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Acronyms and Abbreviations

μg/L microgram(s) per liter
μmhos/cm micromhos per centimeter
bgs below ground surface
AWPF Advanced Water Purification Facility
Blaine Tech Blaine Tech Services, Inc.
COC chain of custody
CPT cone penetrometer test
CDO Cease and Desist Order
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980
City City of Oxnard
COC chain of custody
County Ventura County
CRQL contract-required quantitation limit
Cs 137 cesium 137
DHS California Department of Health Services (now California Department of Public Health (DPH))
DO dissolved oxygen
DPH California Department of Public Health
EPA U.S. Environmental Protection Agency
E&E Ecology & Environment, Inc.
EC electrical conductivity
EC-HPT EC-hydraulic profile test
FCGMA Fox Canyon Groundwater Management Agency
FSP Field Sampling Plan
gpm gallon(s) per minute
GPS global positioning system
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<td>Halaco</td>
<td>Halaco Engineering Co.</td>
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<tr>
<td>HSA</td>
<td>hollow stem auger</td>
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<tr>
<td>ID</td>
<td>inside diameter</td>
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<tr>
<td>K 40</td>
<td>potassium 40</td>
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<tr>
<td>LARWQCB</td>
<td>Los Angeles Regional Water Quality Control Board</td>
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<tr>
<td>LAS</td>
<td>Lower Aquifer System</td>
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<tr>
<td>LIDAR</td>
<td>light detection and ranging</td>
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<tr>
<td>MCL</td>
<td>Maximum Contaminant Level</td>
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<tr>
<td>mg/L</td>
<td>milligram(s) per liter</td>
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<tr>
<td>NAD 83</td>
<td>North American Datum of 1983</td>
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<tr>
<td>NAVD 88</td>
<td>North American Vertical Datum of 1988</td>
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<td>NCL</td>
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<td>NEIC</td>
<td>EPA National Enforcement and Investigation Center</td>
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<td>NOAA</td>
<td>National Oceanographic and Atmospheric Administration</td>
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<td>NPDES</td>
<td>National Pollutant Discharge Elimination System</td>
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<td>NPL</td>
<td>National Priorities List</td>
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<tr>
<td>NTU</td>
<td>Nephelometric Turbidity Unit</td>
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<tr>
<td>O&amp;G</td>
<td>oil and grease</td>
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<tr>
<td>ohm-m</td>
<td>ohm-meter</td>
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<tr>
<td>OID</td>
<td>Oxnard Industrial Drain</td>
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<tr>
<td>OSWER</td>
<td>Office of Solid Waste and Emergency Response</td>
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<tr>
<td>PAH</td>
<td>polyaromatic hydrocarbons</td>
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<tr>
<td>PCB</td>
<td>polychlorinated biphenyl</td>
</tr>
<tr>
<td>pCi/L</td>
<td>picocurie(s) per liter</td>
</tr>
<tr>
<td>psi</td>
<td>pound(s) per square inch</td>
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<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
</tr>
<tr>
<td>QAPP</td>
<td>Quality Assurance Project Plan</td>
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<tr>
<td>Ra 228</td>
<td>radium 228</td>
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<td>Ra 226</td>
<td>radium 226</td>
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ACRONYMS AND ABBREVIATIONS

RSL  Regional Screening Level
SAGE  SAGE Consultants
SMRT  soil moisture resistivity test
SOP  standard operating procedure
Site  Halaco Engineering Co. Superfund Site
SVOC  semivolatile organic compound
SWRCB  State Water Resources Control Board
TDS  total dissolved solids
Th 232  thorium 232
Th 230  thorium 230
Th 228  thorium 228
THM  trihalomethane
TKN  total Kjeldahl nitrogen
TOC  total organic carbon
TPH  total petroleum hydrocarbons
UAS  Upper Aquifer System
ULS  ULS Services Corp.
USGS  U.S. Geological Survey
UWCD  United Water Conservation District
VCWPD  Ventura County Watershed Protection District
VOC  volatile organic compound
WDA  Waste Disposal Area
WDR  Waste Discharge Requirement
WDC  WDC Exploration & Wells
WMU  Waste Management Unit
WWTP  Wastewater Treatment Plant
SECTION 1

Introduction

This report provides the results of surface water and groundwater testing at the Halaco Engineering Co. Superfund Site (Site) in Oxnard, California. Groundwater monitoring wells and piezometers were installed in October and November 2009 and in May 2010 to supplement the existing monitoring well network. Two rounds of surface water and groundwater samples were collected between November 2009 and October 2010. The Site location is shown in Figure 1a.

This report includes a description of the testing effort, a brief narrative and tabular summary of results, and figures depicting selected results. The results of waste, sediment, soil, and soil gas sampling activities performed at the Site are described in four separate reports for the Nature Conservancy Land (NCL) areas, wetlands and beach areas, Oxnard Industrial Drain and lagoon areas, and the Halaco Properties (CH2M HILL, 2011a, 2011b, 2011c, and 2011d). The testing described in the five reports is part of the remedial investigation (RI) performed by the U.S. Environmental Protection Agency (EPA) for the Site. The testing was completed in accordance with an EPA-approved Quality Assurance Project Plan (QAPP; CH2M HILL, 2009a) and Field Sampling Plan (FSP; CH2M HILL, 2009b).

1.1 Objectives

The primary objective of the testing was to provide data needed to determine the nature and extent of surface water and groundwater contamination at the Site. The data also will be used to characterize the human health and environmental risks posed by the contaminated surface water and groundwater and to evaluate remedial options.

1.2 Background

The Site is located in eastern Ventura County at and near 6200 Perkins Road in Oxnard, California. Halaco Engineering Company (Halaco) operated a secondary metal smelter at the Site from 1965 to 2004, recovering aluminum and magnesium for reuse. The site background, including a description of Halaco's operations and waste disposal practices, and the physical and ecological settings, is described in the QAPP. A brief summary is provided below.

The Site includes an 11-acre parcel containing the former smelter, a 26-acre Waste Management Area where wastes were deposited and managed, and adjacent areas affected by Halaco's wastes. The 11-acre and parcel and 26-acre Waste Management Area are referred to as the "Halaco Properties." The 26-acre area includes the Waste Management Unit (WMU), which contained Halaco's former waste settling ponds, and the Waste Disposal Area (WDA) to the north, which received waste from the WMU.
The adjacent areas affected by Halaco’s wastes include portions of:

- Land owned by the Nature Conservancy east and north of the Waste Management Area, referred to as NCL-East and NCL-North
- Wetland and beach areas south of the Smelter Parcel and WMU
- The Oxnard Industrial Drain (OID), which bisects the Halaco Properties, and an associated lagoon

During its 40 years of operation, Halaco acquired scrap metal from more than 400 suppliers in a variety of forms and in varying levels of purity. Halaco processed dross, sludge, castings, sheets, pellets, granules, cans, car parts, and other scrap. Halaco reports that it processed one type of scrap, a low-level radioactive magnesium-thorium alloy, until about 1977. Other metals found in aluminum and magnesium alloys include copper, silver, zinc, lead, chromium, titanium, tin, manganese, and nickel.

Halaco produced large quantities of solid and liquid waste. Most of the waste was “process waste” generated during the smelting process. Other waste was generated by the air pollution control equipment and from used oil and spent solvent. From 1965 to about 1970, Halaco discharged much or all of its waste to a former channel of the OID and a settling pond adjacent to the OID and used waste solids as fill in the smelter area. In about 1970, Halaco began pumping its wastewater across the OID into unlined earthen settling ponds in the area later named the WMU. Beginning in or before 1980, Halaco moved waste solids from the WMU to the WDA.

Halaco reports that all operations ceased in September 2004. In 2007, EPA estimated that more than 700,000 cubic yards of waste solids remained onsite. Most of the solids are in the WMU, which covers about 15 acres and rises up to 35 feet above grade. Previous testing at the Site showed that elevated levels of several metals are present in the waste, and that soils, sediments, and groundwater have been contaminated by Halaco’s wastes. Constituents found at elevated levels included aluminum, barium, beryllium, cadmium, chromium, copper, lead, magnesium, manganese, nickel, and zinc. Elevated levels of radioactive thorium (and decay products) were found in some areas. In past sampling, elevated levels of ammonia and petroleum hydrocarbons also were detected at the Site. The ammonia is believed to be a byproduct of the smelting process.

### 1.3 EPA Actions from 2006 through 2010

In 2006, EPA completed a testing effort at the Site called the Integrated Assessment (Weston Solutions, Inc., 2007) to (1) determine the Site’s eligibility for placement on the Superfund National Priorities List (NPL), and (2) evaluate the need for immediate actions to stabilize the Site. In September 2007, EPA added the former Halaco facility and adjacent areas of contamination to the NPL. Shortly thereafter, EPA began the RI to determine the nature and extent of contamination at the Site, identify human health and ecological risks posed by the contamination, and identify areas needing remediation.

In 2006 and 2007, two removal actions were completed to address immediate site risks while EPA evaluated the Site for placement on the NPL. The first removal action, completed by
the property owners between August 2006 and February 2007, included the removal of drums and other hazardous substances from the Site. A second, EPA-funded removal action was completed in 2007 to stabilize and secure the Site and limit offsite migration of contaminated wastes. It included re-grading the waste pile to reduce the steepness of the slopes; placing matting on the slopes to reduce erosion; stabilizing the banks along the lower portion of the OID; removing an estimated 9,000 cubic yards of waste from the smelter area; removing an estimated 7,600 cubic yards of material from a wetland area adjacent to the Halaco property; and installing more than 6,000 feet of fencing around the perimeter of the Waste Management Area. See the “Team 9” report (2008) for additional details. The aerial photo in Figure 1a was taken after the second removal action was completed.

In 2007, EPA completed additional site characterization activities. These included a radiation assessment of surface and subsurface conditions throughout the Smelter Parcel (Team 9, 2008).

In 2008, EPA completed a screening-level ecological and human health risk assessment to support RI activities for the Site (CH2M HILL, 2008a). This screening-level risk assessment identified major contaminants of potential concern and environmental exposure pathways for ecological and human receptors. This assessment used conservative estimates of exposure and potential ecological and human health effects to identify areas of the Site that may pose unacceptable risks to human health and/or the environment and may warrant remediation.

Also in 2008, EPA completed a preliminary evaluation of the sources, nature, extent, and movement of contamination in surface water and groundwater at the Site (CH2M HILL, 2008b). This preliminary evaluation compiled and evaluated information on the sources, nature and extent of surface water and groundwater contamination at the Site, and the physical processes that affect the movement of the contamination. The document describing the results of this preliminary evaluation is referred to in this report as the Surface Water-Groundwater Technical Memorandum (the “2008 Groundwater Report”).

In 2009, using the results of the Integrated Assessment, the radiation assessment, screening-level risk assessment, and preliminary groundwater evaluation, EPA identified data gaps and prepared a plan for additional sampling and analysis activities needed before remediation can occur (EPA Region 9, 2009). CH2M HILL then prepared the data quality objectives, QAPP, and FSP for the sampling activities described in this report based on the testing plan.

In 2010, EPA demolished two abandoned industrial buildings at the Site. The two buildings were in poor condition and at risk of collapse.
SECTION 2
Initial Conceptual Site Model

This section describes what was known about the nature and extent of contamination at the Site prior to the 2009-2010 RI activities, and why portions of the Site were thought to pose a potential threat to human health or the environment. This section also updates EPA’s 2008 evaluation of regional hydrologic conditions and the sources, nature, extent, and movement of contamination in surface water and groundwater at the Site (CH2M HILL, 2008b).

2.1 Historical Site Conditions

The historical aerial photographs in Attachment A show changes in topography, surface drainage, and land use at the Site between 1929 and 1991. The 14 photographs were compiled and analyzed by the EPA Environmental Monitoring Systems Laboratory (Lockheed Engineering and Management Services Company, 1982, and Lockheed Engineering and Sciences Company, 1991). Figure 1b displays six of the 14 photographs showing key times in the Site’s history. Changes to the Site are also shown in four historical topographic maps in Figure 1c. The four maps are excerpts from 1850s U.S. Coastal Survey maps, a 1904 U.S. Geological Survey (USGS) map, a 1925 Ventura County map, and a 1949 (photo revised 1967) USGS map.

The 1850s, 1904, and 1925 topographic maps (Figure 1c) and the 1929 aerial photograph (Figure 1b) show predevelopment conditions, with the OID flowing southwest through NCL-North and the Smelter Parcel. The OID terminated in a small lagoon near the southeastern corner of the Smelter Parcel. The modern-day lagoon shown in Figure 1a was not present.

The 1945 aerial photograph (Attachment A) appears to show disturbed soil, bulldozer tracks, and fill activities at the Smelter Parcel, and the OID shifted east of its 1929 predevelopment alignment. The activities at the Smelter Parcel are presumed to be associated with the City of Oxnard’s (City’s) municipal burn dump, and remain visible in the 1951 and 1959 photographs. An annotation on the 1959 photograph identifies an “active burial area” covering most of the Smelter Parcel. Also visible in the 1945 photograph is the former coastal canal that conveyed surface water from the Hueneme Drain (a.k.a. Bubbling Springs) southeast to the Mugu Lagoon. This coastal canal was constructed during or before the 1930s according to an Oxnard Drainage District No. 3 drawing (undated). It appears to still be operational in the 1951 photograph, but partially filled with sand and dilapidated in the 1959 photograph. The modern-day lagoon is not present during this period. A copy of the undated drawing is included in Appendix G of the 2008 Groundwater Report.

The 1965 aerial photograph shows the Site prior to development by Halaco. The burn dump is no longer visible and the portion of the coastal canal to the east of the OID appears to be filled with sand. The 1969 photograph shows early Halaco operations at the Smelter Parcel and process waste being discharged to a small pond in the OID. The 1970 photograph shows
a realigned OID channel east of the 1965 alignment. It appears that process waste filled the existing OID channel in the late 1960s to create the alignment that exists today.

The photographs from 1970 through 1991 show Halaco’s waste disposal activities at the Waste Management Area east of the OID. The historical photographs also show a portion of the OID flowing across the west half of the WDA and the northwest corner of the WMU. This historical channel is also indicated by the historical topographic maps (Figure 1c). The disposal of process waste in the WDA is first apparent in the 1981 photograph.

The 1991 aerial photo shows the early stages of the modern-day lagoon. At that time, Ventura County (County) manually breached the naturally occurring coastal sand berm (the “beach berm”) at the end of the J Street Drain to prevent upstream flooding. Flow from the J Street Drain and OID discharged into a small lagoon (compared to its current extent) and then exited the breach to the ocean. The County stopped breaching the beach berm in 1992.

Figure 1d provides a 1972 aerial photograph of Halaco’s operations. More recent aerial photographs and topographic maps prior to and after EPA’s 2007 re-grading of the Waste Management Area are available in the companion report (CH2M HILL, 2011d).

2.2 Regional Hydrologic Conditions

Regional and local surface water and groundwater hydrologic conditions were evaluated and presented in the 2008 Groundwater Report. These conditions are summarized below, with updated information where available. The regional geology and hydrogeology of the deeper groundwater system have been well characterized and documented. The shallow “Semiperched” groundwater aquifer was less well understood in the vicinity of the Site before 2009.

2.2.1 Precipitation

Southern California has a Mediterranean climate characterized by hot, dry summers and cool, wet winters. The temperature extremes at the Halaco Site are moderated by its proximity to the Pacific Ocean. Most rainfall occurs from October through April, defining the wet season. Figure 2a provides an updated chart of annual precipitation through the end of the 2010/11 water year for data obtained from Ventura County Watershed Protection District (VCWPD) Stations 32 (Oxnard Water Department) and 32A (Oxnard Civic Center). The long-term average for Station 32 is 14.58 inches, the minimum is 4.66 inches (1989-90), and the maximum is 38.17 inches (1940-41). The rainfall data were downloaded from vcwatershed.net/hydrodata/.

2.2.2 Surface Water

Surface water features at the Halaco Site include several regional channels that drain the Oxnard Plain and standing surface water in the lagoon, NCL-East, and NCL-North areas at or next to the Site. Figure 2b shows the regional drainage channels that discharge into the wetland area (lagoon) between the Halaco Properties and the Pacific Ocean: the OID, J Street Drain, and Hueneme Drain. These channels drain urban and agricultural runoff from the Port Hueneme and Oxnard areas. The OID and J Street Drain discharge into the lagoon by
gravity. Water from the Hueneme Drain is pumped over a dam structure at its terminus into the J Street Drain and lagoon. This dam is operated by the VCWPD to prevent reverse flow and inundation of the upstream, urbanized area. The hydrology of these surface water bodies is described in Section 4.

### 2.2.3 Hydrogeology

The surface geology and groundwater basins of southern Ventura County are shown in Figure 2c and a regional geologic cross-section through the Oxnard Plain and the Site is shown in Figure 2d. The Halaco site overlies the Oxnard Plain Groundwater Basin, one of several groundwater sub-basins located within the coastal valleys and plains of the Santa Clara-Calleguas Basin. Groundwater in this basin is present in three major aquifer systems, including (from shallowest to deepest) the Semiperched aquifer, Upper Aquifer System (UAS), and Lower Aquifer System (LAS). These aquifer systems tend to be separated by silts and clays of low permeability.

The Semiperched aquifer consists of silts and sands, generally to a depth of between 50 to 100 feet below ground surface (bgs). The Semiperched aquifer is regionally of low yield and poor water quality across the Oxnard Plain and little used, if at all, as a source of water supply. The Semiperched aquifer is underlain by an extensive clay deposit that separates it from the underlying regional aquifer system.

The UAS and LAS comprise the major aquifer units underlying the Oxnard Plain and are regionally a source of water supply. These units consist of highly permeable materials (sands and gravels) generally to a depth of more than 1,000 feet bgs. From shallowest to deepest, the UAS consists of the Oxnard and Mugu aquifers, and the LAS consists of the Hueneme and Fox Canyon aquifers. Except where locally affected by saline intrusion from historical overdraft, these regional aquifers yield significant amounts of good quality water across the Oxnard Plain.

Historically, groundwater extraction from the regional aquifer units exceeded replenishment. This overdraft lowered groundwater levels significantly below sea level in the UAS and LAS, causing coastal saline water intrusion. In response to the overdraft and other concerns, the Fox Canyon Groundwater Management Agency (FCGMA) was established in 1983 to regulate groundwater use in several groundwater basins underlying the southern portion of Ventura County.

Artificial recharge in the Oxnard Forebay (Santa Clara River water diverted into spreading basins), cutbacks in groundwater pumping mandated by FCGMA, and other projects have replenished groundwater levels since the early 1990s in the UAS to where they are currently above sea level. Figure 2e shows the regional groundwater elevations for the UAS in fall 2008 and spring 2009, as interpreted by the United Water Conservation District (UWCD). Groundwater flow direction at the Site indicated by the groundwater elevation contours is toward the east, southeast, and south. However, groundwater levels in the LAS system on the Southern Oxnard Plain remain significantly below sea level because that part of the plain is isolated hydraulically by overlying clay materials that separate it from the UAS, along with a low-permeability structure that separates it from the Northern Oxnard Plain. Figure 2f shows the extent of saline water intrusion in the UAS and LAS in 2005 and 2006.
Figure 2g shows historical groundwater elevations for CM-4, a regional USGS monitoring well cluster installed in the late 1980s. CM-4 is located at the southwest corner of the City’s wastewater treatment plant (WWTP) property to the west of Perkins Road. CM4-200 is the shallowest well in the cluster and screened in the Oxnard aquifer. The other wells (CM4-275, -760, -1095, and -1395) are screened in deeper aquifer units. CM4-275 is also screened in the UAS and the deepest three wells are screened in the LAS. Figure 2g shows the groundwater elevations increasing since early 1990s. Total dissolved solids (TDS) concentrations in the Oxnard aquifer near the Site, as indicated by CM4-200 monitoring data (Figure 2f), has declined from over 5,000 milligrams per liter (mg/L) in the early 1990s to approximately 1,300 mg/L in 2010 in response to the higher groundwater elevations that have resulted from increased artificial recharge in the forebay.

2.2.3.1 Beneficial Use Designation
The Los Angeles Regional Water Quality Control Board (LARWQCB) has assigned beneficial uses to all groundwater in the Oxnard Groundwater Basins, including the Semiperched aquifer, UAS, and LAS.

<table>
<thead>
<tr>
<th>Beneficial Uses</th>
<th>MUN</th>
<th>IND</th>
<th>PROC</th>
<th>AGR</th>
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<tbody>
<tr>
<td>Confined aquifers (UAS and LAS)</td>
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<tr>
<td>Unconfined perched aquifers (Semiperched aquifer)</td>
<td>E</td>
<td>P</td>
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<td>E</td>
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</tbody>
</table>

Notes:
AGR = agricultural supply
IND = industrial service supply
MUN = municipal and domestic supply
PROC = industrial process supply
E = existing beneficial use
P = potential beneficial use

These aquifers have been assigned as having beneficial use for municipal and domestic water supply, industrial service supply, and agricultural supply. All of the aquifers have been assigned as having beneficial use for industrial process supply, except for the Semiperched aquifer zone. However, Finding No. 145 of LARWQCB Order 80-58 provided:

Because of its very poor mineral quality waters from the semi-perched aquifer are not used for domestic, agricultural, or industrial water supply in any significant quantity.

