Public Health Assessment

Final Release

Evaluation of Exposure to Contaminants at the
HALACO ENGINEERING COMPANY

6200 PERKINS ROAD
OXNARD, VENTURA COUNTY, CALIFORNIA

EPA FACILITY ID: CAD009688052

Prepared by the
California Department of Public Health

JANUARY 21, 2010

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR's Cooperative Agreement Partner pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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List of Acronyms

ATSDR—Agency for Toxic Substances and Disease Registry
bgs—below ground surface
cal/EPA—California Environmental Protection Agency
CARB—California Air Resources Board
CBDMP—California Birth Defects Monitoring Program
CDPH—California Department of Public Health
CHS—Center for Health Statistics
CREG—Cancer Risk Evaluation Guideline for one in a million excess cancer risk
CUP—Conditional Use Permit
DTSC—California Department of Toxic Substances Control
EHIB—Environmental Health Investigations Branch
EMEG—Environmental Media Evaluation Guide (ATSDR)
EPA—U.S. Environmental Protection Agency
kg—kilogram
LARWQCB—Los Angeles Regional Waste Quality Control Board
LOAEL—Lowest-observed-adverse-effect level
MCL—Maximum Contaminant Level for drinking water (state and federal)
mg—milligram
MRL—Minimal Risk Level (ATSDR)
NCL—Nature Conservancy Land
ND—not detected
NOAEL—No-observed-adverse-effect level
NOV—Notice of Violation
NTP—National Toxicology Program
OEHHA—Office of Environmental Health Hazard Assessment (Cal/EPA)
OID—Oxnard industrial drain
OSHPD—Office of Statewide Health Planning and Development
PHA—public health assessment
ppm—parts per million
ppb—parts per billion
REL—Reference exposure level (OEHHA)
RfC—Reference concentration (EPA)
RfD—Reference dose (EPA)
RI—remedial investigation
RI/FS—remedial investigation/feasibility study
RMEG—Reference Dose Media Evaluation Guide (ATSDR)
RWQCB—Regional Water Quality Control Board
VOC—volatile organic compound
WDA—waste disposal area
WMA—waste management area
WMU—waste management unit

Summary

The California Department of Public Health and the federal Agency for Toxic Substances and Disease Registry prepared a Public Health Assessment for the Halaco Engineering Company, located at 6200 Perkins Road in the City of Oxnard, Ventura County, California. The Halaco site is located in a wetland area next to Ormond Beach and the Pacific Ocean.

The California Department of Public Health staff visited the neighborhoods and workplaces around the Halaco site and gathered the health concerns of the community members and workers who believe the contamination from Halaco caused their health problems.

What is a Public Health Assessment?

A public health assessment is a report that gives information on hazardous waste sites and their effect on the health of surrounding communities. In the process of writing the report, we look at environmental information and at how people may be exposed to chemicals coming from a waste site or an industrial facility. We analyze the information to see if those chemicals could cause health problems in people living near the facility. Another important part of the public health assessment is responding to community health concerns. If exposure has occurred, we may include relevant and available health information, like cancer registry or hospitalization information.

Site History

From August 1965 to August 2004, Halaco operated the smelter, which recycled metal, mostly aluminum and magnesium. Prior to 1970, Halaco released wastewater into the Oxnard Industrial Drain and into a small lagoon on the smelter property. In 1971, an unlined pond was built on the Waste Management Unit to hold the wastewater. The wastewater was contaminated with heavy metals, ammonia, and for a time in the 1970s, radioactive isotopes.

In the past, Halaco has been cited by authorities for abusing some of its permits to operate. The abuse included surface water discharge, air releases, and other contamination practices. Halaco was also sued by two environmental groups. In April 2003, the Ventura County District Attorney filed criminal charges against Halaco's owners. These actions eventually caused the facility to stop operating in September 2004.

Starting in mid-2006, the U.S. Environmental Protection Agency started a number of actions, including 1) removing hazardous materials in containers, 2) securing the perimeter of the smelter, the Waste Management Unit, and the Waste Disposal Area, and 3) controlling sediment runoff and soil from becoming windblown. The U.S. Environmental Protection Agency also completed a large sampling effort in June 2006. The Halaco site was named to the federal list of Superfund sites on September 2007.

After visiting the site and nearby area, meeting with the community, and reviewing environmental and health information, the California Department of Public Health looked at ten different ways people could have come into contact with Halaco contaminants. These ways are called exposure pathways and are summarized below.

Activities Not Presenting a Public Health Hazard

The U.S Environmental Protection Agency took samples of areas on and around the site, and found Halaco contaminants in the soil and water. The California Department of Public Health reviewed the impact of this contamination and found that the following activities cause no public health hazard:

- No noncancer (other than cancer) public health hazard to trespassers on the Halaco site, from the time the facility closed until now.
- No apparent cancer risk and no noncancer public health hazard for adults and children who visit the Nature Conservancy Land, Ormond Beach, or the wetlands, and who may have swum in the Oxnard Industrial Drain.

Recommendations

To fully identify the contamination, and to ensure that further exposure does not occur from the smelter and the Waste Management Unit/Waste Disposal Area, the California Department of Public Health recommends the following actions:

Analyzing for a wider range of contaminants on the smelter.

Taking additional surface soil samples in the neighborhood, to confirm earlier testing that did not show a long-lasting impact from the Halaco emissions.

Additional securing of the fencing around the smelter.

Posting a warning around the Nature Conservancy Land advising of contamination present on the property.

Air Emissions in the Past Present a Public Health Hazard

While Halaco was operating, nearby workers and residents, and visitors to the area had many concerns about the emissions coming from Halaco. According to a Ventura County Air Pollution Control District (Air District) report on air emissions written in the mid-1990s, the routine, permitted, and controlled emissions did not pose a cancer or noncancer public health hazard.

However, since the 1980s, the Air District has received many nuisance calls. The Air District has a log of nuisance calls for the years 1992-2008; a total of 257 nuisance calls are listed in the log. In response to the nuisance calls and as part of its inspections of the facility, the Air District issued at least 21 violations to Halaco.

The California Department of Public Health found that Halaco released contaminants into the air by operating carelessly or by intentionally avoiding the procedures that would have controlled the emissions. There were uncontrolled emissions of ammonia, particulate matter, sulfur dioxide, and many other contaminants.

The California Department of Public Health concludes that the uncontrolled emissions posed a health hazard. However, there is no information to help us identify all of those other contaminants and the amounts that were released.

Is the Halaco Contamination a Public Health Hazard?

The California Department of Public Health concludes that uncontrolled emissions from Halaco likely posed a public health hazard in the past. However, because of missing environmental data, it is not possible to measure the impact of those emissions.

After reviewing existing information, we found there is no current risk of exposure for nearby residents, for workers in the agricultural fields, for people walking on the beach, the wetlands, or the Nature Conservancy Land, or for people who consume the products grown in those fields. There are concerns for people that might dirt bike ride or engage in other dusty activities on the Nature Conservancy Land or the Waste Disposal Area.

Dirt Bike Riding Presents a Public Health Hazard

The California Department of Public Health found that the activities posing a public health hazard are the ones that create a lot of dust, such as dirt bike riding on the Waste Disposal Area when it used to be uncovered and on the Nature Conservancy Land.

The main hazard for the dirt bike rider on the Waste Disposal Area when it was uncovered was from breathing soil contaminated with manganese and beryllium, once that soil becomes airborne. The main hazard for the dirt bike rider on the Nature Conservancy Land is breathing soil contaminated with manganese, once that soil becomes airborne.

Breathing beryllium in dusty conditions can be linked with sensitivity to beryllium and possibly granulomatous disease of the lung. In some studies, breathing manganese has been linked to neurological changes in workers. However, the estimated levels of manganese that the dirt bike riders breathed on the Waste Disposal Area or on the National Conservancy Land are much lower than the levels that the workers breathed. Therefore it is possible, but not probable, that the dirt bike riders could have health effects from breathing manganese in the soil.

The Waste Disposal Area was fenced in April 2007 and covered with a net that reduces the dust created by the soil.

Health Information for the Community Around the Halaco Site

CDPH looked at health information to see if the chemicals from Halaco caused any health problems. We looked at information about the health of people who lived in areas closest to Halaco, in Port Hueneme and Oxnard. These communities were the most likely to have been exposed to the chemicals. CDPH reviewed information about health problems that are related to the chemicals from Halaco. These health problems include asthma, cancer, birth defects, low birth weight, and preterm births (babies born early).

Asthma

CDPH looked at the rate of asthma, and the rate of people who were in the hospital because of their asthma ("asthma hospitalization"), during the years that the company was in operation and when the company was closed. In areas closer to Halaco, we did not find higher rates of asthma, or higher rates asthma hospitalization, compared to people in areas farther from Halaco when the company was in operation or when the company was closed.

Birth Defects
Information about birth defects in the area was only available for 1989. For this year, we looked at the number of birth defects in babies whose mothers lived in the areas closer to Halaco when their babies were born. The number of children born with birth defects in general in the areas closer to Halaco was not higher than the number seen in areas farther from Halaco. The number of Hispanic babies born with neural tube defects, which is a kind of birth defect, was higher than the numbers seen in areas farther from Halaco. We did not see a higher number of neural tube defects in non-Hispanic babies. However, there were not enough births among non-Hispanic mothers in the areas closer to the Halaco site to determine whether or not exposure to Halaco is related to more mothers of all races and ethnicities having babies with neural tube defects.

Cancer
In areas closer to Halaco, we did not find higher rates of cancer in general, compared to cancer rates in areas further from Halaco. Of the cancers that are related to the chemicals from Halaco, we did find a higher rate of lung cancer in Whites living near Halaco compared to the rate found in the areas farther from Halaco. We did not see a higher rate of lung cancer in Hispanics who lived closer to Halaco. If the lung cancer was caused by exposure to the chemicals from Halaco, we would have expected to see a higher rate in all groups.

Low Birth Weight
CDPH looked at low birth weight in babies born during the years that the company was in operation. The rate of babies born with low birth weight in areas closer to Halaco when the company was in operation was not higher than the rates found in areas closer to Halaco when the company closed and areas farther from Halaco during the entire time period studied.

Preterm Births
CDPH looked at the rate of preterm births in areas closer to Halaco, during the years that the company was in operation. We found that the rate of preterm births in the areas closer to Halaco when the company was in operation was higher than in areas closer to Halaco when the company was closed and areas farther from Halaco during the entire time period studied. We also looked at the rate of preterm births during the years that the company was in operation and compared them to rates of preterm births during the years after Halaco closed. After Halaco was closed, the rate of preterm births in the areas closer to Halaco were slightly lower than in areas farther from Halaco. It is possible that the chemicals from Halaco caused the preterm births, but because there is not much information about the exposures to the chemicals, we cannot be certain.

Background

The California Department of Public Health (CDPH) has prepared this public health assessment (PHA) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), a federal agency within the U.S. Department of Health and Human Services, located in Atlanta, Georgia. This PHA evaluates the public health significance of the Halaco Engineering Company (henceforth referred to as Halaco), and is based on a review of environmental sampling data and health outcome data, the collection of community concerns, and consultation with involved agencies and interested stakeholders. A glossary of terms can be found in Appendix A.

Site Description and Site Visit

The Halaco site is located at 6200 Perkins Road in the City of Oxnard, Ventura County, California (Appendix B, Figure B1). From August 1965 to August 2004, Halaco operated the smelter in Oxnard, which recycled metal, primarily aluminum and magnesium. On June 11, 2007, CDPH staff conducted a preliminary visit at the Halaco site with the U.S. Environmental Protection Agency (EPA)'s Remedial Project Manager.

CDPH visited the following areas on and around Halaco (Appendix B, Figure B1):

- The 11-acre smelting area.
- The 14-acre Waste Management Unit (WMU).
- The 13-acre Waste Disposal Area (WDA).
- The Oxnard Industrial Drain (OID), which separates the smelter from the WMU and the WDA (Appendix C, Photo C1).
- A parcel of land owned by the Nature Conservancy, east of the WMU and WDA (Appendix C, Photo C2).
- A parcel of land owned by the Nature Conservancy, north of the WDA.
- The wetlands to the south of the site.
- Ormond Beach.

The 11-acre smelting area consists of the baghouse unit and the smelter building with the main office. The steel-constructed smelter building was showing signs of deterioration; panels were missing and parts of the roof were exposed (Appendix C, Photo C3). Three large entryways were taped off with caution tape (it is believed these entryways were used to cool down the molds and release emissions into the air). There is a concrete wall in the smelter area but it does not enclose the area. Three sides of the area are closed with a cinder block fence, originally installed by Halaco to keep trespassers out. However, since the site's closure, people have been seen trespassing and wandering onto the area. Halaco had installed a 6-foot barbwire fence surrounding the site, which CDPH staff noted was in need of repair because trespassers were still gaining access through the fence.

The baghouse unit, located behind the smelter building, consists of ten individual large metal compartments; it also showed signs of wear (Appendix C, Photo C4). A baghouse is a chamber containing fabric filter bags that remove particles from furnace stack exhaust gases. The chambers were used to eliminate particles greater than 20 microns in diameter [1].

The grounds of the smelter site were littered with concrete and the soil and dirt were easily blown into the air when walking around many parts of the site. Broken concrete, rebar, and scrap metal lying in piles around the site (Appendix C, Photo C5), as well as gravel near the baghouse area, posed a risk of slipping, tripping, and falling at and around the site.

At the time of CDPH's visit, the WMU and WDA had been stabilized and covered by EPA (Appendix C, Photos C6-C8). The cover consists of a thick rope-like (coir) material that looks like a net on the waste pile and on both sides of the OID (Appendix C, Photo C9). The protective layer prevented the material from crumbling off the waste pile and falling into the OID (Appendix C, Photo C10), and reduced the likelihood of the material getting blown into nearby communities.

CDPH noted that the Halaco site is frequented by trespassers. The evidence of trespassers includes intricate graffiti throughout the smelter area, which most likely required a substantial amount of time and more than one visit to the site to complete (Appendix C, Photos C3 and C5). According to the EPA, the barbwire fence was installed at the end of April 2007; since then, trespassing has decreased. However, in June 2007, CDPH staff noticed that the 6-foot fence topped with barbwire was breached in two locations and allowed relatively easy access to the site afterhours (Appendix C, Photo C11) and holes have been seen in other parts of the fencing (Appendix C, Photo C12). Repairs are made of the fences when the breaching of the fence occurs; however, it appears that entry to the property is on-going even if old ways of getting on the property are repaired. On a visit to the Halaco site in September 2007, CDPH staff observed the gate open around the WMU and WDA, and signs that motorbikes had been ridden across the coir matting.

History of Operations

Halaco built its recycling smelter plant in August 1965 on top of the old Oxnard Dump. Past activities include recovering metals from nonferrous scrap metal such as primary smelting sludge, Volkswagon transmissions, and aluminum cans. The scrap metals were melted (Appendix C, Photos C14-C16), the dross (scum) from the melt was removed, and the remaining melt was poured into molds. The dross was then washed with water to recover any additional salvageable metals in the rotary washer (Appendix C, Photo C13).

Between approximately 1965 and 1971, Halaco discharged its industrial wastewater into the OID [2]. In or before 1971, Halaco was being monitored by the Los Angeles Regional Water Quality Control Board (LARWQCB), and so they started piping their industrial wastewater from the smelter across the OID onto the unlined WMU (Appendix C, Photo C17). The wastewater included material from the washer-tumbler and furnace stack scrubbers. The solids settled out into the pond and some of the clarified water was pumped back to the plant for reuse. Some, maybe most, of the water infiltrated and/or evaporated. The drained material from the WMU was first used to create berms on the WMU, then later in time, was spread on the WDA.

Eventually, the WMU covered an area approximately 14 acres, and reached a height of about 25 feet above the natural ground surface. The volume of the WMU is estimated to be approximately

700,000 cubic yards. At closure, the WDA covered an area of approximately 13 acres, and reached a height of about 5 feet above the natural ground surface. The volume of the WDA is estimated to be approximately 112,900 cubic yards.

Current Status of the Property

Due to Halaco's inability to recover from Chapter 11 bankruptcy in 2002, Halaco closed in September 2004 [3]. In January 2006, after Halaco ceased all operations, Chapter 11 bankruptcy was converted to a Chapter 7 bankruptcy (liquidation). In 2006, Chickadee Remediation Company purchased the WMA and assumed the lease to the former smelter property from the trustee appointed to oversee the Halaco Bankruptcy. Alpha and Omega Development, LLC subsequently acquired the WMU for 2.5 million dollars (Clarence Haack, former owner of Halaco, personal communication, June 2007). Future use of the properties remains uncertain.

Regulatory and Legal Activities Directed at Halaco

Over the years, a number of regulatory agencies and non-governmental organizations addressed environmental and community concerns regarding the Halaco site.

- The Ventura County Air Pollution Control District (Air District) issues permits for sources of air pollution, and issues conditions in those permits to ensure compliance with air pollution rules and regulations. The Air District also enforces the nuisance rule. Halaco was first issued a permit by the Air District in 1976. The Air District conducted annual inspections for compliance related to the permit, inspections related to nuisance calls, and observed certain activities carried out at the facility such as source and air pollution control equipment test.

  Though there were many nuisance calls related to Halaco prior to 1992, the Air District began systematically recording the nuisance calls regarding Halaco in 1992. From 1992 to 2004 when the facility closed, 257 nuisance calls were filed with the Air District; 142 were odor-related.

  According to CDPH's review of the Air District files, the Air District issued 21 Notices of Violations to Halaco, the first one in 1982 [4]. Eleven of the violations were related to nuisance, eight for failing to meet requirements of the permit, and two for operating without a permit for a new part of the air pollution control equipment.

  In the fall of 2003, a jury found Halaco guilty of three misdemeanor counts for unlawful air emissions. Halaco was sentenced to a 3-month probation period and fined 7,500 dollars. Under the terms of probation, Halaco had to install monitoring equipment and send its air data to the Air District for a year. If Halaco exceeded the emission limits established in its air permit, it was required to stop operating immediately. Random air sampling conducted in April and September 2004 revealed that Halaco had exceeded the air permit limits, and thereby violated the terms of its probation. Halaco, already in a Chapter 11 bankruptcy, presumably did not have the funds to return to compliance and to reopen.

- Starting in 1969, Halaco received a Radioactive Materials License from CDPH's Bureau of Radiologic Health, now the Radiologic Health Branch (RHB), to recycle magnesium-thorium alloy. The permit expired in August 1974. During 1965-1977, Halaco received and processed estimated 500 to 600 pounds of magnesium-thorium alloy per year [2].

  In November 2003, RHB believed residual levels of thorium were present in materials in the WMU along the OID, and residual levels of cesium were present in the water transport system at the site, and issued Halaco an Order to Characterize Radioactive Materials at the site. In March 2004, Halaco was notified that it had neither fully nor satisfactorily complied with that order [5].

- LARWQCB began monitoring Halaco's activities in 1971, and in 1980, began regulating them under the National Pollutant Discharge Elimination System permit. In March 2002, LARWQCB ordered Halaco to stop all discharges to the WMU. It was determined that the waste could discharge ammonia to the surface and groundwater. In September 2002, Halaco ceased discharging its waste and began processing waste with a filter press, resulting in filter cake. A filter cake is formed by the substances that are retained in or on a filter. The filter cake grows in the course of filtration and becomes "thicker" as particulate matter is being retained [6]. In July 2003, Halaco was issued a Notice of Violation (NOV) by LARWQCB for failing to properly contain the filter cake waste. In October 2003, Halaco was issued a Cleanup and Abatement Order stating that the current state of the WMU was continuing to threaten Ormond Beach, the wetlands, Oxnard Plain groundwater, and the waters of the State of California [2].

- On October 4, 1979, the predecessor to the California Department of Toxic Substances Control (DTSC), within the California Department of Public Health, took composite samples of materials from the waste ponds and found that they contained "appreciable levels" of several metals.

  On October 17, 1985, DTSC issued a NOV to Halaco for failing to have a permit to treat, store, or dispose of hazardous waste on-site, and for disposing of hazardous waste at a non-permitted facility. Halaco was ordered to cease unlawful disposal and correct the violations by submitting a plan for the removal of wastes and restoration of the wetlands. DTSC issued Halaco another NOV on March 17, 1986, for disposing of hazardous waste without a permit because the waste contained copper and zinc above allowable levels for disposal in a place other than a hazardous waste landfill. On April 29, 1994, DTSC reached a settlement allowing the disposal of the material at higher than typically allowable levels of copper and zinc, because the nature of the soils and the type of waste would mean less likelihood of migration.

- In January 2001, the Santa Barbara Channelkeeper and the Environmental Defense Center filed lawsuits against Halaco in state and federal courts in an effort to force Halaco to clean up the site. The proposed agreement that was agreed upon required Halaco to cease discharging contaminated wastewater to the settling ponds, to stop adding solid waste to the slag heap, to install measures to ensure that polluted stormwater did not run off the site, and to install air pollution monitoring and control technology. Halaco was also required under the proposed settlement to remove a portion of the waste pile over a 30-year period, or else pay up to 500,000 dollars into a fund to be used for environmental enhancement efforts in the area. The proposed settlement agreement further required Halaco to pay 50,000 dollars for a consultant to monitor the company's compliance and to submit to random sampling of its air emissions. Random air emissions testing conducted in April and September 2004 showed that Halaco was violating its probation by exceeding the limits of its air pollution permit. This forced Halaco to permanently cease operating in September 2004.

EPA’s first involvement at Halaco was with the completion of a Preliminary Assessment and Site Inspection on April 1, 1983 [2]. Then EPA conducted an Expanded Site Inspection in August 7, 1992 [2].

EPA became involved again at Halaco following LARWQCB’s written request dated February 21, 2006, asking for federal removal action at the site. EPA conducted a removal evaluation during March and April 2006, and determined that time-critical removal action was needed due to Halaco’s lack of security, evidence of rampant trespass and vandalism, and the presence of uncontrolled hazardous substances at the site. The property owners removed drums and other hazardous substances, fenced the waste pile, and installed a silt curtain and straw wattles.

EPA contractors conducted a sampling project the week of June 19, 2006, and continued through the following week. EPA contractors sampled the following matrices: soil, sediment, surface and groundwater, and air. EPA conducted the following analyses on the samples: X-ray fluorescence, Contract Laboratory Program metals (soil, sediment, and water), volatile organic compounds (VOCs) (water), Soluble Threshold Limit Concentration metals, radionuclides in soil and water, fish tissue, and air filter metals. With the available data, EPA prepared the Integrated Assessment for Halaco Engineering Company on January 10, 2007.

In February 2007, EPA implemented additional measures to stabilize and secure the site, which included controlling the contaminated surface water runoff from the site, windborne erosion of contaminants, and runoff erosion of sediments into the surrounding wetlands and the OID. In order to stabilize the slope, EPA used excavation equipment. Once the waste pile was graded properly, EPA placed natural fiber matting on the slopes, used as a protective measure against erosion of the waste solids into the wetlands and waterways. EPA transferred waste solids from the smelter area to the WMU for temporary storage [7].

On March 2, 2007, EPA discovered elevated concentrations of waste solids in the wetlands just across the foot bridge located on Perkins Road. Sampling of the waste showed elevated levels of alpha radiation (alpha radiation consists of helium-4 nucleus and is readily stopped by a sheet of paper) [8]. EPA and the City of Oxnard consequently closed the foot bridge until the removal action was completed. On March 12-23, 2007, EPA initiated the removal of thorium-contaminated waste. EPA worked with the U.S. Fish and Wildlife Service and the California Coastal Conservancy to ensure minimal impact to the wetlands or endangered species habitat.

EPA nominated the Halaco site to the National Priorities List on March 7, 2007.

In April 2007, EPA completed the installation of the coir matting, a rope-like material used to minimize erosion of the waste solids into the wetlands and the OID. As a security measure, a 6-foot fence topped with barbwire was installed around the perimeter of the WMU. EPA also posted signs warning the public of hazards and advising them to stay away from the site [7].

On May 29, 2007, EPA conducted an assessment of the southeast corner of the smelter and found the following contaminants of concern: radionuclides (thorium series and radium series) and heavy metals. EPA's follow-up actions included a gamma radiation survey and a collection of soil and groundwater samples.

Land Use and Demographics

The land near the Halaco site is mixed industrial, agricultural, and residential (Appendix B, Figure B1). When Halaco started its operations in 1965 it was built on top of a former municipal dump. Halaco's neighbors, the wastewater treatment plant and the paper mill already existed. The rest of the area around the property was largely undeveloped, with farmland and wetlands surrounding the property. During the 1970s and 1980s, many surrounding farms were annexed in favor of development. Today, Halaco's closest neighboring community resides less than ½ mile from the site (Appendix B, Figure B1). To the north and east of the site are agricultural lands and the Nature Conservancy Land (NCL). Ormond Beach and the OID outfall are located directly south of the site, whereas the OID and the northern Wetlands are located north of the site. There are a lot of small businesses close to the Halaco site; many of them are located within two strip malls. The businesses include various retail stores, restaurants, a bakery, and services for legal migrant education and vocational programs. CDPH noted many of the patrons and employees are Spanish-speakers and some are Spanish monolingual.

The former Weyerhaeuser, now Internation Paper. paper recycling plant and the Oxnard Wastewater Treatment Plant, both located on Perkins Road, are the closest entities to the Halaco site. Reliant Energy is located on South Edison Drive, and an industrial metal stamping plant is along Arcturus Avenue, directly above the farmland east of the site (Appendix B, Figure B1).

The two Oxnard neighborhoods closest to the Halaco site are known as Southwinds and Cypress, located ½ mile north and northeast of the site, respectively [9]. Approximately 80% of residents in the Cypress and Southwinds neighborhoods speak a language other than English at home and approximately 30% lived below the federal poverty level in 1999 [10]. The Surfside neighborhood of the City of Port Hueneme is located west of the site. In 1999, less than 20% of residents in the Surfside neighborhood spoke a language other than English at home, and less than 10% lived below the federal poverty line [10]. An elementary school (kindergarten through fifth grade) is located approximately ½ mile from the site in the Southwinds neighborhood; it is designated as a "high poverty school" by the school district. The school serves about 740 students, 83% of whom are learning English as a second language [11]. Many children attending the elementary school belong to families working in agriculture, many of whom migrate. As a result, the student body has a high percentage of transience.

Community Health Concerns

The collection, documentation, and responses to community health concerns are a vital part of the PHA process. This section describes outreach efforts and characterizes past and present exposure and health concerns reported to CDPH. In addition, this section includes an evaluation the community's health concerns based on available scientific literature, within the framework and limitations of the PHA.

CDPH reviewed nuisance call logs maintained by the Air District and other records maintained by the agency. In addition, CDPH conducted outreach to people who worked in the neighboring businesses, as well as people currently living in the residential area near the site, in order to document health concerns related to Halaco.

Past Concerns Reported to the Air District

Prior to 1992, the Air District maintained some paper records to document nuisance calls. A nuisance call investigation conducted by the California Air Resources Board (CARB) on December 27, 1986, stated that the Air District received 13 nuisance calls between August 1985 and December 1986 [12]. It is unknown if this is representative of the number of nuisance calls made during other time periods before 1992. In 1992, the Air District began using a computerized system to log nuisance calls (Keith Duval, personal communication, April 29, 2008).

The Air District provided CDPH with a log of nuisance calls spanning the years 1992-2008; a total of 257 nuisance calls are listed in the log. From 1992 to 1994, the entries provide information about the date, type, and outcome of a the nuisance call. In 1994, the Air District began using a system that allowed for more detailed entries. Particularly, starting in 1994, the Air District's nuisance call history contains more detailed information such as the type and outcome of the nuisance call; the date and time of the nuisance call; the nature of smells or health concerns; the impact of emissions on the quality of life; and details about the caller when provided (e.g., person visiting the beach, person living in the area, person working in the area). A summary of these details is provided next.

The Air District organized nuisance calls as relating to dust, odors of a specific source, odors of an unknown source, and visible emissions or smoke. Other nuisance call types are categorized as 'miscellaneous.' Using this system, the Air District captured 142 nuisance calls relating to odors of a specific source, 99 nuisance calls about visible emissions or smoke, 6 nuisance calls relating to dust, 4 nuisance calls about odor from an unknown source, and 6 miscellaneous nuisance calls. In four cases, the inspections investigating the nuisance calls resulted in a NOV being issued. A Notice to Comply was also issued. Other nuisance calls were classified as either "unable to verify" or "problem, not a violation."

The years 2000 and 2001 contain the most entries, with 49 and 28 nuisance calls, respectively. However, it is not clear if this is due to worse emissions or more diligent reporting. On each of the following days, several nuisance calls were reported: March 27, 1996 (2 nuisance calls); March 1, 2000 (2 nuisance calls); March 7, 2000 (5 nuisance calls); February 13, 2001 (2 nuisance calls); February 1, 2004 (2 nuisance calls); February 25, 2004 (6 nuisance calls); and March 4, 2004 (5 nuisance calls). Nuisance calls made on the same day were similar in terms of the color and smell of emissions, as well as of the health concerns reported.

The most common smells described included ammonia, sulfur, and metal. Smells were often described as foul, obnoxious, toxic, and terrible. Similar accounts have been reported elsewhere [13].

The most common health concerns reported to the Air District were difficulty breathing, experiencing a chemical or metallic taste, headaches, eye irritation, and nausea. People also reported feeling generally sick or affected, without providing more detailed descriptions of their health concerns. Several callers were concerned about potential health effects to students at the nearby elementary school.

In addition to the information above, the Air District's historical log captured information about how residents' and workers' quality of life was impacted by Halaco emissions. For example, several residents reported having to close their windows in order to avoid Halaco-related odors; some said they were unable to sleep because of the strong odors emitted overnight; others would not walk on the beach because of Halaco odors and emissions—one community member was noted as saying that "it is impossible to go for a walk or run by the beach close to Halaco Engineering without getting 'soot' on you." Finally, several callers—workers from neighboring facilities, as well as residents—stated that Halaco soot corroded the paint on their cars.

In some (96) cases, people reporting concerns identified themselves. Based on this information, the overwhelming number of people reporting exposure and health concerns were workers of adjacent facilities (46) and nearby residents (25), followed by visitors to the beach or pier (9), people driving in the area (6), workers at a power plant about ½ mile from the site (3), restoration workers (2), and people representing or concerned about agricultural workers in the fields next to the site (2). Other callers identified themselves as: a shopper at the strip mall, a property owner, and fire department staff.

Process for Gathering Community Health Concerns

CDPH staff gathered community health concerns in person, via telephone, and by email beginning in June of 2007. CDPH coordinated outreach activities with EPA. EPA included an announcement about CDPH outreach in an EPA fact sheet distributed to English- and Spanish-speaking residents by mail and in person [14]. CDPH carried out a series of coordinated community presentations with EPA, providing joint presentations to the community and elected officials in September and October 2007. CDPH met with key leaders from local community-based organizations to identify outreach strategies for different segments of the community. Based on this feedback, CDPH staff met in person with workers of neighboring facilities, performed in-person canvassing of the shopping strip near the Halaco site, and explored future outreach ideas with local school and community health center staff. In addition, some community members contacted CDPH when local newspapers announced CDPH's involvement at the Halaco site [15-18]. CDPH received community concerns in person, by mail, and by e-mail throughout 2007.

Community members were concerned primarily about past exposure to Halaco contaminants, although a few reported specific health concerns that they thought might be related to exposure to contaminants from the Halaco site. CDPH heard from a variety of people, including former Halaco workers, current and former workers of neighboring facilities and businesses, and community residents. Past and current exposure and health concerns are described next.

Past Concerns Reported to CDPH

CDPH collected health concerns throughout 2007. People reporting concerns were workers of neighboring facilities and businesses, key stakeholders from nearby neighborhoods, and former Halaco workers. Their exposure and health concerns are consistent with those in the Air District's historical log; they are summarized next.

People reported smelling ammonia and tasting metal in their mouths. They described emissions as 'soot,' 'ash,' and 'fog' (Appendix C, Photo C18). They reported the soot blowing to Hueneme Road. Many people reported emissions being worse at night; a worker at a neighboring facility stated that it was difficult to take breaks outside during the night shift because Halaco emissions made it difficult to breathe.

People were concerned that they had been in the direct path of Halaco particulates in the past. Some community members reported the prevailing winds of Halaco emissions as being toward the agriculture fields. This is consistent with statements made in the past by CARB staff [19]. Other community members stated that the wind blew primarily towards the waste water treatment plant, and noted that an aluminum pole in the vicinity was corroded on the side facing Halaco.

One community member stated that he walked with his children by the railroad tracks separating Halaco from the nature conservancy area. On one occasion while walking along the railroad tracks, he and his children came across small marble-like stones, which they collected and took home to use as playing marbles. The community member was concerned that the marbles were Halaco waste and a potential exposure risk for his children. The source of the marbles is unclear.

Past health concerns reported to CDPH included short-term effects resulting from exposure to Halaco emissions, such as dry eyes, burning of the nose and throat, nausea, headaches, hacking cough, heaviness or pressure in the chest, and a feeling of smoke in the lungs. Community members reported having some long-term health concerns such as rheumatoid arthritis, diabetes, cancer, bronchitis and worsened asthma.

One community member visited the public parking lot next to Halaco four to five times a week for two to three hours each time, with his adult son, who had been diagnosed with epilepsy. The community member noticed that his son experienced an increase in seizures after visiting the area. The community member was concerned that exposure to Halaco contaminants triggered epileptic seizures for his son.

People with no current health concerns were worried about the potential for long-term health effects due to past exposure to Halaco emissions. The following table shows the health concerns and effects reported to CDPH; health effects are organized as either related or not related to cancer.

Table 1. Cancer and Noncancer Health Concerns and Effects Reported to CDPH

Cancer Concerns/Effects	Noncancer Concerns/Effects
Leiomyosarcoma	**Short-Term Concerns/Effects** Aggravated epileptic seizures Eye, nose, and throat irritation Coughing Dehydration Difficulty breathing Skin irritation **Long-Term Concerns/Effects** Asthma Chronic Bronchitis Diabetes Rheumatoid arthritis

Current Community Concerns

Currently, community members are concerned about potential exposure to contaminants during future remedial activities, and that adequate cleanup ensures the safety of future populations who interact with the land. Community members are concerned that trespassing by graffiti artists and dirt bike riders may be exposed to Halaco contaminants; they have advocated for increased security on site.

Discussion of Environmental Contamination

Table 2 below presents a summary of the exposure situations identified at this site. In this section, we summarize the environmental sampling that is relevant to the evaluation of those exposure pathways (soil, including sediment and sand, surface water, air, and fish) to determine whether a compound is present at a level above background and, if it is present at elevated levels, whether the levels exceed screening criteria (media-specific comparison values).

CDPH first determined those compounds that are present on the site above background levels. The amount of these same compounds was then examined in all the other locations to see if they exceed background levels. Those compounds found elevated above background levels in a media relevant to a pathway are listed in Table 2 below.

Table 2. Exposure Pathways at the Halaco Site, Oxnard, California

Pathway	Media	Exposure Point	Exposure Route	Receptor	Time	Hazards/Contaminants Present Above Background Levels	Status
Residential: Air	Air	Air in and around home	Inhalation	Child and adult resident	Past (the facility closed in September 2005)	No sampling data available; Lots of anecdotal information and Air District violations	Potential
Smelter	Surface soils	Surface soils on the site	Inhalation Ingestion	Trespasser, e.g., graffiti artist	Past and current (since the facility closed in September 2005)	Metals (aluminum, beryllium, copper, lead, and manganese) in the surface soil, and physical hazards of the site	Completed
WMU and WDA	Surface soils	Surface soil in WMU and WDA	Inhalation Ingestion	Dirt bike rider	Past (after the facility closed in September 2005 until the WMU was covered in January 2007)	Metals (aluminum, barium, beryllium, cadmium, copper, lead, and manganese) and radionuclides (thorium-228 and thorium-232) in surface soil of WDA	Completed
Nature Conservancy Land (NCL)	Surface soils in the NCL	NCL property east of WMU and WDA	Inhalation Ingestion	Child and adult visitor	Past, current, and future	Metals (aluminum, copper, lead, and manganese) and radionuclides (thorium-228, thorium-230, thorium-232, and potassium-40) in surface soil	Completed
Nature Conservancy Land (NCL)	Surface soils in the NCL	NCL property east of WMU and WDA	Inhalation Ingestion	Dirt bike rider;	Past, current, and future	Metals (aluminum, copper, lead, and manganese) and radionuclides (thorium-228, thorium-230, thorium-232, and potassium-40) in surface soil	Completed

Table 2. Exposure Pathways at the Halaco Site, Oxnard, California

Pathway	Media	Exposure Point	Exposure Route	Receptor	Time	Hazards/Contaminants Present Above Background Levels	Status
Farm Worker	Surface soil	Agriculture lands	Inhalation Ingestion	Adult farm worker	Past, current, and future	Nothing elevated in limited sampling	Potential
Residential: Soil	Surface soil	Residential soils	Inhalation Ingestion	Child and adult resident	Past, current, and future	Nothing elevated in limited sampling	Potential
Wetlands	Surface sediment; soil in the wetland	Surface soils in the wetlands	Inhalation Ingestion	Child and adult visitor	Past, current, and future	Metals (aluminum, copper, and lead) and radionuclides (thorium-228 and thorium-232) in sediment/soil	Completed
Beach	Sand; surface soil	Beach	Inhalation Ingestion	Child and adult visitor to the beach	Past, current, and future	Radionuclides (cesium-137, thorium-228, and thorium-232) in sand/soil	Completed
OID	Surface water	OID	Inhalation Dermal	Child and adult visitor to the OID	Past, current, and future	Manganese and radionuclides (thorium-228, thorium-230, thorium-232, and potassium-40) in water and sediment	Completed

WMU: Waste Management Unit; WDA: Waste Disposal Area; NCL: National Conservancy Land; OID: Oxnard Industrial Drain.

In this section, we also compare the amounts of each of the compounds to media-specific comparison values, which are estimates of a daily human exposure to a contaminant in a particular media (soil, air, and water) that is unlikely to cause cancer or noncancer (other than cancer) adverse health effects. The media-specific comparison values are developed based on the assumption that the person is exposed daily; they are thus considered screening values for most non-residential exposure scenarios. CDPH did not limit the toxicological evaluation to those compounds present at levels above media-specific comparison values; we evaluated the potential health impact of the mixture of all compounds found at levels above background. The comparison to screening values (media-specific comparison values) is discussed in this section but was not used to determine compounds evaluated in the toxicological evaluation.

In the next section, CDPH further evaluates those pathways where people are being exposed to chemicals above typical levels. Past exposures particularly via air releases from the facility are described qualitatively in this section and the community concerns section. Information about the current conditions at the site primarily comes from EPA's Integrated Assessment. For this work, EPA contracted Weston to conduct an initial site characterization from June 20-29, 2007, at and around the Halaco site. Weston examined soil, sediment, air, waste, surface and groundwater, and fish tissue [2]. All the samples were analyzed for metals, the main contaminants of concern from the Halaco operation. However, because of the combustion that occurred at the smelter and because several storage tanks of petroleum were located on the property, CDPH recommends a wider range of analytes be examined in future sampling. Specifically, we recommend that dioxins and gasoline/fuels be analyzed in the smelter samples. If these compounds are identified above screening levels in the site samples, than these additional analyses should be considered for samples from other areas.

Soil and Waste Samples Collected at the Halaco Site

Weston took 397 measurements in the field using X-ray fluorescence (XRF). Weston took surface (usually the first 6 inches) and subsurface samples from the sediment, soil, or waste piles, and the samples were analyzed at a mobile unit located at the site (Appendix B, Figures B2-B4).

On-site sampling locations included the smelter area, the WMA, and the WMU. Samples were taken in areas most likely to be affected by Halaco's former operations [2]. These areas include surface soils (0-6 inches) beneath chemical storage areas, sumps, and process areas, as well as surface soils where raw materials and/or wastes were staged, stored, or managed on-site. Samples were also taken in areas showing signs of contamination. Off-site samples included the NCL and the agriculture fields located to the north and east of Halaco, and residential soils located adjacent to homes on Hueneme Boulevard (Appendix B, Figure B2) [2]. Sample locations were chosen in the field based on 1) visual indications of contaminant migration, including staining, soil color, or distressed vegetation; 2) proximity to sensitive targets, such as critical habitat or waterways; 3) radiation readings above background; and 4) location access [2].

Background samples for the smelter, WDA, and WMU were taken in the empty lot located across from the smelter on Perkins Street (Appendix B, Figure B3). Beach and wetland background samples were taken west of the site (Appendix B2, Figure B3). OID background samples were collected north of the site (Appendix B, Figures B2 and B3).

XRF samples were analyzed for antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, palladium, selenium, silver, and zinc. CDPH determined the levels of antimony, arsenic, cobalt, molybdenum, palladium, and selenium on the smelter, WMU, and WDA not to be above background levels; thus, these compounds will not be discussed further in this document. In addition, iron will not be evaluated further in this document as it has little human toxicity.

Of the 397 surface soil samples collected at and near the site, 117 solid-matrix samples were submitted for determinate analysis for metals by EPA Method 6010B [2]. The determinate samples were analyzed for 14 contaminants: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, magnesium, manganese, nickel, silver, vanadium, and zinc. CDPH found the levels of antimony, arsenic, cobalt, and vanadium on the smelter, WMU, and WDA to not be elevated above background; thus, these compounds will not be discussed further in this document. In addition, magnesium will not be evaluated further in this document as it has little human toxicity.

In discussing the metals found in the soil and sediment at and around the site, CDPH presents the sampling data for XRF and the determinate samples. Though the determinate analysis provides more accuracy than does the field testing XRF, in some cases there were very limited numbers of determinate samples for a given area. For instance, there are only four surface soil samples from the WDA that were sent for determinate analysis, and only two from both the residential and agricultural areas. CDPH used the determinate analyses for the toxicological evaluations.

Surface soils were screened for gamma-radiation using a Ludhau 2991 with a gamma probe. This data is not used in this report.

Weston sent a total of 130 surface soils and waste samples to a laboratory for the following radionuclide analyses: cesium-137, potassium-40, thorium-228, thorium-230, thorium-232, radium-226, and radium-228. The samples were collected from the following areas: marine sediment, beach sediment, OID, wetlands sediment, residential sediments, smelter, and agricultural area. Many of the samples that were collected were surface samples. CDPH found the samples collected below the surface had higher amounts of thorium isotopes than did the surface data. Isotopes are different forms of the same element that differ by the number of neutrons they have in their nucleus, e.g., thorium 228, thorium-230, and thorium-232.

A subset of the determinate soil and waste samples collected from the smelter and WMU were also analyzed for 49 VOCs.

In June 2006, EPA had their contractors collect additional radiological samples at the Halaco site (Wayne Praskins, personal communication, July 2008). The radium samples were collected at the smelter and the OID. The samples collected in June 2006 in the smelter and OID ranged from depths 1-15 feet below ground surface. CDPH did not use this radiological data because it was not collected from the surface soils which are the media relevant to the exposure pathways.

Soil Samples Collected in the Smelter

As part of the sampling for the Integrated Assessment, Weston took 61 soil/waste XRF readings in the smelter area (Appendix B, Figure B3) [2]. Twenty of the readings were of samples taken from the surface. Three of the surface soils/waste samples were sent to a fixed laboratory for metals and radionuclide analysis as described above. Weston also analyzed four surface soil smelter samples for VOCs.

Several VOCs were measured at trace levels in the four smelter samples. The VOC analytes were detected at levels hundreds to thousands of times lower than the EPA Preliminary Remediation Goals for soil (data not shown). Since the contaminants are below the screening values, CDPH concludes the contaminants do not present a risk for the nearby community; CDPH will not further evaluate those contaminants.

Comparison to Background Levels (Appendix D, Table D1)

- The average and maximum concentrations of ten metals (aluminum, beryllium, cadmium, chromium, copper lead, manganese nickel, silver, and zinc) measured in the determinate analysis in the samples collected from the surface of the smelter exceed the background range.
- The maximum, but not the average, concentrations of thorium-228, thorium-230, and thorium-232 are elevated in the smelter surface samples above the background range.
- The XRF readings corroborated the elevated findings of the determinate metal analyses though the average concentrations of copper and silver are within range of the XRF background range, and cadmium was not detected in either the smelter or background sample by XRF.

