

EXECUTIVE SUMMARY

This report presents the results of the Remedial Investigation (RI) at Site 31, the Former Dump Site at the East Garrison. The objectives of the RI at Site 31 were to collect sufficient data to assess: (1) the lateral and vertical extent of potential contamination, (2) the potential threat to human health and the environment from site-related chemicals, and (3) the potential remedial measures, if needed.

Background

Site 31 is in the southern part of the East Garrison, in and adjacent to a ravine approximately 0.2 mile southeast of the intersection of Watkins Gate Road and Barloy Canyon Road. The dump site is at the boundary of the Leadership Reaction Training Compound on the northern side of the ravine. The visible extent of disposal encompasses an approximately 500-foot-long section of the northern slope of the ravine.

The dump site was reportedly used in the 1940s and 1950s. Apparently, during this time, refuse was wholly or partially incinerated in a 500-ton incinerator, which was located adjacent to the ravine.

Site 31 has been included as part of a 734-acre parcel that also includes the East Garrison. Two hundred acres of this parcel are slated for the Monterey Agricultural Center and the remainder is to be set aside as open space/habitat. The precise future plans for Site 31 are unknown, although the steepness and natural habitats of Site 31 suggest that part will be set aside as open space.

Remedial Investigation Program

The field investigation was performed in two phases. The Phase 1 investigation included:

- Conducting preliminary surface debris mapping
- Conducting a geophysical survey

- Conducting a soil gas survey at 18 probe locations
- Drilling 18 soil borings to a maximum depth of 10.5 feet below ground surface (bgs)
- Collecting subsurface soil samples for lithologic characterization, chemical analysis, and particle size analysis.

On the basis of results of Phase 1 activities, an additional Phase 2 investigation was performed and included:

- Conducting detailed surface debris mapping
- Collecting 58 surface soil samples for lithologic characterization and chemical analysis
- Drilling 21 soil borings to a maximum depth of 71.5 feet bgs
- Collecting subsurface soil samples for lithologic characterization and chemical and physical analyses.

Results and Conclusions of the RI

The history of the site, surface debris mapping, and soil gas and soil sampling indicate that the nature and extent of contamination consist of the following:

- The main potential source of contamination identified at Site 31 is incinerated debris and ash that is probably incinerated refuse. Other potential nonpoint sources of contamination at the site include (1) asphalt pavement operations and stockpiling of coal and (2) the application of pesticides in the vicinity of Site 31.
- Surface and subsurface incinerated and unincinerated debris at the site is within a sand matrix; debris consists of whole, broken, and melted glass, melted and unmelted metal fragments, rusted cans,

empty, crushed 55-gallon drums, burnt and unburnt wood, coal pieces, concrete and asphalt chunks, brick and clay tile fragments, and ash.

- Relatively low concentrations of volatile organic compounds (VOCs) were detected in soil gas throughout the site. Because concentrations were low and VOCs were not detected in soil samples collected adjacent to soil gas sampling points, and because detected concentrations do not appear to be associated with the presence of debris, VOCs in soil gas were not investigated further as part of the RI.
- TPH as diesel, polynuclear aromatic hydrocarbons (PAHs), and dibenzofuran were detected in surface and subsurface soil samples; these chemicals appear to be related to the presence of incinerated and unincinerated debris.
- Pesticides, including 4,4'-DDE, 4,4'-DDT, gamma-BHC, heptachlor, aldrin, dieldrin, and endrin, were detected in surface and subsurface soil samples; these chemicals either may be related to the presence of incinerated and unincinerated debris or may be related to the former applications of pesticides along the ravine slope.
- Chlorinated dibenzodioxins (CDDs) and chlorinated dibenzofurans (CDFs) were detected throughout the site in surface and subsurface soil samples, both inside and outside areas with debris; concentrations appear to decrease away from the dump site. Although the presence of CDDs and CDFs within the debris zone are likely associated with the incineration of the dumped debris, CDDs and CDFs within soils outside the debris area are potentially from the settling of ash emanating from the chimney of the former onsite incinerator or potentially represent background conditions.
- Priority pollutant metals were detected above maximum background concentrations in surface and subsurface soil samples; generally, elevated metal concentrations were associated with the presence of incinerated or

unincinerated debris at or above the sampling location.

- The lateral and vertical extent of several organic and inorganic compounds was not delineated to nondetect or established maximum background concentrations, respectively; however, because concentrations are low and/or are near maximum background conditions, no further investigation was warranted.

Groundwater quality was not investigated at the site because chemicals detected within the soil at the site are relatively immobile; because organic and inorganic compound concentrations are either nondetected, detected at relatively low concentrations, or approach background conditions; and because groundwater is deep (i.e., approximately 135 feet below the bottom of the ravine). However, to evaluate the potential impact to groundwater by detected organic chemicals, VLEACH modeling was performed on selected organic chemicals or groups of chemicals. With the exception of the TPHd surrogate dodecane, the results of the modeling indicated that these chemicals would not leach to groundwater over a 100-year period if left in place at maximum detected site concentrations. The modeling indicated that dodecane might leach to groundwater in 49 years and estimated the maximum concentration of 0.0008 $\mu\text{g/l}$ in 100 years; this is not considered to represent a significant impact to groundwater.

A qualitative analysis of the potential for metals to leach to groundwater indicates that, because the concentration of metals decreases significantly beneath the fill, the pH in soil is relatively high (i.e., pH of 6 to 8), and groundwater is 135 feet below ground surface, the potential for impacts to groundwater quality from metals is very low.

Although several potential migration pathways have been identified for chemicals found at Site 31, no significant migration pathways in air, surface water or groundwater currently exist. Chemicals at Site 31 are generally immobile and persistent. In addition, an evaluation of analytical results of Site 31 soil samples and the results of modeling indicate that chemicals have

not significantly migrated through soil (i.e., greater than a few feet) and should not pose a significant threat to groundwater in the future.

1.0 SITE BACKGROUND

1.1 Physical Description

Site 31, the Former Dump Site, is in the southern part of the East Garrison in and adjacent to a ravine approximately 0.2 mile southeast of the intersection of Watkins Gate Road and Barloy Canyon Road (Plates 1 and 2). The dump site is at the boundary of the Leadership Reaction Training Compound, which includes buildings in a fenced area on the northern side of the ravine (Plate 2). The ravine is approximately 60 feet deep and vegetated with oak trees and low brush, including poison oak. The steep (1 to 1) slope and loose surficial soil make walking difficult. High-voltage power lines cross above the site. The visible extent of disposal encompasses an approximately 500-foot-long section of the northern slope of the ravine. The debris includes whole, broken, and melted glass, melted and unmelted metal fragments, rusted cans, empty, crushed 55-gallon drums, burnt and unburnt wood, coal pieces, concrete and asphalt chunks, brick and clay tile fragments, and ash.

1.2 History

The dump site was apparently used in the 1940s and 1950s. In the 1940s, the East Garrison, which is the oldest of the developed sections of Fort Ord, was developed into a tent city for troops in training or being staged for transport (EA, 1991a). Based on a review of a 1941 map by the Office of Constructing Quartermaster, Fort Ord, the tent city was located approximately 2,000 feet north of Site 31. According to the map, a 500-ton incinerator (labeled T-400) was located at the top of the Site 31 ravine described above, within the Leadership Reaction Training Compound. Although the East Garrison reportedly had been used as a training ground for cavalry and artillery since World War I, no records regarding the use of Site 31 were found.

On the basis of interviews with Fort Ord personnel and of field observations obtained during this investigation, refuse observed on and within the ravine slope appears to date predominantly from the 1940s and 1950s (EA, 1991a). Apparently, during this time, refuse was wholly or partially incinerated in the incinerator described above and dumped over the northern slope of the adjacent ravine. Remnant coal debris, observed west of the existing site building structures, probably represents the location of former stockpiled coal, which probably served as a source of fuel for the incinerator. Also, Site 31 may be the landfill discussed in the Chemical Systems Laboratory (CSL) report, which described a general refuse landfill dating from the 1930s (CSL, 1983). At some later time, the incinerator was removed and dumping ceased, and the Leadership Reaction Training Compound was constructed and used. The site is currently not in use.

1.3 Previous Investigations

No previous surface or subsurface investigation is known to have been performed at this site.

2.0 REMEDIAL INVESTIGATION PROGRAM

2.1 Soil Investigation

The field investigation at Site 31 was conducted to obtain data needed to assess the nature and extent of surface and subsurface contamination associated with landfill material and geologic conditions at the site. Unless specified otherwise, the work was performed in accordance with the final RI/FS Work Plan (HLA, 1991c), the RI/FS Sampling and Analysis Plan (SAP; HLA, 1991b), the Work Plan in the *Draft Site Characterization, Site 31*, dated October 28, 1992, Part 2 of the *Draft Site Characterization, Site 34*, and the site safety and health plans (EA, 1991a; HLA, 1992b). Deviations from the SAP and the Site 31 Site Characterization are noted in the appropriate sections below.

The field investigation was performed in two phases. Field activities are summarized below and in Table 1. Phase 1, conducted between November 1991 and February 1992, included:

- Conducting preliminary surface debris mapping
- Conducting a geophysical survey
- Conducting a soil gas survey at 18 probe locations
- Drilling 18 soil borings to a maximum depth of 10.5 feet below ground surface (bgs)
- Collecting subsurface soil samples for lithologic characterization, chemical analysis, and particle size analysis.

On the basis of results of Phase 1 activities, additional Phase 2 investigation activities were proposed in the *Draft Site Characterization for Site 31*. Phase 2, conducted between August 1993 and March 1994, included:

- Conducting detailed surface debris mapping

- Collecting 58 surface soil samples for lithologic characterization and chemical analysis
- Drilling 21 soil borings to a maximum depth of 71.5 feet bgs
- Collecting subsurface soil samples for lithologic characterization and chemical and physical analyses.

Field investigations are discussed below. Tables 2 and 3 present lists of surface and subsurface soil samples collected for chemical analyses. Appendix A contains soil boring logs. A list of samples submitted for physical testing and a summary of the results are presented in Table 4; physical testing results are presented in Appendix B.

2.1.1 Surface Debris Mapping

Surface debris mapping was performed in both Phase 1 and Phase 2 as described below. In conjunction with conducting the Phase 1 geophysical survey described below, preliminary mapping of surficial debris was performed. The observed nature and lateral extent of surface debris was used in the evaluation of geophysical data. Subsequently, during Phase 2 field activities, detailed surface debris mapping was performed on August 30, 1993, to provide detailed information on the nature and lateral extent of landfill debris and to facilitate surface and subsurface soil sampling. The Phase 1 and 2 mapping activities are described below and the results are presented in Section 4.2.2.