As noted above, the Semiperched aquifer is little used, if at all, for water supply because it is generally high in dissolved solids. It is not protected from overlying agricultural irrigation runoff and other runoff from industrial and municipal areas that can impair water quality.

2.3 Sources, Nature, and Extent of Surface Water and Groundwater Contamination
This section summarizes what was known about the sources and extent of surface water and groundwater contamination prior to conducting the RI activities in 2009 and 2010. This information is summarized from the 2008 Groundwater Report.
2.3.1 Historical Site Investigation and Sampling Analysis Activities

2.3.1.1 1970s Site Investigation, Sampling, and Analysis Activities
The earliest known groundwater sampling activities at the Site occurred in 1970. Halaco performed site investigation, sampling, and analysis activities in accordance with Waste Discharge Requirements (WDRs) issued by the LARWQCB in 1970 to assess the suitability of the Waste Management Area for disposal of Halaco’s wastes and assess potential impacts on surface water and groundwater from waste disposal. Groundwater, surface water, and wastewater samples were collected and analyzed for a variety of chemistry parameters throughout the 1970s as documented in reports by Buena Engineers and various laboratories. The status of the piezometers installed during the 1970s is not known.

2.3.1.2 1981 to 2003 Halaco Monitoring Program
Halaco performed wastewater, surface water, and groundwater monitoring from 1981 through 2003 to comply with revised WDRs issued by the LARWQCB in 1980. Three groundwater monitoring wells were installed at the Waste Management Area in 1981 (MW-1, MW-2, and MW-3) and a fourth was installed in 1983 (MW-4). Groundwater and Halaco process wastewater effluent were sampled twice per year. Surface water was sampled every 2 months from the OID south and north of the Site. Well installation and monitoring data are documented in monitoring reports prepared by Buena Engineers (monitoring period 1981 through 1991), Earth Systems Consultants (monitoring period 1991 through 2001), and Halaco or Brash Industries (monitoring period 2001 through 2003). The four wells were abandoned (destroyed) in 2003 (Padre Associates, 2003a).

2.3.1.3 1985 Halaco Site Investigation
A site investigation was performed in 1985 to characterize (1) surface water and groundwater quality and (2) chemical and geotechnical properties of shallow soils and sediments at the Halaco Site. This included drilling 15 soil borings and installing 18 monitoring wells at the Smelter Parcel and Waste Management Area. A summary of the investigation is provided in a letter by Levine-Fricke (1987).

2.3.1.4 2002 to 2004 Halaco Monitoring Program
Halaco performed expanded surface water and groundwater monitoring activities from 2002 to 2004 to comply with a Cease and Desist Order (CDO) issued by the LARWQCB in 2002. The following nine monitoring wells and two shallow groundwater sampling points were installed in 2003:

- MW-1R (replacement for destroyed MW-1)
- MW-2RA and MW-2RB (replacements for destroyed MW-2)
- MW-3RA and MW-3RB (replacements for destroyed MW-3)
- MW-4RA and MW-4RB (replacements for destroyed MW-4)
- MW-5 and MW-6
- MW-S1 and MW-S2 (shallow sampling points)

Groundwater was sampled quarterly and surface water was sampled every two months. Surface water sampling locations included the OID south and north of the Site, and the lagoon, ocean, and ditch south of the WMU. Two reports provide information on well
installation, geology, and data on the surface water and groundwater flow and chemistry associated with the installation of the nine wells in 2003 (Padre Associates, 2003a, 2003b).

A letter provides information on well installation and data on surface water and groundwater chemistry associated with two shallow groundwater sampling points (Halaco, 2003). The monitoring data are provided in monitoring reports prepared by Halaco or Brash Industries.

### 2.3.1.5 SWRCB and LARWQCB Site Inspections

Site inspections performed by the State Water Resources Control Board (SWRCB), LARWQCB, and California Department of Health Services (DHS) (now the California Department of Public Health [DPH]) provide information on historical site conditions and wastewater, surface water, and groundwater chemistry. Several of these inspections included the collection and analysis of wastewater and surface water samples.

- SWRCB performed inspections on February 28, 1972, and May 15, 1973 (SWRCB, 1972, 1973) to evaluate the suitability of the Waste Management Area for disposal purposes. The inspections did not include the collection or analysis of samples.

- DHS performed an inspection on October 4, 1979, to determine whether Halaco was discharging hazardous waste into the waste pond. The inspection included the collection and analysis of wastewater and surface water samples (DHS, 1979).

- LARWQCB performed inspections on August 14, 1998, and August 19, 1999 (LARWQCB, 1998 and 2000) to evaluate compliance with WDRs. The inspections included the collection and analysis of wastewater and surface water samples.

### 2.3.1.6 1980 and 1991 EPA Site Inspections

Two site investigations performed at the direction of EPA resulted in information on historical site conditions and surface water and groundwater chemistry. These investigations were conducted in 1980 and 1991 as follows:

- National Enforcement Investigations Center (NEIC) (1981) performed a site inspection from December 8 to 11, 1980, to (1) determine whether the waste generated by Halaco was a hazardous waste under the Resource Conservation and Recovery Act and (2) evaluate compliance with the Clean Water Act.

- Ecology & Environment, Inc. (E&E) (1992a and 1992b) performed a site investigation from September 10 to 13, 1991, to determine whether (1) hazardous substances, pollutants, or contaminants were present in wastes in Halaco’s waste pond and WDA, and (2) hazardous substances, pollutants, or contaminants had been released to adjacent areas. This inspection was performed under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended.

### 2.3.1.7 2006 EPA Integrated Assessment

EPA installed nine new shallow groundwater monitoring wells and sampled surface water and groundwater in 2006 as part of the Integrated Assessment (Weston Solutions, 2007). Five of the new wells were installed at the Smelter Parcel (MW-11 through MW-15). Four of
the new wells were installed at the Waste Management Area (MW-16 through MW-19) to supplement the nine existing wells installed by Halaco in 2003. Groundwater samples were collected from the nine new wells and four of the existing wells (MW-1R, MW-2RA, MW-4RA, and MW-6) and analyzed for metals, radionuclides and volatile organic compounds (VOCs).

2.3.1.8 2007/2008 EPA Surface Water and Groundwater Elevation Monitoring
EPA performed a 1-year surface water and groundwater elevation monitoring study from August 2007 through September 2008 that included the following activities:

- Inspecting the 18 existing groundwater monitoring wells at the Site on August 15, 2007, and making repairs to the wellheads of select wells on October 9, 2007.
- Installing two new staff gauges in the NCL-East and NCL-North areas. These two staff gauges supplemented an existing staff gauge at the footbridge at the end of Perkins Road that is used to monitor surface water levels in the OID and lagoon.
- Surveying the two new staff gauges, existing staff gauge, and each of the 18 monitoring wells, and the nearby, multi-level regional groundwater monitoring well (CM4) for horizontal coordinates using the North American Datum of 1983 (NAD 83) and vertical elevation relative to North American Vertical Datum of 1988 (NAVD 88).
- Taking monthly water level measurements from the three staff gauges and 18 monitoring wells from October 2007 through September 2008.
- Taking continuous water level measurements from the three staff gauges, 18 monitoring wells, and CM4 with a pressure transducer and data logger system to assess tidal effects and allow detailed correlation of surface water and groundwater elevation changes.
- Measuring electrical conductivity (EC) in each well during the March 6, 2008 water level measurement event.
- Evaluating available historical data to assess the sources, nature, extent, and movement of contamination in surface water and groundwater.

The results of these activities are provided in the 2008 Groundwater Report.

2.3.1.9 2008 – 2011 Ongoing Surface Water Elevation Monitoring
EPA continued to monitor surface water elevations at the three staff gauges (OID/Lagoon, NCL-East, and NCL-North) following the conclusion of the 2007/08 surface water and groundwater elevation monitoring study. Surface water levels were measured every several weeks. The pressure transducer and data logger installed to monitor surface water levels for the OID/lagoon was left in place and downloaded every several months, until it was found missing following the last data download in June 2009. These data are discussed in Section 4 of this report.

2.3.2 Halaco Process Wastewater and Surface Water
Routine sampling of Halaco’s process wastewater and surface water in the OID began in 1981 and continued until 2004. Typically, surface water monitoring frequencies were every
two months and wastewater monitoring frequencies were semiannual. Analytical parameters varied, but at a minimum included EC, pH, oil and grease (O&G), magnesium, and selected metals (aluminum, copper, zinc). Surface water samples collected between 2002 and 2004 were analyzed for additional metals, TDS, sulfate, chloride, hardness, ammonia, nitrate, nitrite, gross alpha, gross beta, thorium isotopes (Th 228, Th 230, Th 232), radium (Ra 226, Ra 228), VOCs, and total petroleum hydrocarbons (TPH). Other, non-routine sampling, also occurred from the 1970s through 2006, as summarized in Section 3.1 of the 2008 Groundwater Report.

2.3.2.1 Process Wastewater

Halaco discharged its process waste into the OID from 1965 to about 1970. Halaco then discharged hundreds of millions of gallons of wastewater to the WMU from about 1970 to 2002 based on monthly discharge rates reported to the LARWQCB. Based on data from 1981 to 2002, an average of 6 million gallons of wastewater was discharged per year, approximately 1.5 times the annual average volume of rain that would fall over a 10-acre area (the assumed approximate area of the settling ponds), assuming an average of 15 inches of rain per year. Most of the wastewater discharged to the pond would have evaporated or percolated into the subsurface.

Halaco’s process wastewater had a high pH and contained the following:

- High levels of salts and residual metals
- Ammonia generated as a byproduct of the metal smelting operation
- Radionuclides from magnesium-thorium alloy scrap that Halaco reports it processed from 1965 to about 1977
- Organic constituents as a result of waste oil and solvent that was reportedly disposed in Halaco’s furnaces or rotary washers

Physical Characteristics. During the 1980 site inspection, NEIC observed that much of the waste material deposited in the Waste Management Area was “reactive, producing heat, flammable gases, and strong ammonia odors.” NEIC classified the waste solids as white to gray to dark gray and observed that freshly deposited waste solids from the washer felt hot to the touch (40 to 50 degrees Celsius), emitted crackling sounds, and produced flammable gases and strong ammonia odors. Large (1- to 2-foot-diameter) bubble-like formations were observed on some waste materials and gas bubbles were observed rising to the surface of the waste pond. LARWQCB observations made during the 1998 and 1999 site inspections are consistent with those made in 1980 by NEIC. LARWQCB representatives noted that the wastes were grey or sometimes blue-green, observed bubbles rising through settled effluent, and smelled ammonia while on the waste pile.

General Chemistry. Halaco’s wastewater had high levels of salinity (as indicated by elevated EC), high pH, and elevated levels of magnesium. Figure 2i summarizes the EC, pH, and magnesium data from 1981 to 2002. EC ranged up to 311,400 micromhos per centimeter (µmhos/cm), magnesium ranged up to 62,500 mg/L, and pH ranged between approximately 8 and 10. These levels are consistent with the 1980 NEIC and 1998/99 LARWQCB data. The EC and magnesium values are greater than seawater, which has a typical EC of 50,000 µmhos/cm and magnesium at 1,290 mg/L (Drever, 1988).
Metals. Halaco’s wastewater contained high levels of metals. Figure 2j summarizes the aluminum, copper, and zinc monitoring data from 1981 to 2002. Aluminum ranged up to 20,000 mg/L, copper up to 590 mg/L, and zinc up to 426 mg/L. These values are several orders of magnitude greater than seawater, which has typical aluminum, copper, and zinc concentrations of 0.002, 0.0005, and 0.002 mg/L, respectively (Drever, 1988). Barium, beryllium, cadmium, chromium, lead, nickel, and zinc were also elevated in Halaco’s wastewater, as documented by the 1980 NEIC and 1998/99 LARWQCB site inspection data.

Ammonia. Halaco’s wastewater contained high levels of ammonia. The main source of ammonia is believed to be the reaction of aluminum and magnesium with atmospheric nitrogen to produce metal nitrides, which react with water to form ammonia. Wastewater and waste pond samples collected during the 1979 DHS, 1980 NEIC, 1991 E&E, and 1998/99 LARWQCB inspections consistently had ammonia levels ranging from 100 to several hundred mg/L and occasionally up to near 1,000 mg/L. The high levels of ammonia are consistent with the ammonia odors noted during the site inspections.

Nitrate. Halaco’s wastewater contained low levels of nitrate. Wastewater and waste pond samples collected during the 1979 DHS, 1980 NEIC, 1991 E&E, and 1998/99 LARWQCB inspections measured nitrate levels generally at less than 5 mg/L.

Organics. Halaco’s wastewater contained measurable levels of O&G and other organic constituents. Figure 2i summarizes the levels of O&G from 1981 to 2002. The maximum concentration measured was 320 mg/L. When detected, O&G typically ranged from 1 to 100 mg/L. Halaco stored and used large quantities of diesel fuel and oil in its vehicles and equipment, and used petroleum-based solvents for cleaning. Oil and solvent wastes were reportedly poured on metal before placement in the furnaces, and mixed with air pollution control equipment waste and put in Halaco’s washers. Slurry from the washers was discharged to the onsite settling ponds.

Radionuclides. Halaco’s wastewater may have contained elevated levels of radionuclides from magnesium-thorium alloy scrap that Halaco reports it processed from 1965 to about 1977. Radionuclide data for Halaco’s wastewater are not available from this period. The 1999 LARWQCB wastewater sample was analyzed for potassium, uranium, and thorium isotopes. Uranium and thorium appear to be at background levels for this sample. The potassium-40 activity is consistent with the total potassium concentration measured in the sample.

The wastewater chemistry reflected the flux salts used in the smelting process (potassium chloride, magnesium chloride, and sodium chloride) and may also be influenced by the source of Halaco’s process water (the OID). The general chemistry of Halaco’s wastewater is shown in Figure 2k and 2l, together with typical seawater chemistry from Drever (1988). The samples compared in Figures 2k and 2l all have elevated levels of chloride, as does seawater. Of importance in distinguishing Halaco’s wastewater from seawater are the concentrations of potassium and sulfate. Potassium was much higher and sulfate was much lower in the 1980 NEIC, 1999 LARWQCB, and 2001 Halaco wastewater samples compared to seawater, on a percentage basis. The 1998 LARWQCB sample was more similar to seawater.
2.3.2.2 Surface Water

There is evidence that Halaco’s wastes affected surface water quality, particularly during the period that Halaco discharged wastewater to the WMU (approximately 1970 to 2002). However, Halaco’s impact on surface water is often difficult to distinguish from two other sources for many of the chemical constituents in Halaco’s waste: runoff from the 5,935-acre watershed that drains into the OID (Philip Williams & Associates, 2007) and seawater that seasonally moves into the lagoon and OID. The latter process occurs when the naturally occurring sand berm separating the OID and lagoon from the ocean breaches, and seawater moves inland during high tides.

In the OID and lagoon, contamination of surface water probably resulted from direct discharge of waste materials into the OID from 1965 to 1970, erosion and suspension of contaminated bank sediments, stormwater runoff, and groundwater to surface water discharge because of mounding of groundwater under the WMU from the settling ponds from 1970 to 2002. The strongest evidence of an impact from Halaco’s wastes is seen in sampling results for ammonia and O&G between 1980 and 2002. Sampling results also showed, at times, elevated levels of metals, anions, TDS, and EC, but the increases were inconsistent. Since wastewater discharges ended in about 2002 (lowering groundwater levels) and EPA stabilized the waste pile in 2007 (limiting runoff and erosion), impacts on surface water are probably limited to major storm events when discharge velocities in the OID are high and stormwater runoff overwhelms erosion control measures. Discharge of contaminated groundwater to surface water is also possible, particularly when surface water levels drop after the naturally occurring sand berm is breached.

Surface waters (and sediment) in the small ditch immediately to the south of the WMU, and in standing waters in the NCL-East, also had been affected by Halaco’s wastes. Elevated levels of metals, ammonia, and major ions (especially potassium) associated with Halaco’s wastewater were measured in liquids observed to seep from the WMU (in 1999), in ponded water in the NCL-East (in 1980 and 1991), and in the ditch to the south of the WMU (in 2003 and 2004).

In two samples of Halaco’s wastewater collected and analyzed in 2003, the radionuclide Cs 137 was detected. Surface water and groundwater sampling in 2006 did not find elevated Cs 137 levels. Elevated levels of the radionuclide potassium 40 (K 40) have been measured in surface water and groundwater at the Site, but the elevated levels are expected. Potassium chloride salt was used in the smelting process and all potassium-containing materials have a fixed percentage of K 40.

2.3.3 Groundwater

Site investigation and groundwater monitoring activities were performed by Halaco from the 1970s through 2004 and less frequently by others from the 1970s through 2006. Prior to the EPA’s 2009-2010 RI activities, there were 18 groundwater monitoring wells intact and usable, all screened in the upper 10 to 30 feet of the Semiperched aquifer underlying the Site. There were no wells onsite in the deeper portion of the Semiperched aquifer or in the underlying Oxnard aquifer.

Nine of the eighteen wells were sampled quarterly in 2003 and 2004. Analytical parameters varied, but included EC, pH, O&G, magnesium, and selected metals (aluminum, copper,

Monitoring and sampling data showed that Halaco’s wastes had contaminated shallow groundwater at the Site, at least to the depth of the available groundwater monitoring wells. The wells are screened to a depth of approximately -10 feet elevation in the smelter area and -20 feet elevation in the Waste Management Area. Monitoring data had shown elevated levels of several parameters associated with Halaco’s wastes, including TDS, EC, pH, magnesium and other metals, ammonia, and O&G. VOCs were detected infrequently and at low levels in a small number of groundwater samples. Monitoring data also showed relatively high levels of potassium and low levels of sulfate in wells near waste disposal areas, consistent with the composition of Halaco’s wastewater. The horizontal extent of contamination and the vertical extent of contamination below the existing well network were not known.

2.4 Contaminant Fate and Transport

When Halaco discharged wastewater to the WMU from about 1970 to 2002, water table “mounding” under the WMU would have resulted in groundwater flowing radially outward from the historical wastewater disposal areas and vertically downward within the Semiperched aquifer. Until the early 1990s, there were also downward hydraulic gradients between the Semiperched and underlying Oxnard aquifers because of overpumping in the Oxnard aquifer, which lowered groundwater elevations below sea level. It was unknown whether contaminated groundwater in the Semiperched aquifer had moved downward through the underlying aquitard.

Impacts on groundwater continued even though wastewater discharge and mounding no longer occurred and local groundwater flow directions changed after wastewater discharges ended in 2002.

Groundwater monitoring data collected by Halaco in 2003 and 2004, EPA in 2006, and EPA in 2007 and 2008 showed that shallow groundwater in Semiperched aquifer under the Site moved generally inland (northward) and away from surface water recharge areas (lagoon, OID, NCL-East). Potential extraction or removal of groundwater from the Semiperched aquifer north of the Site may have contributed to this overall northerly gradient across the Site. There was a possibility that groundwater leakage into the City’s sanitary sewer trunk line that runs along McWane Boulevard was a source of the depressed groundwater elevations at the northern part of the Site. A video of the inside of the line performed in 2009 by the City did not provide evidence of leakage, but infiltration into the line was still suspected.

Shallow groundwater chemistry near surface water bodies was influenced by whether the OID and lagoon were in non-breach conditions or breach conditions. Shallow groundwater concentrations of ammonia and other parameters indicative of Halaco’s waste were higher during the winter/spring (when the breach conditions and lower water levels generally occur) and lower in the summer/fall (when non-breach conditions and higher water levels generally occur) (CH2M HILL, 2008a).
When lower surface water levels occurred, Halaco-contaminated groundwater moved toward the OID and lagoon, increasing contaminant concentrations in groundwater near the OID and lagoon. Groundwater may at times have discharged into the OID. When higher surface water levels occurred, cleaner surface water moved inland, decreasing (diluting) contaminant concentrations in groundwater near the OID and lagoon.

### 2.5 Threat Posed by Contaminated Surface Water and Groundwater to Human Health and the Environment

Numerous metals and radionuclides exceeded human health screening levels in historical groundwater samples collected at the Site. Historical data also indicated impacts on surface water quality when Halaco was discharging wastewater at the Site.
SECTION 3
Remedial Investigation Activities

This section describes the RI activities that were completed for the Site in 2009 and 2010. RI activities were completed as planned to address the data gaps identified in the QAPP. To control measurement error, analytical measurements were undertaken as documented in the project QAPP, and samples were collected and shipped as documented in the project FSP and field standard operating procedures (SOPs) contained in the FSP. Figure 3 shows surface water sampling locations sampled in and before 2009-2010. Figure 4 shows the locations of groundwater monitoring wells constructed in and before 2009-2010 and cone penetrometer test (CPT) probes that were pushed in 2009. Tables 1 and 2 summarize construction information for the new and existing monitoring wells and piezometers at the Site. Table 3 provides survey data for the wells and piezometers.

