on this information, the Navy assessed the benefit of hot spot removal (that is, enhancing the performance of a remedial alternative relative to the RAOs) based on the following factors:

- The potential for soil hot spots to be a continuing source to groundwater contamination (e.g., chemicals that were identified in both soil and groundwater at concentrations exceeding RIECs)
- The magnitude of soil concentrations relative to RIECs (or alternative ecological risk-based criteria)
- The proximity of the potential hot spot relative to San Francisco Bay (which increases the likelihood of its affect on aquatic wildlife)

Based on these factors, the Navy identified five tiers of hot spots for removal at Parcel E-2 (Figure 12-7) that are discussed below.

- Tier 1 hot spots consist of nearshore locations (within the TIZ) where soil concentrations are greater than 10 times the RIECs (or alternative ecological risk-based criteria) and corresponding groundwater concentrations in monitoring wells consistently exceed aquatic evaluation criteria. As shown on Figure 12-7, Tier 1 hot spots were identified at the shoreline portion of the PCB Hot Spot Area. Proposed excavation boundaries, with estimated depths and volumes, for the Tier 1 hot spots are shown on Figure 12-8.
- Tier 2 hot spots consist of nearshore locations (within the TIZ) where soil concentrations are greater than 10 times the RIEC (or alternative ecological risk-based criteria) and corresponding groundwater concentrations in temporary wells exceeded aquatic evaluation criteria. As shown on Figure 12-7, Tier 2 hot spots were identified at the Metal Slag Area and northwest of the PCB Hot Spot Area. Proposed excavation boundaries, with estimated depths and volumes, for the Tier 2 hot spots are shown on Figures 12-8 and 12-9.
- Tier 3 hot spots consist of locations (inland of the TIZ) where soil concentrations are greater than 100 times the RIECs. Tier 3 hot spots were identified along the northern sidewall of the PCB Hot Spot Area excavation and in the central portion of the East Adjacent Area (Figure 12-7). Proposed excavation boundaries, with estimated depths and volumes, for the Tier 3 hot spots are shown on Figure 12-8.
- Tier 4 hot spots consist of nearshore locations (within the TIZ) where groundwater concentrations in temporary wells exceeded aquatic evaluation criteria and no corresponding soil data were available. Tier 4 hot spots were identified in the northern portion of the Panhandle Area (Figure 12-7). Proposed excavation boundaries, with estimated depths and volumes, for the Tier 4 hot spots are shown on Figure 12-9.

- Tier 5 hot spots consist of locations (inland the TIZ) where soil concentrations are greater than 10 times the RIECs (or alternative ecological risk-based criteria) and corresponding groundwater concentrations in downgradient temporary wells exceeded aquatic evaluation criteria. Tier 5 hot spots were identified in the southern portion of the Panhandle Area (Figure 12-7). Additional Tier 5 hot spots were identified in the East Adjacent Area as part of a 2009 investigation (associated with a groundwater treatability study at Parcel E [Shaw, 2009a]) and were incorporated into an interim removal action at Parcel E-2 (Navy, 2010); these two locations (IR12B029 and IR04MW13A) contain elevated VOC concentrations that pose a risk to future site occupants (via the vapor intrusion pathway) in the adjoining Parcel E. Proposed excavation boundaries, with estimated depths and volumes, for the Tier 5 hot spots are shown on Figures 12-8 and 12-9.

Tier 1 and 2 hot spots are considered most important to enhancing the performance of a remedial alternative relative to the RAOs. As a result, removal of Tier 1 and 2 hot spots are included under Alternatives 2, 3, 4, and 5. Tier 3, 4, and 5 hot spots are considered less important to enhancing the performance of a remedial alternative relative to the RAOs; these hot spots are included only in Alternatives 2, 4, and 5. The Tier 4 hot spots, located primarily along the northern portion of the Panhandle Area between temporary well locations TW013 to TW047, pose a potential risk to aquatic wildlife in the bay because of their location within the TIZ. However, the Tier 4 hot spots were not included in Alternative 3 because of uncertainty related to whether source removal at the locations is necessary to protect aquatic wildlife in the bay. The following factors contributed to the uncertainty: (1) no collocated soil data were available to verify that residual concentrations exceeded the identified hot spot goals; (2) the magnitude of most exceedances (metals and petroleum hydrocarbons) was less than two times the corresponding surface water criteria; and (3) the fate and transport properties of PCBs (which exceed the corresponding surface water criteria by more than eight times) result in very slow contaminant transport rates (IT, 2001). As described in Section 12.1.3, Alternative 3 includes the following actions in close proximity to the Tier 4 hot spots that will minimize potential impact to aquatic wildlife in the bay: (1) excavation of nearshore sediment and soil prior to construction of the shoreline revetment, and (2) installation of a geosynthetic liner under the rock revetment wall.

The lateral and vertical extent of hot spots would be refined through pre-excavation characterization to be performed during the RD. This characterization effort would be guided by specific DQOs to better delineate hot spot contamination. This report assumes that individual hot spots would be excavated to meet the chemical-specific goals presented in Table 12-2; however, the RD may refine these goals to more accurately define the soil concentrations that could leach to groundwater at concentrations exceeding aquatic evaluation criteria. Refined goals, if deemed necessary, would be supported with technical information (such as modeling or site-specific leaching analyses) in the RD.

For Alternative 2, the hot spot removal would consist of extending the planned excavation deeper, as needed, to remove the hot spot contamination. Additional information on the planned hot spot removal under Alternative 2 is provided in Section 12.2.2.4. As discussed in Section 12.2.2, all material excavated under Alternative 2, including the hot spot removal, would be characterized and disposed of off site, following screening for and segregation of radiologically impacted material (which would also be disposed of off site). Any industrial debris (such as drums and associated liquid wastes) and MDAS (such as empty shell casings) would be disposed of off site with LLRW and soil containing chemicals at concentrations exceeding hot spot goals.

For Alternatives 3, 4, and 5, the hot spot removal would consist of targeted excavations and would be implemented as part of the grading process prior to capping. Removal of Tier 1 and 2 hot spots, which are located within or close to the Shoreline Area, would be implemented with the shoreline excavation process described in Section 12.1.3. Additional information on the planned hot spot removal under Alternatives 3, 4, and 5 is provided in Sections 12.2.3.3 and 12.2.4.1. As discussed in Section 12.2.3, following screening for and segregation of radiologically contaminated material (which would be disposed of off site), hot spots would be excavated and disposed of off site; material excavated as part of the overall grading process would be incorporated into the landfill under the new cap extension.

For Alternatives 2, 3, 4, and 5, post-excavation confirmation samples would be collected for analysis to verify that residual chemical concentrations were less than the hot spot goals. Upon receipt of acceptable confirmation sampling results, the excavations would be backfilled with clean imported soil in accordance with the final grading plan (discussed in Sections 12.2.2.6 and 12.2.3.4).

12.2. REMEDIAL ALTERNATIVES DEVELOPED FOR PARCEL E-2

This section describes each of the remedial alternatives selected for Parcel E-2. Common components for each alternative are discussed in Section 12.1, and are only referred to in the following sections as appropriate. Appendix R of this report contains the cost estimates associated with each alternative.

12.2.1. Alternative 1: No Action

For this alternative, no remedial action would be taken. Solid waste, soil, sediment, surface water, and groundwater would be left in place without implementation of any response actions (including monitoring, institutional controls, containment, removal, treatment, or other mitigating actions). The no action alternative is included throughout the FS process as required by the NCP to provide a baseline for comparison with and evaluation of other alternatives.

12.2.2. Alternative 2: Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, institutional controls, and unlined freshwater wetlands)

Figures 12-10, 12-11, and 12-12 present the site plans for Alternative 2. This alternative would involve excavation and off-site disposal of all solid waste and contaminated soil from the Landfill Area. Isolated solid waste locations, soil, and sediment in the adjacent areas (which consist of the Panhandle Area, East Adjacent Area, and Shoreline Area) would also be excavated and disposed of off site. Proposed excavation depths and extents are included on Figure 12-11. The proposed excavation within the Panhandle Area, East Adjacent Area, and Shoreline Area would eliminate exposure to radioactive and nonradioactive contamination, in accordance with the exposure depths specified in the risk assessments, and would extend deeper in areas with known nonradioactive chemical hot spots. Following completion of the final status survey of the excavated subgrade, a demarcation layer would be installed within the radiologically impacted portions of the East Adjacent Area and throughout the Panhandle Area and Shoreline Area to identify remaining radiological hazardous substances at depth, prior to backfilling with clean imported soil. The demarcation layer would consist of a permeable geosynthetic material and magnetic marking tape to ensure proper identification of the bottom of the soil cap. The proposed soil cap and demarcation layer would effectively reduce the dose and residual risk associated with ROCs at the release criteria at and below the original surface to the levels prescribed in the RAOs. Institutional controls, consisting of land use and activity restrictions, would be implemented to prevent exposure to potential residual radioactivity in soil left in place and to preserve the integrity of the soil cap.

All removed solid waste and soil would be disposed of at an off-site facility permitted to accept wastes from a CERCLA site or at a licensed LLRW disposal facility. The excavations would be backfilled with a combination of clean material reclaimed from the current landfill cover and imported clean fill. General fill would be used to backfill most excavated areas. Wetland areas in the Panhandle Area would be backfilled with wetland-compatible soil, and Shoreline Area excavations would be backfilled with a combination of sand and wetland-compatible soil. Site restoration activities would include backfilling and surface grading to prevent surface water ponding (except in wetland areas), and to provide appropriate drainage and vegetation to prevent erosion.

Alternative 2 would involve:

- Implementation of institutional controls (discussed in Section 12.1.1)
- Site preparation, including installation of a sheet-pile wall and dewatering system
- Dewatering, treatment, and disposal of extracted water
- Radiological control procedures, including pre-excavation surface screening, surgical excavation of radioactive material, and post-excavation screening of all excavated material
- Excavation of contaminated material, including removal of Tiers 1, 2, 3, 4, and 5 hot spots (discussed in Section 12.1.6)

- Segregation, stockpiling, characterization, and disposal of excavated material
- Backfilling of excavation areas and completion of final grades to allow restoration of freshwater and tidal wetlands (also includes shoreline protection, as discussed in Section 12.1.3)
- Construction and maintenance of freshwater and tidal wetlands
- Post-construction groundwater and stormwater monitoring (discussed in Sections 12.1.2 and 12.1.4, respectively)

The subsequent subsections discuss the various component of this alternative in further detail (unless previously discussed in Section 12.1).

12.2.2.1. Site Preparation

Site preparation would be required prior to mobilization of all equipment, and would include construction of a wastewater treatment system, a rail spur, a soil staging and drying area, a laydown area, and a modular stormwater holding tank. The dry season (from April through the beginning of October) would provide the best construction time; however, because of the extended construction period required to complete this alternative (estimated to be 48 months), the remedial action would not be limited to this period. The detrimental effects of storm events would be mitigated by minimizing the area of excavation left open at any given time and by implementing engineering controls in active construction areas.

Approximately 400,000 cubic yards of the material to be excavated is below the water table, requiring installation of a dewatering system to be operated during excavation in these areas. Prior to dewatering, approximately 4,500 feet of sheet pile would be installed around the landfill to limit groundwater infiltration during excavation. The required sheet-pile wall would be approximately 50 feet deep and would be keyed into the Bay Mud below the landfill. The sheet-pile wall would be designed to prevent collapse of soil in areas where sufficient cut-back slopes cannot be used. Isolated solid waste locations in the adjacent areas would be outside this sheet-pile wall. The walls of excavations deeper than 4 feet at the isolated solid waste locations would be sloped back for stability, but no sheet pile would be required to adequately dewater excavations in the adjacent areas.

12.2.2.2. Dewatering, Treatment, and Disposal of Extracted Water

Dewatering well points would be installed several weeks before excavation of a given section to ensure that the water table elevation is below the expected bottom of the excavation. Continuous dewatering would be required until all excavated areas are backfilled to elevations above the water table. Excavation activities would be conducted to minimize the duration of excavation below the water table to limit the amount of contaminated water produced from dewatering. Other engineering controls would include berms along the perimeter of the excavations to divert surface water away from the excavations; silt fences along the excavation perimeters to control sediment in construction areas; and decontamination of all equipment leaving the site.

Liquid wastes generated by this alternative would include potentially contaminated water generated from dewatering excavations and saturated wastes and from decontamination activities. Over the course of the remediation effort (estimated at 48 months), it is assumed that an estimated 73 million gallons of potentially contaminated water would require treatment under this alternative. Contaminated water would be treated in an on-site treatment plant to meet appropriate discharge criteria for the publicly owned treatment works. The treatment system would include settling chambers and filtration units for radiological sediment removal, an ion exchange unit for metals removal, and carbon adsorption units for removal of organic chemicals prior to either surface water discharge or discharge to the on-site sanitary sewer.

12.2.2.3. Radiological Control Procedures

The potential presence of radionuclides must be assessed prior to and during excavation activities because the HRA (NAVSEA, 2004) identified most of Parcel E-2 as "radiologically impacted." Radiological control procedures are required to protect the health and safety of site workers and the general public, and to comply with regulatory requirements and principles governing work at radiologically impacted sites. The radiological control procedures would be consistent with the procedures established for the removal actions at the PCB Hot Spot Area and Metal Slag Area (TtFW, 2005a and 2005b). A summary of these procedures, excerpted from the above referenced work plans, are as follows:

- Pre-excavation surface surveys would identify radioactive materials near the surface (0 to 1 feet bgs). The surface surveys would consist of a high-density gamma scan performed over a 50-foot by 50-foot grid system. The resulting 100 percent surface survey would be supplemented, as necessary, with different instruments or soil sampling to confirm the presence of radioactive material.
- Locations with confirmed, elevated radiation levels would be excavated using a backhoe or excavator fitted with a smooth blade bucket and hand-digging tools. Soil removal would continue until the source of the elevated gamma activity reading is removed or a depth of 12 inches is reached. Following removal of the source of elevated gamma activity, a minimum of 1 foot of additional soil in all directions from the source would also be removed and segregated for disposal.
- After the radioactive material and surrounding soil is excavated, the resulting pit would be resurveyed and sampled. If elevated gamma activity persists, further examination of the soil would be made until the source of high gamma activity is found, removed, or a depth of 12 inches is reached. If the source of elevated radioactivity cannot be readily identified as a point source, the material would be segregated for disposal.

- Following identification and removal of radioactive materials in the upper 12 inches of soil from a given work area, an excavator would be used to remove the soil from the upper 12-inch layer in the redefined excavation area.

- The protocol for removing the remaining (nonradioactive) contaminated materials from the excavation area would consist of conducting radiological surveys of each 12-inch lift surface and removing any confirmed radioactive materials prior to full excavation of each lift. This protocol would be repeated until the excavation reaches the final depth.
- All excavated material (except for large debris) would be screened using an array of beta and gamma detectors to identify radioactive materials that may not have been detected during preliminary or subsequent surface surveys and to detect any beta-emitting sources that may be present. In addition, material would be sampled for radioactivity levels that cannot be seen with the beta and gamma detectors. Large debris would be segregated from the surrounding and screened separately for potential radioactivity.
- Any sandblast waste encountered during excavation activities would be handled in accordance with a Navy-approved work instruction specifically written to govern this potentially radioactive material. In addition, one or more site workers, trained in recognizing sandblast waste, would be designated as a "spotter" during excavation activities.

Radioactive material, including any identified mixed waste, would be properly stored on site pending disposal by a certified waste broker through the Navy's Low-level Radioactive Waste Disposal Program.

12.2.2.4. Excavation of Contaminated Material

The table on the following page summarizes the estimated volumes of material (including solid waste, soil, and sediment) that would be excavated from the different areas at Parcel E-2 during implementation of Alternative 2.

Area	Proposed Excavation Depth [a]	Estimated Excavation Volume [b]
Landfill Area	10 to >25 feet bgs	1,008,250 cubic yards
Panhandle Area	3 to 16 feet bgs	99,000 cubic yards
East Adjacent Area	3 to 10 feet bgs	42,750 cubic yards
Shoreline Area	2.5 to 3.5 feet bgs	16,000 cubic yards
	Total:	1,166,000 cubic yards

Notes:

a Excavation depth in Landfill Area based on estimated depth of solid waste and surrounding soil; excavation depths in Panhandle, East Adjacent, and Shoreline Areas (outside of previously remediated areas) were based on the RAOs for soil and sediment and were increased in some areas to facilitate wetlands mitigation and hot spot removal (see Figure 12-11).

b Estimated excavation volumes are based on data from geologic cross sections, thus they may vary due to the uncertainty associated with those cross sections.

In the Landfill Area, excavated material would include potentially contaminated soil beneath and above the solid waste, as well as potentially clean soil (cap material) above the existing landfill liner. The depth of excavation below the solid waste would be determined in the field through confirmation sampling; however, for cost estimating purposes, it was assumed that the excavation would extend 3 feet into clay formations and 5 feet into sand and gravel formations (an average of 4 feet below the bottom of the waste). Approximately 90,000 cubic yards of potentially clean soil from the existing cap would be stockpiled on site, screened for potential radiological contamination (as discussed in Section 12.2.2.3) and reused (as appropriate) as backfill material.

In the Panhandle, East Adjacent, and Shoreline Areas, excavation depths would vary based on the RAOs established for soil and sediment. The assumed minimum excavation depths are 3 feet bgs in the Panhandle and East Adjacent Areas and 2.5 feet bgs in the Shoreline Area, which represent the maximum human or ecological exposure depths for open space reuse. In areas where wetland restoration is required (both in the Panhandle and Shoreline Areas), an additional 1 foot of material, over the required minimum excavation depth, is proposed to facilitate final grading so adequately low surface elevations can be achieved to ensure periodic flooding of the tidal wetlands. In portions of the Panhandle Area where additional source removal may be needed to achieve RAOs, proposed excavation depths were extended to 10 feet bgs. In portions of the PCB Hot Spot Area and the Metal Slag Area (outside of identified residual hot spots), excavation is not required but material in these areas may need to be moved as part of the grading process. Also, as discussed in Section 12.1.6, excavation would be extended deeper as needed to remove Tiers 1, 2, 3, 4, and 5 hot spots.

Standard excavation equipment would be used to excavate material to design grades. Excavation and backfill operations within the sheet-pile wall would be performed in sections to minimize the amount of open excavation, thereby limiting dewatering volume and improving excavation stability. Sections would only be wide enough to provided adequate slope stability for the excavation sidewalls. After the excavation within a given section is completed and confirmed by chemical sampling, it would be backfilled with engineered fill soil to several feet above the seasonal high water-table elevation before excavation begins in the next section. Dewatering, excavation, and initial backfilling would proceed in this manner until all areas below the water table are excavated and backfilled. For excavation in the Shoreline Area, construction would proceed by isolating sections of the shoreline (via sheet pile or inflatable cofferdams) to remove contaminated material and backfill with clean imported material. If no isolation and dewatering are needed along a given shoreline section, some form of control structures (silt curtains) would need to be deployed, along with a monitoring program similar to those for the TCRAs at the Metal Slag Area and Metal Debris Reef.

12.2.2.5. Segregation, Stockpiling, Characterization, and Disposal of Excavated Material

Dump trucks would transport excavated material to an on-site staging area for dewatering (as needed), post-excavation radiological screening, segregation, and stockpiling. Waste characterization would be achieved through either in-situ waste characterization or stockpile characterization, and would involve testing for various chemicals and other physical properties, in accordance with the specified waste characterization ARARs and any additional requirements of the off-site disposal facility.

The cost estimate was developed assuming that approximately 35 percent of the material excavated from the site would be disposed of as D008 (RCRA Lead) waste, 50 percent as non-RCRA hazardous waste, 10 percent as nonhazardous waste, and 5 percent as LLRW (including mixed waste). These waste fractions were estimated using waste characterization data from the removal actions conducted at Parcel E-2 from 2005 to 2007.

Following characterization of a given stockpile and acceptance of the waste profile by the disposal facility, waste would be loaded onto rail cars on site and transported for disposal at the off-site disposal facility. Waste transportation by rail from the site offers a significant cost savings compared to conventional truck transport from the site to the local rail yard. It also reduces vehicular road traffic and associated noise in the surrounding neighborhoods located along the transportation route, as compared to truck transport. To accommodate the use of rail cars to transport waste off site, a rail spur extension would be constructed to connect the planned soil segregation and stockpiling area to the existing rail line leading out of HPS. Assuming a 40-mile roundtrip to the closest rail yard using 23 ton trucks, approximately 48,000 trips would be required, costing approximately $8,000,000. The cost to install a rail spur that connects Parcel E-2 to the local rail line would be less than $1,000,000 (a significant cost and road trip generation savings).

To estimate transportation and disposal costs for this alternative, various disposal facilities were contacted to evaluate their ability to accept the anticipated wastes types and allow for waste delivery by rail. Preliminary cost information was obtained from facilities meeting these criteria, and was used to develop preliminary unit rates for transporting and disposing of the various waste types under Alternative 2. The preliminary unit rates were then used to develop an estimate of the transportation and disposal costs for Alternative 2; however, the estimated transportation and disposal costs are intended only to support the analysis in this RI/FS Report and do not represent firm pricing commitments from individual waste disposal facilities. Uncertainty related to the implementation of Alternative 2 (e.g., the magnitude and range of detected chemicals that may be encountered and fuel costs and landfill capacity at the time of implementation) make such firm pricing commitments impractical. Further, the estimates provided in Appendix R are more than adequate to meet the accuracy prescribed in EPA guidance for FS cost estimates (+50/-30 percent) (EPA, 1988a and 2000).

12.2.2.6. Backfilling and Final Grading

The site would be backfilled to establish positive surface drainage in the area and provide stable final slopes. The Landfill Area would be graded to match adjacent areas. Grading to an elevation lower than the existing landfill elevation would provide a more natural grade, reduce future settlement, and minimize the cost of purchasing, transporting, and placing fill soil. The surface of the backfilled areas would be graded to provide drainage toward San Francisco Bay, as shown on Figure 12-12. A 12-inch-thick layer of topsoil would be placed and vegetated to provide erosion control. Nearly 400,000 cubic yards of clean imported soil, meeting stringent chemical and radiological acceptance criteria, would be required to restore Parcel E-2 in accordance with the conceptual grading plan. Railway lines, sheet piling, roads, and temporary drainage structures east of the landfill would require removal during excavation in these areas. Permanent drainage structures would be constructed as part of the site restoration.

12.2.2.7. Wetlands Restoration

Areas of wetlands damaged or destroyed by implementation of this alternative would be restored. Tidal wetlands would be restored along the shoreline of the Panhandle Area in a manner that is ecologically contiguous with the tidal wetlands being restored at the adjacent property (Yosemite Slough restoration project). To ensure that the final surface elevations are low enough to ensure periodic flooding of the tidal wetlands, excavation and off-site disposal of excavated materials is assumed in the Panhandle Area and adjoining portions of the Shoreline Area. Following compaction of the excavated subgrade in situ, a minimum of 6 inches of bridge soil and 3 feet of hydric soil would be placed in proposed planting areas to provide a growing medium. Additional tidal wetlands may also be constructed on top of excavated areas within the Landfill and East Adjacent Areas. The shoreline would be restored in a manner to allow bay water to flood the tidal wetlands along the shoreline diurnally. Shoreline protection in the form of shallow slopes and revegetation would be implemented along the mitigation area on the shoreline to protect the newly restored wetlands from erosion due to the action of bay waters during extreme storm events. In addition, potential scouring of the mudflat along the shoreline would be controlled as an adaptive management measure, by the strategic placement of large rocks. Seasonal freshwater wetlands would be restored at a similar location as the existing freshwater wetlands (which will be destroyed during the remedial action) and would receive runoff from the western portion of the Landfill Area. It is anticipated that sufficient water will be available to replace the existing freshwater wetland at the selected 1:1 ratio (Appendix O).

Backfill for wetland areas (including both foundation and cover) would be screened against HPALs and guidance values established by the RWQCB (1998 and 2000). The thickness of the backfill material in the adjacent areas would be consistent with the potential exposure depths for ecological receptors (2.5 feet bgs in the Shoreline Area and 3 feet bgs in the Panhandle and East Adjacent Areas). Due to the removal of the wastes in the Landfill Area, there would be no constraints on the wetlands cover thickness above existing fill material. The wetlands would be maintained and monitored in accordance with a wetlands mitigation and monitoring plan.

12.2.3. Alternative 3: Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands)

Alternative 3 involves: (1) excavation and off-site disposal of all radiological surface anomalies and Tier 1 and Tier 2 hot spots in the Panhandle Area, East Adjacent Area, and Shoreline Area (see Section 12.1.6); and (2) excavation and on-site consolidation of soil in portions of the Panhandle Area planned for wetlands restoration and sediment throughout the Shoreline Area. Excavation activities would be followed by containment of solid waste and soil in the Landfill, Panhandle, East Adjacent, and Shoreline Areas. In addition, this alternative would include installation, operation, and maintenance of an active landfill gas control system. This alternative would provide a comprehensive closure strategy for Parcel E-2 that removes and disposes of hot spots from the nearshore area, contains other contaminated material at upland locations under an engineered liner, and restores the nearshore area consistent with the planned reuse (including restoration of wetlands damaged during the remedial action). This alternative assumes that excavation and off-site disposal of hot spots, combined with on-site consolidation of other contaminated soil, would adequately reduce the potential for groundwater contamination to affect aquatic wildlife in the bay. This assumption would be confirmed through long-term groundwater monitoring. In addition, this alternative includes construction of (1) a groundwater diversion system (consisting of an upgradient slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation (Figure 12-5), and (2) a subsurface drainage system along the southern perimeter of the Landfill Area (Figure 12-4) in the event that groundwater monitoring results prompt extraction and treatment of leachate and contaminated groundwater, as required per 22 CCR § 66264.310(b)(2).

The conceptual grading and excavation plans for Alternative 3 are shown on Figures 12-1 and 12-13, respectively. Figure 12-13 identifies the areas where soil and sediment would be excavated to varying depths (at least 3.5 feet bgs in most locations) and areas where excavated material would be consolidated on site after radiological surface anomalies and nonradioactive hot spots are segregated and disposed of off site. Following completion of the final radiological survey of the excavated subgrade, a demarcation layer would be installed within radiologically impacted portions of the East Adjacent Area and throughout the Landfill, Panhandle, and Shoreline Areas to identify remaining radiological hazardous substances at depth, in conjunction with placement of a geosynthetic cap and clean imported soil (collectively referred to as an "engineered cover"). The demarcation layer would consist of a permeable geosynthetic material and magnetic marking tape placed between the soil cover and the geosynthetic cap to ensure proper identification of the containment system. Institutional controls, consisting of land use and activity restrictions, would be implemented to prevent exposure to potential residual hazardous substances in soil left in place and preserve the integrity of the engineered cover. Figure 12-14 presents schematic cross sections of the proposed covers at various locations in Parcel E-2, corresponding to the conceptual excavation plan. The schematic cross sections depict the proposed thicknesses of the covers, specifically the clean imported soil and the on-site soil that would be screened for radioactive contamination exceeding the radiological remediation goals (as specified in Table 8 of the radiological addendum to the RI/FS Report [ERRG and Radiological Survey and Remedial Services, LLC, 2011]).

The grading of solid waste, soil, and sediment, as shown on Figure 12-1, would be required to create stable slopes in the Shoreline Area and allow for wetland creation in the Panhandle Area. Figure 12-15 presents a conceptual cross section adjacent to the PCB Hot Spot Area where, following hot spot excavation, additional excavation would be required to construct the shoreline protection system. As shown on Figures 12-13 and 12-14, all of Parcel E-2 would be covered with 2 feet of clean imported soil underlain by a demarcation layer and at least 1 foot of on-site soil that would be screened for radioactive contamination exceeding the remediation goals. Figure 12-13 identifies that most of the surface area within Parcel E-2 would have a radiologically screened foundation layer that exceeds the minimum 1 foot thickness, ranging from 2 feet thick to greater than 12 feet thick. The varying thickness of the foundation layer is the result of distributing the volume of material to be consolidated on site so that the final surface elevations promote drainage in accordance with landfill closure requirements.

Two variations of Alternative 3, Alternatives 3A and 3B, are presented in the evaluation and cost tables in Appendix R. Alternatives 3A and 3B are identical except for the method of treating collected landfill gas. Alternative 3A assumes that destruction by flare is used for landfill gas treatment. Alternative 3B assumes that adsorption by GAC and a potassium permanganate medium (such as, Hydrosil®) would be used for landfill gas treatment. Section 11.5.4 describes these two landfill gas treatment options.

Alternative 3 would involve:

- Institutional controls (discussed in Section 12.1.1)
- Seismic design components to ensure slope stability and address liquefaction potential in the event of an earthquake
- Screening for and excavation and off-site disposal of isolated radiological anomalies
- Removal and off-site disposal of Tier 1 and Tier 2 hot spots (discussed in Sections 12.1.6 and 12.2.3.3)
- Grading and on-site consolidation of materials from the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) to create stable slopes and allow for wetland construction in the Panhandle Area
- Construction of a new multilayer geosynthetic cap over portions of the Landfill Area not already capped and a new geosynthetic cap over the adjacent areas (except at areas planned for tidal and freshwater wetlands)
- Construction of a groundwater diversion system (consisting of an upgradient slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation
- Installation of a subsurface drainage system along the southern perimeter of the landfill (in the event that groundwater monitoring results require extraction and treatment of leachate and contaminated groundwater)
- Construction of a shoreline protection system (discussed in Section 12.1.3)

- Decommissioning of the existing gas control system and installation (and subsequent maintenance) of an active gas collection system with treatment using a flare (Alternative 3A) or GAC and potassium permanganate (Alternative 3B)
- Installation of stormwater and erosion controls (discussed in Section 12.1.4)
- Post-construction landfill cap inspection and maintenance, and monitoring of landfill gas
- Post-construction monitoring of groundwater and stormwater (discussed in Sections 12.1.2 and 12.1.4, respectively)
- Construction (and subsequent monitoring) of freshwater and tidal wetlands in the Panhandle Area

The subsequent subsections discuss the various components of this alternative in further detail.

12.2.3.1. Seismic Design of Containment System

The seismic design of the containment system planned for Alternative 3 will use information from (1) the 2002 liquefaction potential study at Parcel E-2 (Appendix C to this report), and (2) the qualitative slope stability analyses performed as part of this RI/FS Report (Appendix Q). Alternative 3 includes construction of a toe berm along the southern perimeter of the Landfill Area to stabilize the proposed cap (Figure 12-4). As presented in Appendix C, the potential exists for liquefaction of sand and silt fill materials underlying the perimeter of the Landfill Area during the maximum probable earthquake (a magnitude 7.9 earthquake on the San Andreas Fault Peninsula Segment, centered 12 kilometers from Parcel E-2; see Appendix C). Such liquefaction could affect the stability of the proposed toe berm, which in turn could affect the stability of the proposed cap; therefore, a qualitative slope stability analysis was performed for the toe berm based on residual shear strength within sand and silt fill resulting from liquefaction (Appendix Q).

Results of an iterative slope stability analysis determined that a Tensar® UX1500HS or equivalent geogrid with a long-term design tensile strength of 3,100 pounds per foot should be placed under the proposed toe berm, and should extend upslope to an appropriate anchor point within the proposed landfill cap; this conceptual design would meet or exceed design standards prescribed in EPA guidance (EPA, 1995b). This geogrid layer was added under the toe berm proposed for Alternative 3 (Figure 12-4). Because the analyses presented in Appendix Q are a qualitative assessment of the proposed toe berm evaluated in the FS, a quantitative slope stability analysis will be performed as part of the RD. The Navy plans to collect soil samples along the base of the proposed toe berm and to perform shear strength tests (and other appropriate geotechnical analyses) to support the quantitative slope stability analysis in the RD. The proposed sampling and geotechnical analyses would be detailed in a work plan to be reviewed by the regulatory agencies prior to implementation.

12.2.3.2. Radiological Control Procedures and Anomalies Excavation

The radiological control procedures for Alternative 3 would be consistent with the procedures established for the recently completed removal actions at the PCB Hot Spot Area and Metal Slag Area (TtFW, 2005a and 2005b). These procedures were summarized in Section 12.2.2.3.

The lateral and vertical extent of excavations required to adequately remove isolated radiological anomalies at the surface would be identified through screening and sampling; however, for cost-estimating purposes, it was assumed that surface radiological anomalies requiring off-site disposal would be encountered within 10 percent of the material from 0 to 1 foot bgs during clearing and grubbing operations. In addition, it was assumed that radiological anomalies requiring off-site disposal would be encountered within 5 percent of the material deeper than 1 foot bgs during grading operations. These assumptions resulted in an estimated 16,200 cubic yards of low-level radiologically impacted vegetation and soil being excavated, stockpiled on site, and screened for disposal purposes. Radioactive material, including any identified mixed waste, would be properly stored on site pending disposal by a certified waste broker through the Navy's Low-level Radioactive Waste Disposal Program.

12.2.3.3. Removal of Tier 1 and 2 Hot Spots

As part of this alternative, Tier 1 and Tier 2 hot spots would be removed, as shown on Figure 12-16, in conjunction with the shoreline excavation process described in Section 12.1.3. Following screening for and segregation of radiologically impacted material (which would be disposed of off site), hot spots would be excavated and disposed of off-site; material excavated as part of the overall grading process would be consolidated into the landfill under the new cap extension. The Tier 1 and 2 hot spot excavations entail the removal of approximately 17,300 cubic yards of contaminated material. Additional information on the identification of Tier 1 and 2 hot spots is provided in Section 12.1.6.

12.2.3.4. Grading

The conceptual grading and excavation plans for Alternative 3 are shown on Figures 12-1 and 12-13, respectively. Grading for this alternative would require approximately 80,000 cubic yards of material to be excavated from the Panhandle Area and Shoreline Area to restore wetlands and construct the shoreline protection. The excavated material would be consolidated on site after LLRW and nonradioactive hot spots are segregated and disposed of off site. As shown on Figure 12-13, most of the excavated material would be consolidated in the northern portion of the Landfill Area. This area was selected as the primary location for material consolidation because it does not have an existing cap and would therefore minimize the amount of existing cap that would need to be removed and reinstalled. Smaller volumes of excavated material would be consolidated in the East Adjacent Area and portions of the Panhandle Area surrounding the proposed freshwater wetlands.

Prior to waste consolidation, the existing soil cover in the Landfill Area would be excavated and screened for potential radioactivity, stockpiled on site, and used as foundation material under the cap (if radiological concentrations are acceptable). It is anticipated that all other fill required for the cap construction would be imported to the site from off-site borrow sources.

Shoreline construction would proceed by isolating sections of the shoreline (via sheet pile or inflatable cofferdams) to remove material and build containment structures. If no isolation and dewatering is needed along a given shoreline section, some form of control structures (silt curtains) would need to be deployed along with a monitoring program similar to those for the TCRAs at the Metal Slag Area and Metal Debris Reef. All grading activities would be performed using appropriate radiological control procedures similar to those outlined in Section 12.2.2.3. For the purposes of cost estimating, it was assumed that 5 percent of the material excavated during site grading activities would be radiologically impacted and require off-site disposal.