In conjunction with the Phase 1 geophysical survey, a schematic site map was prepared on November 26, 1991, by extending a baseline along an existing fence and flagging every 25 feet. The distance from these stations to the edge of the ravine was estimated; slope angle and distance to the bottom of the ravine were also estimated. The northern slope of the ravine was then traversed by the HLA geophysicist, who plotted the approximate locations of observed

debris, using a code to distinguish different materials. In this manner, a schematic map was developed of the approximate distribution of observed debris (Plate 3).

Phase 2 mapping activities, conducted between August 16 and 20, 1993, included land surveying of the Former Dump Site and preparation of a topographic map to establish topographic control of the site. Land surveying, conducted by Sandis, Humber, Jones, a licensed land surveying firm, was performed in the vicinity of known surface and subsurface debris and contamination and included the surveying of 13 fence posts placed throughout the ravine to facilitate mapping activities. Subsequently, an HLA geologist mapped surface debris by walking the site and noting the distribution and type of debris on the topographic map. Approximately 1-foot-deep holes were dug throughout the site to distinguish between areas with only surface debris and areas with debris extending below the surface.

2.1.2 Geophysical Survey

HLA geophysicists conducted a geophysical survey on November 26, 1991. The primary objective of the survey was to provide a preliminary indication of the lateral extent of near-surface landfill debris. Approximately 3,000 linear feet of reconnaissance-level electromagnetic (EM) data were collected along four transects oriented parallel to slope contours. Transect 1 was located along the top of the ravine; Transect 2 was located approximately 1/3 of the way down the ravine slope; Transect 3 was located approximately 2/3 of the way down the ravine. Transect 4 extended east from Watkins Gate Road along the base of the ravine slope (Plate 3). A magnetic survey was attempted, but interference from the overhead power lines made the data unusable. A ground-penetrating radar (GPR) survey was not conducted at this site, as proposed in the SAP (HLA, 1991b), because of the steep slopes and unstable footing and the inability of the EM survey (see Section 4.2.1) and magnetic survey to identify suitable targets for GPR profiling. The geophysical methods are described in Part 2 of the Site 34 Site Characterization.

2.1.3 Borehole Clearance

Before intrusive activities were performed (i.e., conducting soil gas surveys and drilling soil borings), proposed sampling locations were cleared for sensitive biological species and unexploded ordnance (UXO). UXO clearance activities, conducted by UXO subcontractor UXB International, Inc., under HLA supervision, also included downhole clearance using a downhole magnetometer at borehole locations.

Although HLA attempted to clear the proposed Phase 1 soil gas probe and boring locations for underground utilities, such clearance could not be obtained because of the steep terrain. Geophysical clearance for underground utilities was not attempted for Phase 2 hand auger boring locations for the same reason; however, HLA cleared the two Phase 2 geotechnical borings (SB-31-19 and SB-31-20) that were drilled by a hollow-stem auger rig at the top of the ravine. Borehole clearance methods are described in Part 2 of the Site 34 Site Characterization.

2.1.4 Soil Gas Surveys

On February 14, 24, and 25, 1992, HydroGeo Chem, Inc., conducted shallow soil gas surveys at Site 31 under the supervision of HLA. The primary objective of the surveys was to provide a preliminary indication of whether total hydrocarbons and/or volatile organic compounds (VOCs) were present in the underlying soil. The surveys consisted of sampling 18 soil gas probes at accessible areas along the northern and western slopes of the ravine and along the ravine floor where the probe could be driven into the soil. The 18 soil gas sampling points, shown on Plate 3, replaced the grid of 14 sampling points described in the SAP.

The target depth for soil gas sampling was approximately 5 feet below ground surface (bgs). Twenty-one soil gas samples from 18 locations were analyzed. Three and two samples were analyzed from Probes 8 and 14, respectively, because the soil borings (drilled adjacent to each soil gas probe location) were relocated because of obstructions. Soil gas samples were analyzed in an onsite mobile laboratory for total hydrocarbons (THC), benzene, toluene,

ethylbenzene, and total xylenes (BTEX), tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (TCA), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2 DCE), vinyl chloride, and methane. A complete description of soil gas survey procedures and techniques is included in Part 2 of the Site 34 Site Characterization.

2.1.5 Surface Soil Sampling

Between August 31 and September 2, 1993, 50 surface soil samples were collected for analysis to assess the lateral extent of potential surface soil contamination (Plate 2). Surface soil sample locations were selected both inside and outside the areas having surface debris. All samples were analyzed by Enseco-California Analytical Laboratory in West Sacramento (Enseco) for priority pollutant metals and hexavalent chromium; selected samples were also analyzed for semivolatile organic compounds (SOCs), polychlorinated biphenyls (PCBs), pesticides, chlorinated dibenzodioxins (CDDs), and chlorinated dibenzofurans (CDFs). Surface soil sample descriptions, the chemical analytical program, and analytical methods are presented in Table 2.

On the basis of results of these analyses, eight additional surface samples were collected at the site between February 25 and March 9, 1994, to further assess the lateral extent of contamination. These samples were analyzed by Enseco for one or more of the following: priority pollutant metals (including only copper in SS-31-62), hexavalent chromium, and CDDs/CDFs (Table 2).

2.1.6 Soil Borings and Soil Sampling

As stated above, soil borings were drilled as part of Phase 1 field activities, between February 12 and 16, 1992, and Phase 2 field activities, between October 20, 1993, and March 9, 1994. The Phase 1 borings (SB-31-01 through SB-31-18) were drilled instead of excavating the six trenches outlined in the SAP (HLA, 1991b), because the steep terrain precluded the use of a backhoe. Each Phase 1 boring was drilled

adjacent to a soil gas probe location. The borings were drilled to assess the nature and extent of potential contamination from landfilling activities. Two Phase 2 soil borings (SB-31-19 and SB-31-20) were drilled to obtain geotechnical data in support of the FS. On the basis of results of the Phase 1 borings and soil sampling and Phase 2 surface soil sampling, the decision was made to drill an additional 19 soil borings as part of Phase 2 activities to further assess the vertical and lateral extent of contamination.

Except for the two geotechnical borings for Phase 2 (SB-31-19 and SB-31-20), borings for both phases were drilled with a hand auger by UXB International, Inc., under HLA supervision. Phase 1 soil borings were drilled to depths of approximately 10 feet bgs, and the remaining (nongeotechnical) Phase 2 borings were drilled to between 2 and 16 feet bgs. Soil samples from hand-auger borings were collected at various intervals for lithologic characterization. The two geotechnical borings (SB-31-19 and SB-31-20) were drilled with a truck-mounted, 8-inch-diameter, hollow-stem auger rig to 51.5 and 71.5 feet bgs, respectively. Soil samples from the geotechnical borings were collected at 5-foot intervals using a split-spoon Sprague and Henwood (S&H) sampler or standard penetrometer (SPT) sampler. The samples were logged in the field by an HLA engineer or geologist as described in Appendix A. Samples from the borings were screened for the presence of organic chemicals using an organic vapor analyzer (OVA). Phase 2 nongeotechnical borings were screened for the presence of mustard agent using an ICAD Miniature Chemical Agent Detector (ICAD). Results of OVA readings are recorded on the boring logs (Appendix A); the ICAD did not detect mustard agent in any soil samples.

Soil samples from borings were submitted to Enseco for chemical analyses and the HLA Soil Laboratory (Phase 1) or SOLEA Soils Laboratory (Phase 2) in Concord for physical testing. Soil sample descriptions, the chemical analytical program, and analytical methods are presented in Tables 2 and 3. Eighteen soil samples were collected from Phase 1 borings and analyzed for VOCs, TPHd, and priority pollutant metals. These soil samples were collected at depths

ranging from 7.5 and 10 feet bgs from within debris fill, nondebris fill, and underlying native sand. In addition, one soil sample from each of six Phase 1 borings (SB-31-02, -04A, -05B, -08, -09, and -10) was submitted for grain size analyses.

Seven soil samples were collected from Phase 2 Borings SB-31-19 and SB-31-20 and analyzed for one or more of the following: moisture content, dry density, organic content, and Atterberg Limits. These samples were collected at depths ranging from 4 to 56.5 feet bgs from within nondebris fill and underlying native sand. Forty-three soil samples collected from the remaining Phase 2 borings were analyzed for one or more of the following: priority pollutant metals, hexavalent chromium, SOCs, pesticides, and CDDs/CDFs. These samples were collected at depths ranging from 0 feet to 16 feet bgs from within debris fill and non-debris fill and native sand. Two samples from Borings SB-31-23 and SB-31-33, respectively, were submitted for physical testing in support of the FS and analyzed for the following: moisture content, organic content, and Atterberg Limits.

2.1.7 Analytical Program

The soil chemical and physical testing program used for Site 31 is summarized above and in Tables 3 and 4. Soil samples collected as part of this investigation were analyzed by Enseco for one or more of the following: priority pollutant metals using EPA Test Series 6000 and 7000, hexavalent chromium (CrVI) using EPA Test Method 7196, total petroleum hydrocarbons (TPH) as diesel using EPA Test Method 8015 Modified, semivolatile organic compounds (SOCs) using EPA Test Method 8270, polychlorinated biphenyls (PCBs) and pesticides using EPA Test Method 8080, and chlorinated dibenzodioxins (CDDs) and chlorinated dibenzofurans (CDFs) using EPA Test Method 8290. All methods were performed according to the SAP. Deviations from the SAP are noted in the appropriate sections above.

2.2 Basewide Investigations

Site 31 was not included in the Basewide Surface Water Outfall Investigation, the Basewide Storm Drain and Sanitary Sewer Investigation, or the Basewide Groundwater Monitoring Program. Surface water sampling was planned at Sampling Location OF-33, where the ravine meets Watkins Gate Road, as part of the Basewide Ecological Risk Assessment; however, surface runoff water was not present in sufficient amounts during four separate storm events in 1994 to enable sampling.

However, plant, animal (i.e., deer mice), and surface soil samples were collected at Site 31 as part of the Ecological Risk Assessment. A summary of the surface soil sample analytical results are presented here; the soil data have not been incorporated into the remainder of this RI because detected chemical concentrations were similar to those detected in samples collected during the RI and because the data are not useful in further evaluating the nature and extent of contamination since the samples represent composites across the site. A detailed discussion of the ecological investigation including the results of the plant and animal sampling is provided in Volume IV, Baseline Ecological Risk Assessment.