3.1 Field Investigation Activities

Field investigations completed in 2009 and 2010 consisted of direct push testing, groundwater monitoring well and piezometer installation, and surface water and groundwater sampling and analysis. Instrumented probes were pushed at 8 locations to depths of 157 feet bgs, piezometers were installed at 12 locations, monitoring wells were installed at 22 locations to depths of 152 feet bgs to supplement the existing network of 18 monitoring wells, and surface water and groundwater elevation measurements were made to assess the lithology, aquifer units, and surface water and groundwater flow conditions at the Site.

Surface water samples were collected from 19 locations and groundwater samples were collected from the 40 monitoring wells and analyzed at offsite laboratories for a wide range of inorganic and organic parameters to assess the nature and extent of contamination. Groundwater samples were also collected from three wells at the City’s Advanced Water Purification Facility (AWPF) to assess background concentrations. The AWPF is located approximately 2,000 feet north of the Halaco Site, immediately north of the railroad tracks and east of Perkins Road (Figure 4). Two rounds of surface water samples were collected at most locations for a total of 33 samples (not including duplicates). Two rounds of groundwater samples were collected from all wells and an additional screening sample was collected from two wells for a total of 88 groundwater samples (not including duplicates).

All surface water and groundwater samples were analyzed for metals and general chemistry, and most (90 percent) were analyzed for five thorium and radium isotopes. Selected surface water samples were analyzed for total organic carbon (TOC) and pH. One round of groundwater samples was analyzed for VOCs, semivolatile organic compounds (SVOCs), and TPH.

These activities are described in more detail in the following sections.
3.1.1  CPT Borings

Instrumented cones were pushed through the subsurface in October 2009 to evaluate geotechnical and hydrogeologic properties of the waste materials, deeper soils, and underlying aquifer units. The results were also used to help plan and design the new groundwater monitoring wells. CPT probes provided information on the physical properties of the soil and aquifer materials. Either EC-hydraulic profile test (EC-HPT) or soil moisture-resistivity-temperature (SMRT) probes were run in conjunction with the CPT probes to measure the electrical conductivity (or electrical resistivity) of the subsurface materials and pore water. An HPT probe was also used in one push to provide information on the hydrogeologic properties of the subsurface materials.

Table 4 lists the probes and depths to which they were pushed. CPT borings were conducted at three locations at the Smelter Parcel (SCP-1 through -3) and five locations at the Waste Management Area (WCP-1 through WCP-5). SCP-3 and WCP-5 were added during the field investigation activities based on preliminary results from SCP-1, WCP-3, and WCP-4.

- SCP-1 was pushed through process waste to the top of the Oxnard aquifer.
- SCP-2 was pushed through burn dump fill into underlying native soils.
- SCP-3 was pushed through burn dump fill to the top of the Oxnard aquifer.
- WCP-1 and -2 were pushed from the top of the WMU into underlying native soils.
- WCP-3, -4, and -5 were pushed through process waste to the top of the Oxnard aquifer.

3.1.2  Monitoring Well Installation

Groundwater monitoring wells were installed at the following locations:

- Three shallow wells (MW-20, MW-21, and MW-22) and three deeper wells (MW-12C, MW-13C, and MW-21C) were installed in the Semiperched aquifer at the Smelter Parcel. The three shallow wells were installed as planned. The three deeper wells were added to assess the horizontal extent of deeper contamination in the Semiperched aquifer that was identified after installing the four deeper Semiperched aquifer wells at the Waste Management Area (MW-2C, MW-3C, MW-6C, and MW-19C).

- One shallow well (MW-24) and five deeper wells (MW-2C, MW-3C, MW-6C, MW-19C and MW-24C) were installed in the Semiperched aquifer at the Waste Management Area. The shallow well (MW-24) and four of the five deeper wells (MW-2C, MW-3C, MW-6C, and MW-19C) were installed as planned. One deeper well (MW-24C) was added to assess the horizontal extent of deeper contamination in the Semiperched aquifer that was identified after installing the four deeper wells (MW-2C, MW-3C, MW-6C, and MW-19C).

- Four deeper wells were installed in the Oxnard aquifer as planned (MW-2D, MW-3D, MW-6D, and MW-19D). These wells were co-located with four deeper wells in the Semiperched aquifer (MW-2C, MW-3C, MW-6C, and MW-19C).

- One shallow well (MW-23B) and one deeper well (MW-23C) were installed in the Semiperched aquifer west of Perkins Road across from the Smelter Parcel (the “Hueneme Parcel”). The shallow well (MW-23B) was installed as planned. The deeper well (MW-23C) was added to assess the horizontal extent of deeper contamination in the
Semiperched aquifer that was identified after installing the three deeper wells at the Smelter Parcel (MW-12C, MW-13C, and MW-21C).

- Two shallow wells (MW-25B, MW-27B) and two deeper wells (MW-25C, MW-27C) were installed in the Semiperched aquifer at NCL-East. The two shallow wells were installed as planned, except that the wells at the MW-25 location were moved approximately 200 feet to the east. The two deeper wells were added to assess the horizontal extent of deeper contamination in the Semiperched aquifer that was identified after installing the initial four deeper wells at the Waste Management Area (MW-2C, MW-3C, MW-6C, and MW-19C). The wells planned at location MW-26 were not installed.

Table 1 provides well construction information and well installation dates.

### 3.1.3 Piezometer Installation

Twelve piezometers were installed in the Semiperched aquifer at four locations as planned. Two were installed at the northern edge of the Smelter Parcel (PZ-1 and PZ-2) and two at the northern edge of the Waste Management Area (PZ-3 and PZ-4) to assess the groundwater elevations and hydraulic gradients near the City’s sewer trunk line. The shallowest “A” piezometers were screened near the water table approximately 10 feet higher in elevation than the sewer line, the “B” piezometers were screened at approximately the same elevation as the sewer line, and the “C” piezometers were screened approximately 10-feet below the elevation of the sewer line. Table 1 provides construction information and installation dates.

### 3.1.4 Monitoring Well and Piezometer Surveying

The new groundwater monitoring wells and piezometers were surveyed for horizontal coordinates and vertical elevations. Elevations were determined for the top of outer protective casing, top of inner well casing, and ground surface next to protective casing.

### 3.1.5 Surface Water and Groundwater Sampling and Analysis

Two rounds of surface water and groundwater samples were collected and analyzed for a wide range of organic and inorganic parameters, as planned. Additionally, one screening sample was collected from two deeper wells at the Smelter Parcel. One round was collected during non-breach conditions when the OID was at a high-water stage, when surface water slowly seeps from the lagoon through the berm toward the ocean. The second round was collected during breach conditions when ocean water moves inland with the rising tide and then drains to the ocean with the falling tide. Table 5 summarizes information about the surface water and groundwater samples collected, the dates that they were collected, and the analyses performed.

Surface water samples were collected at the following locations: OID adjacent to the Halaco Properties (OID-1 through OID-4), OID north of the Halaco Properties (OID-5 through OID-8), lagoon (LAG-1 and LAG-2), ocean (OCE-1 and OCE-2), J Street and Hueneme drains (JSD-1 and HUD-1), ditch south of the WMU (WMU-1 and WMU-2), and NCL-East (NCE-1 through NCE-3). Samples were collected from each location, at two different times, except for the WMU ditch and NCL-East samples. A second WMU ditch sample was not collected because it is dry during breach conditions.
Groundwater samples were collected from all wells, at two different times, as planned. At most locations the first sample was collected during November 2009 during breach conditions, and the second sample was collected during February 2010 during non-breach conditions. Samples from wells installed in May 2010 were collected in June and October 2010.

The surface water and groundwater samples were analyzed for the following:

- Metals (unfiltered and field filtered)
- Radionuclides (Th 232, Th 230, Th 228, Ra 228, and Ra 226)
- General chemistry (ammonia, TDS, major cations [Na, K, Ca, Mg], major anions [Cl, SO₄, CO₃, HCO₃], nitrogen species [NO₃, NO₂, TKN], and other anions (F, Br, hardness, and alkalinity)
- TOC for selected surface water samples only
- Field parameters (EC, pH, T, Eh, dissolved oxygen [DO], turbidity)

Additionally, the first groundwater sample was also analyzed for VOCs, SVOCs, and TPH.

### 3.1.6 Surface Water and Groundwater Level Measurements

Surface and groundwater levels were measured on the following dates:

- November 6, 2009 sampling event 1 (non-breach conditions)
- February 22, 2010 sampling event 2 (breach conditions)
- June 1, 2010 sampling event 3 (non-breach conditions)
- October 25, 2010 sampling event 4 (non-breach conditions)
- December 27, 2010 (breach conditions)

Water levels were measured during each of the four sampling events and in December 2010 after all the wells had been constructed and the beach berm had breached. Surface water elevations were also monitored every several weeks through September 2011.

### 3.2 Field Procedures

CH2M HILL and subcontractors WDC Exploration & Wells (WDC) and Blaine Tech Services, Inc. (Blaine Tech) performed the field activities. CH2M HILL led the direct push, well and piezometer installation, and sample collection activities. CH2M HILL logged all samples, filled and labeled sample containers, completed chain-of-custody (COC) documentation, and shipped samples to the offsite analytical laboratories. WDC cored concrete (where present) and installed the monitoring wells and piezometers. Lankelma, under subcontract to WDC, performed the direct push testing. Blaine Tech developed the monitoring wells and piezometers and also collected the groundwater and surface water samples. CH2M HILL and subcontractor ULS Services Corp. (ULS) cleared locations of potential subsurface utilities using surface geophysical methods for the locations at the Smelter Parcel. Attachment B provides photographs of the monitoring well installation and well development activities.
Monitoring wells and piezometers were installed in accordance with a City Well Permit Application. The City’s Development Services provided notice that the Well Permit Application materials were complete in an October 7, 2009 e-mail.

### 3.2.1 CPT Borings

The CPT cones were fitted with a standard piezometer cone to assess lithology (tip and sleeve resistance) and an SMRT tool to assess water quality anomalies with depth. The original plan was to use an EC-HPT probe instead of the SMRT tool to assess water quality and lithologic permeability with depth. However, the push rods for the EC-HPT tool broke after completing the first push at the initial CPT location (SCP-1). Unsuccessful attempts were made to retrieve the broken EC-HPT tool string, and it was ultimately abandoned in place. A replacement EC-HPT tool was not available, so the SMRT tool was used instead to provide the electrical resistivity data.

### 3.2.2 Monitoring Well Installation

The deeper “C” and “D” monitoring wells at the four Waste Management Area locations (MW-2, MW-3, MW-6, and MW-19) were installed first to assess the deeper soils and aquifer units underlying the site before the remaining wells were installed. These wells were installed using the sonic drilling method which provides a high-quality continuous soil core. The results of the initial CPT testing (described above) and continuous coring were used to identify the deeper site-specific aquifer units underlying the Waste Management Area and Smelter Parcel. A truck-mounted model 400 RS sonic drill rig with a 10-foot-long, 6-inch-inside-diameter (ID) core barrel was used.

The subsequent monitoring wells were installed using hollow-stem auger (HSA) drilling methods. A truck-mounted model CME 85 drill rig with a 5-foot long, 2-inch-ID core barrel was used.

Monitoring wells were constructed inside the drill pipe after reaching total depth with the sonic or HSA drill rigs. Polyvinyl chloride (PVC), Schedule 40 or 80, 2-inch-ID casing and screen assembly was lowered into each borehole. The screens are 10 feet long with 0.020-inch slot size. Sand filter pack was then placed into the borehole across the well screen, followed by a layer of bentonite pellets. Cement-bentonite grout was then tremmied into the borehole to near ground surface as the drill pipe was retrieved.

Monitoring wells were completed with lockable above ground steel monuments or traffic rated vaults flush to the ground. The monuments and vaults were set in a concrete pad sloped to drain away from the well. The monuments were constructed with 5-foot-long steel protective casing extending approximately 2 to 3 feet above ground. Guard posts were installed to protect the above-grade completions.

The wells were initially developed by WDC with the drill rig using a combination of surging and bailing throughout the well screen to settle the filter pack and remove fine-grained materials from the filter pack and aquifer. Additional well development, which included surging and bailing followed by pumping with a Grundfos submersible pump, was performed by Blaine Tech. Field parameters (EC, pH, T, Eh, DO, turbidity) were monitored during the additional well development.
3.2.3 Piezometer Installation

The twelve piezometers at the four locations (PZ-1 through PZ-4) were installed using either direct push methods or HSA drilling methods. The original plan was to install all piezometers using direct push methods. However, the direct push rig encountered refusal and the HSA drill rig was then used to install most of the piezometers.

The piezometers were constructed inside the direct push or HSA drill pipe after reaching total depth. PVC, Schedule 40, 0.75-inch-ID casing and screen assembly was lowered into the borehole. The screen is a pre pack assembly that is 1 foot long with 0.010-inch slot size and a #20/40 sand filter pack.

The piezometers at locations PZ-1 and PZ-2 were installed within the south side of McWane Boulevard with lockable flush-mount vaults. The piezometers at locations PZ-3 and PZ-4 were installed inside the berm along the north edge of the WDA with lockable above ground steel monuments. The monuments and vaults were set in a concrete pad sloped to drain away from the well. The monuments are constructed with 5-foot-long steel protective casing extending approximately 2 to 3 feet above ground. Guard posts were installed to protect the above-grade completions.

3.2.4 Monitoring Well and Piezometer Surveying

The new wells and piezometers were surveyed by SAGE Consultants, Inc. (SAGE), a Professional Land Surveyor. SAGE surveyed the wells and piezometers as follows:

- Elevations were surveyed to an accuracy of 0.01 foot for (1) top of outer protective casing, (2) top of inner well casing, and (3) ground surface next to protective casing. All elevation survey locations are on the north side of the casings and marked. The vertical datum is the NAVD 88. The surveying was performed using differential leveling techniques.

- Horizontal coordinates were surveyed to an accuracy of 0.1 foot. The horizontal coordinate system is the California State Plane Coordinate System, Zone 5. The surveying was performed using survey-grade global positioning system (GPS) equipment.

3.2.5 Surface Water and Groundwater Sampling

Surface water samples were collected by using a telescopic dipper to lower a disposable polyethylene cup to approximately 1 foot below the water surface. The cup was approximately 0.6 liter in size. The disposable cup was extended from the bank to collect the samples. When full, the cup was gently removed from the water and the sample transferred directly to the sample container. Multiple cupfuls were collected to meet the sample volume requirements. For dissolved metals, which required filtration, the samples were poured from the cup into a new polyethylene bailer, through a new disposable 0.45-micron filter, and into the sample containers. Water quality field parameters (EC, pH, T, Eh, DO, turbidity) were measured at the time of sample collection using a YSI 556 and HACH turbidimeter. All sample containers were placed on ice in a cooler immediately after sample collection.
Groundwater samples were collected in accordance with the Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures prepared by EPA (EPA, 1996). Samples were not collected from MW-16 because it was submerged by standing surface water or from MW-17 because the water was extremely turbid. Groundwater well samples were collected using the following pumping systems.

- Groundwater from 2-inch-diameter casings was purged and sampled with a Stainless Steel QED Sample Pro bladder pump. A new disposable polyethylene bladder and stainless steel grip plate was used at each well. New 0.17-inch-ID polyethylene tubing was used for air and water lines at each well.

- Groundwater from 1-inch-diameter casings was purged and sampled with a 0.75-inch Geotech bladder pump. A new disposable polyethylene bladder was used at each well. New 0.17-inch-ID polyethylene tubing was used for air and water lines at each well.

- Due to a bent casing, groundwater from well MW-12 was purged and sampled with a Geotech peristaltic pump. New 0.25-inch silicone tubing was used.

- Due to a bent casing, well MW-18 was purged with a Waterra pump. New 0.5-inch-ID polyethylene tubing with a decontaminated stainless steel check ball was used.

- Blaine Tech attempted to remove three casing volumes from well MW-17 prior to sampling. The well was purged dry twice before it was determined that no sample would be collected due to the high turbidity.

Water quality field parameters (EC, pH, T, Eh, DO, turbidity) were measured during purging and at the time of sample collection using a YSI 556 with Flow Through Cell and a HACH 2100P Turbidimeter. Prior to sample collection the effluent tubing was disconnected from the flow through cell. Sample containers were filled directly from the effluent water line. A new, disposable, 0.45-micron filter was attached in-line to the effluent water line to collect all analyses that required filtration. All samples were placed on ice in a cooler immediately after collection.

### 3.2.6 Surface Water and Groundwater Level Measurements

Surface water levels were measured from staff gauges at the following locations:

- OID, mounted on the footbridge at the end of Perkins Road
- NCL-East, located between MW-2RA and MW-1R
- NCL-North, located in the small pond to the north of the WDA

The OID staff gauge was previously in existence. EPA surveyed the elevation of the “8-foot” mark relative to NAVD 88 for the OID staff gage as part of EPA’s water level study in 2007-2008. This gauge is marked to allow water level readings to an accuracy of 0.01 foot. An offset of 1.52 feet is added to the field reading to obtain the vertical elevation in NAVD 88.

EPA set the two NCL staff gauges in October 2007 as part of EPA’s water level study. These two gauges are set to directly read surface water elevation relative to NAVD 88 to an accuracy of 0.01 foot.
Additionally, the pressure transducer in the OID that EPA installed in October 2007 as part of EPA’s water level study remained in place and continued to collect data at a 10- to 15-minute interval through June 2009. The data logger was periodically downloaded following the completion of EPA’s water level study in September 2008 until the data logger was discovered to be missing during fall 2009.

Groundwater levels were measured from the top of the PVC casing for all monitoring wells and piezometers using a water level indicator graduated to an accuracy of 0.01 foot. Groundwater elevations were calculated by subtracting the depth-to-water reading from the surveyed elevation of the top of the casing.

### 3.3 Sample Collection and Quality Control Samples

Surface water and groundwater samples for laboratory chemical analysis were placed in containers as detailed in Table 5-5 of the FSP. The following quality control samples were collected as specified in the QAPP and FSP:

- Field duplicates were collected at a frequency of 1 in every 10 samples.
- Field equipment blanks were collected at a frequency of once per day when non-dedicated sampling equipment was used.
- Extra volume for laboratory matrix spikes and matrix spike duplicates was collected at a frequency of 1 in every 20 collected samples.

The sample naming convention described in the FSP was used. This included a prefix to identify sample type (SW for surface water or GW for groundwater), the surface water location ID or monitoring well number, and the month-year of sample collection.

Duplicate samples were identified by adding “100” to the sample location number. For example, GW-112-1109 is the duplicate sample for GW-MW-12-1109.

Samples that were field filtered were given an “FF” designation at the end of the sample ID. For example, the field filtered sample from MW-12 would be GW-MW-12-1109-FF. The initial surface water samples collected on November 16, 2009, and groundwater samples collected on November 17, 2009, were inadvertently not given the “FF” designation.

### 3.4 Sample Custody and Tracking Procedures

COC procedures were followed in accordance with the FSP and QAPP. This included generating COC forms requesting analytical services from each of the analytical laboratories. EPA’s Forms II Lite program was used to generate sample labels, bottle tags, and COC forms; track samples from the field to the laboratory; and facilitate electronic capture of sample information into databases for the chemistry samples.

All samples for chemical analysis were placed on ice upon field collection and then shipped on ice to the analytical laboratories, except for the samples for radionuclide analysis. The samples for radionuclide analysis did not require this step. All samples for chemical analysis were shipped to the analytical laboratories using Federal Express to facilitate tracking from the field to the laboratory.
3.5 Chemistry Laboratory Analysis and Data Validation

The surface water and groundwater samples collected for chemical analysis were analyzed in offsite laboratories as follows:

- **Metals.** All samples were analyzed for metals under the EPA Contract Laboratory Program by ALS Laboratory Group (formerly DataChem) in Salt Lake City, Utah. The metals were analyzed using the following techniques:
  - Inductively coupled plasma atomic emission spectroscopy: aluminum (Al), calcium (Ca), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), selenium (Se), sodium (Na), zinc (Zn).
  - Inductively coupled plasma mass spectrometer to generate lower detection limits: antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), cobalt (Co), copper (Cu), lead (Pb), nickel (Ni), silver (Ag), thallium (Tl), and vanadium (V).
  - Cold vapor atomic absorption: Mercury (Hg)

- **Radionuclides.** Most samples were analyzed for three thorium and two radium radionuclides under subcontract by Eberline Services, Inc. at its laboratory in Oak Ridge, Tennessee. Thorium isotopes (Th 232, Th 230, and Th 228) were analyzed using Method DOE HASL 300 4.5.2.3 Modified. Ra 226 was analyzed using EPA Method 903.1 Modified. Ra 228 was analyzed using EPA Method 904.0 Modified.

- **VOCs and SVOCs.** Samples were analyzed for VOCs and SVOC under the EPA Contract Laboratory Program by ALS Laboratory Group (formerly DataChem) in Salt Lake City, Utah.