12.2.3.5. Segregation, Stockpiling, Characterization, and Disposal of Radiologically Impacted Material

Radiologically contaminated material would be transported to an on-site staging area for waste characterization, segregation, and stockpiling. Waste characterization would be achieved through stockpile characterization, and would involve testing for various chemicals and other physical properties, in accordance with the specified waste characterization ARARs and any additional requirements of the off-site disposal facility. The cost estimate was developed assuming that approximately 10 percent of the material excavated from 0 to 1 foot bgs (during clearing and grubbing operations) and 5 percent of the material excavated from deeper than 1 foot bgs (during grading operations) would be disposed of off site as LLRW and the remaining material from the grading process would be used as foundation material under the cap; Tier 1 and 2 hot spots would be excavated and disposed of off site.

Following characterization of a given stockpile and acceptance of the waste profile by the disposal facility, waste would be loaded into waste bins, placed on trucks, and transported to the off-site disposal facility. To estimate transportation and disposal costs for this alternative, preliminary cost information was obtained from disposal facilities able to accept the anticipated wastes types, and was used to develop preliminary unit rates for transporting and disposing of the various waste types under Alternative 3. The preliminary unit rates were then used to develop an estimate of the transportation and disposal costs for Alternative 3; however, the estimated transportation and disposal costs are intended only to support the analysis in this RI/FS Report and do not represent firm pricing commitments from individual waste disposal facilities.

12.2.3.6. Cap Construction

A multilayer geosynthetic cap would be constructed over the solid waste and soil in areas of the landfill not already covered by the existing multilayer geosynthetic cap. As described in Section 11.5.1.3, the multilayer geosynthetic cap would consist of (1) a geocomposite drainage layer, (2) a 60-mil thick HDPE geomembrane, and (3) a GCL. Because of the higher volume and proportion of putrescible waste in the Landfill Area, the extra protection afforded by the multilayer geosynthetic cap is important to the control of landfill gas emissions, as discussed in Section 11.5.1.3. The new cap would be contiguous with the existing multilayer geosynthetic cap, and the geosynthetic materials of both caps would be interconnected to provide continuous containment over the landfill (Figure 12-17). A portion of the existing landfill cap would be removed to achieve the grades shown on Figure 12-1, and a new multilayer geosynthetic cap would be constructed in these areas. An evaluation of the proposed geosynthetic cap was performed using HELP-3 computer software published by the EPA for assessment of infiltration rates through the cap. Based on the HELP-3 modeling, no significant infiltration is anticipated through the proposed geosynthetic cap. Results of the final cover evaluation are presented in Appendix P.

A geosynthetic cap, consisting of a geocomposite drainage layer and a 60-mil thick HDPE geomembrane (see Section 11.5.1.2), would be constructed over the Panhandle, East Adjacent, and Shoreline Areas, except for the restored tidal and freshwater wetlands within the Panhandle Area. The cap in the adjacent areas would be constructed either directly on the prepared subgrade (cover type D as depicted on Figures 12-13 and 12-14) or on top of consolidated material (cover type C as depicted on Figures 12-13 and 12-14). The vegetative layer would be 24-inches thick throughout Parcel E-2. The geosynthetic cap would be connected to the existing and new multilayer geosynthetic cap, as shown on Figure 12-18. The new capped areas would be designed to meet landfill closure requirements as provided in 27 CCR. (The existing multilayer geosynthetic cap on the landfill exceeds these requirements.)

Although the proposed geosynthetic cap would not entirely prevent small amounts of rainwater from infiltrating through defects on the geomembrane layer of the final cap, the amount of infiltration through defects on a properly constructed cap are expected to be insignificant. Any additional leachate generated by infiltration through defects in the geosynthetic cap would have no significant effect on overall effectiveness of the remedy compared to its current condition, where uncapped landfilled wastes are exposed to infiltration through the existing soil cover. In the Panhandle Area outside the restored tidal and freshwater wetlands, the cap could allow small amounts of rainwater to infiltrate through defects or damage to the geosynthetic cap. However, compared to current on-site conditions, infiltration in these areas would be significantly reduced because rainwater quantities infiltrating through defects in the cap are expected to be insignificant.

As discussed above, a geocomposite drainage layer is part of both types of geosynthetic caps for Alternative 3. In addition to providing a drainage path for water infiltrating through the vegetative layer, the geocomposite drainage layer would also deter burrowing animals from penetrating the HDPE geomembrane. The potential for burrowing animals to penetrate a geosynthetic cap is generally considered low by experts in the waste containment industry (Sharma and Lewis, 1992; Karr et al., 1992; Gee and Ward, 1997; AFCEE, 1999); however, this potential cannot be entirely dismissed, thus the geocomposite drainage layer is proposed as an additional deterrent to burrowing animals (to supplement post-closure inspection, maintenance, and animal control measures; see Section 12.2.3.10). The proposed use of a geocomposite drainage layer as an additional deterrent to burrowing animals is similar to approved final designs at several San Francisco Bay area landfill sites (TtEMI, 2005d; IT, 2000; U.S. Department of Energy, 2001). One of the sites, the Site 1 Landfill at the former Naval Air Station Moffett Field, uses regular inspection, maintenance, and low-impact control measures (raptor perches) to effectively manage burrowing animals. The cap at the Site 1 Landfill at the former Naval Air Station Moffett Field has been in place since November 1998 and continues to be protective of human health and the environment (EPA, 2009).

In the restored freshwater wetlands within the Panhandle Area, a 1-foot-thick low-permeability clay liner is proposed to limit potential intrusion of shallow groundwater, which contains chemicals that may be harmful to aquatic wildlife. The clay liner was selected to replace the geosynthetic liner, as proposed in the Draft Final RI/FS Report, because of its improved effectiveness in the presence of shallow groundwater. The geosynthetic cap adjacent to the freshwater wetlands would be keyed into the clay liner to form a continuous low-permeability layer within this portion of the Panhandle Area (Figure 12-2). No cap is proposed for the tidal wetlands area because additional excavation in this area will completely remove contaminated material from 0 to 3 feet bgs, thereby eliminating the exposure pathway for aquatic and terrestrial wildlife and significantly reducing the potential sources to groundwater contamination while integrating the tidal wetlands with the adjoining Yosemite Slough restoration project.

12.2.3.7. Groundwater Diversion System along Western Boundary of Landfill Area

To reduce groundwater flow through the landfill waste, a groundwater diversion system (consisting of an upgradient slurry wall and subsurface drain) would be installed along the western boundary of the Landfill Area, the predominant upgradient source of groundwater entering the landfill. Off-site groundwater would be prevented from flowing directly into the landfill waste by the upgradient slurry wall and would be diverted by the subsurface drain, consisting of a 6-inch-diameter collector pipe buried in a gravel- or sand-filled trench (Figure 12-5). The diverted off-site groundwater would drain by gravity to the newly constructed freshwater wetlands (Figure 12-1). Based on results of preliminary groundwater modeling (Appendix P), the subsurface drain would be placed at approximately 6 feet msl and would drain into the freshwater wetlands, with bottom elevations ranging from 4 to 5 feet msl.

Data from two groundwater monitoring wells (IR01MW403A and IR01MW403B, located within 100 feet of the proposed subsurface drain, Figure M-1) were reviewed to preliminarily assess the quality of groundwater proposed for diversion to the freshwater wetlands; the RD will refine this assessment, as appropriate. Maps presented in Appendix M indicate that most chemical concentrations at wells IR01MW403A and IR01MW403B do not exceed aquatic evaluation criteria. Low concentrations of several chemicals (cyanide, 4,4'-DDD, and dieldrin) were sporadically detected below laboratory reporting limits but greater than aquatic evaluation criteria; these trends do not suggest that cyanide, 4,4'-DDD, or dieldrin are COECs for the freshwater wetlands. Un-ionized ammonia and sulfide have been consistently detected at concentrations exceeding aquatic evaluation criteria and are considered COECs for the freshwater wetlands. As discussed in Appendix M, both of these anions readily transform to non-toxic compounds upon discharge to oxygenated surface water. The subsurface drain will be designed to ensure that groundwater flow is sufficiently aerated prior to discharge into the freshwater wetlands.

12.2.3.8. Subsurface Drainage System along Southern Perimeter of Landfill Area

Groundwater flow modeling was performed to determine the pumping rate that would be required to prevent head buildup against the proposed shoreline protection along the southern perimeter of the Landfill Area. Based on the groundwater modeling results, a 1-foot thick subdrain gravel blanket and a 6-inch drain pipe would prevent hydraulic build-up against the toe berm underlying the shoreline protection system (Figure 12-4). The drainage system and associated groundwater extraction components would meet leachate collection and control requirements at 22 CCR § 66264.310(b)(2).

The subsurface drainage system would be designed to handle the expected flow rate from groundwater upgradient flow recharge. The system would be equipped with riser pipes, submersible pumps, and a transmission pipeline for discharge to an on-site sanitary sewer manhole (Figure 12-16). A permit to discharge to a publicly owned treatment plant (POTW) would be prepared and submitted prior to construction. A contingency plan for installing a groundwater treatment system unit near Parcel E-2 would also be considered in the event that discharge to the POTW is required to meet pre-treatment standards (outlined in 40 CFR § 403); however, this is considered unlikely considering that, based on over 6 years of operational data, no pre-treatment of extracted groundwater was required for the former GES at the PCB Hot Spot Area (see Section 3.8.3).

12.2.3.9. Landfill Gas Control

Future landfill gas generated within the Landfill Area would be controlled by an active landfill gas collection system that would prevent landfill gas from exceeding regulatory thresholds at compliance points. In the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas), landfill gas is not expected to be generated to a degree that requires collection; however, an investigation will be conducted during the RD to more thoroughly evaluate soil gas concentrations in the Panhandle, East Adjacent, and Shoreline Areas to determine if gas collection and control (such as passive subsurface venting) is required. Further, it should be noted that wetlands and bay mud are natural sources of methane, hydrogen sulfide, and other gases similar in composition to landfill gases; if not attributed to in-place waste, these gases would not be subject to gas collection requirements.

As stated above, a landfill gas collection system would be installed to actively collect landfill gas from the Landfill Area. The appropriate landfill gas treatment technology, if necessary, will be determined during the RD based on landfill gas data collected from within the landfill. Landfill gas treatment by flare is assumed for costing and evaluating Alternative 3A, and GAC and potassium permanganate treatment is assumed for Alternative 3B. Figure 12-19 shows the conceptual landfill gas collection system. This system would draw landfill gas from the landfill and away from the landfill perimeter to control gas migration. The system would consist of a series of vertical extraction wells spaced sufficiently close together to ensure removal of landfill gas from all solid waste areas, especially near the landfill perimeter. The vertical extraction wells would be connected to a header pipe that would tie the wells together. A blower assembly would create a vacuum in the header pipe that would draw gas to the central collection point located in the southeast corner of the landfill. The collected gas would then be conveyed to the flare or GAC and potassium permanganate treatment system for destruction or treatment, respectively. The header pipe would be installed underground, and all extraction wells would be terminated flush with the ground and have vaults with lockable covers at the surface to discourage vandalism. The subgrade collection header pipe would daylight inside the collection and treatment compound. The area around the gas treatment system would be fenced to restrict public access.

12.2.3.10. Monitoring, Operation, and Maintenance

Landfill gas monitoring is required to meet the RAOs and to demonstrate compliance with 27 CCR §§ 20917 through 20934, “Gas Monitoring and Control at Active and Closed Disposal Sites.” The specific landfill gas monitoring program will be determined during the RD and included as part of the Parcel E-2 closure plan. The gas monitoring program will be designed to account for:

- Local soil, rock, and hydrogeological conditions
- Locations of buildings and structures relative to the waste disposal area
- Adjacent land use and inhabitable structures within 1,000 feet of the landfill
- Manmade underground structures, such as vaults
- The nature and age of waste and its potential to generate landfill gas

At a minimum, monitoring would be quarterly for methane and NMOCs at wells around the perimeter of the landfill and at on-site structures, such as buildings, subsurface vaults, utilities, and any other areas where potential gas buildup can occur. The landfill gas monitoring program will primarily be performed using field instruments and will include, to the extent practical, comparisons of regularly collected field instrument data for NMOCs with periodic laboratory sample analysis for NMOCs. The data will be used to verify that, in accordance with 27 CCR § 20921, exposure to residual NMOCs does not pose an unacceptable risk to future site users. The anticipated minimum monitoring period is 30 years, or until it is demonstrated that landfill gas no longer poses a threat to human health or the environment.

Several general assumptions were made to develop the FS costs for the landfill gas monitoring component. Landfill gas will not migrate below the groundwater table, which is between 6 and 20 feet bgs, so GMPs would not be screened below the water table; rather, GMPs would be screened from 5 feet bgs (above the historic high groundwater elevation at Parcel E-2) to the historic low groundwater elevation, which varies across Parcel E-2 to a maximum depth of 16 feet bgs (north of landfill). Existing GMPs are located approximately 150 feet apart on the Parcel E-2 boundary north of the landfill and would continue to be used under Alternative 3. Under Alternative 3, it is assumed that additional GMPs would be installed at 150-foot intervals along the western Parcel E-2 boundary and along the eastern edge of the existing multilayer geosynthetic cap. Along the southern boundary of Parcel E-2, the landfill is bounded by San Francisco Bay; thus, landfill gas migration cannot occur in this direction and GMPs would not be required.

In addition, the cap across Parcel E-2 would be inspected and maintained to ensure the integrity of the cap and the vegetative layer. Inspection and maintenance procedures will be detailed in the post-closure maintenance plan for Parcel E-2, consistent with requirements as provided in 27 CCR, and submitted for regulatory agency review in conjunction with the RD. The inspection and maintenance procedures will be developed based upon the Navy's experience to date in maintaining the interim cover at the Parcel E-2 Landfill, as well as at similar sites in the San Francisco Bay area. Inspection procedures would involve checking various site conditions, including searching for evidence of burrowing animals. Maintenance actions would include prompt repair of any damage and use of animal control measures to control burrowing animals. Low-impact control measures, such as the installation of raptor perches, would be preferable as opposed to higher impact control measures, such as the use of poisons, to control burrowing animals at Parcel E-2. Similar inspection and maintenance procedures, coupled with low-impact animal control measures, are being implemented at the Site 1 Landfill at the former Naval Air Station Moffett Field and have been demonstrated to be effective in protecting human health and the environment (EPA, 2009).

12.2.3.11. Wetlands Restoration

Tidal wetlands would be restored along the shoreline of the Panhandle Area and made ecologically contiguous with the tidal wetlands being restored at the adjacent property (Yosemite Slough restoration project). Tidal water would be allowed to flow freely across the shoreline in the Panhandle Area to create a tidal wetland. Any potential scouring of the mudflat would be controlled through design features, including shallow slopes and installation of vegetation. Freshwater wetlands would be restored at a similar location as the existing freshwater wetlands (which will be destroyed during the remedial action), would be underlain by hydric soil and a clay liner, as shown on Figures 12-13 and 12-14. Existing surface drainage that provides hydrologic support for the freshwater wetland would be maintained, and the freshwater supply would be supplemented by the groundwater diversion system (Section 12.2.3.7). It is anticipated that sufficient water would be available to replace the existing freshwater wetland at the selected 1:1 ratio (Appendix O). The freshwater wetlands would include a surface outfall to the drainage ditch along the western Parcel E-2 boundary that would be designed to minimize flooding during storm events.

Wetlands vegetation used for restoration would meet the requirements for the vegetative layer (for example, capable of sustained growth, root depth can be designed not to exceed the top of the low hydraulic conductivity layer, compatible with post-closure land use, and can tolerate soil conditions). Wetlands vegetation is resistant to adverse conditions of climate, disease, and pests; is self propagating; has a high percentage of surface area coverage; and minimizes the need for irrigation and maintenance. However, sustained freshwater and tidal wetlands are dependent on water and the seasonal freshwater wetland requires saturation within 12 inches of the surface to sustain the wetland vegetation.

Stormwater flowing toward Parcel E-2 from the UCSF compound would be intercepted by a drainage ditch north of the new cap, and either diverted to the existing storm sewer system north of Parcel E-2 or conveyed to a discharge point into the freshwater wetlands. Most of the stormwater flowing from the cap would flow south toward San Francisco Bay and be collected in perimeter ditches. The ditches would flow toward inlets located on the southern perimeter of the final cap for discharge to the bay through culverts or for discharge to the freshwater wetlands. Wetlands would be maintained and monitored in accordance with the wetlands mitigation and monitoring plan (Shaw, 2009b).

12.2.4. Alternative 4: Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands)

Alternative 4 involves all of the components of Alternative 3, but also includes (1) excavation and off-site disposal of Tier 3, 4, and 5 hot spots (in addition to Tier 1 and 2 hot spots; see Section 12.1.6); (2) containment of contaminated groundwater with a nearshore slurry wall in areas where the landfill waste is within 100 feet of San Francisco Bay; and (3) the contingency to extend the nearshore slurry wall south into the PCB Hot Spot Area. The need for extending the nearshore slurry wall will be assessed in the RD using updated groundwater monitoring data from wells in and around the excavated portion of the PCB Hot Spot Area, which is currently being collected under the BGMP. The groundwater diversion system (consisting of an upgradient slurry wall and subsurface drain) along the west side of the landfill, as proposed under Alternative 3, would minimize hydraulic head buildup behind the nearshore slurry wall. This alternative would provide a comprehensive closure strategy for Parcel E-2 similar to Alternative 3, but includes the removal of additional hot spots (Tiers 3, 4, and 5) and containment of groundwater in areas where chemical contamination may affect aquatic wildlife in the bay or in the restored freshwater wetlands. This alternative would also include long-term groundwater monitoring.

Figure 12-1 shows the conceptual grading plan for Alternative 4. The grading of solid waste, soil, and sediment would be required to create stable slopes in the Shoreline Area and allow for wetland creation in the Panhandle Area.

Two variations of Alternative 4 (4A and 4B) are presented in the evaluation and cost tables in Appendix R. Alternative 4A and 4B are identical to Alternatives 3A and 3B presented in Alternative 3 and, as described in Section 12.2.3, describe two landfill gas treatment options: destruction by flare (Alternative 4A) and adsorption by GAC and a potassium permanganate medium (Alternative 4B).

Alternative 4 would involve:

- Institutional controls (discussed in Section 12.1.1)
- Seismic design components to ensure slope stability and address liquefaction potential in the event of an earthquake (discussed in Section 12.2.3.1)
- Screening for and excavation and off-site disposal of isolated radiological anomalies (discussed in Section 12.2.3.2)
- Removal and off-site disposal of Tiers 1, 2, 3, 4, and 5 hot spots (discussed in Sections 12.1.6 and 12.2.4.1)
- Grading and on-site consolidation of materials from the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) to create stable slopes and allow for wetland construction in the Panhandle Area (discussed in Section 12.2.3.4)
- Construction of a new multilayer geosynthetic cap over portions of the Landfill Area not already capped and a new geosynthetic cap over the adjacent areas (discussed in Section 12.2.3.6)
- Construction of a groundwater diversion system (upgradient slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation (discussed in Section 12.2.3.7)
- Installation of a subsurface drainage system along the southern perimeter of the landfill (discussed in Section 12.2.3.8)
- Construction of a shoreline protection system (discussed in Section 12.1.3)
- Decommissioning of the existing gas control system and installation (and subsequent maintenance) of an active gas collection system with treatment using a flare (Alternative 4A) or GAC and potassium permanganate (Alternative 4B) (discussed in Section 12.2.3.9)
- Installation of stormwater and erosion controls (discussed in Section 12.1.4)

- Post-construction landfill cap inspection and maintenance, and monitoring of landfill gas (discussed in Section 12.2.3.10)
- Post-construction monitoring of groundwater and stormwater (discussed in Sections 12.1.2 and 12.1.4, respectively)
- Construction (and subsequent monitoring) of freshwater and tidal wetlands in the Panhandle Area (discussed in Section 12.2.3.11)
- Construction of a groundwater containment system (nearshore slurry wall) to prevent the discharge of contaminated groundwater to the bay (discussed in Section 12.2.4.2)
- Post-construction monitoring of groundwater and stormwater (discussed in Sections 12.1.2 and 12.1.4, respectively)

The subsequent subsections discuss the unique components of this alternative in further detail.

12.2.4.1. Removal of Tiers 1, 2, 3, 4, and 5 Hot Spots

As part of this alternative, Tiers 1, 2, 3, 4, and 5 hot spots would be removed, as shown on Figure 12-20, in conjunction with the shoreline excavation and grading processes described in Sections 12.1.3 and 12.2.3.4, respectively. Following screening for and segregation of radiologically impacted material (which would be disposed of off site), hot spots would be excavated and disposed of off-site; material excavated as part of the overall grading process would be incorporated into the landfill under the new cap extension. The Tier 1 through 5 hot spot excavations entail the removal and off-site disposal of approximately 33,500 cubic yards of contaminated material. Additional information on the identification of Tier 1 through 5 hot spots is provided in Section 12.1.6.

12.2.4.2. Groundwater Containment System

Alternative 4 would involve construction of a groundwater containment system consisting of (1) a nearshore slurry wall hydraulically downgradient of the landfill where wastes are within 100 feet of San Francisco Bay; (2) a groundwater diversion system (consisting of an upgradient slurry wall and subsurface drain) along the west side of the landfill to minimize hydraulic head buildup behind the nearshore slurry wall; and (3) a contingency to extend the nearshore slurry wall into the East Adjacent Area (hydraulically downgradient of the PCB Hot Spot Area). The need to extend the nearshore slurry wall will be assessed in the RD using updated groundwater monitoring data, which are currently being collected under the BGMP from wells in and around the excavated portion of the PCB Hot Spot Area. While the subsurface drainage system and associated groundwater extraction components meet the leachate collection and control requirements at 22 CCR § 66264.310(b)(2), the groundwater containment system is included in Alternative 4 to thoroughly evaluate the potential options needed to prevent discharge of COECs in groundwater at concentrations exceeding the chemical-specific ARARs for surface water (described in Section 10.1.2). As discussed in Section 9.3, the identified chemicals in groundwater that may pose a risk to aquatic wildlife in the bay (Appendix M) are considered COECs (that is, of chemicals of ecological concern) given the conservative nature of the risk analysis performed for that pathway.

The conceptual design for the groundwater containment system is shown on Figure 12-20. The location of the nearshore slurry wall downgradient of the landfill waste is shown, relative to other components of the containment system, on Figure 12-2 (Section B). The location of the contingency nearshore slurry wall downgradient of the PCB Hot Spot Area is shown on Figure 12-2 (Section A). As discussed in Section 12.2.3.7, the groundwater diversion system would consist of an upgradient slurry wall designed to impede upgradient groundwater flowing from off-site and a subsurface drain that would direct the off-site groundwater to the newly constructed freshwater wetlands.

Installation of the slurry walls would require trenching 10 to 15 feet below the groundwater table to key the barrier into the Bay Mud aquitard. The slurry walls could be installed in saturated conditions without extensive dewatering; however, installation would need to account for the potential presence of large debris and irregular subsurface voids by contingency planning; for example, performing pre-design studies to identify subsurface irregularities, planning for potential realignment of the wall if large debris is encountered, and providing surplus slurry material to account for irregular subsurface voids. Such techniques were previously used at Parcel E-2 during construction of the GES and the interim gas control system.

12.2.5. Alternative 5: Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and unlined freshwater wetlands)

Alternative 5 involves all of the components of Alternative 4, but eliminates the 1-foot-thick clay liner within the proposed freshwater wetland and replaces it with an additional 1 foot of hydric soil (Figures 12-14 and 12-21). Alternative 5 was developed to evaluate the relative advantages of unlined freshwater wetlands as compared with the lined freshwater wetlands proposed under Alternatives 3 and 4. This alternative would provide a comprehensive closure strategy for Parcel E-2 similar to Alternative 4, but would promote a more natural hydrological function within the freshwater wetland (i.e., allowing interaction between surface water and underlying groundwater).

Figures 12-1 and 12-21 show the conceptual grading and excavation plans, respectively, for Alternative 5. The grading of solid waste, soil, and sediment would be required to create stable slopes in the Shoreline Area and allow for wetland creation in the Panhandle Area.

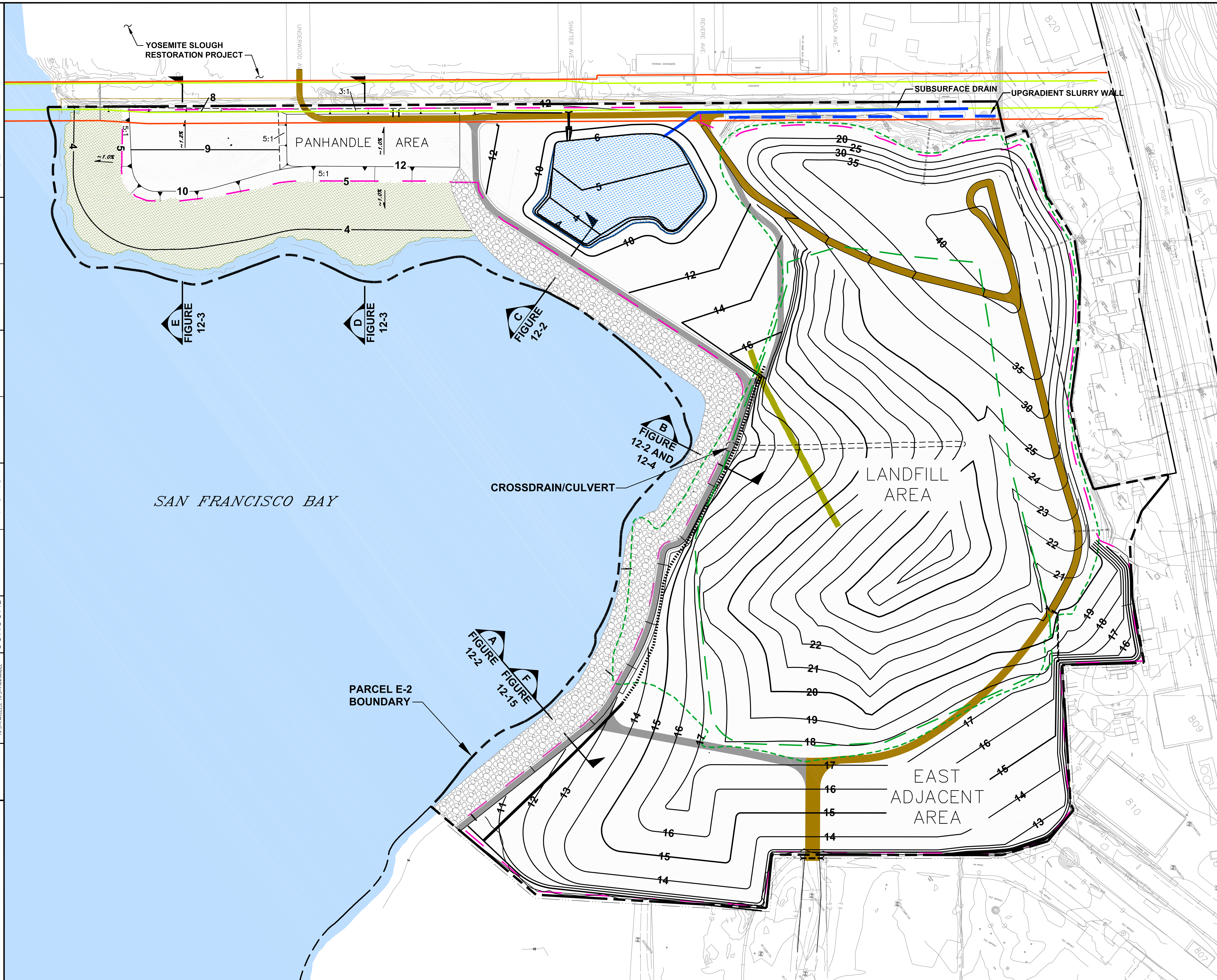
Two variations of Alternative 5 (5A and 5B) are presented in the evaluation and cost tables in Appendix R. Alternatives 5A and 5B are identical to Alternatives 3A and 3B presented in Alternative 3 and, as described in Section 12.2.3, describe two landfill gas treatment options: destruction by flare (Alternative 5A) and adsorption by GAC and a potassium permanganate medium (Alternative 5B).

Alternative 5 would involve:

- Institutional controls (discussed in Section 12.1.1)
- Seismic design components to ensure slope stability and address liquefaction potential in the event of an earthquake (discussed in Section 12.2.3.1)
- Screening for and excavation and off-site disposal of isolated radiological anomalies (discussed in Section 12.2.3.2)
- Removal and off-site disposal of Tiers 1, 2, 3, 4, and 5 hot spots (discussed in Sections 12.1.6 and 12.2.4.1)
- Grading and on-site consolidation of materials from the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) to create stable slopes and allow for wetland construction in the Panhandle Area (discussed in Section 12.2.3.4)
- Construction of a new multilayer geosynthetic cap over portions of the Landfill Area not already capped and a new geosynthetic cap over the adjacent areas (discussed in Section 12.2.3.6)
- Construction of a groundwater diversion system (upgradient slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation (discussed in Section 12.2.3.7)
- Installation of a subsurface drainage system along the southern perimeter of the landfill (discussed in Section 12.2.3.8)
- Construction of a shoreline protection system (discussed in Section 12.1.3)
- Decommissioning of the existing gas control system and installation (and subsequent maintenance) of an active gas collection system with treatment using a flare (Alternative 4A) or GAC and potassium permanganate (Alternative 4B) (discussed in Section 12.2.3.9)
- Installation of stormwater and erosion controls (discussed in Section 12.1.4)
- Post-construction landfill cap inspection and maintenance, and monitoring of landfill gas (discussed in Section 12.2.3.10)
- Post-construction monitoring of groundwater and stormwater (discussed in Sections 12.1.2 and 12.1.4, respectively)
- Construction (and subsequent monitoring) of freshwater and tidal wetlands in the Panhandle Area (discussed in Section 12.2.3.11, except for the 1-foot-thick clay liner within the proposed freshwater wetland being replaced with an additional 1 foot of hydric soil)
- Construction of a groundwater containment system (nearshore slurry wall) to prevent the discharge of contaminated groundwater to the bay (discussed in Section 12.2.4.2)
- Post-construction monitoring of groundwater and stormwater (discussed in Sections 12.1.2 and 12.1.4, respectively)

As discussed previously, the only unique component of Alternatives 5A and 5B (relative to Alternatives 4A and 4B) is the elimination of the 1-foot-thick clay liner within the freshwater wetland. Preliminary groundwater modeling was performed to assess the potential hydrogeologic response under the freshwater wetlands. Results of the preliminary modeling, as presented in Appendix P, suggest that (1) increased infiltration from the freshwater wetlands would create a groundwater mound, and (2) the freshwater wetlands would receive negligible flow from surrounding groundwater that contains chemicals that may be detrimental to aquatic wildlife. The preliminary results suggest that unlined freshwater wetlands may be a viable restoration option; however, more refined modeling would need to be performed in the RD to validate this finding.