Four composite soil samples were collected at Site 31, one composited sample from multiple locations along each of four transects. The linear transects began at the top of the northern slope of the ravine and ended either at the bottom of the ravine or partway up the southern slope of the ravine. Each composite sample was analyzed for priority pollutant metals (EPA Test Series 6000 and 7000), PAHs (EPA Test Method 8310), pesticides (EPA Test Method 8080) and CDDs and CDFs (EPA Test Method 8290).

Pesticides (4,4'-DDE and/or 4,4'-DDT) were detected in two samples at concentrations up to 0.036 mg/kg 4,4'-DDT. PAHs were detected in one sample at concentrations up to 1.8 mg/kg acenaphthene, and one or more CDD/CDF was detected in four samples at concentrations up to 0.290 $\mu\text{g}/\text{kg}$ octachlorodibenzo-p-dioxin. Also, three metals (zinc, antimony, and lead) were

detected in one sample at concentrations above maximum background levels; the concentrations of these metals were 114, 0.7, and 91.1 mg/kg, respectively. Concentrations of these pesticides, PAHs, CDDs/CDFs, and metals were near or below ranges of concentrations previously detected in soil at Site 31.

3.0 PHYSICAL CHARACTERISTICS

3.1 Topography

The Leadership Reaction Training Compound (LRTC) structures are within a relatively flat area, approximately 185 to 200 feet MSL, north and west of the ravine (Plate 2). The area appears to have been graded during site development. The ravine, approximately 60 feet deep in the vicinity of the dump, is oriented east-to-west south of the compound and turns north-to-northeast east of the compound. The slopes of the ravine are relatively symmetrical, although the northern slope appears to be slightly steeper, possibly due to former grading activities. The ravine broadens and its floor widens to the east and northeast.

3.2 Climate

The area's climate is characterized by warm, dry summers and cool, rainy winters. The Pacific Ocean is the principal influence on the climate at Fort Ord, causing fog and onshore winds that moderate temperature extremes. Daily ambient air temperatures at Fort Ord typically range from 40 to 70°F, but temperatures in the low 100s have been measured in the past. Thick fog is common in the mornings throughout the year. Winds are generally from the west in the spring and summer, but variable during the fall and winter. Wind speed is typically low and variable in the mornings until the fog dissipates, strengthening in the afternoon. Average wind speed documented at the Fritzsche Army Airfield (FAAF) between 1960 and 1970 was 5 to 10 knots (Weston, 1990). The average annual rainfall is 14 inches, most of which occurs between November and April.

3.3 Biology

The ecological setting at Fort Ord has been described as part of the Basewide Biological Inventory, Ecological Risk Assessment, and Remedial Investigations performed by HLA and the U.S. Army Corps of Engineers (COE, 1992b). Additional information regarding the plant communities present at Fort Ord can be found in Hickman, 1993; Munz, 1970; Kuchler, 1977; and

Schoenherr, 1992. Ecological information pertinent to Site 31 is summarized below; plant community locations are shown on Plate 4.

Biological communities present at Site 31 include coast live oak woodland, wet ruderal, upland ruderal, and valley needlegrass grassland.

The coast live oak woodland community is characterized by a multilayer community of trees, shrubs, and forbs. This biologically diverse community occurs on the steep, shaded slopes of Site 31. Coast live oak (*Quercus agrifolia* var. *agrifolia*) is the single tree occurring in the overstory. The shrub layer is characterized by dense deciduous shrubs such as western poison oak (*Toxicodendron diversilobum*), fuchsia-flowered gooseberry (*Ribes speciosum*), and oceanspray (*Holodiscus discolor*). Typical herbs growing in the understory include miner's lettuce (*Claytonia perfoliata*), wood fern (*Dryopteris arguta*), and California hedge nettle (*Stachys bullata*).

Wet ruderal community occurs at the toe of the slope. Wet ruderal designation includes communities exhibiting evidence of disturbance and supporting invasive plants. The sandy streambed at Site 31 rarely supports surface water flow except during significant storm events. The dominant species occurring in the base of the drainage are greater periwinkle (*Vinca major*), mugwort (*Artemisia douglasiana*), spring vetch (*Vicia sativa*), California blackberry (*Rubus ursinus*), and sweet fennel (*Foeniculum vulgare*).

Upland ruderal community occurs upslope to the north. Upland ruderal communities are areas supporting primarily non-native weedy plants adapted to disturbed conditions. Disturbed south-facing slopes support shrubs such as coyote brush (*Baccharis pilularis*) and California sagebrush (*Artemisia californica*). Characteristic understory includes herbs such as black mustard (*Brassica nigra*) and ripgut grass (*Bromus diandrus*).

Valley needlegrass grassland community occurs upslope from the drainage, west of the LRTC structure (Plate 4). The grassland is a mid-height (to 1.0 meter), single-storied community dominated by perennial, tussock-forming purple needle grass (*Nassella pulchra*). Native and introduced annual grasses and annual and perennial forbs such as holly-leaf navarretia (*Navarretia atractyloides*), cardionema (*Cardionema ramosissimum*), and yarrow (*Achillea millefolium*) occupy bare ground between the bunches.

Animals commonly observed in these communities include western fence lizard (*Sceloporus occidentalis*), mule deer (*Odocoileus hemionus*), gray fox (*Urocyon cinereoargenteus*), scrub jay (*Aphelocoma coerulescens*), rufous-sided towhee (*Pipilo erythrophthalmus*), wrentit (*Chamaea fasciata*), and California quail (*Callipepla californica*).

The special-status wildlife taxa observed at Site 31 include the Monterey dusky-footed woodrat (*Neotoma fuscipes luciana*). Other special-status taxa that may occur in the vicinity of Site 31 because of known range and potential habitat include loggerhead shrike (*Lanius ludovicianus*), sharp-shinned hawk (*Accipiter striatus*), golden eagle (*Aquila chrysaetos*), Monterey ornate shrew (*Sorex ornatus salarius*), Toro manzanita (*Arctostaphylos montereyensis*), and purple-flowered piperia (*Piperia michaelii*). The status of these taxa is presented in Table 5.

3.4 Surface Water Hydrology

Rainwater readily infiltrates the sandy soil at the site. The building structures and asphaltic pavement at the LRTC, however, are not infiltrated, and runoff is generated. A portion of the runoff generated at the main LRTC structure is captured in storm drains and flows through a storm drain pipe to the base of the adjacent ravine (Plate 2). Runoff from the adjacent Barloy Canyon Road is also conveyed through a storm drain pipe to the base of the ravine. A channel of an intermittent stream is present, in the western end of the ravine. However, this channel is no longer present in the vicinity of the Former Dump Site where the ravine floor begins to flatten. This intermittent stream channel

apparently flows only in association with significant storm events or during periods of prolonged rainfall. Downgradient of the channel, surface water runoff appears to infiltrate the alluvial sands on the flat floor of the ravine.

3.5 Geology

Site 31 is underlain primarily by fine to medium sand to silty or clayey sand of the Aromas Sand (Plates 5 and 6). The sand is generally yellow brown to orange brown and varies from dense to very dense with depth relative to the degree of cementation in individual sand beds. Boring logs from groundwater wells in the vicinity of the site (e.g., Test Well 4) indicate that the Aromas Sand is underlain by gravel, sand, and clay units of the Paso Robles Formation; the formation contact in the vicinity of Site 31 is estimated to be at 60 feet MSL, approximately 60 feet below the bottom of the ravine near the Former Dump Site. A more complete description of the geology of this area is presented in Volume II - RI, Basewide Hydrogeologic Characterization.

Undisturbed, slightly cemented Aromas Sand outcrops in several areas in the relatively flat area adjacent to and north of the ravine as well as at the base of the western portion of the ravine. As a result of previous cut-and-fill activities, undisturbed Aromas Sand is encountered at depths ranging from 0.5 to 1.5 feet bgs in the area between the Leadership Reaction Training Compound and Barloy Canyon Road to greater than 13 feet bgs along the top of the northern ravine slope. Loose, disturbed Aromas Sand blankets most of the site and is generally the thickest on the ravine slopes. Incinerated debris in a gray to brown Aromas Sand matrix is at the surface and at depth along the northern ravine slope south of the compound as a result of former dumping activities. In some areas, the debris/sand is overlain by debris-free sand that was probably placed over the debris/sand during grading activities at the adjacent compound. A description of the debris material encountered is presented in Section 4.2.

The particle size results indicate the soils encountered in the borings are generally sands (SW, SP) to silty or clayey sands (SM or SC). Because a hydrometer was not used, clay content

was not distinguished from silt content. Physical testing results, including particle size analysis data, are summarized in Table 5 and presented in Appendix B.

3.6 Hydrogeology

Site 31 is located within the Salinas Basin. Although no groundwater wells are at the site, data from wells (e.g., Test Well 4, MW-30-01-A) in the vicinity suggest that the groundwater table is approximately 135 feet below the bottom of the ravine, approximately 13 feet MSL. The shallowest aquifer in the vicinity of Site 31 has been designated the Aromas Sand-Paso Robles Aquifer and is probably within the deposits of the Paso Robles Formation. A more complete description of the hydrogeology of this area is presented in Volume II - RI, Basewide Hydrogeologic Characterization.

Because hydrogeologic data from this area are lacking, the direction of groundwater flow is not known. However, water-level data from wells throughout the region indicate that groundwater probably flows northeast to northwest. Seasonal pumping from wells within the Salinas Valley to the north and northeast and from Fort Ord wells to the northwest likely influences regional flow in the vicinity of Site 31.

3.7 Future Land Use

Under the Fort Ord Reuse Group (FORG) preliminary plan for reuse of lands at Fort Ord, Site 31 has been included as part of a 734-acre parcel that also includes the East Garrison and Sites 29, 30, and 32. Two hundred acres of this parcel are slated to become the Monterey Agricultural Center, which will include facilities for agricultural production, storage, cooling, packaging, and distribution, as well as approximately 250 housing units for families and farm workers. Development of the Agricultural Center is expected to take place predominantly in areas that are already developed in the parcel, particularly the East Garrison and the Ammo Supply Point, which is near Site 31 to the southeast. The remainder of the parcel is to be set aside as open space/habitat, with a priority on preserving areas that are natural habitats (FORG, 1993; COE, 1992a). Precise future plans for Site 31 are unknown. The steepness and natural habitats of Site 31 suggest that part will be set aside as open space.

