Previous

BIOTA screening-level evaluation of risk to wetland receptors from maximum concentrations of radionuclides detected in soil.

Food Chain Evaluation

Table 7-32 presents the screening-level HQs for wetland avian receptors. The screening-level assessment showed HQs greater than one for nine metals (arsenic, cadmium, total chromium, copper, lead, nickel, selenium, vanadium, and zinc), total PCBs, total DDT, *alpha*-chlordane, *gamma*-chlordane, *cis*-nonachlor, and *trans*-nonachlor. These constituents were evaluated further in the BERA. There was a lack of effects data necessary to evaluate VOCs, thus the detected VOCs (MEK, acetone, chlorobenzene, cyclohexan, methly-*tert*-butyl ether, methylcyclohexan, and methylene chloride) were carried forward and evaluated in the BERA.

Screening-level HQs were less than one for three metals (barium, mercury, manganese), all SVOCs/PAHs, and PCDD/PCDF TEQs, thus these COPECs are not evaluated further in the wetland avian BERA.

Radionuclide Evaluation

Table 7-33 summarizes the results of the RESRAD-BIOTA screening-level evaluation of risk to wetland receptors from maximum concentrations of radionuclides detected in soil. Pb-210 was analyzed but was not detected in wetland soil samples. The sum of the ratios (maximum soil concentration/BCG) for the five radionuclides evaluated is 0.037. Because the sum of the ratios is less than one, radionuclides are not carried forward to the BERA for the wetland area.

Inhalation of Burrow Air

Inhalation TRVs are not available for avian receptors in the wetland area because soil gas data are not available for the wetland portion of the site. A quantitative evaluation of burrow air in the wetlands could therefore not be conducted; however, this evaluation was conducted in the landfill area of the site where VOC impacts in soil gas are likely worst-case scenario. The results of the evaluation of burrow air for the landfill area will indirectly provide useful information regarding the potential risk presented by this pathway at the site, including within the wetland area.

7.3.3.2.4 Wetland Mammals

Three wetland mammals were chosen as ingestion based exposure receptors. Potential risks to wetland mammals were evaluated through: (1) exposure to COPECs through the food chain; (2) external exposure to radioisotopes; and (3) exposure to VOCs in burrow air. Table 7-32 presents the screening-level HQs for the wetland mammalian receptors, and Appendix K-2 presents the detailed dose and HQ calculations for wetland mammals. Table 7-33 summarizes the results of the RESRAD-BIOTA screening-level evaluation of risk to wetland receptors from maximum concentrations of radionuclides detected in soil.

Food Chain Evaluation

Table 7-32 presents the screening-level HQs for wetland mammals. Screening-level HQs were greater than one for antimony, arsenic, cadmium, copper, lead, manganese, molybdenum, nickel, selenium, and zinc, with the largest HQ being 19.9 for the California vole for nickel. These metals were carried forward for further evaluation in BERA. There was a lack of effects data necessary to evaluate a number of VOCs; therefore, all detected VOCs were carried forward to the BERA.

Screening-level HQs were less than one for 7 metals (barium, beryllium, chromium, cobalt, mercury, thallium, vanadium), all SVOCs/PAHs, 2 VOCs, total PCBs, and for all pesticides other than dieldrin. These COPECs were not evaluated further in the wetland mammalian BERA.

Radionuclide Evaluation

Table 7-33 summarizes the results of the RESRAD-BIOTA screening-level evaluation of risk to wetland receptors from maximum concentrations of radionuclides detected in soil. Pb-210 was analyzed but was not detected in wetland soil samples. The sum of the ratios (maximum soil concentration/BCG) for the five radionuclides evaluated is 0.037. Because the sum of the ratios is less than one, radionuclides were not carried forward to the BERA for the wetland area.

Inhalation of Burrow Air

As previously discussed, soil gas data are not available for the wetland habitat; therefore, a quantitative evaluation of burrow air specifically in the wetland area was not conducted. Evaluation of this particular exposure pathway is performed in the landfill area, which represents a worst-case scenario at the site (see Section 7.3.3.1.4).

7.3.3.3 Wetland Ponds

The screening-level evaluation for the wetland pond habitat includes an assessment of risk to benthic invertebrates, fish and water column invertebrates, and aquatic feeding birds and mammals. The constituents that were not detected in North or South Pond sediments include molybdenum, hexavalent chromium, 38 of 68 SVOCs/PAHs, 47 of 52 VOCs, and 13 pesticides. These constituents are therefore not considered as COPECs for benthic invertebrates, birds or mammals, and are not evaluated in the screening-level assessment. The constituents that were not detected in North or South Pond surface waters include 11 metals, 37 SVOCs/PAHs, 46 VOCs, total PCBs, and all pesticides in North Pond (total PCBs and *gamma*-chlordane were detected in the South Pond). The constituents that were not detected in surface water are not considered COPECs for fish, and were not evaluated in the screening-level assessment.

7.3.3.3.1 Benthic Invertebrates

Table 7-34 presents the EPCs, benchmarks, and hazard quotients where available for constituents detected in pond sediments. Those constituents that could not be evaluated due to the lack of a benchmark include 11 metals, 12 SVOCs, 5 VOCs, and 6 pesticides, so they were carried forward for evaluation in the BERA.

In the North Pond, cadmium, chromium, copper, lead, nickel, silver, and zinc all had screening-level HQs >1. Mercury exceeds one by the greatest margin (HQ=32.93). HQs exceeded one in South Pond sediments for cadmium, copper, mercury, and nickel. Of all the SVOCs measured in both ponds, acenaphthene was the only constituent with a HQ greater than one. Total PCBs, DDT and its metabolites, and chlordane also were detected in both ponds and have screening-level HQs greater than one. These constituents were evaluated further in the BERA.

COPECs with screening-level HQs less than one in the North Pond include antimony, arsenic, 2-methylnaphthalene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, *bis*(2-ethylhexyl)-phthalate, butyl benzyl phthalate, chrysene, dibenz(a,h)anthracene, di-*n*-buytl phthalate, fluoranthene, fluorine, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, phenol, pyrene, 4,4'-DDT, *alpha*-chlordane, and total DDTs. These COPECs were not evaluated further in the BERA.

COPECs with screening-level HQs less than one in the South Pond, and therefore not evaluated further in the BERA include antimony, arsenic, chromium, lead, silver, zinc, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, *bis*(2-ethyllhexyl)phthalate, butyl benzyl phthalate, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorine, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, phenol, and pyrene.

Table 7-35 summarizes the results of the RESRAD-BIOTA screening-level evaluation of risk to wetland pond receptors from maximum concentrations of radionuclides detected in surface water and sediment. Although Pb-210 was detected in pond surface water and sediment samples, it is not included in the RESRAD-BIOTA calculator and could not be included in the risk evaluation.

7.3.3.3.2 Aquatic Invertebrates and Fish

Table 7-36 presents the EPCs, benchmarks, and hazard quotients where available for constituents detected in wetland pond surface water. Those chemicals that were detected but could not be evaluated due to the lack of a benchmark include 7 metals, 12 SVOCs/PAHs, and 7 VOCs. No hazard quotients exceeded one for any of the constituents measured in the North Pond. Only nickel, total PCBs, and *gamma*-chlordane exceeded one in South Pond surface waters, so these chemicals were evaluated further in the BERA.

Table 7-35 summarizes the results of the RESRAD-BIOTA screening-level evaluation of risk to wetland pond receptors from maximum concentrations of radionuclides detected in surface water and sediment. U-235 was not detected in surface water samples, and Ra-228 was not detected in sediment samples. Therefore, these radionuclides were not included in the risk evaluation for exposure to these media. The sum of the surface water ratios (maximum surface water concentration/BCG) for exposure of aquatic and riparian receptors to the five radionuclides evaluated is 0.566. The sum of the sediment ratios (maximum sediment concentration/BCG) for exposure of aquatic and riparian receptors to the five radionuclides evaluated is 0.005. The sum of all of the ratios is below one at 0.572; therefore, radionuclides were not carried forward to the BERA for the wetland pond area.

7.3.3.3.3 Wetland Pond Birds

Three wetland pond birds were chosen as ingestion based exposure receptors. Potential risks to wetland pond birds were evaluated through: (1) exposure to COPECs through the food chain; and (2) external exposure to radioisotopes.

Food Chain Evaluation

Table 7-37 presents the screening-level HQs for wetland pond avian receptors. The screening-level assessment showed HQs greater than one for nine metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, vanadium, and zinc), *cis*-nonachlor, and *trans*-nonachlor. Therefore, these constituents were evaluated further in the BERA. There was a lack of effects data necessary to quantitatively evaluate 5 VOCs that were detected in surface water and sediment, so they were carried forward for further evaluation in the BERA.

Radionuclide Evaluation

Table 7-35 summarizes the results of the RESRAD-BIOTA screening-level evaluation of risk to wetland pond receptors from maximum concentrations of radionuclides detected in surface water and sediment. As mentioned in the previous section, the sum of all of the ratios is below one at 0.572; therefore, radionuclides were not carried forward to the BERA for the wetland pond area.

7.3.3.3.4 *Wetland Pond Mammals*

The raccoon was the only wetland pond mammal chosen as an ingestion-based exposure receptor for the wetland pond area. Potential risks to the raccoon were evaluated through: (1) exposure to COPECs through the food chain; and (2) external exposure to radioisotopes. Table 7-37 presents the screening-level HQs for the wetland pond mammalian receptor.

Food Chain Evaluation

There were no HQs greater than one for the raccoon in the screening-level assessment, so no COPECs (other than COPECs that are carried forward due to a lack of benchmarks or exposure inputs) were carried forward to the BERA for wetland pond mammals.

Radionuclide Evaluation

Table 7-35 summarizes the results of the RESRAD-BIOTA screening-level evaluation of risk to wetland pond receptors from maximum concentrations of radionuclides detected in surface water and sediment. As mentioned in the previous section, the sum of all of the ratios is below one at 0.572; therefore, radionuclides are not carried forward to the BERA for the wetland pond area.

7.4 Baseline Assessment

The BERA provides additional evaluation of COPEC-receptor combinations that are carried through based on the results of the screening-level assessment (i.e., where screening-level exposure estimates exceed conservative ecological effects thresholds or could not be evaluated due to the lack of exposure and/or effects inputs). The baseline assessment incorporates, where available, more realistic and site-specific exposure assumptions (e.g., adjusted site-use factors and 95% UCL concentrations for EPC estimates), site-specific measures of effect (i.e., site-specific toxicity assays), and additional ecological effects thresholds (e.g., low effect as opposed to no effect benchmarks or TRVs) to provide more realistic risk estimates. In the BERA, risk results are presented in the context of identified uncertainty, and background or ambient exposure to develop recommendations regarding potential risk drivers that should be considered in a risk management context. The components of the baseline risk characterization are presented in the following sections and include:

1. Revised Problem Formulation
2. Revised Exposure Assessment
3. Revised Effects Assessment
4. Baseline Risk Estimates
5. Uncertainty Analysis
6. Risk Conclusions and Recommendations.

7.4.1 Revised Problem Formulation

The refinement of the problem formulation is based primarily on the results of the screening-level assessment. Receptor-COPEC combinations with screening-level conservative exposure estimates that fall below conservative screening-level effects criteria (i.e., HQs <1) can be removed from further consideration as part of this refinement. As summarized in Section 7.3.3 (Screening-Level Risk Estimates), a number of constituents were removed from consideration in the BERA. However, with the exception of mammals exposed to wetland ponds sediment and associated biota (see Section 7.3.3.3.4), no receptors were removed from consideration in the baseline assessment. It is recognized that a number of COPECs could not be evaluated in the screening-level assessment due to a lack of exposure and/or effects inputs. These COPECs are not excluded from further evaluation in the BERA, but due to a lack of the same required inputs, these COPECs are not quantitatively evaluated in the BERA.

7.4.2 Revised Exposure Assessment

The revised exposure assessment incorporates more realistic receptor site use, and EPC assumptions resulting in conservative, yet more realistic exposure estimates. Other than the two SUFs discussed in Section 7.4.2.1, the baseline exposure assessment incorporates the same exposure factors for the representative receptors as were used in the screening-level assessment, including approaches used to model tissue EPC inputs to the food web model.

7.4.2.1 Incorporation of Site-Specific SUFs

Most of the selected representative receptors have small foraging ranges relative to the size of the site, and an SUF of 1 was used for the BERA. The receptors that may have foraging ranges larger than the site area include the raccoon, the red fox, the mallard, and the northern harrier. Because the site is surrounded by the bay and former runways, it was assumed that the mammals would not be able to forage off-site, so an SUF of 1 was used for the raccoon and red fox in the BERA. The mallard and the northern harrier could fly to areas off-site to forage. The baseline SUF for the mallard is 0.14 (unitless), based on a wetland pond area of 33 acres and a foraging area of 230 acres for the mallard (Table 7-14). For the northern harrier, the baseline SUF for the upland assessment was 0.23, based on the upland area of 77 acres and a foraging range of 335 acres (Table 7-2). Comparing the 335-acre foraging range to the wetland area of 33 acres results in a baseline SUF of 0.10 for the wetland assessment (Table 7-9).

7.4.2.2 Use of 95% UCL Concentrations for EPCs

U.S. EPA recommends using the average concentration to represent "a reasonable estimate of the concentration likely to be contacted over time" (U.S. EPA, 1989a) and "because of the uncertainty associated with estimating the true average concentration at a site" recommends that the 95 percent UCL be used. U.S. EPA guidance for EPC calculations, *Calculating Exposure Point Concentrations at Hazardous Waste Sites* (U.S. EPA, 2002) plus recommendations in the associated software program ProUCL, developed for U.S. EPA by Lockheed Martin (U.S. EPA, 2004), were followed to calculate 95% UCLs for use as EPCs in the BERA. The lesser of the 95% UCL and the maximum detected concentration was used in the baseline assessment for evaluation of effects from direct contact, from exposure through the food web and from inhalation. Baseline EPCs are presented in the following tables:

- Upland baseline soil EPCs for direct contact endpoints are presented in Tables K-1 and K-2 in Appendix K-1.
- Receptor-specific baseline daily dose estimates for upland receptors are provided on Table 7-38.
- Wetland soil EPCs for direct contact endpoints are presented in Tables K-3 and K-4 in Appendix K-1.
- Receptor-specific baseline daily dose estimates for wetland receptors are provided on Table 7-39.
- Exposure by direct contact was assessed separately for North Pond and South Pond in the BERA. Wetland pond sediment and surface water EPCs for direct contact endpoints are presented in Tables K-5 through K-8.

- Receptor-specific baseline daily dose estimates for Wetland Pond receptors are provided on Table 7-40.
- Background or ambient exposure estimates are provided in receptor-specific dose calculations sheets presented in Appendix K-2. All exposure inputs were used to develop background or ambient exposure estimates.

7.4.3 Revised Effects Assessment

The revised effects assessment incorporates site-specific measures of effect (i.e., site-specific bioassay data) and "high" benchmarks and TRVs. The incorporation of these new elements of the effects assessment provides useful data to aid in the interpretation of screening-level benchmark exceedances for wetland pond media, and to provide a range of risk estimates for food web endpoints. Site-specific bioassay data and alternative benchmarks are discussed in the following sections.

7.4.3.1 Incorporation of Site-Specific Bioassay Data

A screening-level evaluation of wetland pond sediment and surface water indicated that there may be adverse effects to sediment-dwelling animals (benthic invertebrates), water column invertebrates, and fish. To refine the understanding of potential toxicity to these receptors, site-specific toxicity testing was performed on sediment and surface water samples collected from IR Site 2, the CCSP reference area, and appropriate control locations to assess the potential for acute and chronic exposure to site-related COPECs. To evaluate the potential for exposure of benthic invertebrates to sediment-associated COPECs, solid-phase sediment bioassay laboratory exposures using the amphipod *Eohaustorius estuarius* were conducted. To evaluate the potential exposure of water column invertebrates to surface water-associated COPECs, acute and chronic laboratory bioassay exposures were conducted with the mysid shrimp *Americamysis bahia*. To evaluate the potential exposure of fish to surface water-associated COPECs, acute and chronic laboratory bioassay exposures were conducted with the topsmelt fish *Atherinops affinis*. A lack of observed toxicity in these bioassays (as indicated by a greater than ambient or reference toxicity response) indicates a lack of exposure to potentially toxic site-related COPECs at a level greater than ambient or reference exposure. The results of these bioassays, which indicate a lack of exposure to site COPECs at toxic levels, are presented in Section 7.4.4.3 as part of the risk characterization for the Wetland Ponds.

7.4.3.2 Inclusion of "High" Benchmarks for Soil, Sediment, and Water

The benchmarks used in the baseline assessment are based on the same combination of published sources discussed in Section 7.3.2.1, and were selected using the same order of priority. The BERA, however, includes both the low benchmarks presented in the screening assessment, and high benchmarks where available to better define the range of effects. Whereas low benchmarks generally represent COPEC concentrations below which effects are not expected, high benchmarks generally represent COPEC concentrations above which effects are expected. The likelihood of effects occurring at COPEC concentrations that fall between the low and the high benchmark, as well as the true threshold for effects for a given COPEC-receptor pair, generally is not known. A summary of available high benchmarks and sources are provided below:

Upland and Wetland Plants

- The Eco-SSLs and Efroymson (1996) only provided screening-level benchmarks which were discussed in Section 7.3.2.1. These sources do not provide a high benchmark for better evaluating the magnitude of effects in the BERA.

- High benchmarks are available for PAHs based on the plant studies reported in the CCME soil quality guidelines documents (CCME, 1999). The selected high benchmark value for the LPAHs (using naphthalene as the surrogate) is the highest reported EC25 for naphthalene effects to plants via direct soil contact (radish seed emergence; CCME, 1999). As mentioned in Section 7.3.2.1, a range of EC25 values were reported based on the CCME literature search. The selected low benchmark value is the lowest EC25, and the selected high benchmark is the highest EC25 reported. Similarly, the high benchmark for HPAHs (using benzo(a)pyrene as surrogate) is the highest NOEC concentration reported for plant (i.e., rye) exposures to benzo(a)pyrene. Both a low NOEC and a high NOEC were reported via CCME's literature search, and they were selected as the low and high benchmarks.

Upland and Wetland Invertebrates

- High benchmarks are only available for PAHs from Sverdrup (2001); the high value is based on the LC50 value for springtails (*Collembola*).

Benthic Invertebrates:

- NOAA's ER-Ms were used where available as a high benchmark. ER-Ms are the median concentration at which effects where observed. In cases where an ER-M was not available, marine PELs were used (MacDonald et al., 1994). The PEL represents the lower limit of the range of contaminant concentrations that are usually or always associated with biological effects. In cases where neither a ER-M nor a PEL were available, AET-H values were used.

Aquatic Invertebrates:

- Acute marine values were used as high benchmarks from the California Toxics Rule (2000b) and the U.S. EPA's AWQC (2002). In cases where state or federal values were not available, marine acute values presented in NOAA's SQuiRT tables were used as high benchmarks.

7.4.3.3 Inclusion of "High" TRVs

The BERA includes both the low TRVs presented in the screening assessment, and high TRVs where available to better define the range of potential risk. Similar to direct contact benchmarks discussed in Section 7.4.3.2, low TRVs generally represent COPEC levels (represented as a daily dose) below which effects are not expected, and high TRVs generally represent COPEC levels (also in the form of an estimated daily dose) above which effects are expected. The likelihood of effects occurring at estimated daily doses that fall between the low and the high TRVs, as well as the true threshold for effects for a given COPEC-receptor pair, generally is not known.

Low and high TRVs (NOAELs and LOAELs, respectively) selected for evaluation of risk through the food web exposure pathway were discussed in Section 7.3.2.1 and are presented in Table 7-24. Only low TRVs were used in the screening-level risk evaluation. In the BERA evaluation, doses calculated using baseline assumptions were compared to the low and high TRVs. There are a few COPECs for which only low TRVs are available (Table 7-24). For avian receptors, a high TRV is not available for *bis*(2-ethylhexyl) phthalate. For mammalian receptors, high TRVs are not available for anthracene, diethyl phthalate, 1,1,1-TCA, 1,2-DCA, and 4-methyl-2-pentanone (MIBK).

7.4.4 Baseline Risk Estimates

This section presents the findings of the baseline risk estimates for upland (Section 7.4.4.1), wetland (Section 7.4.4.2), and wetland pond (Section 7.4.4.3) habitats. Key ERA uncertainties, and conclusions and recommendations that consider ambient or background risk and exposure, are presented in Sections 7.4.5 and 7.4.6, respectively.

7.4.4.1 Upland

This section presents the baseline risk characterization findings for upland plants, invertebrates, birds, and mammals.

7.4.4.1.1 Upland Plants

Table 7-41 presents the results of the baseline evaluation of risk to upland plants. The chemicals considered in the BERA include those detected chemicals that lacked benchmarks, or whose HQ exceeded one indicating potential risk under the conservative screening-level scenario. COPECs that could not be quantitatively assessed in the screening-level assessment due to a lack of screening-level benchmarks, also could not be evaluated in the baseline assessment. Low benchmark HQs were greater than one for ten metals (antimony, chromium, copper, lead, mercury, molybdenum, nickel, silver, vanadium, and zinc) and PAHs (acenaphthene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, LPAHs and HPAHs). High benchmarks for plants are not available so high benchmark HQs could not be calculated.

7.4.4.1.2 Terrestrial Invertebrates

Table 7-42 presents the results of the baseline evaluation of risk to upland invertebrates. Information is presented to indicate those detected constituents for which no benchmarks were available and for those whose HQs exceeded one in the screening assessment, indicating the need for further evaluation with more realistic EPCs and both a low and a high benchmark. The baseline assessment found that the low HQs for three metals (chromium, copper, and mercury) exceeded one.

7.4.4.1.3 Upland Birds

Table 7-43 presents a summary of baseline results for the western meadowlark, the burrowing owl, and the northern harrier.

The western meadowlark was selected as the representative receptor for omnivorous birds. Baseline low benchmark HQs were greater than 1 for 8 metals (cadmium, copper, chromium, lead, mercury, nickel, vanadium, and zinc), total PCBs, and total DDT. The highest low benchmark HQ for the western meadowlark was for lead (HQ = 297). High benchmark HQs exceeded one for chromium only.

The burrowing owl was selected as the representative receptor for burrowing birds. The low benchmark HQs were greater than one for 7 metals (cadmium, chromium, copper, lead, nickel, vanadium, and zinc), total PCBs, and total DDT. The highest low benchmark HQ was for lead (HQ = 165). With the exception of total DDT, no high benchmark HQs exceeded one.

The northern harrier was selected as the representative receptor for carnivorous birds. Low benchmark HQs were greater than one for lead, and total DDT. No high benchmark HQs were greater than one.

7.4.4.1.4 Upland Mammals

Table 7-43 presents a summary of baseline results for the California vole, the raccoon, and the red fox.

The California vole was selected as the representative receptor for herbivorous mammals. The low benchmark HQs were greater than one for cadmium, manganese, molybdenum, nickel, and zinc. No COPECs had high benchmark HQs greater than one.

The California vole also was selected as the representative receptor for burrowing mammals. Only naphthalene was carried forward and evaluated in the baseline scenario for exposure of burrowing mammals to VOCs in burrow air. The baseline EPC for naphthalene was defined using ProUCL (U.S. EPA, 2004) to calculate a 95% UCL from the available soil gas data. Naphthalene was detected in 34 of 34 soil gas samples collected from the site between March 2003 and March 2005. The concentrations fit a gamma distribution, and the ProUCL recommended 95% UCL was the adjusted gamma UCL (527.5 ppbv, which is equal to 2.8 mg/m^3). The baseline high benchmark HQ was calculated by dividing the 95% UCL by the high TRV, and the result is 0.23 (2.8 mg/m^3/12 mg/m^3). The baseline low benchmark HQ was calculated by dividing the 95% UCL by the low TRV, and the result is 2.42 (2.8 mg/m^3/1.2 mg/m^3).

The raccoon was selected as the representative receptor for omnivorous mammals. Low benchmark HQs were greater than one for cadmium and nickel. No COPECs had high benchmark HQs greater than one.

The Red fox was selected as the representative receptor for carnivorous mammals. Low benchmark HQs were greater than one for cadmium, nickel, zinc, and dieldrin. The highest low benchmark HQ was for nickel (HQ = 9). No high benchmark HQs were greater than one.

7.4.4.2 Wetland

This section presents the baseline risk characterization findings for wetland plants, invertebrates, birds and mammals.

7.4.4.2.1 Wetland Plants

Table 7-44 presents a summary of BERA results for wetland plants. Information is presented regarding those COPECs whose HQs exceeded one in the screening assessment, as well as COPECs for which no benchmarks were available and could not be quantitatively evaluated in the screening-level or the BERA. Low HQs for six metals (chromium, cobalt, mercury, nickel, vanadium, and zinc) exceeded one. The low HQ for chromium was greater than 100. High benchmarks for plants are not available so high benchmark HQs could not be calculated.

7.4.4.2.2 Wetland Invertebrates

Table 7-45 presents a summary of BERA results for wetland invertebrates. Low HQs for were greater than one for three metals (chromium, copper, and mercury).

7.4.4.2.3 Wetland Birds

Table 7-46 presents a summary of baseline results for the Alameda song sparrow, the least sandpiper, the burrowing owl, and the northern harrier.

The Alameda song sparrow was selected as the representative receptor for omnivorous birds. Low benchmark HQs were greater than one for arsenic, cadmium, copper, lead, nickel, vanadium, zinc, total PCBs, *alpha*-chlordane, *gamma*-chlordane, *cis*-nonachlor, and *trans*-nonachlor. The highest low benchmark HQ was for lead (HQ = 203). Vanadium was the only COPEC with a high benchmark HQ greater than one (HQ = 1.1).

The least sandpiper was selected as the representative receptor for benthic-feeding birds. Low benchmark HQs were greater than one for arsenic, cadmium, chromium, copper, lead, nickel, selenium, vanadium, zinc, *bis*(2-ethylhexyl) phthalate , total PCBs, total DDT, *alpha*-chlordane, *gamma*-chlordane, *cis*-nonachlor, and *trans*-nonachlor. The highest low benchmark HQ was for lead (HQ = 459). Vanadium is the only constituent which had a high benchmark HQ greater than one (HQ = 2.5).

The burrowing owl was selected as the representative receptor for burrowing birds. Low benchmark HQs were greater than one for copper, lead, nickel, vanadium, zinc, and total DDT. The highest low benchmark HQ was for lead (HQ = 148). Only vanadium had a high benchmark greater than one (HQ = 1.1).

The northern harrier was selected as the representative receptor for carnivorous birds. The only low benchmark HQs greater than one was for lead (HQ = 9). There were no COPECs with HQs greater than one for the high benchmark scenario.

7.4.4.2.4 Wetland Mammals

Table 7-46 presents a summary of BERA results for the California vole, the raccoon, and the red fox.

The California vole was selected as the representative receptor for herbivorous mammals. The low benchmark HQs were greater than one for cadmium, copper, manganese, molybdenum, nickel, and selenium. The highest low benchmark HQ was for nickel (HQ = 13.7). No COPECs had high benchmark HQs greater than one.

The raccoon was selected as the representative receptor for omnivorous mammals. Low benchmark HQs were greater than one for nickel only (HQ = 2.8). No COPECs had high benchmark HQs greater than one.

The red fox was selected as the representative receptor for carnivorous mammals. Low benchmark HQs were greater than one nickel, zinc, and dieldrin. The highest low benchmark HQ was for nickel (HQ = 5). No compounds had HQs greater than one for the high benchmark scenario.

7.4.4.3 Wetland Ponds

This section presents the baseline risk characterization findings for wetland pond receptors including benthic invertebrates, water column invertebrates, fish, birds, and mammals.

7.4.4.3.1 Benthic Invertebrates

Tables 7-47 and 7-48 present the results of the baseline direct contact toxicity assessment for benthic invertebrates. In the North Pond low HQs exceeded one for 7 metals (cadmium, chromium, copper, lead, mercury, nickel, and zinc), total PCBs, *gamma*-chlordane, dieldrin, total DDD, total DDE, and total DDT. In the South Pond, low HQs exceeded one for 3 metals (cadmium, mercury, and nickel), total PCBs, *gamma*-chlordane, total DDD, total DDE, total DDT, and total DDT.

The results from MEs consisting of comparisons of site-associated concentrations of COPECs to generic, non-site-specific measures of effect (i.e., sediment benchmarks) need to be considered in the context of site-specific toxicity data, when available. Benchmarks are used to conduct a generic, conservative, and predictive assessment, whereas site-specific bioassays provide a more meaningful measure of current conditions with respect to toxicity and risk for the receptor group being evaluated.

To provide for a site-specific evaluation of exposure and associated potential toxicity to benthic invertebrates in the North and South Pond, a 10-day solid-phase acute toxicity bioassay was conducted using the amphipod *E. estuarius*. The 10-day test protocol generally followed American Society of Testing and Materials Method 1367-99 (ASTM, 1999). The acute toxicity testing endpoint was survival at the end of the 10-day exposure, and mean survival in samples was compared with the San Francisco Bay reference envelope tolerance limit (see Appendix C for descriptive statistics of the survival data including the mean, standard deviation, and coefficient of variation for each station). A sample was considered toxic if the mean survival was less than 69.5% of the survival observed in a valid control exposure (SWRCB, 1998). If the mean survival at all stations was greater than the San Francisco Bay reference envelope tolerance limit of 69.5% (SWRCB, 1998), statistical analysis was not conducted. Survival in control sediment exposures was 100%, validating the test (a complete summary of test organism survival by sample and replicate can be found in Appendix C, Table B-1), and survival in the reference toxicant treatments indicated appropriate test organism sensitivity (Appendix C, Table C-1).

E. estuarius survival in most stations exceeded 85%, which is considered nontoxic based on comparisons to tolerance limits presented in SWRCB (1998). The exception to this was a mean survival of 68% observed for sample SED16. Mean survival at this station was influenced by 0% survival observed in one of the five sample replicates (Replicate 4). No animals were found in Replicate 4 of the SED16 sample at test termination, and it is likely that this replicate was not initiated (i.e., amphipods were never added to the test chamber) and potentially represents invalid data for this single replicate. Another possible explanation for the Replicate 4 results at station SED16 is elevated salinity. With the exception of SED16, water quality parameters (temperature, salinity, dissolved oxygen, and pH) generally remained within specified testing ranges during the test. However, salinity levels associated with SED16, the station exhibiting the highest porewater salinity upon arrival at the bioassay laboratory remained elevated throughout the course of the toxicity testing (a summary of water quality measurements gathered in support of this testing is presented in Appendix C, Table A-1). Removing this one replicate from the mean calculation for SED16 raises the mean survival for SED16 to 85%, which is a nontoxic response. Thus, sediment samples from the South and North Ponds at IR Site 2 are considered nontoxic. These results do not indicate risk to benthic invertebrates exposed to COPECs in sediments in the North and South Ponds.

Historic toxicity test results also are available from tests conducted on sediments collected from the wetlands in 1993 and 1994 (see PRC and Tetra Tech Inc., 1992a, 1992b). Solid-phase toxicity tests were conducted on sediments from seven locations (W1, W2, W3, W4, and W5 in the North Pond, and stations W6 and W7 in the South Pond). See Section 3.1.11.2.5 of this RI Report for a general description of these historical toxicity tests. Survival and reburial of the amphipod *E. estuarius* and growth of the polychaete worm *N. arenaceodentata* were measured in five replicate tests conducted on surface sediments from each of the seven sampling locations. Results of the *E. estuarius* bioassay indicated mortality exceeding the San Francisco Bay reference envelope at three of the seven locations: two locations in the northern pond and one location in the southern pond. Results of the *N. arenaceodentata* bioassay show that growth was not different from the reference envelope UTL at any of the sampling stations. *N. arenaceodentata* mortality was not significantly different from laboratory controls at any sampling location.