Figures



DRAWING NUMBER 843812-D39

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY
---	3-13-02, 3-13-02-R1 HPS-PARCELS, HPS-PANHANDLE	CONCORD	BJ 4-6-10	-	-

LEGEND

- LANDFILL AREA
- APPROXIMATE LIMIT OF GEOSYNTHETIC CAP
- EXISTING LIMIT OF GEOSYNTHETIC CAP
- PARCEL E-2 BOUNDARY
- RIPRAP SLOPE PROTECTION
- PEDESTRIAN PATH / WALKWAY
- SERVICE ROAD
- FRESHWATER WETLAND (NO GEOSYNTHETIC CAP)
- TIDAL WETLANDS
- SURFACE WATER DRAINAGE DIVERSION BERM
- CULVERT/DOWNDRAIN
- 23 EXISTING CONTOUR (FEET, MSL)
- 30 PROPOSED CONTOUR (FEET, MSL)
- CCSF PROPOSED YOSEMITE SLOUGH BRIDGE (NON-STADIUM OPTION)
- CCSF PROPOSED YOSEMITE SLOUGH BRIDGE (STADIUM OPTION)
- NEARSHORE SLURRY WALL (SOLID WHERE OPTIONAL)

NOTES:

CCSF CITY AND COUNTY OF SAN FRANCISCO

MSL MEAN SEA LEVEL

1. TOPOGRAPHIC BASE MAP BASED ON AERIAL PHOTOGRAMMETRY DATED 3/13/02.
2. GROUND ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929. (NGVD 29)
3. COORDINATE SYSTEM BASED ON NORTH AMERICAN DATUM OF 1927. (NAD 27)
4. TOPOGRAPHIC BASE COVERAGE DOES NOT GO BEYOND ELEVATION 2'. (NGVD 29)
5. PROPOSED YOSEMITE SLOUGH BRIDGE LOCATION FROM ENVIRONMENTAL IMPACT REPORT FOR PHASE II DEVELOPMENT. (SAN FRANCISCO REDEVELOPMENT AGENCY, 2009)

100 0 100 200

Scale in Feet

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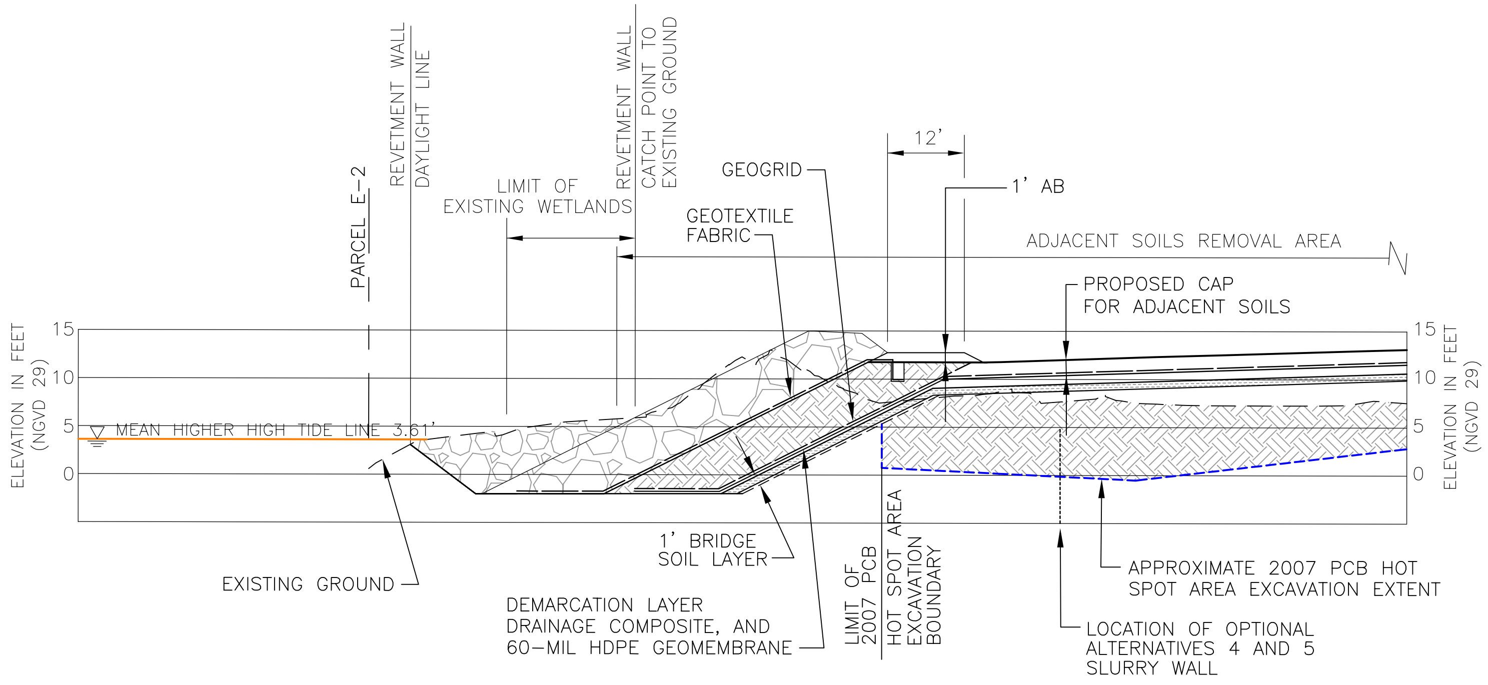
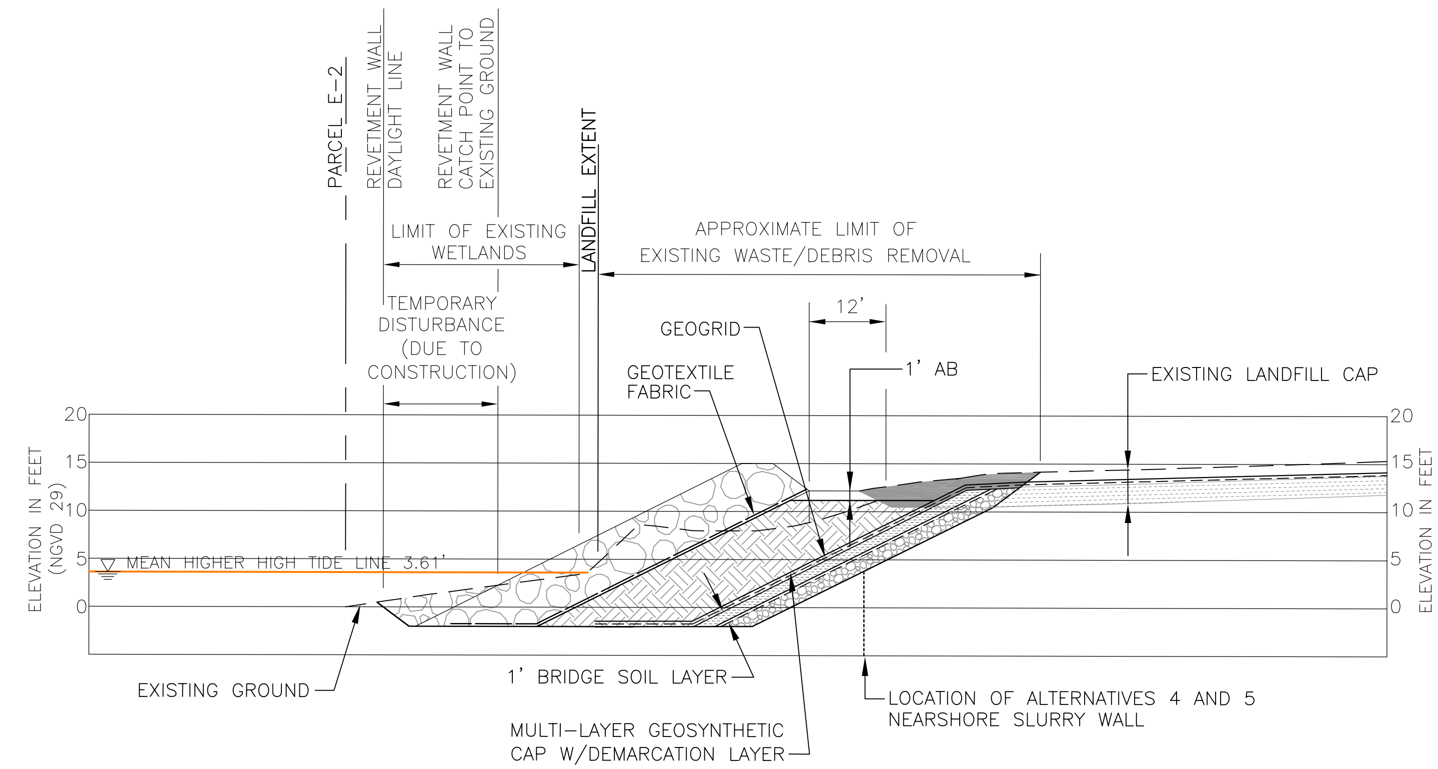
FIGURE 12-1
CONCEPTUAL GRADING PLAN
ALTERNATIVES 3, 4, AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2

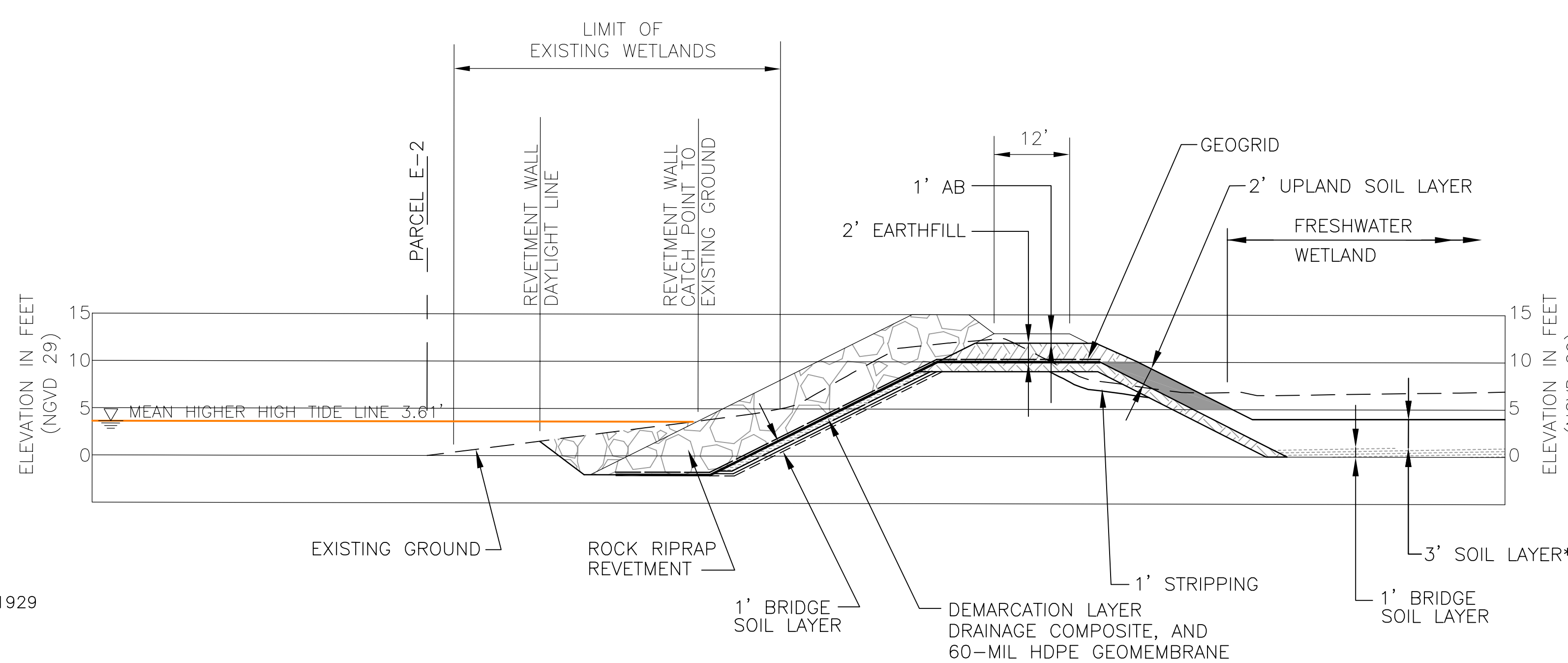
DRAWING NUMBER 843812-B44
APPROVED BY - -
CHECKED BY - -
DRAWN BY BJ 4-5-10
OFFICE CONCORD
X-REF ---
IMAGE ---



SECTION A



SECTION B
ADDITIONAL DETAIL ON FIGURE 12-4



SECTION C
ADDITIONAL DETAIL ON FIGURE 12-5

*ALTERNATIVES 3 and 4: 1' CLAY LINER AND 2' OF HYDRIC SOIL
ALTERNATIVE 5: 3' OF HYDRIC SOIL

LEGEND

	COMPACTED EARTHFILL
	UPLAND SOIL LAYER
	ROCK RIP RAP
AB	AGGREGATE BASE
HDPE	HIGH-DENSITY POLYETHYLENE
NGVD 29	NATIONAL GEODETIC VERTICAL DATUM OF 1929
PCB	POLYCHLORINATED BIPHENYL

15 0 15 30
Horizontal Scale in Feet
10 0 10 20
Vertical Scale in Feet
Vertical Exaggeration (1.5x)

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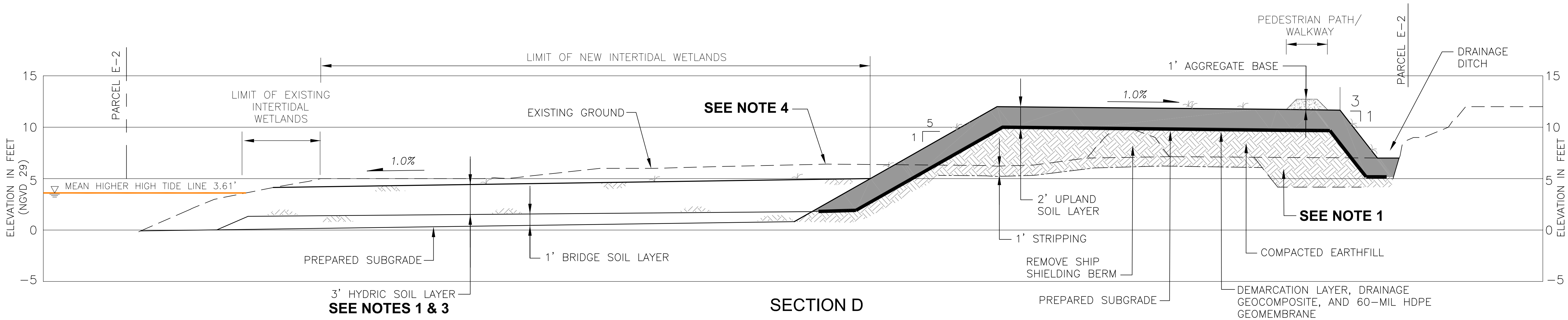
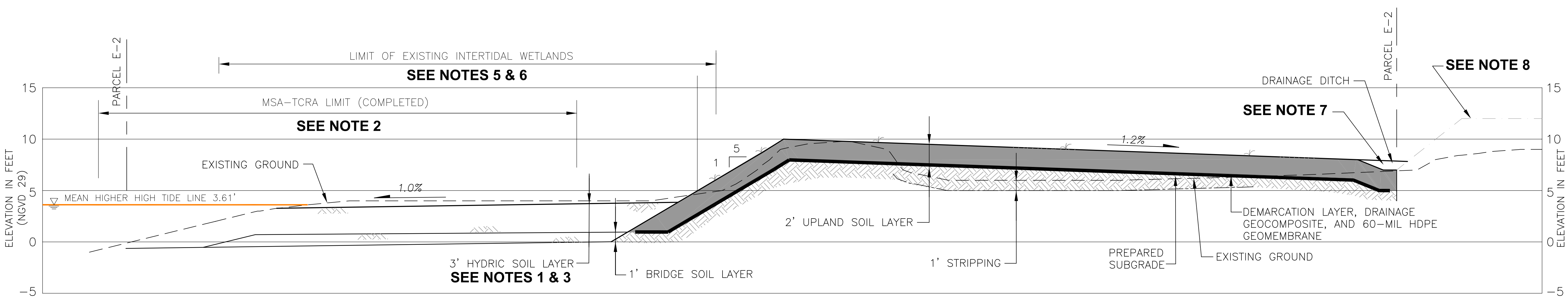
FIGURE 12-2
CROSS SECTIONS A, B AND C
ALTERNATIVES 3, 4, AND 5
Remedial Investigation/Feasibility Study for Parcel E-2



SECTION D



SECTION E

NOTES:

1. REMOVE HOT SPOT MATERIALS IDENTIFIED IN FIGURES 12-7 AND 12-9, PRIOR TO PLACEMENT OF EARTHFILL AND/OR TIDAL WETLAND SOIL COVER.
2. CONDUCT PRE-CONSTRUCTION SURVEY PRIOR TO INSTALLATION OF TIDAL WETLAND SOIL COVER. EROSION PROTECTION INSTALLED FOR THE MSA-TCRA TO BE REMOVED.
3. HYDRIC SOIL TYPE TO BE ELEVATION DEPENDENT:
   ORGANIC BAY MUDS TO BE USED BELOW 3.61' NGVD29 AND ORGANIC SOILS FROM TERRESTRIAL SOURCES FOR AREA BETWEEN 3.61' AND 5' NGVD29.
4. IN 10% OF AREA – BETWEEN 3.61' AND 5' NGVD29, HYDRIC SOIL FINISHED GRADE TO BE 0% TO CREATE FLAT PANNES.
5. SOIL REPLACEMENT COMPLETED HERE, BUT FILL SOILS TO BE EVALUATED FOR SUITABILITY FOR TIDAL WETLAND SUPPORT AND REPLACED WITH HYDRIC SOILS AS NECESSARY.
6. AS-BUILT ELEVATION SURVEY AND POST-TCRA WETLAND OCCURRENCE INFORMATION NOT AVAILABLE FOR MSA; WETLAND DELINEATION MAY NEED TO BE CONDUCTED FOR CONFIRMATION OF POST-TCRA BOUNDARIES.
7. BACKFILL AND RE-GRADE (OPTIONAL) TO MATCH PROPOSED GRADES, SEE DRAWING C-1, YOSEMITE SLOUGH RESTORATION PROJECT, (NOBLE CONSULTANTS INC., 2006).
8. VERIFY/COORDINATE PROPOSED GRADES YOSEMITE SLOUGH RESTORATION PROJECT, SEE DRAWING. C-1, (NOBLE CONSULTANTS INC., 2006)

15 0 15 30
Horizontal Scale in Feet
5 0 5 10
Vertical Scale in Feet
Vertical Exaggeration (3x)

LEGEND

	COMPACTED EARTHFILL
	UPLAND SOIL LAYER
-----	EXISTING SURFACE TOPOGRAPHY
HDPE	HIGH-DENSITY POLYETHYLENE
MSA	METAL SLAG AREA
NGVD 29	NATIONAL GEODETIC VERTICAL DATUM OF 1929
TCRA	TIME-CRITICAL REMOVAL ACTION

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FIGURE 12-3
CROSS SECTIONS D AND E
ALTERNATIVES 3, 4, AND 5

Remedial Investigation/Feasibility Study for Parcel E-2

DRAWING NUMBER 843812-B47
APPROVED BY - -
CHECKED BY - -
DRAWN BY BJ 4-5-10
OFFICE CONCORD
X-REF ---
IMAGE ---

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
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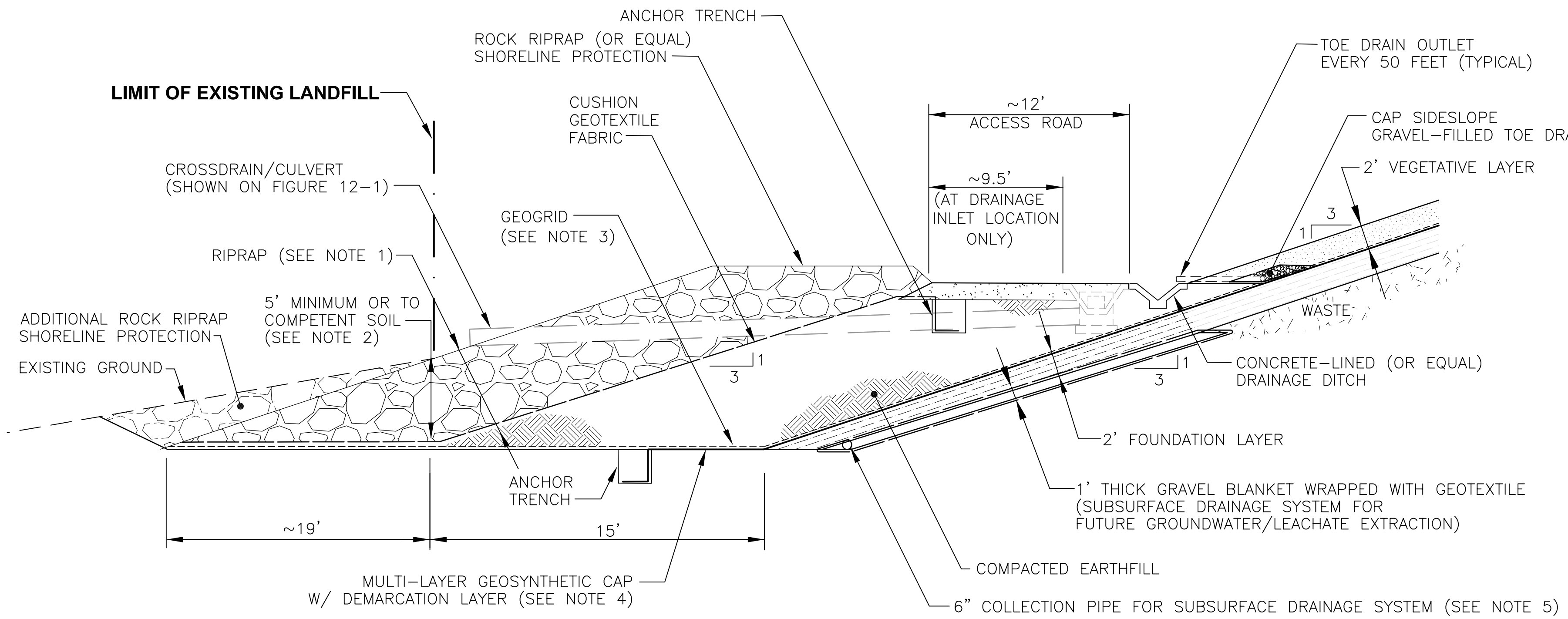

SOUTH PERIMETER CAP TERMINATION WITH ROCK RIPRAP SHORELINE PROTECTION

NOTES:

1. FOR COST ESTIMATING PURPOSES, RIPRAP IS 6 FEET THICK.
2. EXCAVATION TO COMPETENT SOIL MAY NEED TO BE EXTENDED DEEPER THAN FIVE FEET TO ENSURE THAT A STABLE FOUNDATION IS CONSTRUCTED; ADDITIONAL GEOTECHNICAL EVALUATION (INCLUDING SUBSURFACE DATA COLLECTION) WILL BE PERFORMED IN THE REMEDIAL DESIGN AND THE EXCAVATION PLAN WILL BE ADJUSTED ACCORDINGLY.
3. GEOGRID SHOULD BE TENSAR VX 1500 HS OR EQUIVALENT AND SHOULD BE EXTENDED TO AND EMBEDDED WITHIN TOP DECK OF LANDFILL COVER.
4. MULTI-LAYER GEOSYNTHETIC CAP CONSISTS OF DRAINAGE GEOCOMPOSITE, 60-MIL HIGH-DENSITY POLYETHYLENE GEOMEMBRANE, AND GEOSYNTHETIC CLAY LINER (NOT USED ON SIDESLOPE). THIS CAP IS TO BE OVERLAIN BY A DEMARCATION LAYER CONSISTING OF MAGNETIC MARKING TAPE AND ORANGE-COLORED GEOTEXTILE.
5. PROVIDE INSPECTION RISER PIPE AT EACH END AND EVERY 200 FEET.

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FIGURE 12-4
SOUTH PERIMETER CAP TERMINATION WITH ROCK RIPRAP PROTECTION ALTERNATIVES 3, 4, AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
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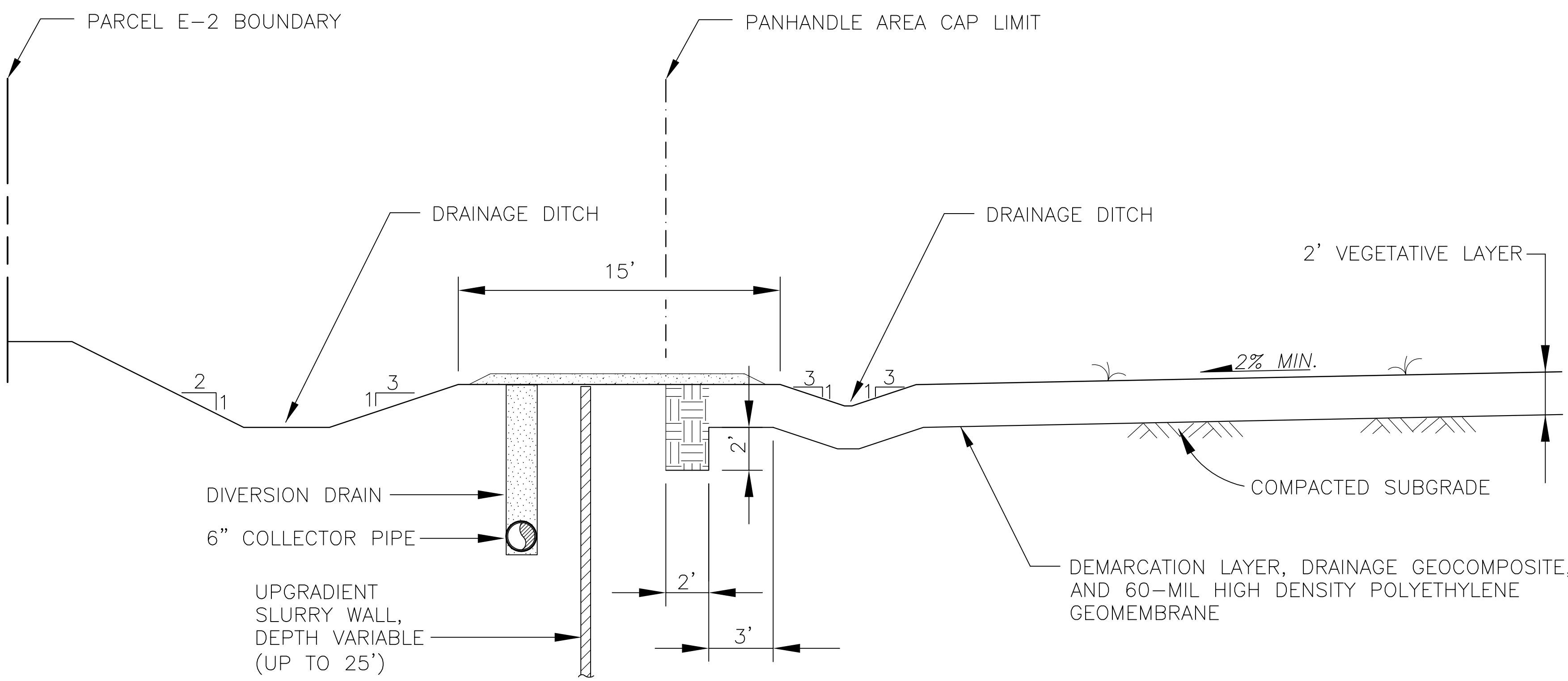

PANHANDLE CAP TERMINATION (WEST BOUNDARY)

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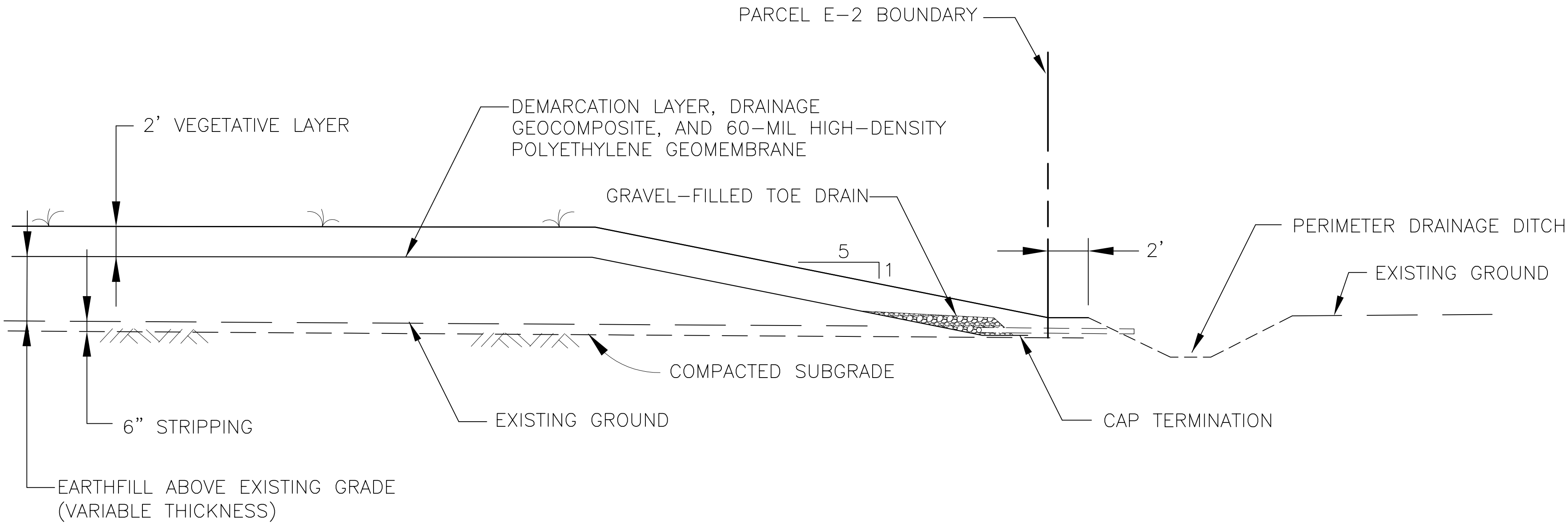
FIGURE 12-5
PANHANDLE CAP TERMINATION
(WEST BOUNDARY)
ALTERNATIVES 3, 4, AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	---	Concord	BJ	4-5-10	-	-	-	-	843812-A45



CAP TERMINATION (EAST BOUNDARY)

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FIGURE 12-6
EAST ADJACENT AREA CAP
TERMINATION (EAST BOUNDARY)
ALTERNATIVES 3, 4, AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2

Evaluation Tier	Location ID	Chemical	Concentration	Units	Depth (ft bgs)	Criterion Type	Criterion	Exceedance Level
1	Grid 109 Sidewall	Total PCBs	640	mg/kg	2.5	PRG	0.74	100X
1	Grid 110 Sidewall	Total PCBs	450	mg/kg	1.8	PRG	0.74	100X
1	Grid 110 Sidewall	Total PCBs	400	mg/kg	6	PRG	0.74	100X
1	Grid 111 Sidewall	Total PCBs	120	mg/kg	2.8	PRG	0.74	100X
1	Grid 111 Sidewall	Total PCBs	750	mg/kg	6	PRG	0.74	100X
1	Grid 139 Sidewall	Total PCBs	8.9	mg/kg	1	PRG	0.74	10X
1	Grid 139 Sidewall	Total PCBs	9.8	mg/kg	8	PRG	0.74	10X
1	Grid 153 Sidewall	Total PCBs	8	mg/kg	7	PRG	0.74	10X
1	Grid 156 Sidewall	Total PCBs	52	mg/kg	2.5	PRG	0.74	10X
1	Grid 159 Bottom	Total PCBs	950	mg/kg	7	PRG	0.74	100X
1	Grid 159 Sidewall	Heptachlor Epoxide	86	mg/kg	6	PRG	0.19	100X
1	Grid 159 Sidewall	Total PCBs	120	mg/kg	3	PRG	0.74	100X
1	Grid 159 Sidewall	Total PCBs	12,000	mg/kg	6	PRG	0.74	100X
1	Grid 165 Bottom	Total PCBs	19	mg/kg	6	PRG	0.74	100X
1	Grid 165 Sidewall	Lead	9,700	mg/kg	1.3	PSC	197	10X
1	Grid 165 Sidewall	Total PCBs	48	mg/kg	1.3	PRG	0.74	10X
1	Grid 165 Sidewall	Total PCBs	99	mg/kg	5	PRG	0.74	100X
1	Grid 170 Sidewall	Lead	2,200	mg/kg	3	PSC	197	10X
1	Grid 171 Sidewall	Total PCBs	380	mg/kg	3	PRG	0.74	100X
1	Grid 86 Sidewall	Lead	9,300	mg/kg	7	PSC	197	10X
1	Grid 86 Sidewall	Total PCBs	1,500	mg/kg	7	PRG	0.74	100X
1	Grid 86 Sidewall	Total PCBs	59	mg/kg	1	PRG	0.74	10X
1	IR01MW44A	Total PCBs	8.6	mg/kg	12	PRG	0.74	10X
1	IR01SH025	Total PCBs	9.6	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH026	Lead	4,400	mg/kg	2.5	ER-M	218	10X
1	IR01SH026	Total PCBs	9.4	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH026	Total PCBs	10	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH028	Total PCBs	19.4	mg/kg	2.5	ER-M	0.18	100X
1	IR01SH028	Total PCBs*	8.8	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH029	Total PCBs	9.4	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH029	Total PCBs	1.9	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH031	Total PCBs*	3.4	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH032	Total PCBs	2	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH032	Total PCBs	4.1	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH034	Total PCBs*	7.6	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH034	Total PCBs*	3.7	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH035	Total PCBs	6.5	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH035	Total PCBs	9.3	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH036	Total PCBs	1,300	mg/kg	10	PRG	0.74	100X
1	IR01SH037	Total PCBs*	3.5	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH037	Total PCBs*	8.2	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH038	Total PCBs	12	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH040	Total PCBs	150	mg/kg	2.5	ER-M	0.18	100X
1	IR01SH040	Total PCBs*	11.8	mg/kg	0.5	ER-M	0.18	100X

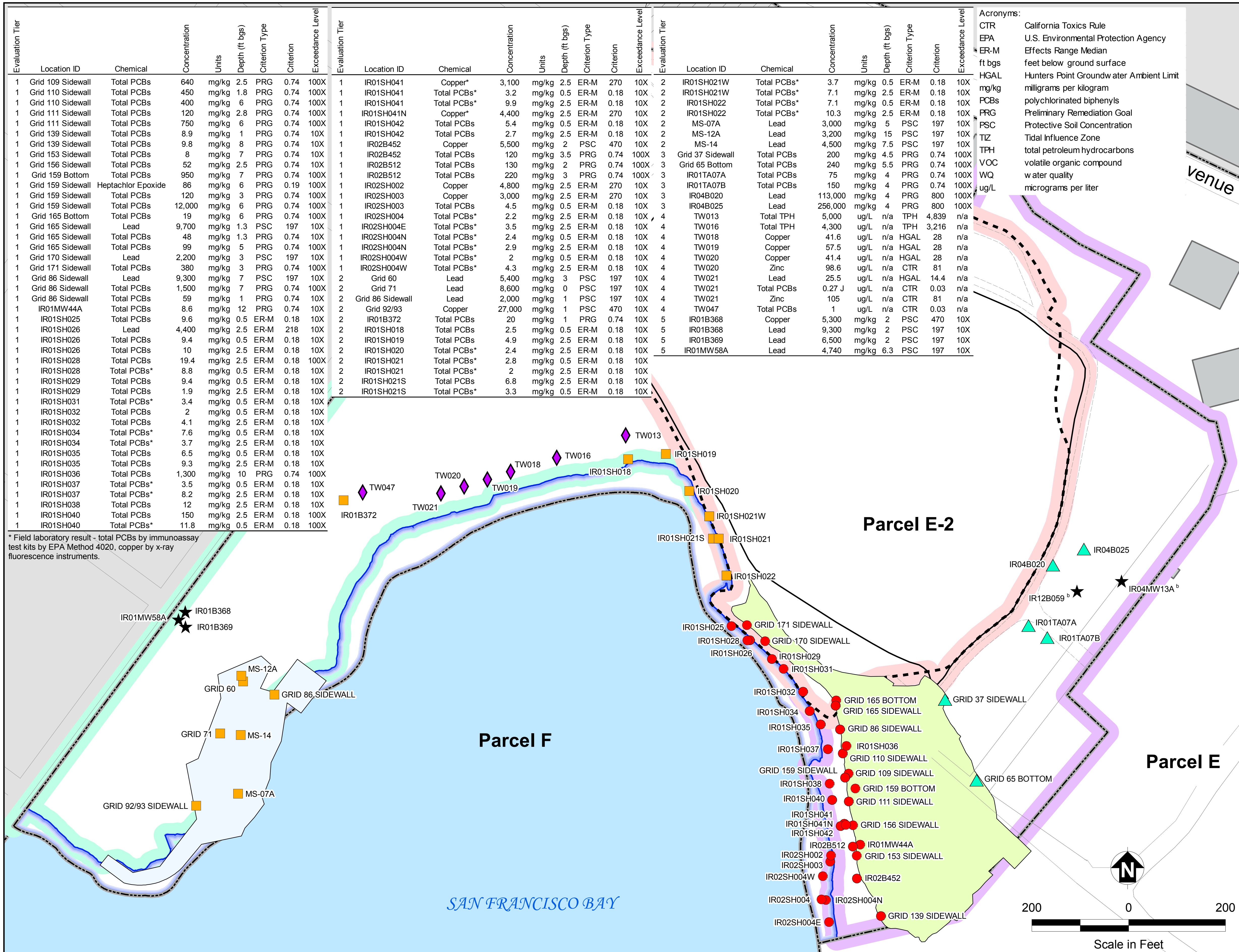
* Field laboratory result - total PCBs by immunoassay test kits by EPA Method 4020, copper by x-ray fluorescence instruments.