Comparison to Media-Specific Comparison Values (Appendix D, Table D1)

- The maximum, but not the average, concentrations of copper, lead, and manganese measured by XRF exceed its media-specific environmental guideline for children.
- The maximum, but not the average, concentrations of aluminum, beryllium, and lead measured in the determinate analyses exceed its media-specific environmental guideline for children.
- The maximum and average concentrations of copper and manganese measured in the determinate analyses exceed its media-specific environmental guideline for children.
- Two of the radionuclides (potassium-40 and thorium 228) measured in the surface soil samples exceed the health comparison values in the both the background and smelter areas.

Samples Collected in the Waste Disposal Area

The WDA is located east of the smelter and north of the WMU (Appendix B, Figure B3). When the Halaco facility was in operation, waste material that had dried on the WMU was spread on the WDA. During the sampling investigation for the Integrated Assessment, Weston collected 18 XRF samples for metal analysis. Four samples collected at the WDA were sent to the laboratory for metal and radionuclide analysis. All the samples were collected at the surface.

Comparison to Background Levels **(Appendix D, Table D2)**

- The maximum and average concentrations of 11 metals (aluminum, beryllium, cadmium, chromium, copper lead, manganese nickel, silver, and zinc) measured in the determinate analyses exceeded the background range.
- The maximum and average concentrations of thorium-228, thorium-230, and thorium-232 were elevated in the smelter surface samples above the background range.
- The XRF readings corroborated the elevated findings of the determinate analyses, though cadmium was not detected in either the smelter or background sample by XRF.

Comparison to Media-Specific Comparison Values (Appendix D, Table D2)

- The maximum, but not the average, concentrations of barium and silver measured by XRF exceed its media-specific environmental guideline for children.
- The maximum and average concentrations of copper, lead, and manganese measured by XRF exceed its media-specific environmental guideline for children.
- The maximum, but not the average, concentration of barium and cadmium measured in the determinate analyses exceed its media-specific environmental guideline for children.
- The maximum and average concentrations of aluminum, beryllium, copper, lead, and manganese measured in the determinate analyses exceed its media-specific environmental guideline for children.
- Two of the radionuclides (potassium-40 and thorium-228) measured in the surface soil samples exceed the media-specific comparison values in both the background and smelter areas.
- The maximum and average amounts of thorium-232 measured in the WDA surface soils exceed its media-specific environmental guideline.

Samples Collected in the Waste Management Unit

The WMU is located south of the WDA. Starting around 1971, Halaco placed its liquid waste into unlined ponds on the land that is now called the WMU. As part of the Integrated Assessment, EPA contractors took 90 XRF readings at depths of 5, 10, 15, and 20 feet below ground surface (Appendix B, Figure B3). Of those XRF samples, 37 samples were sent to the laboratory for metal analysis and 33 were sent for radionuclide analysis. Weston sent ten samples from the WMU for VOC analysis.

Four VOCs were measured at trace levels in the ten smelter samples. The VOCs that were detected were measured at levels hundreds to thousands of times lower than the Preliminary Remediation Goals for soil (data not shown). Since the contaminants are below the screening values, CDPH will not further evaluate those contaminants.

As described above, none of the samples were collected at the surface; the closest to the surface was at 5 feet below ground surface. CDPH did not find a trend in the concentration of barium, copper, lead, and manganese, the deeper the sample was collected. The data from all depths is summarized in Appendix D, Table D3.

Comparison to Background Levels (Appendix D, Table D3)

- The maximum and average concentrations of 11 metals (aluminum, beryllium, cadmium, chromium, copper lead, manganese nickel, silver, and zinc) measured in the determinate analysis in the samples collected from the subsurface of the WMU exceed the background range.
- The XRF metal readings corroborate the determinate sample readings for background exceedances, though the maximum, but not the average, concentration of silver measured in the WMU samples exceeds the background range.
- The maximum, but not the average, concentration of cesium-137, potassium-40, thorium-228, thorium-230, and thorium-232 exceed their corresponding background range.

Comparison to Media-Specific Comparison Values (Appendix D, Table D3)

- The maximum, but not the average, concentration of barium, cadmium, manganese, and silver XRF readings exceed their corresponding media-specific environmental guideline.
- The maximum and average concentrations of copper and lead measured in the subsurface of the WMU by XRF exceed their corresponding media-specific environmental guideline.
- The maximum, but not the average, concentration of beryllium, cadmium, thorium-230, and thorium-232 measured in the determinate samples taken from the subsurface of the WMU exceed their corresponding media-specific environmental guideline comparison value.
- The maximum and average concentrations of aluminum, copper, lead, and manganese measured in the determinate analysis in the subsurface soil of the WMU exceed their corresponding media-specific environmental guideline comparison value.
- The maximum and average concentrations of potassium-40 and thorium-228 exceed their corresponding media-specific environmental guideline comparison value in both the WMU and background soil samples.

Soil Samples Collected in the Nature Conservancy Land

As part of the Integrated Assessment, Weston took 40 XRF readings of the surface soil from the NCL located adjacent to the east side of the WMU and WDA (Appendix B, Figures B2 and B3). Of the XRF samples, 8 were sent for both metal and radionuclide analysis.

Comparison to Background Levels (Appendix D, Table D4)

- Ten of the 11 metals found at higher levels on Halaco property were also found elevated, compared to background in the determinate soil samples collected from the NCL property east of the WMU and WDA. Only silver was not found elevated compared to background.
- The XRF readings found barium, copper, lead, manganese, and zinc at elevated levels compared to background, but did not find cadmium, chromium, and nickel compared to background; this seems to be related to the high detection limits for these compounds using the XRF.

Comparison to Media-Specific Comparison Values (Appendix D, Table D4)

- The maximum, but not the average, concentration of copper, lead, and manganese measured by XRF, and manganese, thorium-230, and thorium-232 measured in the determinate samples exceed their corresponding media-specific environmental guideline comparison value.
- The maximum and average concentrations of aluminum, copper, and lead measured in the determinate samples exceed their corresponding media-specific environmental guideline comparison value.
- Cesium-137, potassium-40, and thorium-232 were measured at levels exceeding their media-specific environmental guideline comparison value in both the surface soil samples collected from the NCL and the background area.

Soil Samples Collected in the Agricultural Farmlands

The agricultural farmlands are located approximately 0.2 miles east and 0.4 miles north of the WDA (Appendix B, Figure B1). As part of the Integrated Assessment, Weston analyzed ten surface soil samples using XRF from the two agricultural areas. Half of the samples were collected from the plot of land east of the WMU (Appendix B, Figure B2). The remaining five samples were collected from the agriculture area north of the site.

Two of the samples collected from the northern agricultural area were sent for metal and radionuclide analysis.

Comparison to Background Levels (Appendix D, Table D5)

- None of the ten metals found at higher levels on the Halaco property were found elevated compared to background in the two agricultural areas that were sampled.
- None of the radionuclides were measured at concentrations that exceed background.

Comparison to Media-Specific Comparison Values (Appendix D, Table D5)

- None of the metal concentrations measured by XRF or determinate analysis in samples taken from the agricultural areas exceed their corresponding media-specific comparison value.
- The concentrations of potassium-40 and thorium-228 measured in both the samples taken from the northern agricultural area and the background area exceed their media-specific comparison value.

Soil Samples Collected in the Nearby Community

The residential sampling area is located approximately north of the smelter area and the WMU (Appendix B, Figure 1). As part of the Integrated Assessment, EPA contractors took ten XRF surface soil readings. The samples were taken along Hueneme Road (East and West) (Appendix B, Figure B2). Two of the surface soil samples were sent to the laboratory for metal and radionuclide analysis.

Comparison to Background Levels (Appendix D, Table D6)

- None of the metals analyzed for in the determinate samples or radionuclide concentrations exceed background values for these compounds.
- The XRF readings corroborate the determinate metal findings except for barium. Barium was measured by XRF at elevated levels compared to the background readings.

Comparison to Media-Specific Comparison Values (Appendix D, Table D6)

- None of the metal concentrations measured by XRF or determinate analysis measured in the surface soil from the residential area exceed their corresponding media-specific environmental guideline comparison value.
- The concentrations of potassium-40 and thorium-228 measured in both the samples taken from the northern agricultural area and the background area exceed their media-specific comparison value.

Sediment/Soil/Sand Samples

Weston collected 101 sediment/soil/sand samples during the sampling event in June 2006 [2]. The samples were analyzed for metals, using both XRF and determinate analysis as was described for the soil sampling, and radionuclides, and were collected from the following areas (Appendix B, Figures B2-B4): 1) the wetlands, south of the smelter and WMU; 2) the OID; 3) Ormond Beach, and 4) the marine area along the same stretch of shore as the beach sediments (the marine samples will not be discussed further in the PHA as there was no clear human exposure pathway for which this data would be helpful in evaluating).

Sediment/Soil/Sand Samples Collected in the Wetlands

The wetlands are located south of the smelter area and WMU (Appendix B, Figure B1).

As part of the Integrated Assessment, EPA contractors collected 29 XRF samples from the surface sediment/soil/sand in the wetlands area; they sent six of these samples to the laboratory for metal and radionuclide analysis [2]. Further west, they took six samples for XRF readings, which were considered background. These six background samples were also sent to the laboratory for metal and radionuclide analysis.

Comparison to Background Levels (Appendix D, Table D7)

- Nine of ten metals found elevated at the Halaco site were also found elevated in the determinate metal analyses from the sediment/soil/sand taken from the wetlands area near Halaco.
- The XRF readings corroborated the determinate metal analysis, except for cadmium and nickel, which were not found elevated compared to background; this appears to be related to the high detection limits for these metals using XRF.
- Thorium-228 and thorium-232 were elevated in the wetland samples taken nearer to Halaco compared to the ones taken farther away (the background samples).

Comparison to Media-Specific Comparison Values (Appendix D, Table D7)

- Copper and lead measured by XRF and in the determinate samples exceed their media-specific comparison value.
- Potassium-40 and thorium-228 concentrations measured in both the wetland samples taken near Halaco and the background area exceed their corresponding media-specific comparison value.

Sediment Samples Collected at the Oxnard Industrial Drain

The OID divides the Halaco site into the smelter region and the WMU/WDA (Appendix B, Figure B2). The water from the OID drains into the nearby lagoon.

As part of the Integrated Assessment, EPA contractors collected six sediment samples from the OID and analyzed them using XRF [2]. These samples and four additional OID sediment samples were sent to the laboratory for metal and radionuclide analysis. Weston collected six samples from the OID north of the smelter and WDA for background. The background samples were sent to the laboratory for metal and radionuclide analysis.

Comparison to Background Levels (Appendix D, Table D8)

- Nine of the ten metals found elevated at the Halaco site were also found elevated in the determinate metal analyses from the sediment/soil taken from the OID near Halaco.
- The XRF readings of chromium, copper, and zinc corroborate the elevated above background findings of the determinate metal analysis.
- Cadmium and nickel, as measured by the XRF in the OID sediment, were not found elevated compared to OID background; this appears to be related to the high detection limits for these metals using XRF.
- Barium, lead, and manganese were not measured by XRF at elevated levels in the OID compared to the background samples.
- Thorium-232 was elevated in the OID samples taken near to Halaco compared to the ones taken farther away (the background samples).

Comparison to Media-Specific Comparison Values (Appendix D, Table D8)

- The maximum concentration of copper measured in the determinate samples exceeds its media-specific comparison value.
- Potassium-40 and thorium-228 concentrations measured in OID samples taken near Halaco and in the background area exceed their media-specific comparison value.

Sediment/Sand Samples Collected at Ormond Beach

The Ormond Beach sampling area is located south of the Halaco plant (Appendix B, Figure B1).

As part of the Integrated Assessment, EPA contractors collected 27 sediment/sand samples along the beach near Halaco for XRF analysis [2]. Six of these samples were sent to the laboratory for metal and radionuclide. Weston also collected six beach samples that were considered background sediment/sand samples and were also analyzed for metals and radionuclides.

Comparison to Background Levels (Appendix D, Table D9)

- Aluminum, barium, chromium, copper, lead, manganese, nickel, and zinc were measured in the determinate samples taken from the beach at levels that exceed the background area concentrations.
- The XRF readings corroborate the determinate sample findings for barium, chromium, lead, and manganese exceeding background, but not for copper and nickel.
- Cesium-137, thorium-228, and thorium-232 were elevated in the beach samples taken near Halaco compared to the background samples.

Comparison to Media-Specific Comparison Values (Appendix D, Table D9)

- None of the metals were detected or measured in the beach samples at levels above their corresponding media-specific environmental guideline comparison value.
- Cesium-137 and thorium-228 were elevated in the beach samples collected near Halaco above their corresponding media-specific comparison value.
- Potassium-40 was elevated above its media-specific comparison value in both the beach samples taken near Halaco and the background area.

Water Samples

Weston collected surface water samples in areas adjacent to the WMU/WDA, areas up-gradient from the Halaco site and the body of water south of the WMU, as well as groundwater samples from monitoring wells located on-site. The samples were sent to the laboratory for metal and radionuclide analysis. Several water samples were analyzed for VOCs. CDPH did not review the groundwater data, as there is no exposure pathway for people with the groundwater.

Surface Water Samples Taken in the Oxnard Industrial Drain

The OID divides the Halaco site into two parcels (smelter and WMU/WDA) (Appendix B, Figure B1). The water from the OID drains into the nearby lagoon.

As part of the Integrated Assessment, EPA contractors collected a total of six surface water samples from the OID where it bisects the smelter and WMU/WDA, and in the wetland where the OID drains (Appendix B, Figure B4). Weston also collected four background samples in the OID in an area north of McWane Boulevard to represent background.

Acetone was the only VOC detected in either the background or site samples (data not shown). Acetone was detected in both site samples at the same concentrations as in the background samples. Acetone may be a lab contaminant or may be present throughout the OID and nearby surface water, but does not appear to be related to Halaco. The levels of acetone measured in all the samples are much lower than the screening level; thus CDPH will not investigate the VOCs in surface water any further.

Comparison to Background Levels (Appendix D, Table D10)

- Aluminum, barium, beryllium, copper, manganese, zinc, and potassium-40 were elevated in the surface water taken near the Halaco site compared to the background samples.

Comparison to Media-Specific Comparison Values (Appendix D, Table D10)

- One of the surface water samples taken near the Halaco site contained manganese at a concentration that exceeds its media specific comparison value.
- The concentration of potassium-40 exceeds it media specific environmental guideline comparison value in the surface water samples taken near the Halaco site and in the background samples.

Air Samples

Weston and Super Technical Assessment and Response Team collected 35 air samples around the WDA and WMU as part of the June 2006 Integrated Assessment Investigation for the Halaco site [2]. During the sampling period, Halaco had already been closed for 2 years.

Air Samples Collected During the Sampling for the Integrated Assessment

Weston collected high-volume air samplers for a 10-hour period on each of 8 days. Air sampling station's locations were picked on the basis of what would be considered an ideal background, and on which locations proved to be the greatest potential health threat posed to the community down-gradient of the site (Appendix B, Figure B5). The air sampling locations were located: off the southwest corner of the WMU (Station AIR1); off the northwest corner of the WMU (Station AIR2); along the eastern side of the WMU on the NCL (Station AIR3); north of McWane Boulevard beyond the City of Oxnard Barricades (Station AIR4); and north of the eastern side of the WMU (Station AIR5). The background sample (Station AIR1) was determined by consulting metrological data collected at the site [2]. A downwind sampler (Station AIR6) was a co-located station near AIR2 (Appendix B, Figure B5) [2].

On the night of June 22, 2006, three generators, the meteorological station, and four of the air pumps were stolen. They were replaced on June 27, 2006. As a result, there were not as many samples collected on June 23, 24, and 26, 2006. The air samples were analyzed for metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, magnesium, manganese, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc), as well as for radionuclides. Based on the on-site analysis by the on-scene coordinator, none of the air filters contained alpha radiation, so they were submitted to the lab for analysis.

Comparison to Background Levels (Appendix D, Table D11)

- CDPH compared the concentration of metals measured in the downwind samples to those measured in the background sample (Station AIR1) for that day. The WDA and the WMU appeared to be contributing some contaminated particulate to the air during the sampling days, as the levels measured in the samples taken at Station AIR1 on a particular day were, as a rule, lower than the levels measured in the other sampling locations. For instance, only one sample contained a lesser amount of beryllium than its corresponding background sample. Only three samples contained a lower level of manganese than its corresponding background sample.

Comparison to Media-Specific Comparison Values (Appendix D, Table D11)

- All of the samples, including the background samples, had concentrations of aluminum, barium, and beryllium, exceeding their noncancer media-specific comparison value.
- The concentrations of cadmium did not exceed its noncancer media-specific comparison value in any of the samples. Cadmium was detected in 14 samples at levels exceeding the cancer health comparison values.
- Manganese was detected in all air samples. The concentration of manganese exceeds its noncancer media-specific comparison value in nine of the samples, none of which are the background samples.
- Nickel was detected in all air samples, but only one of the samples contained a concentration exceeding the noncancer media-specific value.
- Several of the metals detected in the air samples do not have media-specific comparison values: chromium, copper, lead, silver, and zinc.

When the air sampling took place (June 20-28, 2006), the WDA and WMU were uncovered, except variably along the berm wall surfaces, where a soil cover of up to 12 inches was present [2]. The air sampling time took place at the same time as the other sampling efforts (soil, groundwater, and surface water), so the dust generated would have been greater than when no activity was taking place. Nevertheless, when the waste was uncovered, the air sampling demonstrates that contaminated soil could have affected outdoor air quality near the WDA and WMU.

In April 2007, EPA installed coir matting that decreases the soil from blowing off the WMU (Appendix C, Photo C8).

As discussed in the next section, CDPH evaluated exposure to contaminated soil on the smelter, the WDA/WMU, the NCL, the upper wetlands, and Ormond Beach. For each of these situations, the inhalation of soil-derived dust was included in the evaluation. The air concentrations for these evaluations were derived from assumptions of how much soil becomes airborne under particular situations (wind-generated dust or dust-generating activities), not from air measurements.

CDPH is recommending that additional air sampling be conducted in order to compare the concentrations “post coir matting.” CDPH is recommending that for the air sampling, an air sampler be placed near the former Weyerhaeuser, now International Paper, Plant, and one towards the agricultural lands as the data gathered from these monitoring stations would provide helpful exposure information for some of the nearest population.

Fish Tissue Samples

In June 2006, Weston collected fish tissue samples from various locations within the OID and the adjacent lagoon, using nets and fish traps.

Fish Samples Collected from the Oxnard Industrial Drain and Adjacent Lagoon

EPA observed people fishing in the lagoon adjacent to the Halaco facility. The species of fish being caught are not known; however, topsmelt was observed in the lagoon and are known to be eaten by humans on the California coast [20]. Weston collected nine fish tissue samples using nets and fish traps. The fish were bulked together in order to meet the minimum weight requirements for the metals and radionuclide analyses. The samples were then divided into two aliquots, one for each analysis. The fish samples were analyzed for CLP Target Analyte List metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc) and radionuclides.

Trace amounts of metals were found in the samples; however, the concentration detections were below the health comparison values (data not shown). Radionuclides were not present in the fish samples. In a personal conversation with Bob Brodberg of the Office of Environmental Health Hazard Assessment, he stated that radionuclide in fish tissue samples are rarely of concern (personal conversation, Robert Brodberg, Ph.D., OEHHA, Chief, Fish and Water Quality Evaluation Section, January 7, 2008).

Exposure Pathways Analysis

Exposure occurs when a chemical comes into contact with people and enters the body [21]. For a chemical to pose a human health risk, a completed exposure pathway must exist. A completed exposure pathway consists of five elements:

- A source and mechanism of chemical release to the environment.
- A contaminated environmental medium (air, soil, or water).
- A point where someone contacts the contaminated medium (known as the exposure point).
- An exposure route, such as inhalation, dermal absorption, or ingestion.
- An actual human exposure.

Exposure pathways are classified as either completed, potential, or eliminated. In completed exposure pathways, all five elements exist [21]. Potential exposure pathways are either not currently complete (but could become complete in the future) or are indeterminate due to lack of information. Pathways are eliminated from further assessment if one or more elements are missing and are never likely to exist.

A time frame given for each pathway indicates whether the exposure occurred in the past, is occurring now, or is likely to occur in the future [21]. For example, a completed pathway with only a past time frame indicates that exposure is no longer occurring and is not likely to occur in the future.

When contaminants of concern are identified in a media, CDPH will evaluate the pathway by which people are being exposed to the contaminants [21]. The evaluation takes into account how much soil is incidentally ingested, how much air is breathed per hour, how much the person weighs, how many hours the person is in contact with the contaminated media, etc. For inhalation exposure, the air concentration (often adjusted for exposure duration) is compared to the inhalation health comparison value. An exposure dose (for ingestion exposures and for inhalation exposure when an inhalation health comparison value is not available) is estimated and compared to the oral health comparison value. For the dermal pathway, an exposure dose is estimated and compared to the dermal health comparison value. EPA has developed a method to derive dermal slope factors from the oral health comparison value [22].

This exposure dose can then be compared with appropriate toxicity values in order to evaluate the likelihood of adverse health effects occurring [21]. Toxicity values used to evaluate noncancer adverse health effects include ATSDR minimal risk levels (MRLs), EPA reference doses (RfDs) for ingestion and reference concentrations (RfCs) for inhalation, Office of Environmental Health Hazard Assessment (OEHHA) Reference Exposure Levels (RELs) for inhalation, and OEHHA child-specific reference dose (chRD) for ingestion. The MRL and RfD values are estimates of daily human exposure to a contaminant below which noncancer, adverse health effects are unlikely to occur. (See Appendix A for additional information about health comparison values.)

The National Toxicology Program, the International Agency for Research on Cancer, and EPA have reviewed available information from human and animal studies to determine whether certain chemicals are likely to cause cancer in humans [23-25]. The potential for cancer to occur in an individual or a population is evaluated by estimating the probability of an individual developing cancer over a lifetime as the result of exposure. EPA has developed cancer slope factor values for many carcinogens. A cancer slope factor is an estimate of a chemical‘s potential for causing cancer. A cancer slope factor is derived by averaging the exposure over a lifetime, thus it is appropriate to calculate cancer risks from long periods of exposure. Cancer risks can not be appropriately calculated for short-term exposures (less than 7 or 9 years) using EPA or California EPA cancer slope factors.

Exposure doses similar to what was described above for the noncancer health evaluation are derived for the cancer evaluation, except the dose is averaged over the theoretical lifetime of an individual (70 years), not over the period of actual exposure. Estimating a dose for exposure to radionuclides is essentially the same for the ingestion and inhalation pathways with the addition of a decay factor into the equation. Radionuclides are also evaluated for their external dose exposure. EPA has developed health comparison values specific for each exposure route (ingestion, inhalation, and external exposure) for each isotope.

CDPH evaluated ten pathways of possible exposure related to the Halaco site. Those included seven completed and three potential completed pathways. Presenting the information based on exposure pathways allows an individual to read those sections that are most relevant to their situation. For instance, if someone lives in the neighborhood and went to the beach, the most important and relevant pathways for their exposure would be the ones related to “residential” and “beach.”

The equations used by CDPH for the toxicological evaluation are shown in Appendix D, Table D12. Summary tables of the toxicological evaluation of each pathway are presented in Appendix D, Tables D13-D24. In the following pages, we describe our evaluation of these pathways. A brief summary of the toxicological characteristics of those compounds found at levels above background are presented in Appendix E. The toxicological evaluation of the completed pathways involves the use of exposure assumptions. The authors first use “high end” estimates and assumptions to ensure that any potential public health hazards from the chemicals are recognized. The summary of the toxicological evaluation for each pathway, along with the assumptions used in the calculations, are presented in Table 3 below.

Table 3. Summary of Toxicological Evaluation for Completed Exposure Pathways, Halaco Site, Oxnard, California

Pathway	Noncancer Hazard Summary		Cancer Risk		Exposure Assumptions
	Using Maximum Soil Values	Using Average Soil Values	Using Maximum Soil Values	Using Average Soil Values	
On-site trespasser	None expected	None expected	NA	NA	4 hours/day, 90 days/year, for 4 years (between ages 15, 16, 17 and 18); BW=62.25 kilograms; IR_A=1.38 meter^{3}of air/hour; IRS=6.25 milligram soil/waking hour; PEF = 1.32 x 10^9
Dirt bike rider on the Waste Disposal Area	Manganese (inhalation) Beryllium (inhalation and incidental ingestion)	Manganese (inhalation) Beryllium (inhalation)	NA	NA	4 hours/day, 90 days/year, for 1.5 years (between ages 15, 16, 17 and 18); BW=62.25 kilograms; IR_A=1.38 meter^{3}of air/hour; IR_S=6.25 milligram soil/waking hour; PEF = 1 x 10^6
Visitor to the National Conservancy Land	None expected	None expected	No apparent	No apparent	4 hours/day, 90 days/year, for 9 years (from birth to 9 years) and 30 years (from birth to 30 years); BW for 0-9 year old=18 kilograms; BW for adult=63 kilograms; IR_A for 0-9 year old=24.2 liter air/kilogram BW per hour; IR_A for 0-30 year old=16.4 liter air/kilogram BW per hour; ; IR_S for 0-9 year old=0.54 milligram soil/kilogram BW per hour; ; IR_S for 0-30 years old=0.11 milligram soil/kilogram BW per hour; PEF = 1.32 x 10^9
Dirt bike rider on the National Conservancy Land	Manganese (inhalation)	Manganese (inhalation)	No apparent	No apparent	4 hours/day, 90 days/year, for 30 years (ages 15-45); BW for 15-18 year old=62.25 kilograms; BW for adult=70 kilograms; IR_A for 15-18 year old=1.38 meter^{3}of air/hour; IR_A for adult=1.60 meter^{3}of air/hour; IR_S=6.25 milogram soil/waking hour PEF = 1 x 10^6

Table 3. Summary of Toxicological Evaluation for Completed Exposure Pathways, Halaco Site, Oxnard, California

Pathway	Noncancer Hazard Summary		Cancer Risk		Exposure Assumptions
Visitor to the Wetlands	To the mixture for ages 0-9	None expected	No apparent	No apparent	4 hours/day, 90 days/year, for 9 years (from birth to 9 years) and 30 years (from birth to 30 years); BW for 0-9 year old=18 kilograms; BW for adult=63 kilograms; IR_A for 0-9 year old=24.2 liter air/kilogram BW per hour; IR_A for 0-30 year old=16.4 liter air/kilogram BW per hour; ; IR_S for 0-9 year old=0.54 milligram soil/kilogram BW per hour; ; IR_S for 0-30 years old=0.11 milligram soil/kilogram BW per hour; PEF = 1.32 x 10^9
Visitor to the Beach	None expected	None expected	No apparent	No apparent	4 hours/day, 90 days/year, for 9 years (from birth to 9 years) and 30 years (from birth to 30 years); BW for 0-9 year old=18 kilograms; BW for adult=63 kilograms; IR_A for 0-9 year old=24.2 liter air/kilogram BW per hour; IR_A for 0-30 year old=16.4 liter air/kilogram BW per hour; ; IR_S for 0-9 year old=0.54 milligram soil/kilogram BW per hour; ; IR_S for 0-30 years old=0.11 milligram soil/kilogram BW per hour; PEF = 1.32 x 10^9
	Using Maximum Water Values	**Using Average Water Values**	**Using Maximum Water Values**	**Using Average Water Values**	
Swimmer in the Oxnard Industrial Drain	None expected	-	No apparent	No apparent	4 hours/day, 90 days/year, for 9 years (from 8-18 years) and 11 years (from 19 to 30 years); BW for 8-18 year old=47 kilograms; BW for 19-30 year old=72 kilograms; IR_W =0.05 liter water/hour swimming; SA for 8-18 year old=13,960 cm^2 skin; SA for 19-30 year old=18,100 cm^2 skin

NA: exposure was for less than 9 years and cancer risk calculation not appropriate; PEF: Particulate Emission Factor; BW: Body Weight; IR_A: Ingestion Rate of Air; IR_S: Ingestion Rate of Soil; IR_W: Ingestion Rate of Water; SA: Exposed Surface Area of Skin.

Air Exposure During the Time Halaco Was in Operation (1965-2005)

As has been described in the Community Concerns section, there were extensive air exposure concerns documented when the facility was in operation. Unfortunately, there was no monitoring or sampling of the air from that time period that CDPH could use to evaluate the impacts from the air emissions. In the following paragraphs, CDPH reviews some of the emissions that may have come from the facility based on the processes that were conducted there and the Air District's role in regulating the facility.

Halaco Process and Possible Air Emissions

The Halaco facility was a recycling facility; it recovered aluminum and magnesium, primarily from scrap. This is advantageous as it keeps waste from entering a landfill; for instance, aluminum recovery from scrap metal requires a great deal less energy compared to refining aluminum from bauxite ore [26].

Halaco received scrap from sources as varied as aluminum cans, parts from airplanes, Volkswagen car transmissions, forks from bicycles, and primary smelting slag. These materials were brought in by truck and dumped in the Halaco yard. Generally, these stock materials would not be a source of emission, but were on several occasions. The Air District inspectors observed visible emissions coming from the stock in the yard. In 1993, aluminum scrap was dumped in the yard by the supplier, and because it rained, ammonia was formed and created a large odor and visible emission problem. There were 13 nuisance call calls to the Air district with reports of health concerns including sore throat, burning eyes, nausea, labored breathing, and severe headache. The fire department responded to the incident and the Air District cited Halaco [27]. Halaco operations did not involve any pretreatment, as is typical at most smelters [26].

Halaco used natural gas fired rotary furnaces to melt the material. The scrap was placed in a furnace and heated. Dirt, oil, and dross would float to the top and be poured off early in the melt. Slag that was dense settled to the bottom of these vats and was also removed and washed. Molten material in the middle (horizontally stratified) portion of the vat was considered metal suitable for sale as recycled material. This metal was decanted and poured into casts and sold as ingots.

During the magnesium smelts, the process involved magnesium combining with oxygen to ultimately create magnesium oxides. During this process, sulfur dioxide in combination with nitrogen was added to keep the magnesium from burning [26]. Sulfur dioxide could have been released as a gas from the furnaces. During aluminum smelting, chloride salts were added to react with the magnesium to form chlorides.

Addition of chlorine in the furnace results in the formation of magnesium chloride that contributes to fumes leaving the dross [26]. Excess chloride combines with aluminum to form aluminum chloride, a vapor at furnace temperatures, but one that condenses into submicron particles as it cools. Aluminum chloride has an extremely high affinity for water (hygroscopic) and combines with water vapor to form hydrochloric acid. Aluminum chloride and hydrochloric acid are respiratory and dermal irritants and are corrosive. Free chlorine that does not form compounds may also escape from the furnace and become another emission.

The effluent of typical aluminum smelting furnaces has been found to contain metal chlorides of zinc and other metal and metal compounds depending upon what scrap was used in addition to chlorine, hydrogen chloride, aluminum oxide, magnesium oxide, and metal chlorides of magnesium and aluminum [26].

Halaco operations involved taking the dross and the slag to the rotary furnace to be washed with water while it was mechanically agitated. The waste from the rotary furnace was placed in the unlined ponds. The washed dross was further smelted to recover additional aluminum and magnesium scrap.

When the magnesium melt is ready, it is transferred to the magnesium ingot pot or the flux pot. Here too flux material like chlorine is used to keep the material from burning. As the material is poured into the ingots or forms, there can be quite a bit of emissions that can be harder to capture (Photo C15).

Emissions from furnace burners contain carbon monoxide, carbon dioxide, sulfuric oxide and nitrogen oxide. Furnace burner emissions are usually separated from process emissions [26].

Air Pollution Control Systems at Halaco

As described below in the description of the Halaco permits from the Air District, each of the furnaces, the ingot, anode, and flux pots were connected to air pollution control devices. Prior to 1980, the air pollution control systems consisted of baghouses to collect the particulate. Over the years, the technology has changed and the air pollution control devices at Halaco changed. The air pollution control devices also included cyclones to capture large particles, high efficiency air filtration units, and Venturi scrubbers to capture gases, vapors, sulfur oxides, corrosive acidic or basic gas streams, solid particles, and liquid droplets. The baghouse and cyclone dust were typically added back into the furnace. The water from the Venturi scrubber was either reused or placed in the WMU.

Air District Oversight of Halaco

The California Health and Safety Code grants the Air District the regulatory authority to permit non-major stationary sources such as Halaco, and issues conditions in those permits to ensure compliance with air pollution standards [28]. The Air District also enforces the nuisance rule. The Air District conducted annual inspections for compliance related to the permit, inspections related to nuisance nuisance calls, and observed certain activities carried out at the facility such as source and air pollution control equipment test.

Halaco submitted its first permit application to the air district in 1970 (Keith Duval, personal conversation, March 20, 2008). According to the Air District's files, Halaco was granted permits to operate from 1976 to 2005, with a gap in the permitting during 1977 and 1978 (Keith Duval, personal conversation, March 20, 2008).

In the following discussion, CDPH reviews some of the permit parameters: the type of equipment Halaco used in their smelting processes, the allowable permitted emission limits, and the tonnage of aluminum and magnesium the company could smelt during a given year. The amount of aluminum and magnesium the company was limited to on the permit was based on information provided by the facility. Since the permit costs are tied to the amount of material that is smelted, the facility tends to request the amount of material that they reasonably would smelt and not an excessive number, as that would mean their permit costs would be greater than they needed to be.

- From 1976 to 1987, Halaco operated four smelting furnaces, one magnesium ingot pot, two magnesium anode pots, one flux pot, and one underground storage tank [29-38]. Prior to 1987 there were no smelting limitations. In 1980, Halaco was permitted to smelt 19,800 tons of material. Starting in 1981, Halaco was permitted to smelt 40,071.4 tons per year of aluminum and magnesium and 9,440.9 tons per year of magnesium materials.

- Form 1987 to 1988, Halaco operated four furnaces, one magnesium ingot pot, one flux pot, and one underground storage tank [32,33,39]. For the next 2 years (1988 to 1990), Halaco operated four furnaces, one magnesium ingot pot, and one underground storage tank [32,39,40]. During this time period, Halaco's smelting permit was for 40,714.4 tons per year of aluminum and magnesium and 9,440.9 tons per year of magnesium materials.

- From 1990 to 1992, Halaco operated three smelting furnaces, one magnesium ingot pot, and one hot dross enclosure [40-44]. For the next 4 years (1992 to 1996), Halaco operated one additional smelting furnace, while the magnesium ingot pot and the hot dross enclosure both remained at one. During this time period, Halaco's smelting permit was for 40,017.4 tons per year of aluminum and magnesium and 9,440.9 tons per year of magnesium materials.

- From 1996 to 2005, Halaco scaled back their equipment to: one smelting furnace, the magnesium ingot pot and hot dross enclosure both remained at one [45-54]. The permits stated Halaco could smelt 15,000 tons per year of aluminum and magnesium, of which not more than 9,440.9 tons per year was to be magnesium. The plant's permitted emission per year also decreased, with the exception of hydrogen chloride.

As part of the permit, Halaco's permits to operate included levels of emissions for the known pollutants of criteria air pollutants (nitrogen oxides, particular matter, sulfur oxides, carbon monoxide) and hydrogen chloride. Starting in 1990, the Air District included hydrogen chloride in the list of permitted emissions. Starting in 1996, the Air District included ammonia in the list of permitted emissions. These compounds are the ones listed on the permit to operate as they relate to chemicals contributing to smog though they can affect human health as well. Toxic air contaminants, those that can impact human health especially over a long period of exposure, are not really regulated at the federal level, and a state requirement for a risk assessment for these chemicals did not occur until the early 1990s.

Over the years, the compounds that were part of the Halaco's air permit and could have been emitted in large amounts compared to the other compounds listed on the permit were nitrogen oxides (generally in the 30 to 50 tons per year) and particulate matter (30 to 40 tons per year)

[29-56]. Hydrogen chloride was later added to the permitting in 1990, and could be emitted in the range 7 to 11 tons per year [40-56]. The amount of sulfur oxides emitted according to the permit was relatively low (below 0.15 tons per year); however, the use of sulfur dioxide as an anti-burning agent was never calculated for the permit, an oversight noted by the Air District inspector in 2002.

Source Testing

Compliance monitoring of a stationary source can be accomplished on either a continuous or an intermittent basis. Some stationary sources use a continuous emission monitoring (CEM) system that is permanently installed on a stack or process ductwork to measure the emissions of one or more contaminants. The emissions data are recorded, averaged, and stored by a computer data acquisition system. An advantage to using a CEM system is that it provides emissions data under all source operating conditions, including varying loads and operating scenarios, and during malfunctions, startups, and shutdowns. Continuous monitoring was not used at Halaco as this technology has developed somewhat recently. On the other hand, since the mid-1990s Halaco was supposed to monitor certain parameters related to pollution control efficiency on a continuous basis, for instance, measuring the pH where the ammonia was injected and at the baghouse outlet, or measuring the temperature of the air stream entering the baghouse [40-56]. The Air District found these monitoring systems not functional on several occasions and either issued a notice to comply or a NOV.

Instead of, or in addition to, the CEM system measurements, a source may conduct a one-time or periodic compliance emissions test to measure the magnitude of one or more of its emissions. The emissions test is performed following specific procedures developed by EPA or CARB. A test typically consists of three discrete measurement runs, each run lasting one or more hours depending on the test method and pollutant concentration(s). The testing should occur during conditions of plant operation that are representative of normal operation, but also during which maximum emissions are expected. In some cases, testing is done at multiple loads. The source tests had to be conducted while an Air District or CARB representative was present. Given the circumstances, it is not clear if the source test results are really indicative of other operational time, but they do represent the best control situation.

CDPH was able to find source tests conducted at Halaco as early as 1987 and references in documents of source tests conducted in 1981. Starting with the permit for April 1, 1992, to March 31, 1993, a source test for nitrous oxides and particulate matter was required every 2 years [41,42,45-56].

AB2588 Risk Assessment

The Air Toxics "Hot Spots" Information and Assessment Act (AB 2588, 1987, Connelly) was enacted in September 1987 [57]. The Act requires that toxic air emissions from stationary sources (facilities) be quantified and compiled into an inventory according to criteria and guidelines developed by the CARB, that each facility be prioritized to determine whether a risk assessment must be conducted, that the risk assessments be conducted according to methods developed by OEHHA, and that the public be notified of significant risks posed by nearby facilities. In September 1992, the Hot Spots Act was amended by Senate Bill (SB) 1731 (Calderon) to address the reduction of significant risks. Owners of facilities found to pose significant risks by a district must prepare and implement risk reduction audit and plans within 6 months of the determination.

Halaco submitted a risk assessment to the Air District in 1996 using emission inventory data for that same year [58]. The emissions inventory included 16 compounds emitted from the furnaces, six compounds emitted from the vehicular traffic associated with the facility's activities, and ammonia coming from the dross pile (WMU). The increased cancer risk for the maximally exposed individual was 3 in 1,000,000. This does not exceed the 10 in 1,000,000 risk threshold for the AB2588 program.

As a part of the Halaco AB2588 risk assessment, several different acute, or short-term, time periods were evaluated: 1-hour, 4-hour, 7-hour, 30-day) [58]. The largest acute public health hazard for the maximally exposed individual was 0.07 for respiratory irritation for a 1-hour exposure. The chronic, long-term, public health hazard for the maximally exposed individual was 0.1 for a central nervous system endpoint. Both of these values are less than 1.0, the noncancer threshold for the AB2588 program.

The maximally exposed individual was a theoretical person who lived/worked at the east edge of the site at the property line [58]. The risk assessment also evaluated the impact to the nearest resident and the nearest off-site worker. The cancer risk and noncancer hazard were considerably less than for the maximally exposed individual.

Thus, based on conditions of the facility operating properly per the permitting requirements of the Air District, the conditions of the source test (see below for more explanation about source tests) from which the emission inventory was created, the findings of the AB2588 risk assessment did not require public notification [58]. There are some limitations to the AB2588 risk assessment as it does not include some contaminants like diesel exhaust and particulate matter. Additionally, as the Halaco facility smelted different types of scrap, emissions on days other than the source tests may vary from those measured on the source test day.

Notices of Violations Served by the Air District on Halaco

The Air District's inspector has the authority to issue a NOV under the following circumstances: when a considerable number of people are affected by the nuisance, if the inspector's visibility is impaired during an opacity test, and if an inspector catches them violating their permit as part of annual inspection, a nuisance follow-up inspection or a source test. When an inspector would visit the Halaco plant as follow-up to a nuisance call, it was not uncommon for them to inspect a majority of the facility, ie beyond the issues that the nuisance call may raise.

According to CDPH's review of the Air District files, the Air District issued 21 NOVs to Halaco, the first one in 1982 [4]. Eleven of the violations were related to nuisance (health complaint(s) called in or visible emissions), eight for failing to meet requirements of the permit, and two for operating without a permit for a new part of the air pollution control equipment. In most cases, Halaco corrected the action, i.e., fixed the equipment so as to comply with the permit conditions or obtained the correct permit. Only occasionally was the facility fined as part of the NOV. For instance, there were ten NOVs from January 1, 1992 to March 13, 2008, and on four occasions, the facility was fined $500, $1,000, $1,000, and $7,500 [4]. Fines were almost never imposed if the NOV was based on visible emissions or nuisance(s).

The difficulty in citing the facility based on visible emissions is that the Air District staff would have to document the visible emissions using the Opacity test. Opacity is a measure of the degree to which the smoke blocks visible light and, although it is not necessarily directly proportional to the amount of particulate matter emissions, it is an indicator of overall combustion efficiency or control of particulate emissions. The Opacity test can not be used in certain situations that often exist at the Halaco site; for instance, the test can be very inaccurate if there is significant moisture in the air and Halaco is right next to the beach where there is often heavy fog. Additionally, observer positioning for the test is problematic, as the observer has to be at right angle to the plume, with the sun behind the observer, and the sun oriented in the 140 degree sector to his back. Thus, the facility may have been cited with a NOV for visible emissions but rarely was an opacity test able to be performed. Additionally, at those times when the air district inspectors did use the opacity test to record the visible emissions for the NOV, Halaco would challenge the appropriateness of the findings because of the inappropriate conditions for use of the test.

CDPH found in the Air District files several NOVs served on Halaco because of violations of the source test results. For instance, a source test conducted on March 18, 1998 found 2.24 pounds of particulate matter being emitted per ton of material smelted, which exceeds the 1.93 pounds per ton permitted level [59]. Similarly, a source tested on July 1, 2004 measured 5.01 pounds particulate matter per ton smelted, again exceeding the 1.93 pounds per ton permitted level [60]. Source tests performed by CARB in 2000 at the Halaco site also found excess particulate matter being emitted from the air pollution control devices [61].

On several occasions, Air District staff found the air pollution control devices were not working properly.

- During a compliance inspection in 1982, the Air District inspector found the doors taken off furnaces 1 and 3. The doors on furnace 2 were open. The inspector was concerned because “smoke (grayish in color) continued beyond the hood which would normally suck these emissions back to the control equipment” [62].

- During a permit renewal inspection in 1984, Air District staff observed the gasoline tanks vapor phase collection system had the dust cover off, and the dry break was propped open with an aluminum can [63].

- CARB’s inspection in 1986 based on a nuisance call found furnace door 3 was jammed open allowing fugitive gases to escape from the furnace and not be captured by the air pollution control system [12]. They found that a pouring operation at the magnesium ingot pot partially blocked the pick-up point of the air pollution control system. “Some visible emissions were observed coming off the pot during the pour. It appeared that none of the emissions were being collected by pick-up point.” The inspectors reported visible emissions as they approached the plant, the “fugitive emissions were observed to be exhausting from the roof and from the doors in the ingot pot area. The building above the door opening appeared to be blackened indicating that emissions had been released in the past.” Further, they found the air pollution control units not to be operating correctly, “the pressure drop gauge for the mist separator was not working. The scrubbers did not appear to have any monitoring gauges or flow meters to verify if they were working correctly”. They observed, “several locations where holes and gaps were present in the ducting prior to the baghouses. There appeared to be unsealed hatches and corrosion area. The ducting was under negative pressure so no emissions were observed; however, it was felt that this may reduce the draft at the pick-up points.”