- **General Chemistry.** Samples were analyzed for general chemistry parameters by the EPA Region 9 Laboratory.
  - TDS by EPA 2450C
  - Alkalinity (hydroxide, carbonate, bicarbonate, total) by EPA SM2320
  - Anions by EPA 300
  - TOC by EPA 415.3
  - Ammonia was by 350.1
  - TKN by EPA 351.2
  - pH by SM4500
  - EC by EPA 120.1

  The samples collected during June 2010 were inadvertently not analyzed for pH and EC.

- **TPH.** Samples were analyzed for TPH quantitated as gasoline, diesel, and motor oil by the EPA Region 9 Laboratory. TPH as gasoline (TPH-gas) was analyzed as purgeable petroleum hydrocarbons by EPA Method 8015B. TPH as diesel (TPH-diesel) and TPH as motor oil (TPH-oil) were analyzed as extractable petroleum hydrocarbons by EPA Method 8015B.
The laboratory analytical results were reviewed or validated as follows:

- **Metals.** The EPA Contract Laboratory Program lab data for metals went through the EPA Computer-Aided Data Review and Evaluation automated data review. This is equivalent to a stage S2BVE under EPA’s national guidance for validating laboratory analytical data for Superfund use.

- **VOCs and SVOCs.** The EPA CLP lab data for organics went through EXES automated data review and is a stage S3VE under EPA’s national guidance.

- **Radionuclides.** The subcontract Eberline lab data for radionuclides were reviewed by Rob Terry of EPA Region 9’s Technical Support Section and found to be reliable.

- **General Chemistry and TPH.** The EPA Region 9 Lab data for general chemistry and TPH parameters went through internal review. The Region 9 Lab’s internal data review process is equivalent to Tier 1A review under the Region 9 guidance.
SECTION 4

Remedial Investigation Results

This section presents the results of the surface water and groundwater characterization and testing activities completed for the Halaco Site between 2009 and 2011. The results are provided in the following tables, figures, and attachments:

- Table 6 provides groundwater monitoring well and piezometer construction details, and describes the materials in which the wells and piezometers are screened.
- Tables 7 and 8 provide depth-to-water and surface water and groundwater elevation data from 2007 through 2011.
- Tables 9 through 16 provide the general chemistry, total metals, dissolved metals, radionuclides, detected VOCs, detected SVOCs, and TPH analytical results, respectively. Table 16 combines selected general chemistry and metals results to facilitate an evaluation of the major ion chemistry.
- Figures 6a, 6b, and 6c provide cross sections illustrating the subsurface materials and aquifer units encountered during sampling. The figures also show surface water and groundwater elevation data for two dates that represent seasonal high and seasonal low water level elevations. The cross section locations are shown on Figure 5.
- Figures 7a and 7b provide cross sections depicting hydrogeological conditions that may have been present before 2002, when Halaco was still discharging process waste to the WMU.
- Figures 8a and 8b provide cross sections illustrating the tip stress and interpreted material types from the CPT borings. The figures also specify the subsurface materials and aquifer units shown in Figures 6a, 6b, and 6c. Figure 8c is a chart showing the CPT and EC-HPT results for location SCP-1.
- Figures 9a through 9e provide plan view groundwater elevation contour maps for the Semiperched aquifer. Figures 10a and 10b provide groundwater elevation contour maps for the Oxnard aquifer.
- Figures 11a and 11b provide surface water elevation hydrographs. Figure 11a shows the pressure transducer data and “manually” measured water levels from 2007 through 2009. Figure 11b zooms in on a portion of Figure 11a to better show tidal fluctuations.
- Figures 12 through 16 provide groundwater elevation hydrographs for various time periods and depth intervals. Figures 12a and 12b provide hydrographs for the wells screened in the Semiperched aquifer for the period 2007 through 2010. Figures 13a through 13c show more recent data from 2009 and 2010 in more detail. Figures 14a and 14b provide hydrographs for the deeper “C” wells screened in the Semiperched aquifer. Figures 15a and 15b provide hydrographs for the “D” wells screened in the Oxnard aquifer and the nearby regional CM4-200 well. Figure 16 provides a groundwater
elevation hydrograph for the four piezometers screened in the Semiperched aquifer at the City AWPF.

- Figure 17 posts concentrations of several constituents next to selected Site monitoring wells and depicts the approximate east-west extent of groundwater affected by Halaco’s operations.

- Figures 18a, 18b, and 18c provide TDS concentration contours for the first round of samples for each well, which were collecting during November 2009 and June 2010. Figures 19a and 19b provide pre-2002 TDS concentration contours.

- The following figures show surface water and groundwater chemistry data for the two sampling events in 2009 and 2010:
  - Figures 20a, 20b, and 20c – Major ion chemistry
  - Figures 21a, 21b, and 21c – TDS concentrators and pH
  - Figures 22a, 22b, and 22c – TDS and ammonia concentrations
  - Figures 23a, 23b, and 23c – TDS, bromide, and fluoride concentrations
  - Figures 24a, 24b, and 24c – Total metals concentrators
  - Figures 25a, 25b, and 25c – Dissolved metals concentrations
  - Figures 26a, 26b, and 26c – Thorium and radium radionuclide activities

The “a” and “b” figures provide combined surface water and groundwater chemistry data for the two sampling events. The “c” figures provide the chemistry data for the two surface water samples.

- Figure 27 plots the TDS/K ratios versus TDS concentrations in surface water and groundwater.

- Figure 28a provides a time-series chart for OID surface water EC data from 2003 and 2004. Figure 28b provides data from 1980 through 2010.

- Figures 29a provides a time-series chart for groundwater EC data from 1980 through 2010. Figure 29b provides a chart of TDS data from 2003 through 2010, and Figure 29c provides a chart of ammonia data from 2003 through 2010.

- Attachment B provides photographs of CPT testing and well installation activities.

- Attachment C provides the contractor reports for the CPT-SMRT results (Lankelma) and the EC-HPT results (Vironex). The report by Lankelma describes the methodology and interpretation of the data obtained by the CPT-SMRT tool. The report by Vironex provides only a log of the results.

- Attachment D provides charts of CPT, SMRT, and EC-HPT data.

- Attachment E provides boring and construction logs for the new monitoring wells and piezometers. Appendix C of the 2008 Groundwater Report (CH2M HILL, 2008b) provides boring and construction logs for the existing monitoring wells.

- Attachment F provides survey reports for the new monitoring wells and piezometers prepared by the surveyor (SAGE).
• Attachment G provides a table of field parameters measured during well development.

• Attachment H provides a table and charts of field parameters measured during surface water and groundwater sampling.

• Attachment I provides groundwater elevation hydrographs for the following wells:
  - Smelter Parcel Water Table Wells
  - Waste Management Area Water Table Wells
  - Piezometer Clusters (PZ-1 through PZ-4)
  - MW-2 Cluster
  - MW-3 Cluster
  - MW-4 Cluster
  - MW-6 Cluster
  - MW-12 Cluster

• Attachment J provides the list of metals, VOC, and SVOC analytes reported by the laboratories, and the contract-required quantitation limits (CRQLs).

• Attachment K provides time-series surface water concentration charts for 1980 – 2010.
  - OID Surface Water – pH, Long-term Monitoring
  - OID Surface Water – Magnesium, Long-term Monitoring
  - OID Surface Water – Aluminum, Long-term Monitoring
  - OID Surface Water – Copper, Long-term Monitoring
  - OID Surface Water – Zinc, Long-term Monitoring
  - OID Surface Water – Oil & Grease, Long-term Monitoring

  - Groundwater – pH, Long-term Monitoring
  - Groundwater – Magnesium, Long-term Monitoring
  - Groundwater – Aluminum, Long-term Monitoring
  - Groundwater – Copper, Long-term Monitoring
  - Groundwater – Zinc, Long-term Monitoring
  - OID Surface Water – Oil & Grease, Long-term Monitoring

• Attachment M provides time-series groundwater concentration charts for 2003 – 2010.
  - Groundwater – Electrical Conductivity, Post Onsite Discharge Monitoring
  - Groundwater – Magnesium, Post Onsite Discharge Monitoring
  - Groundwater – Potassium, Post Onsite Discharge Monitoring
  - Groundwater – Aluminum, Post Onsite Discharge Monitoring
  - Groundwater – Copper, Post Onsite Discharge Monitoring
  - Groundwater – Zinc, Post Onsite Discharge Monitoring

4.1 Lithology and Aquifer Units

The subsurface lithology and aquifer units identified during the RI activities are shown in Hydrogeologic Cross Sections A-A’, B-B’, and C-C’ (Figures 6a, 6b, and 6c). These cross sections were constructed based on topography mapped after EPA’s 2007 removal action.
(Figure 1g in the Halaco Properties testing report [CH2M HILL, 2011d]), the results of the CPT-SMRT and EC-HPT direct push testing conducted during the RI, descriptions of waste and soil materials identified during drilling for the RI and prior investigations, and the results of surface water and groundwater elevation data collected during the RI. The prior investigations for which waste and soil descriptions were obtained include the southeast smelter investigation conducted by EPA in 2007, the Integrated Assessment investigation conducted by EPA in 2006, and the well installation activities by Halaco in 2003. Data collected from borings drilled for both soil sampling and monitoring well installation were used. The surface water and groundwater data shown in these cross sections are further described below.

The following fill materials and lithologic units from the Semiperched aquifer and the upper portion of the Oxnard aquifer were encountered during RI drilling and well installation:

- **Fill Materials.** The fill materials include uncontaminated soils used as fill (“general fill”), burn dump fill at the Smelter Parcel, and process waste fill at both the Smelter Parcel and Waste Management Area. These fill materials are described in detail in the Halaco Properties testing report.

- **Semiperched Aquifer.** The fill materials are underlain by the Semiperched aquifer, which includes an upper finer-grained layer of clay and silt with sand and silty sand interbeds and a lower coarser-grained layer of sand and silty sand with clay and silt interbeds. The upper fine-grained layer is thickest to the east ranging up to approximately 20 feet east of the WMU and then thins to less than 10 feet west of the Smelter Parcel. The coarser-grained unit is approximately 70 to 80 feet thick.

- **Confining Unit and Oxnard Aquifer.** The base of the Semiperched aquifer is underlain by an approximately 30-foot-thick confining layer of clay and silt that impedes groundwater flow. The Oxnard aquifer underlies this confining layer. The upper portion of the Oxnard aquifer encountered during RI drilling activities consists of sand and gravelly sand with clay and silt interbeds.

The results of the CPT and HPT testing are consistent with the soil types logged during drilling. Figures 8a and 8b illustrate the CPT tip stress data and soil types interpreted from the CPT data. The results are aligned to allow comparisons between test locations. Figure 8c shows the CPT tip stress data, HPT pressure data, and electrical resistivity data obtained with the EC-HPT tool for location SCP-1. The results show the following:

- **Process Waste Fill.** The process waste fill materials at the Smelter Parcel and Waste Management Area are characterized by low tip stress and generally interpreted as fine grained materials with layers of sands and sandy silt. The process waste materials were encountered at the southeastern area of the Smelter Parcel (SCP-1) and at all five CPT locations at the Waste Management Unit (WCP-1 through WCP-5).

- **Burn Dump Fill.** The burn dump fill materials at the Smelter Parcel are characterized by a variable tip stress and generally interpreted as silty sand, sand, or interbedded materials. These burn dump materials were encountered at SCP-2 and SCP-3.

- **Semiperched Aquifer.** The fine-grained materials in the upper part of the Semiperched aquifer are characterized by low tip stress. The underlying coarse-grained materials are
characterized by a much higher tip stress. The electrical resistivity measured by the EC-HPT tool at SCP-1 is very low (less than 1 ohm-meter [ohm-m]) in the coarse-grained materials to the base of this unit at approximately 90 feet bgs, consistent with the high TDS concentrations measured in groundwater from the monitoring well screened in the middle of this unit (MW-12C). The electrical resistivity measured by the CPT-SMRT tool at WCP-3 and WCP-4 is similarly low in this zone, consistent with the high TDS concentrations measured in groundwater from the monitoring wells screened in the middle of this unit (MW-19C and MW-3C). The low electrical resistivity is from Halaco process waste water that has invaded this zone. The electrical resistivity of seawater is also less than 1 ohm-m and is distinguished from process wastewater by chemistry, as further described below.

- **Confining Unit.** The fine-grained confining layer at the base of the Semiperched aquifer is generally characterized by a low tip stress, although some of the fine-grained materials can be cemented and exhibit a higher tip stress. The HPT at SCP-1 reached its maximum pressure of 110 pounds per square inch (psi) in this confining layer, indicating a limited potential for flow through this unit. The electrical resistivity measured in the five locations where the confining unit was tested generally show higher resistivity in the upper half of the confining layer and lower resistivity in the lower portion. These results suggest that the upper half of the confining layer may be affected by Halaco’s wastewater, but the lower portion is not.

- **Oxnard Aquifer.** The Oxnard aquifer is characterized by a very high tip stress, caused by the dense sands and gravels that were encountered in this interval. The electrical resistivity measured by the EC-HPT tool at SCP-1 is relatively high (approximately 40 ohm-m) in these coarse-grained materials. The electrical resistivity measured by the CPT-SMRT tool at WCP-3 and WCP-4 is similarly high in this zone. The high electrical resistivity is consistent with the low TDS concentrations of less than 2,000 mg/L measured in groundwater from the monitoring wells screened in the Oxnard aquifer (MW-2D, MW-3D, MW-6D, and MW-19D). The electrical resistivity of drinking water is typically greater than 20 ohm-m.

### 4.2 Groundwater Monitoring Network

Figure 4 shows the well locations. Table 6 provides groundwater monitoring well and piezometer construction details, and describes the materials in which the groundwater monitoring wells and piezometers are screened.

- **Smelter Parcel Wells.** The wells at locations MW-11, MW-12, MW-13, MW-20, MW-21, and MW-22 are in the Smelter Parcel. MW-14 is located outside the Smelter Parcel at the south end of Perkins Road. MW-15 is located in the street at the intersection of Perkins Road and McWane Boulevard, south of the City’s sewer trunk line.

- **Waste Management Area Wells – Interior Wells.** The wells at locations MW-17, MW-18, MW-19, and MW-24 are in the interior of the Waste Management Area. Wells MW-17 and MW-18 are located on top of the WMU. Well cluster MW-19 (MW-19, MW-19C, and MW-19D) is located between the WMU and WDA. MW-24 is located immediately south of the northern berm at the WDA and south of the City’s sewer trunk line.
• **Waste Management Area Wells – Perimeter Wells.** The wells at locations MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, and MW-16 are around the perimeter of the Waste Management Area. Well MW-1R is located at the southeast tip of the WMU. The shallower wells at cluster MW-2 (MW-2RA and MW-2RB) are located at the base of the WMU and the deeper wells (MW-2C and MW-2D) are located approximately 50 feet west on the WMU bench road. The shallower wells at cluster MW-3 (MW-3RA and MW-3RB) are located in the wetlands area, immediately south of the ditch at the south end of the WMU and the deeper wells (MW-3C and MW-3D) are located approximately 100 feet north on the WMU bench road. The two wells at cluster MW-4 (MW-4RA and MW-4RB) are located immediately north of the sewer trunk line that runs along the north edge of the WDA. Well MW-5 is at the southwest corner of the WMU. The shallow well at cluster MW-6 is located at the northwest corner of the WMU and the deeper wells (MW-6C and MW-6D) are located approximately 150 feet to the south on the WMU bench road. Well MW-16 is located at the northeast corner of the WMU, in the NCL-East property. This well was submerged by standing water during the RI activities and not useable.

• **Hueneme Parcel and NCL-East Wells.** The wells at location MW-23 are located at the Hueneme Parcel. The wells at locations MW-25 and MW-27 are located at NCL-East.

• **Piezometers.** The piezometers at locations PZ-1 and PZ-2 are located in McWane Boulevard between Perkins Road and the OID. The piezometers at locations PZ-3 and PZ-4 are located immediately south of the northern berm at the WDA. The piezometers at PZ-1 through PZ-4 are located immediately south of the sewer trunk line.

The monitoring wells and piezometers are screened in the following zones:

• **“A” Water Table zone.** The water table zone includes wells screened across or immediately beneath the water table in waste, general fill, or finer-grained materials in the upper part of the Semiperched aquifer. Wells screened in process waste include one well at the Smelter Parcel (MW-12) and three wells at the Waste Management Area (MW-17, MW-18, and MW-19). Wells screened in burn dump fill include two wells at the Smelter Parcel (MW-11 and MW-13). The other wells screened at or near the water table include two wells at the Smelter Parcel (MW-14, MW-15) and five wells at the Waste Management Area (MW-2RA, MW-3RA, MW-4RA, MW-5, MW-6, and MW-16). The shallow piezometers (PZ-1a through PZ-4a) are also screened near the water table.

• **“B” Shallow Sand Zone.** The “B” shallow sand zone includes wells screened below the finer grain materials and in the upper part of the coarser grained materials of the Semiperched aquifer. The wells screened in this zone include three wells at the Smelter Parcel (MW-20, MW-21, and MW-22), four wells at the Waste Management Area (MW-1R, MW-2RB, MW-3RB, MW-4RB, and MW-24), one well at the Hueneme Parcel (MW-23B), and two wells at NCL-East (MW-25B and MW-27B). The deeper piezometers (PZ-1bc through PZ-4bc) are also screened in this zone.

• **“C” Medium Sand Zone.** The “C” zone includes the wells that are screened in the middle of the coarser grained materials in the Semiperched aquifer. The wells screened in this zone include three wells at the Smelter Parcel (MW-12C, MW-13C, and MW-21C), five wells screened at the Waste Management Area (MW-2C, MW-3C, MW-6C, MW-19C,
and MW-24C), one well at the Hueneme Parcel (MW-23C), and two wells at NCL-East (MW-25C and MW-27C). No monitoring wells are screened at the base of the coarser grained materials in the Semiperched aquifer.

- **“D” Oxnard Aquifer.** Four “D” wells are screened in sand and gravel material at the top of the Oxnard aquifer at the Waste Management Area (MW-2D, MW-3D, MW-6D, and MW-19D). No monitoring wells are screened in the Oxnard aquifer at the Smelter Parcel. The regional USGS monitoring well located at the west end of the Hueneme Parcel (CM4) includes five piezometers that are screened in different intervals of the UAS and LAS of the Oxnard Plain. From shallowest to deepest these include CM4-200, CM4-275, CM4-760, CM4-1095, and CM4-1395. The shallowest well (CM4-200) is screened in the Oxnard aquifer.

### 4.3 Surface Water Elevations and Flow

Surface water features at the Halaco Site include three channels that drain the Oxnard Plain (OID, J Street Drain, and Hueneme Drain) and standing surface water in the lagoon, NCL-East, and NCL-North areas next to the Halaco Properties. The OID, J Street Drain, and Hueneme Drain discharge into the lagoon. Figure 2b shows the regional drainage channels.

#### 4.3.1 Current Surface Water Elevations and Flow

Flow between these features occurs as follows:

- **Lagoon, OID, Ditch to South of WMU, and Ditch to North of WMU.** When the naturally occurring coastal sand berm (the “beach berm”) is intact, surface water elevations in the lagoon, OID, ditch south of the WMU, and pond at NCL-North are relatively stable. Water levels are unaffected by tidal fluctuations. The beach berm typically breaches during the rainy season’s first significant storm event when increased flow in the OID, J Street Drain, and Hueneme Drain overtop the berm. After the breach, the lagoon and OID levels drop and then fluctuate with the tide. The berm typically remains breached until after the winter rains end and flow in the drains decreases.

- **Ditch to South of WMU.** The ditch south of the WMU is open to the OID and lagoon and is full when the beach berm is intact. The ditch is empty when the beach berm is breached.

- **NCL-North Pond and Ditch.** The pond at NCL-North is hydraulically connected to the OID, and a dike between the pond and the OID appears to affect water levels in the pond. When the beach berm is intact, the pond is full and the ditch extending eastward from the pond along the north side of the extension of McWane Boulevard has standing water. When the berm is breached, the pond and ditch are empty.

- **NCL-East.** Surface water levels in the NCL-East area are controlled by topography. Surface water accumulates from local precipitation and overflow when the lagoon and OID levels are high during non-breach conditions. Ground surface topography in the NCL-East area is sloped from northeast to southwest. Water from the lagoon and OID can enter NCL-East through the ditch south of the WMU and the NCL-North pond area when the lagoon and OID levels are greater than the respective watershed divides that
separate the NCL-East area from each of these two areas. Surface water in NCL-East dissipates through evaporation and percolation when the water level in the OID and lagoon are low, below the two topographic divides. The topographic watershed divides prevent NCL-East from draining back into the lagoon and OID.