Evaluation Tier	Location ID	Chemical	Concentration	Units	Depth (ft bgs)	Criterion Type	Criterion	Exceedance Level
1	IR01SH041	Copper*	3,100	mg/kg	2.5	ER-M	270	10X
1	IR01SH041	Total PCBs*	3.2	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH041	Total PCBs*	9.9	mg/kg	2.5	ER-M	0.18	10X
1	IR01SH041N	Copper*	4,400	mg/kg	2.5	ER-M	270	10X
1	IR01SH042	Total PCBs	5.4	mg/kg	0.5	ER-M	0.18	10X
1	IR01SH042	Total PCBs	2.7	mg/kg	2.5	ER-M	0.18	10X
1	IR02B452	Copper	5,500	mg/kg	2	PSC	470	10X
1	IR02B452	Total PCBs	120	mg/kg	3.5	PRG	0.74	100X
1	IR02B512	Total PCBs	130	mg/kg	2	PRG	0.74	100X
1	IR02B512	Total PCBs	220	mg/kg	3	PRG	0.74	100X
1	IR02SH002	Copper	4,800	mg/kg	2.5	ER-M	270	10X
1	IR02SH003	Copper	3,000	mg/kg	2.5	ER-M	270	10X
1	IR02SH003	Total PCBs	4.5	mg/kg	0.5	ER-M	0.18	10X
1	IR02SH004	Total PCBs*	2.2	mg/kg	2.5	ER-M	0.18	10X
1	IR02SH004E	Total PCBs*	3.5	mg/kg	2.5	ER-M	0.18	10X
1	IR02SH004N	Total PCBs*	2.4	mg/kg	0.5	ER-M	0.18	10X
1	IR02SH004N	Total PCBs*	2.9	mg/kg	2.5	ER-M	0.18	10X
1	IR02SH004W	Total PCBs*	2	mg/kg	0.5	ER-M	0.18	10X
1	IR02SH004W	Total PCBs*	4.3	mg/kg	2.5	ER-M	0.18	10X
2	Grid 60	Lead	5,400	mg/kg	3	PSC	197	10X
2	Grid 71	Lead	8,600	mg/kg	0	PSC	197	10X
2	Grid 86 Sidewall	Lead	2,000	mg/kg	1	PSC	197	10X
2	Grid 92/93	Copper	27,000	mg/kg	1	PSC	470	10X
2	IR01B372	Total PCBs	20	mg/kg	1	PRG	0.74	10X
2	IR01SH018	Total PCBs	2.5	mg/kg	0.5	ER-M	0.18	10X
2	IR01SH019	Total PCBs	4.9	mg/kg	2.5	ER-M	0.18	10X
2	IR01SH020	Total PCBs*	2.4	mg/kg	2.5	ER-M	0.18	10X
2	IR01SH021	Total PCBs*	2.8	mg/kg	0.5	ER-M	0.18	10X
2	IR01SH021	Total PCBs*	2	mg/kg	2.5	ER-M	0.18	10X
2	IR01SH021S	Total PCBs	6.8	mg/kg	2.5	ER-M	0.18	10X
2	IR01SH021S	Total PCBs*	3.3	mg/kg	0.5	ER-M	0.18	10X

Evaluation Tier	Location ID	Chemical	Concentration	Units	Depth (ft bgs)	Criterion Type	Criterion	Exceedance Level
2	IR01SH021W	Total PCBs*	3.7	mg/kg	0.5	ER-M	0.18	10X
2	IR01SH021W	Total PCBs*	7.1	mg/kg	2.5	ER-M	0.18	10X
2	IR01SH022	Total PCBs*	7.1	mg/kg	0.5	ER-M	0.18	10X
2	IR01SH022	Total PCBs*	10.3	mg/kg	2.5	ER-M	0.18	10X
2	MS-07A	Lead	3,000	mg/kg	5	PSC	197	10X
2	MS-12A	Lead	3,200	mg/kg	15	PSC	197	10X
2	MS-14	Lead	4,500	mg/kg	7.5	PSC	197	10X
3	Grid 37 Sidewall	Total PCBs	200	mg/kg	4.5	PRG	0.74	100X
3	Grid 65 Bottom	Total PCBs	240	mg/kg	5.5	PRG	0.74	100X
3	IR01TA07A	Total PCBs	75	mg/kg	4	PRG	0.74	100X
3	IR01TA07B	Total PCBs	150	mg/kg	4	PRG	0.74	100X
3	IR04B020	Lead	113,000	mg/kg	4	PRG	800	100X
3	IR04B025	Lead	256,000	mg/kg	4	PRG	800	100X
4	TW013	Total TPH	5,000	ug/L	n/a	TPH	4,839	n/a
4	TW016	Total TPH	4,300	ug/L	n/a	TPH	3,216	n/a
4	TW018	Copper	41.6	ug/L	n/a	HGAL	28	n/a
4	TW019	Copper	57.5	ug/L	n/a	HGAL	28	n/a
4	TW020	Copper	41.4	ug/L	n/a	HGAL	28	n/a
4	TW020	Zinc	98.6	ug/L	n/a	CTR	81	n/a
4	TW021	Lead	25.5	ug/L	n/a	HGAL	14.4	n/a
4	TW021	Total PCBs	0.27 J	ug/L	n/a	CTR	0.03	n/a
4	TW021	Zinc	105	ug/L	n/a	CTR	81	n/a
4	TW047	Total PCBs	1	ug/L	n/a	CTR	0.03	n/a
5	IR01B368	Copper	5,300	mg/kg	2	PSC	470	10X
5	IR01B368	Lead	9,300	mg/kg	2	PSC	197	10X
5	IR01B369	Lead	6,500	mg/kg	2	PSC	197	10X
5	IR01MW58A	Lead	4,740	mg/kg	6.3	PSC	197	10X

Acronyms:

CTR	California Toxics Rule
EPA	U.S. Environmental Protection Agency
ER-M	Effects Range Median
ft bgs	feet below ground surface
HGAL	Hunters Point Groundwater Ambient Limit
mg/kg	milligrams per kilogram
PCBs	polychlorinated biphenyls
PRG	Preliminary Remediation Goal
PSC	Protective Soil Concentration
TIZ	Tidal Influence Zone
TPH	total petroleum hydrocarbons
VOC	volatile organic compound
WQ	water quality
ug/L	micrograms per liter



Legend

- Evaluation Tier 1 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within TIZ) with corresponding groundwater concentrations consistently exceeding aquatic WQ goals.
- Evaluation Tier 2 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within TIZ) with corresponding grab groundwater concentrations exceeding aquatic WQ goals.
- Evaluation Tier 3 - Soil concentrations 100 times > evaluation criteria.
- Evaluation Tier 4 - Grab groundwater concentrations (within Panhandle Area TIZ) exceeding aquatic WQ goals at locations with no corresponding soil data.
- Evaluation Tier 5 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within 200 feet of TIZ) with downgradient grab groundwater concentrations exceeding aquatic WQ goals*
- Road
- Estimate of Solid Waste Extent
- Gravel Road
- Interim Landfill Cap Extent
- Shoreline Area
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Building
- UCSF Compound
- Parcel Boundary
- San Francisco Bay
- Non-Navy Property
- Tidal Influence Zone (Maximum Tidal Fluctuation ≥ 0.10 foot)

Removal Actions

- Metal Slag Area (2007 excavation limit)[a]
- PCB Hot Spot Area (2007 excavation limit)[a]

Notes:

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

[b] Tier 5 hot spots include two locations (IR12B059 and IR04MW13A) identified as VOC source areas that impact groundwater at Parcel E.

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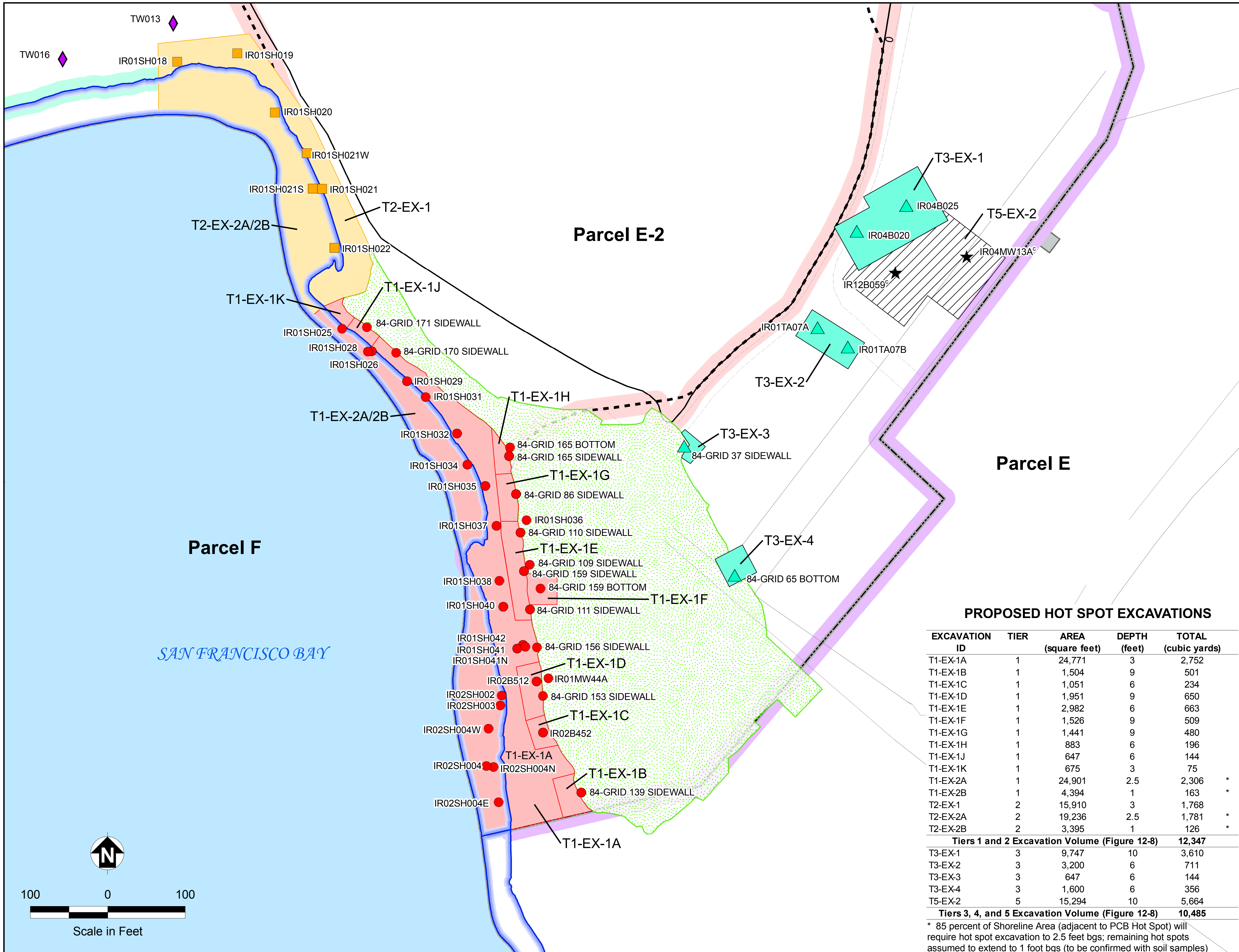
FIGURE 12-7

SOIL HOT SPOT EVALUATION

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Soil_Hotspot_Evaluation.mxd



PROPOSED HOT SPOT EXCAVATIONS

EXCAVATION ID	TIER	AREA (square feet)	DEPTH (feet)	TOTAL (cubic yards)	
T1-EX-1A	1	24,771	3	2,752	
T1-EX-1B	1	1,504	9	501	
T1-EX-1C	1	1,051	6	234	
T1-EX-1D	1	1,951	9	650	
T1-EX-1E	1	2,982	6	663	
T1-EX-1F	1	1,526	9	509	
T1-EX-1G	1	1,441	9	480	
T1-EX-1H	1	883	6	196	
T1-EX-1J	1	647	6	144	
T1-EX-1K	1	675	3	75	
T1-EX-2A	1	24,901	2.5	2,306	*
T1-EX-2B	1	4,394	1	163	*
T2-EX-1	2	15,910	3	1,768	
T2-EX-2A	2	19,236	2.5	1,781	*
T2-EX-2B	2	3,395	1	126	*
Tiers 1 and 2 Excavation Volume (Figure 12-8)				**12,347**	
T3-EX-1	3	9,747	10	3,610	
T3-EX-2	3	3,200	6	711	
T3-EX-3	3	647	6	144	
T3-EX-4	3	1,600	6	356	
T5-EX-2	5	15,294	10	5,664	
Tiers 3, 4, and 5 Excavation Volume (Figure 12-8)				**10,485**	

* 85 percent of Shoreline Area (adjacent to PCB Hot Spot) will require hot spot excavation to 2.5 feet bgs; remaining hot spots assumed to extend to 1 foot bgs (to be confirmed with soil samples)

Legend

- Evaluation Tier 1 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within TIZ) with corresponding groundwater concentrations consistently exceeding aquatic WQ goals.
- Evaluation Tier 2 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within TIZ) with corresponding grab groundwater concentrations exceeding aquatic WQ goals.
- Evaluation Tier 3 - Soil concentrations 100 times > evaluation criteria.
- Evaluation Tier 4 - Grab groundwater concentrations (within Panhandle Area TIZ) exceeding aquatic WQ goals at locations with no corresponding soil data.
- Evaluation Tier 5 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within 200 feet of TIZ) with downgradient grab groundwater concentrations exceeding aquatic WQ goals*
- Tier 1 Hot Spot Excavation Boundaries[a]
- Tier 2 Hot Spot Excavation Boundaries[a]
- Tier 3 Hot Spot Excavation Boundaries[a]
- Tier 5 Hot Spot Excavation Boundaries[a]
- Road
- Gravel Road
- Estimate of Solid Waste Extent
- Interim Landfill Cap Extent
- Shoreline Area
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Building
- Parcel Boundary
- San Francisco Bay

Removal Actions

- PCB Hot Spot Area (2007 excavation limit)[b]

Notes:

TIZ tidal influence zone
VOC volatile organic compound
WQ water quality

[a] Soil/sediment would be excavated and disposed of off-site.
[b] Post- excavation boundary in PCB Hot Spot Area is consistent with information presented in final removal action completion reports (Tetra Tech EC, Inc. 2007a).
[c] Tier 5 hot spots include two locations (IR12B059 and IR04MW13A) identified as VOC source areas that impact groundwater at Parcel E.

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FIGURE 12-8
PROPOSED SOIL HOT SPOT EXCAVATIONS IN SHORELINE AND EAST ADJACENT AREAS

Remedial Investigation/Feasibility Study for Parcel E-2

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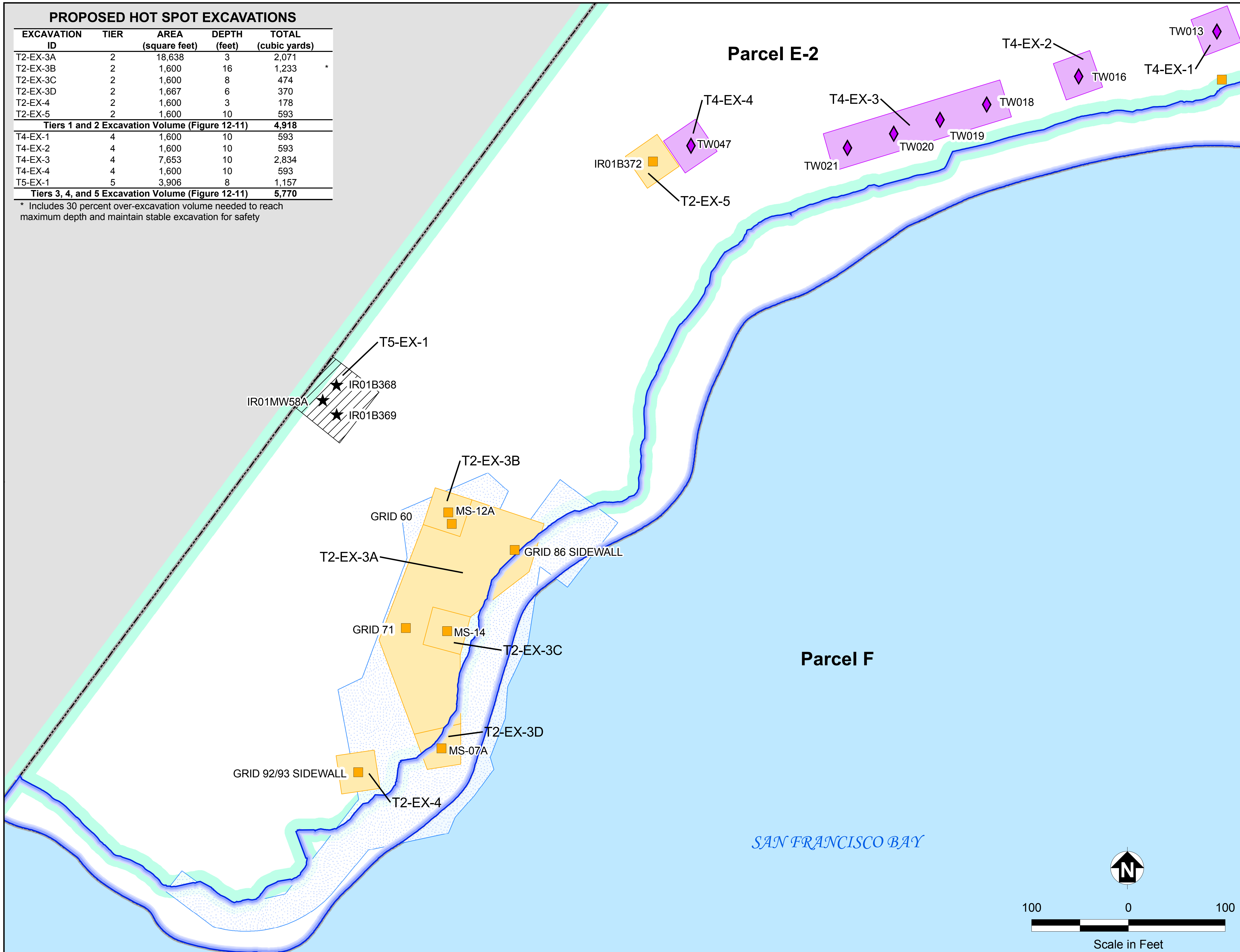
PROPOSED HOT SPOT EXCAVATIONS

EXCAVATION ID	TIER	AREA (square feet)	DEPTH (feet)	TOTAL (cubic yards)	
T2-EX-3A	2	18,638	3	2,071	
T2-EX-3B	2	1,600	16	1,233	*
T2-EX-3C	2	1,600	8	474	
T2-EX-3D	2	1,667	6	370	
T2-EX-4	2	1,600	3	178	
T2-EX-5	2	1,600	10	593	
Tiers 1 and 2 Excavation Volume (Figure 12-11)				**4,918**	
T4-EX-1	4	1,600	10	593	
T4-EX-2	4	1,600	10	593	
T4-EX-3	4	7,653	10	2,834	
T4-EX-4	4	1,600	10	593	
T5-EX-1	5	3,906	8	1,157	
Tiers 3, 4, and 5 Excavation Volume (Figure 12-11)				**5,770**	

* Includes 30 percent over-excavation volume needed to reach maximum depth and maintain stable excavation for safety



Legend

- Evaluation Tier 1 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within TIZ) with corresponding groundwater concentrations consistently exceeding aquatic WQ goals.
- Evaluation Tier 2 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within TIZ) with corresponding grab groundwater concentrations exceeding aquatic WQ goals.
- Evaluation Tier 3 - Soil concentrations 100 times > evaluation criteria.
- Evaluation Tier 4 - Grab groundwater concentrations (within Panhandle Area TIZ) exceeding aquatic WQ goals at locations with no corresponding soil data.
- Evaluation Tier 5 - Soil concentrations 10 times > evaluation criteria at near-shore locations (within 200 feet of TIZ) with downgradient grab groundwater concentrations exceeding aquatic WQ goals
- Tier 2 Hot Spot Excavation Boundaries[a]
- Tier 4 Hot Spot Excavation Boundaries[a]
- Tier 5 Hot Spot Excavation Boundaries[a]
- Shoreline Area
- Panhandle Area
- Building
- Parcel Boundary
- San Francisco Bay
- Non-Navy Property

Removal Actions

- Metal Slag Area (2007 excavation limit)[b]

Notes:

TIZ	Tidal Influence Zone
WQ	water quality

[a] Soil/sediment would be excavated and disposed of off-site.
[b] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech, 2007b).

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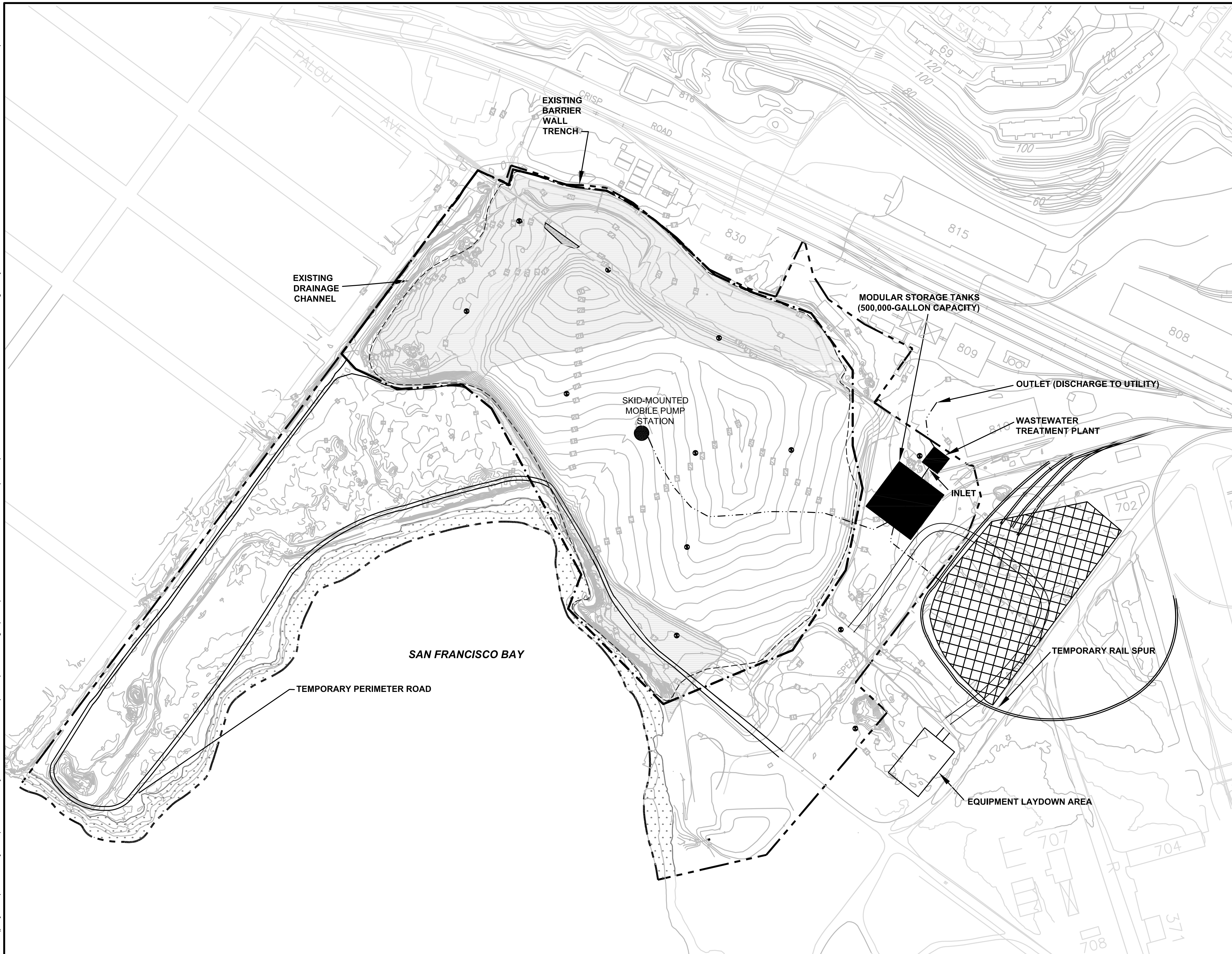
FIGURE 12-9 PROPOSED SOIL HOT SPOT EXCAVATIONS IN PANHANDLE AREA

Remedial Investigation/Feasibility Study for Parcel E-2



LEGEND

- LANDFILL EXTENT
- PARCEL E-2 BOUNDARY
- PIPING
- RAIL ROAD
- TEMPORARY SHEET-PILE WALL
- WELL POINT FOR DEWATERING
- EXISTING SHORELINE AREA
- SOIL STAGING, DEWATERING SEGREGATION AND PROFILING AREA

125 0 125 250

Scale in Feet

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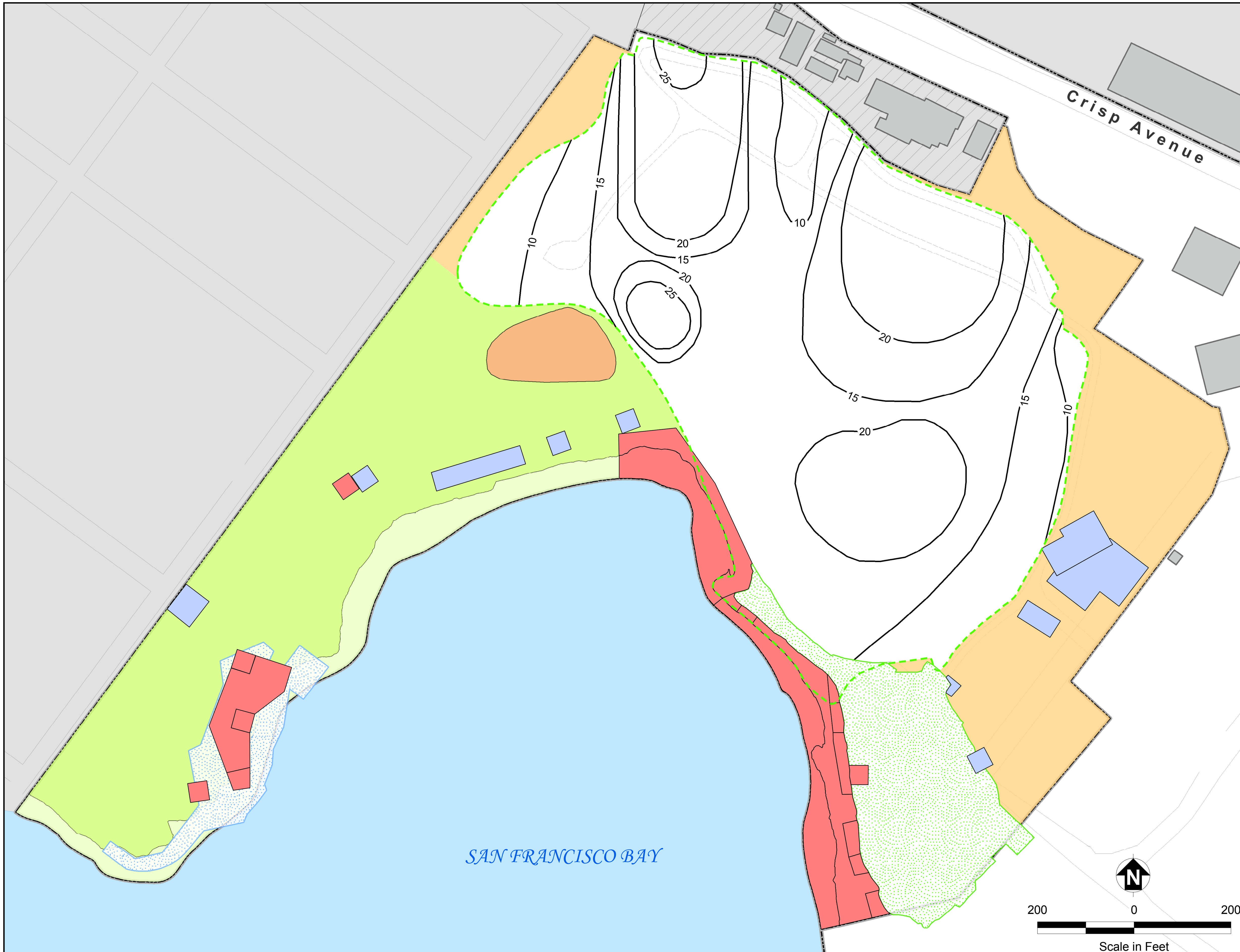
FIGURE 12-10
CONCEPTUAL CONSTRUCTION PLAN
ALTERNATIVE 2

Remedial Investigation/Feasibility Study for Parcel E-2

File: N:\projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\DWG\Final RI_FS for Parcel E-2\Conceptual Construction Plan Alternative 2.dwg Layout: FIG 12-10 User: rbricker Mar 17, 2010 - 1:13pm



Legend

- Landfill Area
- Tiers 1 and 2 Hot Spots (2.5 to 16 feet bgs)
- Tiers 3, 4, and 5 Hot Spots (6 to 10 feet bgs)
- 3 - foot excavation depth
- 3.5 - foot excavation depth
- 4 - foot excavation depth
- 10 - foot excavation depth
- 10 Excavation depth contour line
- Road
- Gravel Road
- Parcel Boundary
- Building
- UCSF Compound
- Non-Navy Property
- San Francisco Bay

Previous Removal Actions

- Metal Slag Area (2007 excavation limit)[a]
- PCB Hot Spot Area (2007 excavation limit)[a]

Notes:

1) All excavation depths shown within the Landfill Area are estimated. Final depths would be determined in the field. All excavation depths are relative to ground surface.

2) Based on the ecological risk assessment, the minimum excavation depth must be 3 feet (bgs) in the Panhandle and East Adjacent Areas, and 2.5 feet (bgs) in the Shoreline Area.

3) To ensure that the final surface elevations are adequately low as to ensure periodic flooding of the tidal wetlands, it is assumed that an additional foot of soil and sediment throughout most of the Panhandle Area (and adjoining portions of the Shoreline Area) will require excavation and offsite disposal.

4) Excavation depths were increased to 10 feet bgs in areas where additional source removal, in the absence of a low-permeability cover, is needed to achieve the remedial action objectives.

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

bgs = below ground surface
ft = feet
PCB = polychlorinated biphenyl
TPH = total petroleum hydrocarbon

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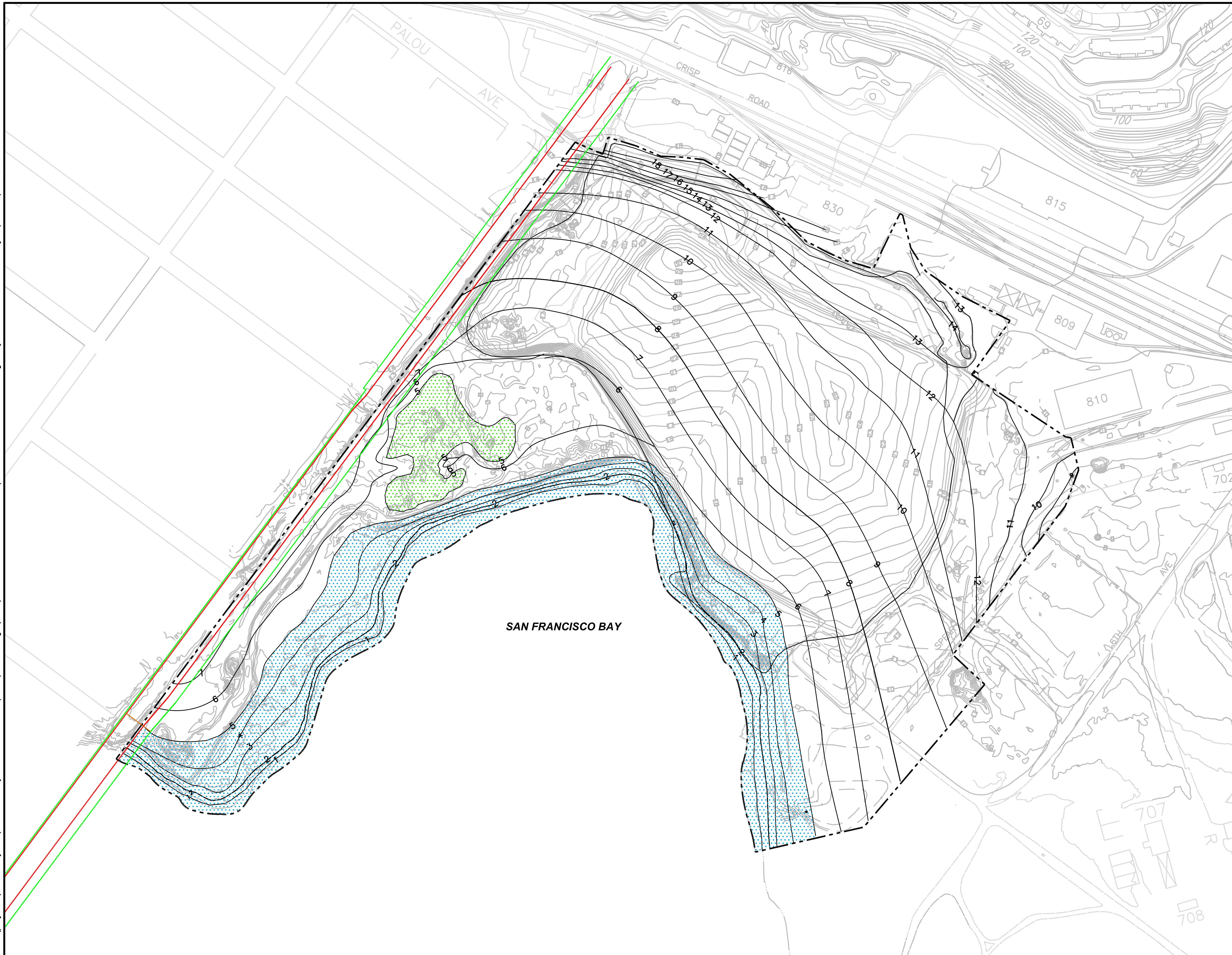
FIGURE 12-11

PROPOSED EXCAVATION DEPTHS ALTERNATIVE 2

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\ProposedExcavations-Alt2.mxd



LEGEND:

- PARCEL E-2 BOUNDARY
- GRADING CONTOUR LINE AND ELEVATION
- CCSF PROPOSED YOSEMITE SLOUGH BRIDGE (STADIUM OPTION)*
- CCSF PROPOSED YOSEMITE SLOUGH BRIDGE (NON-STADIUM OPTION)*
- PROPOSED INTERTIDAL WETLANDS
- PROPOSED FRESHWATER WETLANDS

NOTES:
PROPOSED SHORELINE PROTECTION (DISCUSSED IN SECTION 12.2.2.7) WILL BE INCLUDED TO MINIMIZE EROSION OF INTERTIDAL SEDIMENTS, AND DAMAGE TO PLANTED VEGETATION

* PROPOSED ALIGNMENTS OF YOSEMITE SLOUGH BRIDGE PRESENTED IN ENVIRONMENTAL IMPACT REPORT FOR PHASE II DEVELOPMENT (SAN FRANCISCO REDEVELOPMENT AUTHORITY, 2009)

CCSF = CITY AND COUNTY OF SAN FRANCISCO

125 0 125 250
Scale in Feet

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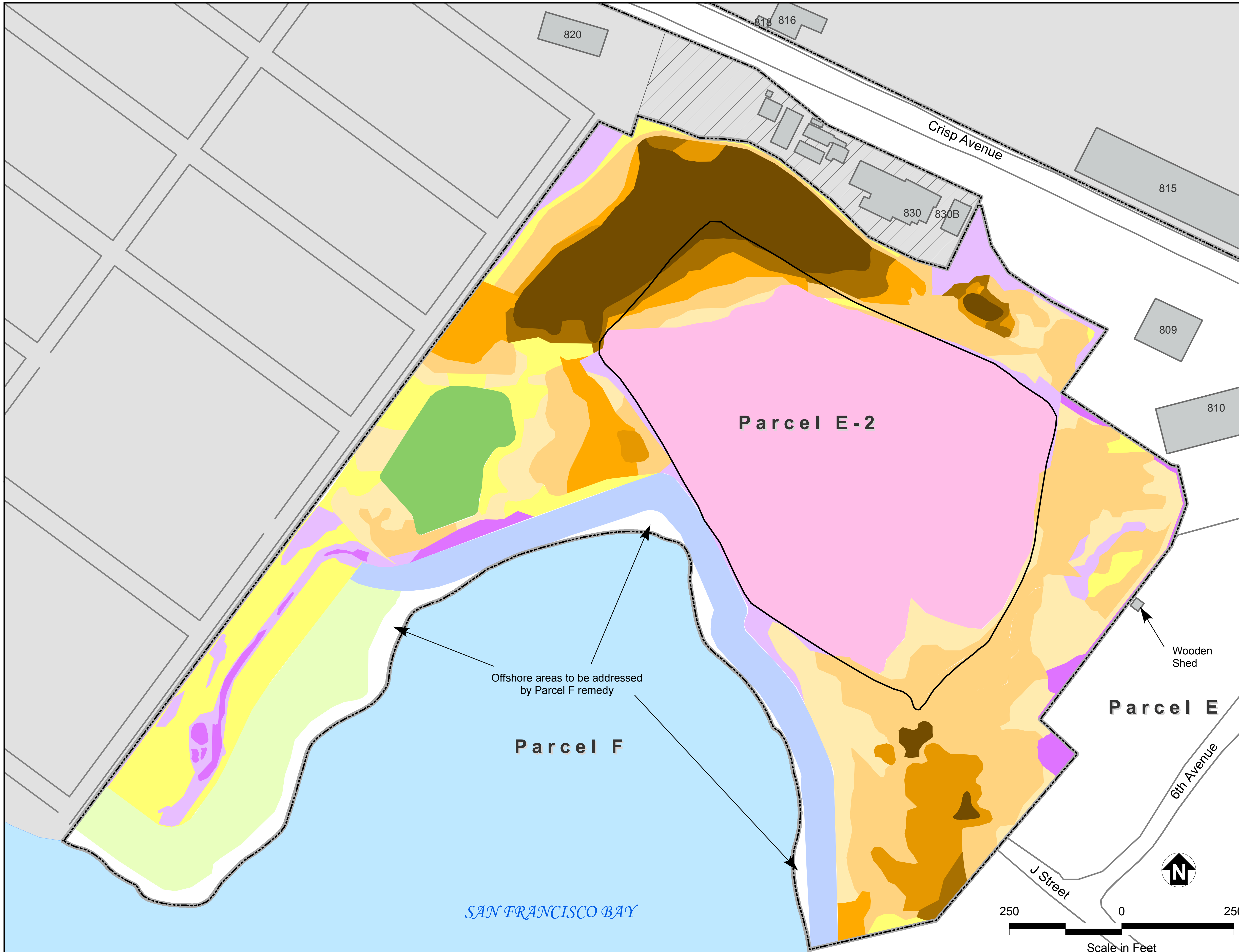
FIGURE 12-12
CONCEPTUAL GRADING PLAN
ALTERNATIVE 2

Remedial Investigation/Feasibility Study for Parcel E-2

File: N:\projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\DWG\Final RI_FS for Parcel E-2\12_10 and 12_12_REV1.dwg Layout: FIG 12-12 User: jchapman Apr 05, 2010 - 10:49am



Legend

Cover Types A1 and A2

- Cover Type A1: Excavation (4 ft minimum) for Tidal Wetlands Construction
- Cover Type A2: Excavation (4 ft minimum) for Freshwater Wetlands Construction

Cover Type B

- Excavation (3.5 ft minimum) for Shoreline Revetment

Cover Type C

- Fill Thickness (1-2 ft)[1]
- Fill Thickness (2-3 ft)[1]
- Fill Thickness (3-5 ft)[1]
- Fill Thickness (5-7 ft)[1]
- Fill Thickness (7-9 ft)[1]
- Fill Thickness (9-11 ft)[1]
- Fill Thickness (11 ft or greater)[1]

Cover Type D

- Cut Thickness (0-1 ft)[2]
- Cut Thickness (greater than 1 ft)[2]

Cover Type E

- Existing Cap to Remain

- Interim Landfill Cap Extent
- Parcel Boundary
- Non-Navy Property
- UCSF Compound
- Building
- Road

Notes:

Cover types presented on Figure 12-14.