- On a follow-up to a nuisance call on January 21, 2003, the Air District observed a “blue smoke ‘puffing’ from holes where the walls of the building met the roof.” [64]. Inside the smelter, the Air District inspector observed that the fume hood for the ingot pot enclosure was not installed. The plant manager said they were doing a new process, pouring much larger ingots and that the fume hood got in the way of this operation, so it was removed. They had started producing the large ingots about 6 months prior though it had taken a few months before they were producing large numbers of them. During the same inspection, the inspector observed the baghouses were turned off so they could be cleaned even though smelting operations were taking place.

  In the fall of 2003, a jury found Halaco guilty of three misdemeanor counts for unlawful air emissions. Halaco was sentenced to 3 months probation and fined $7,500. Under the terms of probation, Halaco had to install monitoring equipment and send its air data to the Air District for a year. If Halaco exceeded the emission limits established in its air permit, it was required to stop operating immediately. Random source testing conducted in April and September 2004 revealed that Halaco had exceeded the air permit limits, and thereby violated the terms of its probation. Halaco, already in a Chapter 11 bankruptcy, presumably did not have the funds to return to compliance and reopen.

Summary

According to the AB2588 risk assessment that was performed in the mid-1990s, the routine, permitted, controlled emissions did not pose a cancer (3 in 1,000,000 increased cancer risk) or noncancer health hazard (hazard index of 0.7 for 1-hour and 0.1 for chronic exposure). However, unpermitted emissions from Halaco occurred many times during the facility’s operation. Based on the Air District’s investigation of numerous nuisance calls and their own compliance inspections, the facility released a number of different compounds to the air either through negligent operation or intentional circumvention of permitted procedures that would have controlled the emissions. In situations such as was observed in January 2003 when the air pollution control device had been disconnected for six months, and the emissions produced during the pouring of the ingots were possibly not captured and treated at all by the air pollution control system. These uncontrolled emissions would easily increase the magnitude of exposure, probably by almost a factor of 9-99, given that most air pollution controls devices are 90-99% efficient. Thus by extrapolation, the risk assessment results for non-cancer (1-hour and chronic) would exceed 1 and thus non-cancer health effects could have. The impact on cancer was also increased during the periods of uncontrolled emissions.

Certainly there were uncontrolled emissions of ammonia, particulate matter, hydrogen chloride of various types. There were probably many other compounds released; however there is no information to help us identify those compounds and the amounts that were released.

Based on the above documentation, CDPH concludes that the facility likely posed a public health hazard during these uncontrolled emissions, which happened fairly regularly.

Health Effects Evaluation for Exposure to Contaminated Soil

For all the exposure evaluations involving soil, including exposure to beach sand and dry sediment area on the upper wetlands, two exposure routes were considered: incidental ingestion and inhalation of disturbed soil. In those locations where thorium isotopes were found at levels above background, external exposure was also included in the cancer evaluation. The following is an explanation of how this evaluation was conducted for both the noncancer and cancer health effects.

Evaluation of Noncancer Health Effects

Ingestion of soil: A dose was calculated using both the maximum and average soil concentration, taking into account the inhalation rate, exposure time, exposure frequency, and exposure duration specific to that particular group of people being exposed. This dose was compared to the oral health comparison value. For exposure calculation involving a young child (age 0-9), the child-specific health comparison values that are being developed by the State of California were used. Currently, child-specific health comparison values are available for cadmium, manganese, and nickel.

Inhalation of disturbed soil: Dust is generated by the wind or by activities that take place with the soil such as digging or riding a bike. In the absence of having data representing the air concentrations that one might breathe at various locations in and around the Halaco site, CDPH used EPA particulate emission factors (PEFs) to generate a theoretical air concentration from the soil concentrations. Two PEFs are typically used: 1.316×10^9 m^3/kg for dust created from the wind and 1.0×10^6 m^3/kg for soil disturbing activities. CDPH used the PEF for wind blown dust generation for most of the exposure pathways. For the dirt bike rider exposure, the PEF for soil disturbance was used. Air concentrations were generated for maximum concentration in the soil. If the maximum soil concentrations posed a public health hazard, an evaluation for the average concentration in the soil was also conducted.

For those chemicals for which an inhalation health comparison value is available (beryllium, cadmium, manganese, and nickel), the air concentration derived from the maximum was adjusted for exposure time and frequency and compared to the inhalation health comparison value. For the chemicals for which no inhalation health comparison value was available (aluminum, barium, chromium, copper, silver, and zinc), a dose was calculated using both the maximum and average soil concentration, taking into account the inhalation rate, exposure time, exposure frequency, and exposure duration specific to that particular group of people being exposed. This dose was compared to the oral health comparison value.

Combined Exposure: Currently, the accepted methodology for evaluating exposure to chemical mixtures is by looking at the additive effect. CDPH evaluated the additive noncancer effect of exposure to these contaminants by estimating the hazard index for those contaminants. The hazard index is a sum of the hazard quotients for each of the chemicals. If the hazard index is above 1, then exposure may pose a noncancer health risk and the mixture is evaluated further.

A hazard quotient was calculated for each chemical and each exposure pathway separately (ingestion and inhalation). The hazard quotient is a ratio of the exposure (dose) to the health comparison value.

Lead Exposure

Exposure to lead is evaluated by using biological models that predict a blood lead concentration that would result from exposure to environmental lead contamination. Children and pregnant women/unborn child are the most sensitive to the toxicity of lead.

For pathways where young children may be exposed to elevated lead levels in soil, or for the dirt bike rider scenarios, CDPH used the LeadSpread developed by DTSC. LeadSpread is a tool that can be used to estimate blood lead concentrations resulting from exposure to lead via dietary intake, drinking water, soil and dust ingestion, inhalation, and dermal contact. Each of these pathways is represented by an equation relating incremental blood lead increase to a concentration in an environmental medium, using contact rates and empirically determined ratios. The contributions via the five pathways are added to arrive at an estimate of median blood lead concentration resulting from the multi-pathway exposure. Lead exposure was evaluated using the maximum concentration present in the soil for those scenarios where the lead was present above background levels in the surface soil. CDPH used the model's default drinking water lead concentration, the California Maximum Concentration Level, of 15 micrograms per liter (µg/L), which is the maximum allowable concentration for a public drinking water source. Default air concentrations were used for the non-dirt bike rider (1.5 $\mu g/m^3$), and no homegrown produce was assumed in the lead risk assessment. For the dirt bike rider, the Occupational Safety and Health Administration's regulatory standard for respirable nuisance dust level was used (5 mg/m^3). The geometric standard deviation of the blood lead level in the population was changed from 1.6 to 2.1 based on national data [65]. The modeled blood lead concentration is then compared to the level of concern for blood lead concentrations in children and women of childbearing age, as recommended by the Centers for Disease Control (CDC) [66,67]. CDC's current level of concern is 10 micrograms of lead per deciliter of blood (µg/dL) and 25 µg/dL for adults (men and women of non-childbearing age).

For the scenarios where young children will not be present and the exposure was not for a dirt bike rider, CDPH used the Adult Lead Methodology that was developed by the EPA [68]. This multi-pathway approach was developed for assessing non-residential adult exposures to lead in soil. This methodology focuses on protecting the fetus of a pregnant woman who is exposed to lead-contaminated soil. Lead is readily transferred across the placenta, and the ratio of lead in fetal blood to maternal blood is about 0.9 [69]. Therefore, the goal of the methodology is to ensure that there is less than a 5% probability that the fetal blood lead concentration will exceed 10 µg/dl.

Cancer Health Evaluation

Cancer health effects are evaluated in terms of possible increased cancer risk. Cancer risk is the theoretical chance of getting cancer. In California, 41.5% of women and 45.4% of men (about 43% combined) will be diagnosed with cancer in their lifetime [70]. This is referred to as the "background cancer risk." The term "excess cancer risk" represents the risk above and beyond the background cancer risk. A one-in-a-million excess cancer risk from a given exposure to the contaminant means that if one million people are chronically exposed to a carcinogen at a certain level over a lifetime, then one cancer above the background risk may appear in those million persons from that particular exposure. For example, in a million people, it is expected that approximately individuals will be diagnosed with cancer from a variety of causes. If the entire population was exposed to the carcinogen at a level associated with a one-in-a-million cancer risk, 430,001 people may get cancer, instead of the expected 430,000. Cancer risk is not a prediction that cancer will occur; it merely suggests that there is a possibility.

Among the general population, exposure to a number of metals is widespread but generally at substantially lower levels than have been found in industry. Occupational studies have linked exposure to arsenic, chromium VI, thorium, nickel, cadmium, beryllium and other metals to specific cancer outcomes [71,72]. Environmental exposures, however, have been more difficult to assess, mainly due to poor exposure profiles (i.e., specific information on dose, duration of exposure, timeframe of exposure, co-morbid issues, etc.). Carcinogens are divided into two categories---genotoxic and epigenetic. Compounds that act directly or indirectly with DNA, are in most cases, mutagens. They have the potential to alter the genetic code. We know the most about this particular category. Much less is known about the epigenetic carcinogens. This includes all carcinogens that are not genotoxic and thus a multitude of mechanisms may be involved. These compounds include metal ions (nickel, beryllium, lead, cobalt, chromium, manganese, titanium); solid state carcinogens (asbestos and silica); immunosupressors, promoters, and xenoestrogens [73,74].

CDPH evaluated exposure via inhalation to beryllium, cadmium, and nickel, as these are the compounds that are considered carcinogenic and have potency numbers available for use in the calculations. A dose was calculated using both the air concentration derived from the maximum and average soil concentration, taking into account the inhalation rate, exposure time, exposure frequency, and exposure duration specific to that particular group of people being exposed. This approach is very similar to the noncancer dose calculation except the dose is averaged over the lifetime and not over the period of exposure as is done with the noncancer calculation. This dose is then multiplied by the slope factor derived from an inhalation study to obtain the increased cancer risk from exposure to that particular chemical.

The chemicals/metals which are not radioactive and which are found on the site at elevated levels, compared to background levels, are not considered to cause cancer when ingested. Therefore, no evaluation for cancer via the ingestion route was conducted.

Compounds that are considered radioactive may emit energy that can be absorbed from outside the body. Thorium isotopes were evaluated for inhalation similar to what was described for chemicals without radioactivity. An ingestion dose was calculated from the maximum soil concentration, taking into account the amount of incidental ingestion of soil, exposure time, exposure frequency, and exposure duration specific to that particular group of people being exposed. External exposure to thorium was also included. The calculations take into account the decay of the isotope. Each pathway specific dose is then multiplied by the slope factor specific for that pathway and then added together to obtain the increased cancer risk from exposure to that particular chemical.

CDPH added the cancer risks from all the chemicals considered carcinogenic to obtain a total cancer risk for the mixture present in the soil.

When estimating a theoretical increased cancer risk, OEHHA recommends using a 9-year minimum exposure duration [75]. According to Halmes et al., estimating theoretical increased cancer risk for short-term exposures is likely to result in an underestimation of cancer risk [76]. An analysis of 11 chemicals for which the cancer study had included animals that received less than lifetime as well as the typical, lifetime exposure suggests that cancer slope factors derived from lifetime studies and applied for less than lifetime exposures would more than likely underestimate the risk [76]. In one case, the dose in the less than lifetime exposure that caused an increase in tumors was at least 100-fold lower than the dose that caused the same tumor effect in animals treated for a lifetime. In addition to the problems with the use of the cancer slope factor derived for a life-time exposure scenario, calculating the dose for the particular exposure scenario at a site involves dividing by 70 years, i.e., averaging the exposure over the lifetime of the individual. This is patently, not biologically defensible. The person getting exposure over a shorter period of time, e.g. 2 years, does not have the opportunity to ask its body to respond to the exposure as if it was really only getting exposed to 2/70 or 1.5% of the dose each year for 70 years. Thus, for any exposure duration of less than 9 years (trespasser on the smelter site, dirt bike rider on the Waste Disposal Area), CDPH did not calculate a cancer risk.

Exposure Pathway for the Trespassers On-Site

With Halaco closing in 2004, the site has become a popular destination for trespassers (e.g., graffiti artists). Reports confirmed that children/teenagers (boys and girls) entered the Halaco site and “tagged” the buildings. During a site visit, CDPH and EPA staff saw breached fences, locks snapped with bolt cutters, and complex graffiti on the buildings. Trespassers may have come into contact with the surface soil contamination via the incidental ingestion and inhalation exposure routes.

As described in the Environmental Contamination section of this document, elevated metals can be found in the surface soil in some parts of the site (Appendix D, Table D1). CDPH assumed the children/teenagers were old enough (15-18 years of age) to go to the site unattended for 4 years (September 2004 to September 2008), 90 days of every year, and the duration of each visit was 4 hours.

In Table D13, Appendix D, CDPH summarizes the toxicological evaluation for the trespasser on the smelter site. The trespasser was assumed to have come into contact with contaminants via the incidental ingestion and inhalation exposure pathways. CDPH assumed wind generated dust for the inhalation pathway.

Inhalation of Soil that Becomes Airborne

The adjusted air concentrations (beryllium, cadmium, manganese, and nickel) derived from the maximum concentration of the chemicals in the soil do not exceed their corresponding inhalation health comparison values (Appendix D, Table D13). For those chemicals with no inhalation health comparison value (aluminum, barium, chromium, copper, silver, and zinc) an exposure dose from inhaling the fugitive dust was calculated. None of the exposure doses derived from inhaling fugitive dust emissions, using the maximum concentration measured in the soil, exceed their corresponding oral health comparison values.

Incidental Ingestion

The exposure doses derived from incidental ingestion of soil were derived for each chemical using the maximum concentration found in the soil (Appendix D, Table D13). The exposure doses are below their respective comparison values. Based on this evaluation, none of the chemicals measured in the soil, individually, would be expected to cause a noncancer health impact to the trespasser on-site.

Combined Exposures

CDPH also evaluated the additive effects of being exposed to more than one chemical in the soil using the hazard index approach (Appendix D, Table D13). The inhalation hazard index derived from the maximum concentrations for the trespasser on-site from exposure to the contaminants of concern is estimated at less than 0.01. The incidental ingestion hazard index derived from the maximum concentrations for the trespasser on-site from exposure to the contaminants of concern is estimated at 0.057. The combined hazard index (inhalation and ingestion) for the maximum concentrations is estimated at 0.063. Since each of the indexes is less than 1, exposure to the combination of metals in the soil should not pose a noncancer health concern to the trespasser.

Evaluation of Exposure to Lead

CDPH’s evaluation of the elevated lead in the surface soil at the smelter gave the following results:

- Using the highest level of lead found in the surface soil (205 mg/kg), the predicted geometric mean blood lead level using the Adult Lead Methodology was 1.8 µg/dl for the pregnant woman and 6.2 µg/dl (95%) in the fetus of the pregnant woman, with a less than 1.3% probability that the fetal blood lead concentration will exceed 10 µg/dl. The goal of the Adult Lead Methodology is to ensure that there is less than a 5% probability that the fetal blood lead concentration will exceed 10 µg/dl, thus the lead in the surface soil at the smelter would not pose a health risk to a pregnant trespasser or the fetus of the pregnant trespasser.

- Using the highest level of lead found in the surface soil (205 mg/kg), the estimated blood lead level for an adult (men and women of non-childbearing age) is 6.1 μg/dL (99^{th} percentile), and for a child, 8.5 μg/dL (99^{th} percentile). These levels are below 10 μg/dL, CDC's current level of concern [77,78]. Thus, the elevated lead in the soil would not pose a health risk to a child or adult (men and women of non-childbearing age) trespasser on the smelter site.

Cancer Evaluation

Berylium, cadmium, and nickel are found in the on-site surface soil at levels higher than background. Exposure to these metals in the on-site surface soil may increase the risk for developing cancer in addition to the non-cancer hazards described in the previous sections. Government agencies have developed theoretical models to quantify cancer risk if the exposure occurs over a long period of time, 30 to 70 years. However, this model is not useful for evaluating cancer risk for short-term exposure durations. In this case, exposure to a trespasser on the site could only have occurred for 4 years, a period too short to calculate a cancer risk using currently available methodologies, see Cancer Health Evaluation Section above for more information.

Exposure Pathway for the Dirt bike Rider on the Waste Disposal Area

With Halaco closing in September 2004, the waste pile became a popular destination for dirt bike riders. Dust was generated during dirt bike riding and the dust was then breathed by the dirt bike riders. In January 2006, EPA worked on the WDA and WMU, and at the end of the work, covered the area with a natural fiber course netting. This effectively keeps dirt bike riders from creating a lot of dust. EPA also fenced the area to keep trespassers out. During a site visit in November 2007, CDPH and EPA staff observed that the gate lock had been broken, the gate was open, and it seemed that bike tracks were visible across the netting.

Dirt bike riders would have come into contact with the surface soil contamination via the incidental ingestion (putting their hands to their mouths with dust and dirt on the hands or gloves) and inhalation exposure routes. As described in the Environmental Contamination section of this document, elevated metals can be found in the soil in the WDA (Appendix D, Table D2) and WMU (Appendix D, Table D3). As no surface data was collected on the WMU, CDPH used the data from the surface soil samples taken on the WDA for the exposure evaluation for the dirt bike rider.

CDPH assumed the children/teenagers were old enough (14-18 years of age) to play unattended at the site. We assumed the body weight to be 61.0 kilograms. For both exposure routes (breathing and ingestion), we assumed the dirt bike rider has had access to the site for 1.5 years (September 2004 to January 2006), 90 visits per year, and the duration of the each visit was 4 hours. For the inhalation evaluation, CDPH considered dust to be generated by soil disturbing activities from the bike riding.

In Tables D14 and D15, Appendix D, CDPH summarizes the toxicological evaluation for a person riding a dirt bike on the waste pile, breathing soil as it is stirred up from the dirt bike, and from incidental ingestion of soil.

Incidental Ingestion

The exposure doses from incidental ingestion of soil calculated using the maximum concentrations of aluminum, barium, cadmium, chromium, copper, manganese, nickel, silver, and zinc did not exceed their corresponding oral health comparison values (Appendix D, Table D14). The exposure dose from incidental ingestion calculated using the maximum concentration of beryllium in the surface soil exceeds its health comparison value. The exposure dose from incidental ingestion calculated using the average concentration of beryllium in the soil did not exceed its health comparison value.

- The exposure dose for the incidental ingestion (0.0027 mg/kg/day), derived from the maximum concentrations of beryllium in the soil, exceeds the chronic Minimal Risk Level (cMRL) of 0.002 mg/kg/day (Appendix D, Table D14). The exposure dose for the incidental ingestion (0.00067 mg/kg/day), derived from the average concentration of beryllium in soil, does not exceed the cMRL. It is more likely that the dirt bike rider would get exposed during the 4-hour visit to exposures more typically associated with the average concentrations of the beryllium in the soil vs. the maximum, and thus there is no public health hazard. However, since the dose associated with the maximum beryllium does exceed the health comparison value, CDPH further evaluated the likelihood of health effects for the dirt bike rider on the WMU/WDA from September 2004 to January 2006.

  The cMRL for beryllium is based on seeing toxic effects in an animal study [79]. Specifically, Morgareidge, Cox, and Gallo conducted studies where dogs were fed beryllium in their diets [80]. Overt signs of toxicity in the 500 parts per million (ppm) group included lassitude, weight loss, anorexia, and visibly bloody feces. A Benchmark Dose Level (BMDL) approach was used to quantify the cMRL (the $BMDL_{10}$ is the lower 95% confidence interval of the dose giving a 10% incidence of the effect). A $BMDL_{10}$ of 0.56 mg beryllium/kg/day was established for this model [79]. The beryllium dose estimates for the dirt bike rider on the WDA are 200 to 835 times below the $BMDL_{10}$. Based on this, it is possible, but not probable, that the dirt bike rider would have experienced health effects from an ingestion exposure to beryllium in the soil.

Inhalation of Soil that Becomes Airborne

The soil's maximum concentrations exposure doses from inhaling disturbed dust for those chemicals with no inhalation health comparison value (aluminum, antimony, barium, chromium, cobalt, copper, molybdenum, selenium, silver, vanadium, and zinc) did not exceed their corresponding oral health comparison values (Appendix D, Table D14). The adjusted air concentration for cadmium and nickel did not exceed their corresponding inhalation health comparison values. The adjusted air concentrations derived from the maximum concentrations of beryllium and manganese exceed their corresponding health comparison value. In the following paragraphs, these exceedances are explored further:

- The adjusted air concentration (1.1 µg/m^3) derived from the maximum concentration of beryllium in the soil exceeds the chronic Reference Exposure Level (cREL) of 0.007 µg/m^3. The adjusted air concentration (0.28 µg/m^3) derived from the average concentration of beryllium in the soil also exceeds the REL (Appendix D, Table D15). This suggests a concern for noncancer effects for the dirt bike rider on the WDA from the exposure to beryllium, thus requiring further evaluation from the CDPH staff.

  The beryllium REL is based on a workplace investigation of beryllium sensitization in a beryllium oxide ceramics plant. Of the 136 employees that took part in the study, eight were beryllium-sensitized (5.9%) as defined by a beryllium lymphocyte proliferation blood test [81]. Of the eight beryllium sensitized employees, six had granulomatous disease based on Tran bronchial lung biopsy. Granulomatous lung disease is incurable, usually irreversible, and may result in death. The machinists had most of the risk. A lowest-observed-adverse-effect level (LOAEL) of 0.55 µg/m^3 was derived from the study for the workers. OEHHA converted the worker LOAEL to a concentration for a continuous exposure level of 0.2 µg/m^3. The estimated air concentrations derived from both the maximum and the average soil concentrations for the dirt bike rider on the WDA exceed the concentration at which sensitivity to beryllium and perhaps granulomatous disease of the lung may occur for some having continuous exposure.

  The exposure assumptions used in deriving the adjusted air concentration (the amount of dust generated, hours per day of exposure, and 90 days per year of dirt bike riding) may result in an overestimation of the hazard. Nevertheless, there is a concern that past dirt bike riding activities (and future ones if the surface soil on the WDA is again exposed) on the WDA could have resulted in serious, non-reversible health impacts.

- The adjusted air concentration (0.35 µg/m^3) derived from the maximum concentration of manganese in the soil exceeds the cMRL of 0.04 ug/m^3 (Appendix D, Table D14). The adjusted air concentration (0.23 µg/m^3) derived from the average concentration of manganese in the soil also exceeds the cMRL (Appendix D, Table D15). This suggests a concern for noncancer effects for the dirt bike rider on the WDA from the exposure to manganese, thus requiring further evaluation from the CDPH staff.

  The manganese MRL is based on workplace study of neurological effects of manganese exposure to 92 male workers in a dry alkaline battery factory [82]. Manganese-exposed workers performed significantly worse than the controls on neurobehavioral tests, with particular differences in reaction time, eye-hand coordination, and hand steadiness [83]. A BMDL approach is used to quantify the cMRL (the $BMDL_{10}$ is the lower 95% confidence interval of the dose giving a 10% incidence of the effect). ATSDR designated the BMDL10 of 74 µg/m3 to be an acceptable surrogate for a no-observed-adverse-effect level (NOAEL) for the worker. ATSDR converted the NOAEL for the worker to a continuous exposure level of 17.6 µg/m^3 for a non-worker scenario. More recently, Gibbs et al. (1999) reported that exposure to 51 µg manganese/m^3 was a NOAEL among workers at a metal-producing plant when using both novel and older neurobehavioral test methods.

The air exposure estimates of manganese in air to which the dirt bike rider on the WDA might be exposed are approximately 50-76 times lower than the $BMDL_{10}$. Based on this, it is possible, but not probable, that the dirt bike riders could experience health effects from inhalation exposure to manganese in the soil.

Lead Exposure

CDPH's evaluation of the dirt bike rider getting exposed to the elevated lead on the WDA gave the following results:

- Using the highest level of lead found in the surface soil (300 mg/kg), the estimated blood lead level for an adult (men and women of non-childbearing age) is 6.1 μg/dL (99^{th} percentile) and for a child is 8.5 μg/dL (99^{th} percentile). These levels are below 10 μg/dL, CDC's current level of concern [77,78]. Thus, the elevated lead in the soil would not pose a health risk to a child or adult (men and women of non-childbearing years) dirt bike riding on the WDA.

Combined Exposures

CDPH also evaluated the additive effects of being exposed to more than one chemical in the soil (Appendix D, Tables D14 and D15). Beryllium and manganese were excluded from the inhalation pathway's list of chemicals in an effort to be able to identify whether the other metals in combination could affect the noncancer health effects. The inhalation hazard index derived from the maximum concentrations for the dirt bike rider on the waste disposal area from exposure to the metals without beryllium and manganese is estimated at 0.35. Beryllium was excluded from the incidental ingestion pathway's list of chemicals in an effort to be able to identify whether the other metals in combination could affect the noncancer health effects. The ingestion hazard index derived from the maximum concentrations without beryllium is estimated at 0.10. The combined hazard index (inhalation and ingestion) for the maximum concentrations of chemicals in the soil is estimated at 0.45.

Using the additive approach of the hazard index, the combination of the metals other than manganese and beryllium detected in the WDA soil above background levels would not be predicted to pose a health impact to the dirt bike rider. However, the hazard quotients of beryllium and manganese separately, and the hazard index of the two together and in combination with the other elevated compounds (nickel, cadmium, and copper) exceed 1. And lead, which is not evaluated using the hazard index approach, is also elevated in the WDA soil. Having the hazard index exceed 1 does not necessarily mean that the combination of exposure would cause a health effect. When investigating mixtures further, ATSDR suggests looking at each organ where the compound's toxicity has been observed. For instance:

- Target organ effects of lead when ingested or breathed and manganese when breathed are neurological.
- Target organ effects of copper and beryllium when ingested are on the gastrointestinal tract.
- The kidney is a target organ when cadmium is ingested or breathed.

- Target organ effects of cadmium, beryllium, and nickel when breathed are on the respiratory system.
- The immune system is a target when nickel is ingested or breathed.
- Target organ effects of nickel when ingested and lead when ingested or breathed are developmental.

Several organ systems (respiratory, neurological, developmental, and gastrointestinal tract) are affected by more than one chemical. The question CDPH then tried to answer was, how would an organ be affected if the exposure involved more than one chemical that affects that organ. Would the combination of chemicals affect the organ in a manner that is simply an adding of the toxicity, or would the effect be greater or less than the additive? For instance, as described above, the estimated exposure levels of manganese and beryllium for the dirt bike rider do not approach the level at which health impacts have actually been seen in published, scientific literature, but what affect would breathing lead, along with manganese, have on manganese's toxicity to the neurological system? What affect would breathing nickel and cadmium, along with beryllium, have on beryllium's effect on the respiratory system? What affect would ingesting copper, along with beryllium, have on beryllium's affect on the gastrointestinal tract? CDPH examined the scientific literature and did not find any information that would directly answer these issues. In the Interaction of Chemicals section, CDPH provides an overview of what is known about the noncancer concerns related to mixtures.

Cancer Evaluation

Berylium, cadmium, nickel, and the thorium isotopes are found in the WDA soil at levels higher than background. Exposure to these metals in the soil may increase the risk for developing cancer. Government agencies have developed theoretical models to quantify cancer risk if the exposure occurs over a long period of time, for example 30 to 70 years. However, this model is not useful for evaluating cancer risk for short-term exposure durations. Exposure to a dirt bike rider on the WDA could only have occurred for 1.5 years, a period too short to calculate a cancer risk using currently available methodologies, see Cancer Health Evaluation Section above for more information.

Exposure Pathways for Visitors to the National Conservancy Land

CDPH heard anecdotal reports of people walking along the railroad tracks and cutting through the NCL. If this route was taken, a person could come into contact with the contamination via the incidental ingestion and inhalation exposure routes. As described in the Environmental Contamination section of this document, elevated metals and thorium isotopes can be found in the surface soil of the NCL (Appendix D, Table D4).

CDPH evaluated a young person (0-9 years of age) and a child/adult (0-30 years of age) who lived in a nearby neighborhood, walked across and visited the NCL for 4 hours per day, 90 days a year. We assumed that the wind generated the dust.

In Tables D16 and D17, Appendix D, CDPH summarizes the toxicological evaluation for the visitor to the NCL. The visitor could have come into contact with contaminants via external exposure to thorium isotopes, and via incidental ingestion and inhalation exposure to the metals and thorium isotopes. For the exposure evaluation, CDPH used data from the NCL surface soil samples taken by EPA's contractor as part of the Integrated Assessment Report (summarized in Appendix D, Table D4).

Inhalation of Soil that Becomes Airborne—Noncancer Health Effects

The adjusted air concentrations (beryllium, cadmium, manganese, and nickel) derived from the maximum concentration of the chemicals in the soil do not exceed their corresponding inhalation health comparison values (Appendix D, Tables D16 and D17). For those chemicals with no inhalation health comparison value (aluminum, antimony, barium, chromium, cobalt, copper, molybdenum, selenium, silver, vanadium, and zinc), an exposure dose from inhaling the fugitive dust was calculated for the young child and the child/adult. None of the exposure doses derived from inhaling fugitive dust emissions, using the maximum concentration measured in the soil, exceed their corresponding oral health comparison values.

Ingestion—Noncancer Health Effects

The exposure doses for the young child and the child/adult from incidental ingestion of soil were derived for each chemical using the maximum concentration found in the soil (Appendix D, Tables D16 and D17). The exposure doses are below their respective comparison values. Based on this evaluation, none of the chemicals measured in the soil, individually, would be expected to cause a noncancer health impact to the visitor to the NCL.

Combined Exposure—Noncancer Health Effects

CDPH also evaluated the additive effects of being exposed to more than one chemical in the soil using the hazard index approach. The inhalation hazard index derived from the maximum concentrations for the visitors to the NCL from exposure to the contaminants of concern is estimated at less than 0.01 for the young child and the child/adult (Appendix D, Tables D16 and D17). The incidental ingestion hazard index derived from the maximum concentrations for the visitors to the NCL from exposure to the metals is estimated at 0.74 for the young child and 0.081 for the child/adult. The combined hazard index (inhalation and ingestion) for the maximum concentrations are both less than 1. Since the indexes are less than 1, exposure to the metals in the soil should not pose a noncancer health risk to the visitor to the NCL.

Lead Exposure—Noncancer Health Effects

CDPH's evaluation of the elevated lead in the surface soil at the NCL gave the following results:

- Using the highest level of lead found in the surface soil (250 mg/kg), the predicted geometric mean blood lead level was 1.8 µg/dl, for the pregnant woman, 6.3 µg/dl (95%) in the fetus of the pregnant woman with a less than 1.4% probability that the fetal blood lead concentration will exceed 10 µg/dl. The goal is to ensure that there is less than a 5% probability that the fetal blood lead concentration will exceed 10 µg/dl, thus the lead in the surface soil at the

NCL would not pose a health risk to a pregnant visitor to the NCL or the fetus of the pregnant visitor to the NCL.

- Using the highest level of lead found in the surface soil (250 mg/kg), the estimated blood lead level for an adult (men and women of non-childbearing age) is 6.1 μg/dL (99^{th} percentile) and for a child, 8.5 μg/dL (99^{th} percentile). These levels are below CDC's current level of concern of 10 μg/dL [77,78]. Thus, the elevated lead in the soil at the NCL would not pose a health risk to a child or adult (men and women of non-childbearing years) visiting the NCL.

Cancer Risk Evaluation: Visitor to the National Conservancy Land

In Tables D16 and D17, Appendix D, CDPH summarizes the cancer exposure evaluation for the visitor going to the NCL. The visitor could have come into contact with contaminants via external exposure and ingestion from the thorium isotopes, and inhalation exposure to the metals and thorium isotopes. The total cancer risk is derived by summing the cancer risks values (incidental ingestion and external exposure to the thorium isotopes and inhalation to the metals and thorium). The total increased cancer risk for the young child (0-9 years of age) from the maximum soil concentration measured in the NCL is 2.5 in 1,000,000 chance of getting cancer. The risk is driven by the external exposure to thorium. The total cancer risk for the child/adult visiting the NCL on a regular basis and being exposed to the maximally contaminated soil is 2.6 in 1,000,000. The risk is driven by the external exposure to the thorium isotopes. The total cancer risk's qualitative interpretation for the visitor to the NCL is no apparent increased risk of getting cancer at the maximum levels measured in the soil.

Exposure Pathway for Dirt bike Riders in the National Conservancy Land

CDPH heard anecdotal reports of children/teenagers riding their bikes along the railroad tracks and the cutting through the NCL. On a CDPH visit to the area in November 2007, CDPH observed two young men riding dirt bikes around the NCL. As described in the Environmental Contamination section of this document, elevated metals and the thorium isotopes can be found in the surface soil (Appendix D, Table D4). A dirt bike rider could come into contact with the contamination in the surface soil via incidental ingestion or inhalation exposure.

CDPH assumed the exposure may have begun when the children/teenagers were old enough (15-18 years of age) to get a dirt bike, and continued into their adult life for another 26 years. We assumed they rode for 4 hours, 90 times per year. CDPH used data from NCL's surface soil samples taken by EPA's contractor as part of the Integrated Assessment Report (Appendix D, Table D4).

In Tables D18 and D19, Appendix D, CDPH summarizes the toxicological evaluation for the dirt biker going to the NCL.

Ingestion—Noncancer Health Effects

The exposure doses for the dirt bike rider were estimated from incidental ingestion of soil using the maximum concentration for each chemical found elevated in the soil (Appendix D, Table D18). The exposure doses are below their respective comparison values.

Inhalation of Soil that Becomes Airborne—Noncancer Health Effects

For those chemicals with no inhalation health comparison value (aluminum, barium, chromium, copper, silver, and zinc), an exposure dose from inhaling the fugitive dust was calculated. The estimated doses for a dirt bike rider inhaling dust using the maximum concentration of chemicals found elevated in the soil did not exceed their corresponding oral health comparison values (Appendix D, Table D18).

The adjusted air concentrations for beryllium, cadmium, and nickel derived from the maximum concentration of the chemicals did not exceed their corresponding health comparison value (Appendix D, Table D18). The adjusted air concentration (0.24 ug/m^3) derived from the maximum concentration of manganese in the soil exceeds the cMRL of 0.04 ug/m^3. The adjusted air concentration (0.10 ug/m^3) derived from the average concentration of manganese in the soil also exceeds the cMRL (Appendix D, Table D19). This suggests a concern for noncancer effects for the dirt bike rider from the exposure to manganese, thus requiring further evaluation from the CDPH staff.

- The manganese MRL is based on human neurological studies and neurobehavioral tests; from these studies, scientists were able to determine a NOAEL for workers in metal producing plants. A BMDL approach is used to quantify the cMRL. The Benchmark Dose Analysis ($BMDL_{10}$) is based on the observing the neurological effects in humans. Specifically, the inhalation study by Roels et al. studied the neurological effects of manganese exposure to 92 male workers in a dry alkaline battery factory [83]. A 95% confidence was estimated for the level of manganese exposure to result in a 10% response rate, the benchmark dose analysis ($BMDL_{10}$) of 74 µg manganese/m^3 was considered to be an acceptable surrogate for a NOAEL. ATSDR converted the NOAEL for the worker to a continuous exposure level of 17.6 µg/m^3. More recently, Gibbs et al. [84] reported that exposure to 51 µg manganese/m^3 was a NOAEL among workers at a metal producing plant when using both novel and older neurobehavioral test methods. The air estimates of manganese to which the dirt bike rider on the NCL could have been exposed are approximately 75 to 180 times lower than the $BMDL_{10}$. Based on this, it is unlikely, but not impossible, the dirt bike riders could experience health effects from inhalation exposure to manganese in the soil.

Lead Exposure

CDPH's evaluation of the dirt bike rider getting exposed to the elevated lead in the soil on the NCL gave the following results:

- Using the highest level of lead found in the surface soil (250 mg/kg), the estimated blood lead level for an adult (men and women of non-childbearing age) is 6.1 µg/dL (99th percentile), and for a child is 8.6 µg/dL (99th percentile). These levels are below CDC's current level of concern of 10 µg/dL [77,78]. Thus, the elevated lead in the soil would not pose a health risk to a child or adult (men and women of non-childbearing years) dirt bike riding on the NCL.

Combined Exposures—Noncancer Health Effects

CDPH also evaluated the additive effects of being exposed to more than one chemical in the soil for the dirt bike rider on the NCL. Manganese was excluded from the inhalation pathway's list of chemicals in an effort to identify whether the other metals in combination could affect the noncancer health effects. The inhalation hazard index derived from the maximum concentrations for the dirt bike rider on the NCL from exposure to the other metals, not including manganese, is estimated at 0.24 (Appendix D, Table D18). The ingestion hazard index derived from the maximum concentrations is estimated at 0.07. The combined hazard index (inhalation and ingestion) for the maximum concentrations of chemicals in the soil is estimated at 0.31.

Using the additive approach of the hazard index, the combination of the metals other than manganese detected in the NCL soil above background levels would not be predicted to pose a health impact to the dirt bike rider. However, the hazard quotient of manganese, and the hazard index of the combination with the other elevated compounds (nickel and beryllium) exceed 1. And lead, which is not evaluated using the hazard index approach, is also elevated in the NCL soil. Having the hazard index exceed 1 does not necessarily mean that the combination of exposure would cause a health effect. When investigating mixtures further, ATSDR suggests looking at each organ where the compound's toxicity has been observed. For instance:

- Target organ effects of lead when ingested or breathed, and manganese when breathed, are neurological.
- Target organ effects of beryllium and nickel when breathed are on the respiratory system.
- Target organ effects of nickel when ingested, and lead when ingested or breathed, are developmental.

Several organ systems (respiratory, neurological, and developmental) are affected by more than one chemical. The question CDPH then tried to answer was, how would an organ be affected if the exposure involved more than one chemical that affects that organ. Would the combination of chemicals affect the organ in a manner that is simply an adding of the toxicity, or would the effect be greater or less than the additive? For instance, as described above, the estimated exposure level for the dirt bike rider breathing manganese does not approach the level at which health impacts have actually been seen in published, scientific literature, but what effect would breathing lead along with manganese have on manganese's toxicity to the neurological system? CDPH examined the scientific literature and did not find any information that would directly answer this issue. In the Interaction of Chemicals section, CDPH provides an overview of what is known about the noncancer concerns related to mixtures.

Cancer Risk Evaluation: Dirt Bike Rider to the NCL

The total cancer risk derived from 30 years of dirt bike riding on the NCL is derived by summing the cancer risks values from inhaling beryllium-, cadmium-, and nickel-contaminated soil that has become airborne, added with the risks from incidentally ingesting the dust, inhaling the dust generated from the soil, and external exposure to the thorium isotopes in the soil.

The total cancer risk for exposure to the maximum contamination in the soil from all exposure pathways, metals and isotopes, is 1.0 in 100,000. The total cancer risk for exposure to the average levels of contamination in the soil from all exposure pathways, metals and isotopes, is 3.6 in 1,000,000. The qualitative interpretation for the bike rider to the NCL is very low increased risk of getting cancer at these levels.

Exposure Pathways for the Farm Worker

Farms are located to the East of the Halaco site (Appendix B, Figure B1). The farm worker would obviously come in contact with the soil in tending of the fields. As discussed in the previous section, the metals measured in the surface soil samples taken from the two agricultural fields located near the Halaco site are not elevated compared to background (Appendix D, Table D5). Though Halaco air emissions landed on the agriculture fields, the soil has been tilled and turned quite a bit over the years, and years of rainwater may have resulted in the chemicals migrating from the surface soils.

Since the levels of metals in the surface soils in the agricultural field are not elevated above what is typical, no toxicological evaluation was conducted.

It is also possible that contamination that exists on the smelter site, Waste Disposal Area, wetlands, beach, and Nature Conservancy Land may become airborne and to some extent travel to the nearby agricultural fields and be breathed by the farm workers. As described in the other exposure pathway analyses sections, breathing windblown dust was not a health concern for the visitor to the wetlands, beach, and Nature Conservancy thus CDPH concludes that the possible impact from windblown dust is not significant for the farm worker.

Exposure Pathways for Nearby Residents

Residential communities are located to the north and northeast directions (less than ½ mile) from the Halaco site (Appendix B, Figure B1). A demographic breakdown is in the Land Use and Demographic section. Anecdotal reports persist that Halaco would release plumes of exhaust during the night. As discussed in the previous section, the metals measured in the surface soil samples taken from the neighborhood boundary are not elevated compared to background (Appendix D, Table D6). However, only ten samples were analyzed in the field and only two samples were analyzed in the laboratory.

The limited sampling that has occurred in the neighborhood does not show an impact from Halaco. Explanations for this include the following: the soil has probably not been left undisturbed over the years, years of rainwater may have resulted in the chemicals migrating from the surface soils, or perhaps the loading of the soil from the air emissions was too low to leave a measurable impact.

Since the levels of metals in the surface soils in the neighborhood are not elevated above what is typical, no toxicological evaluation was conducted. However, CDPH recommends additional soil sampling in residential neighborhoods because of the limited soil sampling that has occurred.

It is also possible that contamination that exists on the smelter site, Waste Disposal Area, wetlands, beach, and Nature Conservancy Land may become airborne and to some extent travel into the community and be breathed by the residents. As described in the other exposure pathway analyses sections, breathing windblown dust was not a health concern for the visitor to the wetlands, beach, and Nature Conservancy thus CDPH concludes that the possible impact from windblown dust is not significant for the resident.

Exposure Pathways for Visitors to the Wetlands

The parking lot on Perkins Road facing the ocean is another popular destination for visitors wanting to visit the lagoon, ocean and/or wetlands. Nearby residents mentioned they used the footbridge when Halaco was operating. As shown in Table D7, Appendix D, elevated levels of metals and two of the thorium isotopes were found in the wetland surface sediment/soil samples.

In March 2007, EPA closed the footbridge due to the discovery of elevated waste solids in the wetlands; the contamination was removed and the footbridge was reopened that summer [85]. The data from the soil that was removed was not used in this analysis, as it was a fairly limited area of impact and it was not considered likely that a person would come to the wetlands and spend all of their time at the edge of the footbridge. This part of the wetlands is very close to the industrial activities occurring at Halaco when it was in operation, close to Perkins Road, but not very close to the beach.

CDPH evaluated a young person (0-9 years of age) and a child/adult (0-30 years of age) who visits the wetlands during 4 hours a day, 90 days a year.

In Tables D20-D22, Appendix D, CDPH summarizes the toxicological evaluation for visitors to the wetlands. The visitor to the wetlands could come into contact with the contamination via the incidental ingestion route or via inhalation of the sediment/soil when it becomes airborne.

Inhalation of Soil that Becomes Airborne—Noncancer Health Effects

The adjusted air concentrations (cadmium, beryllium, manganese, and nickel) derived from the maximum concentration of the chemicals in the soil do not exceed their corresponding inhalation health comparison values (Appendix D, Tables D20 and D21). For those chemicals with no inhalation health comparison value (aluminum, barium, chromium, copper, silver, and zinc), an exposure dose from inhaling the fugitive dust was calculated. None of the exposure doses derived from inhaling fugitive dust emissions for either the young child or the child/adult exceed their corresponding oral health comparison values.

Ingestion—Noncancer Health Effects

The exposure doses derived from incidental ingestion of soil were derived from the chemical's (aluminum, barium, beryllium, cadmium, chromium, copper, manganese, nickel, silver, and zinc) maximum concentrations found in the soil (Appendix D, Tables D20 and D21). All of the exposure doses for both the young child and child/adult were below their respective comparison values.

Based on this evaluation, none of the chemicals measured in the soil, individually, would be expected to cause a noncancer health impact to the visitor to the wetlands area near Halaco.