4.3.1.1 Fall 2007 through Summer 2009

Figure 11a shows the OID surface water elevations measured with a pressure transducer from October 2007 through June 2009 together with manual staff gauge readings for the OID and NCL-East. Tidal fluctuations are shown from October 2007 through September 2008. The tidal elevations are an average of the nearest National Oceanic and Atmospheric Administration (NOAA) tidal monitoring stations to the south (Santa Monica, CA Station 9410840) and north of the Halaco Site (Santa Barbara, CA: Station ID 9411340). The tidal data were downloaded from tidesonline.nos.noaa.gov. Daily rainfall are from VCWPDS’s meteorological Station 32/32A in Oxnard. The rainfall data were downloaded from vcwatershed.net/hydrodata. These data show the following:

- The OID was generally above the 7-foot elevation during the summer months when there was no precipitation and the beach berm was not breached. This condition occurred prior to the beach berm breaching on December 18, 2007, from April 2008 through November 2008 prior to the beach berm breaching on November 25, 2008, and from April 2009 through the rest of 2009.

- The OID fell to below the 7-foot elevation during the winter months when the beach berm breached in response to precipitation and increased flows in the OID, J Street Drain, and Hueneme Drain. The berm breaches when the surface water in the lagoon overtops the berm, as seen during the sharp water level increases in response to rainfall events on December 18, 2007 and November 25, 2008.

- The surface water level in NCL-East increases during the summer months when the OID and lagoon are seasonally high, above approximately 7.5 to 8 feet in elevation. This is the approximate elevation of the high point of the ditch bottom south of the WMU, which occurs at the southeastern tip of the WMU near MW-1R. During the summer months, water from the OID and lagoon flows over this high point and spills into NCL-East. During very high OID levels after a rainfall event and immediately before the beach berm breaches, surface water also has been observed to flow from the ditch north of the WDA across the dirt access road (extension of McWane Boulevard) near the northeast corner of the WDA and into NCL-East. Evidence of this flow from the ditch north of the WDA into NCL-East includes erosion features across the dirt access road immediately outside the fence gate to the Waste Management Area and the presence of dead crayfish, which apparently get washed from the ditch and over this road during the high water levels. There is also local runoff into NCL-East, but the volume contributed is probably small compared to that contributed by the OID and lagoon.

- The surface water level in NCL-East decreases during the rainy winter months when the beach berm is breached and OID and lagoon water levels are seasonally low, below the elevation necessary for water to flow across the high point of the ditch south of the WMU. Surface water in NCL-East then dissipates through evaporation and percolation into the subsurface. NCL-East was observed to be mostly dry during two periods in
2009, once from April 15 to 22 and once from August 29 through October 12, 2009. (The southeastern portion of NCL-E, which is at a lower elevation, retained water.) The first dry event (April) was caused by persistently high winds that enhanced evaporation while the OID was below the spill point of the WMU ditch. Water spilled into NCL-East as soon as the rising OID and lagoon water levels were above the WMU ditch spill point elevation. The second dry event (August 29 through October 12, 2009) resulted from OID and lagoon water levels below the WMU ditch spill point elevation for an extended period of time, allowing most of the water in NCL-East to evaporate and percolate.

Figure 11b zooms in on a portion of Figure 11a to better show the impact of tidal fluctuations when the beach berm is breached. The pressure transducer was initially set too high to capture the lower OID water level elevations during lower tidal stages and subsequently lowered. These data show that the OID water levels fluctuate with the tide above an elevation of approximately 3 feet. The tidal elevations ranged as follows (approximate):

- 4 to 7 feet – Higher high water
- 3 to 5 feet – Lower high water
- 3 feet – Average
- 1 to 3 feet – Higher low water
- -1 to 2 feet – Lower low water

4.3.1.2 Fall 2009 through Summer 2011

Figure 11c shows the OID, NCL-East, and NCL-North surface water elevations obtained manually from the staff gauges from October 2007 through December 2011. The periods when the beach berm was breached are indicated by dashed lines extending from the OID elevation before or after the breach event down to an elevation of 3 feet. Daily rainfall is also shown along with annual rainfall totals. This figure also shows the sampling and water level monitoring events conducted as part of the RI field activities.

The data in Figure 11c show that the beach berm was breached during the 2009-2010 and 2010-2011 winter rainy seasons, similar to the breaches during the 2007-2008 and 2008-2009 winter rainy seasons. However, the beach berm did not breach normally during the 2009-2010 winter rainy season. The surface water elevation reached approximately 12.5 feet in elevation on January 18, 2010, before the berm was manually breached. This elevation is above the OID staff gauge and was estimated by VCWPD using LIDAR (light detection and ranging) remote sensing technology (VCWPD, 2010). The high surface water elevation resulted in localized flooding. Several feet of water were present at the lower elevation areas of the Smelter Parcel, including the area between the former process buildings and Perkins Road (near MW-21), the parking lot (near MW-22), and in the northern undeveloped area (near MW-13). Several feet of water were also present west of the OID outside of the Smelter Parcel (including along Perkins Road, along McWane Boulevard, and within the Hueneme Parcel) and east of the OID at the NCL-East and NCL-North areas. The flooding was relieved when VCWPD performed an emergency breach of the beach berm (using a tracked excavator) to lower the OID and lagoon level and the City pumped out the water from along Perkins Road and the Hueneme Parcel into the lagoon. This was the first time that the VCWPD manually breached the berm since 1992.
4.3.2 **Historical Surface Water Conditions**

At least since the mid 19th century, the OID has flowed through the Site, terminating in a small lagoon on or near the present-day Smelter Parcel. As described below, historical aerial photographs (Figure 1b) and historical topographic maps (Figure 1c) show the location and configuration of the OID and lagoon from the 1850s to present.

### 4.3.2.1 Coastal Canal

A coastal canal that conveyed surface water from the Hueneme Drain (a.k.a. Bubbling Springs) and the OID southeast to the Mugu Lagoon was constructed during or before the 1930s according to an Oxnard Drainage District No. 3 drawing (undated). A notation on the drawing, which is included in Appendix G of the 2008 Groundwater Report, indicates that it was prepared in 1937. The coastal canal is visible in several aerial photographs. It appears to still be operational in the 1951 photograph, but partially filled with sand and dilapidated in the 1959 photograph. The portion of the canal to the east of the OID appears to be filled with sand in a 1965 aerial photograph.

The former coastal canal reportedly helped prevent surface water from backing up into the drains and upstream developed areas. A side effect was that the canal prevented the coastal sand berm from being breached in the vicinity of the Halaco Site. After the coastal canal became non-operational, VCWPD at some time began to manually breach the berm at the mouth of the J Street Drain to prevent water from backing up and affecting developed areas during winter stormwater runoff. Reportedly, VCWPD manually breached the berm at the mouth of the J Street Drain in the fall before the winter rains commenced and also at other times of the year (VCWPD, 2008). The October 11, 1969 photo apparently shows a manual breach of the beach berm at the J Street Drain (see Attachment A).

Remnants of the former coastal drainage canal are present to the south of the Smelter Parcel and the WMU.

- The remnant to the south of the Smelter Parcel extends from the main lagoon area at the mouth of the OID westward to a dike containing the J Street Drain. There does not appear to be significant flow in this remnant except for water moving in and out with the rise and fall of the OID and lagoon.

- The remnant to the south of the WMU extends from the main lagoon area at the mouth of the OID eastward toward NCL-East. The former channel is mostly filled with sediment and windblown material. The source of fill materials includes beach sands and waste from the WMU. The amount and elevation of fill is greater toward the eastern portion of the “ditch.” As described above, surface water from the lagoon enters this ditch during high water levels and, when high enough, flows across a topographic divide at the southern tip of the WMU into NCL-East.

### 4.3.2.2 Oxnard Industrial Drain and Development of the Halaco Properties

By 1945, the OID had shifted east of its 1929 predevelopment alignment. A municipal burn dump was operating in 1945 and throughout the 1950s, as visible in 1951 and 1959 photographs. Burn dump fill activities occurred between Perkins Road and the 1959 OID channel. The OID shifted east again from its 1959 alignment to its current alignment between 1965 and 1970, when Halaco discharged its process waste directly into the OID.
Halaco discharged its process waste to settling ponds at the WMU beginning in about 1970. The elevation of the settling ponds gradually increased from less than 10 feet to more than 20 to 30 feet at the time waste disposal stopped in September 2002. As described below, the settling ponds, when active, dramatically changed groundwater flow conditions in the Semiperched aquifer. This included the emergence of seeps at the base of the WMU berm. These seeps are visible in several aerial photographs from the 1970s (Attachment A).

### 4.3.2.3 Lagoon

The modern-day lagoon was not present prior to 1992. At that time, Ventura County manually breached the naturally occurring coastal sand berm (the “beach berm”) at the end of the J Street Drain to prevent upstream flooding and the J Street Drain discharged directly to the ocean. The OID also discharged directly to the ocean when its beach berm breached. The modern-day lagoon formed when Ventura County stopped manually breaching the beach berm in 1992 in response to a Cease and Desist Order from the U.S. Fish and Wildlife Service (VCWPD, 2008). The lagoon then appears to have increased in size with the combined inflows from the J Street Drain and OID. Since about 1992, the beach berm has naturally breached at the southeast end of the lagoon, except in 2010 when the County performed the emergency breach on January 18, 2010.

### 4.3.2.4 NCL-East

Historical aerial photographs from 1929 through 2001 do not show standing surface water in NCL-East. Also, reports from site inspections conducted in 1980 by NEIC and in 1991 by E&E indicate that this area was not covered with standing surface water but that only seeps at the base of the WMU berm emerged in the area. It is not clear when the current hydrology became established where surface water from the OID seasonally flowed into NCL-East along the ditch south of the WMU and ditch north of the WDA.

### 4.4 Groundwater Elevations and Flow

#### 4.4.1 Current Groundwater Flow Conditions

Shallow groundwater elevations and flow in the Semiperched aquifer at the Halaco Site are influenced by rainfall and surface water elevations in the lagoon between the Site and the Pacific Ocean, the OID, the ditch to the south of the WMU, the ponds in the NCL-North area, and the NCL-East area. Deeper groundwater elevations and flow in the Oxnard aquifer are influenced primarily by regional conditions across the Oxnard Plain. Flow between the Semiperched aquifer and the Oxnard aquifer is restricted by the lower permeability of the confining unit separating the aquifers.

Groundwater elevations were measured five times in 2009-2010: three times when the beach berm was intact and twice when it was breached. Results are provided in Table 8.

Groundwater elevations are posted on hydrogeologic cross sections (Figures 6a, 6b, and 6c) for seasonal high and seasonal low groundwater elevation conditions. In the Semiperched aquifer, the seasonal high occurs when the beach berm is not breached and the low occurs when the berm is breached. Groundwater elevations for October 25, 2010 (high) and February 22, 2010 (low) are posted for the Semiperched aquifer. For the Oxnard aquifer, the seasonal high occurs during the winter and spring months when regional groundwater...
pumping is low and the seasonal low occurs during the summer and fall months when regional groundwater pumping is high. Groundwater elevations for June 1, 2010 (high) and November 16, 2009 (low) are posted for the Oxnard aquifer.

Groundwater elevations are posted and contoured on plan view maps for the Semiperched aquifer for all five dates (Figures 9a through 9e) and for the Oxnard aquifer for two dates representing seasonal low (November 16, 2009) and seasonal high (June 1, 2010) conditions (Figures 10a and 10b).

Figures 12 through 16 provide groundwater elevation hydrographs for various time periods and depth intervals. Figures 12a and 12b provide hydrographs for Semiperched aquifer monitoring wells at the Waste Management Area and at the Smelter Parcel for 2007 through 2010. Figures 13a, 13b, and 13c zoom in on the period from late 2009 through December 2010. Figure 14a and 14b provide hydrographs for just the “C” wells screened deeper in the Semiperched aquifer. Figures 15a and 15b provide hydrographs for the four “D” wells and the USGS CM4-200 regional monitoring well screened in the Oxnard aquifer. Figure 16 provides a hydrograph of the four AWPF piezometers located to the north of the railroad tracks. Additional hydrographs are provided in Attachment I for each of the well and piezometers clusters. Each hydrograph also shows the OID surface water elevation because of its importance in influencing groundwater elevations in the Semiperched aquifer.

4.4.1.1 Semiperched Aquifer under the Smelter Parcel and Waste Management Area

Generally, groundwater in the Semiperched aquifer at the Smelter Parcel and Waste Management Area moves as follows:

- Groundwater in the Semiperched aquifer at the Smelter Parcel and Waste Management Area generally moves northward, from the lagoon toward McWane Boulevard. Northward flow is indicated by the groundwater elevation contours in Figures 9a through 9e. The green solid lines in these figures contour the shallow water table (1-foot contour intervals). The purple dashed lines contour the deeper potentiometric surface in the middle of the aquifer for the “C” wells. The overall northward component of horizontal groundwater flow is also shown in north-south Cross Section B-B’ through the Smelter Parcel (Figure 6b) and C-C’ through the Waste Management Area (Figure 6c). The horizontal component of flow is not shown on east-west Cross Section A-A’ because it is perpendicular to the horizontal direction of flow.

- There is a general downward gradient from the water table “A” wells and surface water bodies (OID/lagoon, NCL-East, WMU ditch, NCL-North pond) to the deeper “B” and “C” wells screened in the coarse grained portion of the Semiperched aquifer. This is indicated by the vertical blue lines that point downward in Cross Section A-A (Figure 6a). The vertical blue lines are not shown on north-south Cross Sections B-B’ and C-C’ because the downward gradient is less pronounced to the south near the lagoon and to the north near the City’s sewer trunk line along McWane Boulevard.

The horizontal northward flow and shallow downward gradients appear to be induced by a low groundwater elevation area to the north of the Smelter Parcel and Waste Management Area and the recharge of shallow surface water from the OID, lagoon, and NCL-East. As noted above, the downward gradients are less pronounced to the north and south of the Halaco Properties which coincide with these conditions. These conditions occur during both
seasonal high (berm is not breached) and seasonal low (beach berm is breached) surface water conditions.

**Berm Not Breached – November 16, 2009; June 1, 2010; and October 25, 2010.** The groundwater elevation contour maps for the three dates when the beach berm was not breached are similar (Figures 9a, 9c, and 9d). Surface water elevations are high (near or above the 8-foot elevation), causing surface water to recharge the Semiperched aquifer and groundwater to move northward. There are several observations worth noting in these figures.

- Groundwater elevations were below 0 feet in elevation at MW-15, PZ-1, and PZ-2 at the north end of the Smelter Parcel, and below 6 feet in elevation at PZ-3 and PZ-4 at the north end of the Waste Management Area.
- Groundwater level contours (in green) are parallel to the OID and lagoon along the eastern and southern edges of the Smelter Parcel, indicating surface water recharge to the Semiperched aquifer.
- Groundwater level contours are generally parallel to the OID, WMU ditch, and NCL-East at the western, southern, and eastern edges of the Waste Management Area, indicating recharge of OID, ditch, and NCL-East water to the Semiperched aquifer.
- Surface water in NCL-North (and in a seasonal pond at the northeast corner of the WDA) provides additional recharge near piezometer clusters PZ-3 and PZ-4 and well cluster MW-4 that prevents groundwater elevations at the north end of the Waste Management Area from dropping to the levels seen at the northern end of the Smelter Parcel.

The dashed purple contours for the deeper “C” wells also indicate northward groundwater gradients at the Waste Management Area and Smelter Parcel. At the Waste Management Area, water levels at the southern-most well near the WMU ditch (MW-3C) were above 8 feet in elevation. Levels at the north end of the Waste Management Area (MW-24C) were three or more feet lower.

**Berm Breached – February 22, 2010, and December 27, 2010.** The groundwater elevation contour maps for the two dates when the beach berm was breached are similar (Figures 9b and 9e). Compared to non-breach conditions, groundwater and surface water elevations were lower, and surface water elevations in the OID and lagoon fluctuated with the tide. The NCL-North pond was dry and surface water elevations at NCL-East were higher (above 7-feet elevation) than in the OID (below 6 feet elevation), indicating that water was trapped east of the topographic divides. This resulted in an east-to-west horizontal gradient in the south half of the Waste Management Area not seen during non-breach conditions.

4.4.1.2 **Semiperched Aquifer under the Hueneme Parcel**

As was observed at the Smelter Parcel, horizontal gradients at the Hueneme Parcel (MW-23B and MW-23C) appeared to be to the north when compared to the lagoon elevation to the south, and the shallow vertical gradients were downward. Groundwater elevations in both the B and C intervals were more than 2 feet below the lagoon elevation to the south.
4.4.1.3  Semiperched Aquifer under NCL-East

The horizontal gradients in the NCL-East area are uncertain because sufficient monitoring wells are not available to determine them (MW-25B, MW-25C, MW-27B, and MW-27C). The shallow vertical gradients were downward and groundwater elevations at the MW-25B and C intervals were below the NCL-East surface water elevation to the south. The shallow vertical gradient at the MW-27 well cluster was variable and generally small, with the groundwater elevations at the MW-27B and C intervals below the NCL-East surface water elevation to the west.

4.4.1.4  Semiperched Aquifer and Groundwater Sink to the North of the Halaco Properties

As described above, the horizontal northward flow direction and shallow downward gradients at the Smelter Parcel and Waste Management Area appear to be induced by a low groundwater elevation area (or “sink”) to the north. A potential cause for the lower groundwater elevations to the north is the City’s sanitary wastewater collection system. The collection system terminates in “northwest” and “southeast” trunk lines that feed into the City’s “headworks” facility located at the WWTP to the northwest of the Halaco Properties. The headworks facility was improved (reconstructed) from approximately 2005 through 2007 to maintain capacity.

**Wastewater Collection System.** At the inlet structure at the headworks, the trunk line “invert” (bottom of pipe) elevation is 75.4 feet (local plant datum) or approximately -17 feet (1988 NAVD). After primary treatment, the raw influent then passes into the influent pump station wet well where the influent is pumped to the WWTP for secondary treatment. The pump station maintains the raw influent level at approximately the trunk line inlet structure invert elevation to allow gravity drainage from the wastewater collection network. The “northwest” trunk line runs south along Perkins Road and then into the headworks. The “southeast” trunk line runs west along McWane Boulevard, north along Perkins Road, and then into the headworks. The location of the southeast trunk line is shown on the monitoring well location map (Figure 4) and other figures in this report. These are large-diameter drainage lines that would have an invert elevation along McWane Boulevard slightly higher than at the headworks inlet.

Potential seepage of groundwater into the southeast trunk line that runs westward along McWane Boulevard and then northward along Perkins Road could induce the low groundwater elevation area to the north of the Smelter Parcel and Waste Management Area. EPA met with City representatives in March 2009 to discuss the potential for groundwater seepage to occur into the trunk line. The City subsequently ran a camera through the trunk line along McWane Boulevard north of the Smelter Parcel but did not identify any seepage.

A large sinkhole was observed on February 8, 2010 along the southeast trunk line immediately to the west of the railroad tracks that cross McWane Boulevard east of the OID. The City was notified and repaired the line, which included dewatering the area using four dewatering wells, over excavating the sink hole, and replacing the trunk line underneath the railroad tracks. The City noted that the trunk line runs through a larger steel conduit under the tracks and that the pipe joints may not have been tight on either side of the undercrossing. The sinkhole formed because the fine backfill material entered the sewer line, potentially through leaky joints. This demonstrates how imperfections can lead to groundwater seepage into the sewer line. Similar imperfections may occur along the rest of the trunk line, including the undercrossing beneath the OID.
Headworks Improvement Construction Dewatering. The City performed construction dewatering activities associated with the headworks improvements over a 2-year period from May 2005 through March 2007 according to 2005, 2006, and 2007 annual National Pollutant Discharge Elimination System (NPDES) self-monitoring compliance reports submitted to the LARWQCB (City of Oxnard, 2006, 2007, and 2008). The locations and construction of the groundwater dewatering wells are documented in a contractor’s construction submittal (ABA, 2005). Average monthly dewatering discharge rates ranged from approximately 500 gallons per minute (gpm) to 4,000 gpm based on the annual reports.

The City installed and measured groundwater levels in four piezometers on June 26, 2006 and June 14, 2007 as part of a geotechnical study for construction of the City’s planned AWPF (CH2M HILL, 2007). Piezometer locations are shown in Figure 4 and located approximately 2,000 feet north of the Site. EPA measured water levels on three additional dates: May 2, 2008; June 14, 2009; and November 15, 2009. These water level data are presented below.

<table>
<thead>
<tr>
<th>Piezometer Number</th>
<th>Approx. Ground Surface Elevation (feet, NAVD 88)</th>
<th>Piezometer Construction (feet, bgs)</th>
<th>Depth to Groundwater (feet, bgs)</th>
<th>Groundwater Elevation (feet, NAVD 88)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Screen Depth</td>
<td>Total Depth</td>
<td>6/26/06</td>
<td>6/14/07</td>
</tr>
<tr>
<td>P-1</td>
<td>9.5</td>
<td>15–45</td>
<td>45</td>
<td>18.5</td>
</tr>
<tr>
<td>P-2</td>
<td>8.8</td>
<td>15–45</td>
<td>45</td>
<td>14.2</td>
</tr>
<tr>
<td>P-3</td>
<td>8.7</td>
<td>15–45</td>
<td>45</td>
<td>14.5</td>
</tr>
<tr>
<td>P-4</td>
<td>10</td>
<td>15–45</td>
<td>45</td>
<td>19.8</td>
</tr>
</tbody>
</table>

Notes:
na = not applicable
nm = not measured

Figure 16 presents a hydrograph of these groundwater elevations and OID elevations during the same time period. These data show the following:

- Groundwater elevations during construction dewatering (June 26, 2006) were below -5 feet in elevation and then rose for more than a year after construction dewatering ended. This indicates that the dewatering at the west side of Perkins Road was drawing-down groundwater levels to the east of Perkins Road.