The results of the *E. estuarius* bioassay are inconsistent with the complete lack of toxicity observed in the *N. arenaceodentata* bioassays, and the more recent bioassays conducted which controlled for potential confounding factors and indicated no toxicity. These results, taken together, indicate that it is unlikely that the *E. estuarius* survival results are entirely due to contaminants in pond sediment or water. These bioassays were conducted as part of a larger effort to assess sediment toxicity at areas offshore of Alameda Point, including the areas immediately offshore of IR Site 2. Laboratory bench sheets or other documentation detailing handling protocols for the organisms used in the wetland bioassays were not available for this RI Report, so it is unknown whether results may have been confounded by other factors.

The bioassays conducted in 2005 to support this ERA controlled for confounding factors and did not indicate toxicity due to COPECs in sediment given current conditions. To the degree that the more recent bioassays are representative of conditions in the ponds at the time the historic bioassays were conducted, the more recent bioassays additionally indicate a lack of historic toxicity, and provide evidence that toxicity observed in historic bioassays may not have been caused by site-related COPECs. Overall, bioassay data from 2005 indicate a lack of current toxicity, and therefore a lack of unacceptable risk to benthic invertebrates in the North and South Ponds.

7.4.4.3.2 Water Column Invertebrates and Fish

State and federal water quality criteria are derived to be generally protective of aquatic life (i.e., invertebrates and invertebrates), and are therefore approapriate for use as benchmarks to assess AEs for both invertebrates and fish. The results of the benchmark comparisons are presented in the following section, as are risk findings for each receptor group. The overall risk findings consider the benchmark comparisons, but also which incorporate more relevant site-specific bioassay results.

Tables 7-49 and 7-50 present the baseline results for aquatic biota. All of the HQs calculated in the screening assessment for North Pond aquatic biota were below one. As a result, the only chemicals carried forward to the baseline assessment are those that lack benchmarks. These constituents cannot be quantitatively evaluated and therefore will be discussed in the uncertainty section.

The baseline assessment of potential risk associated with South Pond aquatic biota having direct contact with these chemicals found that the low HQs for nickel, total PCBs, and *gamma*-chlordane exceeded one.

Results from MEs consisting of comparisons of site-associated concentrations of COPECs to generic, non-site specific measures of effect (i.e., sediment benchmarks) need to be considered in the context of site-specific toxicity data, when available. Benchmarks are used to conduct a generic, conservative, and predictive assessment, whereas site-specific bioassays provide a more meaningful measure of current conditions with respect to toxicity and risk to the receptor group being evaluated. The results of site-specific bioassay results conducted to provide for a site-specific evaluation of exposure and associated potential toxicity to aquatic invertebrates and fish in the North and South Pond are discussed in the following risk characterization sections.

Aquatic Invertebrates

To provide for a site-specific evaluation of exposure and associated potential toxicity to water column invertebrates in the North and South Pond, juvenile mysid shrimp (*A. bahia*) were exposed for seven days to a dilution series of pond water corrected to test-specific salinity. This test produced both acute (survival) and chronic (growth) toxicity endpoints. Test initiation and monitoring procedures generally followed the guidance presented in U.S. EPA (1991a) guidance. At the end of the seven-day exposure period, the test was terminated by gently removing the surviving organisms with a small pipette and transferring them to small glass bowls for counting. A nonparametric Kruskal-Wallis test was used to compare the median survival for a given station to determine whether there were significant differences ($\alpha<0.05$) among stations (including reference stations), ignoring water concentration. The LC50 for survival and EC50 for growth cannot be calculated when survival is greater than 50% for all concentrations and reduction in growth compared to the control is less than 50%.

Summary information for the seven-day acute and chronic toxicity testing using *A. bahia* is presented in Appendix C, Table 3-2. A summary of water quality measurements conducted in support of this test (including reference toxicant exposures) is presented in Appendix C, Table A-2. Dissolved oxygen and pH levels remained within specified testing ranges during the tests, but temperatures generally fell below the target testing range for at least one day of the seven-day exposure. Salinity fell below the target range on at least one day for sample SWA05, and maximum recorded salinities in all treatments were slightly above the upper limit of 32‰, probably due to evaporation of water during the course of the tests. Mean survival and growth for control surface water samples were 98.2% and 0.23 mg, respectively. Both measures exceed test-specific control performance (i.e., average survival ≥80% and average organism growth ≥0.20 mg at test termination), thereby validating the test. Survival in the reference toxicant treatments indicated appropriate test organism sensitivity (Appendix C, Table C-3).

Survival in the 100% nominal concentration for the seven-day acute toxicity testing using *A. bahia* was greater than or equal to 90% for all stations (Appendix C, Table B-2). This survival was considered equivalent to that allowed in the control (≥80%) and the dose-response was not modeled. The Kruskal-Wallis nonparametric test failed to detect any statistically significant differences in median survival between stations ignoring the water concentration ($p = 0.82$).

Growth results for *A. bahia* testing displayed greater variability than survival (Appendix C, Figure 3-2), with mean organism weights ranging from 0.20 mg for the brine control sample exposure to 0.42 mg for the sample SWA02 exposure. The Kruskal-Wallis nonparametric test found significant differences among stations ($p<0.05$), with the brine control sample producing the lowest growth. Simple linear regression of water concentration versus growth was significant ($p<0.05$) for only five samples (SWA03, SWA04, SWA10, SWA12, and SWA14). All water samples with significant regressions also exhibited positive slopes, meaning that higher surface water concentrations actually had a beneficial effect on growth. An EC50 value for growth could not be calculated because none of the waters tested reduced growth below that of the control sample. As a result, EC50 values were estimated to be higher than the highest water concentration tested for each water sample tested (Appendix C, Table 3-2). Because of high survival and growth, it was not possible to calculate LC50 and EC50 estimates for these endpoints. Thus, none of the surface water samples from either the North or South Ponds of IR Site 2 exhibited acute or chronic toxicity compared with water samples from CCSP.

Fish

To provide for a site-specific evaluation of exposure and associated potential toxicity to fish in the North and South Pond, topsmelt (*A. affinis*) were exposed for seven days to a dilution series of pond water corrected to test-specific salinity. Test initiation and monitoring procedures generally followed U.S. EPA (1995) guidance. At the end of the seven-day exposure period, the test was terminated by gently removing and counting the surviving organisms. Temperature and dissolved oxygen generally remained within specified testing ranges, but the upper limit for salinity was exceeded for most samples on at least one test day. The upper or lower limits for pH were exceeded in 5 of 17 samples (Appendix C, Table A-3). Fluctuations in water quality did not affect test organism survival because overall survival for all samples and dilutions exceeded 90% (Appendix C, Table B-4). Mean survival and mean individual growth for the control sample were 90% and 1.01 mg, respectively, at test termination. Both measures exceeded test-specific control performance criteria (average survival ≥80% and average per-individual growth ≥0.85 mg at test termination), thereby validating the tests. Survival in the reference toxicant treatment is presented in Appendix C, Table C-3. The LC50 for copper was <205 μg/L and is considered acceptable by U.S. EPA (1995). A summary of water quality measurements conducted in support of the seven-day acute and chronic toxicity testing using *A. affinis* (including reference toxicant exposures) is presented in Appendix C, Table A-3.

For the seven-day acute and chronic testing using *A. affinis*, there was one replicate of each of eight water concentrations for a given station. If survival at the 100% nominal concentration was greater than or equal to 80%, then any mortality was considered equivalent to the acceptance limit allowed in the control (≥80% survival). Variable survival or growth not reflective of a standard dose-response across water concentrations was considered noise. Thus, descriptive statistics including the mean, standard deviation, and coefficient of variation were calculated for each station averaging over all concentrations (i.e., ignoring concentration). A nonparametric Kruskal-Wallis test was used to compare the median survival for a given station to determine whether there were significant differences ($\alpha<0.05$) among stations ignoring water concentration. LC50 for survival and EC50 for growth could not be calculated when survival was greater than 50% for all concentrations and reduction in growth compared to the control was less than 50%. Linear regression was used to test for a significant slope across water concentration where applicable.

Survival at the 100% nominal concentration for the seven-day acute toxicity testing using *A. affinis* was greater than or equal to 80% for all stations. This survival was considered equivalent to that allowed in the control (≥80%) and the dose-response was not modeled. The Kruskal-Wallis nonparametric test failed to detect any statistically significant differences in median survival between stations ignoring water concentration ($p = 0.24$).

Growth results for *A. affinis* (ignoring water concentration) displayed only slightly greater variability than survival (see Appendix C, Figure 3-4), with mean organism weights ranging from 0.97 mg for sample SWA07 to 1.25 mg for sample SWA03. Median weights were found to be significantly different ($p = 0.001$) among samples, with greater post-test growth detected for higher concentrations (i.e., test dilutions) of site surface water samples, indicating that adverse chronic effects were not present.

A. bahia and *A. affinis* survival was ≥80% for most samples and dilutions. A water concentration-response relationship was not present for the acute endpoint (survival). For some samples, a water concentration-response relationship was observed for the chronic (growth) endpoint, but in all cases, growth increased with increasing test water concentration, indicating that adverse chronic effects were not present. Because of high survival and growth, it was not possible to calculate LC50 and EC50 estimates for these endpoints. Thus, none of the surface water samples from either the North or South Ponds of IR Site 2 exhibited acute or chronic toxicity compared with water samples from CCSP.

The results of these bioassays indicate a lack of site-associated toxicity, and therefore acceptable levels of risk to fish and aquatic invertebrates. It is therefore not recommended that aquatic organisms be considered as drivers for potential risk-management decision making.

7.4.4.3.3 Wetland Pond Birds

Table 7-51 presents the baseline results for the mallard, the least sandpiper, and the great blue heron.

The mallard was selected as the representative receptor for herbivorous birds. No high or low benchmark HQs exceeded one in the baseline assessment.

The least sandpiper was selected as the representative receptor for benthic-feeding birds. Low benchmark HQs were greater than one for arsenic, cadmium, lead, selenium, vanadium, zinc, and *trans*-nonachlor. The highest low benchmark HQ was for lead (HQ = 32). No compounds had high benchmark HQs greater than one.

The great blue heron was selected as the representative receptor for fish-eating birds. Low benchmark HQs for the remaining compounds were either greater than one for the low benchmarks or greater than one for both low and high benchmarks. The constituents which have a benchmark greater than one for the low benchmark, but less then one for the high benchmark, are lead and vanadium. No compounds had HQs greater than one for the high benchmark scenario, so the raccoon was selected as the representative receptor for omnivorous mammals. All screening-level HQs were less than one, and all baseline HQs were less than one.

7.4.5 Uncertainty Analysis

This section discusses the uncertainty associated with the data and methods used in the ERA for IR Site 2. Uncertainty can be introduced through the use of assumptions in the absence of scientific data or through interpretation of the data itself. This uncertainty analysis will focus on uncertainty associated with analytical data collected to support the ERA. As this ERA is intended and designed to assess potential ecological risk associated with "current conditions," uncertainty associated with the application of the conclusions presented in this report to future conditions is outside of the scope of this assessment, and is therefore not expressly addressed here. However, uncertainty exists as to the relevance and/or applicability of this assessment to potential future site conditions, particularly if significant physical alteration and/or a change in the use of the site is involved. Because wetland areas are protected habitats, the wetland area and ponds at the site will remain in its current condition. Potential future scenarios that may involve physical alteration of the site include as yet undefined remedial actions. As it is beyond the scope of this assessment to consider such future scenarios, this uncertainty analysis focuses on uncertainties associated with the evaluation of potential risk associated with current conditions.

The screening-level risk evaluation based on direct contact with and bioaccumulation of chemicals in ecological receptors at IR Site 2 was designed to be conservative, addressing uncertainty by overestimating risk. This approach results in increased confidence that contaminated sites will not be removed from further assessment when, in fact, unacceptable risk actually exists. Results of the screening-level risk evaluation were used to focus the baseline risk evaluation, which more accurately reflects exposure of receptors to site contaminants at IR Site 2. As with all ecological assessments, there are inherent uncertainties. These uncertainties are directly relevant to the utility of the conclusions of this ERA in a risk-management decisions making context. The uncertainties identified should therefore be considered prior to and during the risk management phase. The discussion of identified uncertainties as they apply to the screening-level and baseline risk evaluations is discussed in more detail in the following sections.

7.4.5.1 Exposure Assessment Uncertainty

7.4.5.1.1 Use of SUFs of 1 for Most Receptors/Exposure Areas

A source of uncertainty in the screening-level risk evaluation is the use of a SUF of 1 in the dose assessment for all receptors. San Francisco Bay is a large, rich ecosystem that supports a variety of habitats and numerous species of plants and animals that coexist in a complex and widespread food web. It is probable that most species of benthic-feeding and piscivorous birds forage in areas much larger than IR Site 2.

Additionally, many species of birds in these guilds only reside in San Francisco Bay for a portion of the year. Therefore, the assumption that the birds forage at IR Site 2 100% of the time (as was assumed in the screening-level assessment for all receptors and in the baseline assessment for all receptors except the northern harrier and mallard) greatly overestimates their true exposure.

7.4.5.1.2 Effects of Life History and Environmental Conditions on Exposure Parameters

The exposure parameters used to conduct detailed food web models for birds and mammals were selected to conservatively represent the general feeding strategies of each of the selected receptors. These exposure parameters are not site-specific. Because site-specific habitat characteristics (e.g., availability, distribution, and quality of food) influence feeding strategies and therefore exposure parameters, there is uncertainty associated with using non-site-specific exposure parameters. However, a conservative approach was used for this risk assessment to mitigate this uncertainty. For example, exposure parameters for fish-eating birds assume that sufficient mass and quality of fish exists in the ponds to support fish-eating birds, yet no evidence of significant use of the ponds by fish exists.

7.4.5.1.3 Use of Maximum and 95% UCLs to Develop Exposure Estimates

Tier 1 screening is an inherently conservative process, designed to be more likely to carry forward chemicals than to eliminate chemicals that should be carried forward. The maximum observed value for a constituent in each media was used in the screening-level direct contact and dose assessments, even when this value appeared to be an outlier in comparison to the rest of the site data. This value then was compared to the conservative (low) benchmark or a calculated dose was compared to the TRV. If a constituent exceeded its benchmark, it was carried forward to the baseline direct contact and dose evaluations.

7.4.5.1.4 BAFs

- UFs were unavailable from Sample (1998a) or U.S. EPA (2005a) for VOCs for invertebrates. Because VOCs are not considered to be bioaccumulative, a UF of 1.0 is considered conservative (U.S. EPA, 1995) and was used to estimate VOC concentrations in invertebrates as well as in plant and small mammal tissues. This may result in an overestimate of exposure to VOCs for predators.

- No uptake models or factors were found for molybdenum uptake into terrestrial invertebrates or small mammals. For terrestrial invertebrates, the molybdenum UF calculated using the ratio estimate with Seaplane Lagoon benthic invertebrate and sediment concentrations. For mammals, the highest UF from the other metals (the UF for thallium) was applied. This value was selected to be conservative, but still could result in either an underestimate or overestimate of exposure.

- No uptake models or factors were found for uptake of PAHs and explosives into small mammals. Because mammals readily metabolize PAHs and explosives, UFs of 0 were assumed for these constituents (U.S. EPA, 2005a). This may result in a slight underestimate of exposure to predators, depending on whether any PAHs ingested by prey are fully metabolized prior to consumption.

- An uptake factor of 0 was assumed for transfer of PCDD/PCDF from soil to plant parts generally consumed by ecological receptors at the site. This may result in a slight underestimate of exposure to predators.

- For summed constituents in all tissue types where measured tissue data from the site were lacking, uptake factors or regression models were selected from the individual constituents as conservative surrogates, except for summed DDT, DDD, and DDE, which had separately derived regression models for the sum. Generally, using the most conservative uptake factor or regression model of the individual constituents in a sum would result in an overestimate of exposure.

7.4.5.1.5 Treatment of Non-Detected Individual Constituents for Summed Parameters

Some constituents (PAHs and DDT/DDD/DDE) were evaluated both as individual constituents and as summed parameters, whereas others (PCDD/PCDF and total PCBs) were evaluated only as summed parameters. In cases where an individual constituent was not detected, it was not incorporated into the sum (i.e., the value assigned to the individual constituent was 0). Treating non-detected constituents of sums as 0 may result in an underestimate of exposure.

7.4.5.1.6 Additive, Synergistic, or Antagonistic Interactions

Although the bioassays addressed the possible additive, synergistic, or antagonistic interactions among constituents in sediment, uncertainty exists regarding the potential impact of these types of interactions on birds and mammals. TRVs for birds and mammals address the potential toxicity of individual constituents. Not incorporating additive, synergistic, or antagonistic effects for birds and mammals may result in either an over- or under-estimation of risk.

7.4.5.1.7 Determination of Total PCB Value

As discussed in Sections 5.1 and 7.2.5 of this RI Report, PCBs were evaluated as a sum (i.e., total PCBs) for the ERA. To estimate total PCBs, the NOAA NS&T method was used to calculate a sum based on a subset of PCB congeners (i.e., the 18 NOAA NS&T congeners). Use of this summation method is common practice in San Francisco Bay, and is used by SFEI for their Regional Monitoring Program (RMP). However, there is some uncertainty associated with the total PCB results estimated using the NOAA NS&T method, due to some apparent discrepancies between the NOAA NS&T results and total PCB results estimated using a sum of Aroclors (see Section 5.1 of this RI Report).

To assess the potential significance of this uncertainty, alternative risk calculations were conducted using total PCB EPCs based on the sum of Aroclors. As described in Section 5.1, total Aroclor values were recalculated in three different ways: as the sum of original Aroclors; as the sum of requantified Aroclors; and as the sum of Aroclors on a point-by-point basis factoring in the more conservative (i.e., higher) of the original or modified Aroclor results. To be conservative and assess the greatest possible impact of this source of uncertainty, the highest 95% UCL value of the three different Aroclor sums for each of the upland, wetland, and pond soil/sediment portions of IR Site 2 were used to conduct an alternative calculation of food-web risk. Alternate PCB risk values are compared to the NOAA NS&T derived values in Table 7-52.

For most of the receptors evaluated, only modest increases in HQs were observed using this alternative PCB summation method, and the alternative HQs would not significantly change the conclusions of the risk assessment. However, in the case of the western meadowlark, the HQ significantly increased using the alternative PCB summation method, and use of the alternative results would lead to a high TRV HQ of 1.64 for the western meadowlark in the upland area.

7.4.5.1.8 Radionuclide Assessment Uncertainty

The method used to evaluate risk to wildlife receptors from exposure to radionuclides at IR Site 2 was conservative for the following reasons:

- Maximum IR Site 2 soil, sediment, and surface water radionuclide concentrations were compared to BCGs for the radionuclides developed by DOE.

- The BCGs were calculated with dose limits below which no adverse effects have been observed in aquatic and terrestrial organisms.

- Each of the assumptions and default parameter values were developed with sufficient protectiveness in mind to ensure that the resulting BCGs are appropriately conservative (i.e., are likely to overestimate risk).

- Pb-210 is a long-lived decay product of Ra-226 and currently is not included in the RESRAD-BIOTA calculator. Pb-210 was detected at the site but could not be evaluated in the radionuclide risk assessment. Not including Pb-210 likely results in an underestimate of risk from radionuclide exposure at IR Site 2. However, the screening ratio sums are well below one for all habitat areas, and the inclusion of Pb-210 in the calculator probably would not cause the sums to exceed one.

7.4.5.1.9 Lack of Site-Specific Tissue Data and Use of Modeled Tissue Inputs

Data for many prey items at the site were not available and were calculated or modeled to provide inputs to the food web model.

- Use of uptake factors and regression equations from the literature to model tissue concentrations in upland invertebrates may underestimate or overestimate invertebrate tissue concentrations at the site.

- Uptake factors for calculation of wetland invertebrates were derived from benthic invertebrate tissue concentrations from bioaccumulation bioassays and site sediment concentrations. Benthic invertebrates accumulate some chemicals to a greater extent than terrestrial invertebrates, which would result in an overestimate of exposure. There is additionally inherent uncertainty associated with using laboratory-derived bioaccumulation results to represent bioaccumulation in the field.

- Upland and wetland small mammal tissue concentrations were modeled using bioaccumulation data from the literature, which may not be representative of bioaccumulation occurring in small mammals at the site.

- Use of wetland plant tissue concentrations to estimate wetland pond plant concentrations is conservative because wetland soil chemical concentrations are generally higher than wetland pond sediment concentrations. Assuming uptake mechanisms for aquatic plants are similar to those for wetland plants, this would result in an overestimate of exposure to herbivorous birds feeding in the Wetland Ponds.

- Concentrations of constituents in fish tissue were estimated using UFs derived from data collected in Sea Plane Lagoon. Although Sea Plane Lagoon is in the vicinity of the site, and sediment conditions may be similar, there is uncertainty associated with the applicability and relevance of fish tissue concentrations estimated based on data from a nearby area, as uptake of chemicals by fish is regulated by many factors (e.g., sediment characteristics, fish species age, size and behavior) and is therefore site-specific.

7.4.5.1.10 Incorporation of Conservative Assumptions Regarding Complete Pathways

The following exposure pathways are not currently complete at the site:

- Exposure of fish to surface water in ponds: Extreme fluctuations in water level and associated changes in water quality (dissolved oxygen, temperature, and other parameters) occur daily in the wetland ponds, and fish cannot survive or reproduce under these conditions, which are unlikely to change in the future. Historically, fish observed in North Pond may have come in with tidal action. Any risk to fish posed by chemical concentrations in surface water is unlikely to actually manifest at the site.

- Exposure to fish-eating birds from consumption of fish in wetland ponds: Because fish do not spend significant time periods in the wetland ponds, as described above, it is unlikely that a fish-eating bird will obtain much of its dietary needs from fish in the wetland ponds. In addition, due to the short periods of time fish are likely to spend in the wetland ponds, uptake of site-related chemicals by the fish is assumed to be low. As a result, fish-eating birds are unlikely to uptake significant doses of site-related chemicals.

- Herbivorous birds in wetland ponds: There is currently no aquatic vegetation in the wetland ponds at IR Site 2, and herbivorous birds are not exposed to site-related chemicals via this pathway.

- Burrowing animals were evaluated at IR Site 2 because of one observation of a burrowing owl in the wetland area. Based on this observation, it was assumed that burrowing mammals were also present, because burrowing owls do not make their own burrows, but occupy burrows created by mammals. An additional exposure pathway of concern beyond food web exposure for burrowing animals is inhalation of VOCs present in burrow air resulting from volatilization from the soil. The extent of use of IR Site 2 by burrowing animals is not known, but because a burrowing owl was observed on-site, the exposure pathway was evaluated. Conservative exposure assumptions were used in the evaluation of the inhalation pathway, and risk was likely overestimated. Only TRV data for mammals were available. It is not known whether birds are more or less sensitive than mammals to the effects of VOC exposure through inhalation, and therefore it is not known if the risk conclusions made for burrowing mammals apply also to burrowing birds.

7.4.5.1.11 Groundwater- Surface Water Interaction

The interactions between groundwater in the upland portions of the site, groundwater and surface water in the wetland portions of the site, and surface water in the San Francisco Bay are influenced by tides, precipitation, wind-driven currents, and other variable physical factors (e.g., soil characteristics). This RI and the risk assessments contained herein assume that the upland, wetland, and larger San Francisco Bay are hydraulically connected, and groundwater and surface water may function as transport pathways for migration of contaminants. However, there is uncertainty regarding the significance and the temporal and spatial variability of the interactions. Ultimately, the study designs for groundwater, sediment, and surface water are considered adequate to address exposure and associated risk for receptors potentially exposed to these media.

7.4.5.2 Effects Assessment Uncertainty

7.4.5.2.1 Quantity and Quality of Toxicity Data Used to Derive the Toxicity Reference Values

Uncertainties are associated with the quantity and variable quality of literature-derived toxicity data. In order to reduce the uncertainties in the toxicity data set, most TRVs were generated from three widely accepted sources: BTAG (DTSC, 2001), U.S. EPA's Eco-SSL documents (U.S. EPA, 2005), and ORNL (Sample et al., 1996). Selected TRVs such as PAHs were obtained through a literature search, and the values used have been accepted for other sites by regulatory agencies. It is recognized, however, that new toxicity data are generated every year, and not all of the relevant information may be included in the sources used for this risk assessment. In addition, TRVs for the same chemical can vary significantly among these sources. For example, the avian NOAEL for lead in the Eco-SSL is 1.63 mg/kg/d, whereas the BTAG avian NOAEL (used in this risk assessment) is 0.014 mg/kg/d. The BTAG avian TRV is based on studies that employed lead acetate, a form of lead not commonly found in nature. Lead acetate is highly soluble and more bioavailable than inorganic lead or other lead salts, making it more toxic than other forms of lead that are commonly found in the environment. The Eco-SSL TRVs were developed using only studies of the effects of inorganic lead compounds, which are more relevant at most sites, including IR Site 2. As a result, the risk to birds from exposure to lead at IR Site 2 is overestimated.

It should be noted that the methods used in the three main sources to develop the TRVs vary, and this variation may have an effect on the quality of the TRVs. Each source conducted a literature review for each chemical, but BTAG and ORNL TRVs are based on one study considered the most appropriate by the reviewers. TRVs presented in U.S. EPA Eco-SSL documents (a separate document is published for each chemical) are based on a rigorous review of literature obtained from an extensive literature search. Derivation of the NOAELs on which the Eco-SSLs are based was a collaborative effort of a multi-stakeholder team consisting of federal, state, consulting, industry, and academic participants led by U.S. EPA's Office of Solid Waste and Emergency Response. A weight-of-evidence process was used to derive the TRVs, which is described in Attachment 4-5 to the Eco-SSL guidance (U.S. EPA, 2003).

TRVs for some explosives have been developed by U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM). The USACHPPM values were developed based on studies obtained through an extensive literature search. The protocol described in Standard Practice for Wildlife Toxicity Reference Values (USACHPPM, 2000) allows use of various methods for deriving low and high TRVs, depending on the number of studies and usable data available. A qualitative confidence level is assigned to each TRV (low, medium, or high) using professional judgment and considering factors such as the range of inter-specific variation in response, completeness of the database, and overall quality of the experiments on which the conclusions were based. Greater uncertainty is associated with use of TRVs with low or medium confidence levels; however, it is not known how risk estimates are affected.

A few TRVs were obtained from other sources. The avian TRVs selected for PAHs (other than naphthalene) are from a study performed by Patton and Dieter (1980) based on a non-specific hydrocarbon mixture as a surrogate for all individual PAHs. If a TRV based on exposure to a mixture is used to evaluate exposure to an individual compound in the mixture, then the risk from the individual compound may be overestimated, if it is assumed that the other compounds in the mixture add to the toxicity. Avian TRVs specific to naphthalene are drawn from a study by Wildlife International (1995). An avian NOAEL for chlordane was used that was proposed in comments from the USFWS on the *Final RI Sampling Work Plan* (Battelle et al., 2005). The chlordane NOAEL of 0.0014 mg/kg/day could not be reproduced based on a review of available documents. The value proposed by USFWS is three orders of magnitude lower than the avian NOAEL of 2.1 mg/kg-day calculated by Sample et al. (1996) based on a study of red-winged blackbirds, and likely results in an overestimate of risk to birds from exposure to chlordane.

7.4.5.2.2 Exposure Conditions of Literature-Derived Toxicity Reference Values

The majority of the evaluated toxicity data were derived from laboratory studies and that were conducted in settings that do not mimic true field conditions. Laboratory studies typically control various factors in order to isolate one parameter in particular. Although such controlled experiments result in a more valid interpretation of the isolated parameters or relationship, uncertainty is associated with assuming laboratory exposure conditions are equivalent to in-field exposure conditions. As discussed in the following paragraphs, exposure duration and toxicity characterization are two parameters that exemplify the difficulty in translating literature-derived data to data representing the exposure conditions for receptors at IR Site 2. In development of TRVs, the use of chronic data is preferred. Available toxicological data were not always associated with chronic exposure durations. Therefore, uncertainties were introduced in extrapolating non-chronic test results to chronic receptor toxicity values. These uncertainties were partially handled through the application of uncertainty factors in the derivation of low TRVs.

Uncertainty is associated with the extrapolation of literature-derived toxicity endpoints (especially laboratory-based studies) to equivalent endpoints for receptors at IR Site 2 due to discrepancies in exposure conditions. For example, the stressors affecting a receptor exposed to COPECs in the wild can be very different than those affecting an organism exposed in a laboratory setting. However, the direction, magnitude, and effect of this uncertainty are not known.

7.4.5.2.3 Magnitude of Difference between Low TRV and High TRV

Low TRVs derived by the BTAG, U.S. EPA Eco-SSL, ORNL, and USACHPPM process represent a no effect level, whereas the high TRVs represent the mid-range of effects levels found in the literature. There is a critical point on the dose-response curve at which effects will first be seen, but that dose is not known. The difference between the low and high TRVs is typically an order of magnitude, and HQs between 1 and 10 give an indication of how close the dose may be to the no effect or low effects levels represented by the TRVs. When the difference between the low and high TRV for a COPEC is very great, there is a high degree of uncertainty regarding where effects may first be seen.

The difference between the low and high TRVs is greater than two orders of magnitude for some COPECs, such as avian TRVs for cadmium and lead. A large difference in the high and low TRV for a COPEC increases the uncertainty of risk conclusions based on the magnitude of the low benchmark HQ because it is unknown whether the dose estimated is approaching where first-effects may be found. An extreme case is lead, for which the avian high TRV is 625 times the avian low TRV. The screening-level assessment showed high lead HQ values for avian receptors. The baseline lead low benchmark HQ for birds feeding 100% at China Camp based on the 95% UCL (see Table 7-53) for wetland exposure is 132. Although such a high HQ makes it likely that there would be widespread effects on birds in San Francisco Bay, these effects are not actually observed. Such a large difference between the low and high BTAG avian TRVs for lead and concerns about lead bioavailability and toxicity make it almost impossible to accurately assess risk from lead in San Francisco Bay.

7.4.5.2.4 Use of Surrogate Species Data

In the absence of toxicity data specific to the selected representative receptors at IR Site 2, it is preferable to develop TRVs based on data from species phylogenetically similar to a particular representative receptor. The representative receptors from the various avian and mammalian guilds have different feeding behaviors and diets. For several COPECs, avian TRVs were developed using data for species that are not similar to one or another of the representative receptors in terms of diet or feeding activity. This represents a primary source of uncertainty associated with applying the TRVs to dissimilar species. Without species-specific data, it is impossible to determine whether the data from surrogate species appropriately reflect the sensitivity of a particular representative receptor.

7.4.5.2.5 Use of Surrogate TRVs for Individual and Summed COPECs

The low- and high-chlordane TRVs were used for evaluation of the following components of chlordane: *alpha*-chlordane, *gamma*-chlordane, *trans*-nonachlor, and *cis*-nonachlor. The BTAG avian low TRV for DDT and metabolites was used as a surrogate and the high TRV for DDE was used for evaluation of 2,4'-DDE, 4,4'-DDE, for the sum of 2,4'- and 4,4'-DDE (total DDEs) and for the sum of DDT and metabolites (all six 2,4'- and 4,4'-DDT, DDD and DDE compounds). The low and high TRVs for DDT and metabolites were used for evaluation of 2,4'-DDD, 4,4'-DDD, total DDDs (the sum of 2,4'- and 4,4'-DDD), 2,4'-DDT, 4,4'-DDT, and total DDTs (the sum of 2,4'- and 4,4'-DDT). BTAG low and high mammalian TRVs for DDT and metabolites were used to evaluate each of the individual DDT and metabolite compounds and for the various sums. The naphthalene and benzo(a)pyrene TRVs were used as surrogates for the summed LPAH and HPAH, respectively. Avian TRVs for total PCBs were derived from studies that exposed birds to Aroclor 1254 and Aroclor 1242. Mammalian TRVs for total PCBs were based on toxicological studies that used Aroclor 1254. These TRVs were used to evaluate risk from total PCB values that were calculated by summing individual PCB congener values. Risk from individual components or sums that was estimated using a TRV for a surrogate chemical or mixture may be over- or underestimated, depending on how the toxicity of the individual component relates to the mixture. In the case of PCBs, uncertainty in the risk estimates arises from the relationship of the toxicity of the congener mixture (the particular Aroclor) used in the toxicological study to the toxicity of the mixture present at the site.