1 Represents thickness of on-site foundation soil to be placed after screening for radioactive contamination.

2 Soil cut required to achieve final design elevation; thickness of foundation soil would be 1 foot.

ft = feet

Reference:

The proposed grading shown on this figure is based on the Conceptual Grading Plan Alternatives 3, 4 and 5 (Figure12-1).

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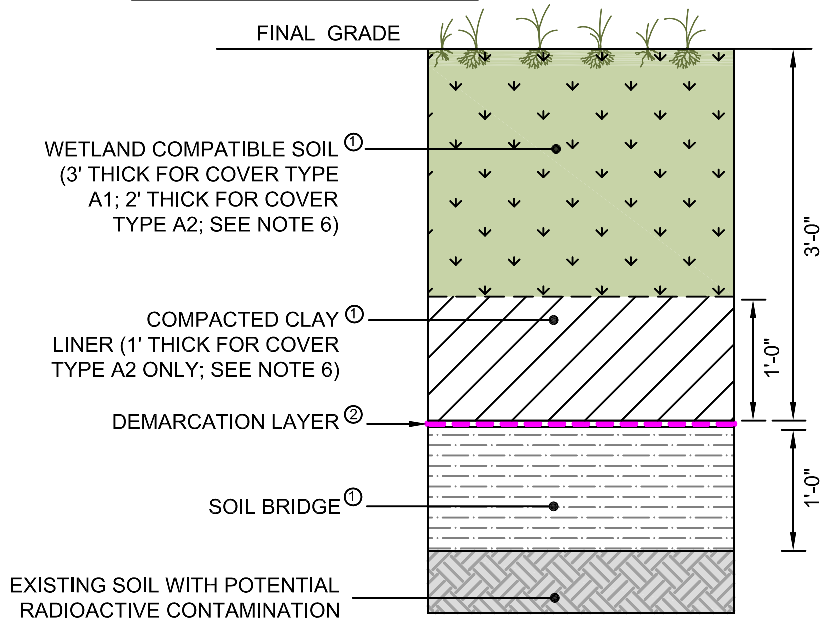
FIGURE 12-13

ALTERNATIVES 3 AND 4 COVER AND EXCAVATION PLAN

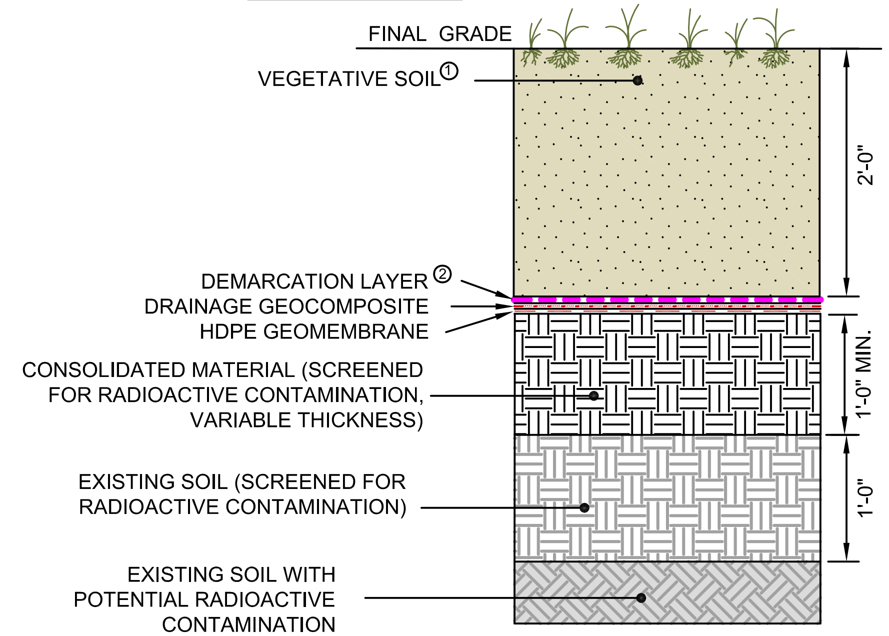
Remedial Investigation/Feasibility Study for Parcel E-2

\\errg.net\active\projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\ProposedExcavations-Alt3_4_rev1.mxd Last updated 12/6/2010 1:27:53 PM

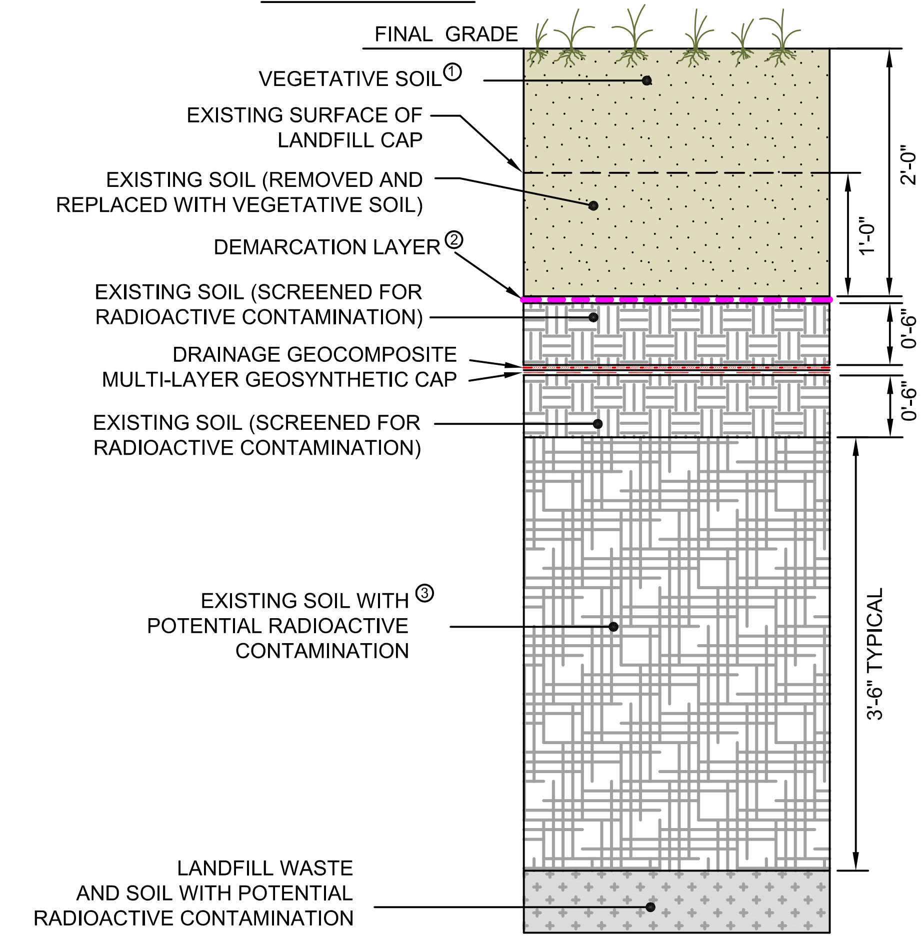
COVER TYPE A1 AND A2



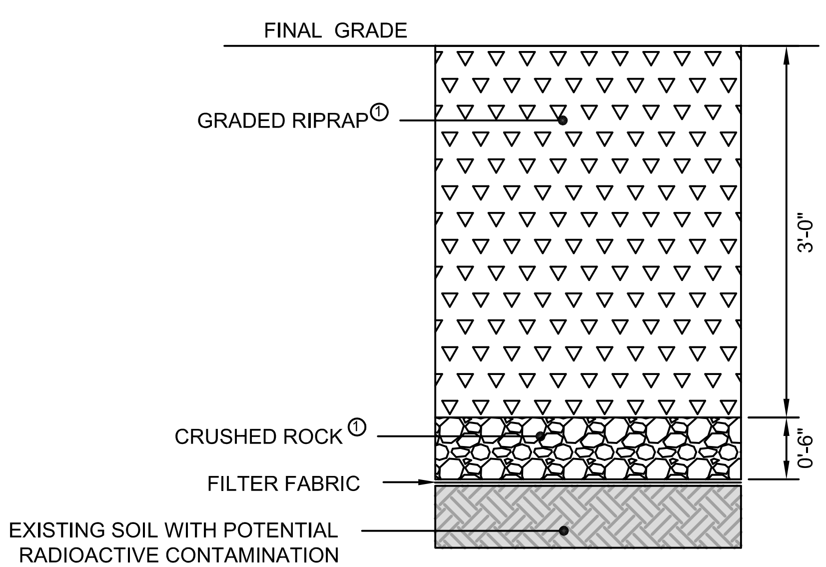
COVER TYPE C



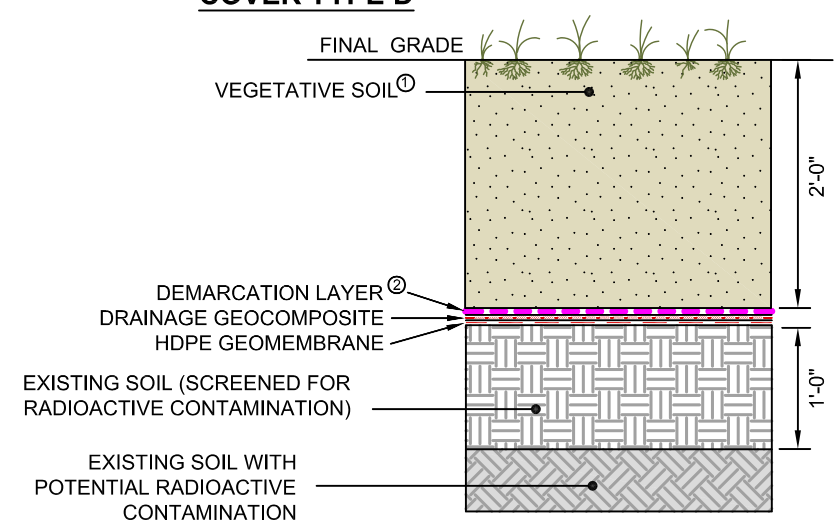
COVER TYPE E



COVER TYPE B



COVER TYPE D



NOTES:

① IMPORTED FILL MATERIAL WOULD MEET CHEMICAL (RADIOACTIVE AND NONRADIOACTIVE) ACCEPTANCE CRITERIA TO BE SPECIFIED IN THE REMEDIAL DESIGN.

② DEMARCATION LAYER CONSISTS OF MAGNETIC MARKING TAPE AND ORANGE-COLORED GEOTEXTILE.

③ EXISTING SOIL PLACED ON TOP OF LANDFILL DURING PRELIMINARY CLOSURE ACTIVITIES IN 1974 AND 2000 (AFTER MILITARY OPERATIONS CEASED).

④ LOCATIONS OF COVER TYPES PRESENTED ON FIGURES 12-13 AND 12-21.

⑤ HDPE = HIGH DENSITY POLYETHYLENE

⑥ ALTERNATIVES 3 AND 4 INCLUDE COVER TYPES A1 AND A2 (SEE FIGURE 12-13); ALTERNATIVE 5 INCLUDES COVER TYPE A1 ONLY (SEE FIGURE 12-21).

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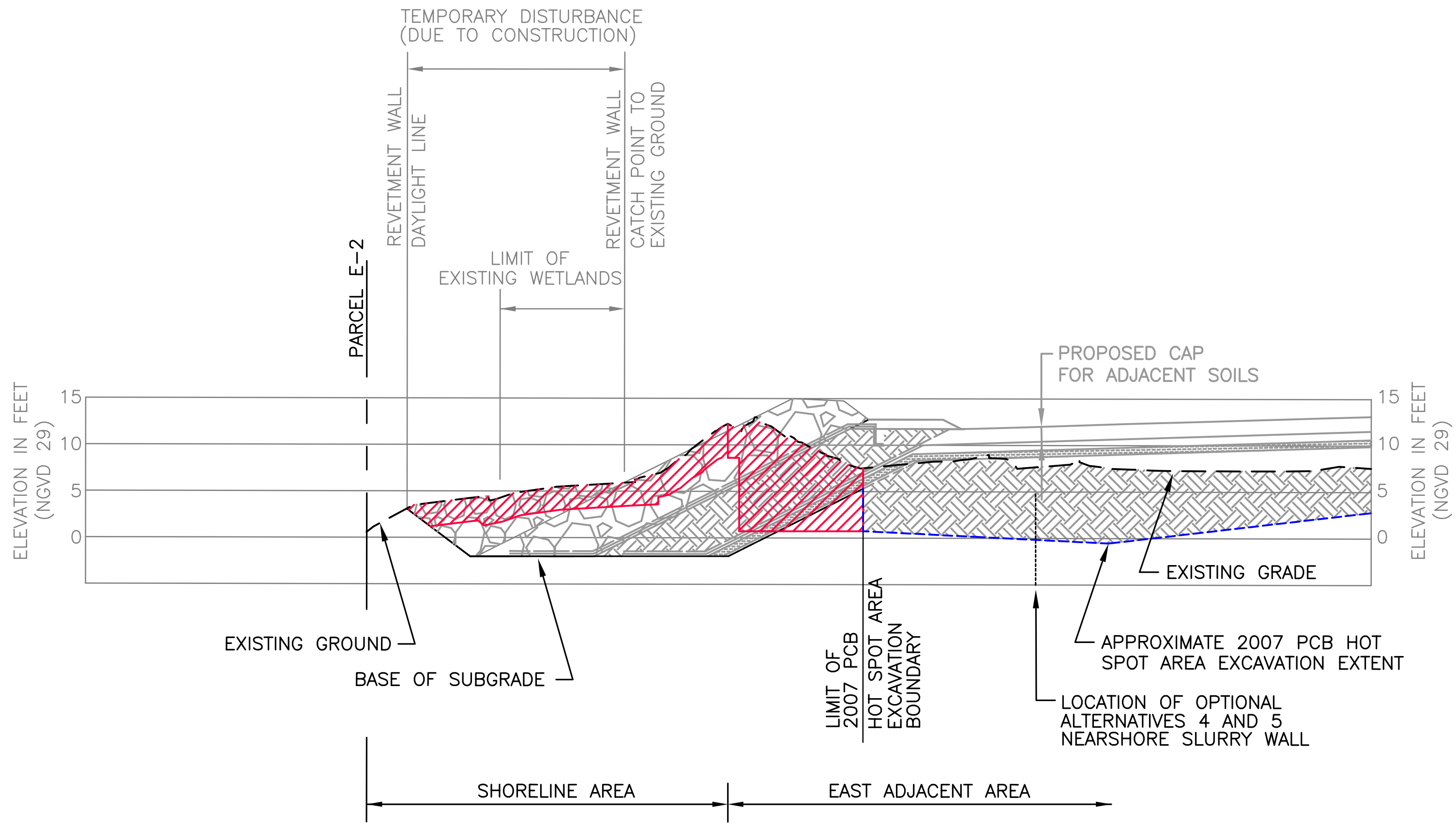
FIGURE 12-14

ALTERNATIVES 3, 4, AND 5 COVER SCHEMATIC

Remedial Investigation/Feasibility Study for Parcel E-2

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	---	Concord	BJ	4-5-10	-	-	-	-	843812-A41



SECTION F

ADDITIONAL DETAIL ON FIGURE 12-2 SECTION A

15 0 15 30
Horizontal Scale in Feet

10 0 10 20
Vertical Scale in Feet
Vertical Exaggeration (1.5x)

LEGEND

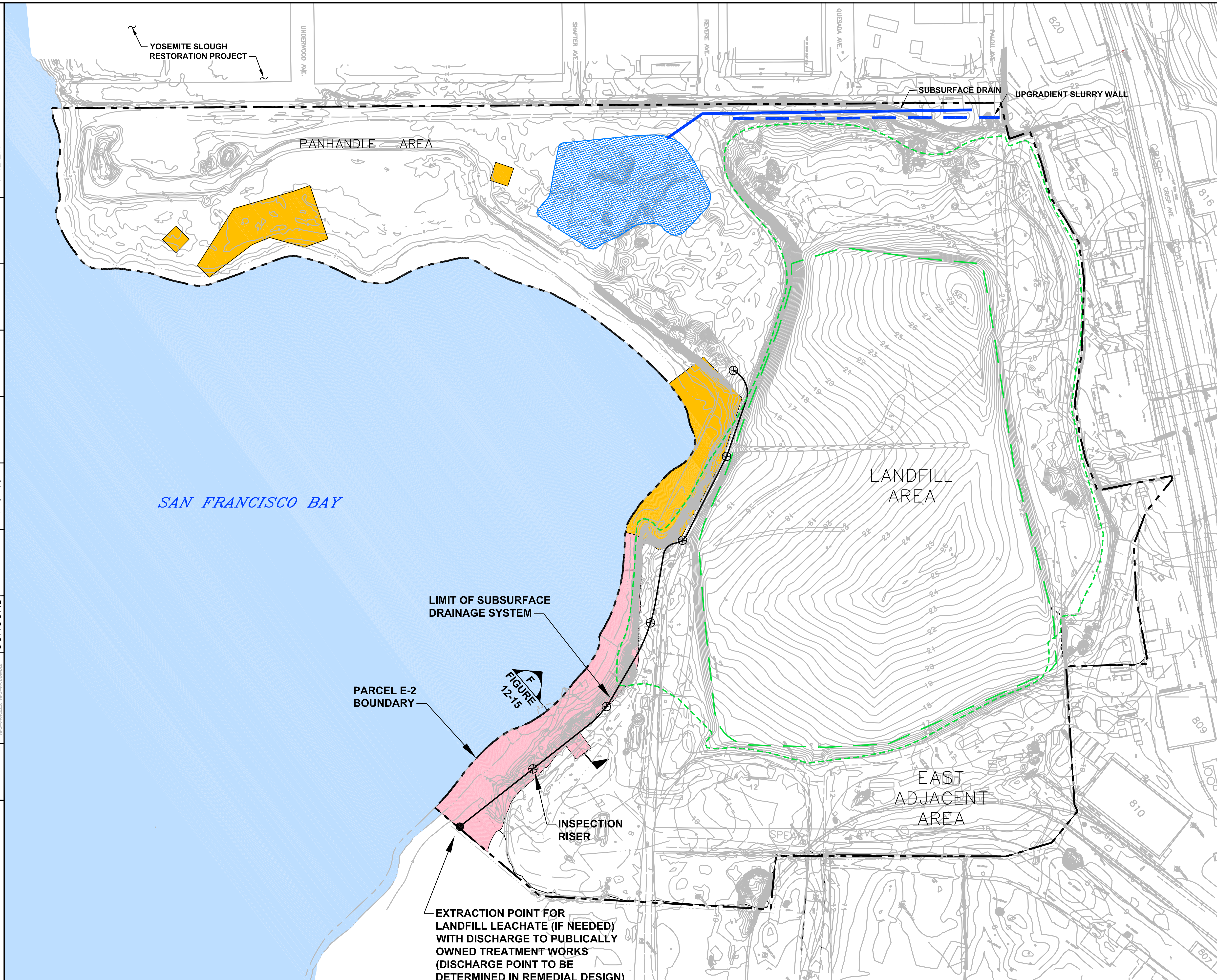
	MINIMUM EXTENT OF 2010 HOT SPOT EXCAVATION
NGVD 29	NATIONAL GEODETIC VERTICAL DATUM 1929
PCB	POLYCHLORINATED BIPHENYL

Shaw® Shaw Environmental, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 12-15
CROSS SECTION F
ALTERNATIVES 3, 4, AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2



LEGEND

- TIER 1 HOT SPOT
- TIER 2 HOT SPOT
- EXISTING LIMIT OF GEOSYNTHETIC CAP
- LANDFILL AREA
- PARCEL E-2 BOUNDARY
- FRESHWATER WETLAND

NOTES:

1. TOPOGRAPHIC BASE MAP BASED ON AERIAL PHOTOGRAMMETRY DATED 3/13/02.
2. GROUND ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929. (NGVD 29)
3. COORDINATE SYSTEM BASED ON NORTH AMERICAN DATUM OF 1927. (NAD 27)
4. TOPOGRAPHIC BASE COVERAGE DOES NOT GO BEYOND ELEVATION 2'. (NGVD 29)
5. ADDITIONAL INFORMATION ON SOIL HOT SPOT EXCAVATIONS ARE PRESENTED ON FIGURES 12-7, 12-8, AND 12-9.

100 0 100 200
Scale in Feet

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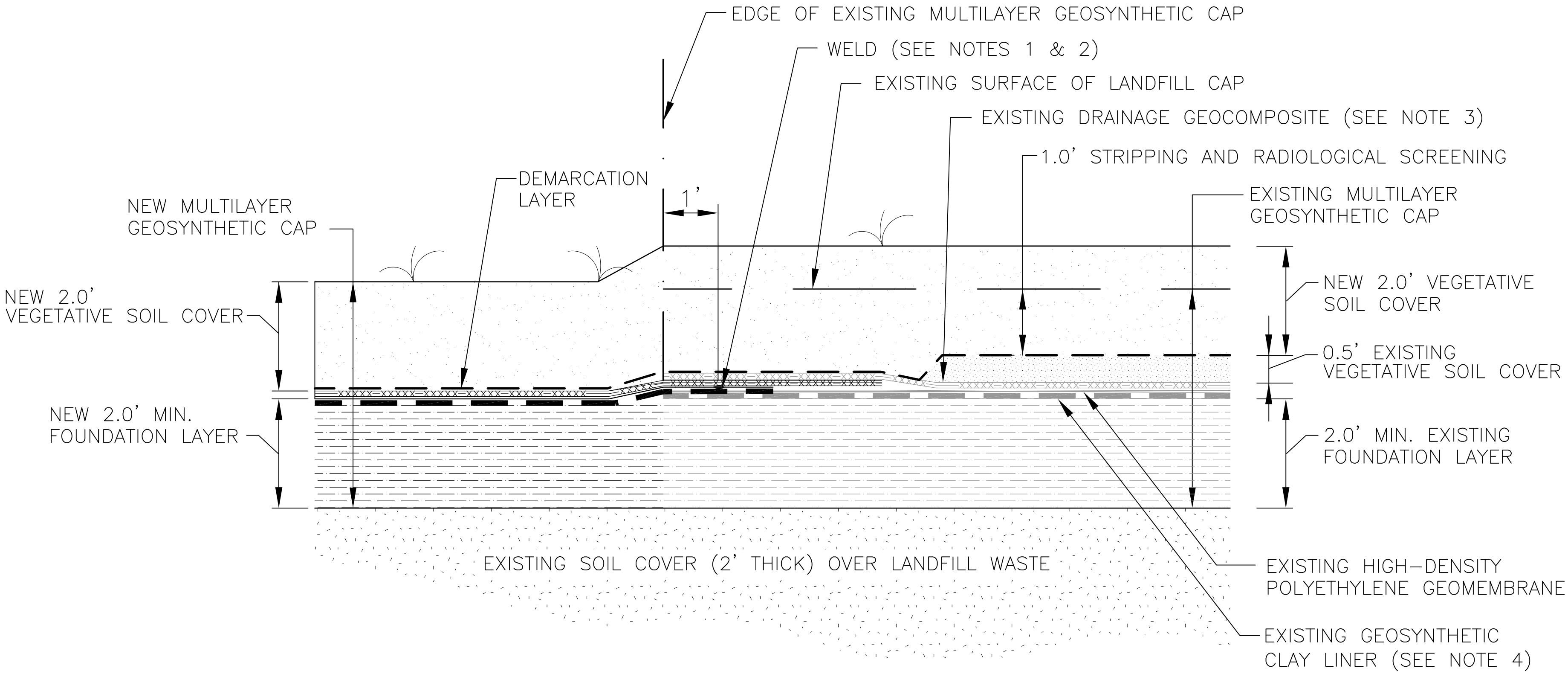
Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 12-16
SOIL HOT SPOT EXCAVATIONS AND
GROUNDWATER CONTAINMENT
ALTERNATIVES 4 AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2

DRAWING NUMBER	APPROVED BY	CHECKED BY	DRAWN BY	OFFICE	X-REF	IMAGE
843812-D41	- -	- -	BJ 4-6-10	CONCORD	3-13-02, 3-13-02-R1 HPS-PARCELS, HPS-PANHANDLE	---

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	---	Concord	BJ	3-25-10	-	-	-	-	843812-A46



LANDFILL CAP TIE-IN

THIS TRANSITION IS BETWEEN COVER TYPES C & E (AS SHOWN IN FIGURES 12-13 AND 12-14) IN LANDFILL AREA ONLY

NOT TO SCALE

NOTES

1. REMOVE EXISTING SOIL COVER AND LAY BACK EXISTING GEOSYNTHETICS FOR NEW GEOMEMBRANE CONNECTION.
2. EXPOSE AND CLEAN 1' MINIMUM WIDTH OF GEOMEMBRANE FOR OVERLAP CONNECTION WITH NEW GEOMEMBRANE. WELD AND SEAM.
3. PROVIDE 4' MINIMUM OVERLAP FOR NEW DRAINAGE GEOCOMPOSITE AND GEOSYNTHETIC CLAY LINER INSTALLATION.
4. GEOSYNTHETIC CLAY LINER WAS INSTALLED ON TOP DECK AREA ONLY AND NOT ON SIDESLOPE OF THE LANDFILL.

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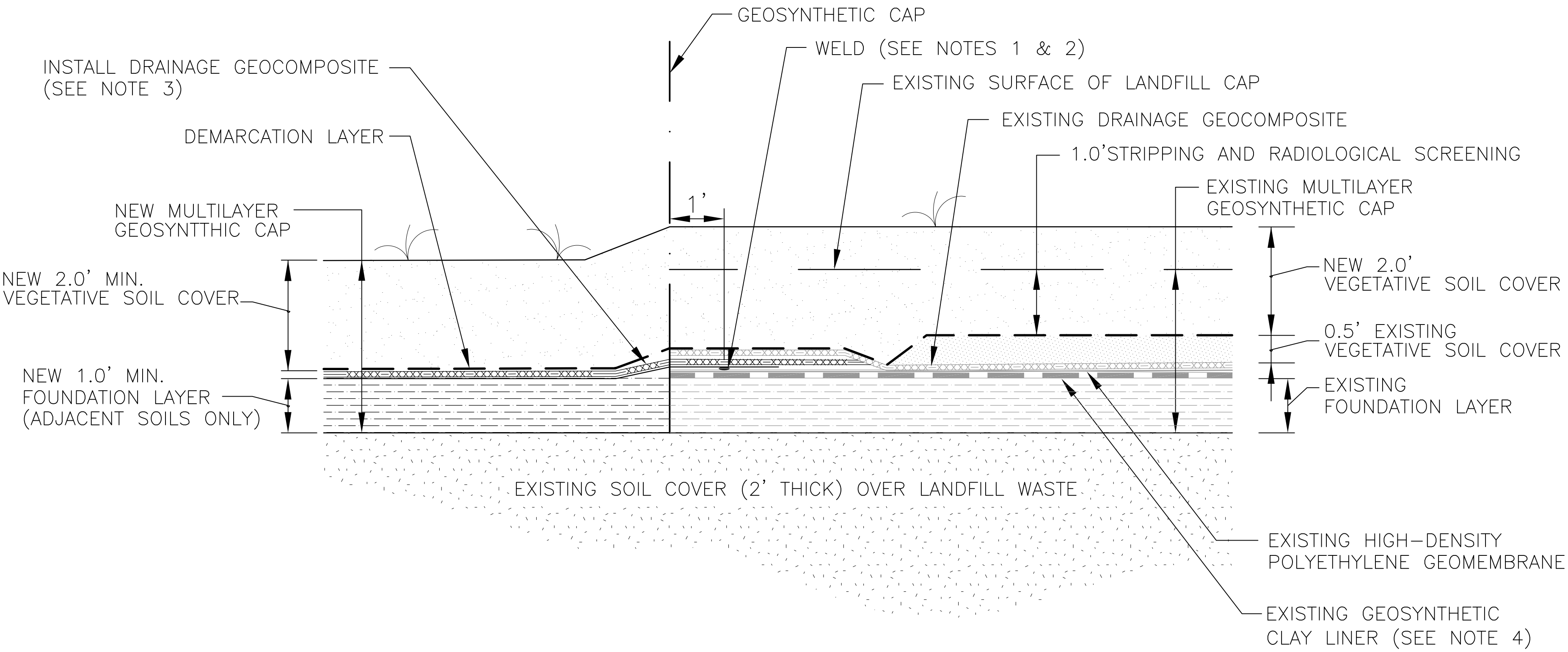
FIGURE 12-17
LANDFILL CAP
TIE-IN, ALTERNATIVES 3, 4, AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	---	Concord	BJ	3-25-10	-	-	-	-	843812-A43



MULTILAYER GEOSYNTHETIC CAP TIE-IN

THIS TRANSITION/TIE-IN IS BETWEEN COVER TYPES C & E (AS SHOWN IN FIGURES 12-13 AND 12-14) IN PANHANDLE AND EAST ADJACENT AREAS

NOT TO SCALE

NOTES

1. REMOVE EXISTING SOIL COVER AND LAY BACK EXISTING GEOSYNTHETICS FOR NEW GEOMEMBRANE CONNECTION.
2. EXPOSE AND CLEAN 1' MINIMUM WIDTH OF GEOMEMBRANE FOR OVERLAP CONNECTION WITH NEW GEOMEMBRANE. WELD AND SEAM.
3. FOR AREA EAST OF LANDFILL ONLY, PROVIDE 4' MIN. OVERLAP FOR NEW DRAINAGE GEOCOMPOSITE INSTALLATION.
4. GEOSYNTHETIC CLAY LINER WAS INSTALLED ON TOP DECK AREA ONLY AND NOT ON SIDESLOPE OF THE LANDFILL.