- Groundwater elevations for the last three water level measurements (May 2, 2008; June 14, 2009; and November 15, 2009) remained several feet below the OID elevation. This indicates that groundwater seepage may have been occurring into the northwest trunk line along Perkins Road or into the headworks facility to the west of Perkins Road. Leakage into the trunk line is indicated to have been a possibility because the OID elevation is highest (above 7-foot elevation), the groundwater elevation in the four piezometers to the west is lower (between -1 and 4-foot elevation), and the groundwater elevation further to the west next to the trunk line could be several feet below 0 elevation, which would result in an overall east-to-west groundwater flow direction potentially induced by groundwater leakage into the trunk line. Groundwater elevations in the four piezometers would have been above the OID elevation if there was no potential leakage into the trunk line and the groundwater flow direction would have been indicated to be west-to-east toward the OID.
Prior to the headworks improvements from 2005 through 2008, the headworks facility may have also led to groundwater seepage and low groundwater elevations to the north of the Halaco Properties.

### 4.4.1.5 Oxnard Aquifer and Confining Unit

In November 2009 and June 2010, groundwater hydraulic gradients in the Oxnard aquifer at the Halaco Properties were toward the southeast and east as indicated by the groundwater elevation contours in Figures 10a and 10b. The purple dashed lines in these figures contour the potentiometric groundwater elevations for the four “D” wells at the Waste Management Area (0.2-foot contour intervals). The local groundwater flow direction determined by these four monitoring wells is generally consistent with the regional interpretation of the groundwater flow conditions by UWCD as shown in fall 2008 and spring 2009 groundwater elevation contour maps for the UAS (Figure 2e). These regional contour maps indicate groundwater flow directions to the east, southeast, or south at the Halaco Properties.

Groundwater elevations in the four “D” wells are similar to those for the nearby USGS regional monitoring well screened in the Oxnard aquifer (CM4-200). This is shown in Figures 15a and 15b which show the groundwater elevations for the five water level monitoring events for the “D” wells and the historical groundwater elevations for CM4-200 obtained from UWCD. Figure 15a is a hydrograph of data from 2007 through 2011 and Figure 15b is a close-up of these data for 2009 and 2010. Consistent with the longer-term record of groundwater elevations in the regional aquifer system, the CM4-2000 elevations rise in the winter and spring and decline in the summer and fall.

The vertical groundwater gradient across the fine-grained confining unit that separates the Semiperched aquifer from the Oxnard aquifer was downward for the two water level events at the end of 2009 and 2010 and upward for the other three events as indicated by the following data from the “C” and “D” well pairs at the Waste Management Unit:

<table>
<thead>
<tr>
<th>Well Pair</th>
<th>11/16/09</th>
<th>2/22/10</th>
<th>6/1/10</th>
<th>10/25/10</th>
<th>12/27/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW-2C/2D</td>
<td>-5.44</td>
<td>0.78</td>
<td>2.02</td>
<td>-1.31</td>
<td>2.52</td>
</tr>
<tr>
<td>MW-3C/D</td>
<td>-6.48</td>
<td>0.21</td>
<td>0.76</td>
<td>-2.90</td>
<td>2.09</td>
</tr>
<tr>
<td>MW-6C/D</td>
<td>-5.30</td>
<td>1.33</td>
<td>1.50</td>
<td>-2.26</td>
<td>3.13</td>
</tr>
<tr>
<td>MW-19C/D</td>
<td>-3.47</td>
<td>3.07</td>
<td>2.99</td>
<td>-0.79</td>
<td>3.71</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>-5.17</strong></td>
<td><strong>1.35</strong></td>
<td><strong>1.82</strong></td>
<td><strong>-1.81</strong></td>
<td><strong>2.86</strong></td>
</tr>
</tbody>
</table>

Note: Positive value indicates upward groundwater gradient and negative value indicates downward gradient.

The difference in the Oxnard aquifer groundwater elevation indicated by CM4-200 and the Semiperched aquifer groundwater elevations indicated by the “C” wells is shown in Figure 14a for the “C” wells at the Waste Management Area and in Figure 14b for the “C” wells at the Smelter Parcel.

The longer-term vertical groundwater gradient across the confining unit was downward prior to the 1990s when the UAS was overdrafted and groundwater elevations in the Oxnard aquifer were below sea level. Since the early 1990s, groundwater elevations in the Oxnard aquifer have been several feet above sea level as shown in Figure 2h, indicating that
the gradient was mostly upward from the Oxnard aquifer to the Semiperched aquifer. Brief periods of downward gradients existed in this period of mostly upward gradients when groundwater elevations in the Oxnard aquifer temporarily declined, such as the two water level monitoring events noted above.

The predominantly upward gradient since the early 1990s indicates that there has been little or no movement of shallow groundwater underlying the Halaco Site downward from the Semiperched aquifer, through the underlying aquitard, and into the Oxnard aquifer of the UAS since that time. However, the vertical gradient was downward prior to the 1990s, indicating a potential for groundwater affected by Halaco’s wastes from the Semiperched aquifer to have impacted the Oxnard aquifer.

4.4.2 Pre-2002 Groundwater Flow Conditions

Groundwater flow conditions in the Semiperched aquifer differed from current conditions when Halaco discharged process waste to the WMU. Pre-2002 conditions are shown in Conceptual Hydrogeologic Cross Sections AA-AA’ (Figure 7a) and CC-CC’ (Figure 7b). These conceptual cross sections are based on the groundwater elevations presented in Hydrogeologic Cross Sections A-A’ (Figure 6a) and C-C’ (Figure 6c), ground surface topography from 2006 (prior to EPA’s regrading of the waste pile in 2007), and the assumption that wastewater was present in the settling ponds. The approximate extent of the former settling ponds is shown in Figure 5.

As described in Section 3, Halaco discharged hundreds of millions of gallons of wastewater to the WMU from about 1970 to 2002. Based on the routine monitoring reports provided by Halaco to the LARWQCB, the discharge rates were approximately 500,000 gallons per month from 1981 to 2002 indicating that an average of 6 million gallons of wastewater was being discharged per year, approximately 1.5 times the annual average volume of rain that would fall over the 10-acre area (the potential area of the settling ponds within the WMU), assuming an average of 15 inches of rain per year. Most of the wastewater discharged to the pond would have evaporated or percolated into the subsurface.

As shown in Figures 7a and 7b, percolation to the subsurface from the settling ponds at the WMU would have caused water table mounding in the elevated waste pile materials, up to more than 20 feet above the regional water table. The increased head from this mounding would have resulted in the following conditions:

- Radial flow away from the pond areas, both laterally outward and vertically downward in the Semiperched aquifer. The groundwater chemistry identified from RI samples collected from the “C” wells deep in the Semiperched aquifer in 2009 and 2010 confirms the conceptual groundwater flow directions depicted in Figure 7a and 7b.

- Groundwater seepage at the base of the WMU slopes. This historical seepage was confirmed by visual observations during the 1973 SWRCB, 1980 NEIC, 1991 E&E, and 1999 LARWQCB site inspections that identified seeps through the dike materials surrounding the settling ponds. These seeps would have formed where the mounded water table intersected the base of the berm materials. Laboratory analyses of samples collected from these seeps confirm that this seepage originated from process water.
These groundwater samples collected in 2009 and 2010 from deep within the Semiperched aquifer and historical seep samples collected in the 1980s and 1990s were high in TDS, ammonia, and other constituents indicative of Halaco’s process wastewater.

4.5 Surface Water and Groundwater Chemistry

Halaco’s wastes have affected groundwater in the Semiperched aquifer, but test results show little or no impact on the deeper Oxnard aquifer. Test results from 2009-2010 do not show impacts on surface water in the OID, lagoon, or NCL-East, although there likely have been impacts on these surface waters in the past.

4.5.1 Sources of Contamination

Potential sources of surface water and groundwater contamination include the large quantities of solid and liquid waste that Halaco discharged, and the municipal burn dump waste that underlies most of the Smelter Parcel. Although not a source of contamination, seawater is another potential cause of groundwater and surface water impacts at the Halaco Site. As summarized in Section 1, most of Halaco’s waste was “process waste” generated during the smelting process. Other wastes were generated by the air pollution control equipment and from used oil and spent solvent.

As described in Section 2 of this report, Halaco’s process wastewater had:

- A high pH and high levels of salts and residual metals
- Ammonia generated as a byproduct of the metal smelting operation
- Radionuclides from magnesium-thorium alloy scrap that Halaco reports processing from 1965 to about 1977
- Organic constituents that may be the result of waste oil and solvent that were reportedly disposed in Halaco’s furnaces and rotary washers

Figures 2i and 2j provide data on the composition of Halaco’s wastewater. The figures provide times-series charts of EC, pH, and O&G, aluminum, copper, and zinc concentrations for wastewater samples collected from 1980 through 2002. Figures 2k and 2l show the major ion chemistry for wastewater samples collected and analyzed by Halaco and various regulatory agencies over time.

After Halaco’s wastewater discharges ended in 2002, waste solids and contaminated soils became the primary source of groundwater and surface water contamination at the Site. The Halaco Properties testing report (CH2M HILL, 2011d) provides a description of the chemistry of the solid waste materials at the Halaco Properties. The solid wastes include Halaco’s process waste, which is present at both of the Halaco Properties, and municipal burn dump waste at the Smelter Parcel. All of the process wastes at the Halaco Properties have high concentrations of a variety of metals, and the older wastes also have elevated levels of the radionuclides thorium and radium. The burn dump waste at the Smelter Parcel has high concentrations of metals. PCBs and dioxins were frequently detected in process waste and burn dump waste samples. Relatively low levels of VOCs and SVOCs were also detected in some samples.
4.5.2  Current Surface Water and Groundwater Chemistry

The approximate extent of groundwater contamination attributable to Halaco’s operations to the east and west is shown in plan view in Figure 17. Results are posted on the figure for TDS, ammonia, and the ratio of TDS to potassium concentrations. High TDS, high ammonia, and a relatively low TDS to potassium ratio are indicative of Halaco’s process wastewater. As shown in Figures 2k and 2j, Halaco’s process wastewater was high in TDS, potassium, and ammonia. TDS concentrations are also posted and contoured on the cross sections included in Figures 18a, 18b, and 18c as an indicator of the approximate extent of groundwater contamination.

Figures 20 through 26 were prepared to assess the impacts of Halaco’s operations on surface water and groundwater quality and help distinguish the effects of Halaco’s wastes from other factors affecting water quality.

- Figure 20 provides information on major ion general chemistry in surface water and groundwater samples collected at the Site. Halaco’s wastewater and seawater are both high in TDS and have similar percentages of chloride as shown in Figures 2k and 2l. Potassium, which is present at relatively high concentrations in Halaco’s process wastewater, is one of the most useful parameters for distinguishing Halaco wastewater from seawater and background conditions. The potassium reflects the flux salts used in the smelting process (potassium chloride, magnesium chloride, and sodium chloride). Another potentially useful parameter is sulfate, which is lower in the wastewater samples than in seawater. However, the actual use of sulfate to distinguish between these two waters in the environment is less useful than potassium because sulfate may change concentrations in response to variations in pH and oxidation-reduction potential conditions and sulfate in other surface water or groundwater sources may influence average groundwater concentrations to the point where sulfate is no longer useful.

- Figures 21 through 23 provide information on TDS concentrations, pH, ammonia, and the anions bromide and fluoride in surface water and groundwater samples collected at the Site. Halaco’s process water had elevated TDS that ranged from that of seawater (35,000 mg/L) up to about twice that of seawater (70,000 mg/L). This is equivalent to an EC of approximately 50,000 to 100,000 µmhos/cm, which is the approximate range of EC observed in Halaco’s process wastewater from 1980 through 2002 (Figure 2i). Halaco’s wastewater had elevated pH ranging between approximately 8 and 10 from 1980 through 2002 (Figure 2i). Halaco’s process water had high ammonia that exceeded 50 to 100 mg/L (Figure 2k). Although Halaco’s process water may have had elevated bromide and fluoride, they are not particularly useful indicators to distinguish wastewater from seawater or background conditions.

- Figures 24 and 25 illustrate the concentrations of total metals (unfiltered) and dissolved metals (field filtered) in surface water and groundwater samples collected at the Site.

- Figures 26 illustrate the concentrations of radionuclides in surface water and groundwater samples collected at the Site.

- Figure 27 illustrates the TDS/K ratios versus TDS concentrations in surface water and groundwater samples collected at the Site.
Figures 20 through 26 include 21 separate charts or graphs. For each figure number (e.g., Figure 20), there is an “a,” “b,” and “c” version (e.g., Figures 20a, 20b, and 20c), which differ as follows:

- The “a” figures present the surface water and groundwater results for non-breach conditions for the November 2009 sampling event (for most monitoring wells), the October 2010 sampling event (for wells installed in May 2010), and the three AWPF piezometers.

- The “b” figures present the surface water and groundwater results for breach conditions for the February 2010 sampling event (for most wells), the June 2010 sampling event (for wells installed in May 2010), and the three AWPF piezometers and NCL-East surface water locations.

- The “c” figures present all surface water results at an expanded concentration scale.

### 4.5.2.1 Surface Water

The general chemistry, radionuclide, and metals testing results from 2009 and 2010 do not indicate impacts to surface water in the OID, lagoon, or NCL-East from Halaco’s operations. The one area where impacts on surface water quality were observed was in the WMU ditch. Samples from the ocean, Hueneme Drain, and J Street Drain were collected to represent background conditions.

The water chemistry in the lagoon and OID near the Halaco Properties is largely dependent on whether the beach berm is breached. When the berm is not breached, surface water in the OID and lagoon consists of the water that drains the inland watershed through the OID, J Street Drain, and Hueneme Drain. This water discharges into the lagoon, where water levels are several feet higher than the ocean, and slowly seeps through the beach berm. When the berm is breached, the water is a mixture of the inland surface water and seawater. Seawater mixes with the water in the lagoon, OID, and J Street Drain as the tide rises and falls. A higher percentage of seawater is likely present in the lagoon, OID, and J Street Drain during high tide as seawater moves inland as opposed to low tide when inland water moves toward the ocean.

Figure 28a is a time-series concentration chart of EC and the magnesium concentration in the OID from 2003 and 2004. These data show higher EC and magnesium concentrations in the lagoon and OID when the berm was breached during the winter months. TDS also could have been shown in this chart instead of EC; however, it was not measured in 2003 and 2004. Similarly, magnesium was the only major cation measured in 2003 and 2004 and is used to supplement EC as an indicator of surface water chemistry.

**Hueneme Drain, J Street Drain, OID, and Lagoon.** The following changes were observed during non-breach conditions, when water flows from the Hueneme Drain, J Street Drain, and OID toward the lagoon with overflow to NCL-East and seepage through the beach berm towards the ocean. See Figures 20 through 26 for charts and graphs presenting selected sampling results, and Table 9 for a tabular summary of results.

- TDS concentrations gradually increased from 1,500 milligrams per liter (mg/L) at OID-8 (more than 0.5 mile north of the Site) to 2,600 mg/L at OID-1 (south end of Site). TDS
concentrations in the lagoon were 2,700 and 2,900 mg/L (LAG-1 and LAG-2). There was a gradual change in concentration between OID-8 and OID-1, but no dramatic increases where the OID passes through the two Halaco Properties to suggest a significant Site impact. TDS concentration in the Hueneme Drain (5,600 mg/L at HUD-1) and J Street Drain (4,300 mg/L at JSD-1) were higher than in the OID and lagoon.

- The relative concentrations of major ions also showed a gradual change from OID-8 through OID-1, with notable increases in the percentages of chloride and sodium and decreases in the percentages of sulfate and calcium along the flow path. The percentage of potassium was small (< 1 percent) and the TDS/K ratio high (> 100) indicating little or no contribution from Halaco’s wastes.

- Ammonia and nitrate concentrations generally decreased from north to south along the OID. Ammonia was not detected at OID-8 and then decreased from 0.14 mg/L at OID-7 (north) to 0.057 mg/L at OID-1 (south). Similarly, nitrate was not detected at OID-8 and then decreased from 15 mg/L at OID-7 (north) to 5.8 mg/L at OID-1 (south).

- The concentrations of total and dissolved metals varied between OID-8 (north) and OID-1 (south), but did not show obvious changes or anomalies that indicated impacts on OID surface water from Halaco’s wastes.

- The radionuclides Th 232, Th 230, Th 228, Ra 228, and Ra 226 were sporadically detected in surface water samples at low levels generally less than 1 picocuries per liter (pCi/L). The low levels are considered representative of background conditions.

The following general chemistry changes were observed during breach conditions, when ocean water flows into the OID, lagoon, and J Street Drain to mix with surface water flowing southward from the Oxnard Plain. Samples were collected at low tide.

- TDS concentrations were higher during breach conditions reflecting the ocean water influence. The TDS of seawater was approximately 35,000 mg/L (OCE-1 and OCE-2). TDS concentrations gradually increased from 2,600 mg/L at OID-8 (north) to 6,800 mg/L at OID-1 (south) and 8,100 and 9,100 mg/L in the lagoon (LAG-1 and LAG-2). There were no dramatic increases where the OID passes through the Halaco Properties to suggest a Site impact. An unexpected decrease is observed at OID-3; however, this sample was collected 1 day after the other OID samples, possibly accounting for the unexpectedly low (3,300 mg/L) TDS concentration.

- The major ion percentages also show a gradual change from OID-8 to OID-1, particularly chloride and sodium (increasing) and alkalinity, sulfate, and calcium (decreasing) as the percentage of seawater increases.

- Ammonia concentrations were low in the OID, lagoon, Hueneme Drain, and J Street samples (< 1 mg/L), similar to the non-breach conditions. They did not show a clear spatial pattern. Nitrate concentrations decreased from 20 mg/L at OID-8 (north) to 9.5 mg/L at OID-1 (south) but did not provide evidence of a Site impact. The nitrate concentration for OID-3 did not fit into the spatial pattern apparent in the other OID samples, similar to the TDS concentration as described above. Ammonia and nitrate were not detected in the four seawater samples.
Neither metals nor radionuclide results showed evidence of a Site impact, as described above for breach conditions.

**WMU Ditch.** The WMU Ditch samples (WMU-1 and WMU-2) were collected during November 2009 when surface water was flowing from the OID and lagoon, through the WMU ditch and into NCL-East. The OID and lagoon water elevation was 8.12 feet and the NCL-East elevation was 7.95 feet during this sampling event.

- TDS concentrations in both WMU ditch samples were 2,700 mg/L, similar to the TDS concentrations at the mouth of the ditch (OID-1) and the two lagoon samples (LAG-1 and LAG-2).
- The major ion percentages for both WMU ditch samples were similar to one another and to the OID sample at the mouth of the ditch (OID-1).
- Ammonia concentrations in the two WMU ditch samples were 0.12 and 0.19 mg/L, slightly higher than in OID-1 and the lagoon, which were about 0.06 mg/L. This difference may be evidence of an impact from the WMU ditch sediments or groundwater seepage from the WMU. Nitrate was not detected in any of these samples.
- The concentrations of metals in the WMU Ditch surface water samples were similar to those in OID-1 and the lagoon samples. Several metals, such as lead, copper, and manganese, increased in concentration in the direction of surface water flow (from WMU-1 to WMU-2), indicating a possible impact from the WMU ditch sediments or groundwater seepage. Other metals decreased in concentration, however, indicating uncertainty about the source of the changes.

**NCL-East.** The NCL-East surface water samples (NCE-1, NCE-2, and NCE-3) were collected during June 2010. In the preceding January, there was significant flooding, prompting VCWPD to manually breach the coastal sand. The berm remained breached through April 2010. The NCL-East surface water elevation dropped to at least 6.4 feet (on February 24, 2010), before rising to 8.00 feet elevation on June 2 and 3, 2010.

- TDS concentrations in the three NCL-East surface water samples ranged from 6,600 mg/L (NCE-3) to 7,100 mg/L (NCE-2), higher than the TDS concentrations in the WMU ditch, OID, or lagoon samples at the mouth of the WMU ditch (2,600 to 2,900 mg/L). The higher TDS concentrations suggest evaporation of the NCL-East surface water.
- Compared to the WMU ditch, OID, and lagoon samples, the NCL-East surface water samples have a higher percentage of chloride and sodium and lower percentage of alkalinity, sulfate, calcium, and magnesium. The reason for the difference in chemistry is not clear. In part the difference could be that the surface water entered NCL-East during the January 2010 flood from multiple areas, and not mostly from the WMU ditch as would normally be the case.
- Ammonia concentrations for the three NCL-East surface water samples were low (0.02 to 0.099 mg/L). Nitrate concentrations were also low.
- The concentrations of metals in the NCL-East surface water samples were higher than in the WMU ditch and corresponding OID and lagoon samples. The higher metals
concentrations are most likely due to evaporation, and possibly from dissolution and suspension of NCL-East sediments.