7.4.5.3 Uncertainty Regarding Background and Reference Estimates

Reference areas near San Francisco Bay are difficult to select due to the widespread effects of human activities in the bay area. Also, due to the varying levels of impact to wetland areas around the bay, it can be difficult to find a site with similar habitat characteristics to the site of interest that is representative of ambient conditions. CCSP is not located in Central San Francisco Bay, and may not be subject to the same ambient inputs as the site. For these reasons, there is uncertainty regarding the representativeness of CCSP and its comparability to IR Site 2. Additionally, a limited number of samples were collected at CCSP, which limits the types and the strength of the comparisons that can be made. Section 4.0 and Appendix B of this RI Report provides details about CCSP's setting and the data collected there.

7.4.5.4 Risk Characterization Uncertainty

Risk associated with a number of COPECs could not be quantitatively evaluated for one or more receptors due to a lack of exposure inputs and/or effects data. For most of these COPECs little is known about environmental fate and transport and/or toxicity. Consequently, these compounds are rarely the focus of ecological risk assessments. The overall impact of not recommending these compounds as potential risk drivers is not considered to be significant, as this ERA addressed all compounds commonly evaluated in an ERA, and commonly identified as risk management drivers on contaminated sites. However, the exclusion of COPECs that could not be quantitatively evaluated as potential risk drivers imparts uncertainty to the conclusions of this ERA, and may contribute to conclusions that overall provide an underestimation of risk to ecological receptors.

7.4.6 Conclusions and Recommendations

Table 7-53 summarizes the ERA output for all COPEC-receptor pairs that had an HQ greater than one using either the low or high TRV/benchmark in the baseline assessment. For birds and mammals, there was only one line of evidence (i.e., food web model results) for each receptor. However, multiple receptors were considered when drawing conclusions for receptor classes (i.e., birds and mammals). Conclusions were based on the most sensitive receptor in each broad receptor class. This conservative approach was used in place of a more traditional or formal weight of evidence evaluation.

The results summarized in Table 7-53 for upland, wetland, and wetland ponds habitats are discussed in the context of recognized uncertainties, and background/ambient exposure/risk to draw overall conclusions and make recommendations regarding ecological risk at the site. Cells representing COPEC-receptor pairs that did not have HQs greater than one in the baseline assessment include additional information to indicate if the screening-level or baseline HQ was less than one, or if the COPEC-receptor pair could not be evaluated due to a lack of necessary inputs (e.g., benchmarks or BAFs).

7.4.6.1 Upland Conclusions and Recommendations

There are a number of potential drivers of risk to plants and invertebrates (based on comparisons to screening-level benchmarks only) including chromium, HPAHs, pyrene, a number of individual PAHs and less significantly a few metals. Potential risk drivers for mammals include cadmium, manganese, molybdenum, zinc, dieldrin, and PCDD/PCDF. Birds are the most sensitive receptors, and potential risk management drivers for birds include cadmium, chromium, copper, lead, mercury, nickel, vanadium, zinc, total PCBs, and total DDT. The western meadowlark is the most sensitive species, and risk estimates are generally higher in the upland area than in the wetland or the wetland ponds, sometimes significantly higher.

Based on these results, it is recommended that metals (cadmium, chromium, copper, lead, mercury, manganese, molybdenum, nickel, vanadium, and zinc), PAHs, dieldrin, PCDD/PCDF, total PCBs, and total DDT be considered as potential risk drivers for plants and invertebrates and/or birds in the upland habitat.

7.4.6.2 Wetland Conclusions and Recommendations

7.4.6.2.1 Plants and Invertebrates

There are few exceedances of low benchmarks using baseline exposure estimates (i.e., cobalt, copper, mercury, nickel, vanadium, and zinc), and HQs for plants are generally less than 3 and HQs for invertebrates generally less than 5. The exception is chromium which has low baseline HQs for plants and invertebrates of 166 and 164, respectively. No site-specific data can be used to assess plants and invertebrates, and no "high" benchmarks are available to incorporate into the screening-level assessment.

Based on these results, it is recommended that chromium be considered as a potential risk driver for plants and invertebrates in the wetland habitat.

7.4.6.2.2 Birds

Baseline hazard quotients exceeded one for avian receptors evaluated for the wetland habitats. The least sandpiper was the most sensitive avian receptor, having low TRV HQs greater than one for nine metals (arsenic, cadmium, chromium, copper, lead, nickel, selenium, vanadium, and zinc) and five organic COPECs (total PCBs, total DDT, *alpha*-chlordane, *gamma*-chlordane, and *trans*-nonachlor). Daily doses and associated baseline HQs calculated to provide an estimate of potential ambient or background exposure and associated risk indicate that for a number of these metals; however, site-associated exposure and risk are likely consistent with background/ambient exposure and risk. Table 7-54 summarizes site low TRV HQs and ambient or reference low TRV HQs (calculated using the same assumptions as site HQs but with EPCs from CCSP instead of site EPCs).

Site exposure of birds to copper, lead, and zinc may represent incremental exposure with respect to ambient or background exposure. Prior to considering these compounds as drivers for potential management activities it is important to consider the magnitude of low benchmark baseline HQs, as well as high benchmark baseline HQs. Given that low TRVs are generally considered to represent no-effect or "safe" levels of exposure below which no effects are expected, and high TRVs are generally considered to represent effect thresholds above which effects may be expected, the magnitude of low TRV HQs (with the exception of lead) and the level of protection indicted by high TRV HQs do not necessarily indicate unacceptable risk for the metals listed above.

Exposure of birds to total PCBs, total DDT, *alpha*-chlordane, *gamma*-chlordane, and *trans*-nonachlor appear to be greater than ambient exposure. Whereas low TRV baseline HQs exceed 1 for total PCBs (3.9), total DDT (1.8), *alpha*-chlordane (15.1), *gamma*-chlordane (19.1), and *trans*-nonachlor (6.86), high TRV HQs were well below one (0.3 for total PCBs and total DDT, 0.001 for *alpha*-chlordane, 0.002 for *gamma*-chlordane, and 0.009 for *trans*-nonachlor).

Based on these results, it is recommended that copper, lead, zinc, total PCBs, total DDT,* alpha*-chlordane, and* gamma*-chlordane be considered as potential risk drivers for birds in the wetland habitat.

7.4.6.2.3 Mammals

The California vole is the most sensitive mammalian receptor in the wetland area, and potential wetland area risk drivers include cadmium, manganese, molybdenum, and nickel. There are other compounds with California vole baseline HQs greater than one, but birds are the more sensitive receptor for the other compounds and will drive any risk management decision making for those compounds. Although baseline low TRV HQs exceed one for manganese, molybdenum, and nickel, site-associated exposure and resulting risk appear to be consistent with background/ambient exposure and associated risk for these three COPECs. Table 7-55 summarizes site low TRV HQs and ambient or reference low TRV HQs for manganese, molybdenum, and nickel (calculated using the same assumptions as site HQs but with EPCs from CCSP instead of site EPCs). As seen in Table 7-55, the potential risk from background/ambient exposure is similar to site risk for manganese, molybdenum, and nickel.

A low TRV baseline HQ for cadmium could not be calculated for CCSP, as cadmium was not detected in any soil samples collected at CCSP. The detection limits for CCSP samples were lower than detected concentrations at the site, indicating that exposure of mammals to cadmium in site-associated soils may be greater than at CCSP. It is important, however, to recognize the uncertainty associated with estimates of background or ambient concentrations of COPECs provided in this report based on data collected at CCSP. CCSP is not located in Central San Francisco Bay, and may not be subject to the same ambient inputs as the site. Additionally, a limited number of samples were collected at CCSP which limits the types and the strength of the comparisons that can be made.

Site exposure of mammals to cadmium may represent incremental exposure with respect to ambient or background exposure. Prior to considering cadmium as a driver for potential management activities it is important to consider the magnitude of the low benchmark baseline HQs (6.8), as well as high benchmark baseline HQ (0.06). Given that low TRVs are generally considered to represent no-effect or "safe" levels of exposure below which no effects are expected, and high TRVs are generally considered to represent effect thresholds above which effects may be expected, the magnitude of low TRV HQs and the level of protection indicted by the high TRV HQ does not necessarily indicate unacceptable risk for cadmium for mammals in wetland soils.

Based on these results, it is recommended that cadmium be considered as potential risk driver for mammals in the wetland habitat.

7.4.6.3 Wetland Pond Conclusions and Recommendations

7.4.6.3.1 Benthic Invertebrates, Water Column Invertebrates, and Fish

The baseline assessment of potential risk associated with direct contact of North Pond benthic invertebrates with constituents found that the low HQs for 8 metals (cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc), total PCBs, DDD and DDE isomers, acenaphthene, dieldrin, *gamma*-chlordane and total DDD, DDE and DDT isomers exceeded one. Mercury and nickel concentrations measured in the North Pond also exceeded high benchmarks, although nickel concentrations were lower than background levels measured at CCSP. In the South Pond baseline assessment, the low HQs calculated for three metals (cadmium, mercury, and nickel), total PCBs, 4,4'-DDD, *gamma*-chlordane, and total DDEs and DDT isomers exceeded one. All of the HQs calculated in the screening assessment for North Pond aquatic biota (water column invertebrates and fish) were below one. The baseline assessment of potential risk associated with direct contact of South Pond aquatic biota with constituents found that the low HQs for nickel, total PCBs, and *gamma*-chlordane exceeded one. The high HQ was not exceeded in any of these instances.

Results from MEs consisting of comparisons of site-associated concentrations of COPECs to generic, non-site-specific measures of effect (i.e., sediment benchmarks or water quality criteria) need to be considered in the context of site-specific toxicity data, when available, as the benchmarks provide for a generic, conservative, and predictive assessment. In contrast, site-specific bioassays provide a more meaningful measure of current conditions with respect to toxicity and risk the receptor group being evaluated, and therefore more heavily weighted in the weight of evidence. Site-specific toxicity tests were conducted with commonly used vertebrate and invertebrate bioassay test species with established sensitivities to environmental contaminants, and both lethal and sub-lethal endpoints were measured. Tests were conducted on relevant environmental media (surface water and sediment) and no site-associated toxicity was observed.

E. estuarius was used to evaluate potential toxicity to benthic invertebrates, and survival in all but one stations exceeded 85%, which is considered nontoxic based on comparisons to tolerance limits presented in SWRCB (1998). The exception was a mean survival of 68% observed for sample SED16. Mean survival at this station was influenced by 0% survival observed in one of the five sample replicates (Replicate 4). No animals were found in Replicate 4 of the SED16 sample at test termination, and it is likely that this replicate was not initiated (i.e., amphipods were never added to the test chamber) and potentially represents invalid data for this single replicate. Removing this one replicate from the mean calculation for SED16 raises the mean survival for SED16 to 85%, which is a nontoxic response.

A. bahia was used to evaluate potential toxicity to water column invertebrates, and survival in the 100% nominal concentration for the seven-day acute toxicity testing using *A. bahia* was greater than or equal to 90% for all stations. This survival was considered equivalent to that allowed in the control ($\geq$80%). Growth results for *A. bahia* testing displayed greater variability than survival. Simple linear regression of water concentration versus growth was significant ($p<0.05$) for only five samples (SWA03, SWA04, SWA10, SWA12, and SWA14). All water samples with significant regressions also exhibited positive slopes, meaning that higher surface water concentrations actually had a beneficial effect on growth.

To provide for a site-specific evaluation of exposure and associated potential toxicity to fish in the North and South Pond, topsmelt (*A. affinis*) were exposed for seven days to a dilution series of pond water samples corrected to test-specific salinity. Survival at the 100% nominal concentration for the seven-day acute toxicity testing using *A. affinis* was greater than or equal to 80% for all stations. This survival was considered equivalent to that allowed in the control (≥80%) and the dose-response was not modeled. The Kruskal-Wallis nonparametric test failed to detect any statistically significant differences in median survival between stations ignoring water concentration ($p = 0.24$). For some samples, a water concentration-response relationship was observed for the chronic (growth) endpoint, but in all cases, growth increased with increasing test water concentration, indicating that adverse chronic effects were not present.

The results from the three bioassays conducted indicate a lack of site-associated toxicity, and therefore indicate acceptable levels of risk to fish and invertebrates inhabiting the wetland ponds at the site. It is therefore not recommended that aquatic organisms be considered as drivers for potential risk management decision-making.

7.4.6.3.2 Birds

Baseline HQs exceeded one for avian receptors evaluated for the wetland pond habitats. The least sandpiper was the most sensitive avian receptor, having low TRV HQs greater than one for six metals (arsenic, cadmium, lead, selenium, vanadium, and zinc) and one organic compound (*trans*-nonachlor). However, daily doses and associated baseline HQs calculated to provide an estimate of potential ambient or background exposure and associated risk indicate that site-associated exposure and risk are likely consistent with ambient exposure and risk for all but one of these metals (i.e., cadmium). Table 7-56 summarizes site low TRV HQs and ambient or reference low TRV HQs (calculated using the same assumptions as site HQs but with EPCs from CCSP instead of site EPCs).

A low TRV baseline HQ for cadmium could not be calculated for CCSP, as cadmium was not detected in any sediment samples collected at CCSP. The detection limits for CCSP samples were lower than detected concentrations at the site, indicating that exposure of birds to cadmium in site-associated sediments may be greater that at CCSP. It is important, however, to recognize the uncertainty associated with estimates of background or ambient concentrations of COPECs provided in this report based on data collected at CCSP. CCSP is not located in Central San Francisco Bay, and may not be subject to the same ambient inputs as the site. Additionally, a limited number of samples were collected at CCSP which limits the types and the strength of the comparisons that can be made.

Site exposure of birds to cadmium, and additionally to *trans*-nonachlor, may represent incremental exposure with respect to ambient or background exposure. Prior to considering either of these compounds as drivers for potential management activities, it is important to consider the magnitude of low benchmark baseline HQs, as well as high benchmark baseline HQs. Low benchmark HQs based on a number of conservative exposure estimates for cadmium and *trans*-nonachlor were 2.7 and 1.9, respectively. Baseline HQs calculated using the same conservative exposure assumptions, but with "high" TRVs for cadmium and *trans*-nonachlor, were 0.03 and 0.0003 respectively. Low TRVs generally are considered to represent no-effect or "safe" levels of exposure below which no effects are expected, and high TRVs are generally considered to represent effect thresholds, above which effects may be expected. Therefore, the magnitude of low TRV HQs and the level of protection indicted by high TRV HQs do not support a finding of unacceptable risk for cadmium and *trans*-nonachlor for birds in wetland sediments.

Based on these results, it is recommended that cadmium and* trans*-nonachlor be considered as potential risk drivers for birds in the wetland pond habitat sediments.

7.4.6.3.3 Mammals

All calculated screening-level HQs for mammals evaluated for the ponds were less than one, indicating a lack of exposure at levels greater than established conservative measures of effect. Therefore, there is no evidence indicating unacceptable risk to mammal receptors that forage in the wetland pond habitat at the site.

8.0: POTENTIAL RISK DRIVERS AND CONTAMINANT FATE AND TRANSPORT

This section summarizes the contaminants of principal concern at IR Site 2 and the pathways responsible for potentially unacceptable risk at the site based on the human health and ecological risk assessments. This section also describes the general processes governing the fate of the contaminants of principal concern in the environment and the general methods of contaminant migration considered relevant to these contaminants at the site.

8.1 Contamination Sources and Potential Risk Drivers

The primary source of contamination at IR Site 2 was the historical disposal of significant quantities of waste material throughout the landfill and in portions of the wetlands. Over the course of its historical operation as a landfill, IR Site 2 received a significant volume of general refuse and a number of various industrial and municipal wastes, including wastes that would be considered hazardous, from various operational units at Alameda Point. Waste materials, for the most part, were placed in the landfill using a typical trench and fill process, and exist below soil cover material across the landfill portion of the site. Several areas presumed to have received discrete waste types (e.g., liquid oil wastes and pesticides) also have been identified at the site. An extensive RI was implemented to characterize the nature and extent of contamination at the site, focusing on portions of the site that would most likely contain site-related contamination. Available historical data, which tend to characterize peripheral portions of the site, also were evaluated during the RI. Human health and ecological risk assessments were implemented according to appropriate methods, and a list of specific compounds and exposure pathways were established that are responsible for potentially unacceptable environmental risk at the site. The human health and ecological risk assessments are presented in detail in Sections 6.0 and 7.0 of this RI Report, respectively. The following subsections describe the contaminants present in distinct portions of the site and the pathways that are responsible for potentially unacceptable risk.

8.1.1 Landfill

The HHRA determined a limited list of potential risk drivers to one or more human receptors in the landfill portion of the site, as summarized in Table 8-1. Specifically, the HHRA concluded that one metal (arsenic), three SVOCs/PAHs (benzo(a)pyrene, benzo(k)fluoranthene, and naphthalene), one pesticide (*delta*-HCH), total PCBs, PCDDs/PCDFs, and two radionuclides (Ra-226 and Ra-228) are potential risk drivers to at least one human receptor class evaluated. Risks from these compounds were determined to be related to their presence in surface soils (arsenic, benzo(a)pyrene, benzo(k)fluoranthene, Ra-228, and total PCBs), subsurface soils (Ra-226, Ra-228, and naphthalene), and groundwater (total PCBs, PCDDs/PCDFs, and *delta*-HCH). As described in Section 6.0 of this RI Report, specific pathways found to be of potential concern during the HHRA of the landfill include direct dermal contact with surface soil or shallow groundwater, incidental ingestion of surface soil, inhalation of vapors from surface or subsurface soil, and exposure to external radiation from surface or subsurface soil. The human receptor classes evaluated during the HHRA for the landfill area included park ranger/tour guide, park ranger/restoration supervisor, site visitor, and construction/excavation worker.

The ERA concluded that several metals (antimony, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, silver, vanadium, and zinc), several SVOCs/PAHs (acenaphthene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, total LPAHs, and total HPAHs), total PCBs, a limited number of pesticides (dieldrin and total DDx), and PCDDs/PCDFs are potential risk drivers for one or more ecological in the landfill portion of the site. Of these compounds, chromium, lead, total HPAHs, and total DDx were identified as the most significant risk contributors (i.e., exhibit the highest HQs). As described in Section 7.0 of this RI Report, contaminants were evaluated based on surface soil sampling data for mammals, birds, and invertebrates. For plants, contaminants were evaluated based on surface and subsurface soil sampling data.

As described in Section 5.0 of this RI Report, sampling was completed at CCSP during the RI to develop a reference dataset against which site data could be compared. CCSP is considered to represent a nearly pristine environment which shares regional attributes with IR Site 2, and which has not been affected by discrete industrial operations. CCSP has consequently served as a representative reference sampling location for a number of environmental investigations in the San Francisco Bay vicinity. Habitat types consistent with the IR Site 2 landfill were sampled at CCSP during the RI.

Several of the compounds identified as potential risk drivers in the landfill portion of the site were also characterized in the upland portion of CCSP. Specifically, metals and SVOCs/PAHs, several of which were concluded by the risk assessments conducted for the landfill portion of the site to be potential risk drivers due to their presence in soil, also were identified in soil from the CCSP upland area. Furthermore, several of the metals and SVOCs/PAHs determined to be potential risk drivers in surface and/or subsurface soil in the landfill portion of IR Site 2 were detected at consistent or even higher concentrations in soil from the CCSP upland area.

- **Landfill Surface Soil** – Mean detected concentrations of arsenic, chromium, copper, lead, manganese, nickel, vanadium, benzo[a]pyrene, and benzo[k]fluoranthene were higher in CCSP upland soil compared to surface soil from the landfill portion of IR Site 2. In addition, the maximum detected concentrations of chromium, manganese, nickel, vanadium, benzo[a]pyrene and benzo[k]fluoranthene were higher in CCSP upland soil compared to surface soil from the IR Site 2 landfill.

- **Landfill Subsurface Soil** – Mean and maximum concentrations of nickel and vanadium were higher in CCSP upland soil compared to subsurface soil from the landfill portion of IR Site 2.

Accordingly, the environmental risk associated with the presence of these compounds in upland soil at CCSP would be expected to be consistent with or even higher than the risk associated with the presence of these metals in soil in the landfill portion of IR Site 2. The relationship between risks associated with contaminants in the landfill portion of the site and ambient risks associated with some of these same compounds is an important one. Nevertheless, in this RI Report, no constituents identified as potential risk drivers through the human health and ecological risk assessments of the landfill portion of the site are discounted based on their concentrations and associated ambient risk at CCSP. However, the relationships between site and ambient risk will become an important consideration during the feasibility study and remedial design phases for IR Site 2.

In addition, it should be noted that the few groundwater samples collected from the landfill portion of the site for analysis of PCDD/PCDF were not filtered. PCDDs/PCDFs were detected in these samples at concentrations that ultimately led to a conclusion of potential risk to human health. The samples were collected unfiltered from temporary well points, meaning that a significant amount of entrained turbidity was present in the samples. All other groundwater samples from the site that were collected using temporary well points were analyzed as appropriate in both an unfiltered and filtered aliquot (i.e., groundwater samples for VOCs were not filtered according to standard practice). Given the tendency of contaminants like PCDDs/PCDFs to remain sorbed to solid matrix material (see below), it is likely that PCDD/PCDF concentrations in the few landfill area groundwater samples would have been lower in the dissolved (i.e., filtered) fraction, and potentially low enough to alter the conclusions regarding the risk posed to human health by these contaminants in shallow landfill groundwater.

Table 8-1 summarizes the findings of the human health and ecological risk assessments conducted for the landfill area of the site. This table was developed to clearly convey the pathways and receptors evaluated through the risk assessments for which individual compounds may pose an unacceptable environmental risk. The table also demonstrates those compounds for which environmental risk is likely similar or greater at CCSP relative to the IR Site 2 landfill, or for which groundwater data were generated only for a total fraction from temporary wellpoints.

8.1.2 Wetland

The HHRA determined a limited list of potential risk drivers to one or more human receptors in the wetland portion of the site, as summarized in Table 8-2. Specifically, the human health risk assessment concluded that one metal (arsenic), three SVOCs/PAHs (benzo(a)pyrene, benzo(k)fluoranthene, and dibenz(a,h)anthracene), one pesticide (dieldrin), total PCBs, and two radionuclides (Ra-226 and Ra-228) are potential risk drivers to at least one human receptor class evaluated. Risks from these compounds were determined to be present in surface soils (arsenic and benzo(k)fluoranthene), subsurface soils (Ra-226 and Ra-228), groundwater (dieldrin and total PCBs), and surface water (benzo(a)pyrene and dibenz(a,h)anthracene). As described in Section 6.0 of this RI Report, specific pathways found to be of potential concern during the HHRA of the wetland include direct dermal contact with surface soil, shallow groundwater, or surface water, incidental ingestion of surface soil, and exposure to external radiation from surface or subsurface soil. The human receptor classes evaluated during the human health risk assessment for the wetland area included park ranger/tour guide, park ranger/restoration supervisor, site visitor, and construction/excavation worker.

The ERA evaluated the non-inundated portions of the wetland and the wetland ponds separately. The assessment concluded that several metals (arsenic, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, vanadium, and zinc), total PCBs, and a limited number of pesticides (*alpha*-chlordane, *gamma*-chlordane, dieldrin, and total DDx) should be considered as potential risk drivers in the risk management phase of the process based on risk findings for one or more ecological receptors in the non-inundated wetland portion of the site. Of these compounds, chromium, and lead were identified as the most significant potential risk drivers (i.e., exhibit the highest HQs). As described in Section 7.0 of this RI Report, contaminants were evaluated based on surface soil sampling data for mammals, birds, and invertebrates. For plants, contaminants were evaluated based on surface and subsurface soil sampling data.

The ERA also concluded that several metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, and zinc), one SVOC/PAH (acenaphthene), total PCBs, and a limited number of pesticides (*gamma*-chlordane, *trans*-nonachlor, dieldrin, and total DDx) should be considered as potential risk drivers in the risk management phase of the process based on risk findings for one or more ecological in the wetland ponds. Of these compounds, mercury and nickel were identified as the most significant potential risk drivers (i.e., exhibit the highest HQs) based on the results of benchmark comparisons alone. As discussed in Section 7.4.6.3, however, the results from the three site-specific bioassays conducted indicate a lack of site-associated toxicity, and therefore indicate acceptable levels of risk to fish and invertebrates inhabiting the wetland ponds at the site. It was therefore not recommended that aquatic organisms be considered as drivers for potential risk management decision-making. Mercury and nickel should, therefore, not be considered as risk management drivers.

As described in Section 7.0 of this RI Report, contaminants were evaluated based on surface water and sediment sampling data for all receptors in the wetland ponds. Specific pathways found to be of potential concern in the wetland ponds based on the ecological risk assessment include direct dermal contact with or incidental ingestion of sediment and incidental ingestion of direct dermal contact with surface water. As described in Section 5.0 of this RI Report, sampling was completed at CCSP during the RI for the explicit purpose of developing a reference dataset against which to compare site data. Habitat types consistent with the IR Site 2 wetland and wetland ponds were sampled at CCSP during the RI.

As with the landfill portion of the site, several of the compounds determined to be potential risk drivers in the wetland portion of the site also were characterized in the wetland and/or open water portions of CCSP. Specifically, metals and pesticides, several of which were concluded by the risk assessments conducted for the wetland portion of the site to be potential risk drivers due to their presence in soil, also were characterized in soil from the CCSP wetland. Furthermore, several of the metals and pesticides determined to be potential risk drivers in surface and/or subsurface soil in the wetland portion of IR Site 2 were detected at consistent or even higher concentrations in soil from the CCSP wetland:

- **Wetland Surface Soils** – Mean detected concentrations of arsenic, chromium, copper, manganese, molybdenum, nickel, selenium, vanadium, zinc, dieldrin, and total DDx were higher in CCSP wetland soil compared to surface soil from the wetland portion of IR Site 2. In addition, the maximum detected concentrations of manganese, molybdenum, vanadium, and total DDx were higher in CCSP wetland soil compared to surface soil from the IR Site 2 wetland.

- **Wetland Subsurface Soils** – Mean detected concentrations of chromium, and vanadium were higher in CCSP wetland soil compared to subsurface soil from the wetland portion of IR Site 2. In addition, the maximum detected concentration of vanadium was higher in CCSP wetland soil compared subsurface soil from the IR Site 2 wetland.

Similarly, several of the metals and pesticides determined to be potential risk drivers in sediment in the wetland ponds at IR Site 2 were detected at consistent or even higher concentrations in sediment from the CCSP open water habitat:

- **North and South Pond Sediment** – Mean and maximum detected concentrations of arsenic, vanadium, *gamma*-chlordane, dieldrin, *trans*-nonachlor, and total DDx were higher in CCSP sediment compared to North and South Pond surface sediment in the open water habitat at IR Site 2. Note that dieldrin was not detected in South Pond sediments.

- **South Pond Sediment** – In addition to the chemicals listed in the previous bullet, the mean and maximum detected concentration of chromium, copper, lead, mercury, nickel, and zinc were higher in CCSP sediment compared to South Pond surface sediment at IR Site 2.

Accordingly, the environmental risk associated with the presence of these compounds in wetland soil and/or sediment at CCSP would be expected to be consistent with or even more elevated than the risk associated with the presence of these metals in soil and/or sediment in the wetland portion of IR Site 2. The relationship between risks associated with contaminants in the wetland portion of the site and ambient risks associated with some of these same compounds is an important one. Nevertheless, in this RI Report, no compounds identified as potential risk drivers through the human health and ecological risk assessments of the wetland portion of the site are discounted based on their concentrations and associated ambient risk at CCSP. However, the relationships between site and ambient risk will become an important consideration during the feasibility study and remedial design phases for IR Site 2.

Table 8-2 summarizes the findings of the human health and ecological risk assessments conducted for the wetland area of the site. This table was developed to clearly convey the pathways and receptors evaluated through the risk assessments for which individual compounds may pose an unacceptable environmental risk. The table also demonstrates those compounds for which environmental risk is likely similar or greater at CCSP relative to the IR Site 2 wetland and/or wetland ponds and for which the conclusion of potentially unacceptable risk is not supported by toxicity testing conducted during the RI.

8.2 Contaminant Fate and Transport

The presence of contamination at IR Site 2 was thoroughly evaluated through the implementation of the RI and the subsequent evaluation of historical and RI sampling data. Section 5.0 of this RI Report provides a comprehensive assessment of the nature and extent of contamination at IR Site 2 based on the RI data generated, data collected historically at the site, and available ambient/background data.

The following subsections describe the potential fate and movement of contamination at the site. Several mechanisms and processes that control the fate of contaminants at IR Site 2 are discussed, including both physical and chemical alteration, degradation, and mobilization/immobilization mechanisms. In addition, the primary modes of migration for contaminants identified at the site are summarized. The discussion below is limited to those classes of compounds and/or individual compounds that have been determined to be potential risk drivers at the site. The fate of environmental contaminants and modes of contaminant movement described ultimately explain the current presence and extent of contamination in various media at the site, and also describe specific processes that are responsible for the finding of potentially unacceptable human health and/or ecological risk at the site. These fate and transport mechanisms also describe the manner in which contaminants are likely to behave in the future and provide, in part, the basis for developing remediation goals and an ultimate remedial strategy.

8.2.1 Contaminant Alteration, Degradation, and Mobilization/Immobilization Mechanisms

8.2.1.1 Physical Processes

Hydrophobic, nonpolar organic contaminants such as PCBs and pesticides, as well as certain valence states or species of metals and other inorganic constituents such as radionuclides, tend to adsorb to solid matrix particles (i.e., soil or sediment). In large part, the adsorption of contaminants to solid matrix particles is controlled by the organic carbon content of the solid matrix, but also is related to the presence and contaminant-binding capacity of finer grain size particles (i.e., clays). The octanol-water partitioning coefficient (K_{ow}) of a compound is often used as a surrogate for the organic carbon partitioning coefficient (K_{oc}), and expresses the tendency of the compound to partition into the octanol phase of an octanol-water system. The octanol fraction of an octanol-water system can be considered as a representation of organic carbon in the solid matrix. As such, K_{ow} values can be used to estimate the tendency of a compound to preferentially adsorb to organic matter in the solid matrix. Compounds with higher K_{ow} values tend to more strongly sorb to solid matrix material. Soil and sediment with higher organic carbon content tends to have a higher capacity to adsorb contaminants. In addition, smaller grain sizes such as clays have higher capacities to adsorb contaminants through electrostatic interactions and natural binding capacities.

At IR Site 2, a significant number of the potential risk drivers concluded from the human health and ecological risk assessments are metals, PCBs, and pesticides, which have higher tendencies to adsorb to soil and/or sediment particles compared to more frequently solubilized and mobile compounds like VOCs. In addition, TOC concentrations were measured in soil and sediment at the site, and suggest that site soil and sediment have a relatively significant capacity to sorb contaminants. Generally, site soils are quite sandy, and therefore natural clay binding capacities would appear to play a lesser role in contaminant immobilization. However, a greater proportion of soil in the wetland area was of smaller particle size, and, in general, the majority of the contaminants responsible for potential risk at IR Site 2 tend to be fairly immobile given their tendency to sorb to solid matrix material and/or organic carbon.

Dissolution from a solid matrix into the aqueous phase can strongly influence the concentration of a constituent in groundwater or surface water. Dissolution into the aqueous matrix is controlled largely by a compound's aqueous solubility, which is a measure of the maximum mass of a compound that could be dissolved in a given volume of water. Compounds with solubilities less than 1 mg/L are generally considered insoluble, and compounds with solubilities greater than 10,000 mg/L are generally considered highly soluble. The compounds determined to be potential risk drivers at IR Site 2 generally have low aqueous solubilities, and therefore tend to not dissolve to a large extent into the aqueous matrix. In fact, only two individual compounds were determined to be potential risk drivers based on their concentrations in site groundwater (i.e., dieldrin in shallow wetland groundwater and total PCBs in shallow landfill groundwater were both determined to pose potential adverse risk to human health based on the potential direct contact exposure to groundwater pathway), and the concentrations of these compounds were actually quite low.