Lead Exposure

CDPH's evaluation of the elevated lead in the surface soil at the wetlands gave the following results:

- Using the highest level of lead found in the surface soil (736 mg/kg), the predicted geometric mean blood lead level was 1.9 µg/dl, for the pregnant woman, 6.8 µg/dl (95%) in the fetus of the pregnant woman, with a less than 1.7%probability that the fetal blood lead concentration will exceed 10 µg/dl. The goal is to ensure that there is less than a 5% probability that the fetal blood lead concentration will exceed 10 µg/dl, thus the lead in the surface soil at the wetlands would not pose a health risk to a pregnant visitor to the wetlands or the fetus of the pregnant visitor to the wetlands.

- Using the highest level of lead found in the surface soil (736 mg/kg), the estimated blood lead level for an adult (men and women of non-childbearing age) is 6.1 µg/dL (99^{th} percentile), and for a child, 8.6 µg/dL (99^{th} percentile). These levels are below CDC's current level of concern of 10 µg/dL [77,78]. Thus, the lead in the soil at the wetlands would not pose a health risk to a child or adult (men and women of non-childbearing years) visiting the wetlands.

Combined Exposures

CDPH also evaluated the additive effects of being exposed to more than one chemical in the soil using the hazard index approach. The inhalation hazard index derived from the maximum concentrations of chemicals in the soil for the child/adult visiting the wetlands is estimated at less than 0.01 (Appendix D, Table D20). The incidental ingestion hazard index derived from the maximum concentrations of chemicals in the soil for the child/adult visiting the wetlands is estimated at 0.11. The combined hazard index (inhalation and ingestion) for the maximum concentrations is estimated at 0.11. Since the hazard index is less than 1 using the maximum levels of contamination, exposure to the surface soil in the wetlands should not pose a noncancer health risk to the child/adult visiting the wetlands.

The inhalation hazard index derived from the maximum concentrations of chemicals in the soil for the young child (0 to 9 years of age) visiting the wetlands is estimated at less than 0.01 (Appendix D, Table D21). The incidental ingestion hazard index derived from the maximum concentrations of chemicals in the soil for the young child visiting the wetlands is estimated at

1.35. The combined hazard index (inhalation and ingestion) for the maximum concentrations is estimated at 1.35.

Since the hazard index for the young child's exposure to the maximum concentrations in the soil in the wetlands exceeds 1, CDPH also evaluated exposure to the average concentrations of the chemicals in the soil. The inhalation hazard index derived from the average concentrations of chemicals in the soil for the young child visiting the wetlands is estimated at less than 0.01 (Appendix D, Table 22). The incidental ingestion hazard index derived from the average concentrations of chemicals in the soil for the young child visiting the wetlands is estimated at 0.70. The combined hazard index (inhalation and ingestion) for the average concentrations is estimated at 0.70. The hazard index is less than 1 for exposure to the young child to the average concentration of chemicals in the wetlands, and this probably represents a more likely exposure scenario than a child always playing in the location where the maximum concentration was found. Thus, it seems that the exposures should not pose a noncancer health risk to the young child visiting the wetlands.

Cancer Risk Evaluation: Visitors to the Wetlands

The visitor to the wetlands could have come into contact with cancer causing contaminants via external exposure and ingestion from the thorium isotopes, and inhalation exposure to the metals and thorium isotopes. The total cancer risk is derived by summing the cancer risks values (incidental ingestion and external exposure to the thorium isotopes, and inhalation to the metals and thorium). The total cancer risk for a child/adult visiting the wetlands for 30 years, calculated assuming the child/adult was exposed to the maximum contamination in the soil of metals and isotopes, and from all exposure pathways, is 9.8 in 10,000,000. The qualitative interpretation for the child/adult visitor to the wetlands is a no apparent increased risk of getting cancer at these levels.

The total cancer risk derived for the child 0-9 years of age visiting the wetlands from exposure to the maximum contamination in the soil from all exposure pathways, metals and isotopes is 9.3 in 10,000,000. The qualitative interpretation for the 0-9 year old visitor to the wetlands is a no apparent increased risk of getting cancer at these levels.

Exposure Pathways for Visitors to Ormond Beach

During the site visit, CDPH staff saw people visiting a stretch of beach in front of the Halaco site. Ormond Beach is considered a popular location with the neighborhood residents. The visitor to the beach could have come in contact with the contamination via the incidental ingestion and inhalation of soil particles. As described in the Environmental Contamination section of this document, elevated metals and thorium isotopes 228 and 232 can be found in the surface soil/sand of the beach (Appendix D, Table D9).

CDPH evaluated a young person (age 0-9 years of age) and a child/adult (0-30 years of age) who visits the beach during 4 hours a day, 90 days a year.

In Tables D23 and D24, Appendix D, CDPH summarizes the toxicological evaluation for visitors to the beach near the Halaco site. The visitors could have come into contact with contaminants in the soil/sand via the incidental ingestion and inhalation exposure pathways. For the inhalation evaluation the concentration of respirable particles in the air was generated from the soil concentrations assuming fugitive dust emissions.

Inhalation of Soil that Becomes Airborne—Noncancer Health Effects

The adjusted air concentrations (cadmium, beryllium, manganese, and nickel) derived from the maximum concentration of the chemicals in the Ormond Beach soil/sand do not exceed their corresponding inhalation health comparison values (Appendix D, Tables D23 and D24). For those chemicals with no inhalation health comparison value (aluminum, barium, chromium, copper, silver, and zinc), an exposure dose from inhaling the fugitive dust was calculated. None of the exposure doses derived from inhaling fugitive dust emissions for either the young child or the child/adult exceed their corresponding oral health comparison values.

Ingestion—Noncancer Health Effects

The exposure doses derived from incidental ingestion of soil were derived from the chemical's (aluminum, barium, beryllium, cadmium, chromium, copper, manganese, nickel, silver, and zinc) maximum concentrations found in the Ormond Beach soil/sand (Appendix D, Tables D23 and D24). All of the exposure doses for both the young child and child/adult were below their respective comparison values.

Based on this evaluation, none of the chemicals measured in the soil, individually, would be expected to cause a noncancer health impact to the visitor to the Ormond Beach near Halaco.

Combined Exposures

CDPH also evaluated the additive effects of being exposed to more than one chemical in the soil using the hazard index approach. The inhalation hazard index derived from the maximum concentrations for the young child visiting the wetlands is estimated at less than 0.01 (Appendix D, Table D24). The incidental ingestion hazard index derived from the maximum concentrations for the young child visiting Ormond Beach is estimated at 0.029. The combined hazard index (inhalation and ingestion) for the maximum concentrations is estimated at 0.029. Since the hazard index is less than 1 using the maximum levels of contamination, the exposures should not pose a noncancer health risk to the young child visiting Ormond Beach.

The inhalation hazard index derived from the maximum concentrations for the child/adult visiting the wetlands is estimated at less than 0.01 (Appendix D, Table D23). The incidental ingestion hazard index derived from the maximum concentrations for the child/adult visiting Ormond Beach is estimated at less than 0.01. The combined hazard index (inhalation and ingestion) for the maximum concentrations is estimated at less than 0.01. Since the hazard index is less than 1 using the maximum levels of contamination, the exposures should not pose a noncancer health risk to the child/adult visiting Ormond Beach.

Lead Exposure

CDPH's evaluation of the elevated lead in the surface soil at the beach gave the following results:

- Using the highest level of lead found in the surface soil (5.4 mg/kg), the predicted geometric mean blood lead level was 1.7 µg/dl, for the pregnant woman, 6.0 µg/dl (95%) in the fetus of the pregnant woman, with a less than 1.2% probability that the fetal blood lead concentration will exceed 10 µg/dl. The goal is to ensure that there is less than a 5% probability that the fetal blood lead concentration will exceed 10 µg/dl, thus the lead in the surface sand/soil at the beach would not pose a health risk to a pregnant visitor to the beach or the fetus of the pregnant visitor to Ormond Beach.

- Using the highest level of lead found in the surface soil (5.4 mg/kg), the estimated blood lead level for an adult (men and women of non-childbearing age) is 6.0 µg/dL (99^{th} percentile) and for a child, 8.5 µg/dL (99^{th} percentile). These levels are below CDC's current level of concern of 10 µg/dL [77,78]. Thus, the lead in the sand/soil at the beach would not pose a health risk to a child or adult (men and women of non-childbearing years) visiting Ormond Beach.

Cancer Risk Evaluation: Visitors to Ormond Beach

The visitor to the beach could have come into contact with cancer-causing contaminants via external exposure and ingestion from the thorium isotopes, and inhalation exposure to the metals and thorium isotopes. The total cancer risk is derived by summing the cancer risks values (incidental ingestion and external exposure to the thorium isotopes, and inhalation to the metals and thorium).The total cancer risk for the child/adult visiting the Ormond Beach with exposure to the maximum contamination in the soil/sand, from all exposure pathways, metals and isotopes, is 1.04 in 1,000,000 (Appendix D, Table D23). The qualitative interpretation for the child/adult to Ormond Beach is a no apparent increased risk of getting cancer at these levels.

The total cancer risk for the child/adult visiting the Ormond Beach with exposure to the maximum contamination in the soil/sand, from all exposure pathways, metals and isotopes, is 9.9 in 10,000,000 (Appendix D, Table D24). The qualitative interpretation for the young child (0-9 years of age) to Ormond Beach is a no apparent increased risk of getting cancer at these levels.

Exposure Pathway for Trespassers Playing in the Oxnard Industrial Drain

Anecdotal reports surfaced that people used to wade/play in the waters close to the Halaco site. As described in the Environmental Contamination section of this document, elevated metals (not including lead) can be found at and around the site in the surface water (Appendix D, Table D10).CDPH evaluated a swimming exposure pathway for a child (8-18 years of age) and adult (18-30 years of age).

CDPH assumed that individuals would swim and incidentally ingest small amounts of water (0.5 milliliters per hour of swimming), and there would be skin absorption over their total body. CDPH assumed the children/teenager's surface area to be 1.39 square meters (m^2) and the adult's surface area to be 1.81 m^2.

In Tables D25 and D26, Appendix D, CDPH summarizes the toxicological evaluation of visitors swimming in water near the Halaco site.

Ingestion—Noncancer Health Effects

The child and the exposure doses derived from incidental ingestion of water contaminated with the maximum concentrations of chemicals (aluminum, barium, beryllium, cadmium, chromium, copper, nickel, silver, and zinc) were below their respective oral health comparison value (Appendix D, Tables D25 and D26).

Skin Absorption--Noncancer Health Effects

The child and the exposure doses derived from dermal absorption of water contaminated with the maximum concentrations of chemicals (aluminum, barium, beryllium, cadmium, chromium, copper, manganese, nickel, silver, and zinc) were below their respective dermal health comparison value (Appendix D Tables D25 and D26).

Based on this evaluation, none of the chemicals measured in the water individually, would be expected to cause a noncancer health impact to the visitors wading in water near the Halaco site.

Combined Exposures

CDPH also evaluated the additive effects of being exposed to more than one chemical in the surface water using the hazard index approach. The combined hazard indices (incidental ingestion and dermal) derived for the visitor (child and adult) swimming in the water and exposed to the maximum concentrations are estimated at 0.051 and 0.050, respectively (Appendix D, Tables D25 and D26). Since each of the indexes is less than 1, the exposures should not pose a noncancer health risk to the person swimming in the water.

Cancer Risk Evaluation: Visitors Wading in Water

None of the chemicals associated with the Halaco site and measured in the surface water near the site are considered to be cancer-causing when ingested; thus, CDPH did not calculate a cancer risk for the visitor swimming in the surface water near the site.

Limitations of the Exposure Evaluation

The identification and analysis of environmental exposures is difficult and inexact. This PHA was prepared using different sources of information. There are varying degrees of uncertainty associated with each source of information. The following describes four broad areas where uncertainties may be found, and provides examples of some of these uncertainties.

Environmental Data

In preparing this PHA, CDPH relied on information provided by EPA and the Air District. CDPH assumes that adequate quality control measures were followed with regard to chain of custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions reported in this PHA depends on the completeness and reliability of the referenced information. As stated previously, there are data gaps in understanding past exposures, which can no longer be filled. We have recommended sampling that can help fill data gaps in understanding current or future exposure.

Exposure Assessment

Exposure assumptions were used to estimate exposure doses. The exposure assumptions used in this PHA are meant to provide conservative (health protective) results for the exposure estimates. For instance, we begin the evaluation by using the maximum concentrations of chemicals found at that location even if they were from different sampling points. CDPH assumed that 100% if the chemicals present in the soil were taken up by the body when the soil was ingested.

For those pathways involving soil/sediment/sand, CDPH evaluated incidental ingestion and inhalation of soil/sediment/sand that becomes airborne. EPA has published conversion numbers (PEFs) that can be used to convert a soil concentration into an air concentration. EPA has published PEF values for a wind-blown dust scenario ($1.31 \times 10^{+9}$ m^3/kg), and for when maintenance and other soil disturbing activities occur ($1.0 \times 10^{+6}$ m^3/kg). These two PEF values, when used to create an air concentration from the same soil concentration, yield results of a thousand-fold difference. CDPH used the PEF for wind-blown situations for most of the exposure pathway scenarios. CDPH used the PEF for soil disturbing activities for the dirt bike rider exposure pathway evaluations. In two personal air sampling events conducted by EPA in places where asbestos in the soil was a concern (not at Halaco), dust generating activities have been shown to be associated with a much higher exposure [86,87]. For instance, a dirt bike rider in the back of the pack was exposed to almost a thousand-fold higher concentration than the ambient levels (i.e., wind-blown dust situations) [86]. In those same studies, the dirt bike rider in the front of the pack was exposed to levels approximately tenfold higher than ambient air (wind blown) levels.

Contaminant Toxicity

Toxicity information for the compounds found elevated above background was generated mostly from animal studies at high doses and in some cases, epidemiological studies of adult worker populations. For most contaminants, we really do not know what effects will result from low level exposure to humans. There are also data gaps in the understanding of many compounds, particularly for impacts to the immune system, and reproduction and development.

To account for some of this uncertainty in contaminant toxicity information, CDPH used health comparison values developed by ATSDR, EPA, and OEHHA. These agencies have incorporated uncertainty (or safety) factors in developing the health comparison values.

Interaction of Chemicals

The approach of evaluating the individual components of the mixture and adding the hazard is taken by public health officials because there is generally a lack of health information available in the scientific literature about the various mixtures found at hazardous waste sites. There are only a few studies available that examined the additivity of toxicity for mixture components [88]. Some of the studies have shown that four compounds administered to an animal in sub-toxic doses in combination had effects that were consistent with additivity or less than additivity if they affected the same organ in a similar toxic mechanism [89], or the same organ via different toxic mechanisms [90]. Other studies by scientists at the same institution found few effects when eight [91] and nine compounds [92] that acted by different toxic mechanisms were given in sub-toxic doses.

Other studies have found that exposure to several compounds at less than toxic doses that affect the same organ, though not by the same toxic mechanism, can result in adverse effects [93-96]. For instance, in a series of studies performed by the National Institute of Environmental Health Sciences, a mixture of 25 groundwater contaminants from hazardous waste sites indicated that toxic effects can result when the compounds were present individually at levels sub-toxic [97].

There have been no studies of the particular mixture of metals and radionuclides present at the Halaco site. Given that there have been no studies of the mixture, CDPH reviewed available literature to see what is known about the interactions of some of the compounds found in the mixture, in particular manganese and beryllium. ATSDR has published documents in which they examine the literature about the interactions of certain compounds; CDPH reviewed the Interaction Profile for Lead, Manganese, Zinc, and Copper [98], and the Interaction Profile for Arsenic, Chromium, and Lead [99]. Most of the data that was available for ATSDR's inclusion in the interaction profile were from binary mixtures, i.e., lead-zinc, lead-manganese, lead-copper, and zinc-copper, but not particularly helpful in addressing interactions between manganese and beryllium. Given the lack of information relevant to the specific mix of chemicals present at the Halaco site, the following is a general overview about chemical interactions taken from ATSDR's guidance [88].

Interactions of chemicals in the body can occur because of chemical-chemical, pharmacokinetic, or pharmacodynamic interactions. A chemical-chemical interaction is possible for the metals found in the soil once taken into the body; however, it seems that interaction could have already occurred in the soil. An example of such an interaction is the oxidation/reduction of a metal from one cationic state caused by another metal, and for some metals, the cationic state does influence the bioavailability of the metal.

Pharmacokinetic interactions of the metals once in the body may also occur. In other words, one metal may influence the absorption, distribution, excretion, and metabolism of another metal. For instance:

- Manganese has been shown to increase the amount of lead that is found in the brains of rats treated with both compared to when lead only was administered [100,101]. Thus, manganese increases the distribution and retention of lead in the brain. On the other hand, manganese does not affect the distribution and retention of lead in the brain. One would predict a greater than additive effect of manganese and lead toxicity on the brain because of the interaction of manganese on the pharmacokinetics of lead.

- Manganese increases how long lead stays in the blood; thus, manganese prolongs the impact of lead on the hematological impacts [102]. It is not clear what mechanism is responsible for manganese's effect on blood retention of lead, but it probably involves a pharmacokinetic interaction. The interaction of manganese and lead on hematological is thought to be greater than additive.

Pharmacodynamic interactions of compounds found elevated on and around the Halaco site may also occur once inside the body. In other words, one metal may interact at the same receptor or target molecule, at a different site on the same molecule, or some other more complex interaction at the mechanistic site of the toxic impact. For instance:

- Cadmium has been found to both increase and decrease the effect of nickel on the kidney [103,104]. In the study that showed a decrease, mice pretreated with cadmium 24 hours before nickel treatment had decreased nickel-induced lethality and lipid peroxidation [104]. The investigators suggested that cadmium-induced production of ceruloplasmin negated the nickel-induced reduction of ceruloplasmin, thus protecting against nickel toxicity.

Due to the lack of information about the interactions of the metals found in the Halaco site, CDPH was not able to further evaluate the health impact of being exposed to the mixture of chemicals for the dirt bike rider on the WDA, the dirt bike rider on the NCL, or the visitor to the wetlands.

Health Outcome Data

ATSDR and CDPH were interested in looking at all available data on health outcomes that may be associated with the contamination released from the Halaco facility during its operation, from 1965 to 2004. The most comprehensive approach to looking at the health outcome data for this situation could involve the following steps:

- Generating an initial list of health symptoms and diseases that are known to be associated with contaminants found at the Halaco site.
- Collecting medical records for people who lived near the Halaco site from 1965 to 2004, thus were likely to have been exposed to Halaco contaminants.
- Collecting medical records for people who did not live near the Halaco site from 1965 to 2004, thus were probably not exposed to Halaco contaminants.
- Comparing how many people had health symptoms and diseases from the initial list of health symptoms and diseases that are known to be associated with contaminants found at the Halaco site among the group living near Halaco, compared to the group not living near Halaco.

Yet this type of approach is difficult to accomplish because in the United States, there are a variety of medical providers that people consult, such as private physicians, health maintenance organizations, government clinics, etc. Because there is no universal, comprehensive medical care system, medical records are not easily obtained. In addition, there is a lack of a centralized health surveillance system that tracks a wide range of health symptoms and diseases occurring among the general population.

However, there are some surveillance and data collection systems for specific health conditions and diseases in California. These surveillance systems vary on the types of health conditions and diseases that are monitored, the time period that data has been collected, and the smallest geographic area for which data is available. This section describes what type of data was available, and presents a discussion of the data results for cancer, asthma, low birth weight, preterm births, and birth defects. Census tracts are often the smallest areas for which we have readily available demographic and disease surveillance data. However, for some of the health outcomes included in this review, only data for much larger geographical areas such as the ZIP code or county level was available.

Table 4 below summarizes the data that CDPH staff was able to obtain for communities located near the Halaco site.

Table 4. Summary of Health Outcome Data Available for the Halaco Site

Specific Health Condition and Disease	Data Source	Time Period For Which Data Is Available	Smallest Geographic Area for Which Data Is Available
Asthma: estimated prevalence rate	California Health Interview Survey	2001, 2003, 2005 (biannual data)	County
Asthma: crude asthma hospitalization rate	California Office of Statewide Health Planning and Development	1990-2006 (annual data)	ZIP code
Cancer: observed and expected number of cases for different types of cancer	California Cancer Registry	1988-2006 (annual data)	Census tract
Birth defects: proportion of births with specific types of birth defects	California Birth Defects Monitoring Program	1989 (one year only)	ZIP code
Low birth weight and preterm births: annual incidences	Center for Health Statistics and California Environmental Health Tracking Program	1982-2006 (annual data)	ZIP code

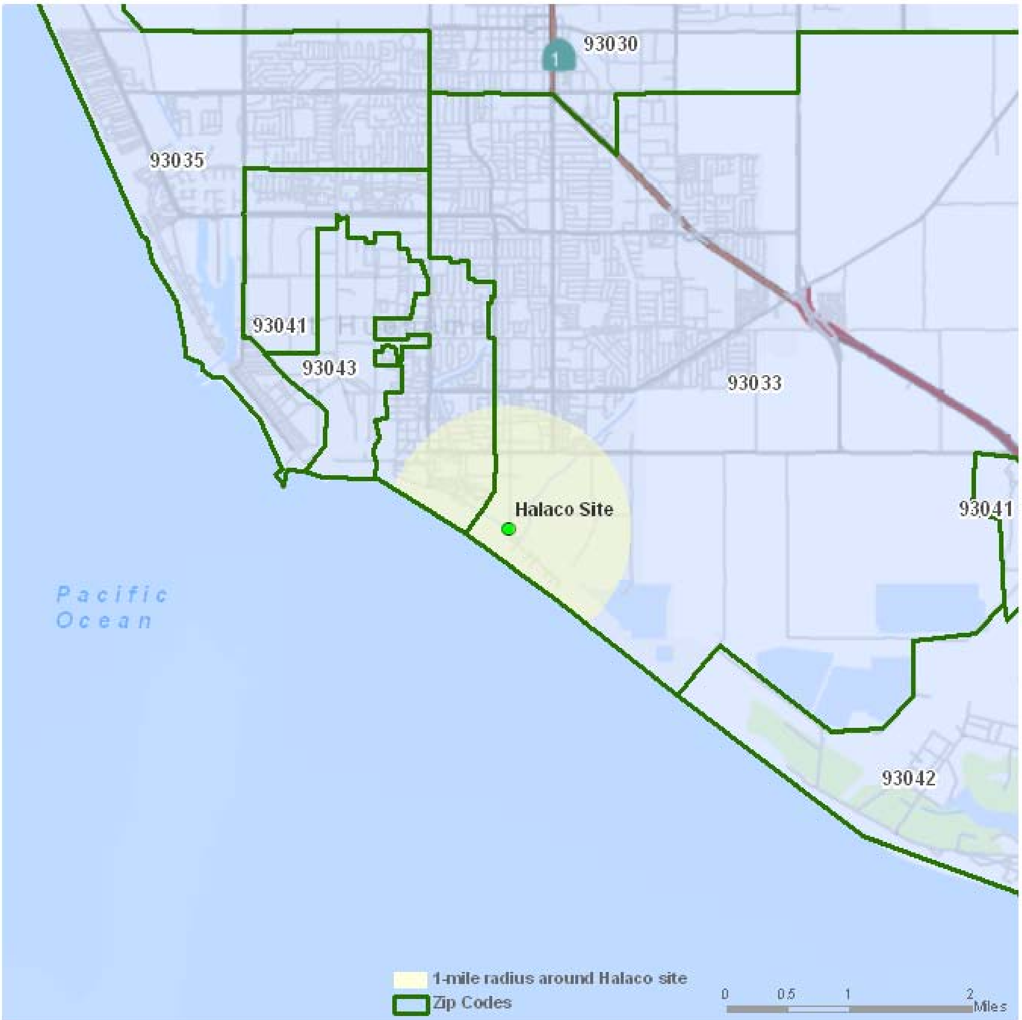
Asthma Statistics Data Review for the Halaco Site

As described in the Environmental Contamination and the Exposure Pathways Analysis sections of this document, contaminants that can affect the respiratory system were released from Halaco when it was an operating facility. In addition, community members living near the Halaco site were concerned that their exposure to the contaminants was associated with having asthma or experiencing common symptoms of asthma, such as coughing, difficulty breathing, and heaviness or pressure in the chest. This data on asthma in the communities surrounding Halaco was obtained from California Breathing, a program housed at CDPH. California Breathing's activities include asthma surveillance, which involves analyses of data to determine if certain populations are experiencing unusually high rates of asthma health effects.

Geographic Areas and Time Periods Reviewed

Though it is ideal to collect data on the census tract level, unfortunately, this level of data was not available for the asthma statistics. Therefore, data is presented here for Ventura County and the ZIP codes within a 1-mile radius of the Halaco site, ZIP codes 93033 (southern Oxnard) and 93041 (Port Hueneme). A map of these two ZIP codes and the Halaco site is included in Figure 1 below.

Figure 1. ZIP Codes 93033 (Southern Oxnard) and 93041 (Port Hueneme) Located Within a 1-Mile Radius of the Halaco Site



Created by S. Smorodinsky, Environmental Health Investigations Branch, California Department of Public Health.

The Halaco facility operated from 1965 to 2004. CDPH staff requested a review of data from 1965 until the latest possible date. California Breathing examined the available data that applied to this time period. Asthma prevalence data collected from the California Health Interview Survey (CHIS) for Ventura County and California overall was examined for the years 2001, 2003, and 2005. Asthma hospitalization data collected by the Office of Statewide Health Planning and Development (OSHPD) was examined for 1990-2006 for the ZIP codes of the exposed areas (93033 and 93041), and the ZIP codes of areas that probably were not exposed (93030, 93103, and 93454).

Data Source 1: Asthma Prevalence Data Through the California Health Interview Survey

CHIS is the largest health survey in California. It is administered through a telephone interview to randomly selected households throughout the state, in order to gather health information about adults, adolescents, and children. The sample size of CHIS was approximately 55,000 households in 2001, 42,000 households in 2003, and 45,000 households in 2005.

CHIS collects information on asthma prevalence among adults and children through a variety of questions. Asthma prevalence is the percent of people interviewed who report ever being diagnosed with asthma by a health care provider. Asthma prevalence estimates are available on the county level for 2001, 2003, and 2005. A 95% confidence interval describes the margin of error of the prevalence estimate. The lower and upper bound of the confidence interval is a range that contains the actual percentage in the population 95% of the time. Another way to say this is that we are 95% confident that the true percent of the population with asthma is within this range [105].

Results of Data from CHIS

When the Halaco facility operated in 2001 and 2003, the 95% confidence intervals for asthma prevalence for all ages in Ventura County and the 95% confidence intervals for asthma prevalence in California overall overlap (Appendix D, Table D27). However, when the Halaco facility was closed in 2005, the 95% confidence intervals for asthma prevalence for all ages in Ventura County and California overall do not overlap.

When the Halaco facility operated in 2001 and 2003, the confidence intervals for asthma prevalence for children in Ventura County and California overall overlap (Appendix D, Table 27). When the Halaco facility was closed in 2005, the 95% confidence intervals for asthma prevalence for children in Ventura County and California overall also overlap.

Analysis of Data from CHIS

In order to determine if the difference between asthma prevalence in Ventura County and asthma prevalence in California overall is statistically significant, the two 95% confidence intervals can be compared. If the confidence intervals do not overlap, then the prevalence in Ventura County compared to California overall is considered “significantly different.” If the confidence intervals do overlap, the conclusion cannot be made that the prevalence in Ventura County is significantly different compared to California overall. In order to find out if they are significantly different, more statistical testing is necessary [105].

Using these criteria, when Halaco operated in 2001 and 2003, we cannot determine if the asthma prevalence for all ages was significantly different in Ventura County compared to California. However, after Halaco was closed in 2005, the asthma prevalence for all ages was significantly lower in Ventura County compared to California. Additionally, we cannot conclude that the differences in asthma prevalence for children are significantly different in Ventura County compared to California overall when Halaco operated in 2001 and 2003, or when Halaco was closed in 2005 (Appendix D, Table D27).

Limitations of Data from CHIS

There are limitations to applying these results from CHIS to provide information about the impact of contaminants on residents living near Halaco. The smallest geographical area for which CHIS data is available is the county level. Thus, the data for Ventura County not only includes communities that were likely to have been exposed to contaminants from Halaco, but also includes many other communities that were not likely to have been exposed to the contamination. Furthermore, only data from 2001 and later is available. The Halaco facility operated from 1965 to 2004. Therefore, this data includes a limited amount of information about when people were exposed during the many years that Halaco was operating.

There are other limitations that are related to the method of data collection used by CHIS [105]. CHIS is a survey that gathers health information from participants through the telephone. This survey relies on self-reporting of personal health information. There may be reporting bias due to participants not accurately recalling past events, feeling pressured to give the interviewer particular responses, or not wanting to share information that feels too personal. People living in homes without phones or living in institutionalized settings, such as nursing homes or college dormitories, cannot be reached. In addition, the survey response rates for CHIS range from 30% to 40%, which is fairly low. The study results may be biased if people who declined to answer the survey and people who could not be reached are different in terms of health, compared to the people who answered the survey.

Data Source 2: Asthma Hospitalization Data from the Office of Statewide Health Planning and Development

Asthma hospitalization rates are from the Patient Discharge Database, which is collected by the OSHPD. The Patient Discharge Database includes data from all licensed acute care hospitals in California, except federal facilities. Data is reported by hospitals to the database semi-annually. In this analysis, asthma hospitalizations were defined as hospital discharges with a principal diagnoses using ICD-9 code 493. Asthma hospitalization rates are available for ZIP codes annually from 1990 to 2006.

Age-Adjusted vs. Crude Asthma Hospitalization Rates

It would be ideal to calculate age-adjusted hospitalization rates so that rates from communities with different age structures can be compared directly. Age-adjusted rates are weighted to a standard population so that age is no longer a factor in the difference between the rates. However, age-adjusted hospitalization rates are difficult to calculate for very small population sizes. Because of the low population size of the ZIP codes of interest in this data review, crude hospitalization rates were calculated instead. Crude hospitalization rates are calculated by 1) calculating the sum of all the cases in the defined community and 2) dividing each sum by the number of people in defined community, according to a data source such as the 2000 U.S. Census. Ideally, the number of people in the community would be available for each year. However, U.S. Census data is only collected every 10 years. Therefore, the population data for 1990 and 2000 Census was used to calculate a slope to represent the population change over time. The linear extrapolation of this slope was used to estimate the population for the ZIP codes of interest from 1991 to 2006. This time span was used because the number of hospitalization cases is available on the ZIP code level for this time period.

Crude hospitalization rates among different communities should be compared with caution. This is because differences among rates may reflect how the characteristics of two communities (e.g., age, race/ethnicity, or other factors) are different, rather than a difference in exposure to contaminants released by Halaco. For example, one community may have a larger proportion of population that is below poverty level. Higher rates of poverty may lead to larger numbers of people who are not receiving regular health care for their asthma. Due to poor management of their asthma, this population may have more severe attacks, thus higher hospitalization rates.

Comparing ZIP Codes That Are Next to the Halaco site and ZIP Codes That Are Not Next to the Halaco Site

Crude asthma hospitalization rates were calculated for ZIP codes within a 1-mile radius to the Halaco site, which include 93033 (southern Oxnard) and 93041 (Port Hueneme). These ZIP codes will be called “ZIPs next to the Halaco site,” and were more likely to have received exposure to contaminants released by Halaco than other areas farther away from the Halaco site. Crude asthma hospitalization rates were also calculated for ZIP codes 93030 (northeastern Oxnard), 93454 (Santa Maria), and 93103 (Santa Barbara), which were farther away from the Halaco site and thus less likely to have received exposure to Halaco contaminants. These ZIP codes will be called “ZIPs not next to the Halaco site.” “ZIPs not next to the Halaco site” were similar to the “ZIPs next to the Halaco site” in terms of known risk factors for asthma.

Though crude hospitalization rates should be compared with caution, providing data for “ZIPs not next to the Halaco site” provide some frame of reference for the rates calculated for the “ZIPs next to the Halaco site.” For example, suppose asthma hospitalization rates for the “ZIPs next to the Halaco site” and rates for the “ZIPs not next to the Halaco site” are not within the same order of magnitude. This would provide evidence that rates for the “ZIPs next to the Halaco site” are different from the rates for the “ZIPs not next to the Halaco site.”

The known risk factors for asthma that were used to select “ZIPs not next to the Halaco site” and the rationale include:

- Age: compared to adults, a larger proportion of children are affected by asthma [105].
- Race: compared to other races, blacks experience higher asthma morbidity and mortality [105].
- Exposure to indoor allergens: being exposed to indoor allergens from house dust mites, cockroaches, dogs, cats, rodents, molds, and fungi has been shown to be an important environmental trigger for asthma [106]. The data used in this statistics review does not provide information on indoor air quality. Instead, the percentage of owner-occupied units and the percentage of renter-occupied units were used as a proxy for exposure to indoor allergens. Higher percentages of owner-occupied units generally indicate better housing conditions, thus less exposure to indoor allergens.
- Income: having lower household income is associated with more frequent asthma symptoms and higher asthma hospitalization rates [105]. Instead of comparing median household income directly, the percentage of individuals living below poverty and high school graduates were used as a proxy for income. Lower household income is associated with a higher percentage of individuals living below poverty and a lower percentage of high school graduates.

It is important to note that the “ZIPs not next to the Halaco site” are not direct matches for “ZIPs next to the Halaco site” for all the risk factors for asthma that were chosen for this analysis. For the risk factors chosen for this analysis, the difference between “ZIPs next to the Halaco site” and ”ZIPs next to the Halaco site” was not greater than 5% for most risk factors. However, the differences between ”ZIPs next to the Halaco site” and ”ZIPs not next to the Halaco site” that are greater than 5% for these risk factors are found for the following ZIP codes:

- 93030 (not next to the Halaco site) and 93033 (next to the Halaco site): the percentage of the population that is white and percentage of the population 25 years or older that are high school graduates for ZIP codes.
- 93103 (not next to the Halaco site) and 93041 (next to the Halaco site): the percentage of the population that is Hispanic.
- 93454 (not next to the Halaco site and 93041 (next to the Halaco site): the percentage of the population that is white, the percentage of the population that is categorized as other (one race), the percentage of occupied housing units that are occupied by the owner, the percentage of occupied housing units that are occupied by the renter.

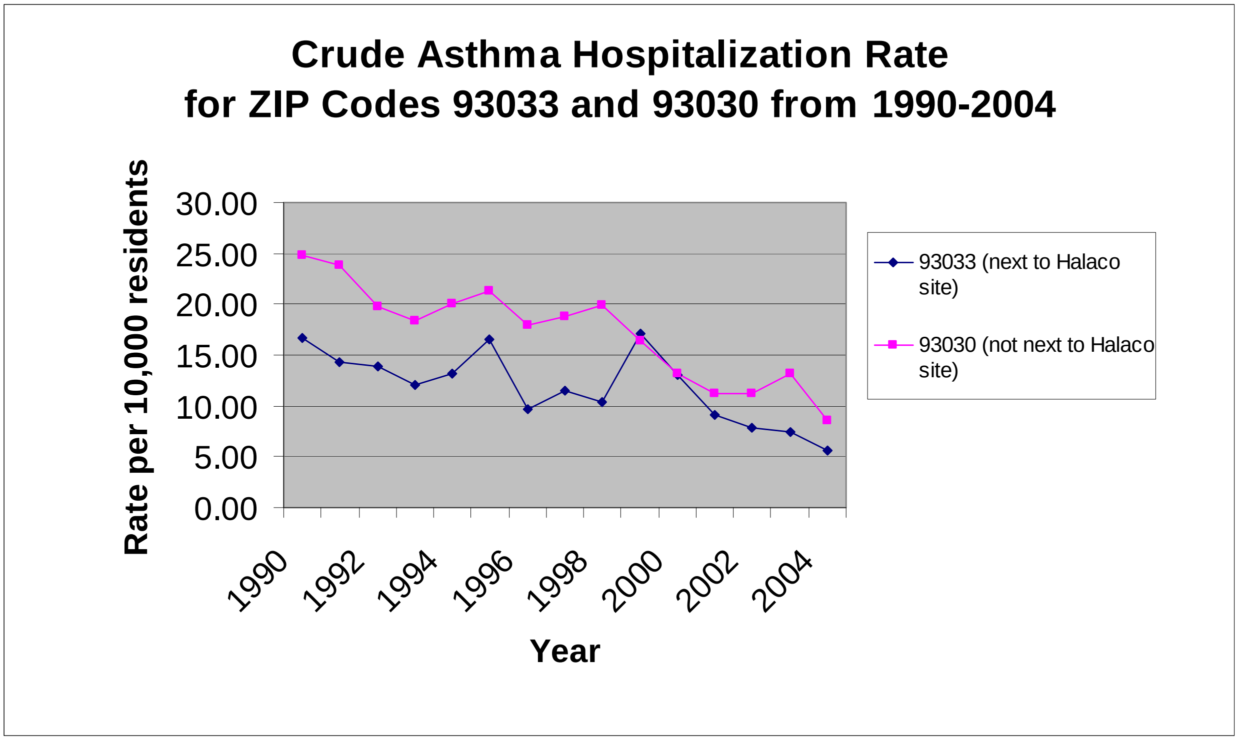
The comparison of the selected risk factors for asthma for the ”ZIPs next to the Halaco site” and “ZIPs not next to the Halaco site” are presented in Appendix D, Tables D28-D30.

For the years when Halaco operated, from 1990 to 2004, the crude asthma hospitalization rates were compared for “ZIPs next to the Halaco site” and “ZIPs not next to the Halaco site.” For the years when Halaco was closed, from 2005 to 2006, the crude asthma hospitalization rates were also compared separately for “ZIPs next to the Halaco site” and “ZIPs not next to the Halaco site.”

Results of Data from OSHPD

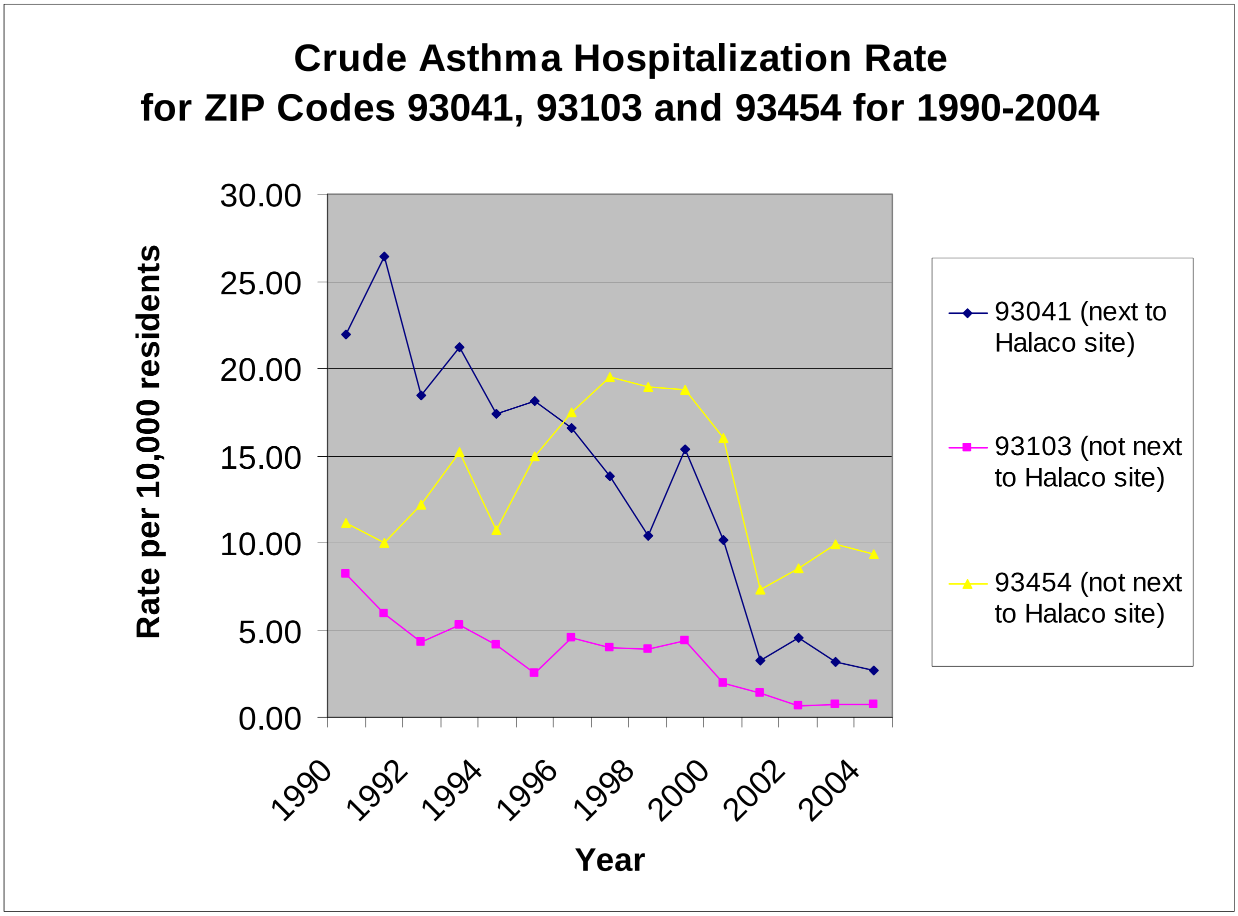
When comparing the ZIP code 93033, which is next to the Halaco site, with ZIP code 93030, which is not next to the Halaco site, the crude asthma hospitalization rate in ZIP code 93033 is consistently lower than the rate in ZIP code 93030 for the entire time period from 1990 to 2004, except for 1999 (Appendix D, Table D31). For 1999, the rate in ZIP code 93033 is only slightly higher than 93030. Figure 2 below graphically shows the crude asthma hospitalization rates for the ZIP code 93033 and ZIP code 93030 when Halaco operated. When Halaco was closed in 2005 to 2006, the crude asthma hospitalization rate in ZIP code 93033 continued to be lower than ZIP code 93030.

Figure 2. Crude Rate of Asthma Hospitalization per 10,000 Residents for ZIP Codes 93033 (Next to the Halaco Site) and 93030 (Not Next to the Halaco Site), from 1990 to 2004



For the time period 1990-1995, the ZIP code 93041, which is next to the Halaco site, has the highest crude asthma hospitalization rates, the ZIP code 93454, which is not next to the Halaco site, has the next highest rate, and the ZIP code 93103, which is not next to the Halaco site, has the lowest rate of the three ZIP codes (Appendix D, Table D32). For 1996-2004, the ZIP code 93454, which is not next to the Halaco site, has the highest rate, the ZIP code 93041, which is next to the Halaco site, has the median rate, and the ZIP code 93103, which is not next to the Halaco site, has the lowest rate (Appendix D, Table D34). Figure 3 below graphically shows the crude asthma hospitalization rates for the ZIP code 93041, the ZIP code 93103, and the ZIP code 93454 when Halaco operated. When Halaco was closed in 2005-2006, the ZIP code 93041, which is next to the Halaco site, has the median rate, while the ZIP code 93454, which is not next to the Halaco site, has the highest rate, and the ZIP code 93103, which is not next to the Halaco site, has the lowest rate.

Figure 3. Crude Rate of Asthma Hospitalization per 10,000 Residents for ZIP Codes 93041 (Next to the Halaco Site), 93103 (Not Next to the Halaco Site), and 93454 (Not Next to the Halaco Site), from 1990 to 2004



Analysis of Data from OSHPD

The crude asthma hospitalization rates for "ZIPs not next to the Halaco site" help provide perspective when viewing crude rates for "ZIPs next to the Halaco site." When Halaco operated and when Halaco closed, the results showed that the crude rates for "ZIPs next to the Halaco site" were within the same order of magnitude as the crude rates for "ZIPs not next to the Halaco site." This provides evidence that rates for "ZIPs next to the Halaco site" are similar that the rates for "ZIPs not next to the Halaco site" both when Halaco operated and when Halaco was closed. Unfortunately, age-adjusted rates are not available for these ZIP codes because of their low population size. Since we could not adjust these rates for age, we could not determine if differences between rates for "ZIPs next to the Halaco site" and "ZIPs not next to the Halaco site" were significant or not. The limitations of comparing the crude rates from "ZIPs next to the Halaco site" and "ZIPs not next to the Halaco site" also include:

- The crude hospitalization rate does not account for differences in race/ethnicity or other risk factors for asthma hospitalization between "ZIPs next to the Halaco site" and "ZIPs not next to the Halaco site." Thus, the crude hospitalization rates from "ZIPs next to the Halaco site" and "ZIPs not next to the Halaco site" cannot provide unbiased information about the possible relationship between the exposure and asthma hospitalization rates.