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 Potential Sources of Contamination

The main potential source of contamination identified at Site 31 is incinerated debris and ash most likely generated by onsite incineration at the East Garrison during the 1940s and 1950s. Debris encountered along the northern slope of the ravine was probably dumped into the ravine after being wholly or partially incinerated. Areas of the slope where debris-free sand overlies debris-containing sands may have resulted from sand being pushed into the ravine during regrading activities connected to the construction of the Leadership Reaction Training Compound. The emanation of ash from the chimney of the former incinerator and the settling of ash onto the ground surface in the vicinity of Site 31 form an additional migration pathway of contaminants. Chemical contaminants expected to be associated with the incinerated and nonincinerated wastes include metals, VOCs, SOCs, PCBs, and CDDs/CDFs.

Coal debris, described below, probably is remnants of the fuel source for the onsite incinerator; the distribution of petroleum hydrocarbons associated with coal have not been assessed as part of this investigation.

Nonpoint sources of contamination at the site may include:

- Asphalt paving operations (as well as stockpiling of coal) at the Leadership Reaction Training Compound which may have released petroleum hydrocarbons and associated constituents
- The application of pesticides in the vicinity of Site 31.

4.2 Nature and Extent of Debris

The following sections describe the nature and extent of debris at Site 31. Descriptions of the debris are based on the results of the geophysical

survey, surface debris mapping, and visual observations made during drilling.

4.2.1 Geophysical Survey

The EM data show moderate- to high-amplitude anomalous responses corresponding to areas of observed debris; however, the operator's excessive slipping, falling, and pushing through dense brush on the steep slope and unstable ground in these areas resulted in a significant amount of "noise" in the EM data. In viewing much of the data, it is not possible to determine whether an anomalous EM response was due to the presence of subsurface debris or to jarring of the instruments during surveying. The EM survey data are of limited use in evaluating the extent of subsurface disposal at Site 31.

4.2.2 Surface Debris

The lateral extent of surface debris as mapped during Phase 1 is shown on Plate 7. Because of the lack of horizontal control due to the high topographic relief, the extent of surface debris and location of structures as presented are relative; surface debris was mapped on a topographic map during Phase 2. Surface debris observed during Phase 1 mapping included whole, broken, and melted glass, melted and unmelted metal fragments, rusted cans, empty, crushed 55-gallon drums, burnt and unburnt wood, coal pieces, concrete and asphalt chunks, brick and clay tile fragments, and ash.

On the basis of the Phase 2 mapping, debris was differentiated into four different groups as shown on Plate 7. The names of the four groups and their characteristics are:

- Sporadic surface debris
 - Is scattered (e.g., wood, metal pieces, whole and broken glass, and coal pieces)
 - Overlies yellowish brown to light yellowish brown silty sand to sandy silt, locally becoming dark yellowish brown

- Extends approximately 500 feet along the northern slope of the ravine and covers approximately 1/2 to 3/4 of the slope (from top to bottom).
- Extensive debris to deeper than 2 feet bgs
 - Consists of twenty-five to 75 percent debris (e.g., bottle caps, pieces of pottery and metal, melted and unmelted glass pieces and bottles, fork, glass stopper)
 - Consists of twenty-five to 75 percent grayish brown silty sand to sandy silt
 - Exists in an area approximately 60 feet by 60 feet on the northern slope of the ravine, to at least 2 feet bgs.
- Moderately extensive to sporadic debris generally shallower than 8 inches bgs
 - Consists of trace to 10 percent debris (e.g., metal fragments, whole and broken bottles, rusted cans, wood, coal pieces, and nylon netting)
 - Consists of ninety to 100 percent dark yellowish brown silty sand to sandy silt
 - Is found generally shallower than 8 inches bgs, locally to below 2 feet bgs
 - Exists in three areas along the northern slope of the ravine.
- Coal debris shallower than 8 inches bgs
 - Consists of ten to 100 percent coal debris in gray to yellow brown sand matrix
 - Overlies yellowish brown to light yellowish brown silty sand to sandy silt
 - Exists in two areas north of the ravine.

4.2.3 Subsurface Debris

Incinerated and unincinerated debris was encountered in soil borings drilled on the northern slope and bottom of the ravine. Debris generally made up 10 percent to 20 percent of the

material encountered, in a dark yellowish brown to dark grayish brown sand to silty sand matrix. Debris included melted and unmelted glass fragments, concrete and asphalt chunks, burnt and unburnt wood, melted and unmelted metal fragments, brick and clay tile fragments, coal pieces, plastic netting, and ash.

The extent of subsurface debris is shown on Plates 8, 9, and 10. Subsurface debris is in an approximately 320-foot by 110-foot (horizontal distance) area along the northern slope of the ravine, extending from top to bottom. Debris-containing sand varies from 2 to 13 feet thick vertically; thicknesses measured perpendicular to the slope are proportionally less. Debris-containing sand extends from the ground surface to a maximum depth of 8.5 feet bgs in the eastern and western portions of this area of subsurface debris and extends from between 1 to 6 feet bgs to 15.5 feet bgs in the remaining areas. Because of the manner in which the material was dumped, the presence and concentration of debris varies significantly both laterally and vertically. For example, two borings (SB-31-03 and SB-31-12), in which debris was not encountered, are within the area interpreted to have debris-containing sands.

4.3 Soil Gas Chemistry

The soil gas survey was performed to assess the presence of VOCs at the site. Relatively low concentrations of VOCs, including total hydrocarbons (THC), were detected in all soil gas samples. Organic compounds detected in soil gas are discussed below. Detected organic compounds are presented in Appendix C.

In Probe SG-31-02, 1,1,1-TCA was reported at a concentration of 0.07 micrograms per liter ($\mu\text{g/l}$). PCE was reported at the detection limit concentration of 0.01 $\mu\text{g/l}$ in Probes SG-31-01 and SG-31-05. All other probes at Site 31 had no detectable concentrations of target chlorinated compounds.

THC was detected in all soil gas samples ranging from 0.16 $\mu\text{g/l}$ to 4.0 $\mu\text{g/l}$. Benzene was detected in Probe SG-31-01 at 0.05 $\mu\text{g/l}$, and toluene was found at a concentration of 0.07 $\mu\text{g/l}$ in SG-31-01 and SG-31-10, and at 0.009 $\mu\text{g/l}$ in SG-31-13.

Ethylbenzene was not detected in any soil gas sample collected at Site 31. Total xylenes were detected at 4 of 21 probe locations, ranging from 0.06 $\mu\text{g}/\text{l}$ to 0.19 $\mu\text{g}/\text{l}$. Methane was analyzed at 15 locations, with results ranging from nondetect to 15.0 $\mu\text{g}/\text{l}$.

Although VOCs were slightly above the detection limits in a number of locations, soil borings drilled next to the soil gas probe locations did not encounter detectable levels of VOCs. Also, because methane was detected in native soil outside the dump area (e.g., SG-31-9), its presence is probably due to naturally occurring organic vegetative material in soil rather than to the presence of debris. As a result, VOCs detected in soil gas samples were not evaluated further as part of the RI.

4.4 Soil Chemistry

Organic and inorganic compounds detected in soil samples are discussed below and in Appendix C and are summarized in Tables 6 and 7. A key to project and laboratory qualifiers assigned during data validation is presented in Table 9. To facilitate the discussion of the distribution of chemicals in soil at Site 31, the locations of the surface debris mapped during the RI are used to identify areas of elevated chemicals in soil. Also, the distribution of chemicals has been described in terms of surface (0 to 2 feet bgs) and subsurface (greater than 2 feet bgs) sample results. Organic and inorganic compounds detected above basewide maximum background concentrations in soil samples are presented on Plate 11.

4.4.1 Organic Chemicals

To facilitate the evaluation of the extent of CDDs, CDFs, and carcinogenic polynuclear aromatic hydrocarbons (PAHs) and their potential carcinogenic toxicities, sample results for CDDs and CDFs were converted to 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalents (TCDD-TEs) using TCDD toxic equivalent factors (TEFs) developed by the EPA, sample results for carcinogenic PAHs were converted to benzo(a)pyrene toxic equivalents (B[a]P-TEs) using B[a]P TEFs, and sample results for noncarcinogenic PAHs were summed to total

noncarcinogenic PAHs. Methods used to develop these toxic equivalents are presented in Volume III - Baseline Human Health Risk Assessment (BRA). Concentrations of the individual CDDs, CDFs, and carcinogenic PAHs are presented in Appendix C. Maximum and minimum concentrations of CDDs, CDFs, and carcinogenic PAHs are presented in Table 6.

The following discusses the organic compounds detected in soil samples and the vertical and lateral extent and relationship to surface and subsurface debris, if applicable. The distribution of selected chemicals and groups of chemicals (CDDs/CDFs, carcinogenic PAHs, 4,4'-DDE, and 4,4'-DDT) is presented on Plate 12. The distribution of organic chemicals is described with respect to the surface debris mapped at the site and the presence of subsurface debris.

- VOCs
- Acetone and methylene chloride were the only VOCs detected in the 18 subsurface soil samples analyzed. Acetone was detected in nine subsurface soil samples at concentrations up to 0.01 milligrams per kilogram (mg/kg); only one of these samples was collected within the debris zone. Methylene chloride was detected in one subsurface soil sample at a concentration of 0.036 mg/kg; no debris was observed in this sample. As discussed in Section 4.6.1 and as indicated by the laboratory qualifiers assigned to these values (see Appendix C), acetone and methylene chloride are considered laboratory contaminants and may not be representative of site conditions.
- In samples collected from SB-31-05 and SB-31-17, two compounds (1,2,3-trichlorobenzene and propanoic acid, 2-methyl-, 1-[1,1-dimethylethyl]) and one "unknown compound" were identified as tentatively identified compounds (TICs). The TICs detected in the sample from SB-31-05 may be related to the presence of debris in overlying sand.
- TPH