It should be noted that the presence of certain compounds can have an impact, either synergistic or antagonistic, on the sorption characteristics and/or solubility and mobility of other compounds. For instance, high concentrations of petroleum consituents can lead to an increase in the solubility of certain organic compounds (e.g., pesticides) that otherwise would be quite insoluble and immobile. Similarly, the presence of some metals (e.g., zinc) can increase the solubility and mobility of other metals (e.g., cadmium). Alternatively, some compounds (e.g., phosphates) can inhibit the solubility and mobility of metals. Based on the data generated at IR Site 2 through the RI, there is no evidence that such additive effects are responsible to any significant degree for altering the typical sorption/dissolution properties of site contaminants.

Volatilization from the aqueous phase can transform an aqueous contaminant into an airborne contaminant. The volatilization of a compound is controlled by its vapor pressure and Henry's law constant (H). Generally, vapor pressures greater than 1 mm Hg indicate volatility, and vapor pressures between 0.001 and 1 mm Hg indicate semi-volatility. Vapor pressures less than 0.001 mm Hg suggest that a compound is not volatile. It should be noted that these general rules for characterizing the volatility of a compound on the basis of vapor pressure do not necessarily correlate to laboratory classifications (i.e., in some instances, a compound assessed using analytical SVOC methodologies might be volatile, whereas a compound assessed using analytical VOC methodologies might actually be only semivolatile). Henry's law constants describe the tendency of a compound to volatilize from an aqueous solution, and higher constants tend to describe compounds that more readily volatilize. Contaminants also can be volatilized in the unsaturated zone directly from the solid matrix. At IR Site 2, very few of the potential risk drivers determined from the human health and ecological risk assessments are considered in any way volatile. In fact, only one compound in the landfill portion of the site was found to pose any potential adverse risk due to its potential to volatilize and subsequently be inhaled. This compound, naphthalene, is actually considered an SVOC on the basis of analytical classification.

Erosion of surface soil can expose and potentially mobilize contaminants, or accelerate processes that otherwise affect contaminants (e.g., removing soil cover could accelerate the degree to which precipitation encounters contamination). Erosion can occur from precipitation and overland runoff, wind action, and tidal forces. At IR Site 2, observations of the site do not suggest that surface soils are eroded to any large extent by wind forces or precipitation and overland runoff. In addition, although the site is surrounded on the west and south by San Francisco Bay, a riprap/stone seawall is present between the site and the bay that buffers the site against any aggressive action from waves or tides. As such, it does not appear that tidal forces are responsible for any significant erosional effect on the site.

Radioactive decay can be responsible for depleting sources of radioactive material. Two radionuclides were determined to be potential risk drivers at IR Site 2, namely Ra-226 and Ra-228 in landfill and wetland soil. Through radioactive decay, radionuclides are sequentially altered to other elemental structures, some of which can still be radioactive, and ultimately transformed to non-radioactive decay products. Ra-226 has a half life of approximately 1,600 years, while Ra-228 has a half life of approximately 6 years. Radium decays into radon gas, and ultimately to stable elemental lead.

8.2.1.2 Biological Processes

Biological degradation can lead to destruction of some environmental contaminants. Oxidation is the means by which heterotrophic organisms acquire energy for growth. Under appropriate conditions, metals and organic compounds can serve as terminal electron acceptors in the oxidation process of indigenous bacteria, and therefore can be degraded or transformed to more inert products or otherwise immobilized in the oxidation pathway. Cometabolism is a process where organisms degrade a substrate fortuitously while consuming another substrate as an energy source. Organisms do not derive any energy specifically from the cometabolized substrate. Certain compounds are more likely to be cometabolized in the environment (e.g., highly chlorinated VOCs or petroleum hydrocarbons), but pesticides are a compound class that can undergo cometabolic degradation. In addition, fungi have been shown to be capable of mediating the degradation of various organic contaminants, including pesticides and PCBs, through enzymatic peroxidation, and some plants are known to be capable of sequestering contaminants. The specific occurrence of biodegradation pathways has not been closely evaluated at IR Site 2, but several of the contaminants determined to be potential risk drivers are known to be degraded through various biodegradation pathways.

8.2.2 Contaminant Migration

Many factors affect the migration of contaminants in the environment. This section describes the primary contaminant migration pathways for the contaminants identified as potential risk drivers that should be considered in the risk management decision-making phase. The potential migration pathways are described separately for the landfill and wetland portions of the site.

8.2.2.1 Landfill

Contaminants originating in the landfill portion of the site could migrate through mass movement or redistribution of the solid matrix. For instance, contaminants in surface soils could migrate to other portions of the landfill, the wetland, the wetland ponds, or offshore during erosional events caused by precipitation and overland transport, tidal forces, or wind energy. As discussed above, none of these erosional forces appear to play a substantial role at IR Site 2. As such, it would not be expected that surface contaminants in any portion of the landfill would migrate to any substantial degree to any other portion of the site directly through erosion and transport of the solid matrix. Over the course of time, however, this migration pathway could play a more substantial role in the movement of contamination, as very small mass movements due to surface water erosion or wind action could cumulatively act to transport some amount of contamination. In addition, surface soils in the landfill portion of the site appear to largely be fill soil used to cover historical waste material. As such, the surface horizon at the landfill tends to be less contaminated in general than subsurface soil intervals.

Contamination originating in the landfill portion of the site could be transported in the dissolved phase in overland runoff generated by precipitation. The local topography of the site is generally sloped from landfill to wetland. In addition, the berms that surround the site and divide the landfill and wetland represent more localized topographic highs. Incident precipitation could cause contamination to leach (i.e., dissolve) into the aqueous phase, creating a pathway to transport dissolved contaminants from location to location, including from the landfill to the wetland, or from the landfill directly to the San Francisco Bay where the landfill is immediately bounded by the bay. Given that precipitation and overland runoff is typically an episodic and short duration event, particularly in the local climate of the site where the majority of precipitation occurs over the course of a few months, this pathway is not likely to be a significant means of transporting contamination at the site. In addition, as indicated above, the surface horizon at the landfill tends to be less contaminated than subsurface soil intervals.

Contaminants associated with buried landfill waste could be dissolved by infiltrating precipitation and fluctuating groundwater. The volume of waste in the landfill area is extensive, and trenching completed during the RI indicates that the soil cover is thin in places and that the waste layer intersects groundwater across the landfill. The nature of the waste material is variable, and both the contaminants present in common municipal waste and the types of industrial and operational wastes known to have been disposed at the landfill represent potentially significant sources for contamination in groundwater. Data summarized in Section 5.0 of this RI Report show that certain compounds are present in groundwater in areas that can be defined as plumes. However, the concentrations of these compounds are low, and the plumes are defined more on the basis of low-level spatial presence than widespread occurrence of high concentrations. For instance, benzene appears to occur in a plume in the central to southeastern portion of the site, but maximum concentrations are localized and on the order of 10 to 20 μg/L. A separate small plume of benzene appears to be present in the northwestern portion of the site, but only over a very limited area and with a maximum concentration of approximately 8 μg/L. Overall, the data evaluated during the RI do not suggest that high-concentration localized contaminant hotspots or source areas are present at the landfill, and the data generated historically and through the RI do not suggest that groundwater beneath the landfill is highly impacted by potential contaminants leaching from the landfill waste mass.

Volatilization is a mechanism that could transport certain contaminants in the vapor phase and into shallow subsurface or ambient air at the site. Volatilization is controlled by the physicochemical properties of various compounds, and is most likely to be significant for highly volatile contaminants. By transporting contaminants from a source phase to the vapor phase, volatilization effectively depletes contaminants from the source phase. Given the shallow depth to groundwater in the landfill portion of the site, source phases for volatilization of contaminants could be both soil and groundwater. The majority of the contaminants at the site are considered semivolatile or nonvolatile. Specifically, metals and radionuclides are considered nonvolatile, and pesticides, PCBs, and PCDDs/PCDFs are generally considered to be nonvolatile or only marginally volatile. SVOCs are considered somewhat volatile. VOCs are the category of contaminants most likely to be of significance in the volatilization pathway. VOCs were detected in the shallow subsurface and in shallow groundwater in the landfill portion of the site, but none were determined to be potential risk drivers in the inhalation pathway. Rather, the only compound determined to pose potentially unacceptable risk in the landfill area through the inhalation pathway was naphthalene, an SVOC, which was evaluated using a screening-level assessment in the HHRA (Section 6.0) that considered a conservative residential exposure scenario.

Contaminants dissolved in groundwater beneath the landfill could migrate according to typical advective and dispersive forces. For the most part, advective and dispersive movement of groundwater contaminants is most significant for compounds with relatively high aqueous solubilities, and least significant for compounds that tend to not dissolve readily in groundwater. The compounds found to be potential risk drivers in the landfill portion of the site are generally not highly soluble and tend to preferentially sorb to solid matrix material rather than dissolve in groundwater. General groundwater flow is from the landfill towards the San Francisco Bay in the northern portion of the landfill, and from the landfill towards the wetland in the central and southern portions of the landfill, although local variability exists in the direction of groundwater flow (see Section 2.0 of this RI Report for a more detailed discussion of site hydrogeology). As such, there is the possibility that shallow groundwater from the landfill portion of the site could impact groundwater beneath the wetland or surface water in San Francisco Bay. In addition, given local topography at the site and the geomorphology of the wetland ponds, there is also the potential that groundwater originating beneath the landfill portion of the site could discharge directly to surface water in the ponds. As supported by the RI data, the presence of a confining unit (i.e., the BSU/Young Bay Mud aquiclude/aquitard) between the FWBZ and SWBZ acts to minimize the potential downward movement of contamination. The regionally continuous Yerba Buena Mud confining unit beneath the site further protects the deep aquifer beneath Alameda Point. Overall, based on the data collected and evaluated in this RI Report, no significant impacts appear to exist in IR Site 2 groundwater, and only a very limited number of compounds in shallow groundwater are responsible for any form of potentially adverse risk.

The offshore portions of Alameda Point, including surface water and sediment in San Francisco Bay immediately surrounding IR Site 2, are being characterized through an extensive but separate investigation program undertaken by the Navy. That characterization effort has to date generated data from sediment and surface water sampling locations immediately adjacent to IR Site 2, none of which have exhibited evidence of environmental impairment related to groundwater discharge from the landfill. Additional characterization is ongoing through the offshore assessment program, and any findings of contamination or risk in San Francisco Bay sediment or surface water will be addressed appropriately, either through that program or in conjunction with remedial planning for IR Site 2. Information from the offshore assessment program will incorporated into the IR Site 2 process as necessary, and in communication with regulators. In addition, a slurry wall was constructed at the site between 1983 and 1985 to impede groundwater flow from the landfill to the Bay (see Section 2.0). Groundwater sampling data from shallow groundwater beneath the wetland do not suggest significant transport of chemical contaminants from the landfill and impairment of groundwater quality beneath the wetland. Furthermore, surface water quality in the wetland ponds is not significantly degraded, and surface water data do not appear to suggest a significant contribution of contamination from shallow landfill groundwater. Lastly, the site is underlain by the BSU, which effectively controls the potential migration of groundwater contaminants to deeper aquifer units.

8.2.2.2 Wetland

Contaminants originating in the wetland portion of the site could migrate through mass movement or redistribution of the solid matrix. Contaminants in wetland surface soils or sediment could migrate to other portions of the wetland, the wetland ponds, or San Francisco Bay during erosional events caused by precipitation and overland transport, tidal forces, or wind energy. As discussed above, none of these erosional forces appear to play a substantial role at IR Site 2. As such, it would not be expected that surface contaminants in any portion of the wetland would migrate to any substantial degree to any other portion of the site directly through erosion and transport of soil or sediment. Over the course of time, this migration pathway could play a more substantial role in the movement of contamination, as very small mass movements due to surface water erosion or wind action could cumulatively act to transport some amount of contamination. In addition, data generated during the RI for surface soils and sediment in the wetland portion of the site demonstrate that these media are not substantially contaminated. For the most part, contaminants in these media were detected at concentrations consistent with ambient and/or background values and below applicable benchmarks used as reasonable points of comparison.

Contamination originating in the wetland portion of the site could be transported in the dissolved phase in overland runoff generated by precipitation. The local topography of the site is generally sloped from landfill to wetland, and within the wetland, generally towards the ponds. In addition, the berms that surround the site and divide the landfill and wetland represent more localized topographic highs. Incident precipitation could cause contamination to leach (i.e., dissolve) into the aqueous phase, creating a pathway to transport dissolved contaminants from location to location, including from the wetland to the wetland ponds, or from the wetland directly to the San Francisco Bay where the wetland is immediately bounded by the bay or in the area where a culvert connects the North Pond to the bay. Given that precipitation and overland runoff is typically an episodic and short duration event, particularly in the local climate of the site where the majority of precipitation occurs over the course of a few months, this pathway is not likely to be a significant means of transporting contamination at the site. In addition, as indicated above, the surface horizon at the wetland tends to be relatively uncontaminated. A similar mechanism that could transport contamination in the wetland portion of the site is seasonal variability in the degree of inundation of the wetland ponds. As pond water levels rise, sediments surrounding the ponds could become increasingly saturated and contaminants could be leached from the sediments into surface water. Given the relatively uncontaminated nature of the wetland pond sediments, this pathway is not likely to be very significant, and would not likely act to transport contamination beyond the very limited pond environment.

Contaminants associated with waste buried in the wetland could be dissolved by infiltrating precipitation and fluctuating groundwater. The specific volume of waste in the wetland area is not known, but is likely to be insignificant compared to the volume of waste present in the landfill portion of the site. The nature of the waste material potentially present in the wetland is limited to metallic debris and dredged material from other Alameda Point locations. The types of wastes potentially disposed in the wetland represent limited sources for contamination in groundwater. However, data generated historically and through the RI do not suggest that groundwater beneath the wetland is highly impacted by contaminants leaching from a considerable waste mass.

Volatilization is a mechanism that could transport certain contaminants in the vapor phase and into shallow subsurface or ambient air at the site. As described above, volatilization is controlled by various physicochemical properties of various compounds, and is most likely to be significant for highly volatile contaminants. By transporting contaminants from a source phase to the vapor phase, volatilization effectively depletes contaminants from the source phase. Given the shallow depth to groundwater in the wetland portion of the site, source phases for volatilization of contaminants could be both soil and groundwater. The contaminants determined to be potential risk drivers at the site are generally considered semivolatile or nonvolatile. Specifically, metals and radionuclides are considered nonvolatile, and pesticides, PCBs, and PCDDs/PCDFs are generally considered to be nonvolatile or only marginally volatile. SVOCs are considered somewhat volatile. VOCs are the category of contaminants most likely to be of significance in the volatilization pathway. VOCs were detected in the shallow subsurface and in groundwater in the wetland portion of the site, but none were determined to be potential risk drivers in the inhalation pathway. Rather, the only compound determined to potentially pose unacceptable risk in the inhalation pathway was naphthalene, an SVOC, and this compound was found to be a potential concern only for the landfill portion of the site.

As with the landfill portion of the site, contaminants dissolved in groundwater beneath the wetland could migrate according to typical advective and dispersive forces. The majority of the compounds found to be potential risk drivers in the wetland portion of the site are not highly soluble and tend to preferentially sorb to solid matrix material rather than dissolve in groundwater. General groundwater flow in the wetland portion of the site is from the wetland towards the San Francisco Bay (see Section 2.0 of this RI Report for a more detailed discussion of site hydrogeology). As such, there is the possibility that shallow groundwater from the wetland portion of the site could impact surface water in San Francisco Bay. In addition, given local topography at the site and the geomorphology of the wetland ponds, there is also the potential that groundwater originating beneath the wetland portion of the site could discharge directly to surface water in the ponds. As supported by the RI data, the presence of a confining unit (i.e., the BSU/Young Bay Mud aquiclude/aquitard) between the FWBZ and SWBZ acts to minimize the potential downward movement of contamination in groundwater. The regionally continuous Yerba Buena Mud confining unit beneath the site further protects the deep aquifer beneath Alameda Point. Overall, based on the data collected and evaluated in this RI Report, no significant impacts appear to exist in IR Site 2 groundwater, and only a very limited number of compounds in shallow groundwater are responsible for any form of potentially adverse risk.

As described above, the offshore portions of Alameda Point, including surface water and sediment in San Francisco Bay immediately surrounding IR Site 2, are being characterized through an extensive but separate investigation program. That characterization effort has to date generated data from sediment and surface water sampling locations immediately adjacent to IR Site 2, none of which have exhibited evidence of environmental impairment related to groundwater discharge from IR Site 2. Additional characterization is ongoing through the offshore assessment program, and any findings of contamination or risk in San Francisco Bay sediment or surface water will be addressed appropriately, either through that program or in conjunction with remedial planning for IR Site 2. Information from the offshore assessment program will be incorporated into the IR Site 2 process as necessary, and in communication with regulators. In addition, surface water quality in the wetland ponds is not significantly degraded, and surface water data do not appear to suggest a significant contribution of contamination from shallow groundwater. Furthermore, the site is underlain by the BSU, which effectively controls the potential migration of groundwater contaminants to deeper aquifer units.

Contaminants present in wetland pond surface water could migrate to shallow groundwater beneath the wetland or directly to San Francisco Bay surface water, particularly given the direct connection between the North Pond and the bay via a pipe culvert. There is no evidence that suggests that surface water in the wetland ponds is significantly impaired, and, as indicated above, the ongoing characterization of the offshore environment around IR Site 2 has not generated data that would suggest the site is adversely impacting bay sediment or surface water.

8.3 General Occurrence and Persistence of Contamination

Many of the compounds determined to be potential risk drivers at IR Site 2 are fairly ubiquitous in the environment. Metals, which are derived from all common geologic formations and several of which are essential nutrients, are generally detected at substantial concentrations in environmental media at all sites under investigation. In addition, mercury specifically is known to occur naturally in geologic formations in the San Francisco Bay region at relatively high concentrations, and naturally occurring mercury has been linked to the closure of municipal drinking water supply wells in the area. As described in Section 5.0 of this RI Report, the concentrations of many metals detected in various media at IR Site 2 were generally consistent with ambient concentrations detected at the project reference area, CCSP. In some cases, concentrations of metals detected at CCSP were actually higher than those detected at the site. However, significantly elevated concentrations of certain metallic environmental contaminants, such as lead, are not necessarily easily explained in this fashion. SVOCs also are generally considered highly ubiquitous in the environment, and are common components of most urban fill material. Similar to metals, concentrations of certain SVOCs detected at CCSP were consistent with or even higher than concentrations detected in site media. Other potential risk drivers, including PCBs, pesticides, and PCDDs/PCDFs, are also generally considered relatively ubiquitous in the environment, and occur at appreciable concentrations in many locations due simply to diffuse pollution from urban and industrial output. However, significantly elevated concentrations of certain SVOCs, PCBs, pesticides, and PCDDs/PCDFs in IR Site 2 media are not necessarily easily explained as ubiquitous environmental contaminants. Graphics (i.e., bubble and box and whisker plots) showing the distribution of contaminants at IR Site 2 and the relationships between concentrations of potential risk drivers at the site compared to ambient concentrations detected at CCSP are provided in Appendices F and H, respectively. No compounds concluded to be potential risk drivers through the human health and ecological risk assessments of various media and pathways at the site are discounted based on their concentrations and associated ambient risk at CCSP or their general environmental ubiquity. However, the possibility that an ambient source or a ubiquitous environmental condition is responsible for certain constituents should and will be taken into consideration when making risk management decisions regarding the need to remediate IR Site 2 based on the presence and extent of these constituents.

The types of environmental contaminants determined to be potential risk drivers at IR Site 2 are generally considered to be persistent, as they tend to be less readily dissolved and less likely to pass through an aquifer system compared to highly soluble compounds like many VOCs. In addition, the potenial risk drivers identified at IR Site 2 tend to strongly sorb to solid matrix material and not migrate as significantly as other contaminants. Also, although degradation mechanisms exist that could ultimately reduce concentrations of the potential risk drivers at IR Site 2, the existence and extent of these mechanisms are currently not fully understood at the site and are not used as the basis to discount any compound(s) identified as contributing to site risk.

8.4 Summary

The human health and ecological risk assessments completed for various environmental media and pathways of potential concern concluded that several compounds are potential risk drivers at IR Site 2. The contaminants determined to be potential risk drivers include several metals, SVOCs, pesticides, PCBs, radionuclides, and PCDDs/PCDFs. Many physical and chemical processes control the ultimate fate of these contaminants in the environment, including binding/complexation reactions, physical decay, and degradation processes. For the most part, the contaminants responsible for potential risk at IR Site 2 are relatively insoluble, tending to remain sorbed to solid matrix material and not preferentially entering the dissolved groundwater or surface water phase.

As described in Section 5.0 of this RI Report, there generally do not appear to be significant discrete contamination source areas, but rather a widespread, diffuse pattern of contaminant occurrence primarily throughout the landfill area of the site. Several mechanisms of contaminant migration are potentially important at the site. These mechanisms, which include direct movement of contamination in solid matrix material, dissolution and movement in overland runoff, dissolution and movement in groundwater, volatilization, and movement in the surface water system, represent not only the most likely modes of contaminant transport in the future, but also the most likely explanations for the current presence and distribution of contamination in environmental media at the site following cessation of historical site operations. Given the relatively limited degree of physical stress on environmental media at the site (e.g., wind, tidal, and precipitation-related erosional forces), the most important mechanisms of contaminant transport are likely the static distribution of contaminants, the dissolution of contaminants from landfill waste material, and the potential movement of dissolved-phase contamination with advective and dispersive groundwater flow.

Several characteristics of the site appear to be responsible for mitigating to some extent the overall environmental impairment observed at the site and the likelihood of extensive additional impairment in the future. Waste in some areas of the landfill appears to generally already be covered by at least some thickness of cover soil (ranging from approximately 4 inches to 3.5 ft), meaning direct exposure to landfill waste at the surface is currently not an issue across the entire landfill. Groundwater migration to deeper aquifer zones is mitigated effectively by the presence of the BSU/Young Bay Mud and the Yerba Buena Mud in the subsurface beneath the site. In addition, a slurry wall exists along some portion of the western site boundary, and historically was installed specifically to control the potential off-site migration of contaminated groundwater.

9.0: SUMMARY AND CONCLUSIONS

IR Site 2 is located in the far southwestern corner of Alameda Point, and was used as the primary landfill for base-related wastes from 1956 until 1978. Waste was placed throughout the northern and eastern areas of the landfill and reportedly in limited parts of the wetlands. It is estimated that the landfill received up to 1.6 million tons of general base garbage (e.g., general household waste, food waste, and paper products) throughout its operation as the main disposal location for Alameda Point. In addition, waste chemical drums, solvents, oily waste and sludge, paint waste, plating waste, industrial strippers and cleaners, acids, mercury, PCB-containing liquids, batteries, low-level radiological waste from radium dials and dial paints, scrap metal, inert ordnance, asbestos, pesticides (solid and liquid), tear gas agent, biological waste, creosote, dredge spoils, and waste medicines and reagents reportedly were disposed of at the site. Historical disposal methods at the site generally consisted of trench and fill operations. Several discrete areas have been identified at the landfill where specific waste types may have been disposed, including oily liquids, pesticides, drums, and asbestos.

Between 1983 and 1985, the Navy completed closure activities at the IR Site 2 landfill in accordance with specific regulatory requirements (i.e., San Francisco RWQCB Resolutions No. 77-7 and No. 83-35). Those activities included placing a partial clay-soil cover, installing an 820-ft-long, 2-ft-wide, and 20- to 30-ft-deep slurry wall to restrict potential contaminant migration to San Francisco Bay, installing a gas venting system, and completing repairs to the seawall surrounding the site. In 1984, closure activities were discontinued, and in 1986 the Navy spread imported soil material on the landfill, graded the landfill to eliminate depressions that could yield ponding during precipitation events, and constructed an earthen perimeter levee around the landfill.

Numerous investigative activities have been completed historically at IR Site 2 to determine the type and extent of contamination and to study ecological health at the site. These activities include:

- Phases 1 and 2A SWAT activities conducted in 1990;
- Phases 5 and 6 SWAT activities conducted in 1991;
- An ecological assessment conducted in 1993;
- WET analysis conducted in 1993;
- Field activities conducted in support of an ecological assessment in 1994 and 1995;
- Radiological surveys conducted from 1995 to 1999;
- Supplemental ecological investigations conducted in 1996 and 1997;
- Regular groundwater monitoring conducted beginning in 1991;
- Biological sampling conducted in support of an ecological risk assessment in 1998;
- An OEW survey and removal action conducted in 2002 and 2003; and
- Geotechnical and seismic evaluations conducted in 2002 and 2003.

A comprehensive RI was implemented at the site during two seasonal sampling events in 2004 and 2005 to address data gaps from these previous investigations and to generate a robust site-specific database related to the overall nature and extent of contamination at IR Site 2. To develop a fully representative dataset of environmental conditions at IR Site 2 during the RI, soil, groundwater, and tissue were sampled in the landfill portion of the site and soil, groundwater, sediment, surface water, and tissue were sampled in the wetland portion of the site. One round of sampling was completed during the dry season of 2004 (October 2004) and a second round of sampling was completed during the wet season of 2005 (March

2005). During the dry season, the vast majority of surface and subsurface soil sampling was completed, as water levels were at or near their annual low. During the wet season, tissue sampling was conducted, as the use of the site by ecological receptors was at or near its peak. The wet season also was the appropriate time to conduct necessary toxicity and bioaccumulation assays, to collect additional data to assess temporal variability in certain environmental media (i.e., surface water in the wetland ponds) with respect to the dry season data, and to collect additional soil and groundwater samples to fill minor data gaps identified in the dry season dataset. In general, data were generated from areas within the footprint of the landfill and within the inundated and non-inundated portions of the wetlands, areas that had largely been uncharacterized during historical investigations. Reference/background data also were generated both at Alameda Point and at portions of CCSP with characteristics similar to the site but not affected by site activities or potential site-related contamination to aid in distinguishing impacts at IR Site 2 from ambient environmental conditions. Over the course of the RI, hundreds of individual samples of various environmental media were collected, providing thorough coverage of the site and its distinct habitat types.

A geophysical survey implemented at IR Site 2 prior to invasive sampling revealed that cover soil in the landfill is underlain by material with a widespread and diffuse pattern of electromagnetic response indicative of historically disposed waste. The wetland portion of the site appears to be largely free of such waste. Although the geophysical surveying did indicate potentially significant volumes of waste in several of the discrete areas presumed to have received specific waste types (e.g., drums or oil), the survey could not conclusively determine that any particular waste type is in fact present, and generally did not indicate that these discrete areas contained a greater or lesser amount of waste material compared to the overall widespread condition observed at the site. Limited exploratory trenching conducted in the landfill portion of the site confirmed the presence of waste material in the subsurface. A wide variety of waste and debris was encountered during the trenching process, including glass, plastic, metal, wood, canvas, paper, concrete, rubber, cable, boots, Styrofoam, carpeting, and fabric. No OEW, drums, cylinders, radiological waste, or other characteristically hazardous materials were identified during the trenching operations.

Numerous compound classes were analyzed for in samples of various environmental media at IR Site 2 and the selected reference locations, including metals, VOCs, PCBs, pesticides, SVOCs/PAHs, PCDDs/PCDFs, explosives, radionuclides, and petroleum hydrocarbons. In combination with appropriate and usable historical data, the RI site characterization data were evaluated to assess the overall nature and extent of contamination at IR Site 2. Appropriate statistical and graphical methods were employed to complete this assessment. A number of individual compounds were detected in the various media sampled at IR Site 2. Many compounds were detected in media at IR Site 2 at concentrations very similar to or even lower than concentrations of these compounds detected in the ambient environment, suggesting that the site and historical operations at the site are not a likely source of these compounds. Alternatively, a number of other individual compounds were detected in media at IR Site 2 at concentrations significantly higher than concentrations of these compounds in the ambient environment, suggesting that the site and historical operations conducted at the site are potentially a source for these contaminants.

The presence of contaminants is relatively widespread in the landfill. Overall, subsurface soil appears more highly impacted compared to surface soil, and the landfill appears more highly impacted than the wetland portion of the site. Data indicate that groundwater at the site is not substantially impacted by contamination. Geologic conditions at the site, which include a generally continuous hydrogeologic confining unit below the shallowest groundwater zone and a deeper confining unit that isolates the deeper aquifer system beneath Alameda Point, further mitigate the potential for widespread groundwater impacts. In addition, although there is some evidence of variability in the nature and extent of contamination in the wetland ponds between seasons and also between ponds, the ponds do not appear to be substantially impacted by the presence of contamination. Certain individual compounds detected in media at IR Site 2 appear to be present in localized hotspots. For instance, lead was detected in soil at two locations at the site at concentrations markedly higher than all other locations. Also, certain VOCs in groundwater appear to demonstrate at least some type of plume behavior. However, with the exception of a fairly limited number of compounds in the various environmental media assessed at the site, the data do not suggest clear source areas or contaminant hotspots but rather a widespread and diffuse occurrence of contaminants.

A HHRA was implemented to evaluate the potential for adverse human health effects from exposure to contaminants at the site. In accordance with guidance from U.S. EPA, the Navy, and DTSC, the HHRA for IR Site 2 was performed using a tiered process. The first tier was a screening-level assessment that included the development of a preliminary CSM focusing on potential pathways between site contamination sources and humans, identification of contaminants of potential concern, and a screening-level assessment of contaminant exposure and human health effects. The second tier was a baseline assessment that formulated specific exposure scenarios, defined specific exposure assumptions, and more thoroughly screened contaminants of potential concern. In the baseline assessment, exposures and effects were modeled for a number of specific endpoints determined to most conservatively represent the potential risk to humans, and human health risks were quantified for each of these endpoints.

The HHRA determined a limited list of potential risk drivers to one or more human receptors in the landfill and wetland portions of the site. Specifically, the HHRA concluded that one metal (arsenic), several SVOCs/PAHs (benzo(a)pyrene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and naphthalene), two pesticides (dieldrin and *delta*-HCH), total PCBs, PCDDs/PCDFs, and two radionuclides (Ra-226 and Ra-228) are potential risk drivers to at least one human receptor class evaluated in the landfill and/or wetland. Risks from these compounds were determined to be related to their presence in surface soils, subsurface soils, groundwater, and/or surface water. Specific pathways found to be of potential concern during the HHRA of the landfill and wetland include direct dermal contact with surface soil, shallow groundwater, or surface water, incidental ingestion of surface soil, inhalation of vapors from surface or subsurface soil, and exposure to external radiation from surface or subsurface soil. The human receptor classes evaluated during the HHRA for the site included park ranger/tour guide, park ranger/restoration supervisor, site visitor, and construction/excavation worker.

In addition, an ERA was conducted to evaluate the potential for adverse effects to ecological receptors through exposure to contaminants at the site. Following guidance from the U.S. EPA and the Navy, the ecological risk assessment for IR Site 2 also was performed using a tiered process. The first tier was a screening-level assessment that included the development of a preliminary CSM focusing on potential pathways between site contamination sources and ecological receptors and the natural environment, identification of contaminants of potential ecological concern, and a screening-level dose response assessment. The second tier was a baseline assessment that formulated specific exposure scenarios, defined specific exposure assumptions, and more thoroughly screened contaminants of potential ecological concern. In the baseline assessment, exposures and effects were modeled for a number of specific endpoints, and ecological risks were quantified for each of these endpoints.

The ERA concluded that several metals (antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, vanadium, and zinc), several SVOCs/PAHs (acenaphthene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, total LPAHs, and total HPAHs), total PCBs, several pesticides (*alpha*-chlordane, dieldrin, *gamma*-chlordane, *trans*-nonachlor, and total DDx), and PCDDs/PCDFs should be considered as potential risk drivers based on risk findings for one or more ecological receptor (i.e., mammals, birds, terrestrial or aquatic invertebrates, and/or plants) in the landfill, wetland, and/or wetland pond portions of the site (benthic invertebrates, water column invertebrates and fish were excluded as potential risk drivers based on the results of relevant site-specific bioassays). Of these compounds, chromium, lead, mercury, nickel, total HPAHs, and total DDx were identified as the most significant risk contributors (i.e., exhibit the highest HQs) for various portions of the site. Contaminants were evaluated based on surface soil sampling data for mammals, birds, and terrestrial invertebrates. For plants, contaminants were evaluated based on surface and subsurface soil sampling data. For the wetland ponds, contaminants were evaluated based on surface water and sediment sampling data for all receptors.