- ZIPs next to the Halaco site" and "ZIPs not next to the Halaco site" were not exactly matched along all selected risk factors for asthma hospitalizations. Thus, the trends observed may reflect differences in these known risk factors for asthma, and not necessarily the contamination from Halaco.

Limitations of Data from OSHPD

There are several limitations in the data from OSHPD due to the data collection method. The hospitalization data comes from physicians' notes for billing purposes. It is possible that doctors may make an incorrect diagnosis. It is also possible that coding of the disease is not consistent among different doctors. Furthermore, there could also be misclassification of race/ethnicity of the patient, which would lead to calculations of rates by race/ethnicity that are inaccurate [105].

Findings of Asthma Statistics Data Review

CDPH's review of data on asthma prevalence and asthma hospitalization did not find evidence that the impact of asthma was greater among communities located closer to Halaco compared to communities further away from the Halaco facility when Halaco operated or after Halaco was closed.

Cancer Statistics Review Data for the Halaco Site

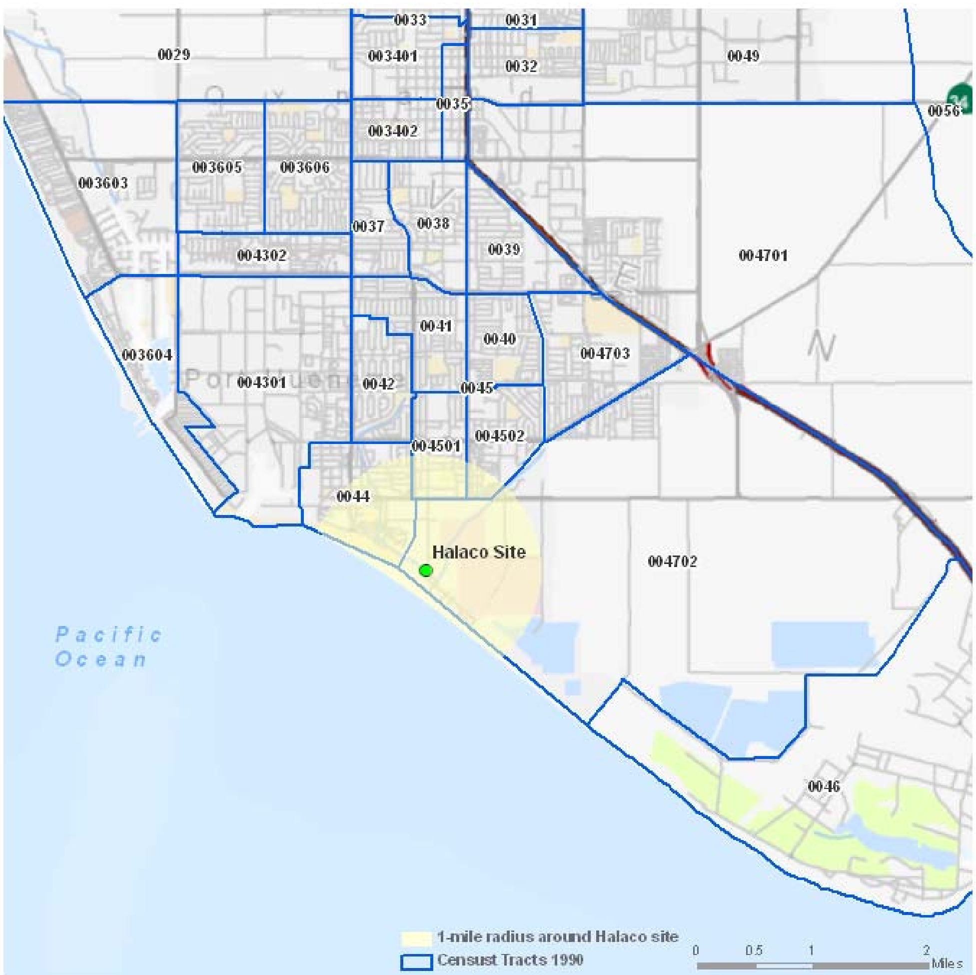
As described in the Environmental Contamination and the Exposure Pathways Analysis sections of this document, contaminants that are associated with causing cancer have been released from the Halaco facility when it was in operation. These contaminants include beryllium, cadmium, nickel, and ionizing radiation. The cancers that are associated with these contaminants include lung cancer, bladder cancer, cancer of the nasal sinuses, thyroid cancer, breast cancer, leukemia, and common skin cancers (basal and squamous cell carcinoma of the skin) [107]. In addition, one community member living near the Halaco site expressed concerns about leiomyosarcoma, which is a rare form of cancer that occurs in the cells of smooth muscle. There is an established link between external radiation and leiomyosarcoma. Thorium has been found on the soils on-site at elevated levels and thorium does affect the body externally. Even though it is unclear if and how much thorium ever was released from the facility, CDPH also included leiomyosarcoma in the cancer statistics analysis.

This data on cancer in the communities surrounding the Halaco site was obtained from the Tri-Counties Cancer Surveillance Program. This program is Region 4 of the California Cancer Registry, and includes San Luis Obispo, Santa Barbara, and Ventura Counties. The California Cancer Registry (CCR) collects information on all of the cancers diagnosed in California, except a few specific types. In particular, CCR does not collect data on common skin cancers, which is one of the cancers associated with contaminants at the Halaco site. CCR provided information on the number of selected cancers observed in the community located near the Halaco site and the number of selected cancers expected in this area based on the demographics (age, race/ethnicity, and sex) of the people living in this area. Upon suggestion by CCR, to make the analysis more complete, the data on all cancers combined and melanoma of skin, which is a less common form of skin cancer, was also included. This review included data on cancer of the lung and bronchus, urinary bladder cancer, cancer of the nasal sinuses, thyroid cancer, female breast cancer, leukemia, melanoma of the skin, leiomyosarcoma, and all cancers combined.

Geographic Areas and Time Periods Reviewed

There are 4 census tracts (44, 45.01, 45.02, 47.02) based on the 1990 U.S. Census and 4 census tracts (44, 45.01, 45.03, and 47.02) based on the 2000 U.S. Census, for which some portion of the census tracts are located within a 1-mile radius of the Halaco site. These census tracts were included in the review. A map of these census tracts and the Halaco site is located in Figure 4 and Figure 5 below.

Figure 4. 1990 U.S. Census Tracts 44, 45.01. 45.02, and 47.02 Located Within a 1-Mile Radius of the Halaco Site



Created by S. Smorodinsky, Environmental Health Investigations Branch, California Department of Public Health.

Figure 5. 2000 U.S. Census Tracts 44, 45.01, 45.03, and 47.02 Located Within a 1-Mile Radius of the Halaco Site

Created by S. Smorodinsky, Environmental Health Investigations Branch, California Department of Public Health.

The Halaco facility operated from 1965 to 2004. SAS requested review of data from 1965 until the latest possible date. The Tri-Counties Cancer Surveillance Program examined the data from January 1, 1988, until December 31, 2006, based on the time period data available. At the time of the analysis, the data from 1988 through 2005 was over 95% complete, and the data for 2006 was only about 70% complete. The data for 2006 was included to make the analysis as current as possible and help extend the time trend analysis.

Information Provided by the Cancer Review

The cancer review provided information about the number of observed cases and expected cases for three different time periods: 1988-1992, 1998-2002, and 1998-2006. The rationale for choosing these particular time periods are explained below.

Observed cases are the number of new cases that have occurred in the census tracts of interest according to medical records obtained by CCR. Observed cases were tabulated by looking at cancer records for the census tracts of interest and the time periods listed above.

Expected cases are the number of cancer cases that can be expected in the census tracts of interest based on population demographics of these census tracts and incidences of selected cancers for the entire Tri-Counties Region. U.S. Census data were analyzed to gather information on the age, race/ethnicity, and sex of people living in the census tracts of interest. The age-, race/ethnicity-, and sex-specific incidence rates are gathered from data from the Tri-Counties Region, which includes data from Ventura, Santa Barbara, and San Luis Obispo counties collected by CCR. To calculate the number of expected cases for each specific population demographic, the specific incidence rate is multiplied by the number of people in that corresponding population demographic.

While SEER data on incidence rates are calculated for each year, U.S. Census data is only collected for 1990 and 2000. CCR's methodology was to 1) calculate expected cases for 1988-1992 by applying an average 5-year incidence rate for the years 1988-1992 to the population demographics for 1990, 2) calculate expected cases for 1998-2002 by applying an average 5-year incidence rate for the years 1998-2002 to the population demographics for 2000, and 3) calculate expected cases for other years besides 1988-1992 and 1998-2002 by direct linear extrapolation. The results from these steps were used to calculate expected cases for the complete time period of 1988-2006.

Expected cases are presented as point estimates with 99% confidence intervals. Confidence intervals are calculated because the point estimate for expected number of cases is approximate, and contains some uncertainty. The bounds of the confidence interval provide a range which is likely to contain the actual number of expected cases. The lower and upper bound of the 99% confidence interval is a range that contains the actual percentage of expected cases 99% of the time.

Comparison of Observed and Expected Cases

Methodology of Analysis

For the different cancer sites chosen, the number of observed and expected cases was compared in three time periods: 1988-1993, 1998-2003, and 1988-2006. CCR's standard protocol is to compare the number of observed and expected cases for each aggregated 5-year period around the census year (i.e., 1988-1992 and 1998-2002). This protocol is used because the 5-year period around the census year provides the most accurate estimates of expected cases.

To compare the observed number and point estimates of the expected cases, a statistical test called a chi-square analysis was run to see if the difference between these two numbers were statistically significant, with a p-value of less than 0.01. A p-value of less than 0.01 means that there is a less than 1% chance that the difference in number of expected vs. observed cases would be due to chance alone, in the absence of a true association. Therefore, we would conclude that there is an important difference in number of expected vs. observed cases, which is likely not due to just a random difference.

Results of Analysis

The number of observed cases of all cancers combined, female breast cancer, leukemia, cancer of the nasal sinuses, thyroid cancer, melanoma of the skin, leiomyosarcoma, and urinary bladder cancer for the census tracts of interest were all similar or lower than the number of expected cases for all time periods studied (Appendix D, Table D33).

For males, the number of observed cases was statistically significantly higher for expected cases for invasive cancer of the lung and bronchus for the 1988-2006 time period. However, for females, the number of observed cases was higher than expected cases for the 1988-2006 time period, but the difference was not statistically significant. Closer examination of the data revealed that the increase in this type of cancer was limited to an increase among non-Hispanic Whites for the 1988-2006 time period. In addition, the number of observed cases in Hispanic females was statistically significantly lower than expected cases for the 1988-2006 time period (Appendix D, Table D34).

Discussion of Findings

According to results of this analysis, the incidence of all cancers combined, female breast cancer, leukemia, and melanoma of the skin, thyroid cancer, cancer of the nasal sinuses, leiomyosarcoma, and urinary bladder cancer in the census tracts of interest were not greater than the expected numbers in a statistically significant way.

However, the observed incidence of lung and bronchus cancer in men had a statistically significant elevation from 1988-2006 compared to the expected rates. However, close examination of the data show that this increase is limited to the non-Hispanic White population. Because the increase is limited to a specific subpopulation of the community of interest, this suggests that factors other than the exposure to contaminants from Halaco were probably responsible for the increase in lung and bronchus cancer in observed in men. If an environmental factor such as contaminants from Halaco were responsible, then one would expect elevated rates of this cancer among all racial/ethnic groups. The factors are difficult to attribute to a specific cause. They could be due to a reporting issue or possibly due to other risk factors for lung and bronchus cancer not measured by this analysis.

Time Trend Charts

Methodology of Analysis

The time trend charts shows the number of observed and expected cases over the time period of 1988-2006 in graphical form. Because the numbers of expected cases are point estimates with some uncertainty associated with them, the 99% confidence intervals for the expected cases are also displayed. For this type of analysis, a significant change in pattern of cancer incidence is defined as when the number of observed cases is greater than the 99% confidence interval value for three or more consecutive years [108].

Results of Analysis

Examination of the control charts show that all cancers combined, female breast cancer, cancers of the lung and bronchus, leukemia, and melanoma of the skin, thyroid cancer, and urinary bladder cancer did not show any significant change in cancer incidence pattern over time. For all selected cancers, the number of observed cases did not exceed the upper limit of the 99% confidence interval for expected number of cases for three or more consecutive years. The only instance of the number of observed cases being larger than the upper limit of the 99% confidence interval was lung and bronchus cancer for 1995. The graph for cancer of the nasal sinuses and leiomyosarcoma were not included because the numbers of observed cases per year were too small. Information on the exact numbers of these observed numbers were withheld to protect the confidentiality of the cases. The time trend graphs are located in Appendix B, Figures B6-B12.

Discussion of Findings

For the years studied, the fluctuations in the incidence of all selected cancers studied, which includes all cancers combined, female breast cancer, cancers of the lung and bronchus, leukemia, and melanoma of the skin, thyroid cancer, cancer of the nasal sinuses, leiomyosarcoma, and urinary bladder cancer were within the boundaries of what could be expected.

Limitations of Cancer Statistics Review

This type of cancer statistics review has several limitations that make it difficult to show whether or not specific exposure causes cancer. These include the following:

- Cancer takes a long time to develop. Many people have cancer for a long time before they are diagnosed. Thus, this analysis does not include cancers that are related to the Halaco site, but have not yet developed in residents who lived near the Halaco site during emission of contaminants.
- Suppose people were exposed to Halaco contaminants in the past, but then moved away when they developed cancer. Their cases would not be counted by the Cancer Registry as part of this community of interest.
- There could be inaccuracies in the demographic data collected by the U.S. Census. These inaccuracies would result in an incorrect number for expected numbers of cancer cases.
- The incidence of cancers examined in this statistics review may be affected by other risk factors for cancer such as diet, exercise, smoking, and access to health care. This review did not measure these other risk factors.

Findings of the Cancer Statistics Review

There was no evidence that the population residing within a 1-mile radius of the Halaco site has experienced higher rates of selected cancers than the population of the overall Tri-Counties Region, after adjustment for differences in age, sex, and race/ethnicity over the time periods examined. These time periods include 1988-2006, 1988-1992, and 1998-2002. Cancer sites examined included all cancers combined, female breast cancer, leukemia, melanoma of the skin, thyroid cancer, cancer of the nasal sinuses, urinary bladder cancer, leiomyosarcoma, and cancers of the lung and bronchus.

Comparison of the observed cases with the point estimates and 99% confidence intervals for expected cases over the time periods 1988-2006, 1988-1992, and 1998-2002, do not suggest that incidence of the selected cancers was elevated due to exposure to Halaco's past emissions. The time trend charts also support this finding by showing that the incidence of the selected cancers during the study period from 1988-2006 do not show unusual fluctuations beyond what is expected.

Birth Defects Statistics Data Review for the Halaco Site

As described in the Discussion of Environmental Contamination section of this document, contaminants associated with birth defects in humans and animals have been released from the Halaco facility when it was in operation. These contaminants include beryllium, cadmium, nickel, and ionizing radiation (from these isotopes: thorium-228, thorium-230, and thorium-232). The birth defects associated with these contaminants include brain abnormalities in humans; delays in development of the skeletal system, neurological system, reproductive system, internal organs, and bone formation in animals; impaired development of the nervous system and reproductive system in animals; skeletal deformities in animals; and changes in brain chemistry in animals [82,109-113]. Community members living near the Halaco site have not expressed any concerns about birth defects to CDPH.

CDPH requested data on the annual incidence of birth defects from the California Birth Defects Monitoring Program (CBDMP) for the community located near Halaco. CBDMP is housed in the California Department of Public Health's Center for Family Health/Maternal, Child and Adolescent Health Division. CBDMP has been granted statutory authority to identify children with birth defects in California. CBDMP maintains a database of children born with structural anomalies, which are reported from conception through the first year of life. CBDMP actively identifies cases through review of hospital logs and medical records from hospitals with maternity services and pediatric services, cytogenetic laboratories and genetic offices, rather than relying on passive reporting from hospitals or physicians. However, CBDMP's statutes do not allow access to private doctor offices and clinics, except for genetic offices.

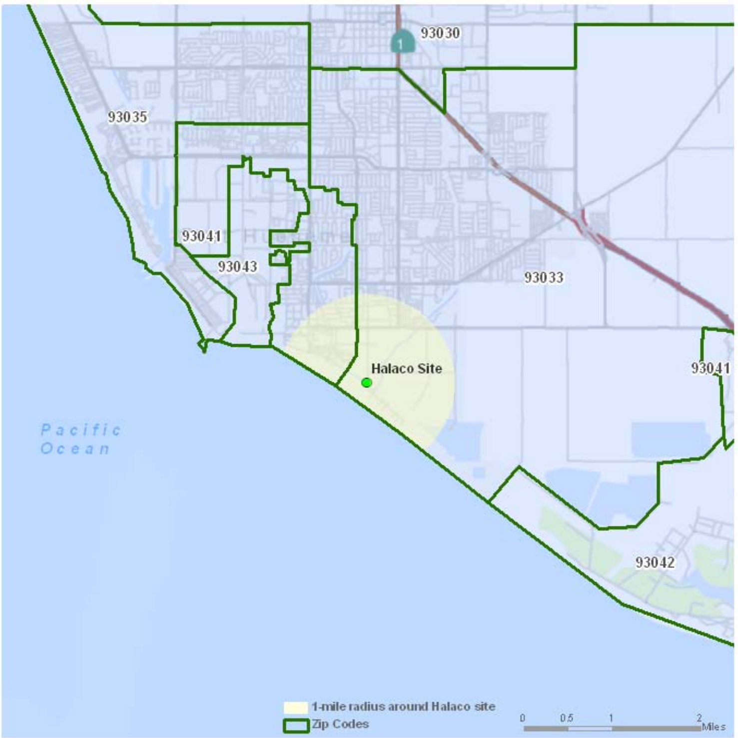
As described above, the available human and animal data on developmental toxicity shows that numerous Halaco site contaminants may affect the development of the brain and skeletal systems. CBDMP concluded that neural tube defects (NTDs) and limb reduction defects would be similar to the types of defects seen in the animal studies. CBDMP recommended that the review only include NTDs and limb reduction defects, which have serious implications on the physical well-being of the child, and thus high public health significance. Therefore, this review includes only NTDs and severe types of limb reduction defects. These particular defects, their corresponding British Pediatric Association codes spanning from 740.000 to 759.999, and their descriptions are listed in Appendix D, Table D35.

Geographic Areas and Time Periods Reviewed

The smallest level of detail that the birth statistics data is available is at the ZIP code level. Data from ZIP codes within a 1-mile radius of the Halaco site were chosen. The ZIP codes within a 1-mile radius of the Halaco site are larger than census tracts within this radius. Thus the ZIP codes are likely to contain more people who were actually not exposed to Halaco contamination than the census tracts. The ZIP codes of the potentially exposed areas are 93033 (southern Oxnard) and 93041 (Port Hueneme). A map of these two ZIP codes and the Halaco site is shown in Figure 6.

The birth defects among the two potentially exposed ZIP codes were combined into one group because it is not possible to assess if one ZIP code received more exposure to contaminants than another. Unfortunately, when the Halaco facility was in operation, there was no air monitoring or sampling to assess how much exposure to contaminants different ZIP codes received. These two ZIP codes will be referred to as "ZIPs next to the Halaco site." Two reference areas were chosen as likely to have little or no exposure to Halaco contaminants. The reference areas were 1) all birth registry counties in California except for Ventura County, which will be referred to as "California," and 2) Ventura County except for the two ZIP codes of interest, which will be referred to as "Ventura County." The "ZIPs next to the Halaco site" were grouped and compared to each reference area, "California" and "Ventura," separately. In 1989, 57 out of 58 California counties were monitored by CBDMP. Data for Los Angeles County were not available for 1989.

Figure 6. ZIP Codes 93033 (Southern Oxnard) and 93041 (Port Hueneme) Located Within a 1-Mile Radius of the Halaco Site



Created by S. Smorodinsky, Environmental Health Investigations Branch, California Department of Public Health.

The Halaco facility operated from 1965 to 2004. During that time, there were a number of changes to the counties in which data were collected by CBDMP. Counties were added to the registry based on enabling legislation and appropriate funds, and deleted in the event of budget cuts. Therefore, there are significant gaps in data. Data for Ventura County for the time that Halaco was operating was only available for one year, 1989.

Information Provided by CBDMP

CBDMP provided data of the number of births with NTDs per 1,000 births and limb reduction defects per 1,000 births, as well as data for all birth defects collected per 100 births, for the calendar year 1989. We converted all rates to ones per 100 births. The total births include all live births and fetal deaths greater than 20 weeks gestation. These data were provided for the ZIP codes 93033 and 93041, which are the areas next to the Halaco site and for reference areas described previously.

Methodology of Analysis

The proportion of births having birth defects among the “ZIPs next to the Halaco site” and the two reference areas, “California” and “Ventura,” were compared using relative risk. In this analysis, relative risk is the ratio of the proportion of births with birth defects in the ”ZIPs next to the Halaco site,” compared to the proportion of birth defects among births in the reference areas. When the relative risk is greater than 1, the risk of birth defects is greater in the”ZIPs next to the Halaco site,” and this could be evidence of a positive association between exposure and disease. When the relative is equal to 1, there is no evidence of association of the exposure with the disease. When the relative risk is less than 1, then the risk is lower in the exposed area. The 95% confidence intervals for each relative risk were also calculated.

In addition, the birth defects rate in the “ZIPs next to the Halaco site” was compared to “California” and “Ventura” using the Mantel-Haenszel chi-square test when the expected values for each cell in the 2 x 2 table were greater or equal to 1. For these instances, the chi-square value and the 2-tailed p-value are presented. If expected values for any cell in the 2 x 2 table were less than 1, then the Fisher Exact test was used, and only the 2-tailed p-value is presented [114].

A p-value of less than 0.05 is generally taken as evidence of a significantly different birth defects rate in the “ZIPs next to the Halaco site” compared to a reference area, “Ventura” or “California.” These comparisons were made for all birth defects, limb reduction defects, and NTDs. NTDs and limb reduction defects were examined separately because they are different in terms of their defect category and causes.

Results of Analysis

Residence in the “ZIPs next to the Halaco site” was not associated with higher numbers of all birth defects as compared to residence in “Ventura” and “California” (Appendix D, Table D36). This data includes total births for mothers of all races/ethnicities.

Births in the “ZIPs next to the Halaco site” had a lower risk of having limb reduction defects compared to births in “Ventura” and compared to births in “California” (Appendix D, Table D37). This data includes total births for mothers of all races/ethnicities.

Births in the “ZIPs next to the Halaco site” had a higher risk of having NTDs compared to births in “Ventura” and compared to births in “California” (Appendix D, Table D38). The p-values for comparison of “ZIPs next to the Halaco site” with “Ventura” and “California” were both statistically significant. This data includes total births for mothers of all races/ethnicities.

Closer examination of the data shows that all NTDs in the “ZIPs next to the Halaco site” occurred among Hispanics, not among non-Hispanics (Appendix D, Table D39). Births among Hispanics in the “ZIPs next to the Halaco site” had a higher risk of having NTDs compared to births among Hispanics in “Ventura” and compared to births in “California” (Appendix D, Table D39). The p-values for comparison of “ZIPs next to the Halaco site” with “Ventura” and “California” were both statistically significant.

There were no NTDs among non-Hispanic mothers living in the “ZIPs next to the Halaco site.” The expected numbers of NTDs in the “ZIPs next to the Halaco site” was calculated by multiplying the total number of births in the “ZIPs next to the Halaco site” by the proportion of NTDs in the reference areas, “Ventura” and “California.” The lack of observed NTDs in the “ZIPs next to the Halaco site” is within the range of what is expected, according to these calculations (Appendix D, Table D40). However, the number of births in the “ZIPs next to the Halaco site” was sufficiently small that the confidence intervals for the relative risk of NTDs among non-Hispanics in the “ZIPs next to the Halaco site” were fairly wide. The confidence intervals were large enough that the relative risk of NTDs among non-Hispanic births in the “ZIPs next to the Halaco site” compared to reference areas may be on the same order of the risk of NTDs in the “ZIPs next to the Halaco site” compared to reference areas seen among Hispanic births (Appendix D, Tables D39 and D41).

The elevations of NTDs among Hispanics compared to non-Hispanics for the “ZIPs next to the Halaco site” and “Ventura” were not statistically significant (Appendix D, Tables D42 and D43). However, higher risks of NTDs among Hispanics were consistently seen in both “Ventura” and “California” (Appendix D, Tables D43 and D44).

Discussion

According to this analysis, the population living in the “ZIPs next to the Halaco site” had a slightly higher risk of any birth defect compared to “Ventura,” but a slightly lower risk of any birth defect compared to “California” in 1989. In addition, the “ZIPs next to the Halaco site” do not have a higher proportion of all birth defects than the populations living in “Ventura” and “California” in a statistically significant way. Overall, based on data from this one year, the evidence suggests that exposure to Halaco contaminants is not resulting in higher numbers of all birth defects.

The population living in the “ZIPs next to the Halaco site” had a lower risk of limb reduction defects compared to “Ventura” and “California” in 1989. These results suggest that exposure to Halaco contaminants is not resulting in higher numbers of all limb reduction defects.

The population living in the “ZIPs next to the Halaco site” had a higher risk of NTDs compared to “Ventura” and “California” in a statistically significant way in 1989.

Closer examination shows that all cases of NTDs in the “ZIPs next to the Halaco site” occurred among Hispanics. Hispanic mothers living in the “ZIPs next to the Halaco site” had a higher risk of NTDs compared to Hispanic mothers living in “Ventura” and “California.” Though there were not statistically significant elevations of NTDs among Hispanics compared to non-Hispanics for the “ZIPs next to the Halaco site” and “Ventura,” the relative risks among Hispanics compared to non-Hispanics in “Ventura” and “California” show a likely association between being Hispanic and having a higher risk of NTDs. However, because the number of births among non-Hispanics was relatively small, it is possible that there was an increased risk of NTDs among non-Hispanic births in the “ZIPs next to Halaco” compared to reference areas, as we had seen among Hispanic births.

The research literature has documented higher rates of NTDs among Hispanics compared to other racial/ethnic groups. Data from CBDMP in 1983 to 1987 found that Hispanics had more than 50% higher risk for all neural tube defect subtypes compared to whites [115]. In addition, national data for 1999-2004, derived from 21 birth defects surveillance systems in the United States, also showed that Hispanic infants had the highest prevalence of NTDs for all years, compared to infants of other races/ethnicities [116].

Insufficient folic acid intake has been identified as a factor which may put Hispanics at higher risk for NTDs; however, this data is not conclusive. Sufficient folic acid is essential to proper neural tube development. The consumption of daily 400 microgram folic acid supplements before conception can reportedly reduce the risk of having an infant with NTD by about 80% [117]. National data from 2001-2002 shows that a higher proportion of Hispanic women have low daily folic acid intake compared to non-Hispanic white women [118]. However, one study also showed that the use of folic acid-containing vitamins only reduced the risk of NTDs among Hispanics by 5%, which was much less reduction than among whites or African Americans [119]. This finding suggests that, though consuming the recommended dosage of folic acid may help reduce NTD risk among Hispanics, there may be other factors, such as genetics, that are contributing to this increased NTD risk.

Researchers have also looked into how genetics may play a role in the development of NTDs. Some studies have shown positive associations between different mutations and polymorphisms in certain folate pathway genes and increased NTD risk [120-123]. One such association includes a genetic variant (the C677T genotype) of the 5,10-methylenetetrahydrofolate reductase gene, which is associated with increased risk of spina bifida (a type of neural tube defect), and which is more common among Hispanics than non-Hispanics [122].

It seems possible that the causes for increased NTD risk among Hispanics might also be the causes for the increased numbers of NTDs in the “ZIPs next to the Halaco site” because all

NTDs among the "ZIPs next to the Halaco site" occurred only among Hispanics. However, currently there is not a clear explanation for the increased rate of NTDs among Hispanics. Thus, it is difficult to determine if a reason other than contamination from Halaco, such as insufficient folic acid consumption or genetic susceptibility, might be associated with the elevation of NTDs in the "ZIPs next to the Halaco site."

Another alternative explanation for the increase in NTDs among Hispanics only is that Hispanics lived in areas of the "ZIPs next to the Halaco site" that received more exposure to contaminants from Halaco, while non-Hispanics lived in areas of the "ZIPs next to the Halaco site" that received less exposure. Unfortunately, we do not have data on whether or not specific areas of the "ZIPs next to the Halaco site" received more exposure to Halaco contaminants than others. So we cannot explore this possibility.

The results for all birth defects, limb reduction defects, and NTDs all have limited relevancy because of the limitations discussed below.

Limitations

There are several limitations for this birth defects statistics review that make it difficult to show whether or not exposure to Halaco contaminants may have caused an increased number of birth defects. These include the following:

- There was only one year of data available for the two ZIP codes located within 1-mile to the Halaco site. This analysis did not show an association between exposure to Halaco contaminants and an increased numbers of all birth defects and limb reduction defects. However, it may be possible that the association we are investigating did not show up the particular year we studied, but might have appeared earlier or later in time. Also, with only one year of data, it was not possible to compare how the numbers of birth defects may have been different when Halaco was operating vs. after Halaco stopped operating.

- People were categorized as more likely exposed than the reference areas on the basis of their residence in a particular ZIP code. Because these ZIP codes are large, irregularly-shaped geographical areas, they may include many people who were not actually exposed (see Figure 6 above). As Figure 6 shows, large portions of the "ZIPs next to the Halaco site" were not located within a 1-mile radius of the Halaco site. If in fact the Halaco emissions caused an impact on birth defects, this incorrect classification of exposure would make it difficult to see this impact. Conversely, the lack of correspondence between the ZIP code and areas that were actually exposed means that an observed increase in risk may be due to other factors besides exposure to Halaco.

- The numbers of birth defects examined in this statistics review may be affected by other known risk factors for birth defects such as genetic factors, smoking, diet, drinking alcohol, and a woman's illness during pregnancy. This review did not measure these other risk factors.

Findings of the Birth Defects Statistics Review

The birth defects data do not show higher numbers of all birth defects and limb reduction defects for the population in areas more likely exposed to Halaco emissions, which included the two ZIP codes that are within a 1-mile radius of the Halaco site, which are more likely to be exposed to Halaco emissions compared to the reference areas that were less likely to be exposed to Halaco emissions for 1989. The reference areas included Ventura County, excluding the two ZIP codes within a 1-mile radius of the Halaco site, and California, excluding Ventura County.

There were greater numbers of NTDs among communities more likely exposed to Halaco emissions, compared to reference areas less likely exposed to emissions. However, all neural tube defect cases in the ZIP codes located within 1-mile of the Halaco site occurred among Hispanics. In addition, the data analysis included evidence showing that that being Hispanic vs. non-Hispanic was associated with greater numbers of NTDs. While the available data showed that the increased risk of NTDs only occurred among Hispanics, we do not have a large enough number of non-Hispanic births to rule out that this increased risk of NTDs could have occurred among non-Hispanics as well. Thus, we do not have a large enough sample of births to determine whether or not there is evidence of an association between the exposure to Halaco and an increased rate of NTDs among both Hispanics and non-Hispanics.

Negative Birth Outcome Statistics Data Review for the Halaco Site

As described in the Environmental Contamination and the Exposure Pathways Analysis sections of this document, contaminants associated with negative birth outcomes have been released from the Halaco facility when it was in operation. These contaminants include lead, arsenic, copper, and zinc. The negative birth outcomes associated with these contaminants include preterm births, low birth weight births, and decreased fetal growth [58,111,124-126]. In addition, two of the air pollutants that were known to have been released form the Halaco facility, sulfur dioxide and particulate matter, have shown positive associations with elevated risk of preterm birth in numerous epidemiological studies [127]. Community members living near the Halaco site have not expressed concerns about negative birth outcomes.

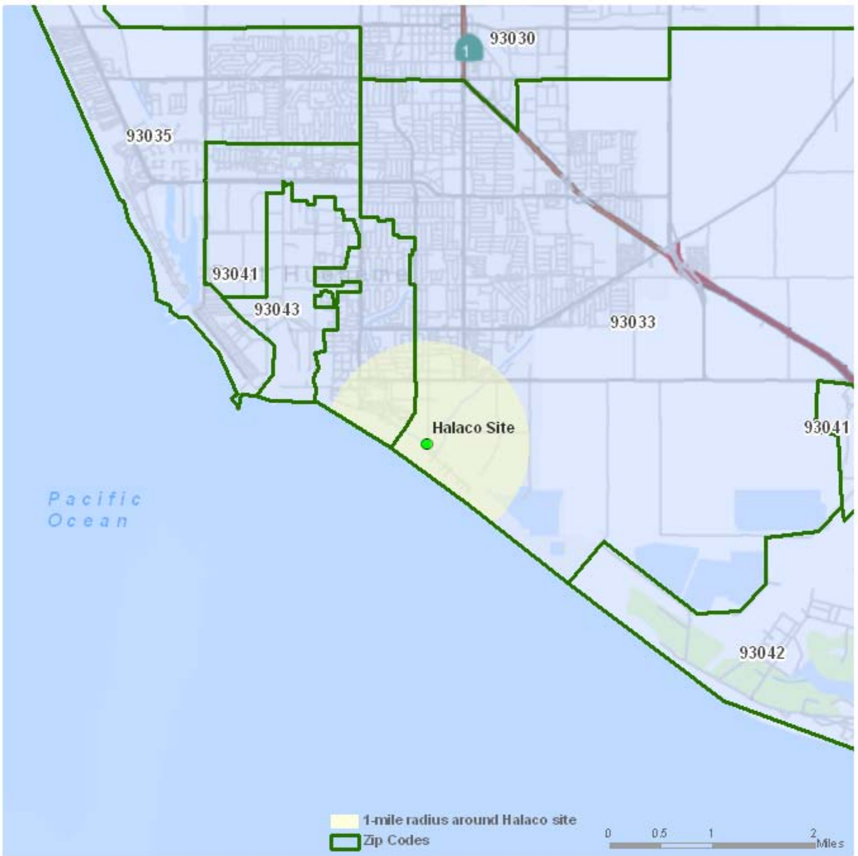
CDPH staff obtained data on the annual incidence of low birth weight and preterm births for the community located near the Halaco site from the CDPH's Center for Health Statistics (CHS), Office of Health Information and Research. CDPH also received CHS data processed by CDPH's California Environmental Health Tracking Program.

Geographic Areas and Time Periods Reviewed

Annual incidences for low birth weight and preterm births were reviewed for Ventura County, ZIP codes 93033 (southern Oxnard) and 93041 (Port Hueneme), from 1982 to 2006. Both ZIP codes are located within a 1-mile radius to the Halaco site, as shown in Figure 7 below. For this analysis, the annual incidence is the rate of negative birth outcomes (such as low birth weight or preterm births) that have occurred among all live births for one year.

Because data at the ZIP code level were unavailable before 1982, data for the years 1982 to 2006, which is the year with the most recently available data, were obtained. However, it would be ideal to examine data for the entire time period that the Halaco facility operated, from 1965 to 2004. Census tract data were not readily available for the negative birth outcome statistics. The ZIP code level was the smallest geographic area available.

Figure 7. ZIP Codes 93033 (Southern Oxnard) and 93041 (Port Hueneme) Located Within a 1-Mile Radius of the Halaco Site



Created by S. Smorodinsky, Environmental Health Investigations Branch, California Department of Public Health.

Negative Birth Outcome Statistics Provided by CHS

Data about births in California, including birth weight, length of gestation, and mother's residential county and ZIP code, are collected through an electronic registration process. Data are entered into the Automated Vital Statistics System at the birth hospital or office of the local registar to generate a birth certificate. Data from some hospitals with alternative electronic data systems are imported into the Vital Statistics System. The electronic data are transmitted from the local registry to the state where the data are checked and edited by CHS. [128]. California birth registration is considered to be complete for births occurring in California [128].

Calculation of Birth Statistics

Annual incidences of low birth weight and preterm births were calculated for ZIP codes located within a 1-mile radius of the Halaco site (93033 and 93041), which are areas closest to the Halaco site and more likely to have been exposed to contaminants from Halaco during the plant's operation, and for Ventura County, which is an area that is less to have been exposed to Halaco contamination, for the years 1982 to 2006. In this analysis, ZIP codes 93033 and 93041 will be referred to as "ZIPs next to the Halaco site," and Ventura County will be referred to as the "reference area."

Low birth weight was defined as birth weight of less than 2,500 grams, or 5.5 pounds. Births in which the weight was unknown were not included in the number of total live births. The incidence of low birth weight births was calculated by dividing the number of low birth weight births by the number of total live births, and then multiplying by 100.

Preterm birth was defined as birth prior to 37 weeks of gestation. Live births of less than 17 weeks gestation and those of 53 weeks or more gestation are included in the "not reported category." The births in the "not reported" category are not included in the total number of live births. The "not reported" category reflects inaccuracies, not actual gestation periods. Births for which the gestation time was unknown were also not included in the number of total live births. The incidence of preterm births was calculated by dividing the number of preterm weight births by the number of total live births, and then multiplying by 100.

Examination of Confidence Intervals

Methodology of Analysis

The 95% confidence intervals were calculated for the low birth weight and preterm birth incidences using the Wilson's score method. The 95% confidence interval describes the uncertainty of the incidence estimate. The lower and upper bound of the confidence interval is a range that contains the actual incidence in the population 95% of the time.

Simple hypothesis testing was conducted by observing if the 95% confidence intervals for the annual incidences in the "ZIPs next to the Halaco site" overlapped with the 95% confidence intervals for the annual incidences of the reference area. If the intervals did not overlap, then the "ZIPs next to the Halaco site" and the reference area were considered to be "significantly different" from each other. If the intervals overlapped, then the conclusion cannot be made that the "ZIPs next to the Halaco site" and the reference area are significantly different from each other. Further statistical testing would be needed to show whether overlapping confidence intervals were significantly different from each other.

Results of Analysis

The percentages of low birth weight births and corresponding 95% confidence intervals for ZIP codes 93033 and 93041 (next to the Halaco site) and Ventura County (reference area) for 1982 to 2006 are presented in Appendix D, Tables D45 and D46. From 1982 to 2006, the confidence intervals for low birth weight births in ZIP Code 93033 and 93041 overlap with the confidence intervals for Ventura County (Appendix B, Figures B13 and B14).

The percentages of preterm births and corresponding 95% confidence intervals for ZIP Code 93033 and 93041 (exposed areas) and Ventura County (reference area) for 1982 to 2006 are presented in Appendix D, Tables D47 and D48. From 1982 to 2006, the confidence intervals for preterm births in ZIP Code 93033 overlap with the confidence intervals for Ventura County (Appendix B, Figure B15). For all years between 1982 and 2006, except for 1983 and 1998, the confidence intervals for the percentage of preterm births in ZIP Code 93041 overlap with the confidence intervals for the reference area (Appendix B, Figure B16).

Discussion of Findings

This basic inspection of confidence intervals shows no evidence that rates of low birth weight were greater in ZIP codes next to the Halaco site compared to the reference area. This analysis suggests that exposure to Halaco contaminants did not result in higher percentages of low birth weight births. For the entire 1982-2006 time period, the percentage of low birth weight births for the ZIP codes 93033 and 93041 were within the same range as the percentage for Ventura County. However, it is important to note that the low birth weight percentages for ZIP code 93041 for 1982-1985 and 1987-1989 were based on fewer than 20 observations. CHS notes that the rates fitting these criteria may be unreliable and show significant variability from year to year [128].

This basic inspection of confidence intervals also shows no evidence of a trend showing that preterm birth rates were greater in the ZIP codes next to the Halaco site than in the reference area. This analysis suggests that exposure to Halaco contaminants did not result in higher percentages of preterm births. For most years during the 1982-2006 time period, the percentage of preterm births for the ZIP codes 93033 and 93041 were within the same range as the percentage for Ventura County.

It is difficult to detect a significant difference between the rates for the ZIP codes next to the Halaco site and the reference area using this method because the population sizes of the ZIP codes next to the Halaco site are much smaller than that of the reference area. Compared to the reference area, the rates in the ZIP codes next to the Halaco site had much larger confidence intervals and rates in the ZIP codes next to the Halaco site showed more variability from year to year. To explore the differences in annual incidences between the ZIP codes next to the Halaco site and reference area in greater depth, formal statistical testing was done to compare the rate for the years when the Halaco facility operated (1982-2004) with the years when Halaco was closed (2005-2006), for both the exposed and reference areas. By combining data from multiple years instead of comparing individual years, the likelihood of multiple testing error was reduced. Multiple testing error is the increased risk of finding a significant difference by chance, instead of a true exposure and disease association because of the high number of comparisons being made. In addition, data from several years also result in greater statistical power. This method is explained in more detail in the next section.

Comparing Rates of Preterm Births and Low Birth Weight When Halaco Operated and After Halaco Closed

Methodology of Analysis

For the ZIP codes next to Halaco (93033 and 93041) and for the reference area (Ventura County), the rates of preterm births and low birth weight for the years of Halaco's operations (1982-2004) were compared to the rates of preterm births and low birth weight for the period after the facility closed (2005-2006).

The rates for the years of Halaco's operations and those for the period after Halaco closed were compared using relative risk. In this analysis, relative risk is the ratio of the rate for the period when people were likely to be exposed compared to the rate for the period when people were not likely to be exposed. When the relative risk is greater than 1, the risk of the negative birth outcome is greater for the years of Halaco's operations, and this is evidence of a positive association between exposure and negative birth outcome. When the relative is equal to 1, there is no evidence of association of the exposure with the negative birth outcome. When the relative risk is less than 1, then the risk of the negative birth outcome is lower for the time period when people were exposed.

In order to find out if both rates were significantly different from each other, the Mantel-Haenszel chi-square test was used. For each comparison, the Mantel-Haenszel chi-square value and the p-value are presented. A p-value of less than 0.05 is generally taken as evidence of an association between residing in a ZIP code next to the Halaco site or reference area during plant operation, compared to after the plant was closed, and an elevated rate.

Results of Analysis

The risk of having low birth weight births during the years of Halaco's operations was slightly higher than during the years when Halaco was closed, for ZIP code 93033. However, the p-value for this elevation was not statistically significant (Appendix D, Table D49).Births during the years of Halaco's operations had a lower risk of being a low birth weight birth compared to births during the years after Halaco closed, for ZIP code 93041 and Ventura County (Appendix D, Tables D50 and D51).

The risk of being a preterm birth during the years of Halaco's operations was slightly higher than the years after Halaco closed, for ZIP code 93033. Furthermore, the p-value for this elevation was statistically significant (Appendix D, Table D52).Births during the years of Halaco's operations had a lower risk of being a preterm birth compared to births during the years after Halaco closed, for ZIP code 93041 and Ventura County (Appendix D, Tables D53 and D54).

Discussion of Findings

The results from the formal statistical testing imply that exposure to Halaco pollutants did not result in a significantly higher risk of low birth weight births in the ZIP codes next to the Halaco site or reference area during the years of Halaco's operations. For the ZIP codes next to the

Halaco site and reference area, the risk of having a low birth weight birth during the years of Halaco's operations compared to the years after Halaco closed was either lower or slightly higher, but not statistically significant.

The results from the formal statistical testing suggest that Halaco exposure may be related to significantly higher risk of preterm birth. The ZIP code 93033, located next to the Halaco site, has an elevated risk of preterm birth for the years of Halaco's operations compared to the years after Halaco closed. However, the reference area (Ventura County) and the ZIP 93041, located next to the Halaco site, did not show this pattern. If another factor besides Halaco is responsible for the increased risk in ZIP code 93033, it would be expected that the risk for the reference area would have also been elevated during the years of Halaco's operations.