### 4.5.2.2 Semiperched Aquifer Groundwater

The general chemistry, radionuclides, and metals testing indicate impacts from inorganic analytes to groundwater within the Semiperched aquifer. The VOC, SVOC, and TPH results indicate lower level impacts. Figure 17 depicts the approximate east-west extent of groundwater impacted by Halaco’s operations. Figures 18a, 18b, and 18c depict TDS concentrations on cross sections A-A’, B-B’, and C-C’.

**General Chemistry.** TDS concentrations in groundwater at the Smelter Parcel and Waste Management Area exceed 50,000 mg/L (Figures 21a and 21b). These high concentrations, believed to result from Halaco’s process wastes, occur throughout the 75-foot-deep Semiperched aquifer (Figures 18a, 18b, and 18c). The maximum measured TDS concentrations were near the water table in the southeastern area of the Smelter Parcel where process waste was discharged into a former channel of the OID (MW-12; 180,000 mg/L) and in the deeper coarse grained interval of the Semiperched aquifer at the Waste Management Area (MW-19C; 88,000 mg/L).

In areas where TDS concentrations are high (> 50,000 mg/L), the relative concentrations of major ions closely resemble that of Halaco’s wastewater (Figures 2k and 2l). The contaminated groundwater and Halaco’s wastewater are both high in potassium and have a TDS/potassium ratio of less than 10 (Figure 27). Additionally, ammonia concentrations in the Semiperched aquifer are similar to those in Halaco’s wastewater, which had ammonia concentrations well over 100 mg/L.

**AWPF.** Groundwater samples from the three AWPF wells (P-1, P-3, and P-4) were collected to assess background conditions. The TDS concentrations in the three wells ranged from 3,000 mg/L to 5,700 mg/L, which is slightly higher than the OID surface water samples nearest the AWPF area (OID-6 and OID-7) during non-breach conditions (3,000 and 2,600 mg/L) and slightly lower than these samples during breach conditions (7,900 and 6,100 mg/L). The major ion chemistry of the groundwater from the AWPF wells is similar to the OID surface water samples during non-breach conditions. The ammonia concentrations ranged from 1.6 to 3.5 mg/L. The sources of water to the AWPF wells are likely to include infiltration from rainfall, horizontal groundwater flow from upgradient areas, and recharge of surface water from the OID during non-breach and breach conditions.

**Smelter Parcel.** Halaco’s operations appear to have contaminated groundwater under much of the Smelter Parcel. TDS concentrations exceed 50,000 mg/L near the water table (MW-12) and in the deeper coarse-grained sediments (MW-12C and MW-13C). Ammonia concentrations at MW-12 and MW-12C exceed 800 mg/L while ammonia concentrations at MW-13C exceed 400 mg/L. The major ion chemistry from these wells resembles Halaco’s process water, which includes having a low TDS/potassium ratio (< 10). The northern and southern extents of impacts on groundwater from Halaco’s operations beyond the Smelter Parcel are not known. The impacts to the east extend to the Waste Management Area. The western extent is near the western edge of the Smelter Parcel, as further described below.

TDS concentrations near the water table decrease in the direction of groundwater flow as indicated by the lower TDS concentrations (MW-13; 10,000/10,000 mg/L) and ammonia
concentrations (MW-13; 31/27 mg/L) in the northern area. Burn dump wastes may contribute to the elevated levels. Causes for the decrease in TDS and ammonia concentrations may include dilution from rainfall infiltration, dilution from recharge of surface water from the OID, and other natural attenuation mechanisms. The major ion chemistry from these wells resembles Halaco’s process water, which includes having a low TDS/potassium ratio. The TDS concentrations in the deeper part of the Semiperched aquifer are high (approximately 50,000 mg/L) and do not show a significant change from MW-12C northward to MW-13C.

The western extent of potential impacts from Halaco’s operations on groundwater is defined by a combination of moderately lower TDS concentrations and changes in the general chemistry.

- At the water table, the extent of potential impacts is defined by the lower TDS concentrations by the well at the south end of Perkins Road (MW-14; 5,600/5,600 mg/L) and the well to the north at the intersection of Perkins Road and McWane Boulevard (MW-15; 5,400/5,500 mg/L). The ammonia concentrations at these locations are also low (MW-14; 1.5/1.6 mg/L, MW-15; 4.1/1.4 mg/L), similar to the ammonia concentrations at the AWPF wells and the major ion chemistry does not resemble background conditions with a TDS/potassium ratio of approximately 50. Groundwater at MW-11, between MW-12 and MW-14 and screened in burn dump waste, does not exhibit significant TDS (4,600/4,700 mg/L) or ammonia (1.5/0.12 mg/L) impacts, although the major ion chemistry resembles Halaco’s process wastewater with a TDS/potassium ratio of less than 10, which indicates some potential impacts from Halaco’s operations. Groundwater at these wells may include recharge of surface water from the lagoon moving toward the north and infiltration from precipitation.

- In the coarser-grained unit, the extent of potential impacts is defined by a combination the moderately lower TDS concentrations and the general chemistry at the two wells in the upper part of the coarse-grained unit (MW-21 and MW-22) and the well in the middle part of the coarse-grained unit (MW-21C). Although the TDS concentration at MW-20 (8,200/8,500 mg/L), MW-21 (7,800/8,600 mg/L), and MW-21C (22,000/23,000 mg/L) are moderately high, the general chemistry does not indicate groundwater from these wells is significantly impacted by Halaco’s process wastes. The TDS/potassium ratio for these wells is between 50 and 100. Groundwater at these wells may include recharge from surface water from the lagoon moving toward the north and infiltration from shallow groundwater.

**Hueneme Parcel.** Groundwater in the coarse-grained part of the Semiperched aquifer at the Hueneme Parcel is characterized by MW-23B and MW-23C. The TDS concentrations at these wells (MW-23B with 9,300/11,000 mg/L and MW-23C with 16,000/18,000 mg/L), ammonia concentrations (MW-23B with 0.70/0.93 mg/L and MW-23C with 0.41/2.7 mg/L), and the general chemistry are similar to the TDS concentrations and major ion chemistry at the wells at the western edge of the Smelter Parcel. Similar to MW-21, MW-22, and MW-21C, groundwater at MW-23B and MW-23C may include recharge from surface water from the lagoon moving toward the north and infiltration from shallow groundwater.

**Waste Management Area.** Groundwater at the Waste Management Area with the high TDS concentrations (> 50,000 mg/L) that is impacted by Halaco’s operations occurs in the central
part of the Waste Management Area at the water table (MW-18 and MW-19) and throughout the entire Waste Management Area in the deeper portion of the coarse-grained zone (MW-2C, MW-3C, MW-6C, MW-19C, and MW-24C). Ammonia concentrations in these areas approach and exceed 1,000 mg/L. The major ion chemistry from these wells resembles Halaco’s process water, which includes having a low TDS/potassium ratio (< 10). The northern and southern extents of potential impacts on groundwater from Halaco’s operations beyond the Waste Management Area are not known. The impacts to the west extend to the Smelter Parcel. The eastern extent is within the NCL-East area, although its exact location is uncertain, as further described below.

The TDS and ammonia concentrations at the water table and upper part of the coarse grained unit at the southern perimeter of the WMU that have resulted from Halaco’s operations are much lower than in the interior, with TDS concentrations less than 10,000 mg/L and ammonia concentrations less than 100 mg/L (MW-1R, MW-3RA, MW-3RB, MW-5). The TDS and ammonia concentrations at the water table and upper part of the coarse grained unit at the eastern (MW-2RA and MW-2RB) and western perimeter (MW-6) of the WMU are also lower than in the interior, but not as low as those from the southern perimeter. The TDS and ammonia concentrations for the wells screened at the water table (MW-2RA and MW-3RA) are lower than the other wells which are screened deeper. The major ion chemistry from these wells resembles Halaco’s process water. As further described below, the TDS and ammonia concentrations were historically higher but have decreased since Halaco stopped discharging to the settling ponds. The historically higher TDS concentrations at the west, east, and southern perimeters of the Waste Management Area may have moved inward and then northward with the general groundwater flow direction and become diluted with surface water recharge from surrounding surface water bodies (OID, lagoon, WMU ditch, and NCL-East) and precipitation infiltrating at the edges of the WMU.

The wells at the northern perimeter of the Waste Management Area that are screened at the water table and the upper part of the coarse grained unit are located north of the sewer trunk line and a large portion of the recharge to groundwater in which these wells are screened likely occurs from the overlying NCL-North ponds (MW-4RA and MW-4RB). Consequently, even though the TDS concentrations in these wells are relatively low, less than 10,000 mg/L, these wells cannot be used to assess the northern extent of impacts from Halaco’s process waste.

**NCL-East.** The eastern extent of Halaco’s impact on groundwater in the coarse-grained part of the Semiperched aquifer is defined by the moderately lower TDS concentrations and the general chemistry at NCL-East at the two wells in the upper portion of the coarse-grained unit (MW-25B and MW-27B) and at the two wells in the middle portion of the coarse-grained unit (MW-25C and MW-27C). The relatively low TDS concentrations at MW-27B (9,600 mg/L; 11,000 mg/L) and MW-27C (3,000 mg/L; 3,000 mg/L) combined with general chemistry indicate that groundwater from these wells is not impacted by Halaco’s process waste. The relatively low TDS concentrations at MW-25B (8,700 mg/L; 9,500 mg/L) combined with general chemistry indicate that groundwater from this well is also not impacted from Halaco’s process waste. However, the higher TDS concentrations at MW-25C (20,000 mg/L; 18,000 mg/L) combined with general chemistry indicates that there may be a slight impact on the deeper part of the coarse-grained unit at this location from Halaco’s process waste.
Metals. The concentrations of metals measured in groundwater in the Semiperched aquifer are illustrated in Figures 24a and 24b for total metals and Figures 25a and 25b for dissolved metals. The highest metals concentrations were generally observed within the interior of the Smelter Parcel and interior of the Waste Management Area where the general chemistry showed the greatest impacts from Halaco’s operations (indicated by elevated TDS, potassium, and ammonia). However, the correlation between metals concentrations and impacts on groundwater is less clear at other wells that are less strongly affected by Halaco’s operations (as determined by general chemistry), making it uncertain whether the elevated metals concentrations are the result of Halaco’s operations. Two of the main factors that contribute to this uncertainty are described below.

First, high sample turbidity was measured in some groundwater samples, particularly those collected from the older wells. High turbidity can affect the measured metals concentrations. Turbidity exceeded 10 Nephelometric Turbidity Units (NTU) in older wells MW-2RB, MW-11, MW-12, MW-14, MW-15, MW-18, and MW-19, which were all constructed in 2003 or 2006, and in AWPF piezometers P-3 and P-4, constructed in 2006. Ten NTU is the recommended maximum turbidity when analyzing for constituents that may be biased by the presence of turbidity (EPA, 2002). Table H-1 lists measured turbidity values. As described in Section 3, except for MW-12 and MW-18, samples were collected using the “low-flow” (minimal drawdown) sampling procedure (EPA, 1996), which minimizes turbidity compared to a higher purge rate sampling methodology. Turbidity levels may have been higher if “low flow” groundwater sample collection techniques were not used at most wells.

The second factor making it difficult to interpret the metals concentrations is varying groundwater geochemistry (e.g., pH, oxidation-reduction potential). Groundwater geochemistry can affect measured metals concentrations by changing the solubility and mobility of a metal. The changes are complex and vary by metal. EPA’s guidance document, Monitored Natural Attenuation of Inorganic Contaminants in Groundwater (2007), provides additional information on the fate and transport of metals in groundwater.

The highest total metals concentrations were generally observed at MW-12 at the Smelter Parcel and MW-18, MW-19, and MW-19C at the Waste Management Area. Metals that exceeded federal or state MCLs in these wells included aluminum (state MCL 1,000 µg/L), arsenic (federal and state MCL 10 µg/L), barium (state MCL 1,000 µg/L), beryllium (federal and state MCL 4 µg/L), cadmium (federal and state MCL 5 µg/L), chromium (state MCL 50 µg/L), nickel (state MCL 100 µg/L), and lead (federal MCL 15 µg/L). Of these metals, aluminum and arsenic also exceeded MCLs in areas outside the area shown to be impacted based on general chemistry and are not particularly useful for delineating impacts from Halaco’s operations.

The dissolved metals concentrations were generally lower than the total metals concentrations when total metals exceeded federal or state MCLs, except for arsenic and barium. Dissolved and total concentrations were similar for arsenic and barium, which generally exceeded MCLs at similar locations for dissolved and total metals. Dissolved cadmium was the only other dissolved metal to exceed MCLs, at MW-12.

EPA has not selected drinking water standards as cleanup levels; the comparison is for informational purposes only.
Radionuclides. Elevated levels of thorium and radium were found in groundwater in the Semiperched aquifer (Figures 26a and 26b). The elevated radionuclide levels were generally in the same area where general chemistry results indicate impacts from Halaco’s operations.

The combined Ra 228 and Ra 226 levels exceeded the MCL of 5 pCi/L in groundwater in wells at the Smelter Parcel (MW-12, MW-12C, and MW-13C) and Waste Management Area (MW-1R, MW-2C, MW-3C, MW-6C, MW-18, MW-19, MW-19C, and MW-24C). The combined Ra 226 and Ra 228 levels slightly exceeded the MCL in two wells that are believed to be outside the area impacted by Halaco’s operations (MW-21C and MW-27B).

Additionally, although there is no MCL for thorium, the combined Th 232, Th 230, and Th 228 levels exceeded 5 pCi/L in one well from the Smelter Parcel (MW-12) and one well from the Waste Management Area (MW-18).

VOCs and SVOCs. VOCs and SVOCs were detected at low concentrations in some groundwater samples (Tables 13 and 14). Eleven VOCs and 34 SVOCs were detected, all below federal MCLs, except for two samples: one sample had pentachlorophenol at an estimated concentration of 1.1 micrograms per liter (µg/L) and another sample had benzo(a)pyrene at an estimated concentration of 0.47 µg/L. The MCL for pentachlorophenol is 1 µg/L and for benzo(a)pyrene is 0.2 µg/L. Most detections were flagged with a “J,” indicating that the compounds were positively identified in the sample but that the concentration is estimated because quality control criteria were not met, or the concentration of the analyte was below the quantitation limit.

The following VOCs were detected:

- The common laboratory contaminants acetone and methylene chloride were detected in several samples. Acetone was detected at a maximum concentration of 74 µg/L. Methylene chloride was detected below the reporting limit of 0.5 µg/L.

- The aromatic compounds benzene, toluene, and xylene were detected in several samples. Benzene was detected at a maximum concentration of 0.98 µg/L. Toluene and xylenes were detected below the reporting limit of 0.5 µg/L.

- The refrigerant 1,1,2-trichloro-1,2,2-trifloroethane (Freon 113) was detected in one sample at an estimated concentration below the reporting limit of 0.5 µg/L, and the refrigerant chloromethane (Freon 40) was detected in three samples at a maximum concentration of 0.92 µg/L.

- The trihalomethanes (THMs) dibromochloromethane, chloroform, and bromoform were each detected in two or three samples each at maximum concentrations of 1.1 µg/L, 17 µg/L, and 1.6 µg/L, respectively.

- Carbon disulfide was detected in two samples at estimated concentrations below the reporting limit of 0.5 micrograms per liter (µg/L).
The following SVOCs were detected:

- Phenol was detected in one sample at 10 µg/L and in several other samples below the reporting limit of 5 µg/L. Additional phenolic compounds (2-chlorophenol, 2-methylphenol, 4-methylphenol, 2,4,6-trichlorophenol, 4-nitrophenol, pentachlorophenol, and 2,3,4,6-tetrachlorophenol) were detected in a limited number of samples, all below the reporting limit of 5 µg/L. Pentachlorophenol was detected in one sample at an estimated concentration of 1.1 µg/L, above its MCL of 1 µg/L.

- Naphthalene and various other polycyclic aromatic hydrocarbons (PAHs) were detected in a limited number of samples below the reporting limit of 5 µg/L. Benzo(a)pyrene was detected in one sample at an estimated concentration of 0.47 µg/L, above its MCL of 0.2 µg/L.

- The common laboratory contaminant bis(2-ethylhexyl)phthalate was frequently detected at estimated concentrations below the reporting limit of 5 µg/L. Similar to bis(2-ethylhexyl)phthalate, caprolactam was also detected in most samples, but at higher concentrations with a maximum of 5 µg/L. It is possible that bis(2-ethylhexyl)phthalate and caprolactam may be artifacts of the discharge tubing that was used to collect the groundwater samples. Additional phthalate compounds (diethylphthalate, di-n-butylphthalate, butylbenzylphthalate, and di-n-octylphthalate) were detected in a limited number of samples, all below the reporting limit of 5 µg/L.

- The following compounds were detected in one or more samples below the reporting limit of 5 µg/L: Benzaldehyde, acetophenone, N-Nitroso-di-n-propylamine, 2,4-dinitrotoluene, and dibenzofuran.

**TPH.** TPH-gas and TPH-diesel were frequently detected in groundwater in the Semiperched aquifer (Table 15). Additionally, TPH-diesel was detected in a limited number of samples at or near the laboratory reporting limit at locations where groundwater is not thought to be impacted by Halaco’s operations.

- The highest measured concentrations of TPH-gas and TPH-diesel in groundwater were in the middle of the coarse-grained unit at both the Smelter Parcel (MW-12 and MW-13C) and the Waste Management Area (MW-6C and MW-24C).

- TPH-gas was detected in shallow groundwater at wells in the interior, but not at the perimeter, of the Waste Management Area (MW-1R, MW-3RA, MW-3RB, MW-5, MW-2RA, MW-4RA, MW-4RB, and MW-24). The general chemistry data also indicate that Halaco’s wastewater has had a greater impact on shallow groundwater at the interior of the Waste Management Area, compared to its perimeter. TPH-diesel was detected at most locations where TPH-gas was detected.

- At the Smelter Parcel, TPH-gas was generally detected in wells where the general chemistry data indicated the greatest impact (MW-12, MW-12C, and MW-13C). TPH diesel was detected in most wells.

- TPH- oil was only detected at MW-14 at the Halaco Properties, at an estimated concentration of 510 µg/L.
- At the Hueneme Parcel and NCL-East wells, TPH-gas was detected at one well (MW-25C; 33 µg/L), TPH-diesel was detected at two wells (MW-23C at 3,100 µg/L and MW-27C at 260 µg/L), and TPH-oil was detected at one well (MW-23C at 6,200 µg/L).

4.5.2.3 Oxnard Aquifer

Groundwater sampling results from the four D zone wells screened in the Oxnard aquifer (MW-2D, MW-3D, MW-6D, and MW-19D) indicate that Halaco’s operations have had little or no impact on groundwater in the Oxnard aquifer. Metals concentrations were generally low. VOCs, SVOCs, and TPH results were generally below detection limits or at low concentrations near analytical reporting limits.

**General Chemistry.** The TDS concentrations in samples from the four D zone wells are less than 1,200 mg/L, far below the 56,000 to 88,000 mg/L measured in groundwater in the overlying C zone wells that exceeded 50,000 mg/L (Figures 21a and 21b). These relatively low TDS concentrations in the Oxnard aquifer are consistent with the concentration recently measured at well CM4, which was 1,300 mg/L at the end of 2009 (Figure 2h).

The major ion chemistry of the groundwater samples collected from the four D zone wells does not resemble Halaco’s process wastewater samples. It more closely resembles groundwater from the three AWPF wells (P-1, P-3, and P-4). See Figures 2k and 2l for Halaco wastewater chemistry, and Figures 20a and 20b for D zone and AWPF well chemistry. In the D zone wells, the potassium concentrations were low (less than 15 mg/L). the TDS/potassium ratio was high (above 80), and the ammonia concentrations were generally low (less than 1 mg/L) in six of eight samples analyzed (Figure 27). Ammonia was elevated for two samples during the first sampling event (MW-2D at 120 mg/L and MW-19D at 5.8 mg/L).

**Metals.** Metals concentrations in groundwater from the four D zone wells are relatively low and appear to represent background conditions. The only metal that exceeds an MCL is total aluminum, which exceeds the state MCL of 1,000 µg/L in groundwater samples from three of the four wells (MW-2D, MW-3D, and MW-19D).

**Radionuclides.** Radionuclide levels in groundwater from the four D zone wells are low and appear to represent background conditions. The combined Ra 228 and Ra 226 levels, and the combined Th 232, Th 230, and Th 228 levels, are below 5 pCi/L.