Several of the compounds determined to be potential risk drivers at IR Site 2 also were characterized in reference media at CCSP. Moreover, several of the compounds determined to be potential risk drivers at IR Site 2 were found at highly consistent or even higher concentrations in media at CCSP. Specifically:

- Mean detected concentrations of arsenic, chromium, copper, lead, manganese, nickel, vanadium, benzo(a)pyrene and benzo(k)fluoranthene were higher in CCSP upland soil compared to surface soil from the IR Site 2 landfill.

- Maximum detected concentrations of chromium, manganese, nickel, vanadium, benzo[a]pyrene and benzo[k]fluoranthene were higher in CCSP upland soil compared to surface soil from the IR Site 2 landfill.

- Mean and maximum concentrations of nickel and vanadium were higher in CCSP upland soil compared to subsurface soil from the landfill portion of IR Site 2.

- Mean detected concentrations of arsenic, chromium, copper, manganese, molybdenum, nickel, selenium, vanadium, zinc, dieldrin, and total DDx were higher in CCSP wetland soil compared to surface soil from the wetland portion of IR Site 2.

- Maximum detected concentrations of manganese, molybdenum, vanadium, and total DDx were higher in CCSP wetland soil compared to surface soil from the IR Site 2 wetland.

- Mean detected concentrations of chromium and vanadium were higher in CCSP wetland soil compared to subsurface soil from the wetland portion of IR Site 2.

- The maximum detected concentration of vanadium was higher in CCSP wetland soil compared to subsurface soil from the IR Site 2 wetland.

- Mean and maximum detected concentrations of arsenic, vanadium, *gamma*-chlordane, dieldrin, *trans*-nonachlor, and total DDx were higher in CCSP sediment compared to North and South Pond surface sediment (dieldrin was not detected in South Pond sediments).

- Mean and maximum detected concentrations of chromium, copper, lead, mercury, nickel, and zinc were higher in CCSP sediment compared to South Pond surface sediment.

Accordingly, the environmental risk associated with the presence of these compounds in media at CCSP would be expected to be consistent with or even higher than the risk associated with the presence of these compounds in media at IR Site 2.

Furthermore, it should be noted that both unfiltered and filtered aliquots were generated for most aqueous samples collected during the RI. However, in developing the human health risk assessment, only data from the unfiltered samples were used. Given that aqueous samples were collected from temporary well points and shallow surface water bodies, a significant amount of entrained turbidity was generally present in the samples. Given the tendency of contaminants like PCBs, PCDDs/ PCDFs, and metals to remain sorbed to solid matrix material, it is possible that conclusions regarding the risk posed by contaminants in shallow groundwater or surface water are overly conservative. Nevertheless, no compounds concluded to be potential risk drivers through the human health assessments were discounted based on their concentrations and associated ambient risk at CCSP, or the bias associated with the use of turbid water samples.

Many physical and chemical processes control the ultimate fate of the IR Site 2 potential risk drivers in the environment, including binding/complexation reactions, physical decay mechanisms, and degradation processes. Several mechanisms of contaminant migration are potentially important at the site. These mechanisms, which include direct movement of contamination in solid matrix material, dissolution and movement in overland runoff, dissolution and movement in groundwater, volatilization, and movement in the surface water system, represent not only the most likely modes of contaminant transport in the future, but also the most likely explanations for the current presence and distribution of contamination in environmental media at the site following cessation of historical site operations. The most important mechanisms of contaminant transport at IR Site 2 are likely the static distribution of contaminants and the dissolution of contaminants from landfill waste material and movement of dissolved-phase contamination with advective and dispersive groundwater flow. However, for the most part, the contaminants determined to be potential risk drivers at IR Site 2 are relatively insoluble and tend to remain sorbed to solid matrix material and not preferentially enter the dissolved phase.

Given the magnitude of the RI implemented at IR Site 2 and the sheer volume of information presented in this RI Report, the Navy has not gone beyond describing the nature and extent of site contamination and developing appropriate human health and ecological risk assessments to identify specific compounds identified as potential risk drivers, and therefore that should be considered in the risk management phase. The next stages for IR Site 2 will be the development of remediation goals, the assessment of suitable remediation strategies, the selection of an appropriate remediation plan, the development of a remedial design, and, ultimately, the implementation of a site remedy. As such, upon finalization of the RI Report, the Navy will develop a thorough remediation feasibility study that will include the definition of remediation goals, the establishment of a required remediation footprint, and the evaluation of remedial strategies.

The feasibility study will thoroughly consider all appropriate risk management requirements within the context of the calculated site risks, the types of contaminants responsible for risk, the distribution of potential risk drivers in the environment, and proposed site redevelopment plans. Risk inputs to the FS will be considered in light of key sources of uncertainty identified in the HHRA and ERA. These uncertainties are directly relevant to the utility of the conclusions of the risk assessments in a risk-management decisions making context; therefore, the uncertainties should be considered prior to and during the risk management phase. Among the various sources of uncertainty identified in this report, uncertainty regarding the appropriate definition of background (or ambient) condition is one of the most important sources of uncertainty potentially requiring further consideration. In a number of places in this report concentrations of site-associated constituents are compared to ambient or background concentrations to put risk, or nature of contamination findings into perspective. Due to the common use of conservatism to mitigate uncertainty when developing risk assessments, findings of potentially unacceptable risk at or below background concentrations are common. As previously discussed, constituents have not been removed from further consideration based on comparisons to ambient or background concentrations, but any remedial options considered in subsequent phases of assessment must consider ambient or background sources in the context of the potential for re-contamination following any remediation efforts.

In accordance with conceptual plans prepared by the ARRA (the local reuse authority for all property conveyance, planning, and reuse implementation at Alameda Point), the anticipated future use for IR Site 2 is recreational. Ultimately, it is anticipated that the site would maintain some limited human presence, and that visitors would be allowed controlled access to the site. During the feasibility study, consideration will be given to site characteristics that appear to be responsible for mitigating to some extent the overall environmental impairment observed at the site and the likelihood of extensive additional impairment in the future. For instance, waste in some areas of the landfill is covered already by at least some thickness of fill cover, meaning that, generally, direct exposure to landfill waste at the surface is currently not an issue across the landfill. In addition, groundwater migration to deeper aquifer zones is controlled effectively by the presence of the BSU in the subsurface beneath the site, and a slurry wall installed specifically to control the potential off-site migration of contaminated groundwater exists along some portion of the western site boundary. Based on the planned future use and ultimate resolution of ambient/background contributions, it is anticipated that a presumptive remedy approach (i.e., landfill capping) would be effective at mitigating any unacceptable risks that are present at the site, and the Navy looks forward to evaluating this alternative among other potentially acceptable alternatives during the Feasibility Study phase of the project.

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FINAL

REMEDIAL INVESTIGATION REPORT
IR SITE 2, WEST BEACH LANDFILL AND WETLANDS
ALAMEDA POINT, CALIFORNIA

VOLUME II

Contract No. N68711-01-D-6009
Task Order No. 0007
Project No. G601507

Prepared for:

Base Realignment and Closure
Program Management Office West
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June 23, 2006

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FIGURES

TABLES

APPENDICES (provided on CD-ROM)