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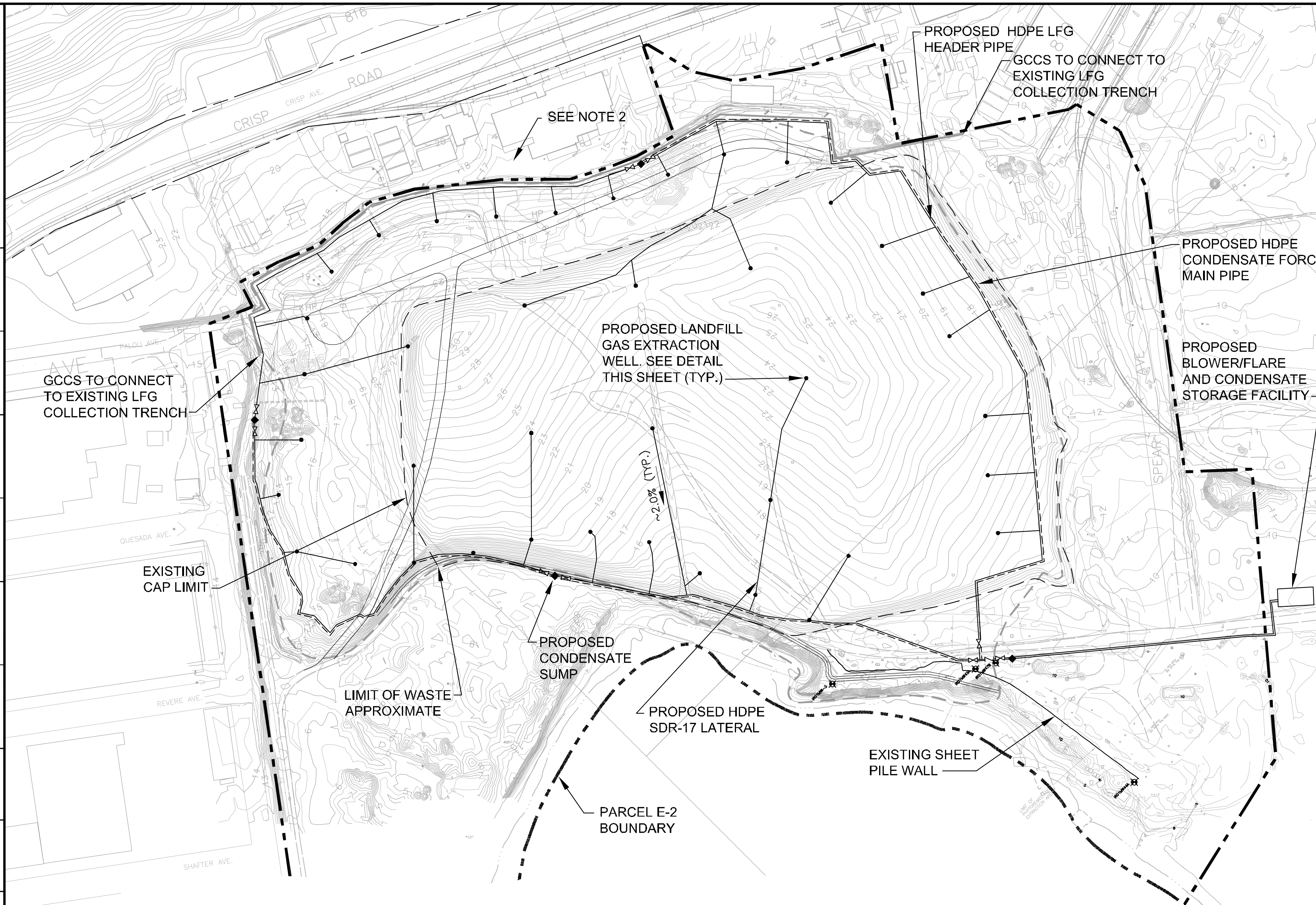
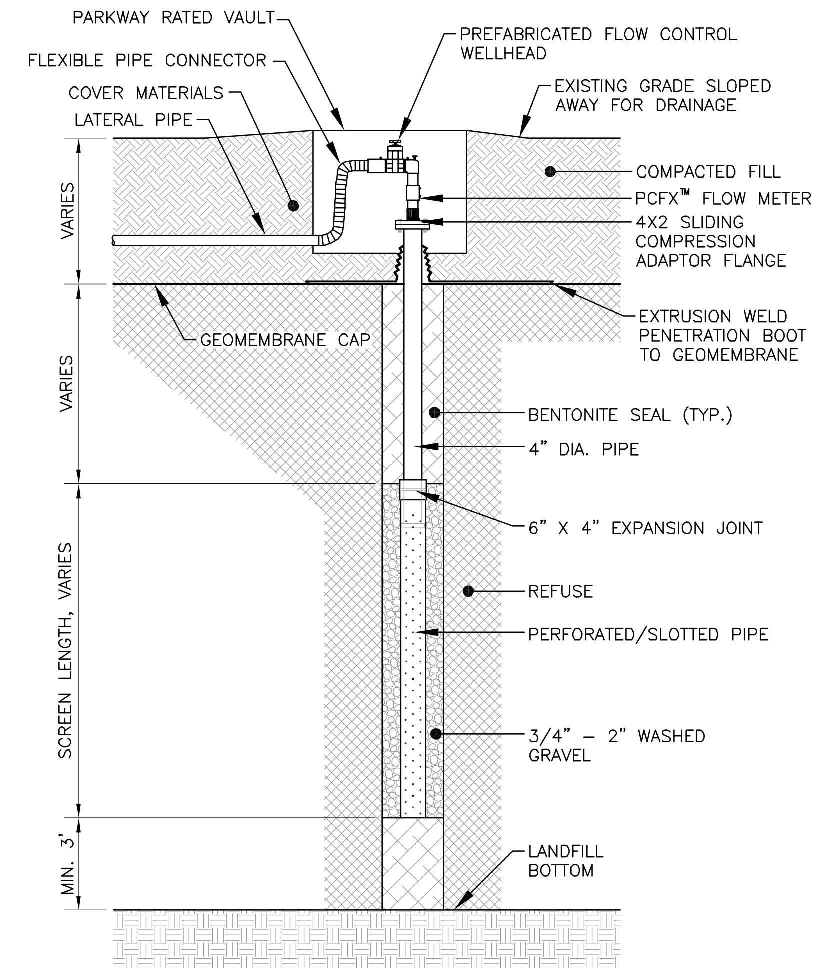
FIGURE 12-18
MULTILAYER GEOSYNTHETIC CAP TIE-IN
ALTERNATIVES 3, 4, AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2





CONCEPTUAL LFG EXTRACTION WELL

SCALE: NOT TO SCALE

N

100 0 100 200

Scale in Feet

LEGEND

- EXISTING CONTOUR
- LANDFILL AREA
- LIMIT OF EXISTING CAP
- PROPOSED LFG HEADER/LATERAL
- PROPOSED CONDENSATE FORCE MAIN
- PROPOSED LFG EXTRACTION WELL
- PROPOSED ISOLATION VALVE
- PROPOSED CHECK VALVE
- PROPOSED CONDENSATE SUMP

NOTES:

1. TOPOGRAPHY INFORMATION PROVIDED BY TETRA TECH EMI BASED ON AERIAL PHOTOGRAMMETRY 3-13-2002.
2. GROUND ELEVATIONS ARE BASED ON NGVD 29. COORDINATE SYSTEM BASED ON NAD 27.
3. INFORMATION REGARDING EXISTING LANDFILL GAS FEATURES MAY NOT REFLECT CURRENT CONDITIONS AND SHALL BE VERIFIED BY CONTRACTOR PRIOR TO CONSTRUCTION.
4. ALL EXISTING WELLS, HEADERS, LATERALS, AND OTHER LANDFILL GAS COLLECTION AND CONTROL SYSTEMS APPURTENANCES SHALL BE PROTECTED, EXTENDED AND/OR AVOIDED AS DIRECTED BY THE OWNER PRIOR TO AND DURING CONSTRUCTION.
5. SLOPE HEADER IN NATIVE SOIL A MINIMUM OF 0.5 PERCENT AND LATERALS OVER REFUSE A MINIMUM OF 2.5 PERCENT.

Shaw® Shaw Environmental, Inc.

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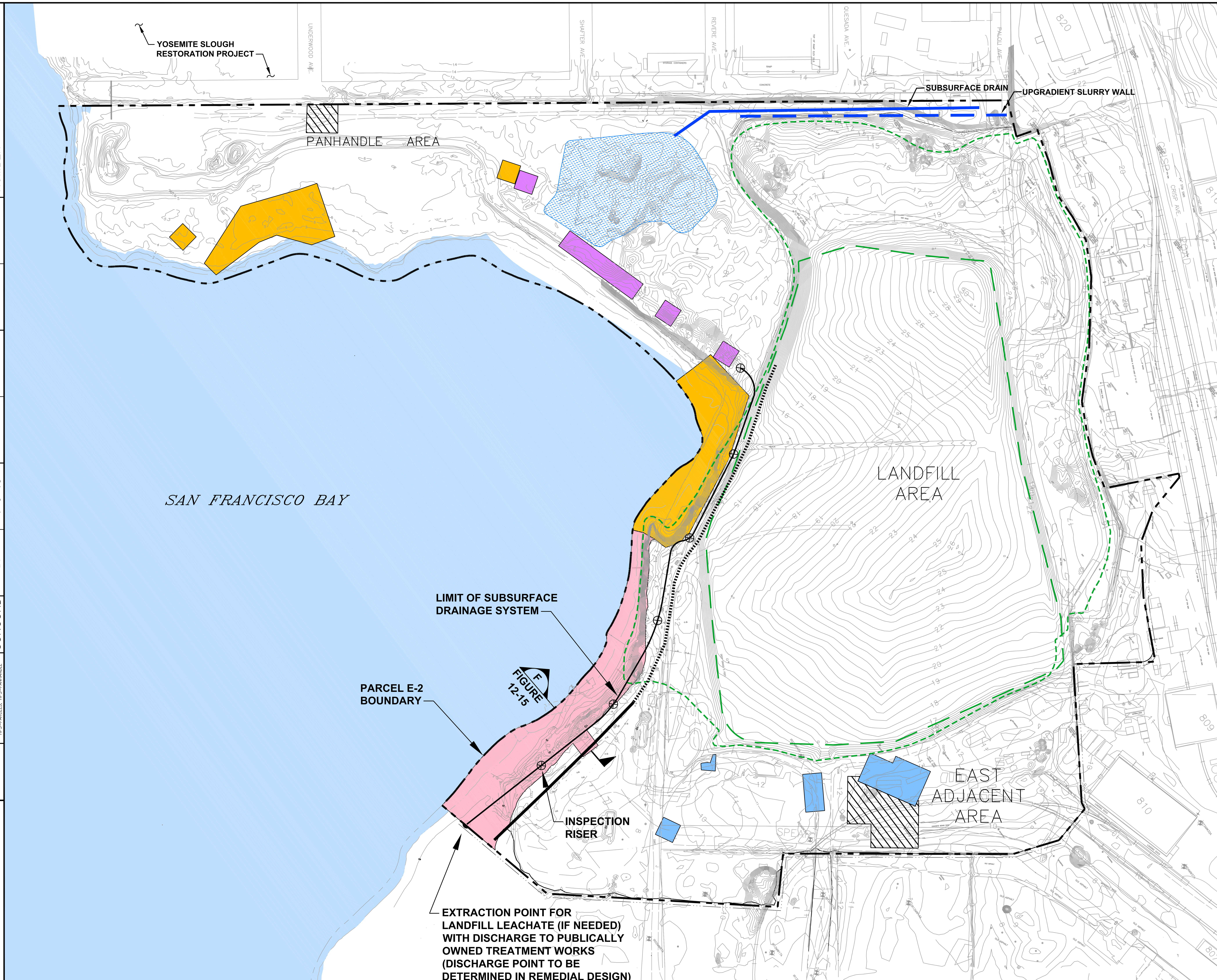
FIGURE 12-19
CONCEPTUAL LANDFILL GAS COLLECTION PLAN
ALTERNATIVES 3, 4, AND 5

Remedial Investigation/Feasibility Study for Parcel E-2

DRAWING NUMBER	843812-B45
APPROVED BY	-
	-
CHECKED BY	-
	-
DRAWN BY	3-25-10
	BJ
OFFICE	CONCORD
X-REF	---
IMAGE	---



LEGEND

- TIER 1 HOT SPOT
- TIER 2 HOT SPOT
- TIER 3 HOT SPOT
- TIER 4 HOT SPOT
- TIER 5 HOT SPOT
- EXISTING LIMIT OF GEOSYNTHETIC CAP
- LANDFILL AREA
- PARCEL E-2 BOUNDARY
- NEARSHORE SLURRY WALL (SOLID WHERE OPTIONAL)
- FRESHWATER WETLAND

NOTES:

1. TOPOGRAPHIC BASE MAP BASED ON AERIAL PHOTOGRAMMETRY DATED 3/13/02.
2. GROUND ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929. (NGVD 29)
3. COORDINATE SYSTEM BASED ON NORTH AMERICAN DATUM OF 1927. (NAD 27)
4. TOPOGRAPHIC BASE COVERAGE DOES NOT GO BEYOND ELEVATION 2'. (NGVD 29)
5. ADDITIONAL INFORMATION ON SOIL HOT SPOT EXCAVATIONS ARE PRESENTED ON FIGURES 12-7, 12-8, AND 12-9.

100 0 100 200

Scale in Feet

Shaw Shaw Environmental, Inc.

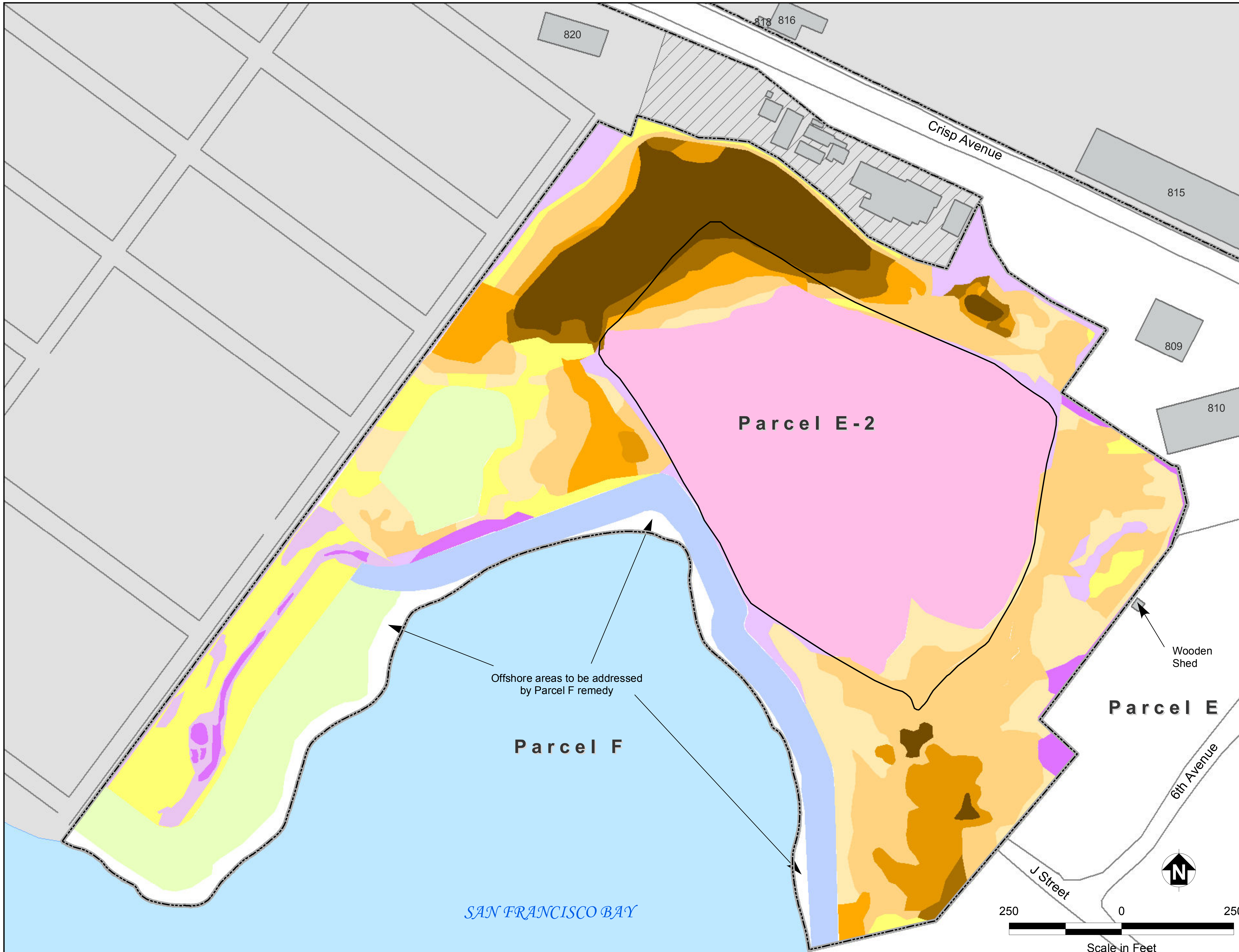
Hunters Point Shipyard, San Francisco, California

Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 12-20
SOIL HOT SPOT EXCAVATIONS AND GROUNDWATER CONTAINMENT ALTERNATIVES 4 AND 5

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR PARCEL E-2

DRAWING NUMBER	843812-D41
APPROVED BY	-
CHECKED BY	-
DRAWN BY	BJ 4-6-10
OFFICE	CONCORD
X-REF	3-13-02, 3-13-02-R1 HPS-PARCELS, HPS-PANHANDLE
IMAGE	---



Legend

Cover Type A1

Cover Type A1: Excavation (4 ft minimum) for Tidal and Freshwater Wetlands Construction

Cover Type B

Excavation (3.5 ft minimum) for Shoreline Revetment

Cover Type C

- Fill Thickness (1-2 ft)[1]
- Fill Thickness (2-3 ft)[1]
- Fill Thickness (3-5 ft)[1]
- Fill Thickness (5-7 ft)[1]
- Fill Thickness (7-9 ft)[1]
- Fill Thickness (9-11 ft)[1]
- Fill Thickness (11 ft or greater)[1]

Cover Type D

- Cut Thickness (0-1 ft)[2]
- Cut Thickness (greater than 1 ft)[2]

Cover Type E

Existing Cap to Remain

- Interim Landfill Cap Extent
- Parcel Boundary
- Non-Navy Property
- UCSF Compound
- Building
- Road

Notes:

Cover types presented on Figure 12-14.

1 Represent thickness of radiologically cleared foundation soil to be placed after screening for radioactive contamination.

2 Soil cut required to achieve final design elevation; thickness of radiologically cleared foundation soil would be 1 foot.

ft = feet

Reference:

The proposed grading shown on this figure is based on the Conceptual Grading Plan Alternatives 3, 4 and 5 (Figure12-1).

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 12-21

ALTERNATIVE 5
COVER AND EXCAVATION PLAN

Remedial Investigation/Feasibility Study for Parcel E-2

\\errg.net\active\projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\ProposedExcavations-Alt5.mxd Last updated 4/6/2010 10:04:57 AM

Tables

Table 12-1. Summary of Remedial Alternatives for the Parcel E-2 Feasibility Study
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

General Response Action	Remedial Technology	Process Options	Alternative No. 1	2	3A	3B	4A	4B	5A	5B
No action	None	None	✓							
Institutional actions	Institutional controls	Legal mechanisms		✓	✓	✓	✓	✓	✓	✓
		Administrative mechanisms		✓	✓	✓	✓	✓	✓	✓
	Site monitoring	Short-term monitoring		✓	✓	✓	✓	✓	✓	✓
		Long-term monitoring		✓	✓	✓	✓	✓	✓	✓
Containment	Caps and covers	Multilayer geosynthetic cap (Landfill Area)			✓	✓	✓	✓	✓	✓
		Geosynthetic cap (nonwetland adjacent areas)[1,2,3]			✓	✓	✓	✓	✓	✓
		Compacted clay liner (freshwater wetland)[3]			✓	✓	✓	✓		
		Demarcation layer (radiologically impacted areas)[4,5]		✓	✓	✓	✓	✓	✓	✓
	Shoreline protection	Vegetation with low-profile stabilization structures (tidal wetlands)[6]		✓	✓	✓	✓	✓	✓	✓
		Rock revetment[7]			✓	✓	✓	✓	✓	✓
	Landfill gas collection (and treatment)	Active gas collection			✓	✓	✓	✓	✓	✓
		Destruction (via combustion)			✓		✓		✓	
		Adsorption (via GAC and potassium permanganate)				✓		✓		✓
	Landfill leachate collection (and treatment)	Subsurface drainage and extraction system			✓	✓	✓	✓	✓	✓
		Off-site treatment (POTW)			✓	✓	✓	✓	✓	✓
		On-site treatment contingency (via GAC)[8]			✓	✓	✓	✓	✓	✓
		Groundwater diversion (Landfill Area, upgradient)			✓	✓	✓	✓	✓	✓
	Groundwater containment	Slurry wall (Landfill Area, downgradient)					✓	✓	✓	✓
		Slurry wall (PCB Hot Spot Area, downgradient)					✓	✓	✓	✓

Table 12-1. Summary of Remedial Alternatives for the Parcel E-2 Feasibility Study *(continued)*

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

General Response Action	Remedial Technology	Process Options	Alternative No. 1	2	3A	3B	4A	4B	5A	5B
Removal	Excavation and off-site disposal	All solid waste, debris, and soil in Landfill Area		✓						
		Solid waste, soil, and sediment (adjacent areas)[1,9]		✓						
		Chemical hot spots (adjacent areas)[1,10]		✓	✓	✓	✓	✓	✓	✓
		Radiological surface anomalies		✓	✓	✓	✓	✓	✓	✓
	Excavation and on-site consolidation	Solid waste and soil (wetlands restoration areas)[11]			✓	✓	✓	✓	✓	✓
		Sediment in Shoreline Area[12]			✓	✓	✓	✓	✓	✓

Notes:

1 Adjacent areas consist of the Panhandle Area, East Adjacent Area, and Shoreline Area; areas not proposed for wetlands restoration will receive geosynthetic cap.

2 Areas proposed for tidal wetlands would be restored without a geosynthetic cap or clay liner (all alternatives); areas proposed for freshwater wetlands would be restored either with a compacted clay (Alternatives 3 and 4) or without any liner (Alternatives 2 and 5).

3 Areas proposed for freshwater wetlands would be restored either with a compacted clay liner (Alternatives 3 and 4) or without any liner (Alternatives 2 and 5).

4 Demarcation layer will identify potential residual radioactivity in subsurface soil and will consist of magnetic marking tape overlaying orange colored geotextile.

5 For Alternatives 3, 4, and 5, demarcation layer will be required in all radiologically impacted areas (Figure 1-14). For Alternative 2, a demarcation layer would not be required in the Landfill Area.

6 Shoreline protection with vegetation in areas for tidal wetlands restoration; protection may be supplemented with low-profile stabilization structures, if needed to dissipate wave energy.

7 Rock revetment in nearshore zones adjacent to Landfill, East Adjacent, and Panhandle Areas (see Figure 12-1).

8 Contingency for on-site treatment is included if extracted leachate does not meet pre-treatment standards (Title 40 CFR Section 403).

9 Excavation depths range from 2.5 to 3.5 feet below ground surface (in accordance with remedial action objectives).

10 Excavation depths range from 2.5 to 16 feet below ground surface (to remove potential sources of groundwater contamination).

11 Excavation depths range from 2 to 8 feet below ground surface (to meet design elevations for tidal and freshwater wetlands in Panhandle Area).

12 Excavation depths range from 2 to 6 feet below ground surface (to meet design elevations for shoreline protection).

CFR Code of Federal Regulations
GAC granular activated carbon
PCB polychlorinated biphenyl
POTW publicly owned treatment works

Table 12-2. Hot Spot Goals for Soil and Sediment
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Hot Spot Tier	Impacted Media	COC/COEC	Hot Spot Goal (mg/kg)	Basis for Hot Spot Goal
Tier 1	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		Heptachlor epoxide	1.9	10 times RG for recreational users[a]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Total PCBs	7.4	10 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
	Sediment	Copper	2,700	10 times RG for aquatic wildlife[a]
		Lead	2,180	10 times RG for aquatic wildlife[a]
		Total PCBs	1.8	10 times RG for aquatic wildlife[a]
		Total TPH	3,500	TPH source criterion[b]
Tier 2	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Total PCBs	7.4	10 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
	Sediment	Copper	2,700	10 times RG for aquatic wildlife[a]
		Lead	2,180	10 times RG for aquatic wildlife[a]
		Total PCBs	1.8	10 times RG for aquatic wildlife[a]
		Total TPH	3,500	TPH source criterion[b]
Tier 3	Soil	Lead	19,700	100 times RG for terrestrial wildlife[a]
		Total PCBs	74	100 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
Tier 4	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Total PCBs	7.4	10 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
		Zinc	7,190	10 times RG for terrestrial wildlife[a]
Tier 5	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		1,1-Dichloroethane	2.8	Residential RBC (for Parcel E)[c]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Tetrachloroethene	0.48	Residential RBC (for Parcel E)[c]

Table 12-2. Hot Spot Goals for Soil and Sediment *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2

Hot Spot Tier	Impacted Media	COC/COEC	Hot Spot Goal (mg/kg)	Basis for Hot Spot Goal
Tier 5 *(cont.)*	Soil	Total TPH	3,500	TPH source criterion[b]
		Trichloroethene	2.9	Residential RBC (for Parcel E)[c]
		Vinyl chloride	0.024	Residential RBC (for Parcel E)[c]

Notes: COCs and COECs for hot spots identified on Figure 12-7.

a RGs for recreational users, terrestrial wildlife, and aquatic wildlife are presented in Section 9.1.1 of RI/FS Report

b TPH source criterion (Shaw Environmental, Inc., 2007). The TPH source criterion represents the most conservative evaluation criterion for potential sources of groundwater contamination that may impact aquatic wildlife in San Francisco Bay, and is selected as the hot spot goal in areas where total TPH is known to be present in groundwater at concentrations exceeding the corresponding RG (see Section 9.3.1 of RI/FS Report). If site conditions at a given hot spot (to be evaluated as part of ongoing groundwater monitoring) indicate that TPH is not present in groundwater at concentrations exceeding the corresponding RG, then total TPH may be eliminated as a COC for that hot spot. The presence of total TPH at individual hot spots will be further evaluated in the remedial design.

c Residential RBCs for the select VOCs are presented as part of the human health risk assessment for Parcel E (Barajas & Associates, Inc., 2008); these VOCs are present in Parcel E-2 and impact groundwater at Parcel E at concentrations that pose a risk to humans. These RBCs represent the most conservative evaluation criteria and are selected as hot spot goals for the purpose of maximizing the effectiveness of the VOC source removal effort and on the presumption that, based on available site data, the VOC source area is limited in volume (see Figure 12-8). If site conditions (to be determined as part of an interim removal action) indicate a larger VOC source area, then alternative remediation efforts will need to be evaluated in the remedial design.

COC chemical of concern
COEC chemical of ecological concern
mg/kg milligram per kilogram
PCBs polychlorinated biphenyls
RBC risk-based concentration
RG remediation goal
TPH total petroleum hydrocarbons
VOC volatile organic compounds

Sources:

Barajas & Associates, Inc. 2008. "Final Revised Remedial Investigation Report for Parcel E, Hunters Point Shipyard, San Francisco, California." May 2.

Shaw Environmental, Inc. 2007. "Final New Preliminary Screening Criteria and Petroleum Program Strategy, Hunters Point Shipyard, San Francisco, California." December 21.

Table 12-3. Actions to be Addressed in Remedial Design for Parcel E-2
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Alternatives	Action
2, 3, 4, and 5	Evaluation of measures for protection of special-status species (American peregrine falcon [*Falco peregrinus anatum*] is only special-status species at Parcel E-2).
2, 3, 4, and 5	Verification of the potential presence of utilities in the eastern portion of the Landfill Area, and evaluation of utilities as a preferential pathway for landfill gas migration.
2, 3, 4, and 5	Potential refinement of the method for comparing groundwater data with aquatic criteria to account for chemical attenuation and the nearshore mixing process to further assess the downgradient effect of groundwater contamination from the Shoreline Area on San Francisco Bay (if needed to supplement current trigger level approach).
2, 3, 4, and 5	Potential development of specific monitoring criteria for A-aquifer groundwater addressing potential risk to aquatic wildlife in San Francisco Bay using more refined fate and transport modeling (if needed to supplement current trigger level approach).
2, 3, 4, and 5	Further evaluation of the shoreline protection system relative to factors such as the potential rise in sea level.
2, 3, 4, and 5	Further groundwater delineation and augmentation of the groundwater data set using additional BGMP data.
2, 3, 4, and 5	Refinement of the preliminary groundwater monitoring plan using additional BGMP data.
2, 3, 4, and 5	Specification of best management practices for stormwater discharge to ensure surface water discharges do not present a threat to aquatic wildlife in San Francisco Bay.
2, 3, 4, and 5	Potential refinement of shoreline remediation approach to maximize efficiencies with the remediation approach for Parcel F.
2, 3, 4, and 5	Pre-design characterization of the lateral and vertical extent of hot spots, and possible refinement of remediation goals through measures such as refined modeling or site-specific leaching analysis.
3, 4, and 5	Quantitative slope stability analysis for the toe berm to ensure stability of the proposed cap.
3, 4, and 5	Further evaluation of the quality of groundwater for proposed groundwater diversion system.
3, 4, and 5	Refined modeling to evaluate interaction between surface water in freshwater wetlands, groundwater from proposed diversion system, and groundwater underlying freshwater wetlands.
3, 4, and 5	Investigation of soil gas in the Panhandle, East Adjacent, and Shoreline Areas to evaluate if gas collection and control is required.

Table 12-3. Actions to be Addressed in Remedial Design for Parcel E-2 *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Alternatives	Action
3, 4, and 5	Evaluation of landfill gas collected from the Landfill Area to determine the appropriate treatment technology.
4 and 5	Evaluation of the need to extend the slurry wall south into the PCB Hot Spot Area; evaluation will use updated groundwater monitoring data from wells in and around the PCB Hot Spot Area.

Notes:

BGMP Basewide Groundwater Monitoring Program

PCB polychlorinated biphenyl

Section 13. Detailed Analysis of Remedial Alternatives

NCP § 300.430(e) and the guidance for conducting RI/FS activities under CERCLA (EPA, 1988a) requires a remedial alternative evaluation based on nine criteria. This section evaluates each alternative described in Section 12 against the nine criteria, which are summarized below.

1. Overall Protection of Human Health and the Environment. This criterion provides an overall assessment of whether the alternative provides adequate protection of human health and the environment. The overall protection assessment draws upon other evaluation criteria, especially compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness. The protectiveness evaluation focuses on how site risks would be reduced or eliminated by the alternative, specifically how effectively an alternative meets the RAOs. This criterion is considered a threshold criterion and must be met by the selected alternative to be considered for use at Parcel E-2.

2. Compliance with ARARs. This criterion is used to determine whether the alternative will meet all identified federal and state ARARs and, if not, whether justification exists for waiving one or more of the ARARs. This criterion is also a threshold criterion that must be met by the selected alternative to be considered for use at Parcel E-2. Section 10 summarizes potential chemical-, location-, and action-specific ARARs associated with the remedial alternatives for Parcel E-2.

3. Long-Term Effectiveness and Permanence. The alternative is evaluated in terms of risk remaining at a site after RAOs have been met. The primary focus of this evaluation is the extent and effectiveness of controls used to manage the risk posed by treatment residuals or untreated wastes. The following factors are considered under this criterion:

- Adequacy of mitigation controls
- Reliability of mitigation controls
- Magnitude of the residual risk

4. Reduction in Toxicity, Mobility, or Volume through Treatment. This criterion addresses the statutory preference for treatment options that permanently and significantly reduce the toxicity, mobility, or volume of chemicals. This preference is satisfied when treatment reduces the principal threats through the following:

- Destruction of toxic chemicals
- Reduction in chemical mobility
- Reduction of the total mass of toxic chemicals
- Reduction of total volume of contaminated media

5. Short-Term Effectiveness. This criterion addresses the effects of the alternative during the implementation and construction phase until RAOs are met. Under this criterion, the alternative is evaluated with respect to its effects on human health and the environment during implementation of the remedial action. The following factors are considered:

- Exposure of the community during implementation
- Exposure of workers during construction
- Environmental effects
- Time required to achieve RAOs

6. Implementability. This criterion addresses the technical and administrative feasibility of implementing the alternative and the availability of various services and materials required during its implementation. The following factors are considered:

- Ability to construct the technology
- Reliability of the technology
- Monitoring considerations
- Availability of equipment and specialists
- Ability to obtain approvals from regulatory agencies

7. Cost. This criterion is based on estimates of capital and O&M costs for the alternative. Capital costs consist of direct and indirect costs. Direct costs include equipment, labor, and materials purchased as necessary to implement the alternative. Indirect costs include engineering, financial, and other services such as testing and monitoring. Annual O&M costs for each alternative include operating labor, maintenance materials and labor, auxiliary materials, and energy costs.

The cost estimate for each alternative is projected to range from 50 percent above to 30 percent below the actual cost. For estimating purposes, the post-closure O&M period is assumed to be 30 years based on landfill post-closure requirements. All costs are converted to a present value cost to allow comparison between alternatives with varying cash flow requirements over time.

8. State Acceptance. State acceptance is a modifying criterion used to evaluate technical and administrative issues and concerns of the state regarding the alternative. This criterion will be addressed in the ROD following comments on the RI/FS Report and the proposed plan.

9. Community Acceptance. Community acceptance is a modifying criterion used to evaluate technical and administrative issues and public concerns associated with the alternative. This criterion will be addressed in the ROD following comment on the RI/FS Report and the proposed plan.

The subsections below evaluate each alternative against these nine criteria. Table 13-1 provides a cost comparison of all the alternatives, and Appendix R provides detailed cost estimates and assumptions for each alternative.

13.1. ALTERNATIVE 1: NO ACTION

Under the no action alternative, no remedial action would take place. Solid waste, soil, and sediment would be left in place; groundwater and surface water would not be contained or treated. The no action alternative would not involve any response actions (e.g., monitoring, institutional controls, containment, removal, treatment, or other mitigating actions). The no action alternative is included throughout the FS process as required by the NCP to provide a baseline for comparison with and evaluation of other alternatives.

13.1.1. Overall Protection of Human Health and the Environment

This alternative would not provide adequate protection of human health and the environment because solid waste, soil, and sediment contributing risks to humans and wildlife would not be removed, contained, or treated. Migration of soil contamination to off-site locations through stormwater erosion would be possible. In addition, erosion could expose additional solid waste, increasing potential risks to humans and wildlife through direct contact. The potential for generation of leachate and migration from infiltration would not change from existing conditions under this alternative. The lack of institutional controls would provide no means of implementing various land use restrictions needed to control unacceptable exposure to the known COCs and COECs at the site. Furthermore, this alternative does not provide any mechanisms for monitoring potential migration of chemicals in landfill gas, surface water, or groundwater. Therefore, the no action alternative does not meet this threshold criterion.

13.1.2. Compliance with ARARs

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

13.1.3. Long-Term Effectiveness and Permanence

The no action alternative would not provide long-term effectiveness or permanence because potential exposures to known areas of contamination would not be controlled. Risk associated with exposure to solid waste, soil, sediment, landfill gas, groundwater, and surface water would not be reduced by remedial action or controlled through institutional controls. In addition, the existing control systems (e.g., landfill cap, gas control system, and stormwater BMPs) would not be maintained and would be considered unreliable to control future exposures. Consequently, the performance of Alternative 1 relative to this criterion is low.