However, the observed elevation in preterm birth rates for ZIP code 93033 may be caused by another factor besides the Halaco contamination. Some known risk factors for preterm births include maternal non-white race, maternal age of less than 18 years old or greater than 40 years old, and pregnancies of multiple gestations [129]. Because information about these risk factors is regularly collected about births in California, further analysis was conducted to examine how these factors may be related to this elevation. The next section contains an evaluation of how these other risk factors affected the rate of preterm birth.

Examination of Other Known Risk Factors for Preterm Birth

Methodology of Analysis

The births from 1982 to 2006 were categorized into the "more likely exposed" or and "less likely exposed" group based on the relative likelihood of exposure to Halaco contaminants in the past based on the time period the birth occurred and its geographic proximity to the Halaco facility. The "more likely exposed" group included all births in the ZIP codes 93033 and 93041 that occurred from 1982 to 2004, the years of Halaco's operations. The "less likely exposed" group included all births in ZIP codes 93033 and 93041 that occurred from 2005 to 2006, the years after Halaco closed, as well as all births that occurred in the reference area (Ventura County) from 1982 to 2006.

For the "more likely exposed" and "less likely exposed" groups, the rates of preterm birth were presented for each individual stratum for a particular risk factor. For type of birth, the strata included singleton vs. multiple births. For maternal race, the strata included: non-Hispanic white, non-Hispanic black, non-Hispanic Asian/Pacific Islander, Hispanic, and non-Hispanic other race. For maternal race, the strata included: less than 20 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, and 40 years and over. Within each individual stratum, preterm birth rates among the "more likely exposed" and "less likely exposed" groups were compared.

The Mantel-Haenszel chi-square test was also used to investigate the association between 1) the risk factor and the exposure status, which is whether a person is categorized in to the "more likely exposed" or "less likely exposed" group and 2) the risk factor and the health outcome, preterm birth. If the risk factor has a statistically significant association with both the exposure status and preterm birth, this is evidence that the risk factor is a potential confounder. A potential confounder is a risk factor for which there is an imbalance among the “more likely exposed” and “less likely exposed” groups that distorts the association between exposure and disease. A p-value of less than 0.05 is generally taken as evidence of an association between a risk factor and exposure status, or between a risk factor and the health outcome.

When the risk factors studied in this analysis were noted to be potential confounders, they were included in a multivariate logistic regression model. A multivariate model shows how various characteristics of an individual can influence an individual’s disease risk. In this case, the results demonstrated how different risk factors, or covariates, influence the odds of having a preterm birth. The odds of preterm birth is the probability that preterm birth will occur compared to the probability that preterm birth will not occur for the particular model. Two logistic regression models were run: 1) a crude, unadjusted model in which the only covariate was exposure status, which is whether or not an individual was likely exposed to Halaco pollutants, and 2) a full, adjusted model which included type of birth, maternal race, and maternal age, as well as exposure status as covariates.

For each coefficient in the model, the p-value, odd ratio, and 95% confidence interval for the odds ratio was examined. A p-value of less than 0.05 is generally considered to be statistically significant, and therefore evidence of an association between the risk factor put into the model and the health outcome, preterm birth. When the odds ratio is greater than 1, the odds of having a preterm birth is greater among those with higher values of the risk factor, and this is evidence of a positive association between the risk factor and disease. When the odds ratio is equal to 1, there is no evidence of association of the risk factor with the disease. When the relative risk is less than 1, then the odds of having a preterm birth is lower among those with higher values of the risk factor. When the upper and lower limits of the 95% confidence interval for the odds ratio was above 1, the odds ratio was considered to show a statistically significant association between risk factor and disease.

Results of Analysis

Before stratifying by any other risk factor, the preterm birth rate in the “more likely exposed” group was greater than the preterm birth rate in the “less likely exposed” group (Appendix D, Table D55). Among singleton births, the “more likely exposed” group has a higher preterm birth rate, while among multiple births, the “less likely exposed” group has a higher preterm birth rate (Appendix D, Table D56). Stratifying by maternal race, the “more likely exposed” group continued to have higher preterm birth rates for Hispanics, non-Hispanic whites, non-Hispanic blacks, and non-Hispanic Asian/Pacific Islanders; however, for non-Hispanic other race, the “less likely exposed” group had a higher preterm birth rate (Appendix D, Table D57). When stratifying by maternal age, for all age groups, the “more likely exposed” group had higher preterm birth rates than the “less likely exposed” group (Appendix D, Table D58).

Each of the covariates was associated with exposure status (Appendix D, Tables D59, D61, and D63). In addition, each of the covariates was associated with having a preterm birth or not (Appendix D, Tables D60, 62, and 64). For all the relationships between each covariate and exposure group, and for each covariate and preterm birth, the p-values were less than 0.05, which is statistically significant.

The results from the crude logistic regression model showed a positive association between the being "more likely exposed" and preterm birth. The odds ratio was 1.18, with a 95% confidence interval that was statistically significant (1.14, 1.22) (Appendix D, Table D65). The p-value for the coefficient for the exposure status was statistically significant, at less than 0.0001.

The results from the full, adjusted logistic regression model continued to show a positive association between being "more likely exposed" and preterm birth. The odds ratio was 1.09 with a 95% confidence interval of (1.05, 1.13) (Appendix D, Table D65). The p-value for the coefficient for the exposure status continued to be statistically significant, at less than 0.0001. The adjusted model also showed positive associations between each of the covariates and preterm birth. The p-values for each coefficient for all covariates were less than 0.05. The odds ratios for all the covariates were greater than 1, and the 95% confidence intervals for all of the odds ratios did not contain 1.

Discussion of Findings

Before stratification by the selected risk factors, the "more likely exposed" group had a higher preterm birth rate than the "less likely exposed" group. Stratifying by selected risk factors for preterm birth, including type of birth, maternal race, and maternal age, did not result in the "more likely exposed" groups having lower rates of preterm birth than the "less likely exposed" groups, except in the cases of multiple births and those of non-Hispanic other race.

There were positive associations between each of the covariates and exposure, and as well as the positive associations between each of the covariates and the health outcome, preterm birth. Thus, all of the covariates were confounders and were included in the logistic regression model.

Both the crude and adjusted models showed a positive association between being "more likely exposed" and preterm birth. Controlling for the additional risk factors for preterm birth that were included in the adjusted model reduced the elevation in the odds of preterm birth due to being "more likely exposed" by about 50%. However, even after controlling for additional covariates, the adjusted model still showed a 9% increase in the odds of having a preterm birth due to being "more likely exposed" with a 95% confidence interval of 5-13%. Due to these findings and the fact that contaminants that are associated with preterm birth have been released from Halaco, it seems possible that the exposures from Halaco are associated with higher rates of preterm birth.

Comparing Rates of Preterm Births in the ZIP Codes Next to Halaco and the Rest of Ventura County After Halaco Closed

Methodology of Analysis

For the years after Halaco closed (2005-2006), the rates of preterm births in the ZIP codes next to Halaco (93033 and 93041) were compared to the rest of Ventura County, excluding ZIP codes 93033 and 93041.

The rates for the ZIP codes next to Halaco and for the rest of Ventura County were compared using relative risk. This comparison helped to assess whether or not living close to the Halaco facility was associated with higher rates of preterm births after Halaco was closed. For this analysis, relative risk is the ratio of the rate of preterm births near the Halaco site after Halaco closed compared to the rate of preterm births farther away from the Halaco site after Halaco closed. When the relative risk is greater than 1, the risk of the negative birth outcome is greater for those living near Halaco, and this is evidence of a positive association between proximity to Halaco, even when the facility was not operating, and preterm birth. When the relative is equal to 1, there is no evidence of association of the proximity to Halaco, even when the facility was not operating, with preterm birth. When the relative risk is less than 1, then the risk of the preterm birth is lower for those living near Halaco, even when the facility was not operating, compared to living farther away from Halaco.

In order to find out if both rates were significantly different from each other, the Mantel-Haenszel chi-square test was used. The Mantel-Haenszel chi-square value and the p-value are presented. A p-value of less than 0.05 is generally taken as evidence of an association between residing in areas closer to Halaco (even when the facility was closed) vs. living in areas farther from Halaco and an elevated rate of preterm birth.

Results of Analysis

After Halaco's closure, births in the ZIP codes near the Halaco site had a lower risk of being a preterm birth compared to births in the rest of Ventura County (Appendix D, Table D66).

Discussion of Findings

The results of this testing suggest that after Halaco's closure, there was no longer a higher risk of having a preterm birth in the ZIP codes near the Halaco site vs. the rest of Ventura County. These results also support previous findings that pollutants released from Halaco may be associated with higher rates of preterm birth. If there was another factor besides Halaco, then it would be expected that there would continue to be a higher risk of preterm birth in ZIP codes near Halaco compared to the rest of Ventura County even after Halaco closed.

Findings of Negative Birth Outcome Statistics Data Review

This analysis does not show that exposure to Halaco contaminants is associated with a higher percentage of low birth weight births for ZIP codes located within a 1-mile radius of the Halaco site, compared to the reference area (Ventura County) for the years 1982-2006. There also does not appear to be a significantly higher risk of low birth weight births in ZIP codes near the Halaco site or reference area during the years of Halaco's operations (1982-2004) compared to the years after Halaco closed (2005-2006).

Though the initial analysis did not show consistently higher percentages of preterm births for ZIP codes located within 1-mile radius of the Halaco site, compared to the reference area (Ventura County), further analyses showed a possible association between exposure to Halaco pollutants and having a preterm birth. There was a significantly higher risk of preterm birth for ZIP code

93033, located within a 1-mile radius of the Halaco site, but not for ZIP code 93041, during the years of Halaco's operations (1982-2004) compared to the years after Halaco closed (2005-2006). The reference area (Ventura County) had a lower risk for preterm births during the years of Halaco's operations compared to the years after Halaco closed. Because ZIP Code 93033 and Ventura County do not show the same pattern over time, this implies that Halaco pollutants released when the plant operated may have been related to the elevation of preterm birth rates in 93033 during years of Halaco's operations.

When additional risk factors besides exposure to Halaco were controlled for, the odds of having a preterm birth in the ZIP codes located within 1-mile radius of the Halaco site during the plant's operation compared to the ZIP codes located within 1-mile radius of the Halaco site after the plant closed and the reference area did decrease. However, the odds ratio was still elevated and statistically significant. These risk factors included type of birth, maternal race, and maternal age. In addition, after Halaco closed, there was a lower risk of preterm birth in the ZIP codes located near Halaco compared to the rest of Ventura County. This provides further evidence that Halaco, and not some other factor, seems to be associated with a higher rate of preterm birth. Because of the lack of air monitoring data to help estimate actual exposure to Halaco pollutants, it is not possible to say that the Halaco contaminants caused the increased odds of having a preterm birth observed in this analysis. There also may have been another factor associated with time period that Halaco operated which contributed to the increased odds of having a preterm birth, but was not identified in this analysis. However, given that contaminants that are associated with preterm birth have been released from Halaco, it is plausible that the exposures from Halaco are associated with increased odds of having a preterm birth.

Limitations

There are several limitations for this negative birth outcome statistics review that make it difficult to show whether exposure to Halaco contaminants have caused an increased number of low birth weight and preterm births. These include the following:

- The methods used to determine whether people were "more likely exposed" to Halaco contamination were fairly crude. For 1982-2006, people were categorized as "more likely exposed" based on their residence in a particular ZIP code. As Figure B13 in Appendix B shows, large portions of the two ZIP codes categorized as areas that were more likely exposed were not located within a 1-mile radius of the Halaco site. If in fact the Halaco emissions caused an impact on low birth weight or preterm births, this incorrect classification of exposure would make it difficult to see this impact.

- Because the populations in the ZIP codes located within a 1-mile radius of the Halaco site (93033 and 93041) were so small, the methods used to compare these ZIP codes and the reference area have limited statistical power. If there really was an association between living in a ZIP code next to the Halaco site and higher rates of low birth weight or preterm birth, it would be difficult to detect. The larger width of the 95% confidence intervals for the rates in the ZIP codes located next to the Halaco site, compared to the much smaller width of the 95% confidence intervals for rates in the reference areas, illustrates this difficulty.

Community Concerns Evaluation

It is important to note the current scientific understanding of exposure to chemicals and related health effects is limited. Most of the information has been derived from studies on animals or workers who have received much higher levels of exposure than typically seen at sites where environmental contamination exists. This is further complicated by the fact that most studies look at chemicals on an individual basis, not as mixtures (exposure to multiple chemicals). These limitations add uncertainty to the conclusions about potential health impact as a result of exposure to contaminants.

CDPH evaluated community concerns by investigating their known causes, including environmental or chemical agents. We are not able to draw a link between the health effects expressed to CDPH and contaminants at the Halaco site for a number of reasons: first, the environmental data needed to understand potential exposures is not available; toxicological information on chemicals is limited; there is limited understanding of the effects from exposure to multiple chemicals; and there are many factors that contribute to causation of a disease, making it almost impossible to identify a specific or single factor, such as an environmental exposure. In order to provide some context, the evaluation of cancer concerns includes an overview of cancer risk factors and health disparities.

In this section, CDPH evaluated potential environmental links to illnesses by searching for contaminants of concern in the Collaborative on Health and the Environment's Toxicant Disease Database. The database lists illnesses associated with contaminants and vice versa. The Collaborative on Health and the Environment categorized the amount and quality of evidence linking contaminants to health outcomes as "strong," "good," and "limited," where strong means a causal association has been established; good means an association is being established; and limited means an association has begun to be suggested.

Cancer Risk Factors and Health Disparities

Cancer as a whole is the second leading cause of death in the United States after heart disease. There are many different types of cancer, and each type has different causes and risk factors. It is rarely possible to know why a particular individual develops cancer, but studies have found certain risk factors to be associated with specific cancers. For example, prolonged exposure to sunlight is a risk factor for skin cancer and cigarette smoking is a risk factor for lung cancer.

Usually, there are several factors that work together to cause cancer. A risk factor is something that may increase the chances that someone will develop an illness. For example, a number of factors may increase a person's risk for lung cancer: cigarette smoking; having a genetic susceptibility; poor diet; and exposure to another cancer-causing agent like asbestos. However, having a risk factor does not guarantee that the person will develop an illness. Even if a person has several risk factors, he/she may never develop the illness [130]. Some risk factors can be avoided or controlled, such as one's diet, level of physical activity, and use of tobacco. Other risk factors such as family history or genetics cannot be avoided. Cancer risk factors are described next.

Gender is a factor that influences cancer risk. Lung cancer is now the leading cause of cancer in both men and women. With the exception of lung cancer, men and women differ in cancer risk.

The second and third most common cancers in men are colon and prostate, respectively. For women, the second and third most common cancers are breast and colon, respectively [131].

Age is another important risk factor. People at different ages have different levels of risk for certain cancers. For example, in men the risk for testicular cancer decreases with age, but the risk for prostate cancer increases with age. In general, the older a person gets, the more likely he/she will get cancer. Thus, more cancer cases will occur in populations that have a greater proportion of elderly persons.

People of different ethnic and racial backgrounds get cancer following different patterns. These differences are known as cancer health disparities—they are inequalities that occur when members of one group of people do not enjoy the same health status as other groups [132]. Cancer health disparities occur as a result of differences in income, education, access to healthcare, lifestyle, and/or environmental and biological factors [132]. The American Cancer Society reports that African American men have the highest cancer-related death rate of 339 deaths per 100,000 in the United States, followed by white men with a rate of 243 deaths per 100,000, and Hispanic men with a rate of 171 deaths per 100,000. African American women have the highest rate of cancer related death with a rate of 194 deaths per 100,000, followed by white women with a rate of 165 deaths per 100,000, and American Indian women with a rate of 114 deaths per 100,000 [132].

Evaluation of Cancer Health Concern at the Halaco Site

As described in the community concerns section, the cancer concern reported to CDPH was leiomyosarcoma. Leiomyosarcoma is a rare form of cancer that occurs in the cells of smooth muscle [133]. Smooth muscle is the type of muscle that carries out movements made involuntarily by the body, such as movements of the blood vessels or stomach. Leiomyosarcoma tumors are usually found in the uterus or abdomen [133]. Risk factors for developing leiomyosarcoma and other soft tissue cancers are still being investigated. One study found elevated risks for leiomyosarcoma as a result of chlorophenol exposure and cutting oil exposure in work settings [134]. The Collaborative on Health and the Environment does not have an entry for leiomyosarcoma.

In addition to the cancer concern raised by the community, CDPH investigated the cancer risk posed by the contaminants from Halaco's operations. Several contaminants, beryllium, cadmium, and nickel via the inhalation route and the thorium radionuclides via incidental ingestion, inhalation, and external exposure are considered to be cancer causing. CDPH found that the long-term exposure from these chemicals in the soil/wetlands/sand would cause insignificant cancer risk for the beach, wetlands, and Nature Conservancy visitor.

The AB2588 risk assessment found that the routine operations from Halaco would not have been associated with a significant cancer risk for the maximally exposed individual (a hypothetical person located at the eastern fenceline). It is unknown what exposures to cancer-causing compounds may have occurred during the uncontrolled emissions from Halaco and the associated cancer risk

CDPH reviewed the numbers of cancers overall and other selected cancers (female breast, leukemia, melanoma of the skin, thyroid, nasal sinuses, urinary bladder, lung and bronchus, and leiomyosarcoma) that occurred in census tracts within a 1-mile radius of Halaco from the study period from 1988 through 2006. The numbers of observed cases compared with the numbers of expected cases do not suggest that incidence of the selected cancers was elevated due to exposure to Halaco contaminants. CDPH also reviewed time trend charts that support this finding by showing that the incidences of the selected cancers during the study period do not show unusual fluctuations beyond what is expected. However, this review is limited. It does not capture cancer cases that have not yet developed, nor does it count cancers in people who were exposed to Halaco contaminants but then moved away before developing cancer.

Evaluation of Noncancer Health Concerns at the Halaco Site

CDPH documented community concerns not related to cancer. These included short-term effects reportedly felt at the time of exposure, as well as some longer term concerns: asthma, bronchitis, diabetes, rheumatoid arthritis, and seizures. Noncancer concerns are evaluated next in alphabetical order.

Asthma

Asthma is a disorder of the airways in which they become inflamed, causing the airflow in and out of the lungs to be restricted [135]. This results in periodic attacks of wheezing, shortness of breath, chest tightness, and coughing. Asthma can be triggered by inhaling pet dander, dust, dust mites, molds, pollens, and cockroach allergens [136]. Respiratory infections, exercise, cold air, stress, food, drug allergies, and tobacco smoke can also trigger asthma attacks. Latino children have higher rates of asthma; this is believed to be due in part to concurrent exposure to risk factors such as multiple pollutants, substandard housing and limited access to healthcare [137].

The link between exposure to environmental contaminants and asthma has been widely studied and some of the compounds found in the soil and near the Halaco site and emitted as part of Halaco's operation have been shown in the workplace to be associated with asthma. Manganese has been known to cause asthma in workplace settings [138]. Work-related asthma is the primary respiratory concern in the aluminum industry [139]. Exposure to lead may also contribute to the increase of asthma and other allergic conditions [140]. Workplace exposure to nickel and chromium has also been associated with asthma [141]. In a 2004 study, welders exposed to metal fumes experienced asthma in greater numbers compared to non-welders [142]. Metal fumes in this study included iron (31.1 mg/m^3); nickel (0.023 mg/m^3); lead (0.021 mg/m^3); manganese (0.036 mg/m^3); and chromium (0.24 mg/m^3). In another welder study, exposure to metal fumes including beryllium, copper, lead, and manganese has been associated with asthma and other respiratory health effects [143]. The metals levels measured in the 2004 welder study were 4 to 200-times higher concentration than those that were estimated for the dirt bike rider on the NCL or on the WMU/WDA. According to the AB2588 risk assessment, the maximally exposed individual from the routine emissions from the Halaco facility when it was in operation (a hypothetical person living right on the eastern fenceline) would be exposed on an annual basis to levels 4,000 to 75,000 times lower than the welder worker study.

The Collaborative on Health and the Environment lists a number of contaminants being linked to asthma including ammonia, air pollution, smoking, and secondhand smoking. [144]. The Collaborative classifies the evidence linking these contaminants to asthma as strong. Ammonia and particulate matter were emitted from Halaco in its routine operation and during its uncontrolled releases.

CDPH reviewed available health outcome data for asthma: asthma prevalence data collected via a telephone survey conducted in years 2001, 2003, and 2005 and asthma hospitalization data for years from 1990 through 2006. These two data sources did not imply the impact of asthma was greater among communities more likely to have been exposed to Halaco emissions compared to control areas less likely to have been exposed to Halaco emissions. However, these results have limited relevancy because asthma data is only available for recent years, and not for the early years of Halaco's operation. The data was also only available for large geographic areas, including the county and ZIP code levels. Thus, an area classified as exposed to contamination from Halaco may include many people who were not actually exposed. If in fact the Halaco emissions caused an impact on asthma, this incorrect classification of exposure would dilute the ability to see this impact.

Chronic Bronchitis

The bronchi are the air passages that lead to the lungs; bronchitis is an inflammation of the bronchi [145]. The inflammation results in shortness of breath, chest tightness and coughing, often accompanied by yellow or green mucus. Chronic bronchitis occurs when the inflamed bronchi produce a lot of mucus, which makes it difficult for air to makes its way in and out of the lungs. There is no cure for chronic bronchitis; treatment is focused on relieving symptoms. Chronic bronchitis is usually caused by smoking, although it can also be caused by long-term exposure to fumes, dust, strong acids, and other chemicals in the workplace. When bronchitis is due to workplace exposures, it is known as industrial bronchitis [146]. In these cases, treatment is centered in avoiding the substances that causes inflammation by increasing air circulation or wearing protective masks. Health of the bronchi can be improved as long as exposure is halted. If exposure to irritants continues, the lungs could be permanently damaged. People with industrial bronchitis are encouraged to avoid smoking.

The Collaborative on Health and the Environment cites a strong body of evidence linking chronic bronchitis to several contaminants, including aluminum, ammonia, metals, and welding fumes [144]. Healthy adults exposed to particulate matter from an area near a smelter (not Halaco) showed distinct airway inflammation, compared with healthy adults exposed to air from a different area [147]. The metals in the particulate matter air samples inhaled were: cadmium (0.04 ug/L), lead (7.8 ug/L), chromium (3.4 ug/L), nickel (17.2 ug/L), copper (123.6 ug/L), and zinc (93.9 ug/L); vanadium and iron were also present at 9.0 ug/L and 93.9 ug/L, respectively [147]. A workplace study in Iran found that bronchitis was more common among welders than non-welders, especially if they smoked [142]. Metal fume concentrations inside welders' masks were: iron (31.1 mg/m^3), nickel (0.023 mg/m^3), lead (0.021 mg/m^3), manganese (0.36 mg/m^3), and chromium (0.24 mg/m^3) [142]. In this study, welders also experienced other respiratory symptoms including coughing, phlegm, wheezing, asthma, and shortness of breath.

Diabetes

Diabetes is a disease in which the body does not produce enough insulin to break down sugar, or glucose [148]. Too much glucose in the blood can eventually damage the eyes, kidneys, and nerves. There are three types of diabetes: in Type 1 diabetes, the body does not make insulin; in Type 2 diabetes, the body does not make or use insulin well; the third type of diabetes is called gestational diabetes and develops in pregnant women. Symptoms of diabetes include fatigue, thirst, weight loss, blurred vision, and frequent urination, although it is possible for symptoms to be absent [148]. Diabetes treatment includes exercise, weight control, nutrition therapy, medication, and frequent monitoring of glucose levels. A healthy diet and regular exercise have been shown to prevent diabetes [149].

The relationship between environmental contaminants and diabetes has begun to be explored. In a recent review of the scientific literature, exposures to arsenic and dioxin were found to have a possible relationship to increased risk for diabetes [150]. In these studies, people were exposed to arsenic in drinking water and in workplace settings, including copper smelters and glass art workshops; people were exposed to dioxin in industrial workplace settings, industrial accidents, or during while on military service. However, the links between exposure to environmental contaminants and diabetes are only suggestive and need to be explored further [150]. The Collaborative on Health and the Environment cites the evidence linking arsenic to diabetes as strong, and the evidence linking dioxin to diabetes as limited [144].

Rheumatoid Arthritis

Rheumatoid arthritis is a form of arthritis that occurs most commonly among women and appears between the ages of 25 and 55 [151]. Rheumatoid arthritis causes swelling, pain, stiffness, and loss of function in joints, as a result of the body's immune system attacking its own tissues. It occurs most commonly in the joints in the wrists and fingers [151]. Rheumatoid arthritis can be present for a short time or for a lifetime [151]. The causes of rheumatoid arthritis are not clear, although suspected risk factors include genes, the environment, and hormones [151]. Treatment for arthritis can include medication, diet and exercise, and surgery [151,152]. Rheumatoid arthritis is different from a common arthritis known as osteoarthritis, which occurs with older age.

The Collaborative on Health and the Environment cites a strong body of evidence linking silica exposure to rheumatoid arthritis; a good body of evidence linking tobacco smoke to rheumatoid arthritis; and a limited body of evidence linking estrogens, pesticides, and solvents to rheumatoid arthritis. However, the Collaborative does not provide information about the exposure level that may result in a health outcome [144].

Aggravated Epileptic Seizures

Seizures occur due to abnormal electrical activity on one or both sides of the brain [153]. Epileptic seizures are recurring and due to a brain disorder. A cause for epilepsy can rarely be established; no cause can be found in seven out of ten people [154]. Among the few known causes of epilepsy are head injuries or lack of oxygen during child birth; brain tumors; genetic conditions; lead poisoning; problems in brain development before birth; meningitis; and encephalitis [154]. Epilepsy occurs most frequently among people in early childhood, adolescence, and people over age 65 [154]. Seizures can be triggered by a variety of factors including missed medication; changes in sleep cycles and hormonal fluctuations; adding or removing prescription medication; emotional stressors such as worry, anxiety, or anger [155]. Treatment for epilepsy includes medication; surgery; stimulation of the vagus nerve (a large nerve located in the neck); a diet rich in fats and low in carbohydrates; and/or use of complementary treatment [156].

The Collaborative on Health and the Environment cites strong, good, and limited evidence linking seizures to environmental contaminants, but does not provide information about the dose at which health effects may occur [144]. The contaminants listed as having strong evidence of a link to seizures are: carbon monoxide, cyanide, lead, and mercury. The contaminants listed as having good strength of evidence linking them to seizures are: aluminum, halogenated hydrocarbons, methyl bromide, organochlorine pesticides, organophosphates, pesticides, and phosphine. The Collaborative cites limited strength of evidence linking seizures to exposure to: beryllium, boron, hexachlorophene, organotins, pyrethrins/pyrethroids, and solvents [144].

Other Short-Term Health Concerns

Community members reported health concerns unrelated to cancer such as breathing difficulties, irritation of the skin, eyes, nose, and throat. Community members reported experiencing these effects during the time of exposure. Although a definitive link cannot be made due to a lack of historical emissions data, it is possible that these health concerns occurred as a result of exposure to Halaco emissions. Skin irritation could have been allergic contact dermatitis, which has been associated with exposure to nickel and cadmium in workplace settings [141].

Long-Term Effects and Prevention of Disease

It is difficult to determine the long-term health effects resulting from exposure to contaminants at a place such as the Halaco smelter. In addition to those noted above, several studies have found that workers in smelters or places where metals are galvanized or welded are at risk of suffering from respiratory illness, including asthma and lung disease [157-159]. Subsequent exposure to smoking increases the risk of developing respiratory illness [142,160]. The long-term effects of human exposure to beryllium are still being investigated. A study examining workers at an aluminum smelting plant found evidence of beryllium sensitization, the first stage of chronic beryllium disease [161]. A study by the British Airway Health Services investigating disease among airline welders exposed to thorium found no excess of disease among welders compared with non-welders [162]. It is not possible to determine exactly what Halaco workers or people in the vicinity of the smelter were exposed to when Halaco was operating. People who are concerned about past exposure to contaminants affecting the respiratory system are advised to abstain from smoking and take other steps to protect the health of their lungs, such as regularly getting a flu shot.

ATSDR Child Health Considerations

ATSDR recognizes that infants and children may be more sensitive than adults to environmental exposures. This sensitivity is a result of several factors: 1) Children may have a greater exposures to environmental toxicants than adults because pound for pound body weight, children drink more water, eat more food and breathe more air than adults; 2) Children play outdoors close to ground which increases their exposure to toxicants in dust, soil, surface water and in the ambient air; 3) Children have a tendency to put their hands in their mouths while playing, thereby exposing them to potentially contaminated soil particles at higher rates than adults (also, some children ingest nonfood items, such as soil, which is pica behavior); 4) Children are shorter than adults, which means they can breathe dust , soil, and any vapors close to the ground; 5) Children grow and develop rapidly and can sustain permanent damage if toxic exposures occur during critical growth stages; and 6) Children and teenagers may disregard “No Trespassing” signs and wander onto restricted locations. Because children depend on adults for risk identification and management decisions, CDPH and ATSDR are committed to evaluating their special interests at hazardous waste sites. CDPH considered children for each of the pathways evaluated, in collecting and analyzing the health outcome data, and in the collection of community concerns. All ages, including children, were included in calculations of cancer incidences and crude asthma hospitalization rates. Separate data for children were not available for these indicators. Data on asthma prevalence was specifically available for children, and was included in this review.

Conclusion

Based on visits to the site and surrounding area, meetings with community, reviews of available environmental and health outcome data, CDPH evaluated ten ways (or exposure pathways) people could have come in contact with the contaminants from the Halaco site. The following is a summary of the evaluation of these pathways:

While the facility was in operation, nearby workers and residents, and visitors to the area had many concerns about the emissions coming from the facility. For instance, the Air District provided CDPH with a log of nuisance calls spanning the years 1992-2008; a total of 257 nuisance calls are listed in the nuisance call log. Those calling the Air District typically complained of the smells or the visible cloud in the air. The most common smells described included ammonia, sulfur, and metal. Smells were often described as foul, obnoxious, toxic, and terrible. The most common health concerns reported to the Air District were difficulty breathing, experiencing a chemical and/or metallic taste, headaches, eye irritation, and nausea. The emissions impacted the community’s and workers’ quality of life. For example, several residents reported having to close their windows in order to avoid Halaco-related odors; some said they were unable to sleep because of the strong odors emitted overnight; others would not walk on the beach because of Halaco odors and emissions—one community member was noted as saying that “it is impossible to go for a walk or run by the beach close to Halaco Engineering without getting ‘soot’ on you.”

Though there is no air data from the Halaco operation period, CDPH considers past emissions from the facility to have posed a health hazard. According to the AB2588 risk assessment that was performed in the mid-1990s, the routine, permitted, controlled emissions did not pose a cancer (3 in 1,000,000 increased cancer risk) or noncancer health hazard (hazard index of 0.07 for 1-hour and 0.1 for chronic exposure). However, unpermitted and uncontrolled emissions from Halaco occurred many times during the facility's operation.

Based on the Air District's investigation of numerous nuisance calls and their own compliance inspections, the facility released a number of different compounds to the air either through negligent operation or intentional circumvention of permitted procedures that would have controlled the emissions. Such a situation occurred in late 2002 when the air pollution control device had been disconnected for 6 months, and the vapors produced during the pouring of the ingots were not captured and treated by the air pollution control system. These uncontrolled emissions would easily increase the magnitude of exposure, probably by almost a factor of 10-100, given that most air pollution controls devices are 90%-99% efficient. Thus by extrapolation, the risk assessment results for noncancer (1-hour and chronic) would exceed 1 and thus non-cancer health effects could have occurred. The impact on cancer was also increased during the periods of uncontrolled emissions.

On the basis of existing information, the Halaco contamination has not affected the surface soil in the nearby residential and agricultural areas. Thus, there is no current exposure risk for nearby residents, workers in the agricultural fields, or consumers of products grown in those fields.

Other areas have been sampled and found to contain elevated soil or water levels of contaminants associated with the Halaco site. CDPH's review of the impact of this contamination has found that the following activities pose no apparent public health hazard:

- No noncancer public health hazard to trespassers on-site from the time the facility closed until now. Exposure to cancer-causing chemicals in soil could have occurred for a short period of time, approximately four years; however, this is too short a period of time to quantify risk for the trespasser.
- No apparent cancer risk and no noncancer public health hazard for adults and children visitors to the NCL for many years.
- No apparent cancer risk and no noncancer public health hazard for adults and children visitors to Ormond Beach for many years.
- No apparent cancer risk and no noncancer public health hazard for adults and children whom may have swum in the OID.
- No apparent cancer risk and no noncancer public health hazard for adult and children who may visit the wetlands area.

CDPH found the activities posing a public health hazard are the ones that create lots of dust, such as dirt bike riding on the WDA and the NCL. Inhaling manganese- and beryllium-contaminated soil that becomes airborne is the primary concern for the dirt bike rider on the WDA. Inhaling manganese-contaminated soil that becomes airborne is the main concern for the dirt bike rider on the NCL.

Inhaling beryllium in such dusty conditions could be associated with sensitivity to beryllium and perhaps granulomatous disease of the lung. Inhaling manganese has been associated with neurological changes in workers; however, the estimated levels of manganese the dirt bike riders breathed on the WDA or the NCL are considerably lower than those that the workers breathed. Thus it is possible, but not probable, that the dirt bike riders could experience health effects from inhalation exposure to manganese in the soil.

As with all exposure pathways, CDPH examined the impact to the dirt bike rider from exposure to more than one chemical. Several organ systems (respiratory, neurological, developmental and gastrointestinal tract) can be affected by more than one chemical with elevated levels in the WDA and NCL soils. CDPH examined the scientific literature and did not find any information that would specifically address the mixture found in those soils, or how they may interact in the body; thus, it is not clear if the mixture of metals found at elevated levels could affect the health of the community surrounding the Halaco site.

Exposure to beryllium, cadmium, nickel, and thorium in the Nature Conservancy soil over a 30-year period for the dirt bike rider results in a very low increased cancer risk. Exposure to cancer-causing chemicals in soil occurred over too short a period of time (1.5 years) to quantify risk for the dirt-bike rider on the WDA.

The WDA was covered with a material that reduces the dust that can be created from the soil, thus eliminating the dirt bike rider exposure concern. In addition, the WDA was fenced in April 2007.

CDPH did not find any evidence that the population residing within a 1-mile radius of the Halaco site have experienced higher rates of selected cancers than what was expected for this population, after adjustment for differences in age, sex, and race/ethnicity over the period 1988-2006. Cancer sites examined included female breast, leukemia, melanoma of the skin, thyroid, nasal sinuses, urinary bladder, lung and bronchus, and leiomyosarcoma. CDPH also did not find any unusual fluctuations beyond what is expected for the incidences of the selected cancers during the study period. However, this review is limited. It does not capture cancer cases that have not yet developed, nor does it count cancers in people who were exposed to Halaco contaminants but then moved away before developing cancer.

In addition, CDPH’s review of asthma prevalence and asthma hospitalization data did not find evidence that the impact of asthma was greater among communities located closer to the Halaco site and thus were more likely to have been exposed to Halaco emissions, compared to reference communities located farther away from the Halaco site and thus were less likely to have been exposed to Halaco emissions. These data included the times when Halaco operated and when Halaco was closed. However, because asthma data was not available before 1990, CDPH was not able to assess the impact of Halaco’s operation from 1965-1989. In addition, because data was also only available for large geographic areas, areas classified as more likely exposed to contamination from Halaco may include many people who were not actually exposed. If the Halaco emissions really caused an impact on asthma, this incorrect classification of exposure would make it difficult to identify this impact.

CDPH did not find evidence that there were higher numbers of all birth defects combined and limb reduction defects for the ZIP codes located within a 1-mile radius of the Halaco site, which were more likely to have been exposed to Halaco emissions, compared to reference areas, that were less likely to have been exposed to Halaco emissions, for 1989. There were greater numbers of neural tube defects (NTDs) in areas for the population located within a 1-mile radius of the Halaco site than reference areas for 1989. All cases of NTDs among this population that was more likely exposed occurred among Hispanics. There is no data on whether or not Hispanics received greater exposure to Halaco contamination than other racial/ethnic groups. Past research suggests that Hispanics in general may have higher rates of NTDs compared to other racial/ethnic groups, due to insufficient prenatal folic acid consumption and genetic susceptibility. Thus, it is possible that there are other reasons besides contamination from Halaco for why Hispanics living in areas most likely exposed to Halaco contaminants have elevated rates of NTDs. A significant limitation of this review is that there is only one year of data and it is not possible to look at trends over time. Also, because data were only available for ZIP codes, areas classified as exposed to contamination from Halaco may include many people who were not actually exposed.

CDPH did not find any evidence that exposure to Halaco contaminants resulted in a higher percentage of low birth weight births for two ZIP codes (93033 and 93041) located within a 1-mile radius of the Halaco site and which are more likely to have been exposed to Halaco emissions, compared to the reference area (Ventura County) which was less likely to have been exposed to Halaco emissions, from years 1982-2006. There also does not appear to be a significantly higher risk of low birth weight births in ZIP codes located next to the Halaco site or reference areas during the years that the Halaco facility operated (1982-2004) compared to the years that Halaco was closed (2005-2006).

The initial analysis did not show consistently higher percentages of preterm births for two ZIP codes (93033 and 93041) located within a 1-mile radius of the Halaco site compared to the reference area (Ventura County). However, further analyses showed evidence of possible association between living in the ZIP codes next to the Halaco site and having a preterm birth. ZIP code 93033 had a significantly higher risk of preterm birth for the years of Halaco's operations (1982-2004) than the years after the Halaco facility closed (2004-2006), while reference area (Ventura County) had a lower risk for preterm birth. This finding implies that the Halaco pollutants may have been related to the elevation of preterm birth rates in 93033 during Halaco operation.

CDPH found that even when additional risk factors for preterm birth were controlled for, there were still elevated odds of having a preterm birth associated with living in the two ZIP codes next to the Halaco site during Halaco's operation in the past. The additional risk factors included type of birth, maternal race, and maternal age. This elevation was statistically significant. Furthermore, after Halaco closed, there was a lower risk of preterm birth in the ZIP codes located near Halaco compared to the rest of Ventura County. This provides further evidence that Halaco, and not some other factor, seems to be associated with a higher rate of preterm birth. Because of the lack of data quantifying the actual exposure that community members received from the Halaco facility, it is not possible to be sure that the Halaco pollutants are solely responsible for this increased odds in having a preterm birth. There also may have been another factor associated with time period that Halaco operated which contributed to the increase in the number of preterm births, but was not identified in this analysis. Yet, considering contaminants which have been associated with preterm birth were released from Halaco in the past, this analysis shows that there may be a possible association between Halaco pollutants released during plant's operation in the past and elevated odds of preterm birth.

Recommendations for Further Actions

On the basis of available data, CDPH and ATSDR recommend that:

- A wider range of chemicals, including dioxins and gasoline/fuels, be evaluated in the smelter and waste pile.
- Additional testing of the surface soil in undisturbed areas in nearby neighborhoods be conducted to confirm earlier testing that showed no long-term impact from the Halaco releases.
- EPA ensure access is limited to the smelter as much as possible by installing or repairing the broken fences around the site and restricting access to the site via the fence to office building roof and the concrete wall on the south end of the site.
- The current owner or EPA continues to keep trespassers off the WMU and WDA.
- EPA and owners of the NCL restrict access and post additional signs in English and Spanish around the NCL located east of the WDA and WMU, warning of possible health implications associated with the site especially restricting any activities that may cause dust generation, until the contamination that has migrated from Halaco has been remediated.
- EPA ensures the integrity of the coir matting covering the WMU and WDA until a final remedy is completed.
- Future construction activities incorporate erosion control and dust mitigation mechanisms.

Public Health Action Plan

The Public Health Action Plan (PHAP) for this site contains a description of the action taken, to be taken or under consideration by ATSDR and CDPH, at and near the site. The purpose of the PHAP is to ensure that this PHA not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment.

Public Health Actions Completed

1. CDPH has visited the site and surrounding neighborhood on several occasions to identify hazards and people that may be or may have been affected by the operations and contamination associated with Halaco.
2. CDPH has met with former Halaco workers, nearby businesses and their employees, and nearby communities (public availability meeting, EPA public meeting) to gather information about the practices conducted at the Halaco facility and concerns related to exposure and health.
3. CDPH has contacted nearby communities (Southwinds and Cypress neighborhood associations), various community groups (Mixteco Community Organizing Project, Ormond Beach Task Force), the nearby school and school district, and the local

community clinics to let them know of our work on the site and to gather concerns related to exposure and health.

4. CDPH has responded to requests for presentations to the Port Hueneme City Council (October 17, 2007 and October 15, 2008) and the Ventura County Supervisors (October 16, 2007) meetings.

Public Health Action Planned

1. CDPH will work with former workers, nearby workers, community members, and other stakeholders to share the findings of the PHA.

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Certification

This public health assessment, Evaluation of Exposure to Contaminants at the Halaco Engineering Company, Oxnard, California, was prepared by the California Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health assessment was begun. Editorial review was conducted by the cooperative agreement partner.

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The Division of Public Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with the findings.

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Appendix A. Glossary of Terms

Absorption
How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure
Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Adverse Health Effect
A change in body function or the structures of cells that can lead to disease or health problems.

ATSDR
The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and ten regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency, which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

Background Level
An average or expected amount of a chemical in a specific environment or, amounts of chemicals that occur naturally in a specific environment.

Benchmark Dose
A dose or concentration that produces a predetermined change in response rate of an adverse effect (called the benchmark response or BMR) compared to background.

California Human Health Screening Levels (CHHSLs)
CHHSLs are concentrations of 54 hazardous chemicals in soil or soil gas that the California Environmental Protection Agency (Cal/EPA) considers to be below thresholds of concern for risks to human health. The CHHSLs were developed by the California Office of Environmental Health Hazard Assessment (OEHHA) as screening numbers to aid in the estimation of cleanup costs for contaminated soil. The thresholds of concern used to develop the CHHSLs are an excess lifetime cancer risk of one-in-a-million (10^{-6}) and a hazard quotient of 1.0 for noncancer health effects. The CHHSLs were developed using standard exposure assumptions and chemical toxicity values published by the U.S. Environmental Protection Agency (EPA) and Cal/EPA

Cancer Risk
The potential for exposure to a contaminant to cause cancer in an individual or population is evaluated by estimating the probability of an individual developing cancer over a lifetime as the result of the exposure. This approach is based on the assumption that there are no absolutely "safe" toxicity values for carcinogens. The U.S. Environmental Protection Agency and the California Environmental Protection Agency have developed cancer slope factors and inhalation

unity risk factors for many carcinogens. A slope factor is an estimate of a chemical's carcinogenic potency, or potential, for causing cancer.

If adequate information about the level of exposure, frequency of exposure, and length of exposure to a particular carcinogen is available, an estimate of excess cancer risk associated with the exposure can be calculated using the slope factor for that carcinogen. Specifically, to obtain risk estimates, the estimated, chronic exposure dose (which is averaged over a lifetime or 70 years) is multiplied by the slope factor for that carcinogen.

Cancer risk is the theoretical chance of getting cancer. In California, 41.5% of women and 45.4% of men (about 43% combined) will be diagnosed with cancer in their lifetime. This is referred to as the "background cancer risk." The term "excess cancer risk" represents the risk above and beyond the "background cancer risk." A "one-in-a-million" excess cancer risk from a given exposure to a contaminant means that if one million people are chronically exposed to a carcinogen at a certain level, over a lifetime, then one cancer above the background risk may appear in those million persons from that particular exposure. For example, in a million people, it is expected that approximately 430,000 individuals will be diagnosed with cancer from a variety of causes. If the entire population was exposed to the carcinogen at a level associated with a one-in-a-million cancer risk, 430,001 people may get cancer, instead of the expected 430,000. Cancer risk numbers are a quantitative or numerical way to describe a biological process (development of cancer). In order to take into account the uncertainties in the science, the risk numbers used are plausible upper limits of the actual risk, based on conservative assumptions.