SECTION 2.0
FIGURES

FINAL
REMEDIAL INVESTIGATION REPORT
IR SITE 2, WEST BEACH LANDFILL AND WETLANDS

DATED 23 JUNE 2006

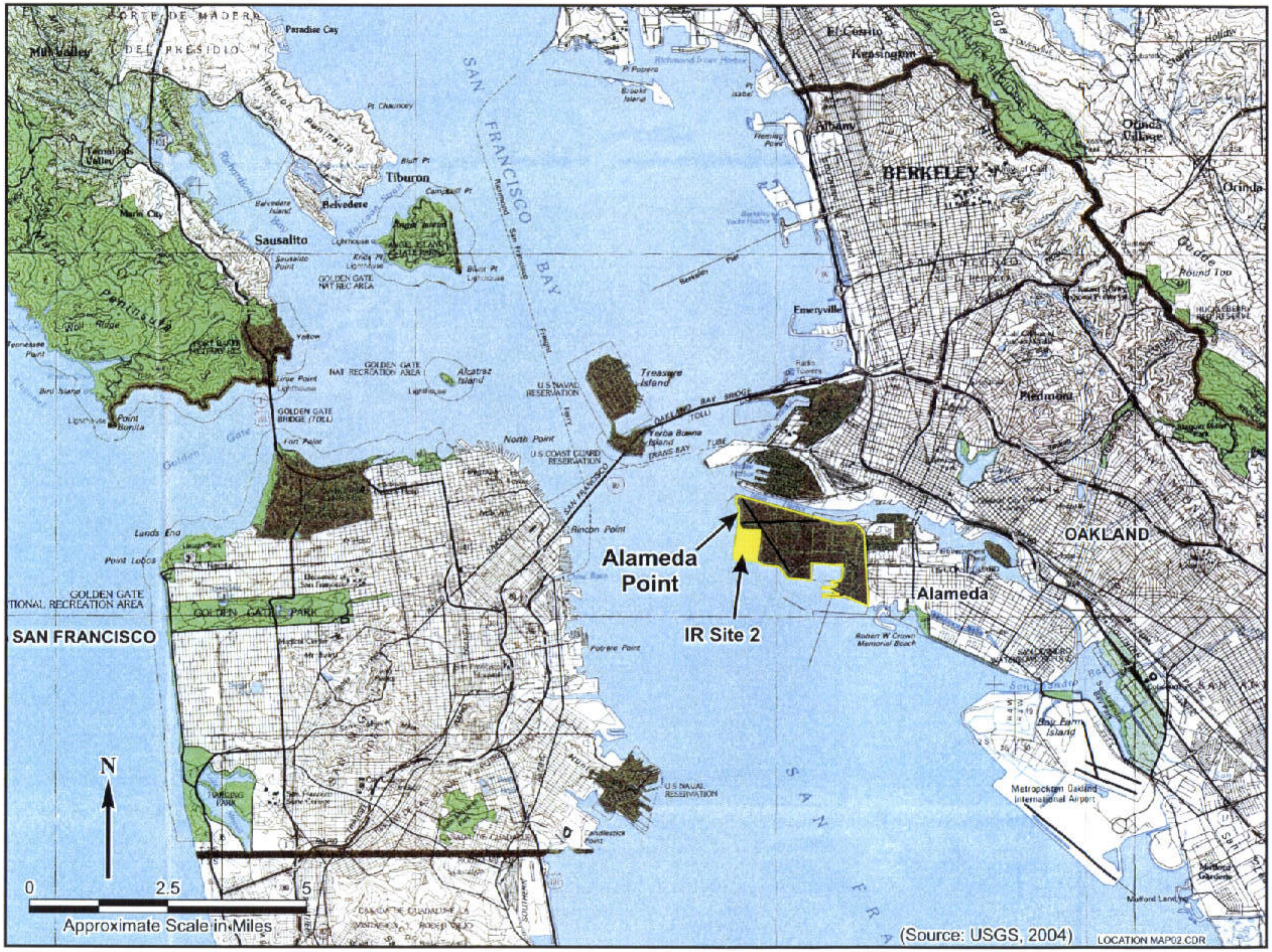

Figure 2-1. Location Map of Alameda Point and IR Site 2

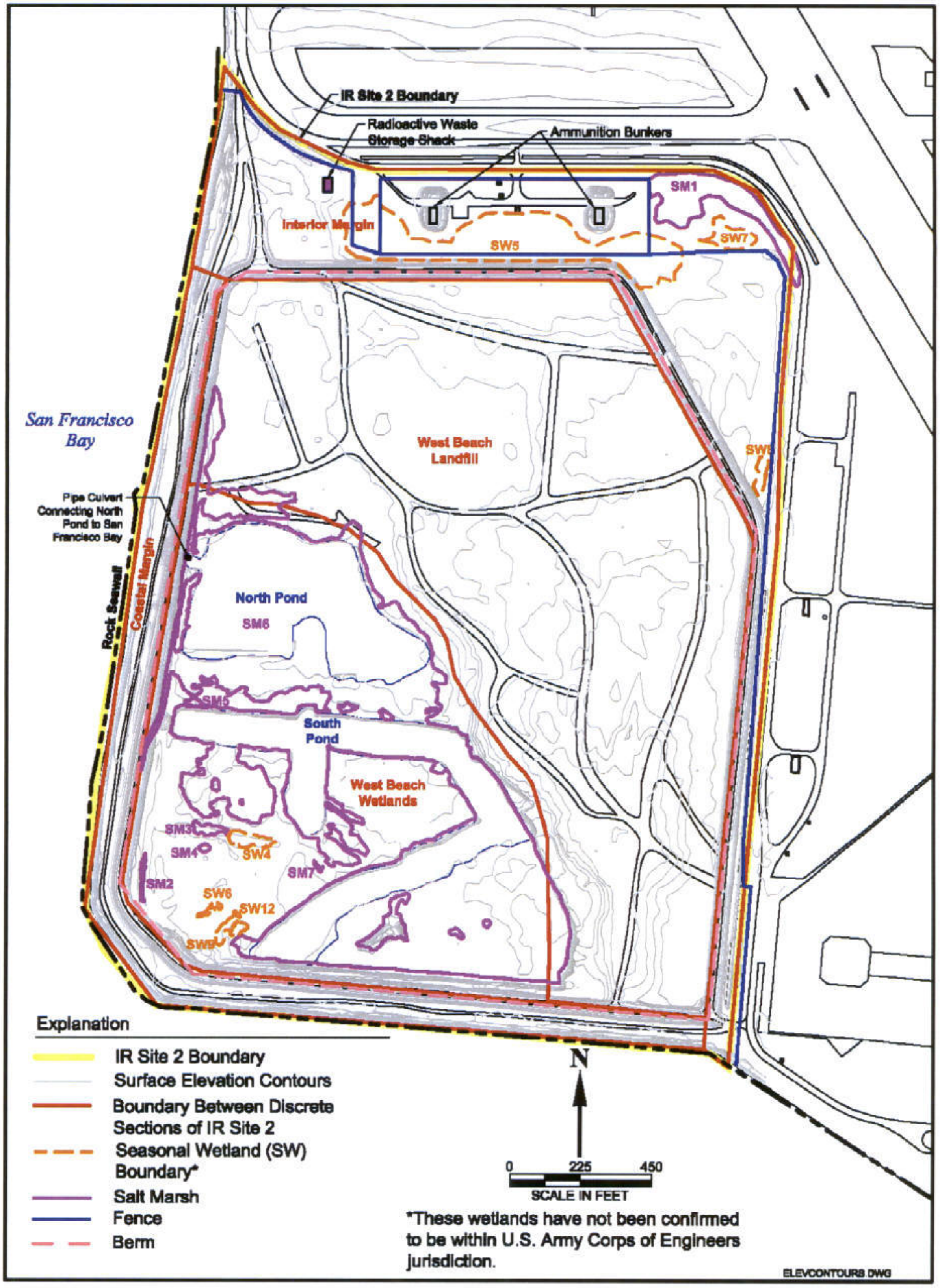

Figure 2-2. Site Map of IR Site 2

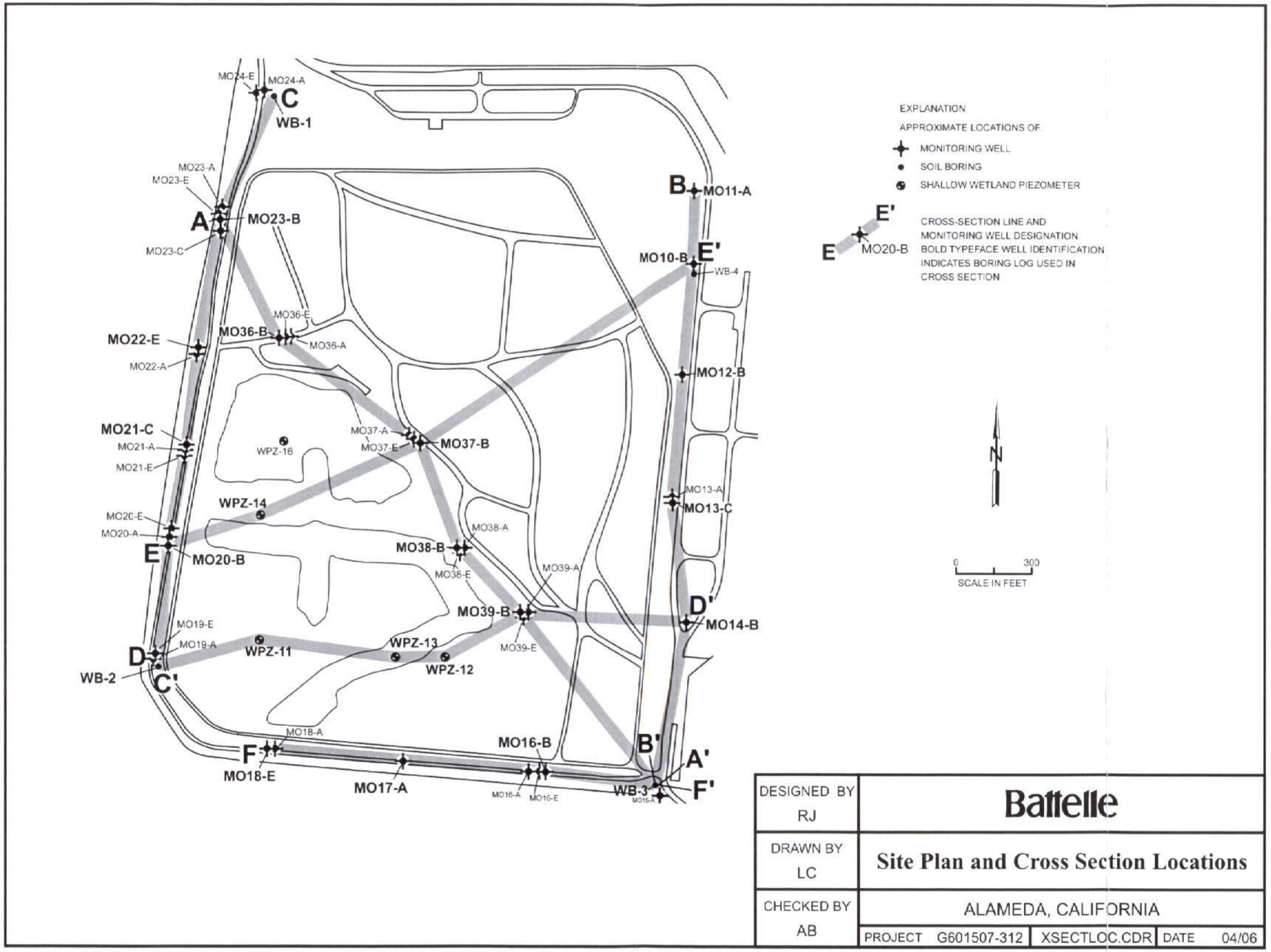

Figure 2-3. IR Site 2 Geologic Cross-Section Plan Map

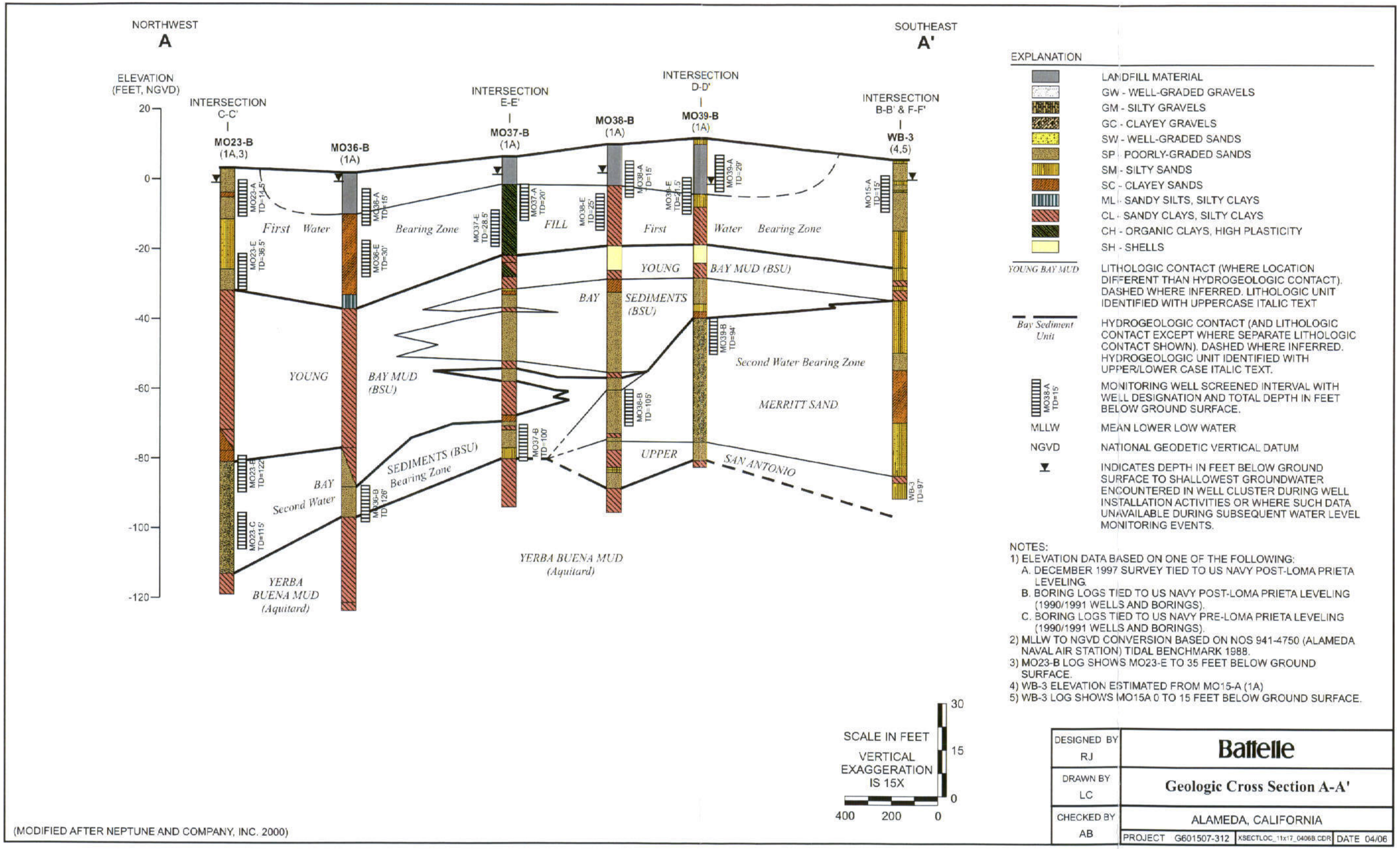

Figure 2-4. IR Site 2 Geologic Cross-Section A-A′

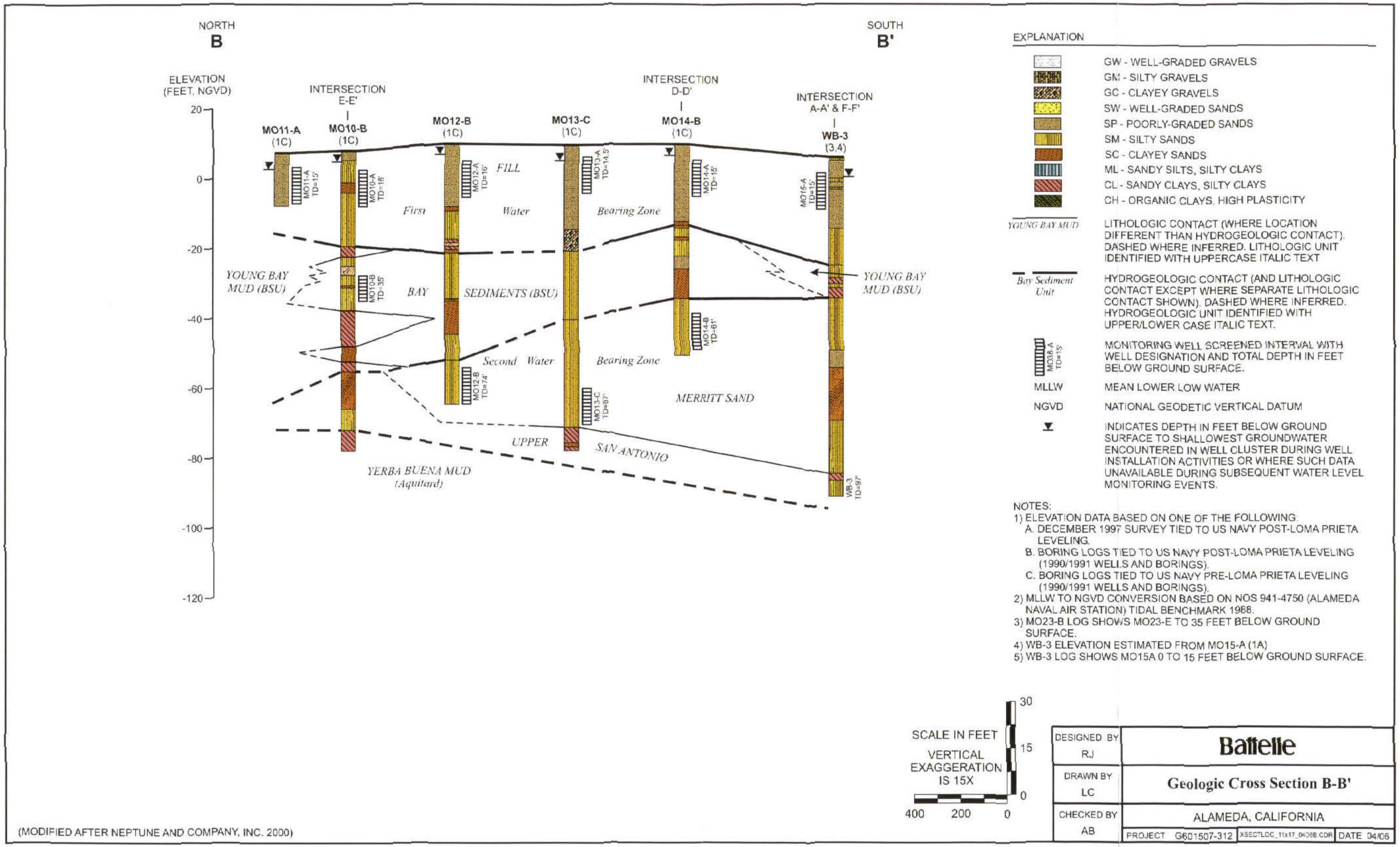

Figure 2-5. IR Site 2 Geologic Cross-Section B-B′

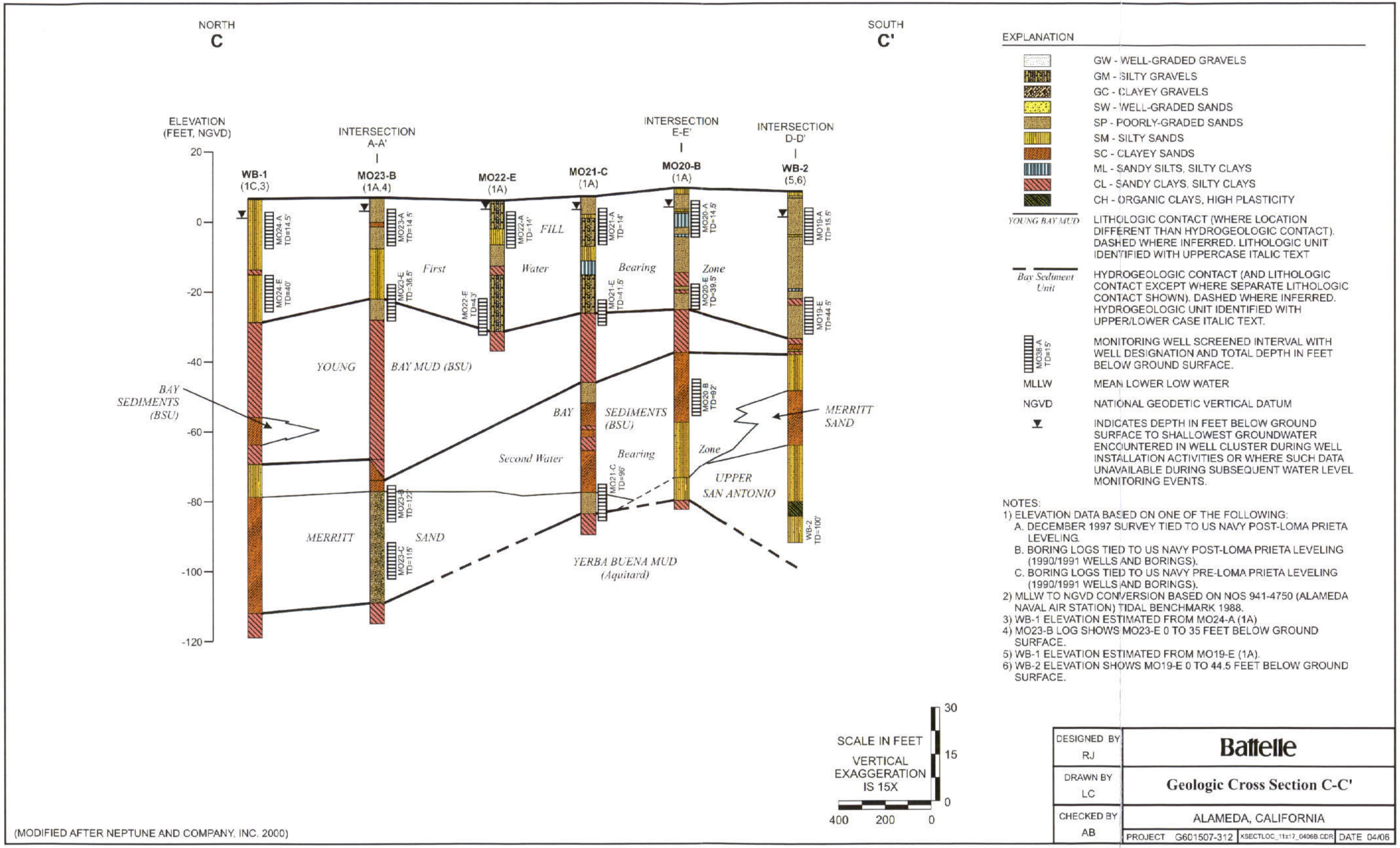

Figure 2-6. IR Site 2 Geologic Cross-Section C-C′

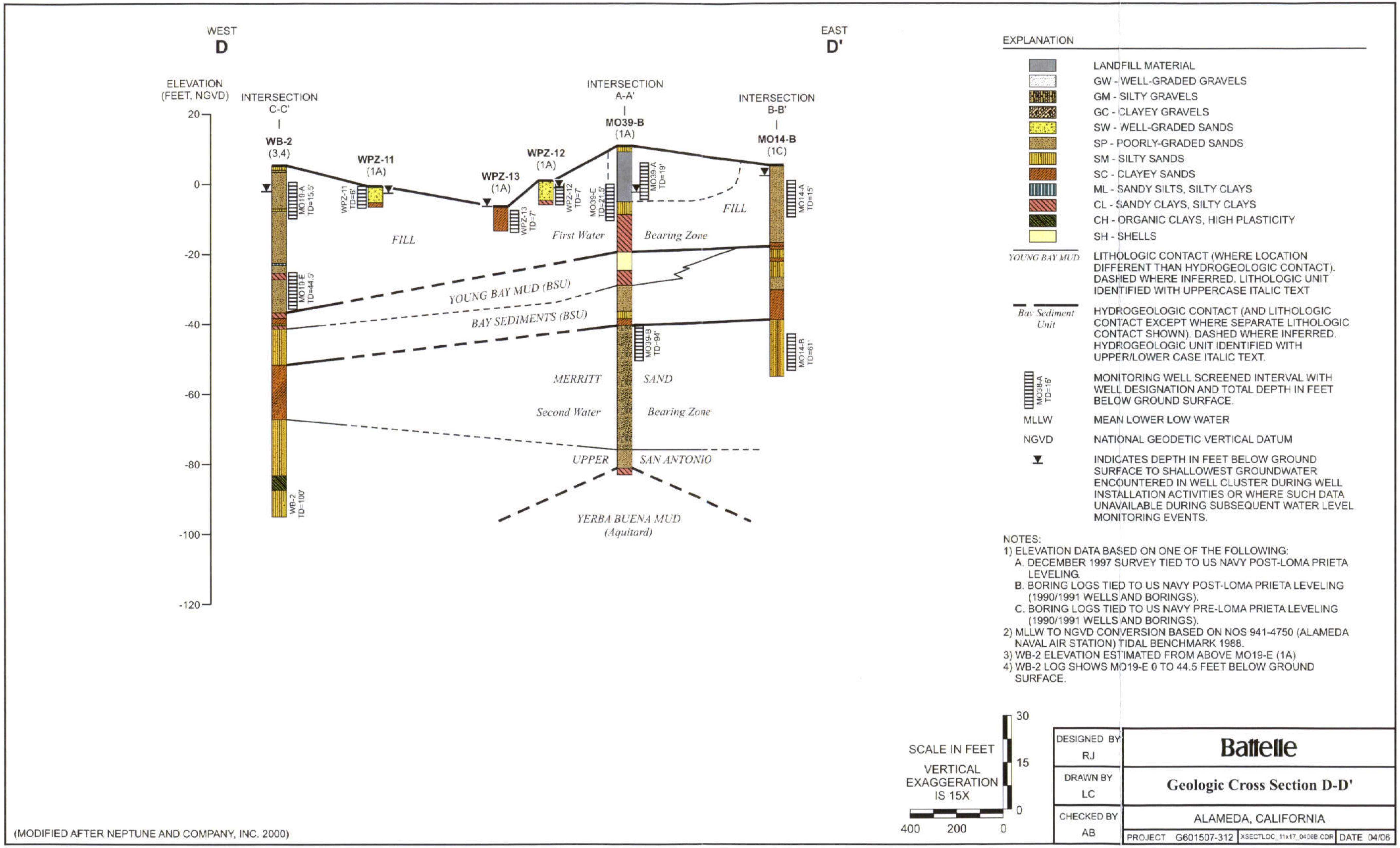

Figure 2-7. IR Site 2 Geologic Cross-Section D-D′

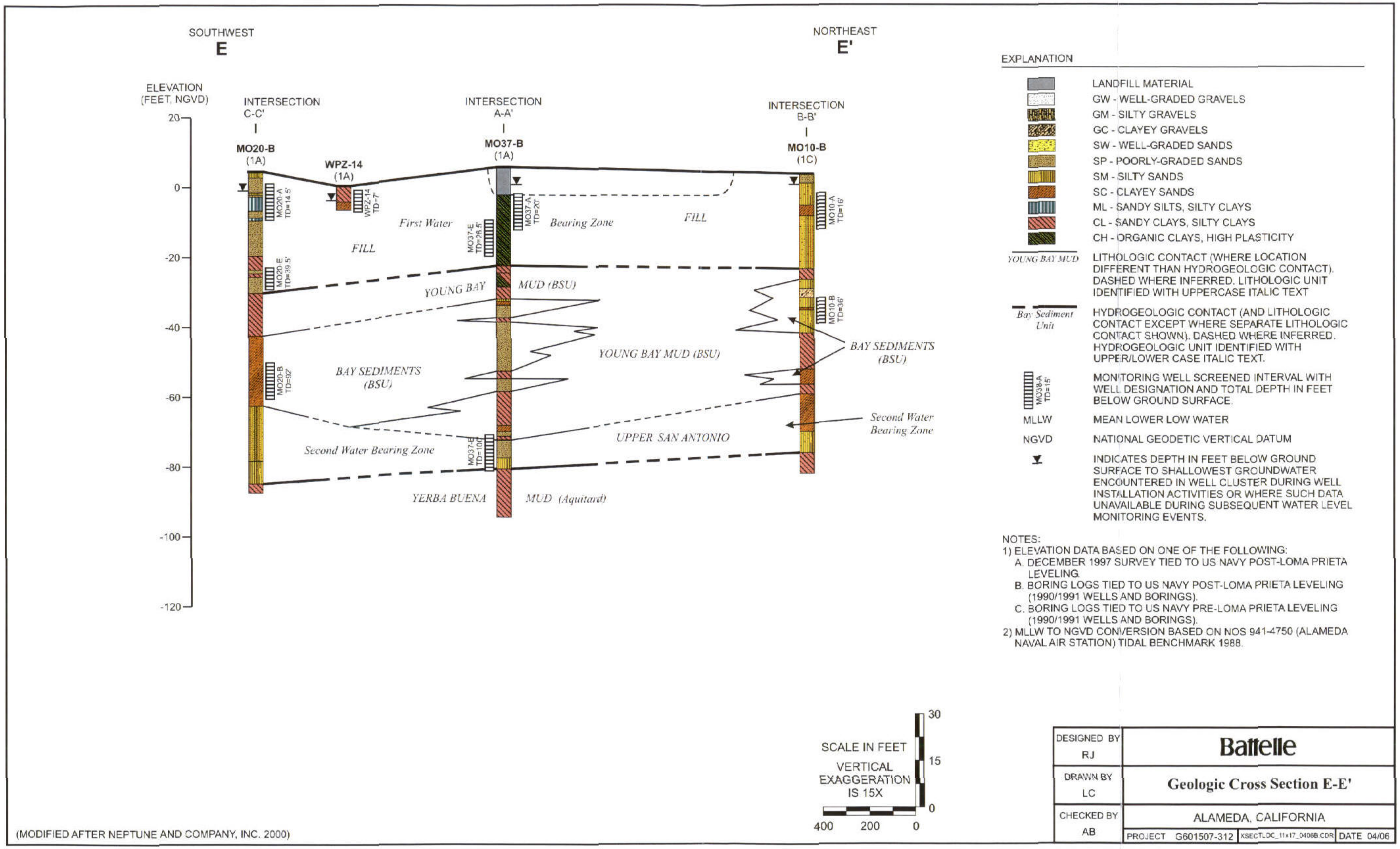

Figure 2-8. IR Site 2 Geologic Cross-Section E-E′

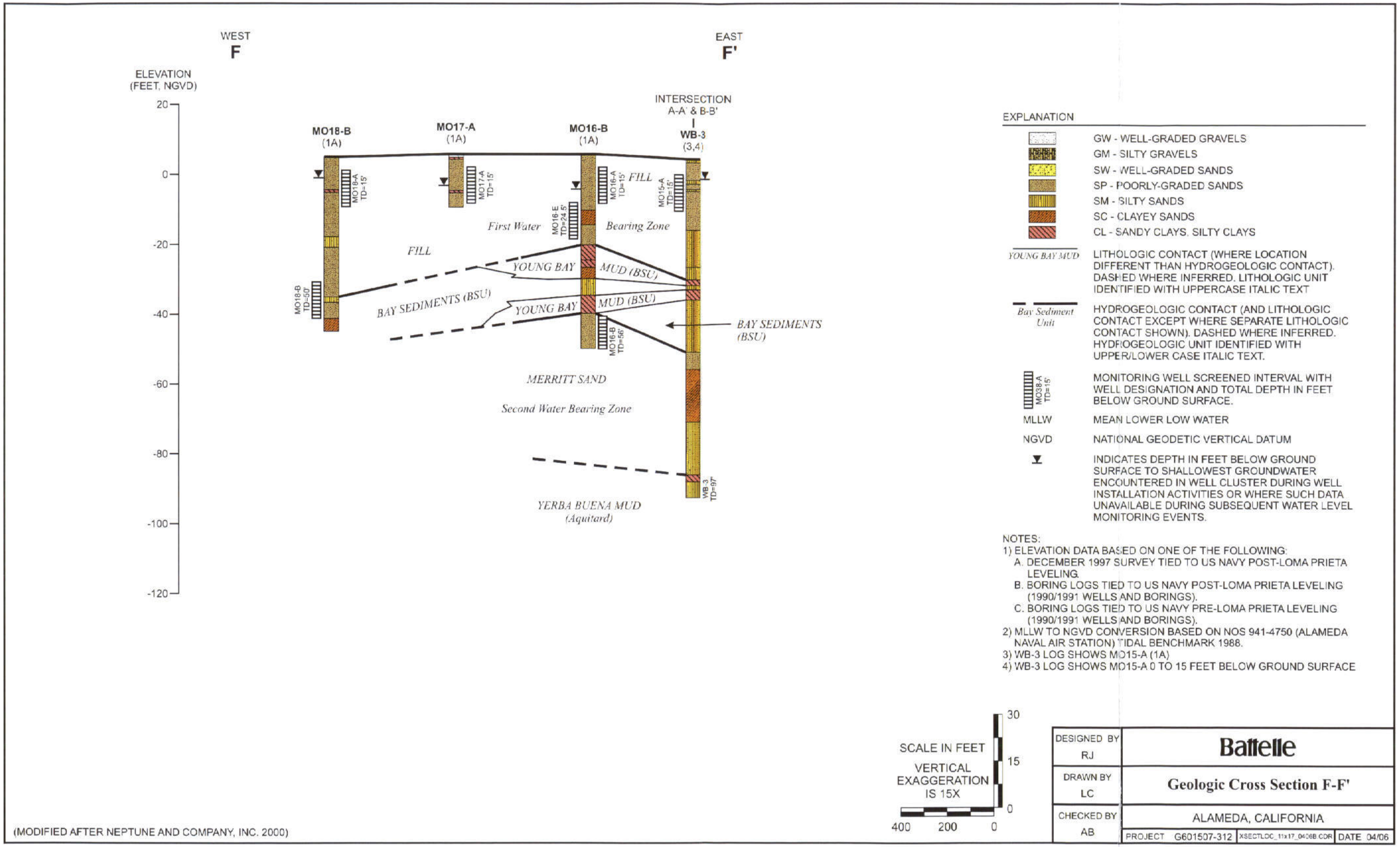

Figure 2-9. IR Site 2 Geologic Cross-Section F-F′

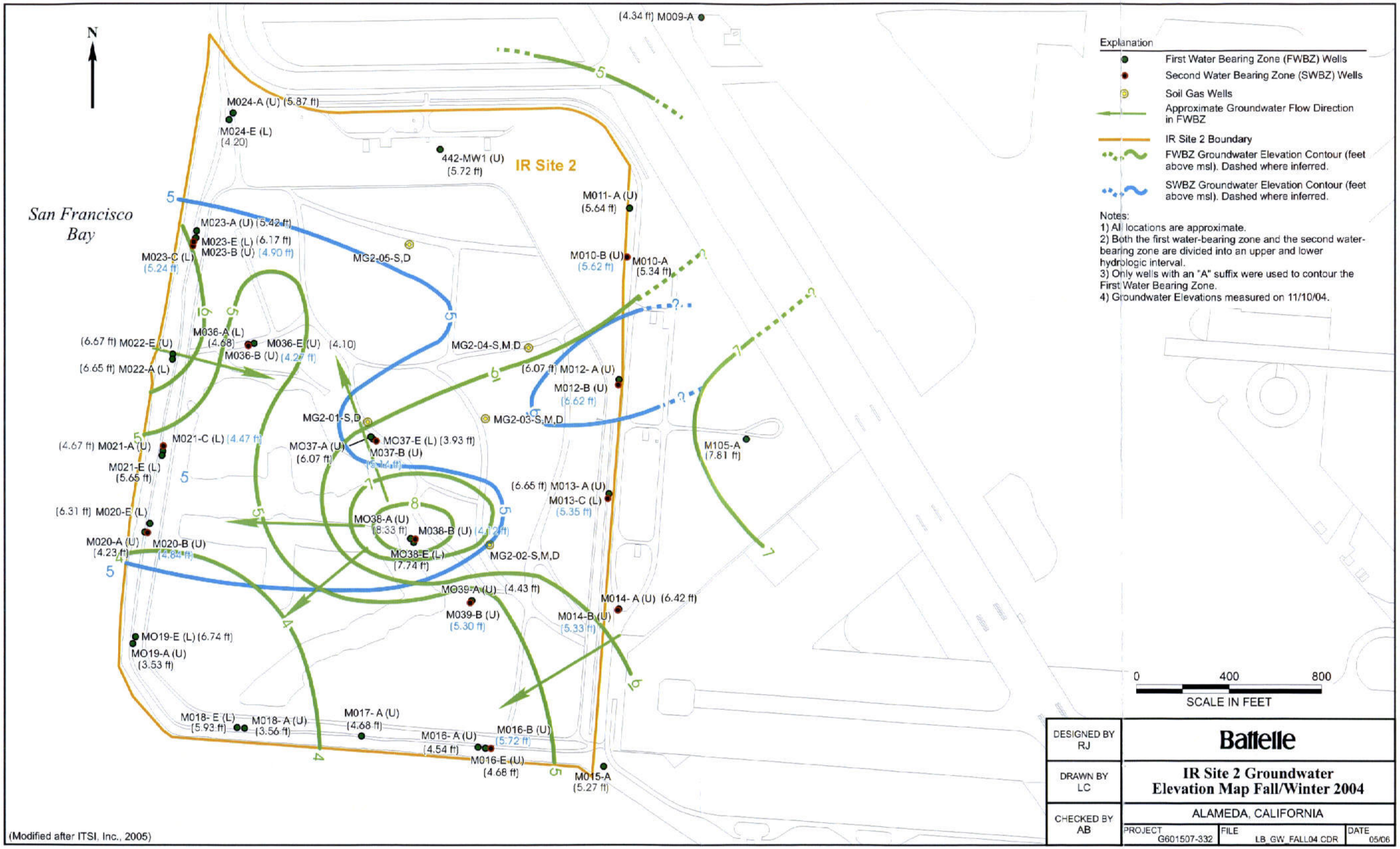

Figure 2-10. Groundwater Elevation Map for IR Site 2

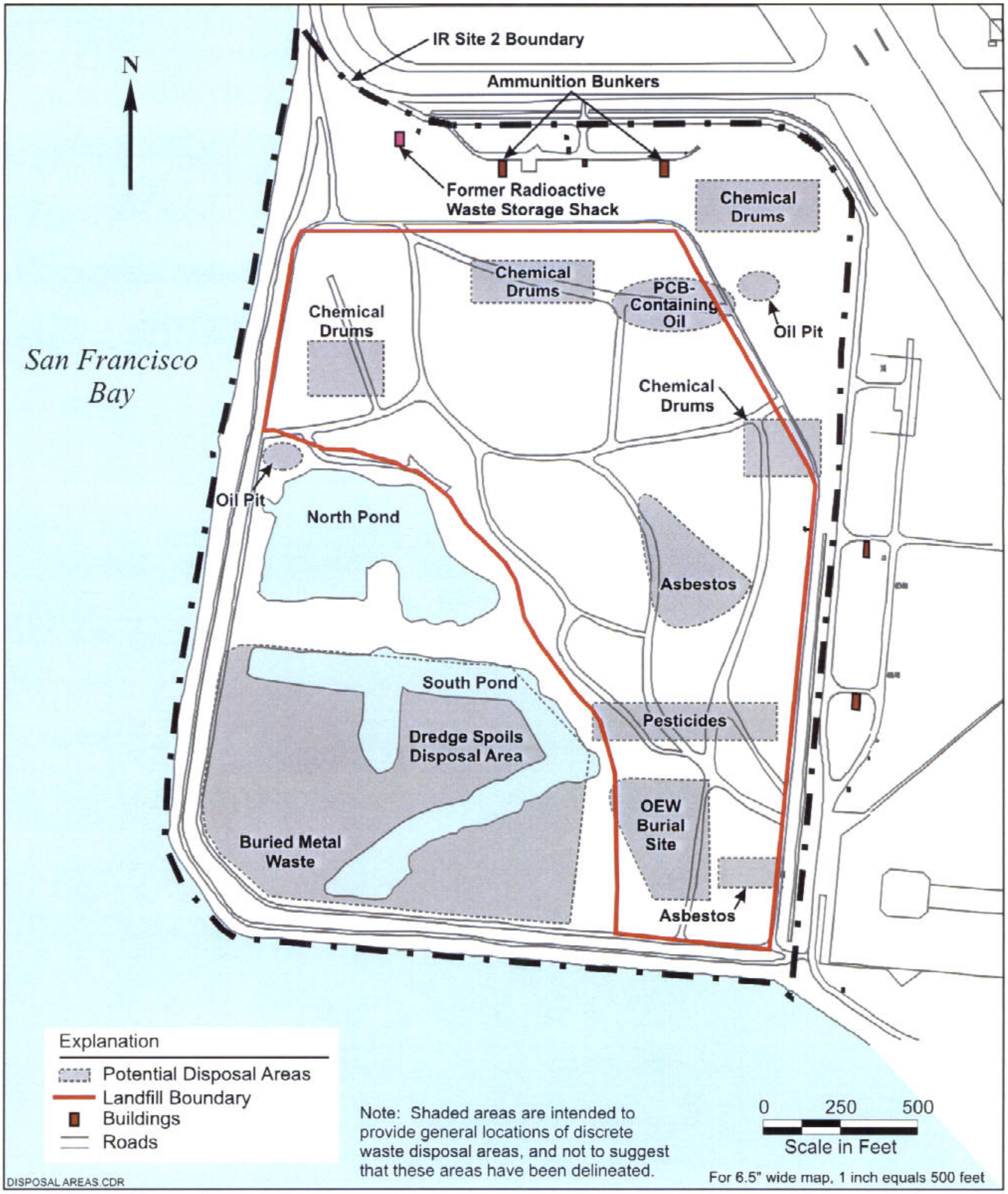

Figure 2-11. Approximate Locations of Waste Disposal Areas Identified During the IAS

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SECTION 2.0
FIGURES

FINAL
REMEDIAL INVESTIGATION REPORT
IR SITE 2, WEST BEACH LANDFILL AND WETLANDS

DATED 23 JUNE 2006

Table 2-1. Reference Summary for Ecological Resources at IR Site 2

Type of Data	Primary Source	Secondary Source
Species lists for plants, invertebrates, fish, amphibians, reptiles, birds and mammals	multiple - see below	PRC, 1996b
Plant and avian species observations	HRG, 1993a	PRC, 1996b (Appendix G)
Plant, bird and mammal species observed	PRC, 1995	PRC, 1996b (Appendix G)
Benthic invertebrates observed	PRC, 1993	PRC, 1994
Fish, amphibian, reptile, bird and mammal species observed	Feeney and Collins, 1993	PRC, 1996b (Appendix G)
Waterfowl observed	Bailey and Collins, 1993	Feeney and Collins, 1993
Amphibian, reptile, bird, and mammal species observed	PRC, 1994	PRC, 1996b (Appendix G)
Avian species observed	Morrison et al., 1992	PRC, 1996b (Appendix G)
Wetland delineation	HRG, 1993b	PRC, 1994 (Appendix F) and TTFW, 2004
Delineation of jurisdictional wetlands and nesting bird survey (of proposed excavation area - not whole site)	FWEC, 2003	NA
Fish observed	PRC, 1996a	NA
Bat survey	Constantine, 1996	NA
Tissue collection for plants, fish, small mammals - conducted in 1997	Data collection activities for the RI by TtEMI; data unpublished	NA
Plant and avian species observed	TtEMI, 1998a	NA
Plant species observed	TTFW, 2004	NA

NA = not applicable.

Table 2-2. Mammalian Species Observed at IR Site 2

Common Name	Scientific Name	Observed in 1997[a]	Special Status?	SF Bay Resident	Primary Habitat	Secondary Habitat	Breeding	Feeding Guild[b]
Long-Tailed Weasel	*Mustela frenata*			Y	u		Yes	c
Domestic Rabbit	*Oryctolagus cuniculus*	7/4		Y	u		Yes	h
Black-Tailed Hare	*Lepus californicus*	52/10		Y	u	w	Yes	h
Botta Pocket Gopher	*Thomomys bottae*			Y	u		Yes	h
California Ground Squirrel	*Spermophilus beecheyi*	35/8		Y	u		Yes	o
Raccoon	*Procyon lotor*			Y	u	w	Yes	o
Striped Skunk	*Mephitis mephitis*			Y	u	w	Yes	o
House Cat	*Felis domesticus*			Y	u	u	Yes	o
Red Fox	*Vulpes vulpes*			Y	w	u	Yes	c
Norway Rat	*Rattus norvegicus*			Y	bw		Yes	o

Special Status
CSC = California species of special concern
FE = Federally endangered
FT = Federally threatened
CE = California endangered

SF Bay Residence?
Y = year round
W = winter
F = fall
S = summer

Habitat
u = upland
w = wetland
o = open water (i.e., pond or bay)
bw = break water

Feeding Guild
h = herbivore
o = omnivore
I = insectivore
c = carnivore

(a) Total number of individuals observed/number of survey events (e.g., a total of 52 black-tailed hare were observed over the course of 10 sampling events).
(b) Feeding guild information is based on PRC, 1996b (Appendix G).

Table 2-3. Avian Species Observed at IR Site 2

Common Name	Scientific Name	Observed in 1997[a]	Special Status?	SF Bay Resident	Primary Habitat	Secondary Habitat	Breeding	Feeding Guild[b]
Red-Throated Loon	*Gavia stellata*			W	o			c
Common Loon	*Gavia immer*		CSC	W	o			c
Pied-Billed Grebe	*Podilymbus podi*			W	o			c
Horned Grebe	*Podiceps auritus*			W	o			c
Eared Grebe	*Podiceps nigricollis*	2/1		W	o			c
Western Grebe	*Aechmophorus occidentalis*	5/4		W	o			c
Clark's Grebe	*Aechmophorus clarkii*			W	o			c
Sooty Shearwater	*Puffinus griseus*			T	o			c
Fork-Tailed Storm Petrel	*Oceanodroma furcata*		CSC	T	o			c
American White Pelican	*Pelecanus erythroorhynchos*		CSC	T	o	w		c
California Brown Pelican	*Pelecanus occidentalis californicus*	2/1	FE	T	o			c
Double-Crested Cormorant	*Phalacrocorax auritis*	36/3	CSC	Y	o			c
Brandt's Cormorant	*Phalacrocorax penicillatus*	20/2		Y	o			c
Pelagic Cormorant	*Phalacrocorax pelagicus*	1/1		Y	o			c
Great Blue Heron	*Ardea herodias*	13/5		Y	w	o		c
Cattle Egret	*Bubulcus ibis*			W	w	u		c
Great Egret	*Casmerodius albus*	6/3		Y	w	u		c
Snowy Egret	*Egretta thula*	2/2		Y	w	b		c
Black-Crowned Night Heron	*Nycticorax nycticorax*	1/1		Y	w			c
Snow Goose	*Chen caerulescens*			W	w			h
Canada Goose	*Branta canadensis*	1100/10	FT	W	w	u	yes	h
Green-Winged Teal	*Anas crecca*	2/1		W	w			h
Mallard	*Anas platyrhynchos*	371/10		Y	w	o	yes	h
Northern Pintail	*Anas acuta*	17/3		Y	w			h
Cinnamon Teal	*Anas cyanoptera*	6/3		Y	w			h
Northern Shoveler	*Anas clypeata*	212/6		Y	w			o
Gadwall	*Anas strepera*	27/4		W	w		yes	h
Eurasian Wigeon	*Anas penelope*	6/3		W	w			h
American Wigeon	*Anas americana*	281/6		W	w	o		h
Canvasback	*Aythya valineria*	7/2		W	o	w		o
Greater Scaup	*Aythya marila*			W	o			o
Lesser Scaup	*Aythya affinis*	38/3		W	o			o
Oldsquaw	*Clangula hyemalis*			W	o			o
Black Scoter	*Melanitta nigra*			W	o			o
Surf Scoter	*Melanitta perspicillata*	5/2		W	o			o
White-Winged Scoter	*Melanitta fusca*			W	o			o

Table 2-3. Avian Species Observed at Alameda Point IR Site 2 (Page 2 of 4)

Common Name	Scientific Name	Observed in 1997[a]	Special Status?	SF Bay Resident	Primary Habitat	Secondary Habitat	Breeding	Feeding Guild[b]
Common Goldeneye	*Bucephala clangula*	2/1		W	o			o
Bufflehead	*Bucephala albeola*	20/2		W	o	w		o
Red-Breasted Merganser	*Mergus serrator*			W	o			o
Ruddy Duck	*Oxyura jamaicensis*	2/1		Y	o			o
American Coot	*Fulica americana*	242/6		Y	w	o		o
Black-Necked Stilt	*Himantopus mexicanus*	130/10		Y	w		yes	c
American Avocet	*Recurvirostra americana*	174/7		Y	w		yes	o
Black Bellied Plover	*Pluvialis squatarola*	5/2		Y	w	b		c
Western Snowy Plover	*Charadrius alexandrinus nivosus*		CSC	Y	w		yes	c
Semipalmated Plover	*Charadrius semipalmatus*	4/1		W,F,Sp	w	b		c
Killdeer	*Charadrius vociferus*	80/10		Y	u	w	yes	c
Willet	*Cataptrophorus semipalmatus*	3/1		W	b	w		c
Long-Billed Curlew	*Numenius americanus*		CSC	W	w			c
Marbled Godwit	*Lemosa fedoa*			W	b	w		c
Least Sandpiper	*Calidris minutilla*	107/7		S,F,W	w	b		o
Dunlin	*Calidris alpina*	9/2		W	w	b		c
Short-Billed Dowitcher	*Limnodromus griseus*	126/7		W	b	w		o
Long-Billed Dowitcher	*Limnodromus scolopaceus*			W	w			o
Common Snipe	*Gallinago gallinago*			W	w			c
Red-Necked Phalarope	*Phalaropus lobatus*			T	w	o		c
Greater Yellowlegs	*Tringa melanoleuca*	49/3						
Pomarine Jaeger	*Stercorarius pomarinus*			T	o			c
Parasitic Jaeger	*Stercorarius parasiticus*			T	o			c
Bonaparte's Gull	*Larus philadelphia*			T	o			c
Heermann's Gull	*Larus heemanni*			F,S	o			c
Mew Gull	*Larus canus*			W	o	w		c
Ring-Billed Gull	*Larus delawarensis*	162/4		Y	b	w,o		o
California Gull	*Larus californicus*	2741/8	CSC	Y	b	w		c
Herring Gull	*Larus argentatus*	16/4		W	o	w		o
Thayer's Gull	*Larus thayeri*	5/1		w	o	w		c
Western Gull	*Larus occidentalis*	721/8		Y	o	w		o
Glaucous-Winged Gull	*Larus glaucescens*			W	o	w		o
Black Tern	*Chlidonias niger*			F,Sp	o	w		c
Caspian Tern	*Sterna caspia*	1082/6		S	o	w	yes	p
Elegant Tern	*Sterna elegans*		CSC	S	o			P
Forster's Tern	*Sterna forsteri*	9/3		Y	o	w		C

Table 2-3. Avian Species Observed at Alameda Point IR Site 2 (Page 3 of 4)

Common Name	Scientific Name	Observed in 1997[a]	Special Status?	SF Bay Resident	Primary Habitat	Secondary Habitat	Breeding	Feeding Guild[b]
Least Tern	*Sterna antillarum brownii*		FE	S	o	w	yes	p
Common Murre	*Uria aalge*			T	o			c
Turkey Vulture	*Cathartes aura*	2/2		Y	u	w		c
Osprey	*Pandion haliaetus*		CSC	W	o	w,u		c
Black-Shouldered Kite	*Elanus caeruleus*		cfp	Y	w	u		c
White-Tailed Kite	*Elanus caeruleus*			Y	u	w		c
Northern Harrier	*Circus cyanus*	16/5	CSC	Y	u	w	yes	c
Cooper's Hawk	*Accipiter cooperii*			Y	u	w		c
Red-Tailed Hawk	*Buteo jamaicensis*			Y	u	w		c
Red-Shouldered Hawk	*Buteo lineatus*	1/1		Y	u			c
Rough-Legged Hawk	*Buteo lagopus*			W	u			c
Golden Eagle[a]	*Aquila chrysaetos*	1/1		T	o	u		c
American Kestrel	*Falco sparverius*			Y	u			c
Merlin	*Falco columbarius*		CSC	W	u			c
American Peregrine	*Falco peregrinus anatum*		FE	Y	o	u		c
Ring-Necked Pheasant	*Pahsianus colchicus*			Y	u			o
Rock Dove	*Columba livia*	21/6		Y	u			h
Mourning Dove	*Zenaida macroura*	3/1		Y	u			h
Great-Horned Owl	*Bubo virginianus*			Y	u	o		c
Barn Owl	*Tyto alba*			Y	u			c
Burrowing Owl	*Athene cunicularia*		CSC	Y	u		yes	c
Anna's Hummingbird	*Clypte anna*			Y	u			o
White-Throated Swift	*Aeronautes saxatalis*			Y	u			o
Belted Kingfisher	*Ceryle alcyon*			Y	w			c
Northern Flicker	Colaptes auratus		SE	Y	w			o
Black Phoebe	*Sayornis nigricans*			Y	w			i,o
Say's Phoebe	*Sayornis saya*			W	u			i
Western Kingbird[a]	*Tyrannus veritcalis*	2/2		S	u			i
California Horned Lark	*Erimophila aplestris actia*	1/1	CSC	Y	u		yes	o
Cliff Swallow	*Hirundo pyrrhonota*			S	u	w		o
Tree Swallow	*Tachycineta bicolor*			Y	u	w		i,o
Violet-Green Swallow	*Tachycineta thalassina*			Y	u	w		i,o
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*			Y	u	w	yes	i,o
Barn Swallow	*Hirundo rustica*	20/5		S	u			i
Scrub Jay	*Aphelocoma coerulescens*			Y	u			o
American Crow	*Corvus brachyrhynchos*			Y	u			o

Table 2-3. Avian Species Observed at Alameda Point IR Site 2 (Page 4 of 4)

Common Name	Scientific Name	Observed in 1997[a]	Special Status?	SF Bay Resident	Primary Habitat	Secondary Habitat	Breeding	Feeding Guild[b]
Common Raven	*Corvus corax*			Y	u			o
American Robin	*Turdus migratorius*			Y	u			o
Loggerhead Shrike	*Lanius ludovicianus*		CSC	Y	u	u	yes	c
Northern Mockingbird	*Mimus polyglottus*			Y	u			o
American Pipit	*Anthus rubescens*			W	u			o
European Starling	*Sturnus vulgaris*	301/5		Y	u			o
Yellow-Rumped Warbler	*Dendroica coronata*			W	u			o
Savannah Sparrow	*Passervulus sandwichensis*	2/1		Y	u	w		o
Alameda Song Sparrow	*Melospiza melodia pusillula*	30/1	CSC	Y	w	u		o
Chipping Sparrow	*Spizella passerina*			S	u			o
White-Crowned Sparrow	*Zonotrichlia leucophrys*			Y	u			o
Golden-Crowned Sparrow	*Zonotrichlia atricapilla*			W	u			h
House Sparrow				Y	u			o
Brown-Headed Cowbird	*Molothrus ater*			Y	u			o
Red-Winged Blackbird	*Agelaius pheoniceus*	743/10		Y	w			o
Salt Marsh Common Yellowthroat	*Geothlypis trichas sinuosa*		CSC	Y	w			o
Western Meadowlark	*Sturnella neglecta*	48/5		Y	u			o
Brewer's Blackbird	*Euphagus cyanocephalus*	2/1		Y	u			o
Pine Siskin	*Cardelus pinus*			Y	u			o
House Finch	*Carpodacus mexicanus*	76/5		Y	u		yes	o
American Goldfinch	*Carduelis tristis*	30/2		Y	u	w		o

Special Status
CSC = California species of special concern
FE = Federally endangered
FT = Federally threatened
CE = California endangered

SF Bay Residence?
Y = year round
W = winter
F = fall
S = summer
Sp = spring

Habitat
u = upland
w = wetland
o = open water (i.e., pond or bay)
bw = break water
b = beach

Feeding Guild
h = herbivore
o = omnivore
I = insectivore
c = carnivore

(a) Total number of individuals observed/number of survey events (e.g., a total of 13 great blue herons were observed over the course of 5 sampling events).
(b) Feeding guild information is based on PRC, 1996b (Appendix G).