13.1.4. Reduction in Toxicity, Mobility, or Volume

The no action alternative would not reduce the toxicity, mobility, or volume of solid waste, soil, sediment, landfill gas, groundwater, or surface water because none of these media would be treated, contained, or removed. In fact, shut down of the currently operational gas control system would presumably result in increases in landfill gas toxicity, mobility, and volume. Therefore, the performance of Alternative 1 relative to this criterion is low.

13.1.5. Short-Term Effectiveness

This alternative would not have any adverse short-term effects because it would not involve remediation activities that might pose risks to the community, workers, or the environment. Therefore, the performance of Alternative 1 relative to this criterion is high.

13.1.6. Implementability

No resources are required to implement this alternative, and no known administrative considerations would affect its overall implementability. Therefore, the performance of Alternative 1 relative to this criterion is high.

13.1.7. Cost

No capital or O&M costs are associated with the no action alternative.

13.1.8. State and Community Acceptance

State and community acceptance criteria will be assessed in the ROD following comment on the RI/FS Report and the proposed plan.

13.1.9. Summary of Detailed Analysis for Remedial Alternative 1

Because Alternative 1 did not meet the first threshold criterion (overall protection of human health and the environment, Section 13.1.1), it is not considered an acceptable alternative, and is retained only to provide a baseline for comparison to and evaluation of other alternatives.

13.2. ALTERNATIVE 2: EXCAVATE AND DISPOSE OF SOLID WASTE, SOIL, AND SEDIMENT (INCLUDING MONITORING, INSTITUTIONAL CONTROLS, AND UNLINED FRESHWATER WETLANDS)

Alternative 2 would involve excavation and off-site disposal of all solid waste, debris, and soil in the Landfill Area. Isolated solid waste locations and soil in the Panhandle Area and East Adjacent Area, as well as sediment within the Shoreline Area, would also be excavated and disposed of off site. The proposed excavation in the Panhandle Area, East Adjacent Area, and Shoreline Area would eliminate exposure to radioactive and nonradioactive contamination, in accordance with the exposure depths in the risk assessments, and would extend deeper in areas with known nonradioactive chemical hot spots. Groundwater monitoring would also be included under this alternative to (1) evaluate chemical concentrations in groundwater while the aquifers naturally recover and (2) confirm that concentrations at the point of compliance do not exceed chemical-specific ARARs. This alternative would also include institutional controls (consisting of land use and activity restrictions) that would be implemented across the entire parcel to prevent exposure to COCs and COECs in soil and groundwater. In the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas), wetlands disturbed during excavation activities would be restored on top of the clean fill.

13.2.1. Overall Protection of Human Health and the Environment

Under Alternative 2, contaminated solid waste, soil, and sediment from Parcel E-2 would be removed to protect human health and the environment by (1) eliminating potential exposure of humans and wildlife to contaminated solid waste, soil, or sediment through direct contact or inhalation; (2) reducing or eliminating generation and migration of landfill gas; and (3) removing potential sources that could contaminate groundwater and surface water. In addition, implementation of institutional controls would reduce the potential exposure of humans to subsurface soil (greater than 3 feet bgs) in the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) and groundwater throughout Parcel E-2. Therefore, Alternative 2 meets this threshold criterion.

13.2.2. Compliance with ARARs

Alternative 2 would meet all chemical-, location-, and action-specific ARARs that come into effect during implementation of the remedy, including those related to excavation and off-site disposal, institutional controls, and site monitoring.

Alternative 2 would meet the potential chemical-specific ARARs (identified in Section 10) for groundwater and air. This determination presumes that institutional controls, which restrict the use of groundwater, would remain in place until chemical concentrations in groundwater have attenuated to less than remediation goals. Removal of solid waste from the landfill would reduce or eliminate generation and migration of landfill gas. In addition, Alternative 2 would meet the various chemical-specific ARARs for waste characterization that would be triggered by excavation and disposal of solid waste, soil, and sediment.

Alternative 2 would meet the potential location-specific ARARs identified for the protection of coastal, wetlands, and biological resources by adhering to the substantive requirements of each ARAR. These actions would include wetlands mitigation.

Alternative 2 would meet the potential action-specific ARARs for excavation and disposal, institutional controls, and monitoring of surface water and groundwater. Potential action-specific ARARs for long-term gas monitoring, solid waste containment, and leachate collection and control would not be triggered because the landfill solid waste would be removed.

Alternative 2 meets this threshold criterion.

13.2.3. Long-Term Effectiveness and Permanence

Under Alternative 2, solid waste, soil, and sediment posing unacceptable risk to humans and wildlife would be permanently removed. In addition, removal of the contaminant sources (contaminated solid waste, soil, and sediment) would likely reduce any residual concentrations of COCs and COECs in groundwater and eventually allow restrictions on B-aquifer groundwater use to be removed once chemical concentrations have attenuated to less than remediation goals. In addition, institutional controls would require that workers adequately protect themselves from exposure when conducting activities that may lead to groundwater exposure. Consequently, the performance of Alternative 2 relative to this criterion is high.

13.2.4. Reduction in Toxicity, Mobility, or Volume

The removal actions proposed under Alternative 2 would not reduce the volume of contaminated solid waste, soil, or sediment because the material would be transferred to another location. However, excavated material would be placed at a licensed disposal facility with engineered containment systems. In addition, the toxicity and mobility of contaminants in the material could be reduced because some of the excavated material might require treatment prior to disposal.

The volume of contaminated A-aquifer groundwater in the Landfill Area would be reduced by extraction and treatment, which is required as part of the excavation process. In addition, excavation of the Tier 1 through Tier 5 hot spots and potential TPH soil sources (up to 10 feet bgs) in the Panhandle, East Adjacent, and Shoreline Areas would likely further reduce the toxicity of groundwater in Parcel E-2. However, these removals would not eliminate the presence of hazardous substances in groundwater throughout Parcel E-2, and institutional controls and long-term groundwater monitoring would be required to protect human health and the environment. Therefore, the performance of Alternative 2 relative to this criterion is moderate.

13.2.5. Short-Term Effectiveness

Alternative 2 would involve the potential exposure of site workers and the surrounding community to contaminants during the estimated 4 years of excavation and disposal of solid waste, soil, and sediment throughout Parcel E-2. In addition, the reexposure of buried waste to the atmosphere would accelerate the decay of putrefiable wastes, which would produce offensive odors. Institutional controls, engineering controls, and site monitoring would be implemented to minimize, but not eliminate, the potential exposure of site workers and the surrounding community. Institutional controls would ensure the proper training of site workers. Engineering controls would limit exposures by restricting site access to trained personnel, using dust control methods to reduce wind-blown contaminants, and implementing stormwater BMPs to control suspended sediment in surface runoff. Site monitoring would track potential migration of contaminants during construction.

The proposed removal of all solid waste and soil within the Parcel E-2 Landfill presents the most acute risk to site workers relative to other actions proposed under Alternative 2. This determination is based on the uncertainty of waste types found in the landfill and the excavation depth required for complete removal of solid waste and contaminated soil. If not implemented properly, deep excavation in saturated solid waste and debris could cause slope failure hazards during excavation, which in turn could jeopardize surrounding buildings and facilities. Proper engineering design and installation of a sheet-pile wall would minimize, but not eliminate, this risk.

Removal, storage, and treatment of contaminated solid waste, soil, sediment, and water would increase the potential for spills. This alternative assumes that wastes would be loaded onto rail cars on site and transported to the disposal facility by rail, rather than by trucks traveling through the community to transport the waste to a rail yard. Because of the anticipated volume of solid and liquid wastes, trucking waste through the community would substantially increase road traffic in the local community. This traffic would increase the potential for spills or accidents that could expose the community to contaminants. The risk of spills and accidents is greatly reduced by using on-site rail loading because:

- Fewer waste transfers must be made (from the site directly to rail car, as opposed to the two-phase site to truck and then truck to rail car)
- Rail cars would not be required to travel on community roads
- Fewer trips would be generated because a fully loaded rail car would haul more than a truck and multiple rail cars would be transported together

As discussed above, Alternative 2 would pose short-term risks to site workers and the surrounding community during the estimated 4-year period required to excavate and dispose of solid waste, soil, and sediment throughout Parcel E-2. These risks would be minimized, but not eliminated, by the use of institutional controls, engineering controls, and site monitoring. In light of these risks, the performance of Alternative 2 relative to this criterion is low.

13.2.6. Implementability

Although excavation and off-site disposal is a common remediation technology that has been successfully implemented at HPS, the size and scale of the excavation proposed under Alternative 2 presents numerous technical barriers that must be overcome for successful implementation. As discussed in Section 13.2.5, excavation of all solid waste and soil in the landfill would present acute risks to site workers that would be minimized with various controls, such as the installation of sheet piling around the landfill. The large excavation volumes considered under Alternative 2, coupled with the heterogeneous site conditions, make such controls difficult to implement. In addition, the proximity of excavation areas to San Francisco Bay presents implementation issues associated with controlling releases into the bay and preventing flooding during high tides. Administrative barriers are not anticipated; however, local citizens may be concerned about increased rail and road traffic required for implementation (e.g., waste transportation for off-site disposal, construction equipment and supply mobilization and demobilization, importation of backfill soil). Technical difficulties and uncertainties associated with this alternative are described below.

The presence of subsurface debris, such as very large concrete debris encountered during installation of the existing gas control system, would increase the difficulty and expense of installing a sheet-pile wall around the landfill needed to minimize groundwater intrusion and improve excavation stability. If a sheet-pile wall is not installed, additional cut-back of slopes would be necessary to provide sufficient stability and would require excavation of adjoining non-Navy property or portions of the bay. In addition, without a sheet-pile wall, it would be very difficult to control intrusion of bay water into the excavation.

Backfilling the excavated areas would be required to restore Parcel E-2 for future open space use, including recreation areas and restored wetlands, as outlined in the 2010 amended Redevelopment Plan (SFRA, 2010). The backfilling plan, accounting for final elevations substantially lower than the pre-excavation elevations, would involve importing nearly 400,000 cubic yards of material that is free of contamination and does not contain metals concentrations in excess of existing ambient levels. The magnitude of this backfilling effort poses numerous technical difficulties including: (1) identifying acceptable sources of backfill material in the local area to minimize transportation; (2) coordinating transportation of the material to the site (by truck, rail, or barge); (3) staging the large volume of material on-site while minimizing the impact to ongoing remediation efforts and reuse of other portions of HPS; and (4) managing the backfilling activities in conjunction with ongoing excavation and disposal activities. Presuming that the above-listed difficulties could be adequately addressed, proper placement and compaction of backfill on the soft Bay Mud would be difficult. If sufficient compaction of the lower layers could be achieved, proper compaction of overlying layers would also be difficult to achieve. Inadequate or improper compaction could lead to settlement or slope stability issues that could affect future site use.

The degree of characterization performed at Parcel E-2 is considered sufficient for evaluation of a remedial alternative, but is insufficient to precisely characterize excavated materials for off-site disposal. Given the large volume and heterogeneous nature of the fill at Parcel E-2, evaluation of excavated materials and determination of off-site treatment and disposal requirements makes Alternative 2 difficult to implement. For example, all of the estimated 1,170,000 cubic yards of material proposed for excavation from Parcel E-2 would require screening for radioactivity, which would take nearly 3 years to complete.

Based on the factors discussed above, the performance of Alternative 2 relative to this criterion is low. This performance rating is based primarily on the site conditions within the Landfill Area because over 85 percent of the excavation volume in Alternative 2 is located within the Landfill Area.

13.2.7. Cost

The capital cost of this alternative is estimated at $358 million. Major capital expenditures would be required for excavation, characterization, segregation, and disposal of excavated material from Parcel E-2. O&M costs are estimated at $3.8 million and consist of institutional controls and groundwater, stormwater, and wetlands monitoring. Including other periodic costs over the 34-year implementation period (4-year construction period and 30 years of monitoring), the estimated present value for this alternative is $346 million.

Unanticipated waste treatment and disposal requirements for excavated materials affect the estimated costs. With the exception of cover soil material in the existing multilayer cap, all material excavated from the landfill and adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) were assumed to require disposal at an off-site waste landfill. Cover soil material in the existing multilayer cap was assumed to be clean and reusable as backfill material. For cost-estimating purposes, approximately 35 percent of the material excavated from the site would be disposed of as D008 (RCRA Lead) waste, 50 percent as non-RCRA hazardous waste, 10 percent as nonhazardous waste, and 5 percent as low-level radiologically impacted waste (including mixed waste). These waste fractions were estimated using waste characterization data from the removal actions conducted at Parcel E-2. To reduce costs and road traffic through the local community, it was assumed that all hazardous material would be loaded onto rail cars on site and transported via rail to a disposal facility.

Because of the high costs, the performance of Alternative 2 relative to this criterion is low (that is, it has a low cost-effectiveness).

13.2.8. State and Community Acceptance

State and community acceptance criteria will be assessed in the ROD following comment on the RI/FS Report and the proposed plan.

13.2.9. Summary of Detailed Analysis for Remedial Alternative 2

Alternative 2 meets the two threshold criteria and would serve as an effective and permanent remedy in the long-term. However, numerous issues exist regarding the short-term effectiveness, implementability, and cost of Alternative 2. This finding is consistent with EPA's finding, based on an examination of FS documents for 30 CERCLA municipal landfills, that technologies associated with collection, treatment, and discharge were routinely screened out, primarily because of their difficult implementation and high cost (EPA, 1994).

As presented in Section 8.2.3.4, the Parcel E-2 Landfill meets all of the criteria specified in EPA guidance for application of the containment presumptive remedy. However, the Navy has agreed to evaluate Alternative 2 to provide information to support the community's review of potential remedial alternatives for Parcel E-2, and will therefore retain it for comparative analysis in Section 14.

13.3. ALTERNATIVE 3: CONTAIN SOLID WASTE, SOIL, AND SEDIMENT WITH HOT SPOT REMOVAL (INCLUDING MONITORING, INSTITUTIONAL CONTROLS, AND LINED FRESHWATER WETLANDS)

Alternative 3 involves: (1) excavation and off-site disposal of all radiological surface anomalies and excavation and Tier 1 and Tier 2 hot spots in the Panhandle Area, East Adjacent Area, and Shoreline Area; and (2) excavation and on-site consolidation of soil in portions of the Panhandle Area planned for wetlands restoration and sediment throughout the Shoreline Area. Excavation activities would be followed by containment of solid waste and soil in the Landfill, Panhandle, East Adjacent, and Shoreline Areas. In addition, this alternative would include installation and O&M of an active landfill gas control system. This alternative would provide a comprehensive closure strategy for Parcel E-2 that removes and disposes of hot spots from the nearshore area, contains other contaminated material at upland locations under an engineered liner, and restores the nearshore area consistent with the planned reuse (including restoration of wetlands damaged during the remedial action). This alternative assumes that excavation and off-site disposal of hot spots, combined with on-site consolidation of other contaminated soil, would adequately reduce the potential for groundwater contamination to affect aquatic wildlife in San Francisco Bay. This assumption would be confirmed through long-term groundwater monitoring. In addition, this alternative includes construction of (1) a groundwater diversion system (consisting of a slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation, and (2) a subsurface drainage system along the southern perimeter of the Landfill Area in the event that groundwater monitoring results prompt extraction and treatment of leachate and contaminated groundwater, as required per 22 CCR § 66264.310(b)(2).

Two variations of Alternative 3 are presented in Table 13-1 and Appendix R. Alternatives 3A and 3B are identical except for the landfill gas treatment method. Alternative 3A assumes that destruction by flare is used for landfill gas treatment. Alternative 3B assumes that adsorption by GAC and a potassium permanganate medium (such as, Hydrosil®) would be used for landfill gas treatment. Section 11 describes these two landfill gas treatment options. All gas treatment options were retained during the evaluation of technologies and process options, pending the results of a gas generation study that will better determine the characteristics of the landfill gas. Finally, Alternative 3 would be constructed to allow freshwater and tidal wetlands to be restored on top of the cap in the Panhandle and Shoreline Areas.

A more detailed list of the components included in Alternative 3 is provided below. Each of these components is described in detail in Section 12.

- Institutional controls
- Seismic design components to ensure slope stability and address liquefaction potential in the event of an earthquake
- Screening for and excavation and off-site disposal of isolated radiological anomalies
- Removal and off-site disposal of Tier 1 and Tier 2 hot spots
- Grading and on-site consolidation of materials from the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) to create stable slopes and allow for wetland construction in the Panhandle Area
- Construction of a new multilayer geosynthetic cap over portions of the Landfill Area not already capped and a new geosynthetic cap over the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas), except for the restored tidal and freshwater wetlands within the Panhandle Area (tidal wetlands would be restored without a liner and freshwater wetlands would be restored with a 1-foot-thick clay liner)
- Construction of a groundwater diversion system (consisting of a slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation

- Installation of a subsurface drainage system along the southern perimeter of the landfill (if groundwater monitoring results require extraction and treatment of leachate and contaminated groundwater)
- Construction of a shoreline protection system
- Decommissioning of the existing gas control system and installation (and subsequent maintenance) of an active gas collection system with treatment using a flare (Alternative 3A) or GAC and potassium permanganate (Alternative 3B)
- Installation of stormwater and erosion controls
- Post-construction landfill cap inspection and maintenance, and monitoring of landfill gas
- Post-construction monitoring of groundwater and stormwater
- Construction (and subsequent monitoring) of freshwater and tidal wetlands over the cap in the Panhandle Area

13.3.1. Overall Protection of Human Health and the Environment

Alternative 3 would protect human health and the environment by preventing unacceptable human or ecological exposure to contaminated solid waste, soil, and sediment at Parcel E-2. The combination of hot spot removal and off-site disposal, consolidation of other contaminated material, containment through capping, and implementation of institutional controls would prevent humans and wildlife from direct contact, incidental ingestion, and inhalation of eroded waste particulates. Landfill gas would be controlled, extracted, and treated (if necessary) by the gas collection system.

Human health and the environment would be protected from groundwater contamination through institutional controls to prevent exposure to groundwater within the Parcel E-2 and regular monitoring to ensure that groundwater concentrations at the point of compliance do not exceed chemical-specific ARARs. In addition, potential migration of groundwater contamination would be controlled because the low-permeability cap and stormwater control structures would significantly reduce infiltration relative to existing conditions, and the subsurface drainage system would collect and control potentially contaminated groundwater and landfill leachate. Therefore, Alternative 3 meets this threshold criterion.

13.3.2. Compliance with ARARs

Alternative 3 would meet the potential chemical-specific ARARs (identified in Section 10) for groundwater and air. This determination presumes that, following removal of hot spots and other contaminated soil and sediment in the Panhandle, East Adjacent, and Shoreline Areas, the groundwater monitoring program will confirm that chemical concentrations in A- or B-aquifer groundwater at the Parcel E-2 boundary (the point of compliance) do not exceed the potential chemical-specific ARARs. Potentially contaminated A-aquifer groundwater and leachate at the southern perimeter of the Landfill Area would be collected and controlled as required in 22 CCR § 66264.310(b)(2). The gas control system would prevent unacceptable concentrations of methane or NMOCs from moving past the compliance point or migrating into nearby structures. In addition, Alternative 3 would meet the various chemical-specific ARARs for the proper characterization of IDWs (from activities such as monitoring well replacement).

Alternative 3 would meet the potential location-specific ARARs identified for the protection of coastal, wetlands, and biological resources by adhering to the substantive requirements of each ARAR. These actions would include wetlands mitigation.

Alternative 3 would meet all of the potential action-specific ARARs for landfill gas control, institutional controls, and monitoring of surface water, groundwater, and landfill gas. Alternative 3 would meet all of the potential action-specific ARARs for containing solid waste.

Consequently, Alternative 3 meets this threshold criterion.

13.3.3. Long-Term Effectiveness and Permanence

Under Alternative 3, the final control systems (cap, gas control system, shoreline protection and subsurface drainage system, and stormwater BMPs) would control potential exposure to contaminated solid waste, soil, and sediment; control landfill gas; reduce groundwater migration; and prevent off-site transport of contaminated soil via stormwater erosion. With proper maintenance and monitoring, closure of the landfill and adjacent areas would be both effective and permanent in the long-term. The cap system, in particular the toe berm underlying the shoreline protection system at the southern perimeter of the Landfill Area, would also be designed for stability under static and earthquake conditions. Although Parcel E-2 has a predicted liquefaction potential, perimeter slopes would be designed with a synthetic soil reinforcement material to limit the effects of settlement and slope instability during potential soil liquefaction. In addition, institutional controls would increase the effectiveness of the remedy by establishing legal and administrative mechanisms to manage the control systems and to ensure that land uses are compatible with the final cap.

The landfill gas collection system would be designed with sufficient capacity to handle any anticipated variations in future landfill gas generation rates. Because of the age of the landfill, generation rates for landfill gas are expected to decline slowly in the future; therefore, with proper O&M, the landfill gas collection system would effectively control migration of landfill gas in the long-term until generation of landfill gas ceases to be a concern. Treatment of landfill gas, if necessary, would effectively prevent unacceptable risks from inhalation.

Presuming that the groundwater monitoring program would verify that A-aquifer groundwater emanating from the Panhandle and East Adjacent Areas and B-aquifer groundwater throughout Parcel E-2 do not contain chemical concentrations at the Parcel E-2 boundary (the point of compliance) exceeding the potential chemical-specific ARARs, Alternative 3 could be effective in protecting human health in the long-term because institutional controls would prohibit the use of Parcel E-2 aquifers as a source of drinking water and require that workers adequately protect themselves from exposure when conducting activities that may lead to groundwater exposure. Potential migration of chemicals in groundwater would be reduced with installation of the cap and the upgradient groundwater diversion system, coupled with leachate collection and control at the southern perimeter of the Landfill Area. The upgradient groundwater diversion would require regular inspection and maintenance to ensure its proper function.

Based on the discussion above, the long-term effectiveness and permanence of this alternative would be moderate.

13.3.4. Reduction in Toxicity, Mobility, or Volume

Under Alternative 3, operation of the control systems would reduce the mobility of several contaminated media by containing solid waste, soil, and sediment; controlling migration of landfill gas; limiting infiltration; collecting potential contaminated groundwater and landfill leachate; and preventing off-site transport of contaminated soil via stormwater erosion. However, except for potential treatment of landfill gas and contaminated groundwater and landfill leachate, this alternative involves containment and not active treatment; thus, the toxicity and volume of contaminated media would not be reduced. The performance of Alternative 3 relative to this criterion is moderate.

13.3.5. Short-Term Effectiveness

Under Alternative 3, the surrounding community and site workers could be exposed to dust, noise, and increased construction traffic during the estimated 2 years required to construct the cap and associated control systems. This exposure would be greatest during excavation and grading in the Panhandle Area and Shoreline Area. The risk of exposure to landfill contaminants or landfill gas would be low because disturbance of the landfill contents would be minimized.

Site workers could be exposed through direct contact with waste materials. This exposure would be minimized through the use of institutional controls to ensure the proper training of site workers, engineering controls to minimize airborne dust, and site monitoring to track potential migration of contaminants during construction. In addition, the risk of contaminant release to San Francisco Bay during construction in the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) would be alleviated through engineering controls (such as, inflatable cofferdams, silt curtains, and stormwater BMPs) to restrict sediment transport. Alternative 3 has moderate to high short-term effectiveness.

13.3.6. Implementability

Containment is the EPA's recommended remedy for CERCLA municipal landfills (EPA; 1991a, 1993a, 1994, and 1996; also provided in Appendix H to this RI/FS Report). The technologies for constructing the cap and landfill gas control system at Parcel E-2 have been frequently used throughout the United States and more specifically are proven and accepted technologies in the San Francisco Bay area. Construction methods would involve industry standard practices and equipment commonly used during construction of a landfill cap. Experienced construction personnel, materials, services, and equipment would be readily available. Implementation along the shoreline may prove difficult because of the depth of some waste that must be excavated to construct stable slopes; however, engineering controls could be designed to allow for successful excavation. Surface water controls would be required to prevent inundation of working areas from the tides and to prevent transport of contaminated materials into the bay. For the grading activities in the Panhandle Area, deeper excavation may require dewatering and associated water management, disposal, or treatment. Construction of the slurry wall along the western boundary would require a deep trench to key the barrier into the Bay Mud aquitard, and the potential exists for large debris and irregular subsurface voids to be encountered during trenching. However, these conditions can be addressed through proper engineering and construction techniques that have been previously used at Parcel E-2 during construction of the GES and the interim gas control system.

Coordination, consultation, and the general support of public agencies, including EPA Region 9, DTSC, RWQCB, CIWMB, BAAQMD, and the CCSF, is anticipated. This alternative is considered to be administratively implementable. The Navy would be responsible for establishing and maintaining institutional controls until the time of transfer.

Based on the factors discussed above, the performance of Alternative 3 relative to this criterion is moderate.

13.3.7. Cost

The total capital cost of this alternative is estimated to be approximately $57.7 million for Alternative 3A (enclosed flare for landfill gas treatment) and $56.9 million for Alternative 3B (GAC and potassium permanganate adsorption for landfill gas treatment). O&M and groundwater monitoring costs for Alternatives 3A and 3B are $23.7 million and $26.0 million, respectively. Including other periodic costs over the 32-year implementation period (2-year construction period and 30 years of monitoring), the estimated present values for Alternatives 3A and 3B are $72.2 million and $72.9 million, respectively.

13.3.8. State and Community Acceptance

State and community acceptance criteria will be assessed in the ROD following comment on the RI/FS Report and the proposed plan.

13.3.9. Summary of Detailed Analysis for Remedial Alternative 3

Alternative 3 meets the two threshold criteria and would serve as an effective and permanent remedy in the long-term. The control systems to be used to maintain the protectiveness of the alternative would require regular O&M, along with site monitoring, to ensure its effectiveness. Alternative 3 presents some challenges to ensure its short-term effectiveness and successful implementation; however, similar caps have been constructed throughout the San Francisco Bay area. Overall, Alternative 3 is considered a feasible alternative, and will be retained for comparative analysis in Section 14.

13.4. ALTERNATIVE 4: CONTAIN SOLID WASTE, SOIL, SEDIMENT AND GROUNDWATER WITH HOT SPOT REMOVAL (INCLUDING MONITORING, INSTITUTIONAL CONTROLS, AND LINED FRESHWATER WETLANDS)

Alternative 4 involves the same components of Alternative 3 (refer to Section 13.3) and also includes (1) excavation and off-site disposal of Tier 3, 4, and 5 hot spots (in addition to Tier 1 and 2 hot spots; (2) containment of contaminated groundwater with a nearshore slurry wall where landfill waste is within 100 feet of San Francisco Bay; and (3) the contingency to extend the nearshore slurry wall south into the PCB Hot Spot Area. The need for extending the nearshore slurry wall will be assessed in the RD using updated groundwater monitoring data that is currently being collected under the BGMP from wells in and around the excavated portion of the PCB Hot Spot Area. The groundwater diversion system along the west side of the landfill, as proposed under Alternative 3, would minimize hydraulic head buildup behind the nearshore slurry wall. This alternative would provide a comprehensive closure strategy for Parcel E-2 similar to Alternative 3, but includes the removal of additional hot spots (Tiers 3, 4, and 5) and containment of groundwater in areas where chemical contamination may affect aquatic wildlife in the bay or in the restored freshwater wetlands. This alternative, like Alternatives 2 and 3, would also include long-term groundwater monitoring.

Two variations of Alternative 4, Alternatives 4A and 4B, are presented in the evaluation and cost tables in Appendix R. Alternatives 4A and 4B are identical to Alternatives 3A and 3B presented in Alternative 3. These alternatives describe two landfill gas treatment options: destruction by flare (Alternative 4A) and adsorption by GAC and a potassium permanganate medium (Alternative 4B).

A more detailed list of the components included in Alternative 4 is provided below. Each of these components is described in detail in Section 12.

- Institutional controls
- Seismic design components to ensure slope stability and address liquefaction potential in the event of an earthquake
- Screening for and excavation and off-site disposal of isolated radiological anomalies
- Removal and off-site disposal of Tiers 1, 2, 3, 4, and 5 hot spots

- Grading and on-site consolidation of materials from the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) to create stable slopes and allow for wetland construction in the Panhandle Area
- Construction of a new multilayer geosynthetic cap over portions of the Landfill Area not already capped and a new geosynthetic cap over the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) , except for the restored tidal and freshwater wetlands within the Panhandle Area (tidal wetlands would be restored without a liner and freshwater wetlands would be restored with a 1-foot-thick clay liner)
- Construction of a groundwater diversion system (slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation
- Installation of a subsurface drainage system along the southern perimeter of the landfill
- Construction of a shoreline protection system
- Decommissioning of the existing gas control system and installation (and subsequent maintenance) of an active gas collection system with treatment using a flare (Alternative 4A) or GAC and potassium permanganate (Alternative 4B)
- Installation of stormwater and erosion controls
- Post-construction landfill cap inspection and maintenance, and monitoring of landfill gas
- Post-construction monitoring of groundwater and stormwater
- Construction (and subsequent monitoring) of freshwater and tidal wetlands over the cap in the Panhandle Area
- Construction of groundwater containment system to prevent the discharge of contaminated groundwater to San Francisco Bay

13.4.1. Overall Protection of Human Health and the Environment

Alternative 4 would be equally protective of human health and the environment as Alternative 3 because Alternative 4 includes all the components of Alternative 3 (refer to Section 13.3.1). Alternative 4 also includes (1) removal and off-site disposal of Tier 3, 4, and 5 hot spots (in addition to Tier 1 and 2 hot spots); (2) containment of contaminated groundwater in areas where landfill waste is within 100 feet of the bay, and diversion of upgradient groundwater along the west side of the using a containment structure; and (3) the contingency to extend the groundwater containment structure south into the PCB Hot Spot Area. Therefore, Alternative 4 meets this threshold criterion, as did Alternative 3.

13.4.2. Compliance with ARARs

Alternative 4, like Alternative 3, would meet the potential chemical-specific ARARs (identified in Section 10) for groundwater and air because Alternative 4 includes all the components of Alternative 3 (refer to Section 13.3.2). For Alternative 4, implementation of a groundwater containment system downgradient of the Landfill Area and PCB Hot Spot Area would provide further assurance that

A-aquifer groundwater concentrations at these locations would not exceed the potential chemical-specific ARARs. Therefore, Alternative 4 meets this threshold criterion, as did Alternative 3.

13.4.3. Long-Term Effectiveness and Permanence

Alternative 4 would include all components included in Alternative 3 that contribute to its long-term effectiveness and permanence because Alternative 4 includes all the components of Alternative 3 (refer to Section 13.3.3). In addition to these common components that contribute to long-term effectiveness and permanence, Alternative 4 would include additional hot spot removal and a downgradient groundwater containment system that would further reduce the potential for contaminated groundwater to discharge to San Francisco Bay. The downgradient slurry wall would require regular monitoring (water level measurements at piezometers and sampling at monitoring wells) to ensure that the slurry wall is effectively containing groundwater. In addition, the upgradient groundwater diversion would require regular inspection and maintenance to ensure its proper function.

Based on the discussion above, the long-term effectiveness and permanence of this alternative would be moderate to high.

13.4.4. Reduction in Toxicity, Mobility, or Volume

Under Alternative 4, operation of the control systems would reduce the mobility of several contaminated media by containing solid waste, soil, and sediment; controlling migration of landfill gas; limiting infiltration; containing groundwater to reduce potential generation of leachate; and preventing off-site transport of contaminated soil via stormwater erosion. As in Alternative 3, the toxicity and volume of solid waste, soil, and sediment would not be reduced except for potential treatment of landfill gas and contaminated groundwater and landfill leachate. The performance of Alternative 4 relative to this criterion is moderate.

13.4.5. Short-Term Effectiveness

The same exposure risks (to the surrounding community and site workers) and environmental risks (by contaminant release to the bay during construction) described under Alternative 3 apply to Alternative 4 (refer to Section 13.3.5). Construction of the slurry wall is not anticipated to increase the short-term risks to site workers relative to the other construction activities planned for the Panhandle, East Adjacent, and Shoreline Areas. Therefore, Alternative 4 has moderate to high short-term effectiveness, as does Alternative 3.

13.4.6. Implementability

Containment is the EPA's recommended remedy for CERCLA municipal landfills (EPA; 1991a, 1993a, 1994, and 1996; also provided in Appendix H to this RI/FS Report). The technologies for constructing the cap, groundwater control system, and landfill gas control system at Parcel E-2 have been frequently used throughout the United States and more specifically are proven and accepted technologies in the San Francisco Bay area. Most of the factors controlling implementability described for Alternative 3 are common to both Alternatives 3 and 4 (refer to Section 13.3.6). Therefore, the performance of Alternative 4 relative to this criterion is moderate, as it was for Alternative 3.

13.4.7. Cost

The total capital cost of this alternative is estimated to be approximately $65.6 million for Alternative 4A (enclosed flare for landfill gas treatment) and $65.3 million for Alternative 4B (GAC and potassium permanganate adsorption for landfill gas treatment). O&M and groundwater monitoring costs for Alternatives 4A and 4B are $23.7 million and $26.0 million, respectively. Including other periodic costs over the 32-year implementation period (2-year construction period and 30 years of monitoring), the estimated present values for Alternatives 4A and 4B are $79.9 million and $81.1 million, respectively.

13.4.8. State and Community Acceptance

State and community acceptance criteria will be assessed in the ROD following comment on the RI/FS Report and the proposed plan.

13.4.9. Summary of Detailed Analysis for Remedial Alternative 4

Alternative 4 meets the two threshold criteria and would serve as an effective and permanent remedy in the long-term. The control systems to be used to maintain the protectiveness of the alternative would require regular O&M, along with site monitoring, to ensure its effectiveness. Alternative 4 presents some challenges to ensure its short-term effectiveness and successful implementation; however, similar caps have been constructed throughout the San Francisco Bay area. Overall, Alternative 4 is considered a feasible alternative, and will be retained for comparative analysis in Section 14.

13.5. ALTERNATIVE 5: CONTAIN SOLID WASTE, SOIL, SEDIMENT, AND GROUNDWATER WITH HOT SPOT REMOVAL (INCLUDING MONITORING, INSTITUTIONAL CONTROLS, AND UNLINED FRESHWATER WETLANDS)

Alternative 5 involves all of the components of Alternative 4, but eliminates the 1-foot-thick clay liner within the proposed freshwater wetland and replaces it with an additional 1 foot of hydric soil (Figures 12-14 and 12-21). Alternative 5 was developed to evaluate the relative advantages of unlined freshwater wetlands as compared with the lined freshwater wetlands proposed under Alternatives 3 and 4.

This alternative would provide a comprehensive closure strategy for Parcel E-2 similar to Alternative 4, but would promote a more natural hydrological function within the freshwater wetland (i.e., allowing interaction between surface water and underlying groundwater).

Two variations of Alternative 5, Alternatives 5A and 5B, are presented in the evaluation and cost tables in Appendix R. Alternatives 5A and 5B are identical to Alternatives 3A and 3B presented in Alternative 3. The alternatives describe two landfill gas treatment options: destruction by flare (Alternative 5A) and adsorption by GAC and a potassium permanganate medium (Alternative 5B).