Chronic Exposure
A contact with a substance or chemical that happens over a long period of time. The Agency for Toxic Substances and Disease Registry considers exposures of more than 1 year to be chronic.

Completed Exposure Pathway
See Exposure Pathway.

Concern
A belief or worry that chemicals in the environment might cause harm to people.

Concentration
How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant
See Environmental Contaminant.

CREG (ATSDR's Cancer Risk Evaluation Guide for 1 in 1,000,000 increased cancer risk)
CREGS are screening values for air, soil and water, developed by ATSDR. To derive water and soil CREGs, ATSDR uses CSFs developed by the U.S. Environmental Protection Agency and reported in the Integrated Risk Information System (IRIS). The IRIS summaries, available at http://www.epa.gov/iris, provide detailed information about the derivation and basis of the CSFs for individual substances. ATSDR derives CREGs for lifetime exposures, and therefore uses exposure parameters that represent exposures as an adult. An adult is assumed to ingest 2 liters

per day of water and weigh 70 kilograms. For soil ingestion, ATSDR assumes a soil ingestion rate of 100 milligram per day, for a lifetime (70 years) of exposure.

Like EMEGs, water CREGs are derived for potable water used in homes, including water used for drinking, cooking, and food preparation. Soil CREGs apply only to soil that is ingested. A theoretical increased cancer risk is calculated by multiplying the dose and the cancer slope factor When developing CREGs, the target risk level (10^{-6}), which represents a theoretical risk of one excess cancer case in a population of one million, and the CSF are known. The calculation seeks to find the substance concentration and dose associated with this target risk level.

Dermal Contact
A chemical getting onto your skin. See Route of Exposure.

Dose
The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as the "amount of substance(s) per body weight per day."

Dose/Response
The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration
The amount of time (days, months, and years) that a person is exposed to a chemical.

EMEG (ATSDR's Environmental Media Evaluation Guide)
EMEGs are screening values based on noncancer health endpoints, developed by ATSDR. EMEGS have been developed for air, soil and water. Water EMEGs are derived for potable water used in homes. Potable water includes water used for drinking, cooking, and food preparation. Exposures to substances that volatilize from potable water and are inhaled, such as volatile organic compounds released during showering, are not considered when deriving EMEGs.

To derive water EMEGs, ATSDR uses the chronic oral MRLs from the Toxicological Profiles, available at http://www.atsdr.cdc.gov/toxpro2.html. Ideally, the MRL is based on an experiment in which the chemical was administered in water. However, in the absence of such data, an MRL based on an experiment in which the chemical was administered by gavage or in food may have been used. The Toxicological Profiles for individual substances provide detailed information about the MRL and the experiment on which it was based.

Children are usually assumed to constitute the most sensitive segment of the population for water ingestion because their ingestion rate per unit of body weight is greater than the adults' rate. An EMEG for a child is calculated assuming a daily water ingestion rate of 1 liter per day for a 10-kilogram child. For adults, a water EMEG is calculated assuming a daily water ingestion rate of 2 liters per day and a body weight of 70 kg.

For soil EMEGS, ATSDR uses the chronic oral MRLs from its Toxicological Profiles. Many chemicals bind tightly to organic matter or silicates in the soil. Therefore, the bioavailability of a chemical is dependent on the media in which it is administered. Ideally, an MRL for deriving a soil EMEG should be based on an experiment in which the chemical was administered in soil. However, data from this type of study is seldom available. Therefore, often ATSDR derives soil EMEGs from MRLs based on studies in which the chemical was administered in drinking water, food, or by gavage using oil or water as the vehicle. The Toxicological Profiles for individual substances provide detailed information about the MRL and the experiment on which it was based.

Children are usually assumed to be the most highly exposed segment of the population because their soil ingestion rate is greater than adults' rate. Experimental studies have reported soil ingestion rates for children ranging from approximately 40 to 270 milligrams per day, with 100 milligrams per day representing the best estimate of the average intake rate. ATSDR calculates an EMEG for a child using a daily soil ingestion rate of 200 milligrams per day for a 10-kg child.

Environmental Contaminant
A substance (chemical) that gets into a system (person, animal, or environment) in amounts higher than that found in Background Level, or what would be expected.

Environmental Media
Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. Environmental Media is the second part of an Exposure Pathway.

Exposure
Coming into contact with a chemical substance. For the three ways people can come in contact with substances, see Route of Exposure.

Exposure Assessment
The process of finding the ways people come in contact with chemicals, how often, and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Frequency
How often a person is exposed to a chemical overtime; for example, every day, once a week, or twice a month.

Exposure Pathway
A description of the way that a chemical moves from its source (where it began), to where, and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having five parts: 1) a source of contamination, 2) an environmental media and transport mechanism, 3) a point of exposure, 4) a route of exposure, and 5) a receptor population. When all five parts of an exposure pathway are present, it is called a Completed Exposure Pathway.

Hazard Index
The sum of the Hazard Quotients (see below) for all contaminants of concern identified, to which an individual is exposed. If the hazard index (HI) is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the hazard index is greater than 1, then adverse health effects are possible. However, an HI greater than 1 does not necessarily suggest a likelihood of adverse effects. The HI cannot be translated to a probability that adverse effects will occur, and is not likely to be proportional to risk.

Hazard Quotient
The ratio of estimated site-specific exposure to a single chemical from a site over a specified period to the estimated daily exposure level, at which no adverse health effects are likely to occur. If the Hazard Quotient is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the Hazard Quotient is greater than 1, then adverse health effects are possible. The Hazard Quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. It is especially important to note that a Hazard Quotient exceeding 1 does not necessarily mean that adverse effects will occur.

Hazardous Waste
Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Comparison Value
Media-specific concentrations that are used to screen contaminants for further evaluation.

Health Effect
ATSDR deals only with Adverse Health Effects (see definition in this glossary).

Ingestion
Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (see Route of Exposure).

Inhalation
Breathing. It is a way a chemical can enter your body (see Route of Exposure).

LOAEL (Lowest-Observed-Adverse-Effect Level)
LOAEL is the lowest dose of a chemical in a study (animals or people), or group of studies, that produces statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

MCL (Maximum Contaminant Level)
The US EPA and the CDPH have issued drinking water standards, or MCLs for more than 80 contaminants in drinking water. The MCLs are set based on known or anticipated adverse human health effects (which also account for sensitive subgroups, such as, children, pregnant women, the elderly, etc.), the ability of various technologies to remove the contaminant, their effectiveness, and cost of treatment. For cancer risk, the MCLs is generally set at concentrations that will limit an individual risk of cancer from a contaminant to between 1 in 10,000 (low

increased excess risk) to 1 in 1,000,000 (no apparent increased excess risk) over a lifetime. As for non-cancer effects, the MCL is set at a concentration below which no adverse health effects are expected to occur.

Media Specific Comparison Values
Media Specific Comparison Values are concentrations of a substance in a particular media (e.g., in water, soil, air, etc) to which humans may be exposed over a specified period of time without experiencing adverse health effects. Media specific comparison values are developed using health comparison values. ATSDR has developed media specific guidelines called EMEGs, RMEGs, and CREGs which are derived from the health comparison value based on a single route of exposure. PRGs and CHHSLs are developed from health comparison values based on multi-pathway exposure.

Noncancer Health Comparison Values: ATSDR's Minimal Risk Level (MRL), U.S. EPA's Reference Dose (RfD) and Reference Concentration (RfC), OEHHA's Reference Exposure Level (REL) and child-specific Reference Dose (chRD)
MRL, RfD, RfC, and REL are estimates of daily exposure to the human population (including sensitive subgroups), below which noncancer adverse health effects are unlikely to occur. The chRD are developed to address chemical contaminants at sites where schools may be built and address impacts for infants, toddlers, and children up to age 18. MRLs, RfDs, RfCs, RELs, and currently available chRDs only consider noncancer effects. Because they are based only on information currently available (NOAEL, LOAEL, or benchmark dose approach), some uncertainty is always associated with MRL, RfD, RfC, REL, and chRD. "Uncertainty" factors are used to account for the uncertainty in our knowledge about their danger. The greater the uncertainty, the greater the "uncertainty" factor and the lower MRL, RfD, RfC, REL, chRD.

When there is adequate information from animal or human studies, MRLs, RfDs, chRDs are developed for the ingestion exposure pathway; RELs, MRLs and RfCs are developed for the inhalation exposure pathway.

Separate noncancer toxicity values are also developed for different durations of exposure. ATSDR develops MRLs for acute exposures (less than 14 days), intermediate exposures (from 15 to 364 days), and for chronic exposures (greater than 1 year). The California EPA develops RELs for acute (less than 14 days) and chronic exposure (greater than 1 year). EPA develops RfDs and RfCs for acute exposures (less than 14 days), and chronic exposures (greater than 7 years). MRLs, RfDs, and currently available chRDs for ingestion are expressed in units of milligrams of contaminant per kilograms body weight per day (mg/kg/day). RELs, RfCs, and MRLs for inhalation are expressed in units of milligrams per cubic meter (mg/m^3).

The noncancer health comparison values may not protect hypersensitive (allergic) individuals.

NOAEL (No-Observed-Adverse-Effect Level)
NOAEL is the highest dose of a chemical at which there were no statistically or biologically significant increases in the frequency or severity of adverse effects seen between the exposed population (animals or people) and its appropriate control. Some effects may be produced at this dose, but they are not considered adverse, nor precursors to adverse effects.

PHA (Public Health Assessment)
A report or document that looks at chemicals at a hazardous waste site and determines if people could be harmed from coming into contact with those chemicals. The PHA also recommends possible further public health actions if needed.

Plume
A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney, contaminated underground water sources, or contaminated surface water (such as lakes, ponds, and streams).

Point of Exposure
The place where someone can come into contact with a contaminated environmental medium (air, water, food, or soil). For example, the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population
A group of people living in a certain area or the number of people in a certain area.

PRG (U.S. Environmental Protection Agency's Preliminary Remediation Goals)
PRGs are developed by the EPA to estimate contaminant concentrations in the environmental media (soil, air, and water), both in residential and industrial settings, that are protective of humans, including sensitive groups, over a lifetime. PRGs were developed for both industrial and residential settings because of the different exposure parameters, such as, different exposure time frames (e.g., industrial setting: workers are exposed for 8 hours/day and 5 days/week vs. residential setting: families are exposed 24 hours/day and 7 days/week; and different "human" exposure points (e.g., industrial setting: healthy adult males vs. residential setting: males, females, young children, and infants), etc. Media concentrations less than the PRGs are unlikely to pose a health threat; whereas, concentrations exceeding a PRGS do not automatically determine that a health threat exists, but suggest that further evaluation is necessary. PRGs are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements.

Public Health Hazard Categories (ATSDR)
Depending on the specific properties of the contaminant(s), the exposure situations, and the health status of individuals, a public health hazard may occur. Sites are classified by ATSDR by using one of the following public health hazard categories:

Urgent Public Health Hazard
This category applies to sites that have certain physical hazards or evidence of short-term (less than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. These sites require quick intervention to stop people from being exposed. ATSDR will expedite the release of a health advisory that includes strong recommendations to immediately stop or reduce exposure to correct or lessen the health risks posed by the site.

Public Health Hazard
This category applies to sites that have certain physical hazards or evidence of chronic (long-term, more than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. ATSDR will make recommendations to stop or reduce exposure in a timely manner to correct or lessen the health risks posed by the site. ATSDR may recommend any of the following public health actions for sites in this category:

- Cease or further reduce exposure (as a preventive measure)
- Community health/stress education
- Health professional education
- Community health investigation

Indeterminate Public Health Hazard
This category applies to sites where critical information is lacking (missing or has not yet been gathered) to support a judgment regarding the level of public health hazard. ATSDR will make recommendations to identify the data or information needed to adequately assess the public health risks posed by this site.

No Apparent Public Health Hazard
This category applies to sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but the exposures are not at levels likely to cause adverse health effects.

No Public Health Hazard
This category applies to sites where no exposure to site-related hazardous substances exists. ATSDR may recommend community health education for sites in this category. For more information, consult Chapter 9 and Appendix H in the 2005 ATSDR Public Health Assessment Guidance Manual available at http://www.atsdr.cdc.gov/HAC/PHAManual/.

Qualitative Description of Estimated Increased Cancer Risks

Quantitative Risk Estimate	Qualitative Interpretation
Less than 1 in 100,000	No apparent increased risk
1 in 100,000 to 9 in 100,000	Very low increased risk
1 in 10,000 to 9 in 10,000	Low increased risk
1 in 1,000 to 9 in 1,000	Moderate increased risk
Greater than 9 in 1,000	High increased risk

Receptor Population
People who live or work in the path of one or more chemicals, and who could come into contact with them (see Exposure Pathway).

RMEG (Reference Dose Media Evaluation Guides)
ATSDR develops RMEGs using EPA's reference doses (RfDs), available at http://www.epa.gov/iris, and default exposure assumptions, which account for variations in intake rates between adults and children. EPA's reference concentrations (RfCs), available at http://www.epa.gov/iris, serve as RMEGs for air exposures. Like EMEGs, RMEGs represent concentrations of substances (in water, soil, and air) to which humans may be exposed without experiencing adverse health effects. RfDs and RfCs consider lifetime exposures, therefore RMEGs apply to chronic exposures.

Route of Exposure
The way a chemical can get into a person's body. There are three exposure routes: 1) breathing (also called inhalation), 2) eating or drinking (also called ingestion), and 3) getting something on the skin (also called dermal contact).

Safety Factor
Also called Uncertainty Factor. When scientists do not have enough information to decide if an exposure will cause harm to people, they use uncertainty factors and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

Source (of Contamination)
The place where a chemical comes from, such as a smokestack, landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first point of an exposure pathway.

Sensitive Populations
People who may be more sensitive to chemical exposures because of certain factors such as age, sex, occupation, a disease they already have, or certain behaviors (cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Toxic
Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology
The study of harmful effects of chemicals on humans or animals.

Volatile Organic Chemical (VOC)
Substances containing carbon and different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen. These substances easily volatilize (become vapors or gases) into the atmosphere. A significant number of VOCs are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry-cleaning fluids).

Appendix B. Figures

Figure B1. Site Location Map, Halaco Site, Oxnard, California

Source (Integrated assessment draft report, WestonSolutions, Inc. Jan 07)

Figure B2. Solid Matrix Sample Location Map, Halaco Site, Oxnard, California

Source (Integrated assessment draft report, WestonSolutions, Inc. Jan 07)

Figure B3. Solid Matrix Sample Location Near Halaco Site, Oxnard, California

Source (Integrated assessment draft report, WestonSolutions, Inc. Jan 07)

Figure B4. Surface Water Sample Locations Along the Oxnard Industrial Drain, Halaco Site, Oxnard, California

Source (Integrated assessment draft report, WestonSolutions, Inc. Jan 07)

Figure B5. Locations of Air Sampling Stations, Halaco Site, Oxnard, California

Source (Integrated assessment draft report, WestonSolutions, Inc. Jan 07)

Figure B6. Time Trend Chart for All Cancers Combined, Halaco Site, Oxnard, California

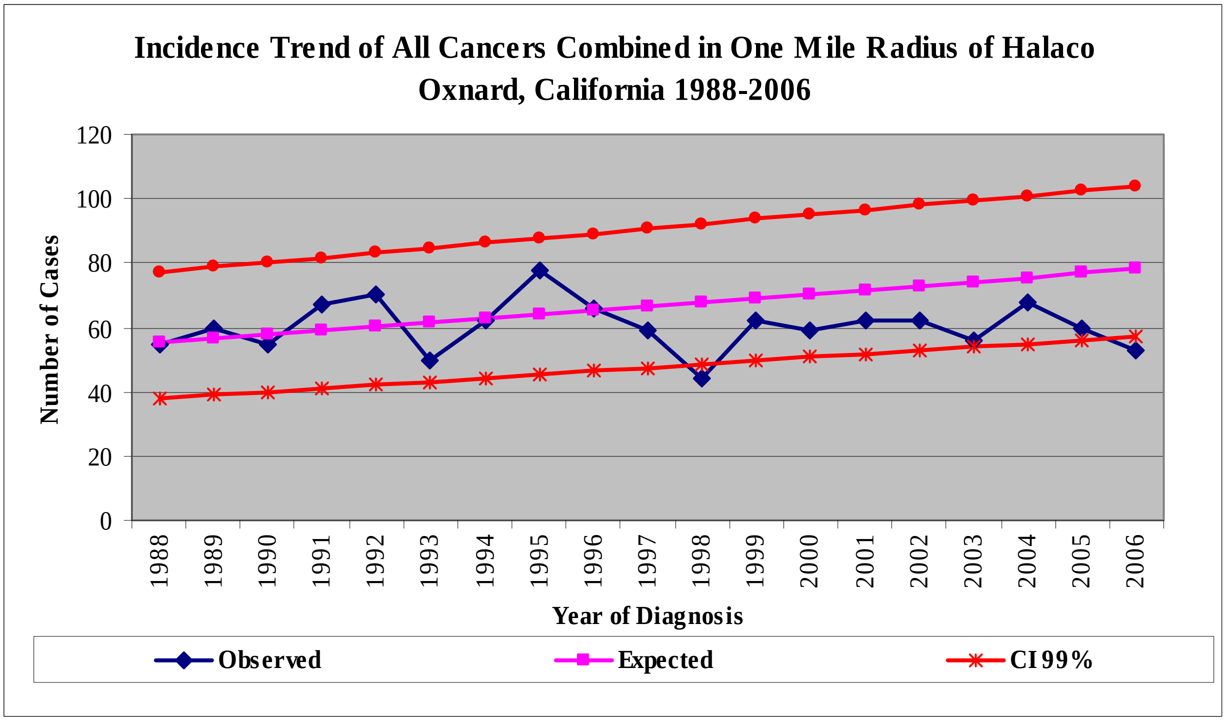


Figure B7. Time Trend Chart for Female Breast Cancer, Halaco Site, Oxnard, California

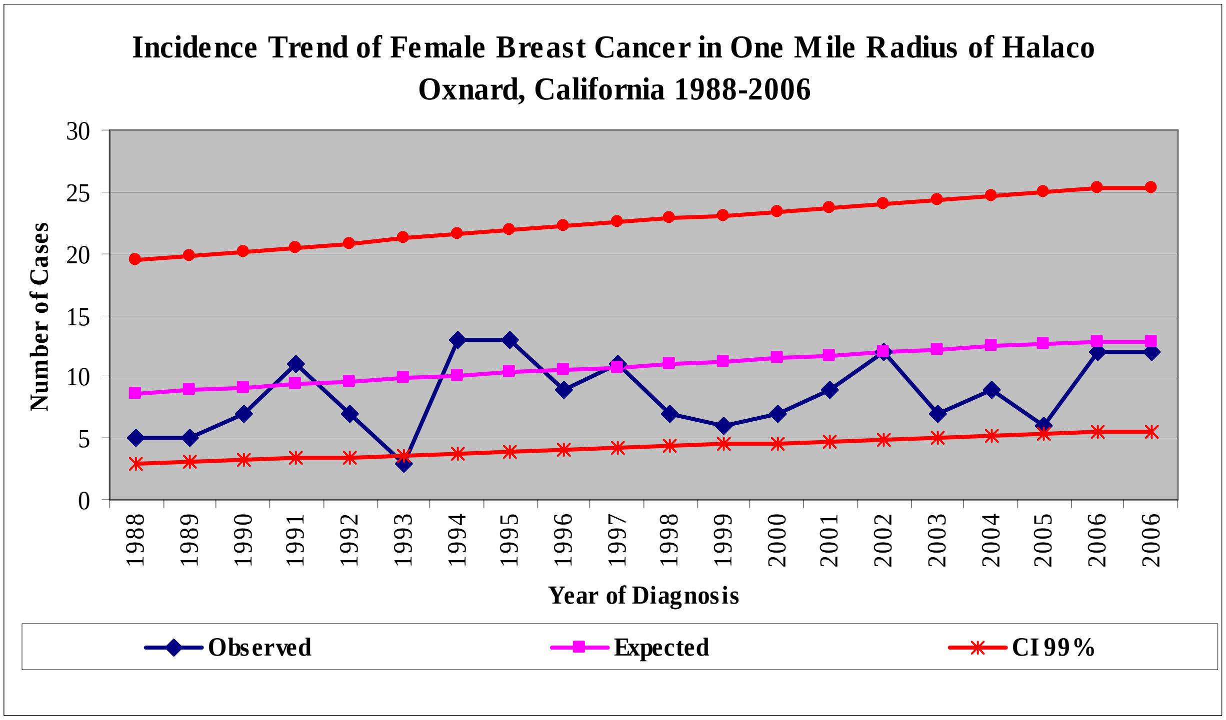


Figure B8. Time Trend Chart for Lung Cancer, Halaco Site, Oxnard, California

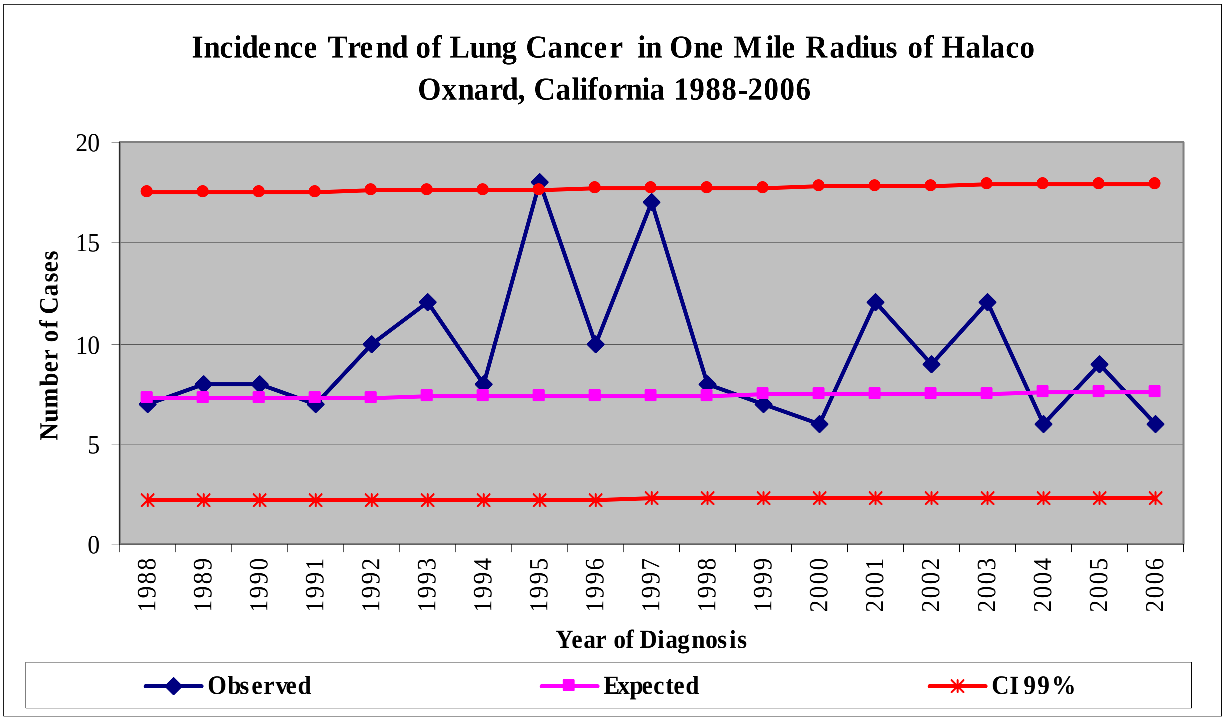


Figure B9. Time Trend Chart for Leukemia, Halaco Site, Oxnard, California

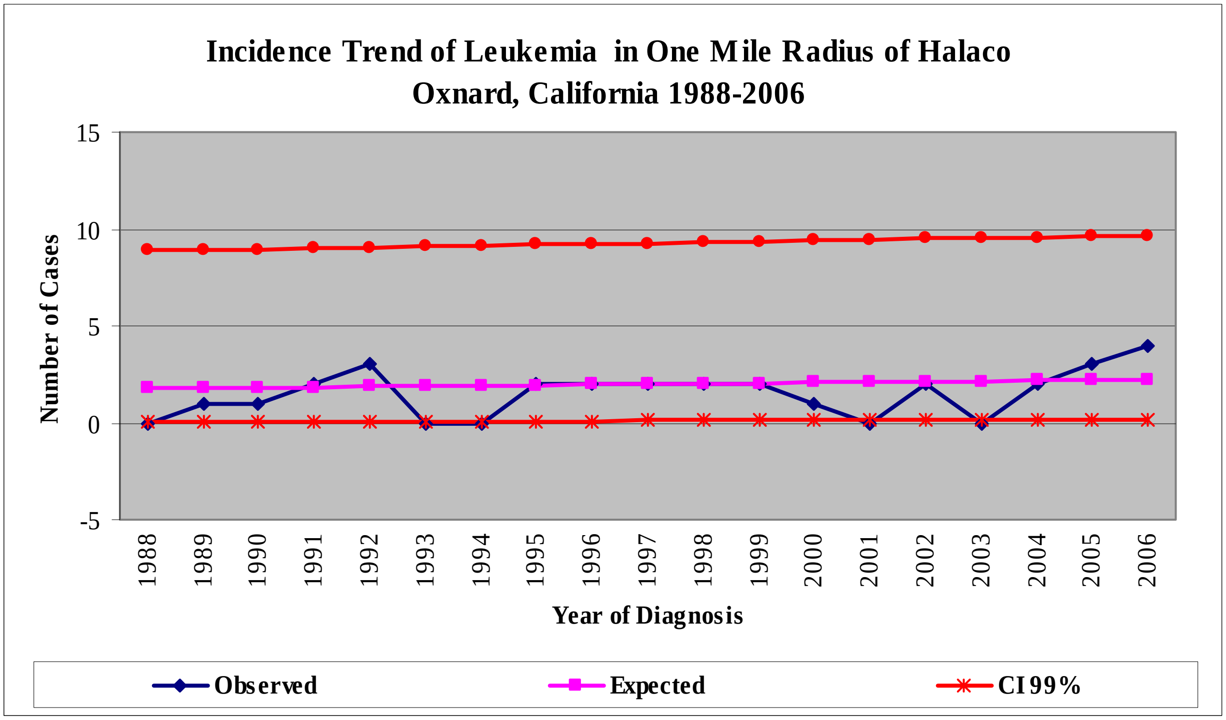


Figure B10. Time Trend Chart for Thyroid Cancer, Halaco Site, Oxnard, California

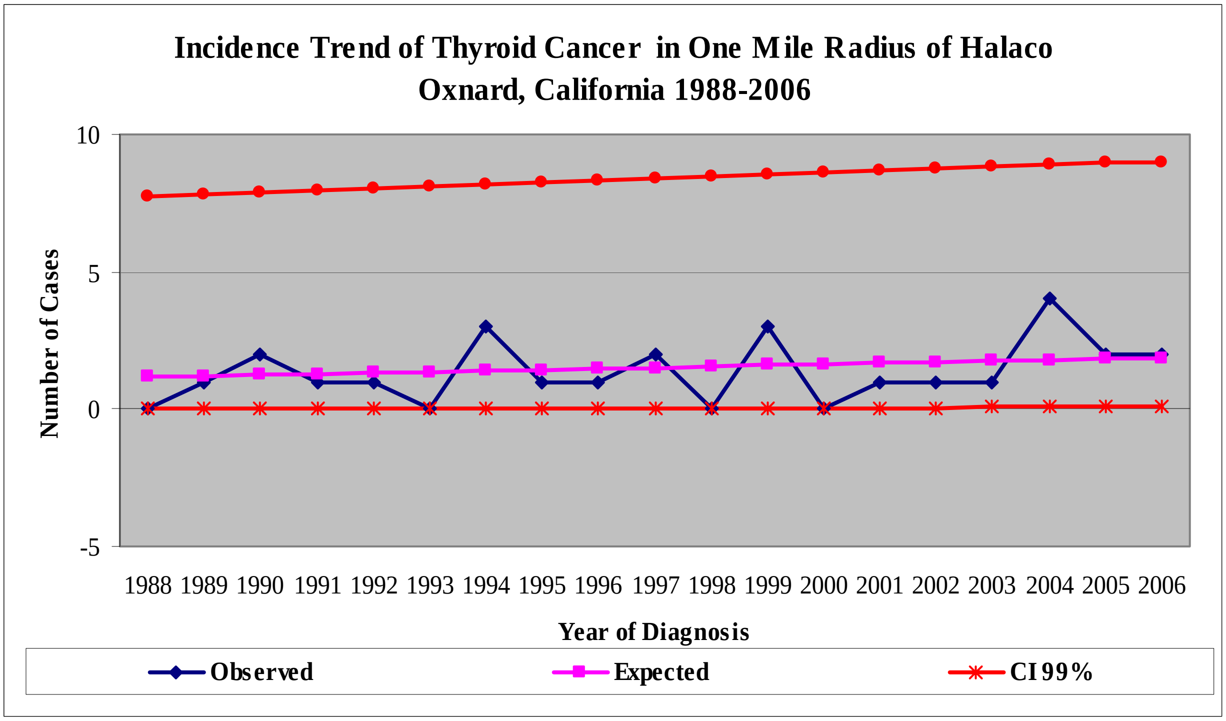


Figure B11. Time Trend Chart for Skin Melanoma, Halaco Site, Oxnard, California

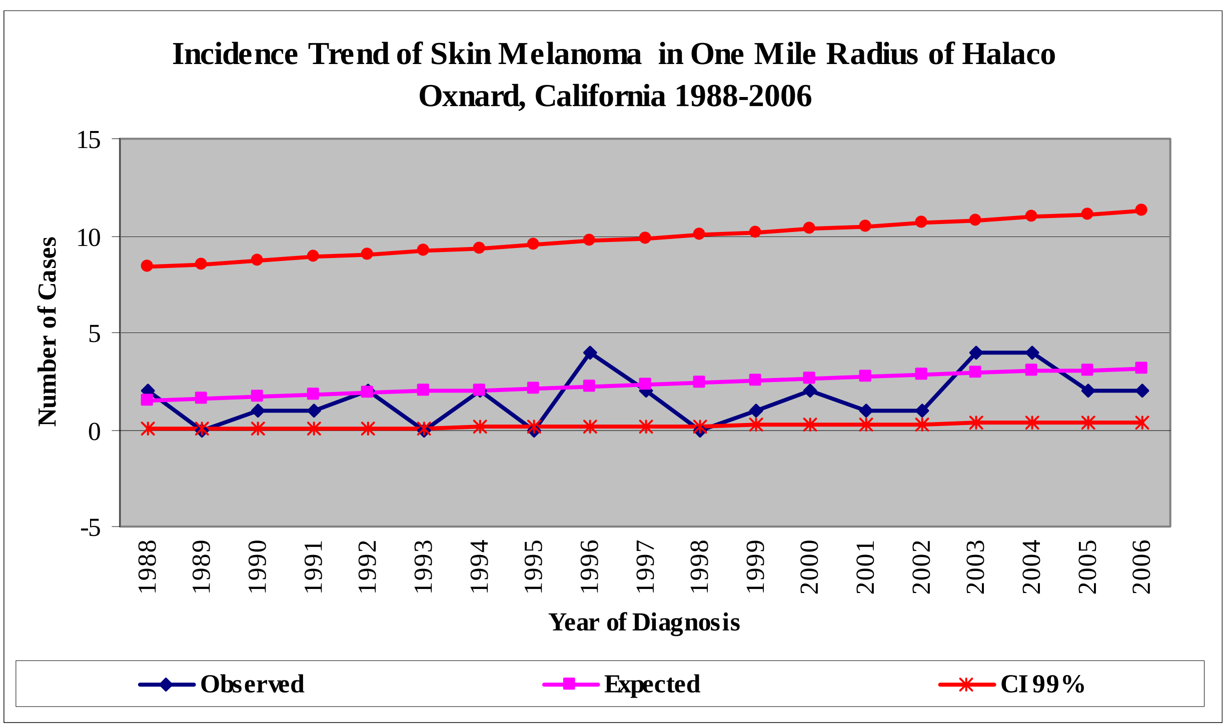


Figure B12. Time Trend Chart for Urinary Bladder Cancer, Halaco Site, Oxnard, California

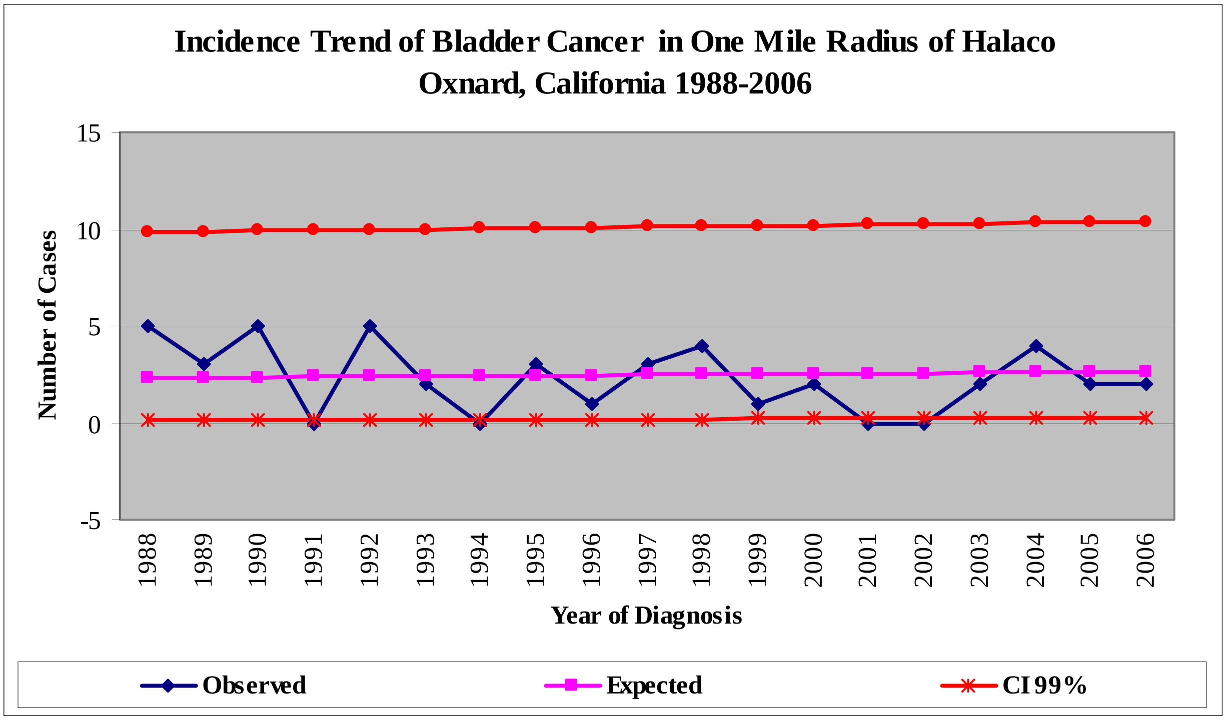


Figure B13. Percentage of Low Birth Weight Births and 95% Confidence Interval for Ventura County (Reference Area) and ZIP Code 93033 (Exposed Area) for 1982-2006

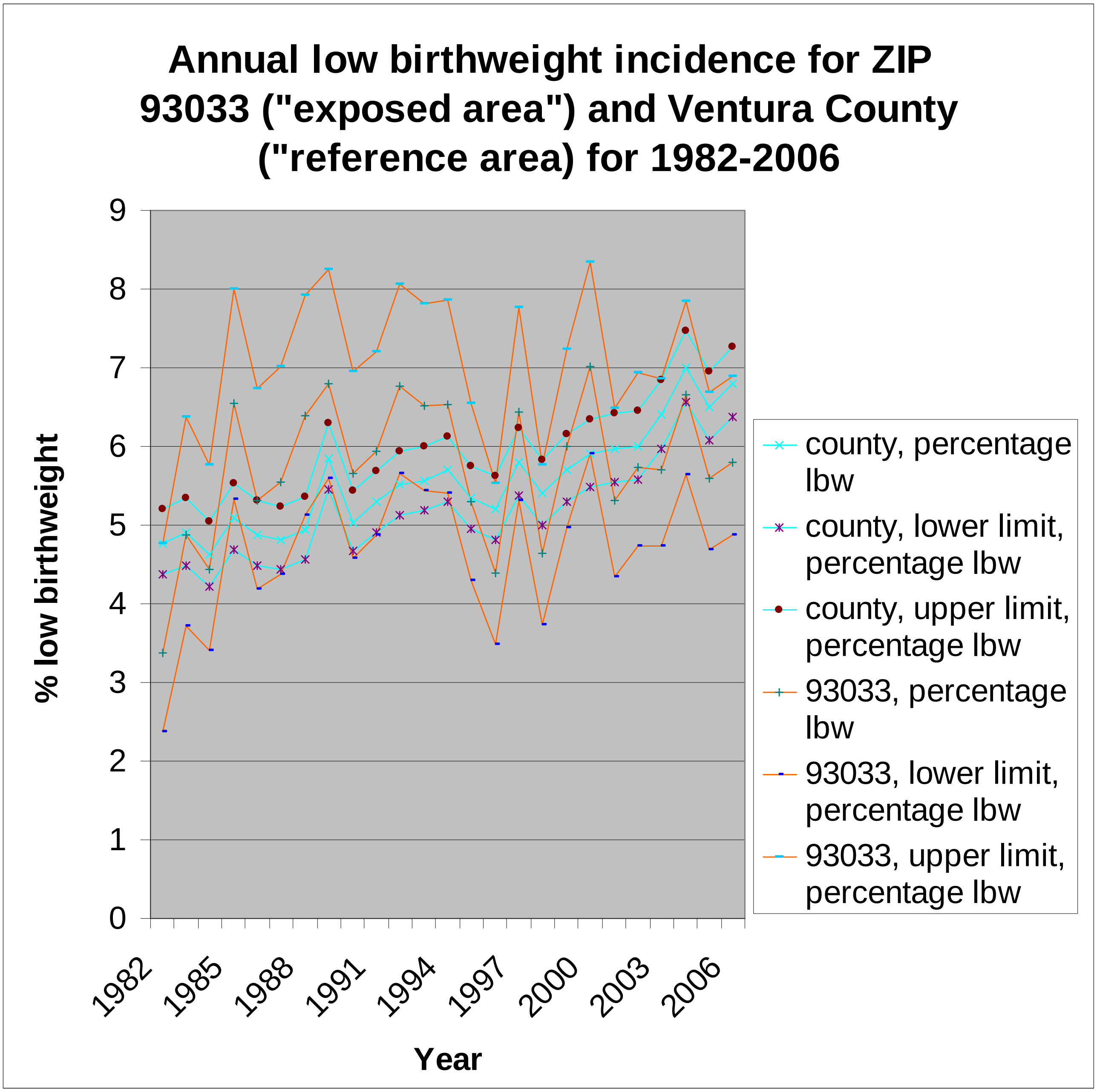


Figure B14. Percentage of Low Birth Weight Births and 95% Confidence Interval for Ventura County (Reference Area) and ZIP Code 93041 (Exposed Area) for 1982-2006

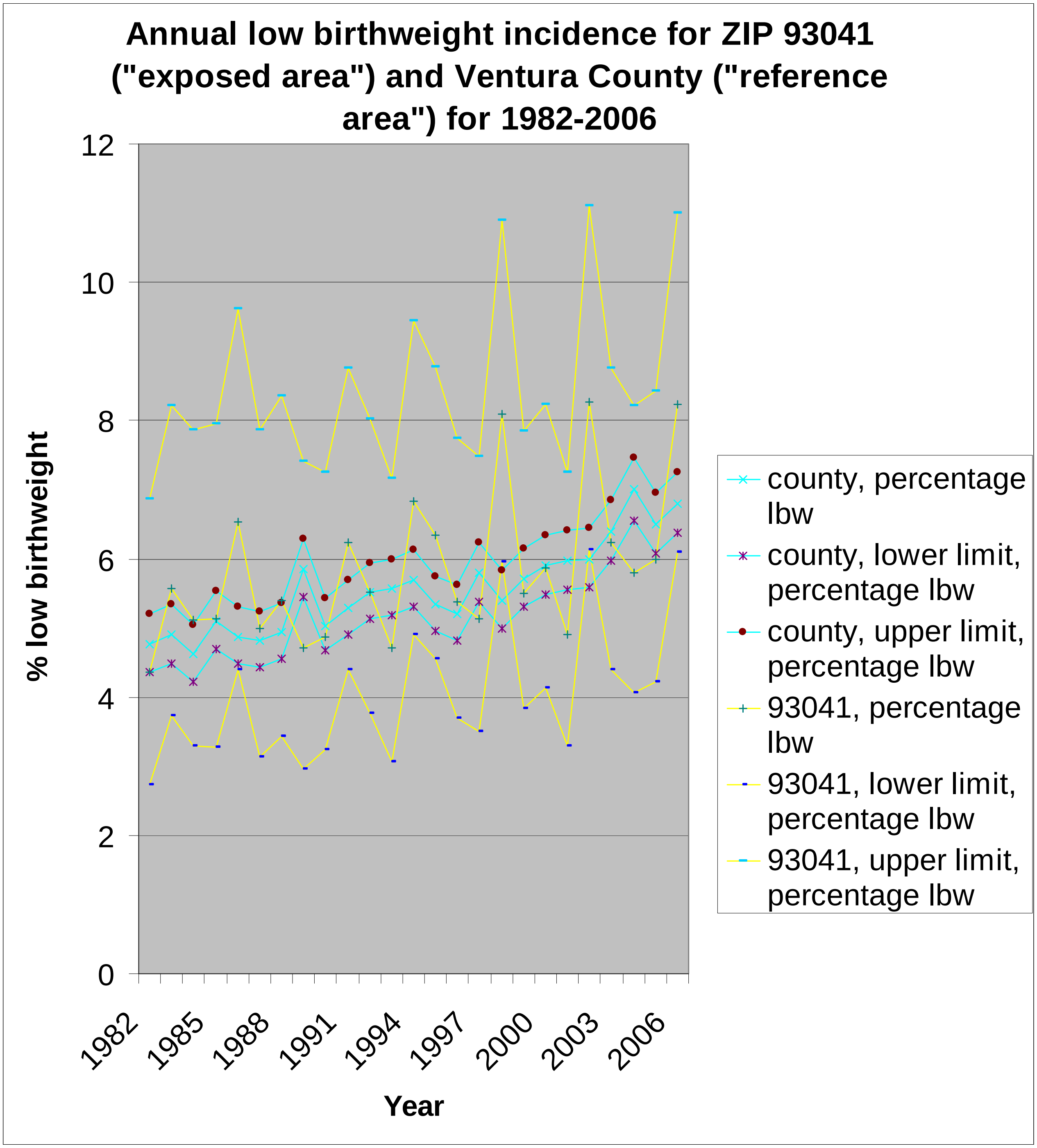


Figure B15. Percentage of Preterm Births and 95% Confidence Interval for Ventura County (Reference Area) and ZIP Code 93033 (Exposed Area) for 1982-2006