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SECTION 3.0
FIGURES

FINAL
REMEDIAL INVESTIGATION REPORT
IR SITE 2, WEST BEACH LANDFILL AND WETLANDS

DATED 23 JUNE 2006

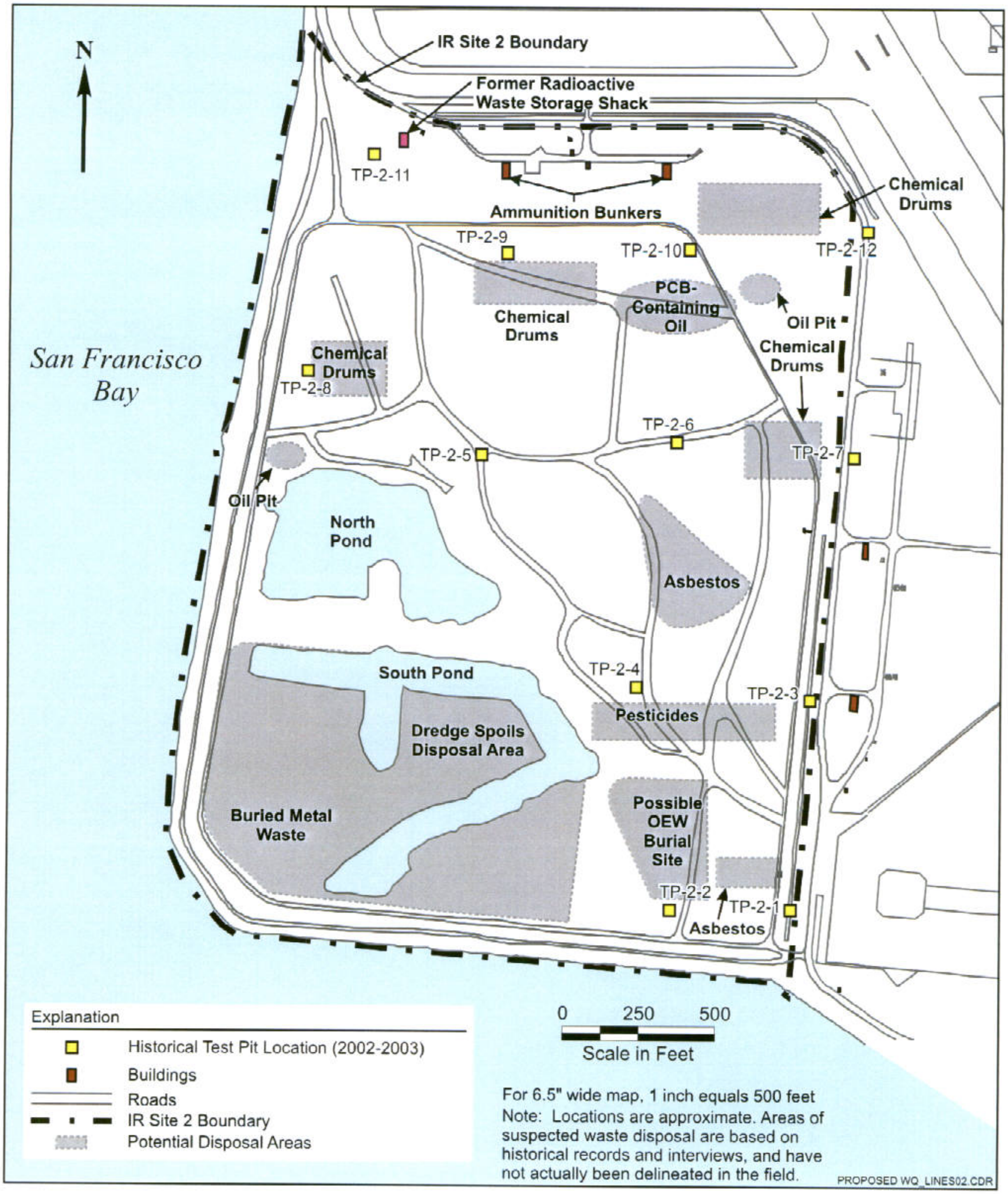

Figure 3-1. Previous Test Pit Locations and Possible OEW Burial Site

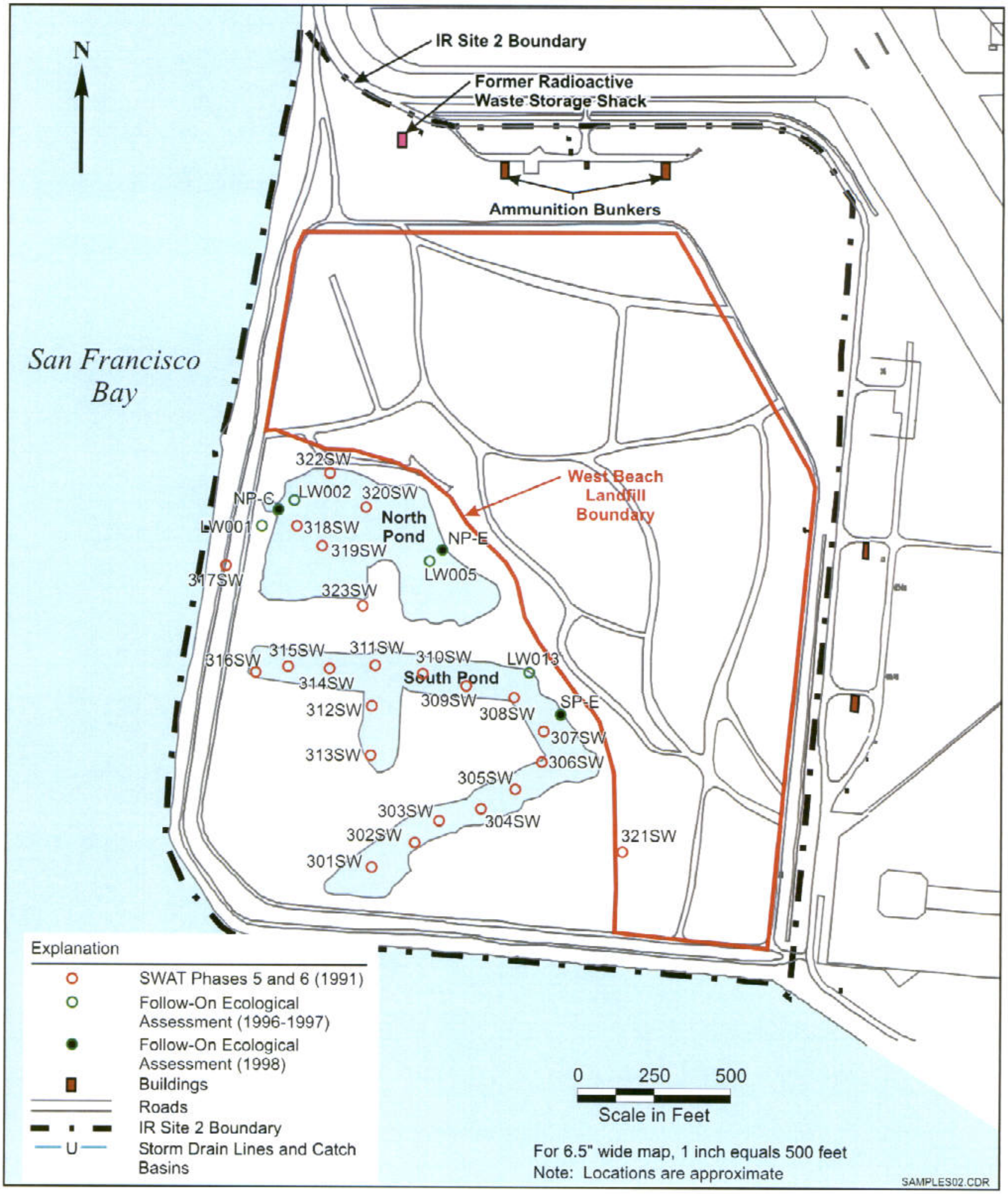

Figure 3-2. Historical Surface Water Sampling Locations

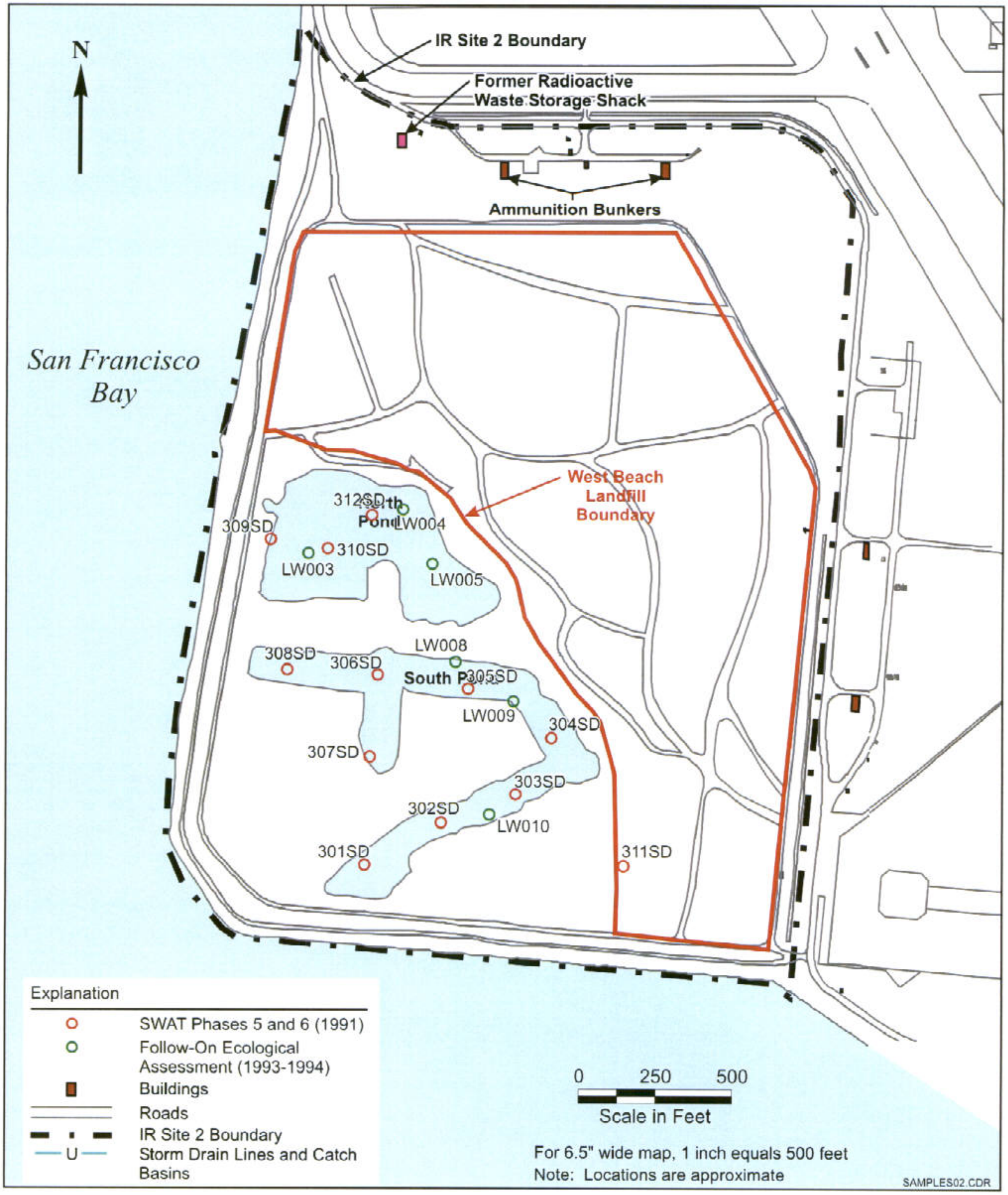

Figure 3-3. Historical Sediment Sampling Locations

Figure 3-4. Historical Surface Soil Sampling Locations

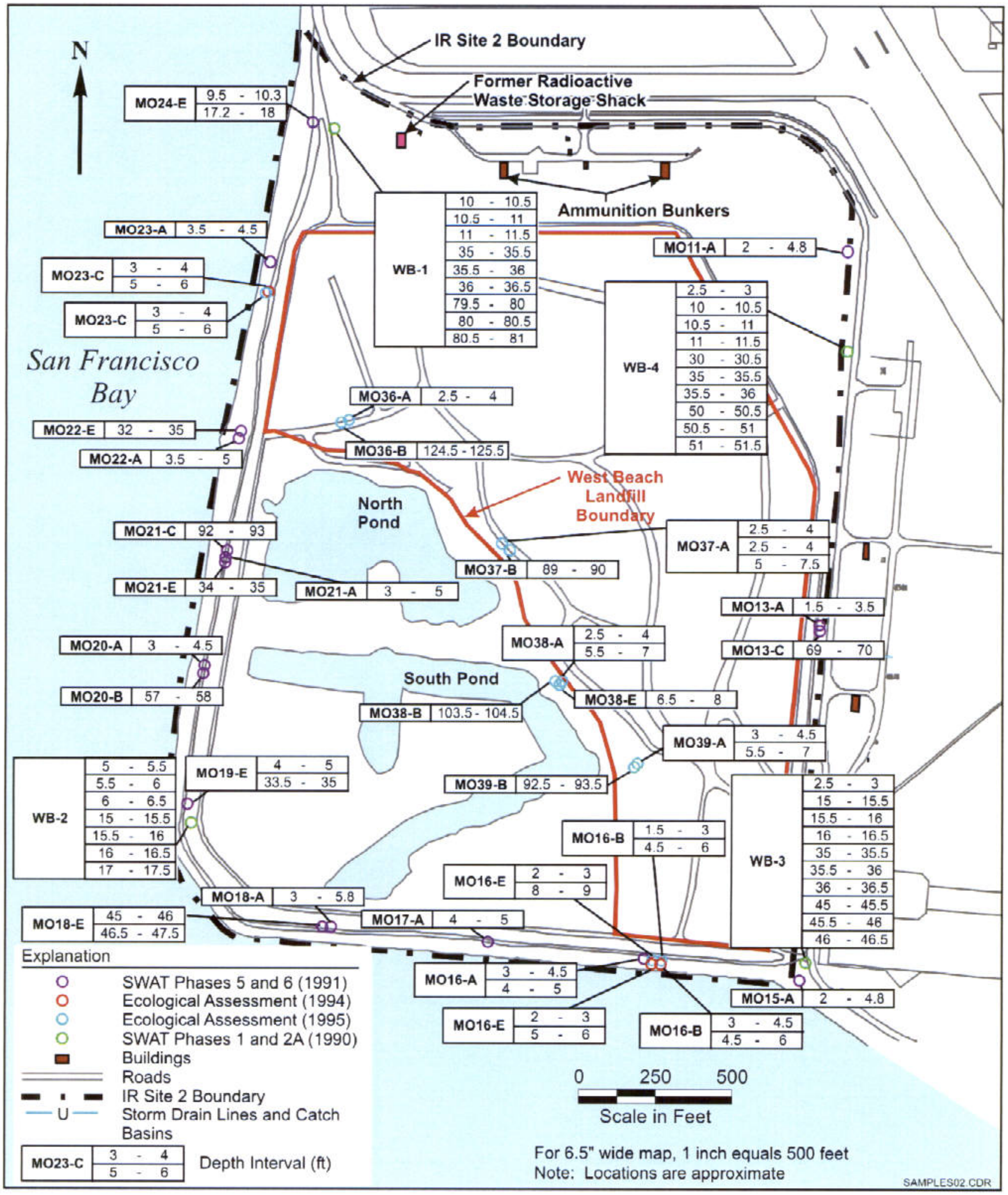

Figure 3-5. Historical Subsurface Soil Sampling Locations

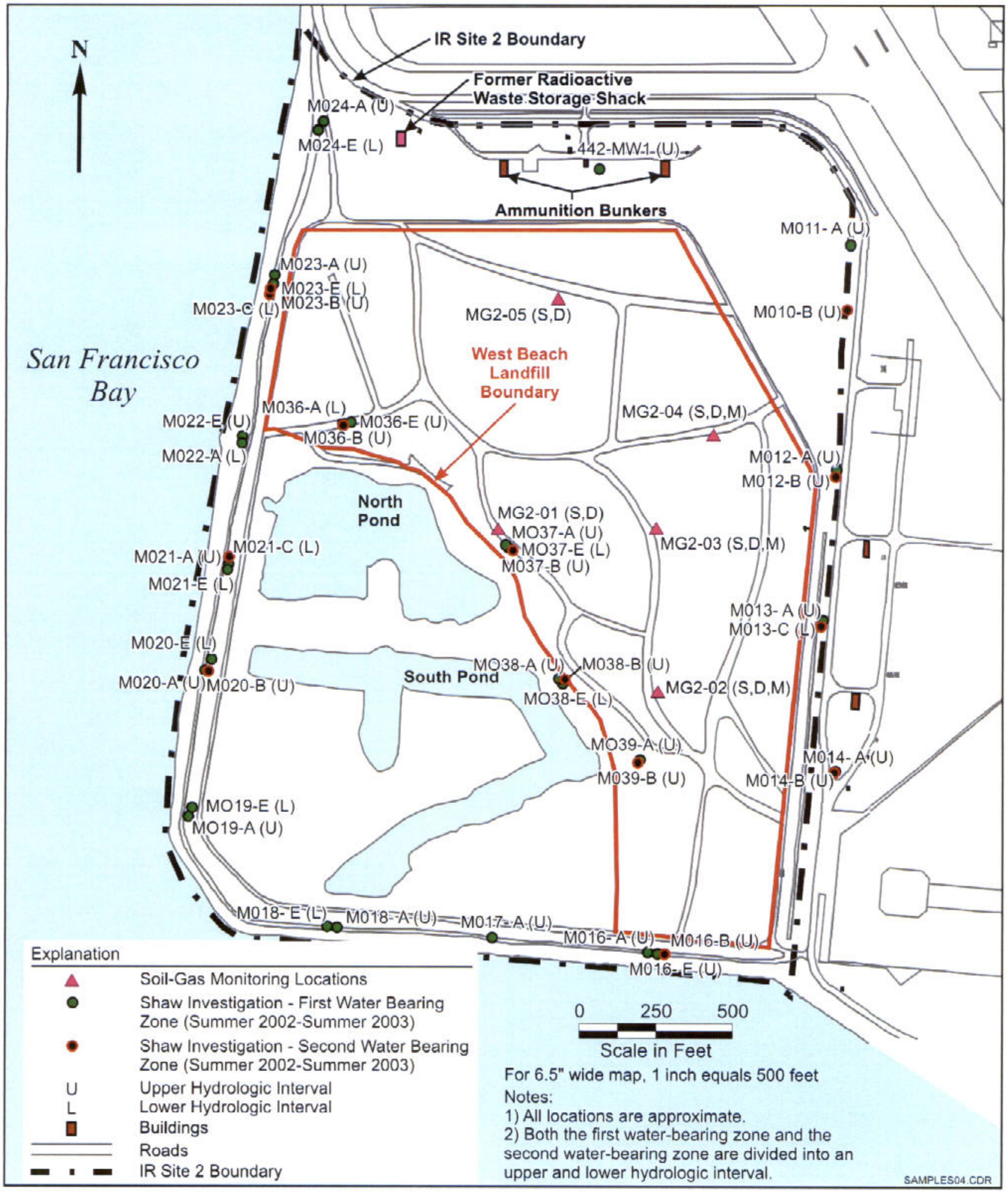

Figure 3-6. Monitoring Well and Soil-Gas Point Locations

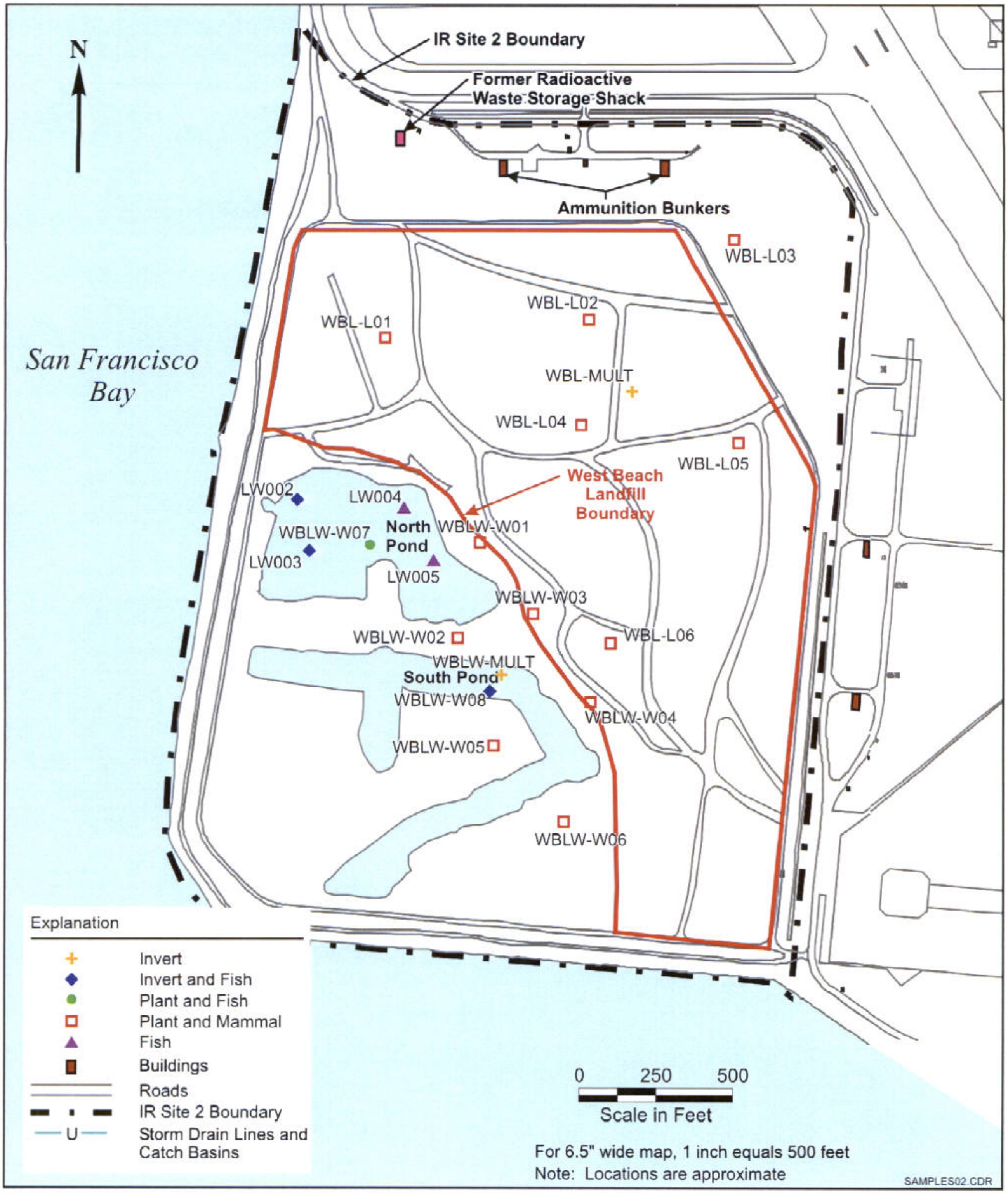

Figure 3-7. Historical Tissue Sample Locations

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TABLES

FINAL
REMEDIAL INVESTIGATION REPORT
IR SITE 2, WEST BEACH LANDFILL AND WETLANDS

DATED 23 JUNE 2006

Table 3-1. Summary of Test Pit Explorations

Test Pit #	Total Depth Excavated (ft)	Depth to Refuse (ft)	Visual Soil Classification of Existing Cover Soil with Munsell Colors Description and Other Geomaterials Found	Items Found	Comments
TP-2-1	1.50	1.00	3- to 4-inch grass/root and soil cover above SP-moist fine sand with <10 percent LPF, olive brown 2.5 yellow red (4/3), slight moisture with shell fragments.	Minor metal and plastic in a fine sand soil matrix.	Soil and refuse discoloration-reddish/organic color.
TP-2-2	2.50	1.50	3-inch grass/root and soil cover above SP-moist fine sand with <10 percent LPF, olive brown 2.5 yellow red (4/3), slight moisture with shell fragments.	Paper, plastic wood, etc.	No odor
TP-2-3	2.00	1.00	3-inch grass/root and soil cover above SP-moist fine sand with <10 LPF, olive brown 2.5 yellow red (4/3), slight moisture with shell fragments.	Rubber and fine hose pieces, plastic, etc.	Refuse in a sandy silt matrix, slight moisture and no odors.
TP-2-4	2.50	2.00	6-inch grass/root and soil cover above SM-sandy silt, very dark grayish brown 2.5 yellow red (4/2), medium plasticity and consolidated.	Plastic and >20 percent paper	Refuse in a sandy silt matrix, slight moisture and no odors.
TP-2-5	2.00	0.16	2-inch grass/root and soil cover above sandy silt mixed with construction debris.	Construction debris consisting of concrete, pipe, gravel, some brick etc.	No sample collected due to approximately 20 percent of construction debris.
TP-2-6	1.00	2.00	Less than 2-inch grass/root and soil cover above SP-moist find sand with <10 percent LPF, olive brown 2.5 years (4/3), slight moisture with shell fragments.	Stained metal, wood, paper, etc.	Refuse discoloration-reddish/orange color, soil matrix dark brown silty sand.
TP-2-7	4.00	0.25	3-inch grass/root and soil cover above (1) SM-sandy silt, very dark grayish brown 2.5 yellow red (4/2), medium plasticity and consolidated with approximately 5 percent construction debris. (2) SP-moist fine sand with <10 percent LPF, olive brown 2.5 yellow red (4/3), slight moisture with shell fragment, extends from approximately 2 to 3 ft.	Construction debris consisting of asphalt, brick, stone, etc. At 3 ft, paper, plastic, wire, wood, etc.	Based on the presence of 5 percent construction debris from 3 inches to 3 ft, would not consider suitable soil cover, refuse at 3 ft has discoloration-reddish/orange color.
TP-2-8	2.50	1.50	3-inch grass/root and soil cover above SP-moist fine sand with <10 percent LPF, olive brown 2.5 yellow red (4/3), slight moisture with shell fragments.	Wood, metal	Refuse discoloration-reddish/orange color, solid matrix dark brown silty sand and not odors.

Table 3-1. Summary of Test Pit Explorations (Page 2 of 2)

Test Pit #	Total Depth Excavated (ft)	Depth to Refuse (ft)	Visual Soil Classification of Existing Cover Soil with Munsell Colors Description and Other Geomaterials Found	Items Found	Comments
TP-2-9	3.00	0.16	2-inch grass/root and soil cover above (1) SM-sandy silt, very dark grayish brown 2.5 yellow red (4/2), medium plasticity and consolidated with approximately >10 percent construction debris, typical refuse encountered at 1.5 ft below ground surface. (2) SM-moist fine sand with silt, olive brown 2.5 yellow red (4/3), slight moisture with shell fragment, extends from approximately 1 to 1.5 ft)	Construction debris consisting of asphalt, brick, stone, etc. At 1.5-ft paper, plastic, wire, wood, etc.	Based on the presence of 10 percent construction debris from 2 inches to 1 foot would not consider suitable soil cover, refuse at 1.5 ft has discoloration-reddish/orange color.
TP-2-10	2.50	1.00	3-inch grass/root and soil cover above SM-moist fine sand with silt, medium plasticity, olive brown 2.5 yellow red (4/3).	Wood, metal, cloth, paper (20 percent), etc.	Refuse in a sandy silt matrix, test pit excavated to 2.5 ft and water entered excavation and stabilized at 2 ft below ground surface.
TP-2-11	3.00	0.16	2-inch grass/root and soil cover above (1) SM-sandy silt, very dark grayish brown 2.5 yellow red (4/2), medium plasticity and consolidated with approximately >10 percent construction debris, typical refuse encountered at 1.5 ft below ground surface.	Construction debris consisting of asphalt, brick, stone, etc., refuse mostly wood.	Based on the presence of 10 percent construction debris from 2 inches to 1 foot would not consider suitable soil cover, refuse at 1.5 ft has discoloration-reddish/orange color.
TP-2-12	3.00	2.00	6-inch grass/root and soil cover above SM-moist fine sand with silt, medium plasticity, olive brown 2.5 yellow red (4/3)	Glass, plastic, paper (10 percent), etc.	Refuse in a sandy silt matrix, test pit excavated to 3 ft and water encountered.

Source: FWEC (2003).
LPF = low plasticity fines.
SM = silty sand.
SP = poorly graded sand.

Table 3-2. Summary of Radiological Surveying Activities Previously Conducted at IR Site 2

Year	Activities Conducted	Analytes	Location
1995	Near-surface radiation survey	Radium (Ra-226)	Landfill
1996	Radiation Survey	Radium (Ra-226)	Coastal Margin, Interior Margin and Landfill
1998-1999	Radiation survey	Radium (Ra-226)	Former Radioactive Waste Storage Shack

Table 3-3. Summary of Historical Wetland Pond Surface Water Sampling and Analyses Conducted at IR Site 2

Year	Activities	Analyses	Location
1991	SWAT Phases 5 and 6: 50 surface water samples from 23 locations	Metals, PAHs, SVOCs, VOCs, PCBs, pesticides, TPH, solids, acidity, hardness, alkalinity, anions and conductance	North and South Ponds (Figure 3-2)
1996-1997	Supplemental Ecological Assessment: 5 surface water samples from 7 locations	Metals, PAHs, SVOCs, PCBs, pesticides, TPH, organotins, pH, and sulfide	North and South Ponds (Figure 3-2)
1998	Ecological Assessment: 30 surface water samples from 3 sample locations	Metals, PAHs, SVOCs, PCBs, pesticides, pH, solids, salinity and conductance	North and South Ponds (Figure 3-2)

SVOC = semivolatile organic compound.
TPH = total petroleum hydrocarbons.
VOC = volatile organic compound.

Table 3-4. Summary of Historical Wetland Pond Sediment Sampling and Analyses Conducted at IR Site 2

Year	Activities	Analyses	Location
1991	SWAT Phases 5 and 6: 13 sediment samples from 12 locations	Metals, PAHs, SVOCs, VOCs, PCBs, pesticides, TPH, TOC and moisture	North and South Ponds (Figure 3-3)
1993-1994	Ecological Assessment: 20 sediment samples from 7 locations	Metals, PAHs, SVOCs, pesticides, oil and grease, organotins, radium, TOC and moisture	North and South Ponds (Figure 3-3)
1996-1997	Supplemental Ecological Assessment: 6 sediment samples from 6 locations	Metals, PAHs, SVOCs, pesticides, TPH, organotins, TOC, moisture, salinity, BOD, sulfide, ammonia	North and South Ponds (Figure 3-3)

BOD = biochemical oxygen demand.
TOC = total organic carbon.