- TPH as diesel (TPHd) was detected in one subsurface soil sample from Boring SB-31-06 at a concentration of 12 mg/kg. The lateral extent is defined by adjacent Phase 1 borings; the vertical extent has not been defined to nondetect levels. The presence of TPHd may be related to the presence of moderately extensive debris in overlying sand.
- SOCs
 - Carcinogenic PAHs were detected in one surface sample (SS-31-29) at a B(a)P-TE concentration of 0.078 mg/kg (Plate 12) and were not detected in any subsurface samples. SS-31-29 was collected from an area with moderately extensive surface debris. The lateral extent of carcinogenic PAHs is defined by nondetects in nearby sampling locations; the vertical extent is defined by nondetects in 6- and 15-foot-deep samples from adjacent Boring SB-31-30 (within approximately 10 feet of SS-31-29).
 - Noncarcinogenic PAHs were detected in three surface samples (SS-31-34, SS-31-29, and the surface sample from Boring SB-31-29), each within approximately 80 feet of one another, at total concentrations up to 0.45 mg/kg and were not detected in any subsurface soil samples. The lateral extent is defined by nondetect levels to the south and southeast of these sample locations; the vertical extent is defined by nondetect concentrations at 6 and 3 feet bgs in Borings SB-31-30 (adjacent to SS-31-29) and SB-31-29, respectively. Noncarcinogenic PAHs may be related to the presence of moderately extensive surface debris at or near these locations.
 - Dibenzofuran was detected in one surface sample (SS-31-29) at a concentration of 0.034 mg/kg and was not detected in any subsurface samples. Its detection may be related to the moderately extensive surface debris observed at this sampling location. Dibenzofuran was not detected in underlying samples collected from adjacent Boring SB-31-30.
- Pesticides
 - Eleven compounds were identified as TICs in addition to "unknown compounds." With the exception of 4,4'-DDD and 4,4'-DDE detected in SS-31-34, these TICs appear to be either hydrocarbon related or naturally occurring.
 - Gamma-BHC, heptachlor, aldrin, dieldrin, and endrin were detected in one subsurface sample (SB-31-33 at 15 feet bgs) at concentrations up to 0.015 mg/kg for endrin and were not detected in surface samples. The sample was collected below the debris. The presence of these chemicals may be related to the moderately extensive presence of debris in overlying sand.
 - 4,4'-DDE and 4,4'-DDT were detected in three surface samples (SS-31-28, SS-31-29, and SS-31-34) at concentrations up to 1.4 mg/kg for 4,4'-DDE and 1.7 mg/kg for 4,4'-DDT (Plate 12). The compounds were also detected in two subsurface samples in Borings SB-31-33 and SB-31-34 at concentrations up to 0.065 mg/kg for 4,4'-DDE and 0.12 mg/kg for 4,4'-DDT. The extent is not laterally defined to nondetect concentrations east and west of these borings or vertically in either boring. Although these chemicals have not been fully defined to nondetect levels, the concentrations may be related to moderately extensive surface debris on the eastern part of the site, with two exceptions. Both exceptions are just outside the area of moderate surface debris observed in samples or overlying soil (except for Surface Sample SS-31-28, which did not contain debris).
- CDDs and CDFs
 - CDDs and CDFs were detected in 17 surface samples at TCDD-TE concentrations up to 0.028 µg/kg

(Plate 12) and in nine subsurface samples at concentrations up to $0.029 \mu\text{g}/\text{kg}$ at a depth up to 9 feet. CDDs and CDFs are present both inside and outside of areas with debris at the surface, but are generally present only in zones of debris in the subsurface. Concentrations generally decrease outside debris areas and, with the exception of Boring SB-31-34, concentrations are generally not detected at depth. Samples from SB-31-34 were not collected below the debris zone.

In general, organic chemicals detected, including TPH as diesel, PAHs, dibenzofuran, and pesticides, are related to the presence of moderately extensive debris, either within or overlying the sampling location. Although CDDs and CDFs have been detected both inside and outside the debris zone, they are generally not present at depth (i.e., below 10 feet bgs). Concentrations generally decrease laterally outside the debris area. The VOCs detected in soil, acetone and methylene chloride, are probably laboratory contaminants and may not be representative of site conditions.

4.4.2 Inorganic Chemicals

The analytical results for priority pollutant metals in soil samples were evaluated initially by comparing the data to maximum background concentrations for these metals as measured at specific depths and in specific lithologies in the Basewide Background Soil Investigation (HLA, 1993e). The maximum background concentrations of the metals were selected as the main screening criteria to highlight data that might represent potential areas of contamination and/or release. Data were not eliminated from consideration in the Risk Assessment on the basis of this criteria.

At some soil depths, certain priority pollutants were not detected in the background. For shallow soils (<2 feet bgs), antimony, cadmium, and selenium were not detected; for deep soils (>2 feet bgs), mercury and selenium were not detected. For screening purposes, detected concentrations for the above metals were considered as potential contaminants.

Table 8 presents a summary of the metals for which one or more samples exceeded maximum background concentrations specific to soil type and depth. Soil from Site 31 is categorized as NQTP (not Paso Robles Formation) for purposes of background comparisons with inorganics concentrations. See Basewide Background Soil Investigation, Volume II, for further discussion of soil types. Plate 11 presents all priority pollutant metals detected above their maximum background concentrations at the depths and in lithologies measured in the background study. Where detected concentrations are below background, no data are posted on Plate 11.

All metals were detected above depth-specific maximum background concentrations in at least one sample. In general, as seen on Plate 11, more than one metal is detected above maximum background concentrations from samples collected from within the debris zones. The largest number of metals were detected above background from samples collected at the surface in the extensive debris zone (shown in a red pattern) and from within the moderately extensive debris zones (shown in a green pattern). The distribution of metals in the subsurface is more sporadic, but metals above background are generally confined to areas of sporadic, moderate, and extensive surface debris with a few exceptions in which metals were detected slightly above background concentrations outside of the sporadic debris zones.

Hexavalent chromium (CrVI) was not detected in any of the soil samples analyzed for CrVI. The analytical results for CrVI were not qualified, as discussed further in Section 4.6.2. The data should be considered usable without qualification as a qualitative indication of the potential for CrVI to be present in site soils. Matrix spike data indicate that soil conditions at the site do not favor the formation or stability of CrVI.

For purposes of discussion, five of the six metals considered to be chemicals of potential concern (COPCs) to human health (Volume III - Baseline Human Health Risk Assessment) were selected for presentation on Plate 13. The five metals are arsenic, cadmium, copper, antimony, and lead.

The sixth metal considered a COPC, beryllium, was not selected because it was not detected as high above maximum background concentrations as the other metals; it was also not detected as frequently. Although the frequency of detection was not a primary criteria used for selecting these metals, a few metals (copper and lead) were among the most frequently detected in both shallow and deep samples.

The distribution of these five metals is described below. Samples collected from 0 to 2 feet bgs are considered surface samples; samples collected at greater than 2 feet bgs are considered subsurface samples.

- Arsenic
 - Arsenic was detected in four surface samples and five subsurface samples above the maximum background concentrations of 3.4 and 4.5 mg/kg, respectively, at maximum concentrations of 5.8 mg/kg for surface and 40.8 mg/kg for subsurface samples, respectively.
 - Three of the four surface samples in which arsenic exceeded the shallow background concentration were collected from within the extensive debris zone. One sample was collected from within the sporadic debris zone.
 - Four of the five subsurface samples that exceeded background were collected from the sporadic debris zone; one was collected from the extensive debris zone. All samples but one were collected from within a debris zone. One sample from SB-31-04 was collected from just below the base of the debris. A boring drilled adjacent to SB-31-04 during Phase 2 sampling did not detect arsenic above background concentrations at a depth of 15 feet bgs.
- Cadmium
 - Cadmium was detected in 15 surface samples at concentrations of up to 8.2 mg/kg; the shallow maximum background concentration for cadmium is considered nondetect for screening purposes. Eight of the surface samples exceeded the deep background concentration of 1.9 mg/kg. Two subsurface samples exceeded the maximum background concentration of 1.9 mg/kg. The maximum subsurface concentration detected was 6.7 mg/kg.
- Copper
 - Ten of the 15 surface samples were collected within the extensive or moderately extensive debris zone. Four of the surface samples were collected within the sporadic debris zone and one outside of all debris zones. Seven of the eight surface samples that exceeded the deep background concentration were collected from within the extensive debris zone. The other sample was collected from the moderately extensive debris zone.
 - One of the two subsurface samples was collected from within the extensive debris zone. The other sample was collected from the sporadic debris zone.
- Cadmium was not detected above background concentrations in any samples collected below the debris.
- Copper
 - Copper was detected above the maximum background concentration for shallow soil of 18.2 mg/kg in 11 surface samples, at a maximum concentration of 699 mg/kg. It was also detected above the maximum background concentration of 8.2 mg/kg in 10 subsurface samples, at a maximum concentration of 1,180 mg/kg.
 - Seven of the eight surface samples that exceeded the deep background concentration were collected from within the extensive debris zone. The other sample was collected from the moderately extensive debris zone.
 - Seven of the ten subsurface samples were collected from the sporadic debris zone, two samples were collected from the

extensive debris zone, and one sample was collected from the moderately extensive debris zone. Copper was detected at concentrations just above the maximum background in two samples collected below the debris.

- Antimony

- Antimony was detected in 19 surface samples at concentrations up to 25.4 mg/kg; the shallow background concentration for antimony is considered nondetect for screening purposes. Four of the shallow samples exceeded the deep maximum background concentration of 8.2 mg/kg. Antimony was detected in one subsurface sample at a concentration of 21 mg/kg, which is above the deep maximum background concentration.
- Seventeen of the 19 surface samples were collected within one of the debris zones. The highest concentrations of antimony were generally detected in surface soil from either the extensive or moderately extensive debris zones. Three of the four surface samples that exceeded the deep maximum background concentration were collected from the extensive debris zone. The fourth sample was collected from the sporadic debris zone.
- The subsurface sample was collected from the extensive debris zone. No samples that exceeded the maximum deep background concentration were collected below the debris.

- Lead

- Lead was detected above the maximum background concentration for shallow soil of 51.8 mg/kg in 23 surface samples, at a maximum concentration of 22,100 mg/kg. Lead was detected above the maximum background concentration of 3.7 mg/kg in 19 subsurface samples, at a maximum concentration of 3,620 mg/kg.

- All but four of the surface samples that exceeded maximum background concentrations were collected from within sporadic, moderately extensive, or extensive debris zones. Two of the four samples that exceeded maximum background concentrations were collected at the base of the ravine where sporadic debris has been identified below the surface. The other two samples were collected at the top of the ravine at concentrations less than two times background concentrations.
- All but one subsurface sample, from SB-31-07, was collected from an area of mapped surface debris. SB-31-07 is near an area of moderately extensive surface debris. Lead was detected below the debris zone in eight samples at a maximum concentration of 123 mg/kg.

Review of the five metals selected to represent the distribution of metals detected above maximum background concentrations at the site indicated that background concentrations of metals are exceeded most frequently in the area of extensive debris, followed by the areas of sporadic and moderately extensive debris at the surface. The distribution of metals is more sporadic with depth but is generally confined to areas of surface and/or subsurface debris.

To evaluate the nature and extent of metals contamination at Site 31, the distribution of lead was evaluated further. Lead was selected for further evaluation because it is the most prevalent and toxic metal detected at the site and represents the greatest potential risk to human health and the environment.