A more detailed list of the components included in Alternative 5 is provided below. Each of these components is described in detail in Section 12.

- Institutional controls
- Seismic design components to ensure slope stability and address liquefaction potential in the event of an earthquake
- Screening for and excavation and off-site disposal of isolated radiological anomalies
- Removal and off-site disposal of Tiers 1, 2, 3, 4, and 5 hot spots
- Grading and on-site consolidation of materials from the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) to create stable slopes and allow for wetland construction in the Panhandle Area
- Construction of a new multilayer geosynthetic cap over portions of the Landfill Area not already capped and a new geosynthetic cap over the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas), except for the restored tidal and freshwater wetlands within the Panhandle Area (tidal and freshwater wetlands would be restored without a liner)
- Construction of a groundwater diversion system (slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation
- Installation of a subsurface drainage system along the southern perimeter of the landfill
- Construction of a shoreline protection system
- Decommissioning of the existing gas control system and installation (and subsequent maintenance) of an active gas collection system with treatment using a flare (Alternative 5A) or GAC and potassium permanganate (Alternative 5B)
- Installation of stormwater and erosion controls
- Post-construction landfill cap inspection and maintenance, and monitoring of landfill gas
- Post-construction monitoring of groundwater and stormwater
- Construction (and subsequent monitoring) of freshwater and tidal wetlands over the cap in the Panhandle Area
- Construction of groundwater containment system to prevent the discharge of contaminated groundwater to San Francisco Bay

13.5.1. Overall Protection of Human Health and the Environment

Alternative 5 would be equally protective of human health and the environment as Alternative 4 because Alternative 5 includes all of the components of Alternative 4 (refer to Section 13.4.1). For Alternative 5, elimination of the liner under the freshwater wetlands could allow contaminated groundwater from the surrounding area (at concentrations that may be detrimental to aquatic wildlife) to flow into the restored wetlands. However, results of preliminary groundwater modeling (Appendix P) suggest that the freshwater wetlands would receive negligible flow from surrounding groundwater that contains chemicals that may be detrimental to aquatic wildlife. Therefore, Alternative 5 meets this threshold criterion, as did Alternative 4.

13.5.2. Compliance with ARARs

Alternative 5, like Alternative 4, would meet the potential chemical-specific ARARs (identified in Section 10) for groundwater and air because Alternative 5 includes all of the components of Alternative 4 (refer to Section 13.4.2). For Alternative 5, elimination of the liner under the freshwater wetlands could allow contaminated groundwater from the surrounding area (at concentrations exceeding promulgated surface water criteria) to flow into the restored wetlands. However, results of preliminary groundwater modeling (Appendix P) suggest that the freshwater wetlands would receive negligible flow from surrounding groundwater that contains chemicals that may be detrimental to aquatic wildlife. Therefore, Alternative 5 meets this threshold criterion, as did Alternative 4.

13.5.3. Long-Term Effectiveness and Permanence

Alternative 5 would include all of the components included in Alternative 4 that contribute to its long-term effectiveness and permanence because Alternative 5 includes all of the components of Alternative 4 (refer to Section 13.4.3). For Alternative 5, elimination of the liner under the freshwater wetlands could allow contaminated groundwater from the surrounding area (at concentrations that may be detrimental to aquatic wildlife) to flow into the restored wetlands. However, results of preliminary groundwater modeling (Appendix P) suggest that the freshwater wetlands would receive negligible flow from surrounding groundwater that contains chemicals that may be detrimental to aquatic wildlife. In addition, the lack of a liner would promote a more natural hydrological function within the freshwater wetlands and would likely increase its ecological function. Based on the discussion above, the long-term effectiveness and permanence of this alternative would be moderate to high.

13.5.4. Reduction in Toxicity, Mobility, or Volume

Under Alternative 5, operation of the control systems would reduce the mobility of several contaminated media by containing solid waste, soil, and sediment; controlling migration of landfill gas; limiting infiltration; containing groundwater to reduce potential generation of leachate; and preventing off-site transport of contaminated soil via stormwater erosion. As in Alternatives 3 and 4, the toxicity and volume of solid waste, soil, and sediment would not be reduced except for potential treatment of landfill gas and contaminated groundwater and landfill leachate. The performance of Alternative 5 relative to this criterion is moderate.

13.5.5. Short-Term Effectiveness

The same exposure risks (to the surrounding community and site workers) and environmental risks (by contaminant release to the bay during construction) described under Alternative 3 apply to Alternative 5 (refer to Section 13.3.5). Construction of the slurry wall is not anticipated to increase the short-term risks to site workers relative to the other construction activities planned for the Panhandle, East Adjacent, and Shoreline Areas. Therefore, Alternative 5 has moderate to high short-term effectiveness, as do Alternatives 3 and 4.

13.5.6. Implementability

Containment is the EPA's recommended remedy for CERCLA municipal landfills (EPA; 1991a, 1993a, 1994, and 1996; also provided in Appendix H to this RI/FS Report). The technologies for constructing the cap, groundwater control system, and landfill gas control system at Parcel E-2 have been frequently used throughout the United States and, more specifically, are proven and accepted technologies in the San Francisco Bay area. Most of the factors controlling implementability described for Alternative 3 are common to Alternatives 3, 4, and 5 (refer to Section 13.3.6). For Alternative 5, elimination of the liner under the freshwater wetlands could allow contaminated groundwater from the surrounding area (at concentrations that may be detrimental to aquatic wildlife) to flow into the restored wetlands. As discussed previously, the potential groundwater intrusion is considered negligible; however, periodic monitoring would be required to ensure that water quality within the wetland is acceptable. Alternative 5 offers improved performance relative to administrative implementability because several regulatory agencies, including EPA Region 9, have expressed a preference toward unlined freshwater wetlands that promote a more natural hydrological function. Therefore, the performance of Alternative 5 relative to this criterion is moderate to high.

13.5.7. Cost

The total capital cost of this alternative is estimated to be approximately $65.6 million for Alternative 5A (enclosed flare for landfill gas treatment) and $65.4 million for Alternative 5B (GAC and potassium permanganate adsorption for landfill gas treatment). O&M and groundwater monitoring costs for Alternatives 5A and 5B are $23.7 million and $26.0 million, respectively. Including other periodic costs over the 32-year implementation period (2-year construction period and 30 years of monitoring), the estimated present values for Alternatives 5A and 5B are $80.0 million and $81.2 million, respectively.

13.5.8. State and Community Acceptance

State and community acceptance criteria will be assessed in the ROD following comment on the RI/FS Report and the proposed plan.

13.5.9. Summary of Detailed Analysis for Remedial Alternative 5

Alternative 5 meets the two threshold criteria and would serve as an effective and permanent remedy in the long-term. The control systems to be used to maintain the protectiveness of the alternative would require regular O&M, along with site monitoring, to ensure its effectiveness. Alternative 5 presents some challenges to ensure its short-term effectiveness and successful implementation; however, similar caps have been constructed throughout the San Francisco Bay area. Overall, Alternative 5 is considered a feasible alternative and is retained for comparative analysis in Section 14.

Tables

Table 13-1. Cost Estimate Summaries

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Remedial Alternative	Total Capital Cost	Total O&M and Monitoring Cost	Total Periodic Cost	Period of Analysis	Total Cost	Present Value[1]
1	$ --	$ --	$ --	NA	$ --	$ --
2	$357,651,507	$ 3,831,834	$139,285	34 years	$361,622,626	$346,465,203
3A	$ 57,723,835	$23,694,630	$675,298	32 years	$ 82,093,763	$ 72,243,536
3B	$ 56,904,200	$25,962,630	$675,298	32 years	$ 83,542,127	$ 72,925,647
4A	$ 65,603,596	$23,694,630	$675,298	32 years	$ 89,973,524	$ 79,914,634
4B	$ 65,325,916	$25,962,630	$675,298	32 years	$ 91,963,844	$ 81,123,731
5A	$ 65,643,139	$23,694,630	$675,298	32 years	$ 90,013,067	$ 79,953,130
5B	$ 65,364,259	$25,962,630	$675,298	32 years	$ 92,002,187	$ 81,161,059

Notes: The costs presented above do not include radiological-specific tasks that are detailed in the radiological addendum to the RI/FS Report (ERRG and RSRS, 2011). The total estimated cost to perform these tasks, which are common to Alternatives 2, 3, 4, and 5, is estimated at $5,515,000.

1 Based on a 2.8% discount factor, as specified for federal facility sites in Appendix C of Office of Management and Budget Circular A-94 (effective January 2008, http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html)

ERRG Engineering/Remediation Resources Group, Inc.

NA not applicable

O&M operation and maintenance

RSRS Radiological Survey and Remedial Services, LLC

Source:

ERRG and RSRS. 2011. "Final Radiological Addendum to the Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." March 4.

Section 14. Comparative Evaluation of Remedial Alternatives

The comparative evaluation of remedial alternatives presented in this section includes the relative performance of each alternative (that has met the first two threshold criteria) with respect to the five balancing criteria, as outlined in the NCP and presented in Section 13. The NCP states: "The national goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste." As discussed in Section 13.1.1, Alternative 1, the no action alternative, does not meet the first threshold criterion, Overall Protection of Health and the Environment. Alternative 1 is retained for comparison as required by the NCP. The remaining alternatives (Alternatives 2, 3, 4, and 5) meet both threshold criteria (Overall Protection of Human Health and the Environment and Compliance with ARARs); thus, all four alternatives are included in this comparative evaluation. Alternative 2 involves excavation and disposal of solid waste, soil, and sediment (including monitoring, institutional controls, and unlined freshwater wetlands). Alternative 3 involves containment of solid waste, soil, and sediment with hot spot removal (including monitoring, institutional controls, and lined freshwater wetlands). Alternative 4 involves containment of solid waste, soil, sediment, and groundwater controls with hot spot removal (including monitoring, institutional controls, and lined freshwater wetlands). Alternative 5 is identical to Alternative 4 except that the freshwater wetlands would be restored without a liner.

The following evaluation compares Alternatives 2, 3, 4, and 5, each of which meets the two threshold criteria, against the five balancing criteria:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, and Volume through Treatment
- Short-term Effectiveness
- Implementability
- Cost

This evaluation serves to identify and assess the relative performance of each alternative with respect to these five criteria to assist the decision-making process. As discussed in Section 13, the last two criteria, State and Community Acceptance, will be assessed in the ROD following comment on the RI/FS Report and the proposed plan. Table 14-1 summarizes the comparative analysis and presents each remedial alternative with rankings of its relative performance to each of the five balancing criteria.

14.1. LONG-TERM EFFECTIVENESS AND PERMANENCE

The no action alternative (Alternative 1) would not provide long-term effectiveness or permanence because potential exposures to known areas of contamination would not be controlled.

Alternatives 2, 3, 4, and 5 would each be effective in the long-term. Alternative 2 would provide the highest degree of long-term effectiveness for Parcel E-2 because solid waste, soil, and sediment posing unacceptable risk would be permanently removed from the site, whereas Alternatives 3, 4, and 5 would leave contaminant sources, with the exception of hot spots in the Panhandle Area, East Adjacent Area, and Shoreline Area, in place at the site to be contained via capping. Alternative 3 would provide a moderate degree of long-term effectiveness because the final control systems (cap, gas control system, and stormwater BMPs) would control potential exposure to contaminated solid waste, soil, and sediment; control migration of landfill gas; and prevent off-site transport of contaminated soil via stormwater erosion. With proper maintenance and monitoring, closure of the landfill and adjacent areas (Panhandle Area, East Adjacent Area, and Shoreline Area) would be both effective and permanent in the long-term. The inclusion of a groundwater containment system and expanded hot spot removal for Alternatives 4 and 5 provide improved long-term effectiveness in preventing discharge of contaminated groundwater to San Francisco Bay. As a result, Alternatives 4 and 5 would provide a moderate to high degree of long-term effectiveness. Alternative 5 may offer slightly improved long-term effectiveness relative to Alternative 4 because the lack of a liner would promote a more natural hydrological function within the freshwater wetlands and would likely increase its ecological function. However, the long-term effectiveness rating of Alternative 5 poses some uncertainty because it relies on the presumption that, based on preliminary groundwater modeling results, the net inflow of potentially contaminated groundwater from the surrounding area into the freshwater wetlands is negligible. Additional analysis would be performed in the RD to verify surface water and groundwater interaction in this area. For the purposes of this RI/FS Report, Alternatives 4 and 5 are considered to have the same long-term effectiveness.

Alternatives 2, 3, 4, and 5 are effective in the long-term at minimizing exposure to contaminated groundwater. Presuming the groundwater monitoring program would verify that chemical concentrations in A- or B-aquifer groundwater at the Parcel E-2 boundary (the point of compliance) do not exceed the potential chemical-specific ARARs, Alternative 3 could be effective in protecting human health in the long-term because the cap would reduce infiltration, the groundwater diversion system would reduce leachate generation, and the subsurface drainage system would collect and control contaminated groundwater and landfill leachate, thus reducing the potential for migration of chemicals in groundwater. Alternatives 4 and 5 would provide a more robust groundwater containment system in the Landfill Area and would include, as a contingency, extension of the downgradient slurry wall into the PCB Hot Spot Area. Although Alternatives 2, 3, 4, and 5 each would remove the shoreline portion of the PCB Hot Spot

Area, only Alternatives 4 and 5 would contain potentially contaminated groundwater in this area from discharging to San Francisco Bay.

Institutional controls would increase the effectiveness of Alternatives 3, 4, and 5 by establishing legal and administrative mechanisms to manage the control systems and to ensure that land uses are compatible with the final cap. In Alternative 2, excavation and off-site disposal of contaminant sources (contaminated solid waste, soil, and sediment and hot spot removal) would reduce residual concentrations of COCs and COECs in groundwater, and once chemical concentrations have attenuated to less than the remediation goals, restrictions on B-aquifer groundwater could be removed.

In all four alternatives, institutional controls would prohibit the use of Parcel E-2 aquifers as a source of drinking water and require that workers adequately protect themselves from exposure when conducting activities that may lead to groundwater exposure.

All four alternatives would reduce the potential for migration of landfill gas in the long-term. Alternative 2 would remove the subsurface waste; effectively eliminating generation of subsurface gas. With proper O&M, the landfill gas collection system associated with Alternatives 3, 4, and 5 would effectively control migration of landfill gas in the long-term, until generation of landfill gas ceases to be a concern. If necessary, treatment of landfill gas would effectively prevent unacceptable risks from inhalation.

Results of the comparative evaluation indicate that Alternatives 4 and 5 have a higher degree of long-term effectiveness than Alternative 3, because Alternatives 4 and 5 includes groundwater containment and expanded hot spot removal. Alternative 2 has the highest degree of long-term effectiveness, mainly because the bulk of the contaminant source would be removed. If successfully implemented, however, Alternatives 4 and 5 would provide a very similar level of long-term effectiveness by significantly reducing risks to human health and the environment. Alternative 1 would have the lowest long-term effectiveness.

14.2. REDUCTION IN TOXICITY, MOBILITY, AND VOLUME

The no action alternative (Alternative 1) would not reduce the toxicity, mobility, or volume of solid waste, soil, sediment, landfill gas, groundwater, or surface water because none of these media would be treated, contained, or removed.

Neither Alternatives 2, 3, 4, nor 5 would reduce the volume of contaminated solid waste, soil, or sediment. In Alternative 2, the material would be transferred to another location and would not undergo any significant volume reduction. However, excavated material would be placed at a licensed disposal facility with engineered containment systems, thus reducing its mobility. In addition, because some of the excavated material might require treatment prior to disposal, there would be a reduction in the toxicity and mobility of contaminants in the material. Alternatives 3, 4, and 5 would also reduce the mobility of several contaminated media by containing solid waste, soil, and sediment; controlling migration of landfill gas; limiting infiltration and leachate generation; collecting and controlling potential contaminated groundwater and landfill leachate; and preventing off-site transport of contaminated soil via stormwater erosion.

In Alternative 2, the volume of contaminated A-aquifer groundwater in the Landfill Area would be reduced by extraction and treatment, which is required as part of the excavation process, and excavation of Tier 1 through 5 hot spots and TPH soil sources would likely reduce the toxicity of groundwater in these areas. However, these removals would not eliminate the presence of hazardous substances in groundwater throughout Parcel E-2, and long-term groundwater monitoring would be required to ensure that A- or B-aquifer groundwater concentrations at the compliance boundary meet the remediation goals.

Because Alternatives 3, 4, and 5 involve primarily containment and not active treatment, the volume of contaminated media would not be substantially reduced. Operation of the planned control systems would reduce the mobility of several contaminated media by containing solid waste, soil, and sediment; controlling migration of landfill gas; limiting infiltration and potential generation of leachate; and preventing off-site transport of contaminated soil via stormwater erosion. However, except for potential treatment of landfill and contaminated groundwater and landfill leachate, this alternative involves containment and not active treatment; thus, the toxicity and volume of contaminated media would not be reduced.

Alternatives 2, 3, 4, and 5 are expected to perform equally with respect to reduction in toxicity, mobility, and volume of contaminants. Volume reductions of the contaminated media targeted for remediation (solid waste, soil, and sediment) would be negligible, while reductions in mobility and toxicity of contaminants would presumably be moderate for all three alternatives. Alternative 1 would perform the poorest with respect to this criterion.

14.3. SHORT-TERM EFFECTIVENESS

Short-term effectiveness is a measure of the benefits seen by implementation of a remedial alternative and the risks associated with its implementation.

Due to the invasive nature of the excavation remedy, Alternative 2 would pose more short-term risks to site workers and the surrounding community than the containment remedies (Alternatives 3, 4, and 5). These risks could include exposure to dust, noise, and increased construction traffic. Alternative 2 is estimated to span a 4-year period, during which excavation and disposal of solid waste, soil, and sediment would take place. This period is twice as long as the estimated 2-year construction period to implement Alternatives 3, 4, or 5, which involves construction of a cap and its associated control systems.

Alternatives 3, 4, and 5 would also require less disruption of the in-place solid waste, soil, and sediment than the excavation remedy. Under all three alternatives, risks to site workers and the surrounding community would be minimized, but not eliminated, by the use of institutional controls, engineering controls, and site monitoring.

In light of the elevated risks and longer construction duration associated with the excavation remedy, the short-term effectiveness of Alternative 2 is deemed to be substantially lower than Alternatives 3, 4, and 5 (the containment alternatives), which are expected to have moderate to high short-term effectiveness. Alternative 1 would have the highest relative short-term effectiveness because it would not involve remediation activities that might pose risks to the community, workers, or the environment.

14.4. IMPLEMENTABILITY

Alternative 2 presents numerous technical barriers that must be overcome for successful implementation due to the size and scale of the proposed excavation, thus the implementability of this remedy is lower than Alternatives 3, 4, and 5. Various controls would need to be implemented to minimize acute risks to site workers associated with the excavation remedy. The massive scale of the excavation effort, coupled with the heterogeneous site conditions, make such controls difficult to implement. Other complications associated with the implementability of this remedy include:

- Proximity to San Francisco Bay
- Harmful effects on the community caused by increased rail and road traffic required for implementation (e.g., waste transportation for off-site disposal, construction equipment and supply mobilization and demobilization, importation of backfill soil)
- Difficulties that may be encountered during installation of the sheet-pile wall
- Difficulties associated with coping with groundwater and bay water intrusion in the excavation area
- The lack of waste characterization information needed to facilitate planning and managing the waste disposal process effectively
- The laborious and time-consuming nature of the radiological screening process

The technologies for constructing the cap and landfill gas control systems for Alternatives 3, 4, and 5 have been frequently used throughout the United States and more specifically are proven and accepted technologies in the San Francisco Bay area. Construction methods would involve industry standard practices and equipment commonly used during construction of a landfill cap. The qualified personnel, materials, services, and equipment required to implement Alternatives 3, 4, and 5 are readily available. No administrative barriers to implementation are expected because coordination, consultation, and the general support of public agencies, including EPA Region 9, DTSC, RWQCB, CIWMB, BAAQMD, and the CCSF, is anticipated. Alternative 5 offers improved performance relative to administrative implementability because several regulatory agencies, including EPA Region 9, have expressed a preference toward unlined freshwater wetlands that promote a more natural hydrological function.

Based on the factors discussed above, the implementability of Alternatives 3, 4, and 5 far exceeds that of Alternative 2, which has a low implementability. The no action alternative (Alternative 1) would have the highest relative implementability because no resources are required to implement this alternative and no known administrative considerations would affect its overall implementability.

14.5. COST

The estimated costs for the alternatives being considered in this comparative analysis are detailed in Appendix R. The estimated costs in Appendix R do not include radiological-specific tasks that are detailed in the radiological addendum to the RI/FS Report (ERRG and RSRS, 2011). The total estimated cost to perform these radiological-specific tasks, which are common to Alternatives 2, 3, 4, and 5, is estimated at $5,515,000. The total estimated costs for the alternatives considered in the RI/FS Report and the radiological addendum are provided below.

Remedial Alternative	Estimated Cost (Present Value)
Alternative 1 – No Action	$0
Alternative 2 – Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, institutional controls, and unlined freshwater wetlands)	$351.5 million
Alternative 3A – Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, institutional controls, lined freshwater wetlands, and gas treatment by flare)	$77.7 million
Alternative 3B – Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, institutional controls, lined freshwater wetlands, and gas treatment by GAC and potassium permanganate)	$78.4 million
Alternative 4A – Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, lined freshwater wetlands, and gas treatment by flare)	$85.4 million
Alternative 4B – Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, lined freshwater wetlands, and gas treatment by GAC and potassium permanganate)	$86.6 million
Alternative 5A – Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, unlined freshwater wetlands, and gas treatment by flare)	$85.5 million
Alternative 5B – Contain Solid Waste, Soil, Sediment, and	$86.7 million

Remedial Alternative	Estimated Cost (Present Value)
Groundwater with Hot Spot Removal (including monitoring, institutional controls, unlined freshwater wetlands, and gas treatment by GAC and potassium permanganate)	

It should be noted that Alternative 2 has the highest degree of uncertainty associated with the estimated costs because of the uncertainty associated with the constitution of the waste material to be excavated. More detailed cost estimates are included in Appendix R and summarized in Table 13-1. It should also be noted that Alternatives 2, 3 (A and B), 4 (A and B), and 5 (A and B) all include institutional controls, groundwater monitoring, completion of the shoreline protection, stormwater discharge management and monitoring wetlands restoration, and varying degrees of hot spot removal in the Panhandle, East Adjacent, and Shoreline Areas.

14.6. STATE AND COMMUNITY ACCEPTANCE

State and community acceptance criteria will be assessed in the ROD following comment on the RI/FS Report and the proposed plan.

14.7. SUMMARY OF COMPARATIVE ANALYSIS

Table 14-1 summarizes the comparative analysis. The no action alternative (Alternative 1) would not be effective in protecting human health and the environment. Alternatives 2, 3 (A and B), 4 (A and B), and 5 (A and B) would be effective remedial alternatives for Parcel E-2. Alternatives 3 (A and B), 4 (A and B), and 5 (A and B) appear to be significantly more feasible, predictable, cost-effective, time-effective, and implementable remedies, when compared to Alternative 2. Alternatives 4 (A and B) and 5 (A and B) offers improved long-term effectiveness but has a higher cost relative to Alternative 3 (A and B). Alternative 5 (A and B) offers improved administrative implementability relative to Alternative 4 (A and B).

Figures

Remedial Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long Term Effectiveness and Permanence	Reduction through Treatment	Short Term Effectiveness	Implementability	Cost
	Threshold Criteria (Yes or No)		Balancing Criteria				
Alternative 1 – No Action No remedial action would be taken to remove solid waste, soil and sediment; groundwater and surface water would not be contained or treated Required by the NCP and is used as baseline against which other remedial actions are compared.	**Alternative 1 – No** Would not remove, contain, or treat solid waste, soil, sediment and groundwater contributing to human health and ecological risk Does not include institutional controls Does not provide any mechanisms for monitoring potential contaminant migration in landfill gas, surface water, or groundwater Would not meet all RAOs	**Alternative 1 – No** Because no action is proposed, this alternative does not comply with ARARs	**Alternative 1** Potential exposures to known areas of contamination would not be controlled Risk associated with exposure to solid waste, soil, sediment, landfill gas, and groundwater would not be reduced Existing control systems (landfill cap, gas control system, and stormwater BMPs) would not be maintained ***Performance: Low***	**Alternative 1** Would not reduce the toxicity, mobility, or volume of landfill solid waste, leachate, landfill gas, or soil exceeding evaluation criteria Shut down of operational gas control system may result in increases in toxicity, mobility, and volume ***Performance: Low***	**Alternative 1** Would not have an adverse short-term impacts because it would not involve remediation activities that might pose risks to the community, workers, or the environment ***Performance: High***	**Alternative 1** No resources are required to implement this alternative. No known administrative considerations would impact its overall implementability. ***Performance: High***	**Alternative 1** Total Capital Cost: No Cost Total O&M Cost: No Cost Total Periodic Cost: No Cost Period of Analysis: N/A Total Cost: No Cost Present Value: No Cost
Alternative 2 – Excavation and Disposal of Solid Waste, Soil, and Sediment (Including Monitoring and Institutional Controls) Excavation and off-site disposal of all solid waste, debris and soil in Landfill Area. Excavation and off-site disposal of: 1. Solid waste and soil from Panhandle and East Adjacent Areas 2. Sediment in Shoreline Area 3. Tier 1 though 5 hot spots in the Panhandle, East Adjacent, and Shoreline Areas Institutional Controls (legal and administrative mechanisms to enforce various land use restrictions) Site monitoring (groundwater and stormwater) Wetlands Restoration	**Alternative 2 – Yes** Would eliminate potential exposure of humans and wildlife to contaminated solid waste, soil, or sediment through direct contact or inhalation Would reduce or eliminate landfill gas generation and migration Would remove potential sources that could contaminate groundwater and surface water	**Alternative 2 – Yes** **Can meet all ARARs including:** Chemical-specific ARARs for groundwater and air Location-specific ARARs identified for the protection of coastal, wetlands, and biological resources Action-specific ARARs for excavation and disposal.	**Alternative 2** Solid waste, soil, and sediment posing unacceptable risk would be permanently removed Removal of contaminants would reduce residual concentrations of COCs in groundwater Institutional Controls would prohibit use of Parcel E-2 aquifers as a source of drinking water and require workers to protect themselves from exposure ***Performance: High***	**Alternative 2** Toxicity and mobility of contaminants in solid waste, soil, and sediment would be reduced Volume of contaminated A-aquifer groundwater would be reduced by extraction and treatment Toxicity of groundwater would likely be reduced due to excavation Would not reduce concentrations of hazardous substances in groundwater ***Performance: Moderate***	**Alternative 2** Risk to site workers and surrounding community Removal, storage, and treatment of contaminated solid waste, soil, sediment, and water would increase potential for spills ***Performance: Low***	**Alternative 2** Presence of subsurface debris would increase difficulty and cost of installing the sheet pile wall around the landfill need to minimize groundwater intrusion and improve excavation stability Without sheet pile wall, would be difficult to control intrusion of Bay water into excavation Screening of excavated materials prior to treatment and disposal would be time-consuming and costly ***Performance: Low***	**Alternative 2** Total Capital Cost: $343 million Total O&M Cost: $3.83 million Total Periodic Cost: $139 thousand Period of Analysis: 34 years Total Cost: $347 million Present Value: $332 million
Alternative 3 – Containment of Solid Waste, Soil, and Sediment with Hot Spot Removal (Including Monitoring and Institutional Controls) 1. Excavation and off-site disposal of radiological anomalies and Tier 1 and 2 hot spots in the Panhandle, East Adjacent, & Shoreline Areas 2. Excavation and on-site consolidation of soil in portions of the Panhandle Area planned for tidal wetlands restoration and sediment throughout the Shoreline Area Excavation followed by: 3. Containment of solid waste and soil in the Landfill Area with a multi-layer cap 4. Containment of solid waste, soil, and sediment in the adjacent areas with a geosynthetic cap 5. Active landfill gas active collection and treatment system: Flare (Alternative 3A) and GAC/KMnO4 (Alternative 3B) 6. Leachate collection/treatment and diversion of upgradient groundwater along the west side of the landfill 7. Institutional Controls (legal and administrative mechanisms to enforce various land use restrictions) 8. Site monitoring (groundwater, landfill gas, and stormwater) 9. Wetlands Restoration	**Alternative 3 – Yes** Would prevent humans and wildlife from direct contact, incidental ingestion, and inhalation of eroded waste particulates Landfill gas would be controlled, extracted, and treated Would prevent exposure to groundwater contamination through institutional controls Would prevent groundwater migration by reducing infiltration relative to existing conditions	**Alternative 3 – Yes** **Can meet all ARARs including:** Chemical-specific ARARs for groundwater and air Location-specific ARARs identified for the protection of coastal, wetlands, and biological resources Action-specific ARARs for landfill gas control, and monitoring of surface water, groundwater, and landfill gas. Action-specific ARARs for containing solid waste	**Alternative 3** Caps, gas control system, shoreline protection, groundwater diversion system, and subsurface drainage system, and stormwater BMPs would control potential exposure to contaminated solid waste, soil, and sediment; control landfill gas; reduce groundwater migration; and prevent off-site transport of contaminated soil via stormwater erosion. ***Performance: Moderate***	**Alternative 3** Mobility of contaminated media would be reduced by: 1) Containing solid waste, soil, and sediment 2) Controlling landfill gas migration 3) Limiting infiltration 4) Collecting potential contaminated groundwater and landfill leachate 5) Preventing off-site transport of contaminated soil via stormwater erosion Toxicity and volume of contaminated media would not be reduced. ***Performance: Moderate***	**Alternative 3** Risk of exposure to landfill contaminants or landfill gas would be low because disturbance of the landfill contents would be minimized Risk of contaminant release to the Bay during construction would be alleviated through engineering controls to restrict sediment transport ***Performance: Moderate to High***	**Alternative 3** Implementation along shoreline could be difficult due to depth of waste to be excavated Surface water controls would be required Deeper excavations in Panhandle Area may required dewatering and associated water management, disposal, or treatment. Also, construction of the slurry wall would require a deep trench to key the barrier into the Bay Mud aquitard; large debris and irregular subsurface voids may encountered during trenching – proper engineering techniques required Considered to be administratively implementable ***Performance: Moderate***	**Alternative 3** Alternative 3A: Total Capital Cost: $60.4 million Total O&M Cost: $23.7 million Total Periodic Cost: $675 thousand Period of Analysis: 32 years Total Cost: $84.7 million Present Value: $74.8 million Alternative 3B: Total Capital Cost: $60.1 million Total O&M Cost: $26.0 million Total Periodic Cost: $675 thousand Period of Analysis: 32 years Total Cost: $86.7 million Present Value: $76.0 million
Alternative 4 – Containment of Solid Waste, Soil, Sediment and Groundwater with Hot Spot Removal (Including Monitoring and Institutional Controls) *Same as Alternative 3 (above)* Also includes: 1. Expanded hot spot removal, with off-site disposal, of Tier 3 through 5 hot spots in the Panhandle, East Adjacent, and Shoreline Areas 2. Containment of contaminated groundwater in areas where landfill waste is within 100 feet of San Francisco Bay 3. Contingency to extend the groundwater containment structure south into the PCB Hot Spot	**Alternative 4 – Yes** *Same as Alternative 3 (above)* Would also reduce exposure risk through: 1) Expanded hot spot removal 2) Groundwater containment within 100 feet of the bay 3) Possible extension of groundwater containment structure into PCB hot spot	**Alternative 4 – Yes** **Can meet all ARARs including:** *Same as Alternative 3 (above)* Also, groundwater containment would provide further assurance that A-aquifer groundwater concentrations would not exceed the potential chemical-specific ARARs	**Alternative 4** *Same as Alternative 3 (above)* Also, long-term performance and permanence enhanced by: 1) Expanded hot spot removal 2) Groundwater containment within 100 feet of the bay 3) Possible extension of groundwater containment structure into PCB hot spot ***Performance: Moderate to High***	**Alternative 4** *Same as Alternative 3 (above)* ***Performance: Moderate***	**Alternative 4** *Same as Alternative 3 (above)* ***Performance: Moderate to High***	**Alternative4** *Same as Alternative 3 (above)* ***Performance: Moderate***	**Alternative 4** Alternative 4A: Total Capital Cost: $66.7 million Total O&M Cost: $23.7 million Total Periodic Cost: $675 thousand Period of Analysis: 32 years Total Cost: $91.1 million Present Value: $81.0 million Alternative 4B: Total Capital Cost: $66.5 million Total O&M Cost: $26.0 million Total Periodic Cost: $675 thousand Period of Analysis: 32 years Total Cost: $93.1 million Present Value: $82.2 million

Modifying Criteria
State and Community Acceptance
(Evaluated in the ROD after comment on the RI/FS and proposed plan)

Acronyms:

ARARs	Applicable or relevant and appropriate requirements
BMPs	Best management practices
COCs	Chemicals of concern
GAC	Granulated activated carbon
KMnO4	Potassium permanganate
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operation and maintenance
RAOs	Remedial action objectives
RI/FS	Remedial Investigation / Feasibility Study
ROD	Record of Decision

Note:
* Alternative 2 provided for completeness; this alternative does not meet the threshold criteria and is not required (by the NCP) to be compared against other alternatives

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 14-1
Comparative Analysis of Remedial Alternatives

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\Graphics\14-1_Remedial Alternative Comparison Flow Chart_All.vsd

Tables

Table 14-1. Comparative Analysis of Parcel E-2 Remedial Alternatives

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California

ALTERNATIVES	Overall Protection of Human Health and the Environment [a]	Compliance with ARARs [a]	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost ($ Million)	Overall Rating by Alternative
Alternative 1: No Action	No	No	○	○	●	●	$0	NA
Alternative 2: Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, ICs, and unlined freshwater wetlands)	Yes	Meets ARARs	●	◑	○	○	$351.5	○
Alternative 3: Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, ICs, and lined freshwater wetlands)	Yes	Meets ARARs	◑	◑	◕	◑	$77.7 (A) $78.4 (B)	◑
Alternative 4: Contain Solid Waste, Soil, Sediment and Groundwater with Hot Spot Removal (including monitoring, ICs, and lined freshwater wetlands)	Yes	Meets ARARs	◕	◑	◕	◑	$85.4 (A) $86.6 (B)	◕
Alternative 5: Contain Solid Waste, Soil, Sediment and Groundwater with Hot Spot Removal (including monitoring, ICs, and unlined freshwater wetlands)	Yes	Meets ARARs	◕	◑	◕	◕	$85.5 (A) $86.7 (B)	◕

Legend:

- ○ Low
- ◑ Moderate
- ◕ Moderate to High
- ● High

Notes:

a Overall protection of human health and the environment and compliance with ARARs are threshold criteria and alternatives are judged as either meeting or not meeting the criteria.

ARARs applicable or relevant and appropriate requirements
ICs institutional controls
NA not acceptable

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