Table 3-5. Summary of Historical Wetland Pond Porewater Sampling and Analyses Conducted at IR Site 2

Year	Activities	Analyses	Location
1996	Supplemental Ecological Assessment: 41 porewater samples from 3 locations	Metals, PAHs, SVOCs, PCBs, herbicides, pesticides, and TPH	North Pond
1997	Supplemental Ecological Assessment: 48 porewater samples from 3 locations	Metals, PAHs, SVOCs, PCBs, herbicides, pesticides, and TPH	South Pond

Table 3-6. Summary of Geotechnical Tests Performed on Soil Samples Collected at IR Site 2

Test	Method	Quantity
Atterberg limits	ASTM D 4318	23
Moisture content/dry density	ASTM D 2216/2937	48
Particle size distribution	ASTM D 422	21
Unconsolidated-undrained triaxial shear	ASTM D 2850	5
Consolidated-undrained triaxial shear	ASTM D 4767	5
Water content	ASTM D 2216	1
Percent passing No. 200 sieve	ASTM D 1140	30
Direct shear	ASTM D 3080	4
Miniature vane shear	ASTM D 4648	25
Specific gravity	ASTM D 854	3
Consolidation	ASTM D 2435	4

Table 3-7. Summary of Historical Surface Soil Sampling Activities Conducted at IR Site 2

Year	Activities Conducted	Analyses	Location
1990	SWAT Phases 1 and 2A: 10 surface soil samples from 4 borings.	Metals, PAHs, SVOCs, pesticides, PCBs, and radionuclides	Coastal Margin and Landfill (Figure 3-4)
1991	SWAT Phases 5 and 6: 168 surface soil samples from 151 borings.	Metals, PAHs, SVOCs, VOCs, pesticides, PCBs, radionuclides, and TPH	IR Site 2 (Figure 3-4)
1994	Ecological Assessment: 8 surface soil samples from 7 borings.	TPH	IR Site 2 (Figure 3-4)
1990	Installation of Groundwater Monitoring Wells: 3 surface soil samples from 3 borings.	Metals, PAHs, SVOCs, pesticides, PCBs, herbicides, and radionuclides	Coastal Margin and Landfill (Figure 3-4)
1991	Installation of Groundwater Monitoring Wells: 13 surface soil samples from 11 borings.	Metals, PAHs, SVOCs, pesticides, PCBs, oil and grease, TPH, and radionuclides	Coastal Margin and Landfill (Figure 3-4)
1994	Installation of Groundwater Monitoring Wells: 3 surface soil samples from 3 borings.	Metals, PAHs, SVOCs, VOCs, and TPH	Coastal Margin and Landfill (Figure 3-4)
1995	Installation of Groundwater Monitoring Wells: 8 surface soil samples from 7 borings.	Metals, PAHs, SVOCs, pesticides, PCBs, TPH, and radionuclides	Coastal Margin and Landfill (Figure 3-4)

Table 3-8. Summary of Historical Subsurface Soil Sampling Activities Conducted at IR Site 2

Year	Activities Conducted	Analyses	Location
1990	SWAT Phases 1 and 2A: 36 subsurface soil samples from 4 borings.	Metals, PAHs, SVOCs, VOCs, pesticides, PCBs, radionuclides, pH, and TOC	Coastal Margin and Landfill (Figure 3-5)
1991	SWAT Phases 5 and 6: 23 subsurface soil samples from 18 borings.	Metals, PAHs, SVOCs, VOCs, pesticides, PCBs, radionuclides, pH, TOC, and moisture	Coastal Margin and Landfill (Figure 3-5)
1994	Ecological Assessment: 6 subsurface soil samples from 3 borings.	Metals, PAHs, SVOCs, VOCs, TPH, pH, and moisture	IR Site 2 (Figure 3-5)
1995	Ecological Assessment: 20 subsurface soil samples from 12 borings.	Metals, PAHs, SVOCs, VOCs, pesticides, PCBs, TPH, radionuclides, TOC, pH, and moisture	IR Site 2 (Figure 3-5)

Table 3-9. Summary of Analyses for Quarterly Groundwater Monitoring Program

Analyte	Analysis Method
VOCs	EPA 8260B
SVOCs/PAHs	EPA 8270C
PAHs	EPA 8310
TPH	EPA 8015B
Dissolved metals	EPA 6010B/6020/7470/7481
Hexavalent chromium	EPA 7196
Total cyanide	335.2
Gross alpha and beta	EPA 900
Radium	EPA 903
Radium 228	EPA 904
Radioactive strontium	EPA 905
Tritium isotopes	EPA 906
Gamma-emitting radionuclides	EPA 901.1
Anions: nitrate, nitrite, chloride, and sulfate	EPA 9056 or 300
Monitored Natural Attenuation: alkalinity, sulfide, dissolved gases methane, ethane, and ethene	EPA 310.1, 376.2 RSK 175

Table 3-10. Summary of Soil-Gas Monitoring Parameters

Analyte	Method	Sampling Frequency
VOCs	EPA TO-15	Quarterly
Fixed gases: CO_2, CO, O_2, N, methane, ethane, and ethene	ASTM D1946	Annually
Methane and hydrogen sulfide	Field Measured	Quarterly

Table 3-11. Plant Species Observed at IR Site 2 During Historical Plant Surveys

Species Name	Common Name
Centaurium muenlenbeigii	Centaury
Malva parviflora	Cheeseweed
Plantago species	Common plantain
Baccharis pilularis var. consanguinea	Coyote brush
Geraneum dissectum	Cranesbill
Gnaphalium species	Cudweed
Rumex crispus	Curly dock
Foeniculum vulgare	Fennel
Carpobiotus edulis	Fig-marigold (ice plant)
Erodium bothyrs	Longbeaked storksbill
Salicornia virginica	Pickleweed
Plagiobothyrys species	Popcorn flower
Carduus species	Italian thistle
Distchlis spicata	Saltgrass
Lotus formosissimus	Seaside trefoil
Lathyrus species	Sweet pea
Vicia species	Vetch
Raphanus sativus	Wild radish
Brassica rapa	Wild turnip

Table 3-12. Summary of Toxicity Test Results

	Test Organism							
	Eohaustorius estuarius				*Neanthes arenaceodentata*			
Station	Mean Percent Survival	Std. Dev.	Mean Percent Reburial	Std. Dev.	Mean Number Survival	Std. Dev.	Mean Organism Weight (mg)	Std. Dev.
West Beach Landfill Wetland								
Control	98.0	2.7	100.0	0.0	5.0	0.0	13.6	1.5
W1	96.7	4.1	99.1	2.3	5.0	0.0	12.6	1.8
W2	97.0	4.5	100.0	0.0	4.8	0.4	11.6	3.5
W3	98.3	2.6	98.3	2.6	5.0	0.0	11.2	1.8
Lab Replicate	98.0	2.7	97.9	2.9	N/A	N/A	N/A	N/A
W4	34.0	16.4	96.0	5.5	4.8	0.4	11.8	2.6
W5	49.2	32.3	100.0	0.0	5.0	0.0	10.7	2
Lab Replicate	N/A	N/A	N/A	N/A	4.8	0.4	11.5	2.4
W6	51.0	18.5	100.0	0.0	5.0	0.0	10.6	1.1
W7	78.0	18.2	100.0	0.0	5.0	0.0	12.6	2.6
Runway Wetland								
Control	99.0	2.2	100.0	0.0	5.0	0.0	19.3	0.3
R1	96.7	4.1	100.0	0.0	5.0	0.0	20.7	1.5
Lab Replicate	100.0	0	100.0	0.0	N/A	N/A	N/A	N/A
R2	92.0	2.7	98.9	2.5	5.0	5.0	20.3	1.2
R3	44.2	4.9	94.6	5.9	5.0	5.0	19.3	0.9
Lab Replicate	N/A	N/A	N/A	N/A	5.0	5.0	19.2	1.7
R4	99.0	2.2	0.0	0.0	5.2	5.2	19.8	2.1

Std. dev. = standard deviation.
N/A = not applicable.

Table 3-13. Background Concentrations of Inorganic Metals in Yellow Area Soils

Chemical (mg/kg)	Sample Quantitation Limit	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Standard Deviation	95% UCL Concentration	Coefficient of Variation
Aluminum	NA	51/51	20.0	13,300	6,156	2,532	6,869	0.41
Antimony	1.3-7.3	3/51	2.8	3.6	2.9	0.69	3.1	0.24
Arsenic	10-12	22/51	1.1	33	7.6	6.4	9.4	0.84
Barium	21-24	44/51	19.8	260	30.4	1.9	43.5	0.18
Beryllium	1-1.2	10/51	0.3	1.3	0.58	0.19	0.63	0.33
Cadmium	0.36-1.2	12/51	0.33	2.9	0.66	0.49	0.80	0.74
Calcium	NA	51/51	500	97,000	3,441	2.0	5,269	0.08
Chromium	NA	51/51	5.0	69.7	32.1	8.4	34.4	0.26
Cobalt	5-7.6	20/51	4.3	11.4	4.3	2.3	4.9	0.53
Copper	5.5-5.6	49/51	4.2	49	15.9	12.0	19.3	0.76
Iron	NA	51/51	10.0	20,800	10,324	3,859	11,410	0.37
Lead	NA	51/51	3.3	752	22.2	2.8	51.7	0.33
Magnesium	NA	51/51	500	8,820	2,541	1.6	3,178	0.06
Manganese	NA	51/51	5.0	330	136.9	73.6	157.6	0.54
Mercury	0.05-0.15	5/10	0.05	0.18	0.08	0.05	0.12	0.68
Nickel	NA	51/51	5.0	71.1	27.8	9.8	30.6	0.35
Potassium	NA	51/51	500	1,700	921	291	1,003	0.32
Silver	0.18-6	6/51	0.52	30	2.9	4.1	4.0	1.4
Sodium	125-610	11/51	232	1,380	353	260.8	425.9	0.74
Titanium	NA	41/41	280	663	456	77.1	480.2	0.17
Vanadium	NA	51/51	15.6	50.0	25.7	7.9	27.9	0.31
Zinc	NA	51/51	17.0	140.0	47.8	31.9	56.8	0.67

Source: TtEMI (2001).
NA = not available.

Table 3-14. Background Concentrations of Inorganic Metals in Shallow Groundwater at Alameda Point

Chemical (µg/L)	Reported Detection Limit	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	95% UCL Concentration	80 LCL/95 Concentration	Maximum Contaminant Level (MCL)[b]
Aluminum	8.4-223	51/176	3	3,970	32.12	96.2	439.13	1,000
Antimony	2-37.5	12/176	2.5	47.8	5.83	11.8	45.77	6
Arsenic	1.9-100	94/179	2	40.7	4.54	8	28.39	50
Barium	4.3-55.4	144/176	2.3	1,260	34.06	123.3	574.73	1,000
Beryllium	0.1-3.7	18/176	0.94	3	0.49	1	3.83	4
Cadmium	0.2-8.0	16/176	0.32	6.5	0.53	1.3	5.38	5
Calcium	898-1,370	176/180	620	513,000	17,865	78,223	379,269	NA
Cr(VI)[a]	100	1/3	4	4	34.7	100.6	NA	NA
Chromium	0.6-32	23/176	0.74	82.8	1.54	3.4	13.79	50
Cobalt	2.3-17.2	6/176	2.5	10.5	3.5	4.6	11.57	NA
Copper	0.4-69.7	54/176	2.1	27.3	3.97	7.5	27.48	1,000
Iron	4.8-363	119/180	7.2	24,400	108.58	1,624	7,135	300
Lead	0.8-20	18/180	1.2	28.4	0.91	1.3	3.88	NA
Magnesium	NA	180/180	549	1,070,000	15,092	103,358	500,168	NA
Manganese	1.1-12.3	172/180	1.1	2,480	86.01	1,171	5,213	50
Mercury[a]	0.1-0.29	3/180	0.2	0.3	0.1	0.1	0.15	2
Molybdenum	2.0-25.4	5/100	3.1	19.4	4.59	5.6	11.52	NA
Nickel	1.7-49.1	13/180	2.7	151	5.6	7.4	19.06	100
Potassium	763-2,340	175/180	1,200	505,000	14,314	40,552	182,153	NA
Selenium[a]	1.9-54	1/180	2.5	2.5	1.58	1.9	5.97	50
Silver[a]	0.4-5.4	2/170	2.4	4.8	1.48	1.6	3.33	100
Sodium	NA	180/180	4,600	8,160,000	198,988	937,369	4,539,829	NA
Thallium[a]	1.7-76	3/175	3.6	5.2	2.21	2.3	5.8	2
Vanadium	1.4-19.5	69/180	2	50.8	4.97	8.4	28.65	NA
Zinc	0.5-32.8	55/180	2.8	46,800	4.87	10.5	42.91	5,000

Source: TtEMI (2001).
NA = not available.
NC = not calculated.
80 LCL/95 = 80th lower confidence limit on the 95th percentile of the distribution.
95 UCL = 95th upper confidence limit.

(a) Statistics are based on a normal distribution; too few detections were available to determine probability distribution.
(b) Groundwater MCLs required to support municipal supply are based on the Water Quality Control Plan, San Francisco Bay Basin, Region 2 (RWQCB, 1995).

SECTION 5.0
FIGURES

FINAL
REMEDIAL INVESTIGATION REPORT
IR SITE 2, WEST BEACH LANDFILL AND WETLANDS

DATED 23 JUNE 2006

Figure 5-1. Elevated Gamma Scan Locations, >4,000 CPM Net

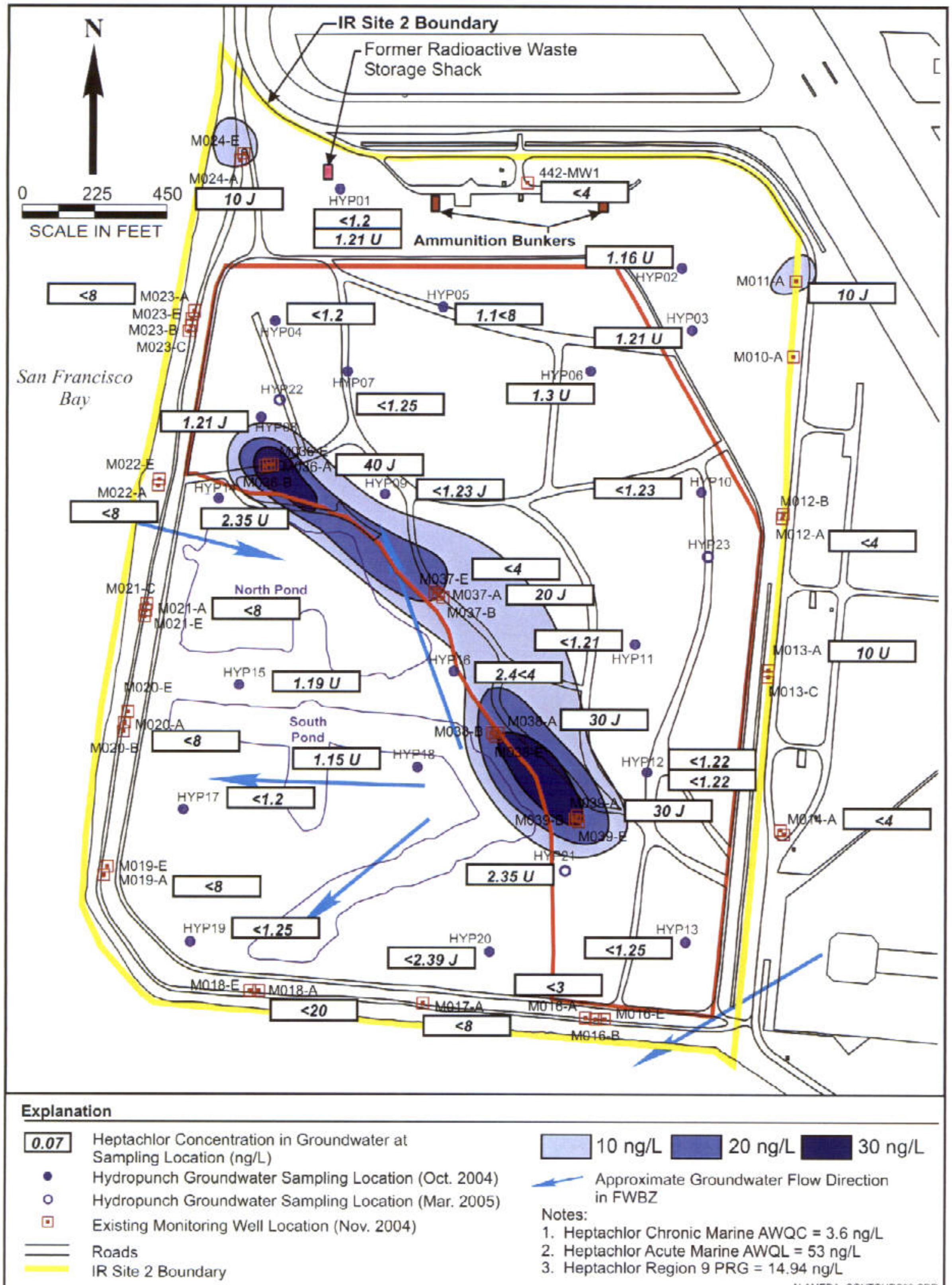

Figure 5-2. Isonconcentration Map of Heptachlor in FWBZ Groundwater, Fall 2004/Winter 2005

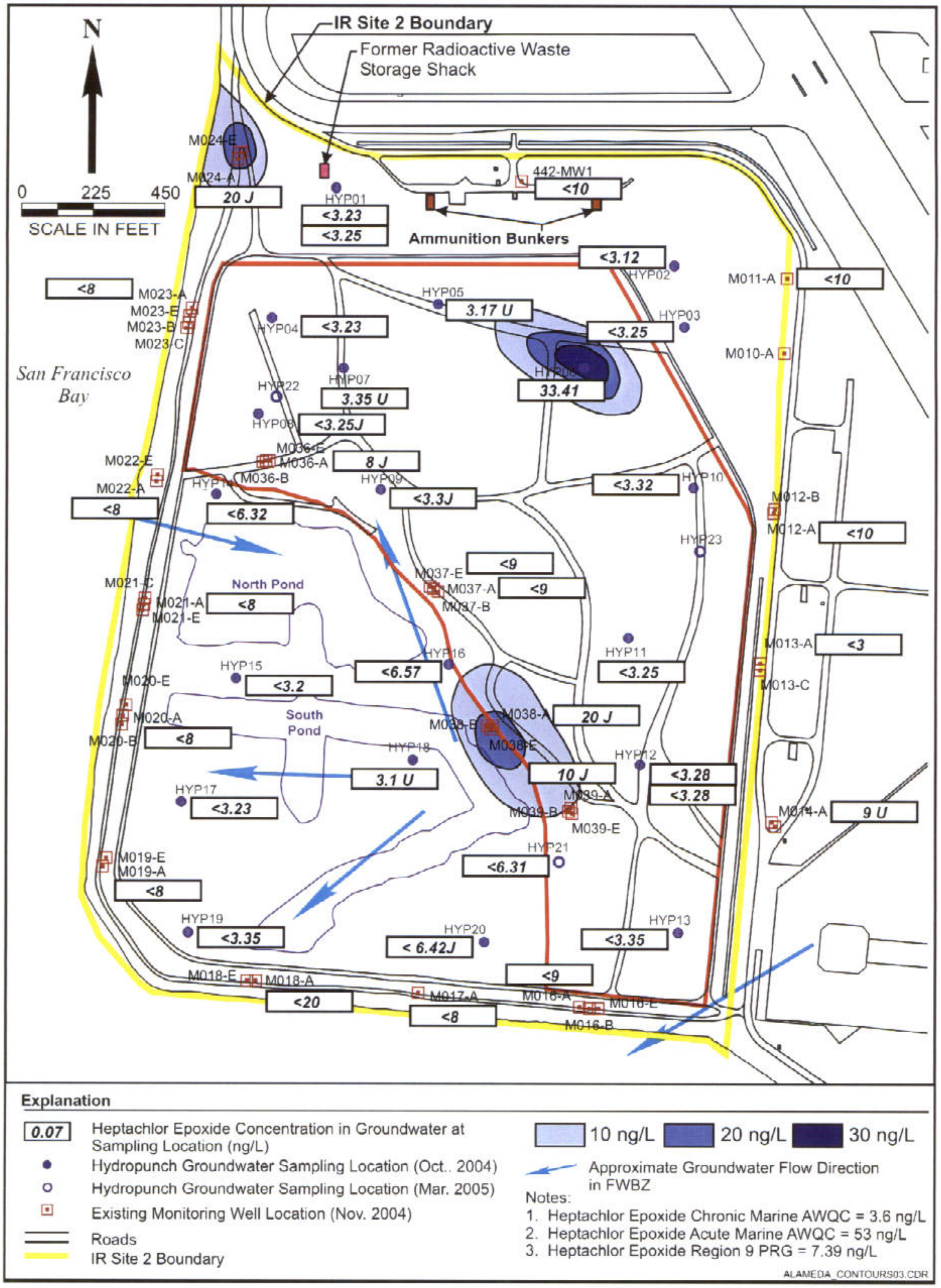

Figure 5-3. Isonconcentration Map of Heptachlor Epoxide in FWBZ Groundwater, Fall 2004/Winter 2005

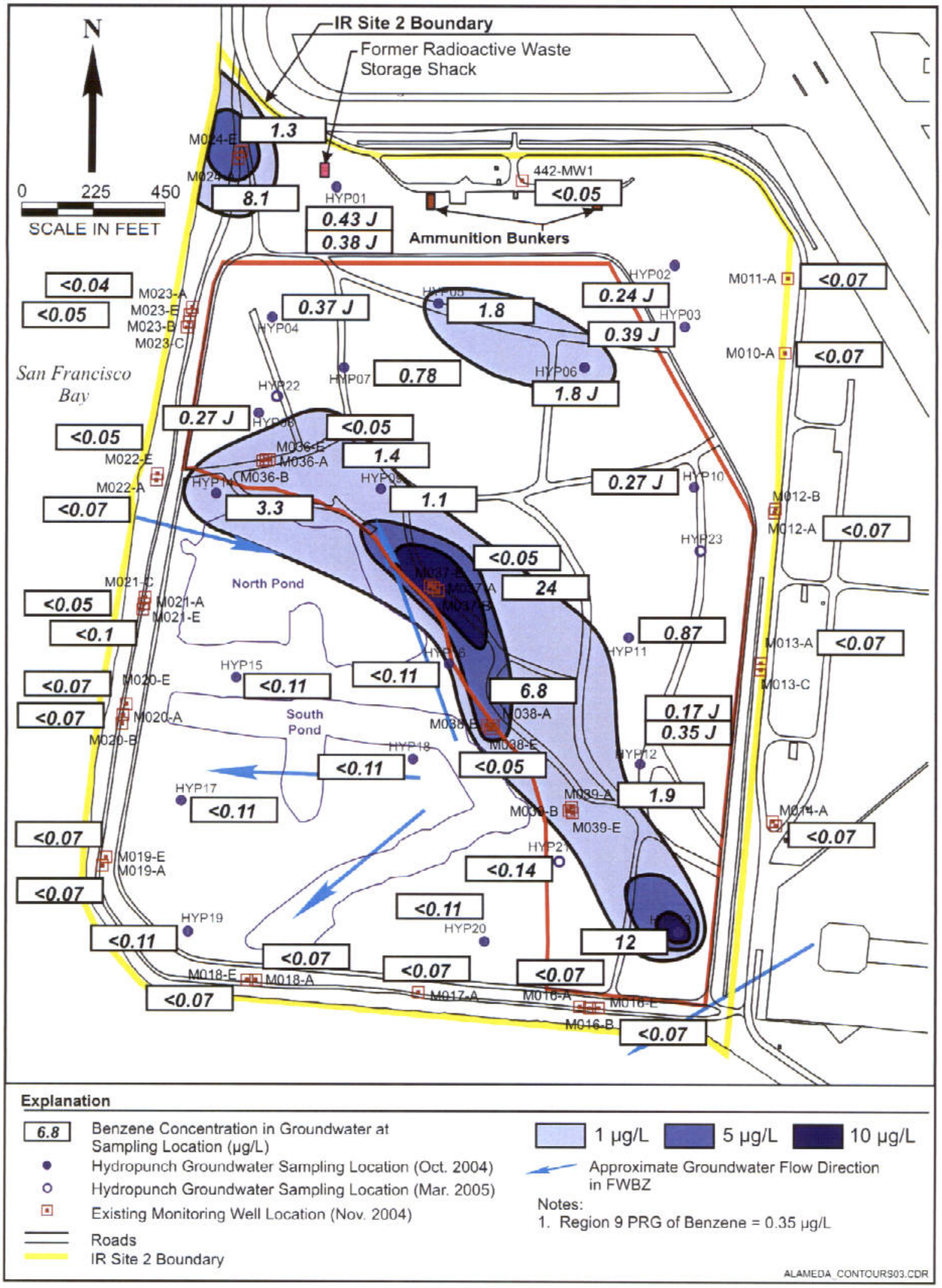

Figure 5-4. Isonconcentration Map of Benzene in FWBZ Groundwater, Fall 2004/Winter 2005

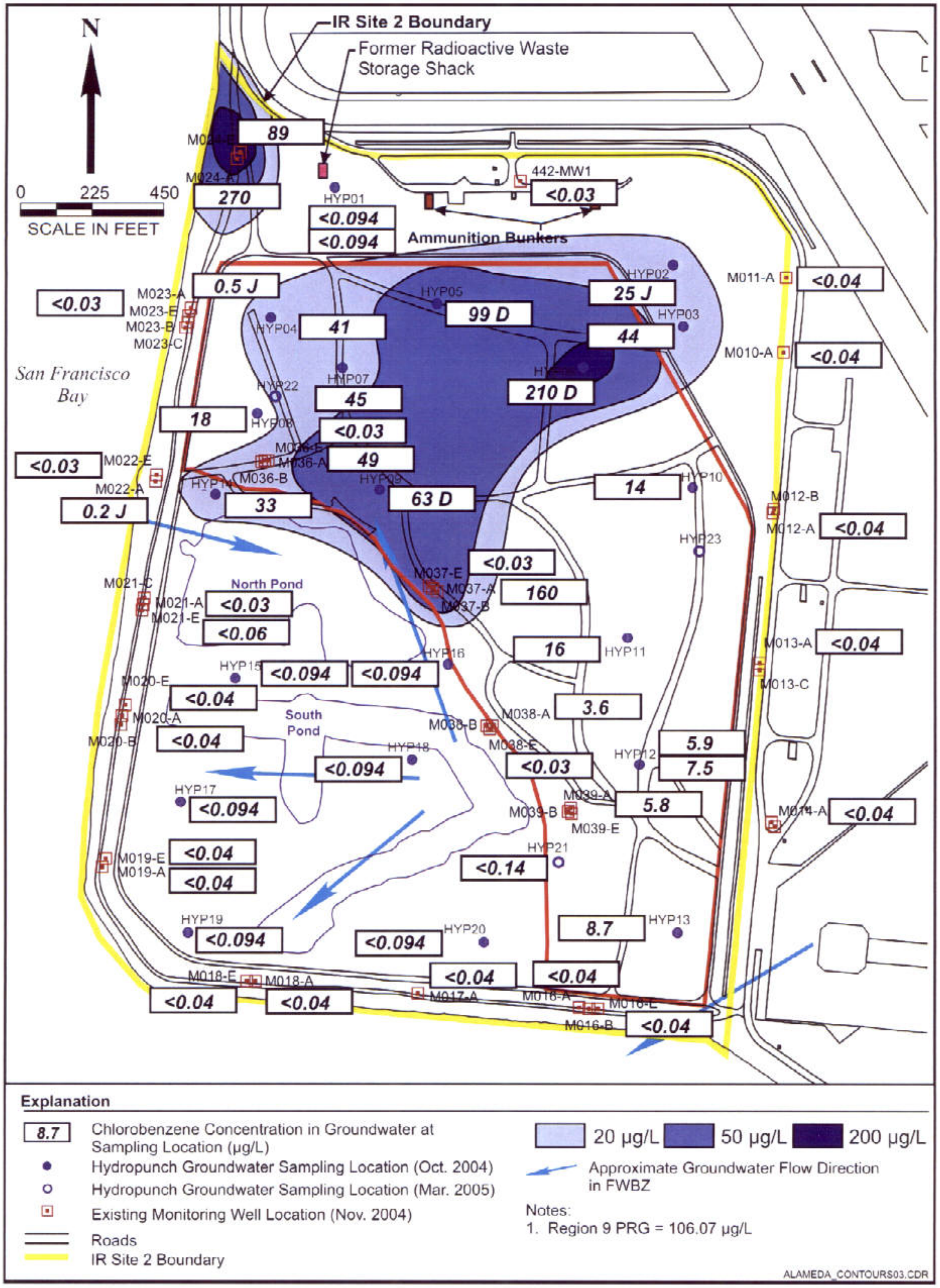

Figure 5-5. Isonconcentration Map of Chlorobenzene in FWBZ Groundwater, Fall 2004/Winter 2005

Continue

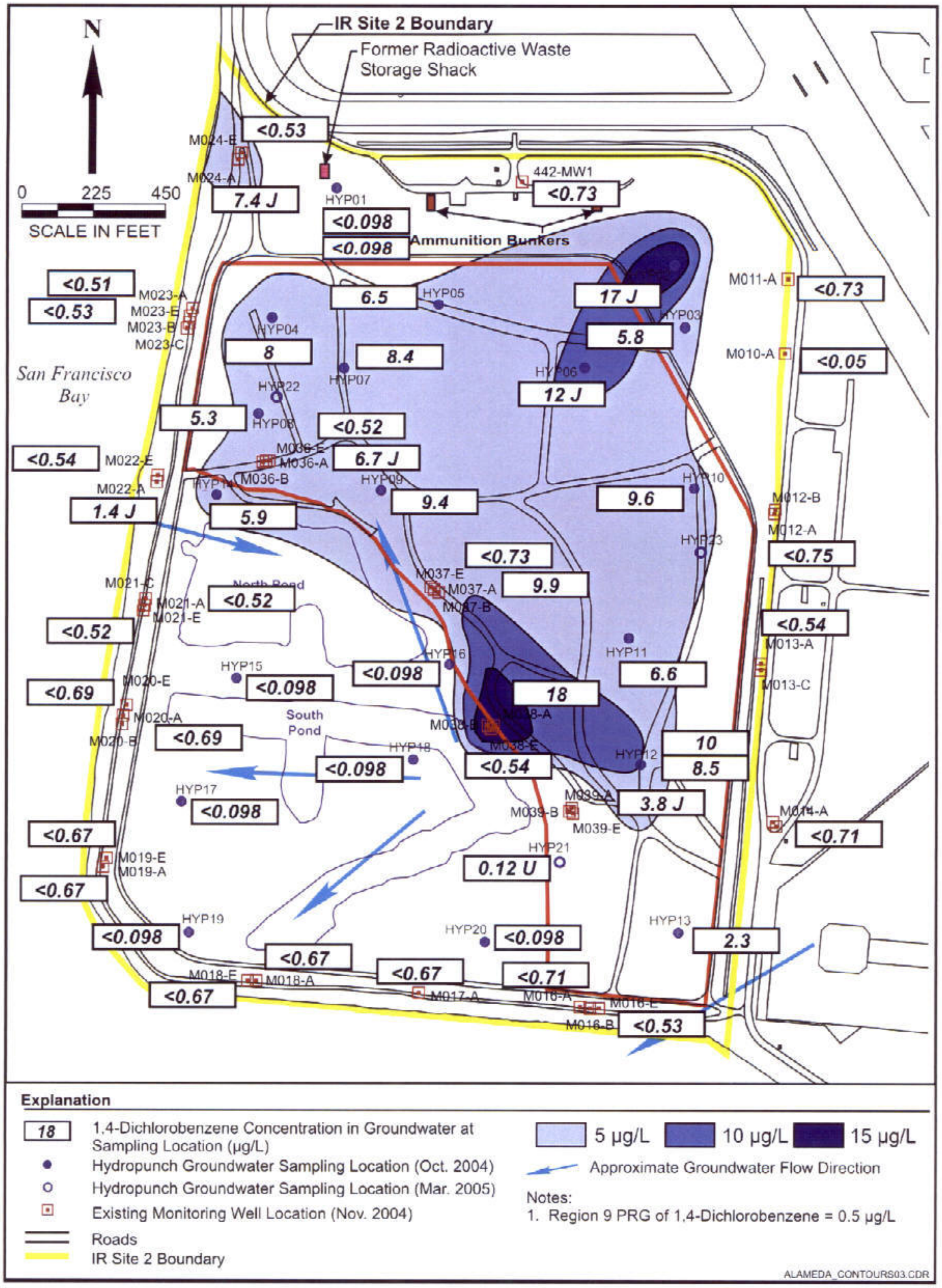

Figure 5-6. Isonconcentration Map of 1,4-Dichlorobenzene in FWBZ Groundwater, Fall 2004/Winter 2005