For the purposes of the discussion presented herein, lead concentrations are compared to the total threshold limit concentration (TTLC) for lead (1,000 mg/kg); the screening concentration for exposure of vegetation to pollutants in soil; and a conservative screening concentration for an acceptable human health risk for a recreational use exposure. Risk-based cleanup levels are presented in Volume III, the Baseline Human Health Risk Assessment for Site 31.

- Concentrations of lead above 1,000 mg/kg are limited to two areas, the extensive debris area (with a maximum lead concentration of 22,100 mg/kg) and an area of subsurface debris located at about 7 to 10 feet bgs in the area of sporadic debris (SB-31-05 and SB-31-27).
- The vertical extent of lead in concentrations greater than 1,000 mg/kg is limited to areas within the debris and drops off an order of magnitude or more beneath the debris. For example, lead concentrations of over 22,000 mg/kg are detected at the surface in the extensive debris zone, but drop to a maximum of 123 mg/kg beneath the debris zone.
- In general, as described above, two areas in which lead is detected above 1,000 mg/kg also have the highest concentrations of the other priority pollutant metals.

4.5 Potential Groundwater Impacts

The analytical results of soil sampling were reviewed to evaluate the potential impacts on groundwater of chemicals detected at the site. The potential impacts of organic compounds detected in soil were evaluated both qualitatively and quantitatively through modeling using vadose zone leaching (VLEACH) and Groundwater Mixing models. Potential impacts from metals detected in soil were evaluated qualitatively.

- Organic Chemicals
 - VLEACH modeling was performed on selected organic chemicals or groups of chemicals to evaluate the potential impacts on groundwater. The chemicals or groups of chemicals selected for modeling included CDDs/CDFs, 4,4'-DDE, 4,4'-DDT, other selected pesticides, and TPHd. The parameters used in the modeling and the results of the analyses are presented in Appendix D. Results of the modeling indicate that CDDs/CDFs and selected pesticides would not leach

to and be detected in groundwater over a 100-year period.

- TPHd was modeled using three surrogate compounds (dodecane, naphthalene and chrysene). Of the three surrogates, the modeling indicated that only dodecane might leach to groundwater in 49 years and estimated a maximum concentration of 0.0008 micrograms per liter ($\mu\text{g/l}$) in 100 years. Based on the limitations associated with the VLEACH and groundwater mixing models, this is not considered to represent a significant impact to groundwater.
- Carcinogenic and noncarcinogenic PAHs were not modeled as a group of chemicals; however, the most mobile of carcinogenic PAH (chrysene) and noncarcinogenic PAH (naphthalene) was modeled as a surrogate compound for TPHd. Also, carcinogenic and noncarcinogenic PAHs as well as dibenzofuran were not modeled because the vertical extent of these detected chemicals is less than 15 feet bgs and concentrations were relatively low. Methylene chloride and acetone were not modeled because they are suspected laboratory contaminants.
- Metals
 - All priority pollutant metals were detected above the *maximum* background concentrations as discussed in Section 4.4.2 and are considered potential site-related chemicals with a potential for leaching to groundwater.
 - The mobility of the potential site-related metals is generally a function of compound solubility, soil type, cation exchange capacity (CEC), pH, and salinity. Mobility is generally favored by low pH (less than 5), reduced cation exchange capacity (CEC), oxidizing conditions, and high salinity. The pH at the site ranged from 5.1 to 8.0. Data on CEC, oxidation reduction potential, and salinity at the site are not available.

- The occurrence of metals was also reviewed to evaluate the distribution of metals with depth. In most cases, as described in Section 4.4.2, the highest concentrations of metals were detected at the surface and within the debris. With a few exceptions, concentrations of metals were generally within background levels below the debris fill. Where metals were detected above background beneath the fill, the concentrations dropped over an order of magnitude from concentrations detected in samples from the fill material.
- The distribution of metals at Site 31, combined with a depth to groundwater of 135 feet and pH conditions of greater than 5, indicate that the potential for impacts to groundwater quality by metals at this site is very low.

4.6 Data Quality Assessment

The analytical data at Site 31 were reviewed to assess whether the data were acceptable under the data quality objectives (DQOs) that follow:

- Assess whether a release of potential chemicals of concern has occurred at the site
- Refine the list of chemicals of concern at the site
- Assess the horizontal and vertical extent of the chemicals of concern in soil at the site
- Collect physical soil data so that fate and transport properties of site soils can be assessed
- Collect soil gas data to screen the site for chemicals of concern and aid in locating future soil borings
- Collect soil data for site-specific risk assessment. The Baseline Human Health Risk Assessment for Site 31 is presented in Volume III of this report.
- Collect data consistent with the precision, accuracy, representativeness, completeness,

and comparability requirements provided in the QAPP (HLA, 1991b).

The analytical results from both Phase 1 and Phase 2 were validated according to procedures specified in the SAP (HLA, 1991b), Revisions to the QAPP (HLA, 1992k), and Part 2 of the *Draft Site Characterization, Site 34 - Fritzsche Army Airfield Fueling Facility*, dated June 12, 1992. The quality of the data was evaluated by comparison to a set of quality control criteria, including precision, accuracy, and completeness. The quality assurance/quality control (QA/QC) samples used to assess data quality included laboratory duplicate samples, matrix spike/matrix spike duplicates (MS/MSD), blank spike/blank spike duplicate (BS/BSD; also known as laboratory control samples [LCS]), and method blanks. Holding times and laboratory surrogate spike recoveries were also evaluated. In addition, detailed validation involved review of instrument calibration procedures, calculations, and laboratory data records. Sections 4.6.1 and 4.6.2 summarize the results of Phase 1 and Phase 2 data validation, respectively.

4.6.1 Phase 1 Data Validation

The results of data validation performed on Phase 1 samples from Site 31 are summarized below and presented in Appendix E of the *Draft Site Characterization, Site 31 - Former Dump Site*, dated October 27, 1992.

No Phase 1 data were rejected on the basis of the cursory or detailed validation. Although HLA added qualifiers to some data, they are generally considered valid and technically usable. However, the common lab contaminants methylene chloride and acetone affected the reliability of the analysis for these chemicals, as indicated by the laboratory-assigned qualifiers.

4.6.2 Phase 2 Data Validation

The results of data validation performed on Phase 2 data are discussed below and presented in Appendix E of this report.

Results of the Phase 2 data validation indicate that the data are useable when the data quality objectives of the project, presented above, are

considered. The completeness goal of 80 percent was met for all test methods except hexavalent chromium. Although some results have been qualified, most of the qualifiers do not significantly impact the intended use of the data.

One sample analyzed for EPA Test Method 8080 was qualified due to a recovery of 0 percent. Twelve of the target analytes were reported as nondetected. Because no anomalies were observed during the extraction of the sample, the laboratory indicated that the sample matrix could be the cause of the poor recovery. Because such a matrix interference could result in the reporting of false negatives, the nondetected results were qualified as rejected.

Twenty-four sample results for various EPA Test Method 8270 compounds were qualified due to continuing calibrations not meeting the QC criteria. Samples that were qualified as estimated for calibrations had continuing calibration percent difference (%D) results that were below the control limits but were at least -30 percent. Eight sample results for 4-nitrophenol and 4-nitroaniline were qualified as rejected because the %D values were between -30 and -64 percent. Because laboratory instrument detection limits are at least 1/5 of the reporting limit for these methods, false negatives are highly unlikely when the continuing calibration %D is between -30 and -70 percent. However, continuing calibration acceptance criteria are more stringent than other quality assurance/quality control (QA/QC) parameters because of the uncertainty in the analytical measuring system indicated by the %D results and the potential for propagation of analytical bias when other QC exceedances are present.

Ninety-four sample results for antimony, cadmium, copper, lead, nickel, and selenium were qualified as estimated due to high blank spike, matrix spike, or graphite furnace atomic absorption (GFAA) post-digestion spike recovery. A high spike recovery can indicate either a sample matrix effect or a measurement bias in the analytical system. Such bias could result in the overestimation of the true amount of these metals in the associated samples.

One hundred and eleven sample results for antimony, arsenic, chromium, lead, selenium, thallium, and zinc were qualified as estimated due to low blank spike, matrix spike, or GFAA post-digestion spike recovery. A low spike recovery can indicate either a sample matrix effect or measurement bias in the analytical system. Such bias could result in the underestimation of the true amount of these metals present in the associated samples. Because the spike recoveries were above 30 percent, and the instrument detection limits are at least 1/3 of the reporting limits, the possibility of false negatives is low.

Three sample results for arsenic were qualified as rejected due to very low matrix spike recovery. A low spike recovery can indicate either a sample matrix effect or a measurement bias in the analytical system. Such bias could result in a significant underestimation of the true amounts of these metals in the associated samples. Because the spike recovery was below 30 percent, the possibility of false negatives is high enough to justify rejection of the data.

Twenty-two sample results for zinc were qualified as estimated due to laboratory duplicate precision criteria not being met. Duplicate precision criteria are a measure of the stability of the analytical system. They do not indicate that the instrument sensitivity is affected, and the potential for false negatives or false positives is very low.

Six SDGs had hexavalent chromium (CrVI) matrix spike recoveries below 30 percent. Matrix spike samples were reanalyzed and similar recoveries were obtained. BS/BSD data were within control limits indicating that the method was capable of producing acceptable results. MS data indicate that the method as applied to the sample matrix produces unreliable results. CrVI analysis is unique with respect to the stability of the analyte in the matrix; under most field and laboratory analytical conditions, CrVI in soil will be rapidly reduced to trivalent chromium (CrIII), rendering CrVI matrix spike data inconclusive. In a U.S. Department of Health and Human Services toxicological profile for chromium, it is noted that "the reduction of CrVI to CrIII is possible in aerobic soils that contain appropriate

organic energy sources to carry out the redox reaction. The reduction of CrVI to CrIII is facilitated by low pH." (ATSDR, 1993a).

Neither validation guidelines nor data qualification protocol provide for an appropriate mechanism to address data quality under these unique circumstances. Therefore the N2 (Not Qualified) code has been applied to the CrVI results. CrVI data are usable for assessing the potential for the presence of CrVI at the site because matrix spike data indicate that soil conditions at the site do not favor the formation or stability of CrVI. Rai, Eary, and Zachara have noted that "commonly occurring reductants, such as ferrous iron and organic material, can transform Cr(VI) to Cr(III)." (Rai et al., 1989). Further discussion of CrVI persistence can be found in the Introduction of Volume II (Section 3.0).