**VOCs and SVOCs.** VOCs and SVOCs were detected at low concentrations in some groundwater samples collected from the D zone wells (Tables 13 and 14). Four VOCs and five SVOCs were detected, all below federal MCLs. Except for caprolactam, all detections were below the reporting limit and flagged with a “J.”

The following VOCs were detected:

- The common laboratory contaminant methylene chloride was detected in one sample.
- The aromatic compounds benzene and xylenes were detected in two samples.
- The THM bromoform was detected in one sample.
The following SVOCs were detected:

- 4-methylphenol was detected in one sample.
- Naphthalene was detected in two samples and 2-methylnaphthalene was detected in one sample.
- The common laboratory contaminant bis(2-ethylhexyl)phthalate was detected in two samples.
- Caprolactam was detected in all four samples at a maximum concentration of 250 µg/L.

TPH. TPH-diesel was detected in all four samples from the D zone wells at a maximum of 270 µg/L. TPH-gas and TPH-oil were not detected in any of the samples.

### 4.5.3 Historical Surface Water and Groundwater Chemistry

Surface water and groundwater chemistry at the Site differed from about 1965 to 2002 when Halaco disposed wastewater into the OID (1965 to 1970) and WMU (1970 to 2002). Figures 19a and 19b show TDS concentrations that may have been present before 2002.

#### 4.5.3.1 Surface Water

**Smelter Parcel.** Surface water chemistry data are not available from the late 1960s, when Halaco discharged wastewater into the OID. The discharge most likely degraded water quality, probably increasing levels of TDS, metals, ammonia, O&G, and other compounds.

**Wastewater Seeps from Waste Management Area.** As described in Section 6.2.2 of the 2008 Groundwater Report, liquids were observed seeping from the Waste Management Area in the 1980s and 1990s. The levels of salts, metals, and ammonia in the seeps were similar to the levels measured in wastewater discharged by Halaco to the waste pond, suggesting that the seepage originated as wastewater.

Most of the seeps were documented to occur along the eastern dike, but seeps were also observed along the north pond dike. Seeps could have occurred along any of the dikes to the north, south, east, and west of the pond, as shown in the cross sections included as Figures 19a and 19b.

**OID and Lagoon.** The 2008 Groundwater Report (Section 6.3.1) includes a comparison of water quality in the OID upstream (north) of the site, water quality at the site, and water quality downstream (south) of the site to assess whether Halaco’s operations had an impact on surface water quality in the OID or lagoon. Water quality was regularly monitored at one location north of the site and one location south of the site from 1981 through 2004.

The comparisons suggested but did not provide consistent evidence of an impact from Halaco’s operations on surface water quality. As an example, Figure 28b shows the EC monitoring results for the OID upstream (north) and downstream (south) locations from 1980 through 2004, and in 2009 and 2010. The variability over time is greater than the difference in EC between the north and south locations. At times, EC is higher at the northern monitoring location. At other times, EC is higher south of the site. Bigger influences on chemistry in the OID and lagoon may be surface runoff from the OID watershed and seawater when the beach berm is breached. Additional time-series charts for
the 1980 through 2010 surface water data are provided in Attachment K for pH, magnesium, aluminum, copper, zinc, and O&G.

**WMU Ditch.** The 2008 Groundwater Report (Section 6.3.2) indicated that surface water in the WMU ditch may have been affected by the Site, most likely from solid waste materials in the ditch or groundwater seepage from the WMU. Ammonia levels measured in water collected from the ditch in 2003 and 2004 ranged from 5.6 to 150 mg/L (except for one outlier of 0.3 mg/L), suggesting impacts from Halaco’s operations.

**NCL-East.** The 2008 Groundwater Report (Section 6.3.4) describes elevated levels of ammonia and metals in surface water samples collected in NCL-East, and suggests that their source was wastewater seepage through the WMU berm. The areal extent of surface water appears to have been limited when the samples were collected, as indicated by the historical aerial photos (1978, 1981, and 1991) and sample collection descriptions. Ammonia concentrations ranged from 30 mg/L during a 1980 investigation up to 1,220 mg/L in a 1991 investigation.

The high concentrations appear to have been the result of wastewater seepage through the berm. This seepage no longer occurs because the wastewater pond and associated water table mounding that led to the seeps no longer exist.

**4.5.3.2 Groundwater**

**Smelter Parcel.** Groundwater water chemistry data are not available from the late 1960s, when Halaco discharged wastewater into the OID. The discharge most likely degraded groundwater quality, probably increasing levels of TDS, metals, ammonia, O&G, and other compounds. Groundwater samples collected from wells installed in 2006, 2009, and 2010 confirm that groundwater at the Smelter Parcel has been impacted by Halaco’s operations. The highest concentrations of TDS, ammonia, and metals measured at the Site have been at MW-12, which is a monitoring well screened near the water table in process waste.

**Waste Management Area.** The 2008 Groundwater Report (Section 6.4) includes an analysis of historical groundwater quality data completed to assess potential impacts on groundwater from Halaco’s operations. As described in Section 2, water quality was regularly monitored at four monitoring wells in the Waste Management Area from 1981 through 2003 and at an expanded network of nine monitoring wells from 2003 through 2004. These wells were screened near the water table and in the upper portion of the coarse-grained unit of the Semiperched aquifer.

The groundwater monitoring results from 1981 through 2003 showed elevated concentrations of TDS and metals attributable to Halaco’s waste disposal activities. The EC levels were significantly greater than for seawater (50,000 µmhos/cm) and some results exceeded 100,000 µmhos/cm, consistent with the EC of Halaco’s process water. O&G was also present in groundwater, presumably from Halaco’s operations. Time-series charts for EC are provided in Figure 29a for 1981 through 2003. Time-series charts for pH, magnesium, aluminum, copper, zinc, and O&G are provided in Attachment L for 1980 through 2010.
SECTION 5

Conclusions

This section provides conclusions regarding surface water and groundwater flow, surface water and groundwater chemistry, and the extent of contamination in surface water and groundwater at the Site. It also summarizes information on the fill materials and aquifer units encountered during the investigation.

Instrumented direct-push probes were pushed at 8 locations to a depth of 157 feet bgs, piezometers were installed at 12 locations, and monitoring wells were installed at 22 locations to a depth of 152 feet bgs to supplement the existing network of 18 monitoring wells. Surface water and groundwater elevation measurements were made to assess the lithology, aquifer units, and the surface water and groundwater flow conditions at the Site. The direct push probes made use of CPT-SMRT and EC-HPT tools.

Surface water samples were collected from 19 locations and groundwater samples were collected from 40 monitoring wells and analyzed at offsite laboratories to assess the nature and extent of contamination. Additional groundwater samples were collected at three locations thought to represent background conditions. At least two groundwater samples were collected from each well for a total of 88 groundwater samples. Two rounds of surface water samples were collected at most locations for a total of 33 samples (not including duplicates).

All surface water and groundwater samples were analyzed for metals and general chemistry, and most (90 percent) were analyzed for radionuclides. Some surface water samples were analyzed for TOC and pH. One round of groundwater samples was analyzed for VOCs, SVOCs, and TPH.

These data, and findings from previous studies, indicate the following.

5.1 Lithology and Aquifer Units

The following fill materials and lithologic units were encountered during drilling and well installation (from shallow to deep):

- **Fill materials**, including Halaco’s process wastes and the remains of a former municipal dump. These fill materials are described in detail in the Halaco Properties testing report.

- **Semiperched aquifer**, including an upper finer-grained layer of clay and silt with sand and silt interbeds and a lower coarser-grained layer of sand and silty sand with clay and silt interbeds. The upper fine-grained layer is up to approximately 20 feet thick east of the WMU and thins to less than 10 feet west of the Smelter Parcel. The lower coarser-grained unit is approximately 70 to 80 feet thick.

- **Confining unit at the base of the Semiperched aquifer**. This confining unit is approximately 30 feet thick and consists of clay and silt that impede groundwater flow.
• **Oxnard aquifer.** The upper portion of the Oxnard aquifer consists of sand and gravelly sand with clay and silt interbeds.

### 5.2 Surface Water Flow

Surface water features at the Halaco Site include surface water channels that drain the Oxnard Plain (OID, J Street Drain, and Hueneme Drain) and standing surface water in the lagoon, NCL-East, and NCL-North areas next to the Halaco Properties. The OID, J Street Drain, and Hueneme Drain discharge into the lagoon. Flow between these features occurs as follows:

- **Lagoon and OID.** When the coastal sand berm is intact, surface water elevations in the lagoon, OID (at the Halaco Site), ditch south of the WMU, and NCL-North pond are relatively high and stable. The beach berm typically breaches during the rainy season’s first significant storm event when flows increase in the OID, J Street Drain, and Hueneme Drain. After the breach, the lagoon and OID levels drop and then fluctuate with the tide. The berm typically remains breached until after the winter rains end and flow in the drains decreases.

- **Ditch to South of WMU.** The ditch south of the WMU is open to the OID and lagoon and is full when the beach berm is intact. The ditch is empty when the beach berm is breached.

- **NCL-North Pond and Ditch.** The pond at NCL-North is hydraulically connected to the OID, although there appears to be a dike between the pond and the OID. The pond is full when the beach berm is intact and empty when the beach berm is breached. Water occurs in the ditch extending eastward from the pond along the north side of the extension of McWane Boulevard when the pond is full.

- **NCL-East.** Surface water levels in the NCL-East area are controlled by topography. Surface water accumulates from local precipitation and overflow from the lagoon and OID when levels are high during non-breach conditions. Ground surface topography in the NCL-East area is sloped from northeast to southwest. Water from the lagoon and OID can enter NCL-East through the ditch south of the WMU and the NCL-North pond area when the lagoon and OID levels are greater than the respective watershed divides that separate the NCL-East area from these two areas. Surface water in NCL-East dissipates through evaporation and percolation when the water level in the OID and lagoon is low, below the two topographic divides. The topographic watershed divides prevent water in NCL-East from draining back into the lagoon and OID.

An atypical event occurred when the surface water elevation in the OID reached an approximately 12.5-foot elevation before the berm was manually breached by VCWPD on January 18, 2010. The berm did not breach in response to moderate rainfall, as is typical, leading to extensive flooding. The flooding was relieved when the berm was manually breached (using a tracked excavator) to lower the OID and lagoon level. This was the first time that the VCWPD is known to have manually breached the berm since 1992.
5.3 **Groundwater Flow**

At the Site, shallow groundwater elevations and the movement of groundwater in the Semiperched aquifer are influenced by water elevations in the lagoon, the OID, the ditch south of the WMU, the ponds in the NCL-North area, and the NCL-East area east of the Waste Management Area. Groundwater elevations and groundwater movement in the deeper Oxnard aquifer are influenced by regional flow conditions across the Oxnard Plain. Flow between the Semiperched aquifer and the Oxnard aquifer is restricted by the low-permeability sediments separating the two aquifers.

5.3.1.1 **Semiperched Aquifer**

Groundwater elevations in the Semiperched aquifer drop during the rainy season when surface water elevations are seasonally low in response to the beach berm being breached. They rise when the beach berm is intact and surface water elevations are seasonally high. This results in higher groundwater elevations in the summer months and lower elevations in the winter months.

The horizontal groundwater flow direction at the Site in the Semiperched aquifer is toward the north, from the lagoon toward McWane Boulevard. This occurs year-round. There is generally a downward hydraulic gradient from the water table to the deeper part of the Semiperched aquifer.

The northward flow direction appears to be induced by a low groundwater elevation area to the north of the Halaco Properties. The downward gradient is caused by recharge of surface water from the OID, lagoon, and NCL-East at both seasonal high (berm is not breached) and seasonal low (beach berm is breached) surface water conditions.

A potential cause for the lower groundwater elevations to the north of the Halaco Properties is the City’s sanitary wastewater collection system. The City’s sanitary wastewater collection system terminates in “northwest” and “southeast” trunk lines that feed into the headworks facility. The southeast trunk line is buried under McWane Boulevard along the north edge of the Halaco Properties. Seepage of groundwater into the southeast trunk line could induce the low groundwater elevation area to the north of the Halaco Properties.

The headworks facility was reconstructed from approximately 2005 through 2007. Groundwater was pumped during construction to lower the water table. Groundwater elevation data collected during and after construction indicate that groundwater elevations were below sea level from 2005 through 2007 and remained low following the completion of construction dewatering. The low groundwater levels suggest that northward gradients may have existed during construction activities and that groundwater may be seeping into the northwest and southeast trunk lines.

5.3.1.2 **Oxnard Aquifer and Confining Unit**

At the Site, the horizontal groundwater flow direction in the Oxnard aquifer is toward the east and southeast as determined by the four deep monitoring wells screened in the upper part of this aquifer. This is consistent with the regional interpretation of the groundwater flow conditions by UWCD.
Groundwater elevations in the four monitoring wells are similar to those measured in the nearby USGS regional monitoring well (CM4-200). Seasonally, groundwater elevations rise in the winter and spring and decline in the summer and fall as observed at CM4-200 since it was installed in the late 1980s.

The vertical groundwater gradient across the fine-grained confining unit that separates the Semiperched aquifer from the Oxnard aquifer was downward for two water level measurements at the end of 2009 and 2010 and upward for three other measurements taken during 2010.

The longer-term vertical groundwater gradient across the confining unit was downward prior to the 1990s, when the UAS was overdrafted and groundwater elevations in the Oxnard aquifer were below sea level. Since the early 1990s, groundwater elevations in the Oxnard aquifer have been several feet above sea level, leading to a gradient that has mostly been upward from the Oxnard aquifer to the Semiperched aquifer. Brief periods of downward gradients occurred during this period of mostly upward gradients when groundwater elevations in the Oxnard aquifer temporarily declined.

The predominantly upward gradient since the early 1990s indicates that there has been little or no movement of shallow groundwater underlying the Halaco Site downward from the Semiperched aquifer, through the underlying aquitard, and into the Oxnard aquifer since that time. However, the vertical gradient was downward prior to the 1990s, indicating a potential for groundwater affected by Halaco’s wastes from the Semiperched aquifer to have impacted the Oxnard aquifer.

5.4 Sources of Contamination

Halaco’s wastes appear to be the primary source of the groundwater contamination in the Semiperched aquifer at the Site, although the municipal burn dump waste that underlies the Smelter Parcel may also affect groundwater quality. The chemistry of Halaco’s waste solids and the City’s burn dump waste is described in the Halaco Properties companion report (CH2M HILL, 2011d). Prior to 2002 when discharge to the settling ponds stopped, the height of Halaco’s settling ponds caused large downward hydraulic gradients and deep penetration of Halaco’s wastewater into the underlying Semiperched aquifer. Halaco’s process wastewater had:

- A high pH and high levels of salts and residual metals
- Ammonia generated as a byproduct of the metal smelting operation
- Radionuclides from magnesium-thorium alloy scrap that Halaco reports it processed from 1965 to about 1977
- Organic constituents as a result of waste oil and solvent that was reportedly disposed in Halaco’s furnaces or rotary washers

5.5 Surface Water Chemistry

The general chemistry and metals testing results for the two surface water sampling events completed in 2009 and 2010 do not indicate impacts on water in the OID or lagoon. Both the
absolute concentrations and the spatial patterns of the measured concentrations were evaluated.

Ammonia and metals testing results indicate some impact on surface water in the WMU ditch. The ammonia concentration in the two WMU ditch surface water samples was slightly higher than in the OID sample at the mouth of the ditch and the two lagoon samples. In addition, the ammonia concentrations increased along the ditch in the direction of flow. The metals concentrations in the two WMU ditch surface water samples were similar to the OID sample at the mouth of the ditch and the two lagoon samples. However, a slight increase in some metals concentrations occurred in the direction of surface water flow along the ditch, indicating a potential impact from the WMU ditch sediments or groundwater seepage from the WMU. Conversely, the concentrations of other metals decreased, making it uncertain whether Halaco wastes were the cause of the observed increases.

TDS and metals concentrations were higher in the NCL-East surface water samples than in the WMU ditch samples and OID/lagoon samples at the mouth of the WMU ditch. The most likely cause of the higher TDS and metals concentrations is evaporation of NCL-East surface water, although other causes cannot be ruled out. Surface water may have entered NCL-East during the January 2010 flooding event from sources other than the WMU ditch, and Halaco wastes in NCL-East sediments may have contributed metals or other dissolved solids.

The thorium and radium activities in water samples from the OID, lagoon, and NCL-East were similar to activities measured in areas unaffected by Halaco’s operations.

5.6 Groundwater Chemistry

5.6.1 Semiperched Aquifer Groundwater

The general chemistry, radionuclides, and metals testing results indicate impacts from Halaco’s wastes on groundwater in the Semiperched aquifer. The VOC, SVOC, and TPH results also indicate impacts from Halaco’s wastes and possibly from the former municipal burn dump.

The extent to which groundwater has been impacted by Halaco’s operations has been approximately bounded to the west and east. The approximate western boundary is the western edge of the Smelter Parcel. The approximate eastern boundary is in the NCL-East area, although the boundary has not been precisely defined because of the limited number of monitoring wells in this area. The northern and southern boundaries of the affected area have not been determined.

General Chemistry. TDS concentrations in the affected groundwater exceed 50,000 mg/L. High concentrations occur throughout the Semiperched aquifer down to the top of the aquitard that separates the Semiperched aquifer from the deeper Oxnard aquifer.

The major ion chemistry and the ammonia concentrations in the affected groundwater closely resemble the levels measured in Halaco’s process wastewater samples. The affected groundwater is unusually high in potassium, has a TDS/potassium ratio typically less than
30, and generally has more than 100 mg/L ammonia. Groundwater with the greatest impacts has TDS greater than 50,000 mg/L, a TDS/potassium ratio less than 10, and ammonia greater than 1,000 mg/L.

At the Smelter Parcel, the impacts (concentrations) are greatest near the water table in the southeastern area where Halaco’s process waste is buried. Concentrations near the water table decrease toward the north in the direction of groundwater flow. Burn dump waste materials also may be affecting groundwater quality.

At the Waste Management Area, the impacts (concentrations) are greatest near the water table and the deeper portion of the Semiperched aquifer in the middle of the Waste Management Area. Impacts at the southern, eastern, and western perimeter of the WMU are generally much lower near the water table than in the interior but remain high in the deeper portion of the Semiperched aquifer. Shallow impacts at the perimeter were probably higher historically, but have decreased since Halaco stopped discharging to the settling ponds. The historically higher shallow concentrations at the perimeter may have moved inward and then northward in the direction of groundwater flow and become diluted with surface water recharge from surrounding surface water bodies (OID, lagoon, WMU ditch, and NCL-East).

Metals and Radionuclides. Metals concentrations and thorium and radium activities are elevated throughout the affected portion of the Semiperched aquifer. Metals that exceeded federal or state drinking water MCLs for unfiltered (or “total metals”) samples include aluminum, chromium, arsenic, barium, beryllium, cadmium, lead, and nickel. Metals that exceeded federal or state drinking water MCLs for field filtered (or “dissolved metals”) samples include arsenic, barium, and cadmium. The elevated metals for the unfiltered samples may, in part, be due to the presence of turbidity in samples from some of the older wells installed before 2009.

VOCs and SVOCs. VOCs and SVOCs were detected at low concentrations in some groundwater samples. All detections were below MCLs except for one detection of pentachlorophenol and one detection of benzo(a)pyrene, both near their quantitation limits.

TPH. TPH-gas and TPH-diesel were frequently detected in the affected portion of the Semiperched aquifer. In addition, TPH-diesel was detected in a limited number of samples at or near the laboratory reporting limit at locations outside the area where groundwater is thought to be impacted by Halaco’s operations based on general chemistry. TPH-oil was detected in two samples, one at an estimated concentration below the reporting limit.

5.6.2 Oxnard Aquifer

The general chemistry and radionuclide testing results indicate little or no impact from Halaco’s operations on groundwater in the Oxnard aquifer. Metals concentrations appear to generally be at background levels, and VOCs and SVOCs were infrequently detected at low concentrations near the reporting limit. However, ammonia and TPH-diesel were detected at unexpectedly high levels in some samples.

General Chemistry. The TDS concentrations in samples from the four wells screened in the Oxnard aquifer were less than 2,000 mg/L, far below the TDS concentration in affected portions of the Semiperched aquifer, which exceeds 50,000 mg/L. These relatively low TDS
concentration are consistent with the current concentration at CM4-200, which was 1,300 mg/L at the end of 2009. In addition, the major ion chemistry of groundwater from the four wells does not resemble the chemistry of Halaco’s process wastewater samples. Ammonia was detected in the first of the two sampling events in two of the four wells screened in the Oxnard aquifer, at 120 mg/L and 5.8 mg/L.

**Metals.** Metals concentrations and thorium and radium activities were relatively low and appear to represent background conditions.

**VOCs and SVOCs.** A limited number of VOCs and SVOCs were detected at low concentrations in some groundwater samples, all below federal MCLs.

**TPH.** TPH-diesel was detected in all four samples at a maximum of 270 µg/L. TPH-gas and TPH-oil were not detected in any of the samples.
SECTION 6

References


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