5.0 CONTAMINANT FATE AND TRANSPORT

This section summarizes the potential transport pathways and mechanisms that control the fate and transport of chemicals in air, surface water (runoff), unsaturated zone soil and groundwater at Site 31. The following sections discuss the potential transport pathways that were identified (Section 5.1), the physical and chemical characteristics that control the mobility and persistence (i.e., fate) of the contaminants found at Site 31 (Section 5.2), and the transport pathways that appear to be viable, based on data collected during the RI (Section 5.3). The general factors that influence the fate and transport of chemicals at Fort Ord RI sites are discussed in detail in Section 3.0 of the Introduction to Volume II.

5.1 Potential Pathways

Plate 14 presents a conceptual site model of the potential transport pathways for organic and inorganic compounds detected in soil at Site 31. Pathways by which humans or biota would be exposed (exposure pathways) were evaluated further during the Human Health Risk Assessment (Volume III) and Ecological Risk Assessment (Volume IV). There are six current potential migration pathways identified for air, surface water, unsaturated zone soil, and groundwater specific to Site 31 contaminants:

- Volatilization of chemicals into the air from soil
- Entrainment of wind-generated dust particles in air
- Leaching of chemicals into underlying unsaturated zone soil and to groundwater
- Transport of chemicals in soil via soil erosion or slope wash
- Transport of chemicals in surface runoff water via surface channels and storm drains
- Infiltration of channeled storm runoff water.

5.2 Contaminant Mobility and Persistence

This section describes the general mobility and persistence of the chemicals found in soil at Site 31. The properties that govern the mobility and persistence are discussed in detail in the Introduction to Volume II (Section 3.0).

5.2.1 Organic Compounds

Although several physical and chemical properties can be used to indicate how a chemical will behave in the environment, the environmental fate of an organic chemical in soil and groundwater can be generally predicted based on the octanol water partition coefficient (K_{ow}). As stated in Ney (1990), compounds with high K_{ow} (i.e., $K_{ow} > 1,000$ [unit less]) are indicative of low water solubility, immobility, nonbiodegradability, and a chemical that is bioaccumulative, accumulative, persistent, and sorbed in soil. (See Table 3 presented in the Introduction to Volume II, Section 3.0). Conversely, compounds with low K_{ow} (i.e., $K_{ow} < 500$) are indicative of high water solubility, mobility, little to no bioaccumulation or accumulation, and degradability by microbes, plants, and animals. Also, a chemical in or on soil and water may volatilize into the air. Vapor pressure (VP), one of the more important factors influencing volatilization, is an indicator of volatilization potential. Based on Ney's classification (1990), chemicals with a low vapor pressure ($VP < 1 \times 10^{-7}$ mm Hg) are less likely to volatilize (i.e., low volatilization potential); a chemical with a high vapor pressure ($VP > 1 \times 10^{-2}$ mm Hg) is more likely to volatilize. The following sections discuss the mobility and persistence of the site-related organic chemicals in soil and water and the potential for volatilization into the air; physical and chemical properties of the organic compounds (e.g., K_{ow} , VP) are presented in Tables 2a through 2c of the Introduction to Volume II.

The chemicals found at Site 31 and presented in the discussion below include semivolatile organic

hydrocarbons (SOCs; carcinogenic and noncarcinogenic polycyclic aromatic hydrocarbons [PAHs], and dibenzofuran), total petroleum hydrocarbons as diesel (TPHd), organochlorine pesticides (gamma-BHC, heptachlor, aldrin, dieldrin, endrin, 4,4'-DDE, and 4,4'-DDT), chlorinated dibenzodioxins (CDDs) and chlorinated dibenzofurans (CDFs), and priority pollutant metals. Volatile organic compounds (VOCs) detected in Site 31 soils (i.e., acetone and methylene chloride), which are highly mobile and volatile, have not been discussed in this fate and transport section because the detections are considered laboratory contaminants.

5.2.1.1 SOCs, Organochlorine Pesticides, and CDDs/CDFs

The SOCs, organochlorine pesticides, and CDDs/CDFs found at Site 31 are generally highly persistent and of low mobility and volatilization potential in soil. Dibenzofuran and some of the noncarcinogenic PAHs and pesticides, however, have medium volatilization potentials; these PAHs and pesticides include naphthalene, 2-methylnaphthalene, phenanthrene, pyrene, fluoranthene, 4,4'-DDE, 4,4'-DDT, aldrin, endrin, gamma-BHC, and heptachlor. Since relatively immobile persistent compounds are expected to remain adsorbed to soil or ash, the primary migration pathways are transport by surface runoff and particulate entrainment into the air phase. For dibenzofuran and the noncarcinogenic PAHs and pesticides mentioned above, a secondary migration pathway would be volatilization from soil.

5.2.1.2 TPH as Diesel

TPH as diesel (TPHd), which was only detected in one soil sample at a concentration of 12 mg/kg at Site 31, is a complex mixture of numerous organic constituents that vary in physical and chemical properties such as water solubility, density, K_{oc} , K_{ow} , volatilization, and half-life. Because these analyses are gross measurements of the total concentration of the constituents that make up TPHd, there are no standard values for the physical and chemical mobility and persistence factors for TPH.

One approach to discussing the mobility and persistence of complex mixtures is to evaluate the individual components of the mixtures and focus on the priority pollutants. Compounds that are commonly found in fresh diesel fuel and that have been detected in soil at Site 31 include noncarcinogenic PAHs (naphthalene, 2-methylnaphthalene, fluoranthene, and pyrene) and carcinogenic PAHs (benzo(a)anthracene and benzo(a)pyrene). Section 5.2.1.1 discusses the mobility and persistence of these constituents.

5.2.2 Inorganic Compounds

All thirteen priority pollutant metals were detected above maximum background concentrations at Site 31. The mobility and persistence of these metals in the environment are influenced by the concentration, form, and oxidation state of the metal, and by the composition and physiochemical properties of the soil. Soil properties that may affect the fate and transport of these metals include: bulk density, surface area, particle size distribution, pH, oxidation/reduction potential, cation exchange capacity (CEC), salinity, and type and the concentration of organic matter, clay minerals and oxides. A more detailed discussion of how each of these properties affects fate and transport is presented in the Introduction to Volume II (Section 3.0).

The following discussion, which is based on McLean and Bledsoe (1992), summarizes the general mobility and persistence of the priority pollutant metals detected above maximum background concentrations in soil at Site 31. The specific characteristics of each metal are presented in the Introduction to Volume II (Section 3.0).

Above the pH values of approximately 5 to 8, most metal cations (i.e., lead, copper, zinc, beryllium, cadmium, chromium [CrIII], mercury, nickel, thallium, and silver) tend to adsorb to or react with particles or compounds including clays, phosphates, sulfates, carbonates, hydroxides, and organic material, hence decreasing the mobility. Lead and copper tend to be adsorbed to a greater extent by soil and soil constituents than most metals; however, contrary to most cations, lead and copper have a high

affinity for some ligands (e.g., sulfates, hydroxide, carbonate) so can form the complexes that actually increase their mobility in soil. Also, the formation of soluble complexes with inorganic and organic ligands (particularly chloride) will increase the mobility of cadmium in soil. As discussed in the Introduction to Volume II (Section 3.0), chromium can exist as CrIII and CrVI, CrVI being the more toxic. Because CrVI has not been detected at Site 31, it is not discussed here.

The metalloids arsenic and selenium exist in two and four oxidation states, respectively, each having different adsorption characteristics with respect to changing pH. For example, maximum adsorption of As(V) was found to occur at pH 5 and maximum adsorption of As(III) at pH 7 (Griffin and Shimp, 1978). Antimony is also expected to exhibit behavior similar to arsenic. Because these metalloids form complexes that are anionic in character and charge is pH-dependent, increasing pH tends to decrease sorption, which increases solubility and mobility. Also, the concentration and form of these metals are governed by pH, redox potential, and soil composition.

Analytical results from Site 31 soil samples collected from within the debris area indicate that soils range in pH from 6 to 8 and organic content ranges from 2.4 to 4.2 percent. These pH and organic content condition, other factors being constant, tend to promote the immobility of metals, except for antimony, arsenic, and selenium. By nature, metals are highly persistent. Because antimony, arsenic, and selenium have either not been detected or have not been detected above maximum background concentrations below debris-containing sand, it does not appear that these metalloids have migrated from debris-containing soils at Site 31.

5.3 Pertinent Migration Pathways at Site 31

This section discusses the pertinent migration pathways for Site 31 and the potential significance of each migration pathway, based on an evaluation of the chemicals detected at Site 31 and the persistence and mobility of the chemicals detected.

5.3.1 Air

As shown on Plate 14, chemicals at Site 31 may enter the air through particulate entrainment. Chemicals that sorb to soil, such as metals, and PAHs and CDDs/CDFs with high K_{ow} are likely to be transported as dust. However, the entrainment of dust via wind is not a significant pathway at Site 31 because 1) the soil is generally sandy and there is little fine material (i.e., clay or silt) available for entrainment as dust, 2) the chemical-bearing soil is in a ravine sheltered from significant wind, and 3) much of the ground surface has been stabilized by grass and other vegetation.

Because no VOCs were detected in the soil (except for probable laboratory contaminants such as acetone and methylene chloride), volatilization is not considered a mechanism for the migration of contaminants into the air. The chemicals detected at Site 31 have relatively low vapor pressures and would not be readily volatilized to the air at ambient temperature conditions. However, there is a possibility that a few SOCs could volatilize, as discussed in Section 5.2.

5.3.2 Surface Water

Surface water at Site 31 refers to surface water runoff and water flowing in the storm drains. Although rainwater generally infiltrates the sandy soil at Site 31, runoff may occur during significant storm events within a few channels on the side slopes of the ravine and possibly the flat graded area in the Leadership Reaction Training Compound (LRTC). Runoff that accumulates in the LRTC is transmitted through storm drain pipes to the base of the ravine; this is not a migration pathway at Site 31 because the soil in the drainage area does not contain debris-related contaminants. Surface water that may reach the bottom of the ravine during a significant storm event should readily infiltrate the loose sandy soil. Although there is no indication of surface water flow (e.g., ripple marks) along the bottom of the ravine, runoff may also occur there during a significant storm event. Because analytical results indicate that contaminants from the ravine slope have generally not migrated to the ravine bottom via

surface water runoff as well as other mechanisms (e.g., soil erosion and slope wash), the potential migration pathway of runoff through the ravine bottom is not considered significant.

Chemicals may enter channelized surface water by particle suspension or by dissolution. Except possibly for antimony, arsenic, and selenium, inorganic compounds detected in soil at Site 31 are expected under site pH conditions to sorb moderately strongly to site soil particles and might, therefore, be transported by potential runoff as suspended particulates. These organic compounds have limited water solubilities but high soil sorption tendencies and, therefore, may also be transported via sorption to soil particles carried by potential runoff. Antimony, arsenic, and selenium, which would be expected to be more mobile under site pH conditions, have not been detected in the soil below the debris area (i.e., at the bottom of the ravine), and, therefore, do not appear to have migrated via surface water. For reasons discussed in Section 5.2, dissolution of chemicals at Site 31 is not generally expected to occur.

The extent to which Site 31 chemicals may be transported depends on the mobility and persistence of the chemical, the soil type, and the magnitude of flow. For Site 31, surface water is not considered a significant migration pathway for the following reasons: 1) surface water infrequently occurs at Site 31, 2) site conditions are not conducive to the dissolution of most of the detected chemicals, and 3) considering that the contaminants have been in place for over 40 years, concentrations of chemicals detected in the soil along the ravine bottom are generally low compared to concentrations in upslope debris-containing soils.

5.3.3 Unsaturated Zone Soil

Chemical compounds at Site 31 have been identified along the ravine slope in shallow unsaturated zone soil primarily associated with the presence of incinerated and unincinerated debris. The sources of chemical compounds include the dumping of incinerated and unincinerated debris into the ravine and the potential application of pesticides. Neither of these sources currently exist. The chemicals

detected in Site 31 soil may enter underlying unsaturated soil by leaching. The potential for these chemicals to leach into underlying soil and possibly to groundwater depends on the physical and chemical properties of the chemicals, the chemical concentrations, soil type, pH (for metals), redox potential (Eh), and other site-specific conditions (e.g., surface cover and annual rainfall).

The chemicals identified most commonly in soil at Site 31 (metal cations, PAHs, 4,4'-DDE, 4,4'-DDT, CDDs and CDFs) have limited water solubilities and high soil sorption tendencies under site conditions. For soils within the debris area at Site 31, the measured pH ranges from 6.0 to 8.0 and the measured organic content ranges from 2.4 to 4.2 percent; this indicates that there is little potential for metal cations to leach significantly. Although metalloids with negative charges (i.e., antimony, arsenic, and selenium) are believed to be more mobile under site conditions, analytical results from soil samples collected from within the debris and below the debris indicate that organic compounds and priority pollutant metals including antimony, arsenic, and selenium are not leaching significantly at Site 31. Chemical concentrations decrease significantly within a few feet of the bottom of the debris to nondetect, relatively low concentrations, or below or approaching maximum background conditions.

In summary, the migration of chemicals in soil to groundwater at Site 31 is most unlikely for the following reasons: 1) most detected chemical compounds are relatively immobile, 2) the depth to groundwater is at least 135 feet below the bottom of both the ravine and the debris, and 3) although chemical compounds have been present at Site 31 for over 40 years, chemical concentrations decrease significantly outside the debris area. This indicates limited leaching of chemicals from the debris to the surrounding soil. In addition, VLEACH modeling was performed on selected organic chemicals or groups of chemicals as described in Section 4.5. With the exception of the TPHd surrogate dodecane, the results of the modeling indicated that these chemicals would not leach to groundwater over a 100-year period if left in place at maximum detected site concentrations.

The modeling indicated that dodecane might leach to groundwater in 49 years and estimated the maximum concentration of less than 0.01 $\mu\text{g/l}$ in 100 years; this is not considered to represent a significant impact to groundwater.

5.3.4 Groundwater

As discussed above, the migration of chemicals at Site 31 in soil to groundwater is considered unlikely, based on VLEACH modeling for organics, the soil properties, and limited vertical extent of organic and inorganic compounds in soil underlying the debris, so groundwater is not considered a migration pathway for contaminants at Site 31.

5.3.5 Summary

Although several potential migration pathways have been identified for chemicals found at Site 31, no significant migration pathways in air, surface water or groundwater currently exist. Chemicals at Site 31 are generally immobile and persistent. In addition, an evaluation of analytical results of Site 31 soil samples and the results of modeling indicate that chemicals have not significantly migrated through soil (i.e., greater than a few feet) and should not pose a significant threat to groundwater in the future.

6.0 SUMMARY OF RI AT SITE 31

This section summarizes the results of the Site 31 RI.

Site 31, the Former Dump Site, is characterized as follows:

- The site is a steep-sloped ravine adjacent to the Leadership Reaction Training Compound. Visible surficial debris extends approximately 500 feet along the northern slope of the ravine.
- Wholly or partially incinerated refuse, apparently generated by a former incinerator at the top of the northern ravine slope, was dumped over the slope.
- The site is underlain by disturbed and undisturbed Aromas Sand. The shallowest aquifer beneath the site is the Aromas-Paso Robles Aquifer; the groundwater table is approximately 135 feet below the ravine floor.

The history of the site, surface debris mapping, and soil gas and soil sampling indicate that the nature and extent of contamination consist of the following:

- The main potential source of contamination identified at Site 31 is incinerated debris and ash that is probably incinerated refuse. Other potential nonpoint sources of contamination at the site include:
 - Asphalt pavement operations and stockpiling of coal
 - The application of pesticides in the vicinity of Site 31.
- Surface and subsurface incinerated and unincinerated debris at the site is within a sand matrix; debris consists of whole, broken, and melted glass, melted and unmelted metal fragments, rusted cans, empty, crushed 55-gallon drums, burnt and unburnt wood,

coal pieces, concrete and asphalt chunks, brick and clay tile fragments, and ash.

- Relatively low concentrations of VOCs were detected in soil gas throughout the site. Because concentrations were low and VOCs were not detected in soil samples collected adjacent to soil gas sampling points, and because detected concentrations do not appear to be associated with the presence of debris, VOCs in soil gas were not investigated further as part of the RI.
- Acetone and methylene chloride were the only VOCs detected in soil samples analyzed; these VOCs are considered laboratory contaminants.
- TPH as diesel, PAHs, and dibenzofuran were detected in surface and subsurface soil samples; these chemicals appear to be related to the presence of incinerated and unincinerated debris.
- Pesticides, including 4,4'-DDE, 4,4'-DDT, gamma-BHC, heptachlor, aldrin, dieldrin, and endrin, were detected in surface and subsurface soil samples; these chemicals either may be related to the presence of incinerated and unincinerated debris or may be related to the former applications of pesticides along the ravine slope.
- CDDs and CDFs were detected throughout the site in surface and subsurface soil samples, both inside and outside areas with debris; concentrations appear to decrease away from the dump site. The presence of CDDs and CDFs may be related either to the dumping of incinerated refuse or to the settling of ash emanating from the chimney of the former onsite incinerator.
- Priority pollutant metals were detected above maximum background concentrations in surface and subsurface soil samples; generally, elevated metal concentrations were associated with the presence of incinerated or

unincinerated debris at or above the sampling location.

- The lateral and vertical extent of several organic and inorganic compounds was not delineated to nondetect or established maximum background concentrations, respectively; however, because concentrations are low and/or are near maximum background conditions, no further investigation was warranted.

Because chemicals detected within the soil at the site are relatively immobile and because groundwater is deep (i.e., approximately 135 feet below the bottom of the ravine), groundwater quality was not investigated at the site. However, to evaluate the potential impact to groundwater by detected organic chemicals, VLEACH modeling was performed on selected organic chemicals or groups of chemicals. With the exception of the TPHd surrogate dodecane, the results of the modeling indicated that these chemicals would not leach to groundwater over a 100-year period if left in place at maximum detected site concentrations. The modeling indicated that dodecane might leach to groundwater in 49 years and estimated the maximum concentration of 0.0008 $\mu\text{g/l}$ in 100 years; this is not considered to represent a significant impact to groundwater.

A qualitative analysis of the potential for metals to leach to groundwater indicates that, because the concentration of metals decreases significantly beneath the fill, the pH in soil is relatively high (i.e., pH of 6 to 8), and groundwater is 135 feet below ground surface, the potential for impacts to groundwater quality from metals is very low.

Although several potential migration pathways have been identified for chemicals found at Site 31, no significant migration pathways in air, surface water or groundwater currently exist. Chemicals at Site 31 are generally immobile and persistent. In addition, an evaluation of analytical results of Site 31 soil samples and the results of modeling indicate that chemicals have not significantly migrated through soil (i.e., greater than a few feet) and should not pose a significant threat to groundwater in the future.

7.0 CONCLUSIONS

The following presents the conclusions of the RI for Site 31:

- Past site uses have impacted the soil quality at the site. The primary impacted area is along the northern slope of a ravine where past dumping of incinerated and unincinerated debris had occurred. Soil associated with the debris contains TPH as diesel, SOCs, pesticides, CDDs and CDFs, and metals above maximum background levels. The presence of pesticides may be related to the debris and/or to former applications of pesticides along the ravine slope. The presence of CDDs and CDFs, which have been detected throughout the site in surface and subsurface samples, may be related to the settling of ash emanating from the chimney of the former onsite incinerator or to other unidentified nonpoint sources as well as to the dumping of incinerated debris.
- The lateral and vertical extent of several organic and inorganic compounds was not delineated to nondetect or established maximum background concentrations, respectively; however, because concentrations are low and/or are near maximum background conditions, no further investigation was warranted. The nature and extent of contamination from onsite sources at Site 31 have been adequately characterized to perform the Human Health Risk Assessment and the Feasibility Study at this site. The results of the Human Health Risk Assessment and the Feasibility Study are presented in Volumes III and V, respectively. Additional sampling was performed as part of the Ecological Risk Assessment; the Ecological Risk Assessment is presented in Volume IV.
- Groundwater quality was not investigated at the site. Because chemicals detected within the soil at the site are relatively immobile; because organic and inorganic compound concentrations are either nondetected, detected at relatively low concentrations, or approach background conditions, and because groundwater is deep (i.e., approximately 135 feet below the bottom of the ravine). Also, based on the results of VLEACH modeling for organic compounds and a qualitative analysis of the potential for metals to leach to groundwater, concentrations of VOCs, other organic chemicals, and metals detected in onsite soils should not significantly impact groundwater.
- Although several potential migration pathways have been identified for chemicals found at Site 31, no significant migration pathways in air, surface water or groundwater currently exist. Chemicals at Site 31 are generally immobile and persistent. In addition, an evaluation of analytical results of Site 31 soil samples and the results of modeling indicate that chemicals have not significantly migrated through soil (i.e., greater than a few feet) and should not pose a significant threat to groundwater in the future.