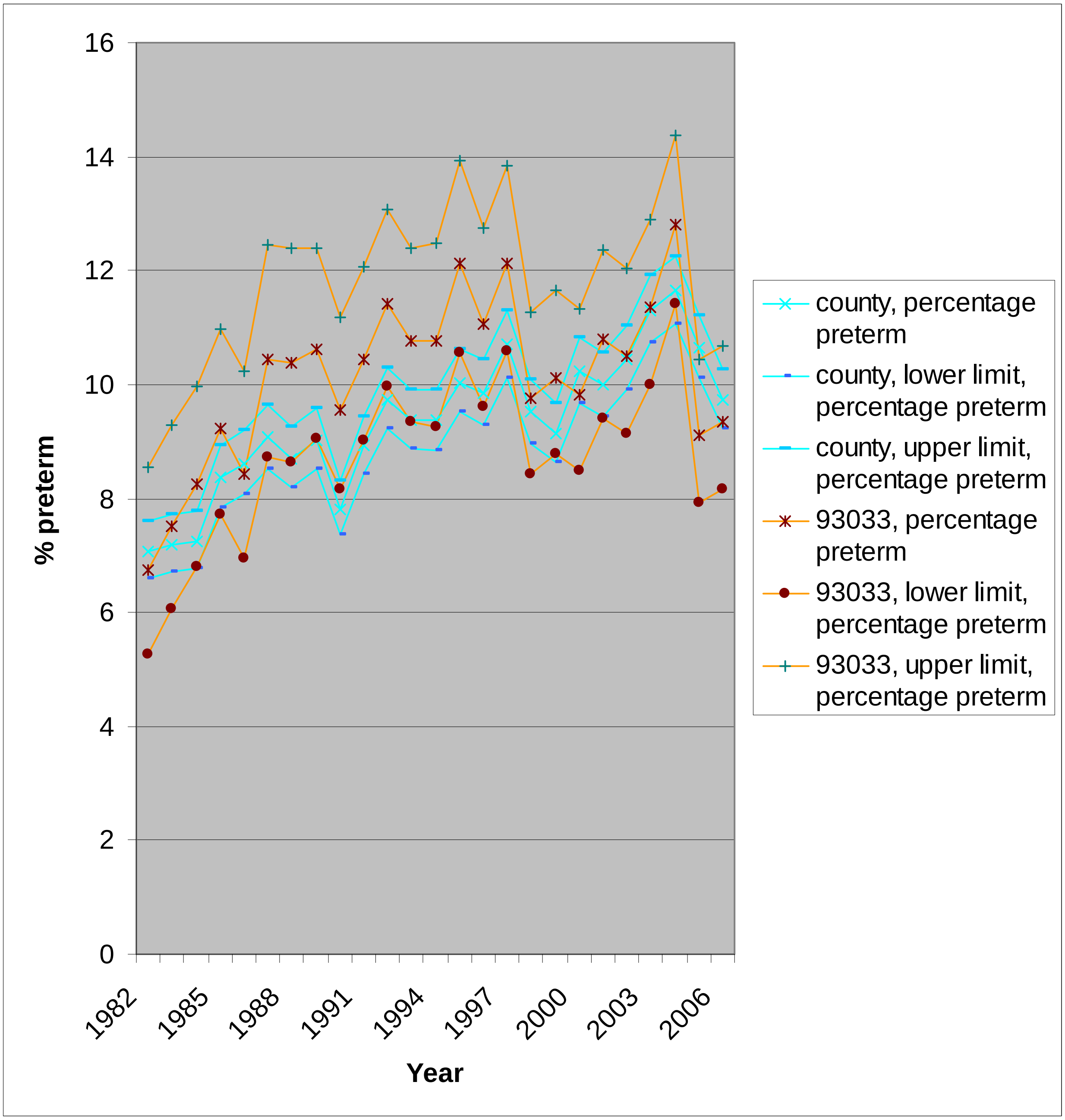
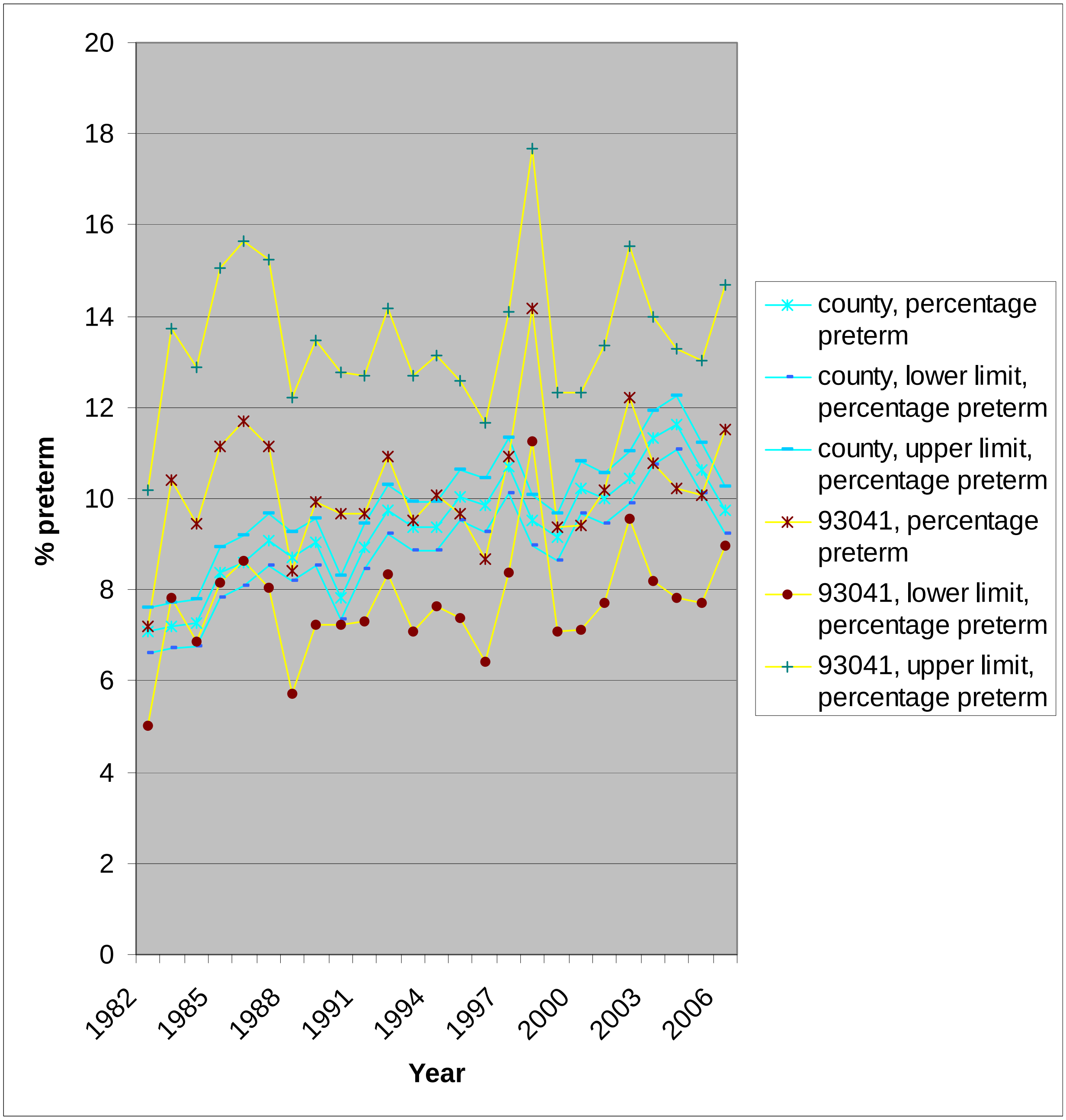


Figure B16. Percentage of Preterm Births and 95% Confidence Interval for Ventura County (Reference Areas) and ZIP Code 93041 (Exposed Area) for 1982-2006



Appendix C. Photos

Photo C1. View of the Smelter part of the Halaco site from the top of the Waste Management Unit showing the Oxnard Industrial Drain, Halaco Site, Oxnard, California

Photo taken by U.S. Environmental Protection Agency, February 2007.

Photo C2. Lone sign in front of the National Conservancy Property, Halaco Site, Oxnard, California

Photo taken by anonymous community member, date unknown.

Photo C3. Smelter showing deterioration, Halaco Site, Oxnard, California

Photo taken during staff visit of Halaco Site, June 2007.

Photo C4. Baghouse, Halaco Site, Oxnard, California

Photo taken during staff visit of Halaco site, June 2007.

Photo C5. Graffiti and scrap metal hazard, Halaco Site, Oxnard, California

Photo taken during staff visit of Halaco site, June 2007.

Photo C6. U.S. Environmental Protection Agency contractors stabilizing Waste Management Unit and Waste Disposal Area, Halaco Site, Oxnard, California

Photo taken by U.S. Environmental Protection Agency, March 2007.

Photo C7. U.S. Environmental Protection Agency contractors stabilizing Waste Management Unit, Waste Disposal Area, and Oxnard Industrial Drain, Halaco Site, Oxnard, California

Photo taken by U.S. Environmental Protection Agency, March 2007.

Photo C8. Coir netting partially applied to Waste Management Unit and Waste Disposal Area, Halaco Site, Oxnard, California

Photo taken by U.S. Environmental Protection Agency, April 2007.

Photo C9. Coir netting covering Waste Management Unit and Waste Disposal Area, Halaco Site, Oxnard, California

Photo taken during staff visit of Halaco site, June 2007.

Photo C10. Waste Management Unit and Oxnard Industrial Drain stabilized, Halaco Site, Oxnard, California

Photo taken during staff visit of Halaco site, June 2007.

Photo C11. Breaks in the fence, Halaco Site, Oxnard, California

Photo taken during staff visit of Halaco site, June 2007.

Photo C12. Hole in the fencing surrounding the facility, Halaco Site, Oxnard, California

Photo taken by anonymous community member, date unknown.

Photo C13. Rotary washer on the Halaco Site, Oxnard, California

Photo taken during staff visit of Halaco site, June 2007.

Photo C14. Inside smelter building, furnaces to the right, material soon to be placed in furnace on left, Halaco Site, Oxnard, California

Photo taken by Ventura County Air Pollution Control District during source testing, April 1, 2004.

Photo C15. Melted metal flowing from ingot pot into ingot forms, Halaco Site, Oxnard, California

Photo taken by Ventura County Air Pollution Control District during source testing, April 1, 2004.

Photo C16. Ingot forms in foreground, Halaco Site, Oxnard, California

Photo taken by Ventura County Air Pollution Control District during source testing, April 1, 2004.

Photo C17. Aerial view of Halaco when it was an operating facility, showing the smelter in the foreground and the Waste Management Unit in the background, Halaco Site, Oxnard, California

Photo taken from http://gallery.venturacountystar.com/slideShows_view_dyn.cfm?listPos=6&slideShowID=148.

Photo C18. Visible emissions coming from the Halaco facility as seen from Hueneme Road, Halaco Site, Oxnard, California

Photo taken by Ventura County Air Pollution Control District, May 6, 2004.

Appendix D. Tables

Table D1. Surface Soil Data Collected at the Smelter, Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Site Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate Site Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	24,000-**72,800** (40,933)	9,140-16,400 (11,127)	Yes	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	<572-8,759 (1,911)	310-763 (643)	Yes	310-5,960 (2,417)	55-220 (147)	Yes	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium	-	-	-	26.4-**120** (72)	0.4-0.6 (0.5)	Yes	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<21.8-<32.6	<24.1-<27.4	No	<0.6-5.9 (2.4)	0.2-1.4 (1.0)	Yes	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<44-364 (192)	<88-<114	Yes	19-318 (120)	17.5-29.7 (21.4)	Yes	100,000 Residential CHHSLs
Copper	<35.4-**11,048** **(73)**	28-110 (88)	No	80-**2,220** **(810)**	22.8-61.4 (34.9)	Yes	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	17.8-**302** (127)	20.0-47.5 (32.8)	Yes	8-**205** (74)	8.0-39.1 (22.9)	Yes	150 PRG
Manganese	<59-**3,166** (1,629)	180-508 (355)	Yes	**4,520-6,700** **(5,273)**	245-643 (386)	Yes	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<42-339 (86)	<75-<95		13-164 (65)	17.4-24.7 (21.0)	Yes	1,000 RMEG (child) 10,000 RMEG (adult)
Silver	<111-239 (78)	<123-199 (105)	No	<1.2-8.2 (4.7)	<1.0-2.0 (0.8)	Yes	300 RMEG (child) 4,000 RMEG (adult)
Zinc	89-9,412 (1,917)	<42-127Yes (62)	Yes	550-3,260 (1,453)	76-242 (126)	Yes	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							
Cesium-137 isotope	-	-	-	<0.031-<0.078 (0.028)	<0.048-**0.073** (0.065)	No	0.06 PRG (residential)

Potassium-40 isotope	-	-	-	**13.1-22.3 (17.1)**	**16.2-27.1 (22.6)**	No		0.108 PRG (residential)
Thorium-228 isotope	-	-	-	**<0.350-2.290 (0.936)**	**0.912-1.440 (1.194)**	No		0.153 PRG (residential)
Thorium-230 isotope	-	-	-	<0.373-2.150 (0.937)	0.642-1.320 (0.932)	No		3.49 PRG (residential)
Thorium-232 isotope	-	-	-	<0.118-3.140 (1.097)	0.794-1.560 (1.205)	No		3.10 PRG (residential)

Only surface soil samples from the Integrated Assessment are summarized [2].
XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D2. Surface Soil Data Collected at the Waste Disposal Area, Halaco Site, Oxnard, California

Contaminant	**XRF Concentration (Average)**	**XRF Site Background (Average)**	**XRF Concentration Exceeds XRF Background?**	**Determinate Concentration (Average)**	**Determinate Site Background (Average)**	**Determinate Concentration Exceeds Determinate Background?**	**Media-Specific Comparison Value**
Metals (all values in mg/kg)							
Aluminum	-	-	-	27,000-**120,000** **(78,500)**	9,140-16,400 (11,127)	Yes	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	254-**35,958** (4,464)	310-763 (643)	Yes	3,200-**49,000** (15,100)	55-220 (147)	Yes	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium	-	-	-	22-**27,000** **(6,785)**	0.4-0.6 (0.5)	Yes	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<22.0-<44.8	<24.1-<27.4	No	0.6-**26.0** (9.2)	0.2-1.4 (1.0)	Yes	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<42-642 (219)	<88-<114	Yes	40-1,700 (588)	17.5-29.7 (21.4)	Yes	100,000 Residential CHHSLs
Copper	61-**10,017** **(1,864)**	28-110 (88)	Yes	120-**2,800** **(1,580)**	22.8-61.4 (34.9)	Yes	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	<4.4-**555.8** **(152.7)**	20.0-47.5 (32.8)	Yes	10-**300** **(168)**	8.0-39.1 (22.9)	Yes	150 PRG
Manganese	186-**16,729** **(4,677)**	180-508 (355)	Yes	**3,500-8,500** **(5,675)**	245-643 (386)	Yes	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<39-405 (97)	<75-<95	Yes	50-610 (245)	17.4-24.7 (21.0)	Yes	1,000 RMEG (child) 10,000 RMEG (adult)
Silver	<118-**1,894** (209)	<123-199 (105)	No	5.6-62.0 (21.4)	<1.0-2.0 (0.8)	Yes	300 RMEG (child) 4,000 RMEG (adult)
Zinc	88-6,898 (1,875)	<42-127 (62)	Yes	1,100-2,500 (1,700)	76-242 (126)	Yes	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							

Cesium-137 isotope	-	-	-	<0.034-<0.112	<0.048-**0.073** (0.065)	No	0.06 PRG (residential)
Potassium-40 isotope	-	-	-	**4.2-9.0 (6.3)**	**16.2-27.1 (22.6)**	No	0.108 PRG (residential)
Thorium-228 isotope	-	-	-	**0.358-19.100 (5.511)**	**0.912-1.440 (1.194)**	Yes	0.153 PRG (residential)
Thorium-230 isotope	-	-	-	0.244-8.740 (3.174)	0.642-1.320 (0.932)	Yes	3.49 PRG (residential)
Thorium-232 isotope	-	-	-	0.258-**19.800** (**5.572**)	0.794-1.560 (1.205)	Yes	3.10 PRG (residential)

Only surface soil samples from the Integrated Assessment are summarized [2].
XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D3. Subsurface Soil Data Collected at the Waste Management Unit, Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Site Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate Site Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	7,800-**290,000** **(117,606)**	9,140-16,400 (11,127)	Yes	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	289-**48,316** (8,219)	310-763 (643)	Yes	130-19,000 (6,986)	55-220 (147)	Yes	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium	-	-	-	0.4-**170.0** (40.0)	0.4-0.6 (0.5)	Yes	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<24.1-**59.9** (16.9)	<24.1-<27.4	Yes	0.6-**15.0** (5.2)	0.2-1.4 (1.0)	Yes	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<55-880 (231)	<88-<114	Yes	15-760 (258)	17.5-29.7 (21.4)	Yes	100,000 Residential CHHSLs
Copper	246-**9,660** **(1,494)**	28-110 (88)	Yes	15-**12,000** **(2,169)**	22.8-61.4 (34.9)	Yes	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	22.1-**531.5** **(171.9)**	20.0-47.5 (32.8)	Yes	4-**1,100** **(221)**	8.0-39.1 (22.9)	Yes	150 PRG
Manganese	402-**9,571** (2,911)	180-508 (355)	Yes	220-**12,000** **(3,416)**	245-643 (386)	Yes	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<46-489 (59)	<75-<95	Yes	13-570 (131)	17.4-24.7 (21.0)	Yes	1,000 RMEG (child) 10,000 RMEG (adult)
Silver	<110-**342** (101)	<123-199 (105)	No	<1.1-28.0 (5.9)	<1.0-2.0 (0.8)	Yes	300 RMEG (child) 4,000 RMEG (adult)
Zinc	502-6,654 (1,488)	<42-127 (62)	Yes	40-6,800 (1,743)	76-242 (126)	Yes	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							
Cesium-137 isotope	-	-	-	<0.025-**0.125** (0.030)	<0.048-**0.073** (0.065)	No	0.06 PRG (residential)

Potassium-40 isotope	-	-	-	**1.9-55.0 (9.0)**	**16.2-27.1 (22.6)**	No	0.108 PRG (residential)
Thorium-228 isotope	-	-	-	<0.337-**4.480 (0.566)**	**0.912-1.440 (1.194)**	No	0.153 PRG (residential)
Thorium-230 isotope	-	-	-	<0.274-**5.250** (0.624)	0.642-1.320 (0.932)	No	3.49 PRG (residential)
Thorium-232 isotope	-	-	-	<0.116-**4.790** (0.470)	0.794-1.560 (1.205)	No	3.10 PRG (residential)

No surface soil were taken on the Waste Management Unit so data reflects all subsurface data (5-20 feet below ground surface).
XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D4. Surface Soil Data Collected at the Nature Conservancy Land, Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Site Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate Site Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	16,300-**174,000** **(91,850)**	9,140-16,400 (11,127)	Yes	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	573-5,824 (1,450)	310-763 (643)	Yes	296-6,190 (2,365)	55-220 (147)	Yes	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium	-	-	-	1.5-15.9 (9.5)	0.4-0.6 (0.5)	Yes	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<21.4-<35.3	<24.1-<27.4	No	0.6-6.0 (4.0)	0.2-1.4 (1.0)	Yes	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<81-268 (107)	<88-<114		34-363 (207)	17.5-29.7 (21.4)	Yes	100,000 Residential CHHSLs
Copper	81-**3,115** **(877)**	28-110 (88)	Yes	169-**3,790** **(2,086)**	22.8-61.4 (34.9)	Yes	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	19.0-**209.6** (109.8)	20.0-47.5No (32.8)	Yes	53.4-**250.0** **(179.9)**	8.0-39.1 (22.9)	Yes	150 CalPRG
Manganese	255-**3,304** (904)	180-508 (355)	Yes	426-**5,720** (2,438)	245-643 (386)	Yes	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<67-551 (62)	<75-<95	No	31-265 (122)	17.4-24.7 (21.0)	Yes	1,000 RMEG (child) 10,000 RMEG (adult)
Silver	<109-225 (74)	<123-199 (105)	No	<1.1-<1.6	<1.0-2.0 (0.8)	No	300 RMEG (child) 4,000 RMEG (adult)
Zinc	<41-4,242 (943)	<42-127 (62)	Yes	253-5,950 (2,455)	76-242 (126)	Yes	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							
Cesium-137 isotope	-	-	-	<0.059-**0.203** **(0.062)**	<0.048-**0.073** (0.065)	No	0.06 PRG (residential)

Potassium-40 isotope	-	-	-	**9.9-76.7 (28.5)**	**16.2-27.1 (22.6)**	Yes	0.108 PRG (residential)
Thorium-228 isotope	-	-	-	<1.130-**6.730 (3.062)**	**0.912-1.440 (1.194)**	Yes	0.153 PRG (residential)
Thorium-230 isotope	-	-	-	0.612-**6.170** (2.907)	0.642-1.320 (0.932)	Yes	3.49 PRG (residential)
Thorium-232 isotope	-	-	-	0.737-**5.440** (2.570)	0.794-1.560 (1.205)	Yes	3.10 PRG (residential)

Only surface soil samples from the Integrated Assessment are summarized [2].
XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D5. Surface Soil Data Collected at the Agriculture Lands, Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Site Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate Site Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	7,020;7,100 (7,060)	9,140-16,400 (11,127)	No	70,000 Chronic EMEG (adult)
Barium	763-872 (817)	310-763 (643)	Yes	101;105 (103)	55-220 (147)	No	400,000 Chronic EMEG (adult)
Beryllium		-	-	0.4;0.4 (0.4)	0.4-0.6 (0.5)	No	1,000 Chronic EMEG (adult)
Cadmium	<21.6-<28.4	<24.1-<27.4	No	1.0;1.3 (1.2)	0.2-1.4 (1.0)	No	100 Chronic EMEG (adult)
Chromium	<82-128 (67)	<88-<114		13.0;14.4 (13.7)	17.5-29.7 (21.4)	No	100,000 Residential CHHSLs
Copper -	<51-107 (65)	28-110 (88)	No	16.1;16.3 (16.2)	22.8-61.4 (34.9)	No	7,000 Intermediate EMEG (adult)
Lead	18.8-32.0 (23.5)	20.0-47.5 (32.8) No	No	8.3;9.6 (9.0)	8.0-39.1 (22.9)	No	150 PRG
Manganese	251-395 (317)	180-508 (355)	No	254;256 (255)	245-643 (386)	No	40,000 RMEG (adult)
Nickel	<72-<76	<75-<95	No	14.4;14.8 (14.6)	17.4-24.7 (21.0)	No	10,000 RMEG (adult)
Silver	<111-143 (76)	<123-199 (105)	No	<1.0;<1.0	<1.0-2.0 (0.8)	No	4,000 RMEG (adult)
Zinc	<38-51 (28)	<42-127 (62)	No	52.9;53.4 (53.2)	76-242 (126)	No	200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							

Cesium-137 isotope	-	-	-	<0.060;<0.083	<0.048-**0.073** (0.065)	No	0.273 PRG (outdoor worker)
Potassium-40 isotope	-	-	-	**26.3;26.6 (26.5)**	**16.2-27.1 (22.6)**	No	0.113 PRG (outdoor worker)
Thorium-228 isotope	-	-	-	**0.833;1.100 (0.967)**	**0.912-1.440 (1.194)**	No	0.254 PRG (outdoor worker)
Thorium-230 isotope	-	-	-	0.889;1.170 (1.030)	0.642-1.320 (0.932)	No	20.2 PRG (outdoor worker)
Thorium-232 isotope	-	-	-	0.687;1.120 (0.904)	0.794-1.560 (1.205)	No	19 PRG (outdoor worker)

Surface soil data taken from the Integrated Assessment [2].
XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D6. Surface Soil Data Collected at the Residential Community, Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Site Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate Site Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	4,320;11,600 (7,960)	9,140-16,400 (11,127)	No	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	760-956 (857)	310-763 (643)	Yes	94;179 (136)	55-220 (147)	No	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium		-	-	0.3;0.6 (0.4)	0.4-0.6 (0.5)	No	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<10.3-<11.8	<24.1-<27.4	No	0.5;0.8 (0.6)	0.2-1.4 (1.0)	No	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<87-187 (88)	<88-<114		8.7;19.1 (13.9)	17.5-29.7 (21.4)	No	100,000 Residential CHHSLs
Copper -	60-106 (80)	28-110 (88)	No	13.6;27.9 (20.8)	22.8-61.4 (34.9)	No	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	23.7-80.6 (42.2)	20.0-47.5No (32.8)	No	17.7;47.8 (32.8)	8.0-39.1 (22.9)	No	150 PRG
Manganese	311-503 (394)	180-508 (355)	No	179;359 (269)	245-643 (386)	No	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<71-<79	<75-<95	No	10.9;21.2 (16.1)	17.4-24.7 (21.0)	No	1,000 RMEG (child) 10,000 RMEG (adult)
Silver	<104-195 (87)	<123-199 (105)	No	<1.0;<1.4	<1.0-2.0 (0.8)	No	300 RMEG (child) 4,000 RMEG (adult)
Zinc	<37-43 (22)	<42-127 (62)	No	66.5;82.5 (74.5)	76-242 (126)	No	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							
Cesium-137 isotope	-	-	-	<0.041;<0.055	<0.048-**0.073** (0.065)	No	0.06 PRG (residential)

Potassium-40 isotope	-	-	-	**21.7;24.0 (22.9)**	**16.2-27.1 (22.6)**	No		0.108 PRG (residential)
Thorium-228 isotope	-	-	-	**0.614;0.633 (0.624)**	**0.912-1.440 (1.194)**	No		0.153 PRG (residential)
Thorium-230 isotope	-	-	-	0.700;0.739 (0.720)	0.642-1.320 (0.932)	No		3.49 PRG (residential)
Thorium-232 isotope	-	-	-	0.618;0.685 (0.652)	0.794-1.560 (1.205)	No		3.10 PRG (residential)

Surface soil data taken from the Integrated Assessment [2].

XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D7. Surface Soil Data Collected at the Wetlands, Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Wetland Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate Wetland Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	**96,400-205,000 (154,400)**	1,510-5,810 (3,405)	Yes	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	741-4,770 (1,605)	768-1,470 (975)	Yes	1,310-4,620 (2,713)	22-748 (228)	Yes	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium	-	-	-	7.1-19.7 (10.9)	0.1-2.8 (0.8)	Yes	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<21.7-<32.2	<22.0-<26.5	No	3.1-**17.0** (7.1)	0.2-1.0 (0.6)	Yes	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<72-317 (168)	<79-138 (55)	Yes	166-503 (325)	3.7-17.2 (8.5)	Yes	100,000 Residential CHHSLs
Copper	86-**5,124 (1,890)**	52-129 (83)	Yes	**2,120-5,960 (3,850)**	3.5-76.5 (23.9)	Yes	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	23.0-**519.5 (198.8)**	15.9-52.3 (37.1)	Yes	**164-736 (416)**	4.3-35.0 (19.5)	Yes	150 PRG
Manganese	299-2,671 (1,097)	173-511 (359)	Yes	879-2,980 (1,813)	55-322 (197)	Yes	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<58-194 (75)	<69-<77	No	82-244 (167)	3.6-12.2 (7.8)	Yes	1,000 RMEG (child) 10,000 RMEG (adult)
Silver	<110-290 (79)	<108-168 (95)	No	<1.1-<2.1	<1.0-<1.4	No	300 RMEG (child) 4,000 RMEG (adult)
Zinc	64-4,954 (1,700)	<36-155 (49)	Yes	1,860-5,210 (3,050)	17.4-138.0 (61.2)	Yes	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							
Cesium-137 isotope	-	-	-	<0.043-**<0.125**	<0.026-**0.073** (0.036)	No	0.06 PRG (residential)

Potassium-40 isotope	-	-	-	**7.2-36.8 (16.5)**	**20.6-45.4 (25.4)**	No	0.108 PRG (residential)
Thorium-228 isotope	-	-	-	**<0.879-2.550 (1.339)**	**<0.341-1.260 (0.663)**	Yes	0.153 PRG (residential)
Thorium-230 isotope	-	-	-	<0.297-1.610 (0.756)	<0.339-1.840 (0.707)	No	3.49 PRG (residential)
Thorium-232 isotope	-	-	-	<0.541-2.460 (0.975)	<0.396-1.170 (0.628)	Yes	3.10 PRG (residential)

Surface soil data taken from the Integrated Assessment [2].
XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D8. Sediment Data Collected at the Oxnard Industrial Drain (OID), Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Wetland Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate OID Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	1,960-47,000 (14,249)	246-8,580 (2,796)	Yes	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	517-1,180 (819)	768-1,470 (975)	No	40-2,970 (769)	0.4-147.0 (44.1)	Yes	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium		-	-	0.2-10.3 (2.8)	0.1-0.5 (0.2)	Yes	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<22.3-<28.5	<22.0-<26.5	No	0.1-2.9 (1.0)	<0.4-1.0 (0.5)	Yes	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<84-481 (151)	<79-138 (55)	Yes	5.7-108.0 (31.1)	<1.3-16.2 (5.5)	Yes	100,000 Residential CHHSLs
Copper -	78-314 (175)	52-129 (83)	Yes	13-**854** (169)	4.5-30.2 (12.3)	Yes	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	19.1-59.4 (32.5)	15.9-52.3 (37.1)	No	3.4-139.0 (40.2)	2.4-23.2 (7.7)	Yes	150 PRG
Manganese	176-626 (434)	173-511 (359)	No	69-1,450 (594)	0-555 (191)	Yes	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<70-<92	<69-<77	No	5.0-73.4 (25.3)	0.4-18.4 (6.3)	Yes	1,000 RMEG (child) 10,000 RMEG (adult)
Silver		<108-168 (95)	No	<1.3-<2.4	<1.3-4.1 (1.2)	No	300 RMEG (child) 4,000 RMEG (adult)
Zinc	<38-608 (157)	<36-155 (49)	Yes	29-1,450 (322)	2.2-136.0 (80.3)	Yes	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							
<106-<132 Cesium-137 isotope	-	-	-	<0.039-<**0.120**	<0.034-<**0.065**	No	0.06 PRG (residential)

Potassium-40 isotope	-	-	-	**18.0-26.3 (22.0)**	**21.4-51.9 (28.7)**	No	0.113 PRG (residential)
Thorium-228 isotope	-	-	-	0.117-**2.040 (1.196)**	**<0.383-1.470 (0.634)**	No	0.153 PRG (residential)
Thorium-230 isotope	-	-	-	0.194-2.430 (1.239)	<0.389-0.978 (0.541)	Yes	3.49 PRG (residential)
Thorium-232 isotope	-	-	-	0.228-1.780 (1.090)	<0.282-1.750 (0.696)	No	3.10 PRG (residential)

Sediment data taken from the Integrated Assessment [2].

XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D9. Surface Soil/Sand Data Collected at the Ormond Beach, Halaco Site, Oxnard, California

Contaminant	XRF Concentration (Average)	XRF Ormond Beach Background (Average)	XRF Concentration Exceeds XRF Background?	Determinate Concentration (Average)	Determinate Ormond Beach Background (Average)	Determinate Concentration Exceeds Determinate Background?	Media-Specific Comparison Value
Metals (all values in mg/kg)							
Aluminum	-	-	-	1,750-2,510 (2,035)	1,350-1,760 (1,525)	Yes	50,000 Chronic EMEG (child) 70,000 Chronic EMEG (adult)
Barium	547-1,009 (701)	670-828 (735)	Yes	82-297 (226)	26.9-57.2 (39.7)	Yes	30,000 Chronic EMEG (child) 400,000 Chronic EMEG (adult)
Beryllium		-	-	0.1-0.2 (0.2)	0.1-0.1 (0.1)	No	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)
Cadmium	<19.8-<26.3	<20.2-<22.3	No	<0.0-0.5 (0.2)	<0.5-<0.5	No	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Chromium	<74-960 (279)	82-123 (96)	Yes	5.7-18.3 (11.1)	3.4-4.9 (4.1)	Yes	100,000 Residential CHHSLs
Copper -	<47-149 (73)	<46-78 (60)	No	2.5-3.6 (3.2)	1.7-2.4 (2.1)	Yes	500 Intermediate EMEG (child) 7,000 Intermediate EMEG (adult)
Lead	8.6-28.8 (16.7)	8.1-15.3 (12.1)	Yes	2.5-5.4 (4.2)	1.2-1.8 (1.6)	Yes	150 PRG
Manganese	<67-1,458 (460)	76-206 (145)	Yes	75-120 (99)	49.5-70.1 (61.2)	Yes	3,000 RMEG (child) 40,000 RMEG (adult)
Nickel	<65-104 (39)	<65-<67		4.4-6.6 (5.4)	3.4-4.1 (3.7)	Yes	1,000 RMEG (child) 10,000 RMEG (adult)
Silver	<102-240 (75)	<102-173 (84)	No	<1.0-<1.0	<1.0-<1.0	No	300 RMEG (child) 4,000 RMEG (adult)
Zinc	<33-<53	<34-<34No	No	10.4-15.8 (12.9)	7.8-10.5 (9.0)	Yes	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/g)							
Cesium-137 isotope	-	-	-	<0.057-**0.092** **(0.044)**	<0.030-<0.044	Yes	0.06 PRG (residential)

Potassium-40 isotope	-	-	-	**10.4-15.6 (12.2)**	**17.2-21.2 (18.9)**	No	0.108 PRG (residential)
Thorium-228 isotope	-	-	-	**0.643-2.720 (1.326)**	<0.320-<1.010	Yes	0.153 PRG (residential)
Thorium-230 isotope	-	-	-	<0.321-0.886 (0.542)	<0.100-0.559 (0.236)	No	3.49 PRG (residential)
Thorium-232 isotope	-	-	-	0.526-**3.670** (1.448)	<0.280-0.496 (0.302)	Yes	3.10 PRG (residential)

Surface soil/sand data taken from the Integrated Assessment [2].

XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. mg/kg: milligram per kilogram; pCi/g: picocuries per gram. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; CHHSLs: California Environmental Protection Agency California Human Health Screening Levels; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D10. Surface Water Data Collected at the Oxnard Industrial Drain

Contaminant	OID Concentration Range of Detections (Average of Detections)	Number of Detections / Number of Samples	OID Background (Average)	Exceed Background?	Media-Specific Comparison Value
Metals (all values in µg/L)					
Aluminum	46-534 (272)	6/6	19.3-47 (27)	Yes	40,000 Chronic EMEG (child) 10,000 Chronic EMEG (adult)
Barium	33.3-153 (93.2)	6/6	33.6-42.3 (36.8)	Yes	6,000 Chronic EMEG (child) 20,000 Chronic EMEG (adult)
Beryllium	0.07-0.25 (0.17)	5/6	0.06-0.09 (0.08)	Yes	20 Chronic EMEG (child) 70 Chronic EMEG (adult)
Cadmium	0.36-0.37 (0.37)	2/6	<5	No	2 Chronic EMEG (child) 7 Chronic EMEG (adult)
Chromium	<10	0/6	<10	No	100 MCL
Copper	5.3-67.1 (26.4)	6/6	5.2-5.7 (5.4)	Yes	100 Intermediate EMEG (child) 400 Intermediate EMEG (adult)
Lead	<10	0/6	<10	No	15 PRG
Manganese	99-**1,100** (317)	6/6	109-154 (123)	Yes	500 RMEG (child) 2,000 RMEG (adult)
Nickel	3.0-5.2 (4.2)	6/6	3.6-4.5 (4.1)	No	200 RMEG (child) 700 RMEG (adult)
Silver	<10	0/6	<10	No	50 RMEG (child) 200 RMEG (adult)
Zinc	12.3-47.5 (30.4)	6/6	5.1-13.1 (9.5)	Yes	3,000 Chronic EMEG (child) 10,000 Chronic EMEG (adult)
Radionuclides (all values in pCi/L)					

Cesium-137 isotope	<2.81-<3.56	0/6	<2.71-<3.30	No	1.57 PRG (tap water)
Potassium-40 isotope	**81-264.0 (103.0)**	3/6	<24.8-**45.5 (28.5)**	Yes	1.93 PRG (tap water)
Thorium-228 isotope	<0.518-<1.372	0/6	<0.391-<1.220	No	0.159 PRG (tap water)
Thorium-230 isotope	<0.408-<0.902	0/6	<0.195-<0.637	No	0.523 PRG (tap water)
Thorium-232 isotope	<0.313-<0.680	0/6	<0.239-<0.682	No	0.471 PRG (tap water)

Surface water data taken from the Integrated Assessment [2].
XRF: X-ray fluorescence; Bolded contaminant name: the XRF concentration or the determinate concentration exceed the media-specific environmental guideline comparison value. µg/L: microgram per liter; pCi/L: picocuries per liter. EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide; MCL: maximum contaminant level; RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide; PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted.

Table D11. Air Data Collected Around the Waste Disposal Area and the Waste Management Unit, Halaco Site, Oxnard, California

Station	Date	Aluminum	Barium	Beryllium	Cadmium	Chromium	Copper	Lead	Manganese	Nickel	Silver	Zinc
Media-specific or Health Comparison Value		**5.0 RfC**	**0.5 rPRG**	**0.0007 REL 0.0004 CREG**	**0.02 REL 0.0006 CREG**	**-**	**-**	**-**	**0.2 REL**	**0.05 REL 0.09 cMRL**	**-**	**-**
All values in μg/m³												
AIR-1	June 20, 2006	**43.8**	**9.25**	**0.0024**	<0.0007	0.0610	0.0371	0.0115	0.034	0.0134	<0.0018	6.4576
AIR-2	June 20, 2006	**48.7**	**9.28**	**0.0055**	0.0008	0.0709	0.1701	0.0229	**0.230**	0.0247	<0.0017	6.2106
AIR-3	June 20, 2006	**56.8**	**10.13**	**0.0043**	0.0013	0.0805	0.2392	0.0356	**0.244**	0.0253	<0.0018	6.4576
AIR-4	June 20, 2006	**49.4**	**9.81**	**0.0025**	0.0008	0.0681	0.0190	0.0115	0.038	0.0143	<0.0021	6.6693
AIR-5	June 20, 2006	**50.1**	**10.80**	**0.0027**	<0.0008	0.0663	0.0204	0.0104	0.035	0.0161	<0.0020	7.4104
AIR-1	June 21, 2006	**29.2**	**3.67**	**0.0013**	0.0020	0.0441	0.0709	0.0160	0.025	0.0167	<0.0013	2.8442
AIR-2	June 21, 2006	**37.1**	**6.18**	**0.0027**	0.0007	0.0519	0.1341	0.0188	0.112	0.0150	<0.0013	3.9522
AIR-3	June 21, 2006	**256.9**	**55.40**	**0.0139**	0.0043	0.3705	0.2248	0.0745	0.162	**0.0808**	<0.0106	36.6991
AIR-4	June 21, 2006	**34.7**	**6.70**	**0.0020**	0.0016	0.0501	0.0331	0.0148	0.054	0.0140	0.0025	4.5521
AIR-5	June 21, 2006	**32.0**	**6.49**	**0.0017**	<0.0005	0.0445	0.0290	0.0098	0.021	0.0110	<0.0013	4.5168
AIR-6	June 21, 2006	**44.8**	**8.72**	**0.0052**	<0.0006	0.0639	0.1687	0.0252	**0.241**	0.0188	<0.0016	5.6107
AIR-1	June 22, 2006	**28.1**	**4.80**	**0.0016**	0.0006	0.0406	0.0235	0.0090	0.020	0.0110	<0.0012	3.4335
AIR-2	June 22, 2006	**41.6**	**6.46**	**0.0055**	0.0012	0.0635	0.3031	0.0374	**0.289**	0.0280	<0.0012	4.0228
AIR-3	June 22, 2006	**29.9**	**5.72**	**0.0033**	<0.0005	0.0431	0.0572	0.0100	0.078	0.0128	<0.0012	3.8111
AIR-4	June 22, 2006	**20.9**	**3.81**	**0.0017**	<0.0005	0.0320	0.0274	0.0135	0.094	0.0128	<0.0012	2.7313
AIR-5	June 22, 2006	**32.0**	**6.35**	**0.0018**	<0.0005	0.0455	0.0399	0.0067	0.027	0.0119	<0.0012	4.3051
AIR-6	June 22, 2006	**33.8**	**6.03**	**0.0060**	0.0006	0.0498	0.1733	0.0241	**0.261**	0.0162	<0.0012	3.8463
AIR-1	June 23, 2006	**36.7**	**7.27**	**0.0020**	0.0007	0.0533	0.0431	0.0000	0.029	0.0139	<0.0016	5.2226
AIR-6	June 23, 2006	**46.9**	**8.82**	**0.0081**	<0.0006	0.0685	0.1380	0.0181	**0.308**	0.0189	<0.0016	5.8577

Table D11. Air Data Collected Around the Waste Disposal Area and the Waste Management Unit, Halaco Site, Oxnard, California

Station	Date	Aluminum	Barium	Beryllium	Cadmium	Chromium	Copper	Lead	Manganese	Nickel	Silver	Zinc
Media-specific or Health Comparison Value		**5.0 RfC**	**0.5 rPRG**	**0.0007 REL 0.0004 CREG**	**0.02 REL 0.0006 CREG**	-	-	-	**0.2 REL**	**0.05 REL 0.09 cMRL**	-	-
All values in µg/m^3												
AIR-1	June 24, 2006	**30.6**	**5.43**	**0.0017**	<0.0006	0.0431	0.0413	0.0071	0.022	0.0079	<0.0014	3.7405
AIR-2	June 24, 2006	**48.0**	**10.34**	**0.0041**	<0.0008	0.0667	0.1013	0.0134	0.114	0.0142	<0.0019	6.9164
AIR-1	June 26, 2006	**78.3**	**16.20**	**0.0040**	0.0027	0.1115	0.0801	0.0199	0.065	0.0284	0.0031	11.9272
AIR-2	June 26, 2006	**60.3**	**11.05**	**0.0084**	0.0009	0.0882	0.3141	0.0350	**0.448**	0.0367	0.0028	6.8458
AIR-4	June 26, 2006	**56.1**	**11.40**	**0.0029**	0.0010	0.0829	0.0200	0.0154	0.049	0.0201	0.0067	7.6574
AIR-6	June 26, 2006	**7.7**	**1.64**	**0.0006**	<0.0001	0.0107	0.0297	0.0021	0.018	0.0029	<0.003	1.1045
AIR-1	June 27, 2006	**21.1**	**3.95**	**0.0016**	<0.0003	0.0323	0.0568	0.0323	0.050	0.0197	0.0009	2.6501
AIR-2	June 27, 2006	**23.5**	**4.45**	**0.0043**	<0.0003	0.0352	0.1443	0.0119	0.138	0.0336	0.0010	2.8195
AIR-3	June 27, 2006	**21.7**	**3.67**	**0.0026**	0.0005	0.0331	0.1479	0.0108	0.098	0.0363	0.0011	2.5125
AIR-4	June 27, 2006	**46.6**	**7.69**	**0.0025**	<0.0008	0.0706	0.1510	0.0157	0.077	0.0332	0.0026	5.3637
AIR-6	June 27, 2006	**30.5**	**5.29**	**0.0132**	0.0004	0.0476	0.2431	0.0227	**0.469**	0.0347	0.0020	3.2782
AIR-1	June 28, 2006	**18.2**	**3.78**	**0.0010**	<0.0003	0.0323	0.0234	0.0053	0.021	0.0150	0.0008	2.5125
AIR-2	June 28, 2006	**23.5**	**3.74**	**0.0037**	<0.0003	0.0360	0.1073	0.0120	0.176	0.0250	0.0012	2.4948
AIR-3	June 28, 2006	**27.9**	**4.34**	**0.0033**	0.0004	0.0423	0.2541	0.0291	**0.239**	0.0473	<0.0007	2.5089
AIR-4	June 28, 2006	**31.7**	**5.89**	**0.0017**	<0.0005	0.0452	0.0101	0.0062	0.023	0.0092	0.0013	3.9522
AIR-6	June 28, 2006	**18.2**	**2.87**	**0.0040**	<0.0003	0.0294	0.0893	0.0090	0.192	0.0281	0.0013	1.8914

Data source [2].
Bold values indicates that the concentration exceeds the noncancer health comparison value.
RfC: U.S. Environmental Protection Agency's Reference Concentration; rPRG: U.S. Environmental Protection Agency Region 9 residential Preliminary Remediation Goal; REL: Office of Environmental Health Hazard Assessment's Reference Exposure Level; CREG: Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide for 1 in 1,000,0000 increased cancer risk; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level.
µg/m^3: microgram per cubic meter.

Table D12. Assumptions Used for Calculations of Noncancer and Cancer Doses, Halaco Site, Oxnard, California

<table>
<tr><th colspan="2">Exposure Parameter</th><th>Units</th><th>Intake Equation for Chemical Evaluation</th><th>Intake Equation for Radionuclide Evaluation</th></tr>
<tr><td colspan="5">Incidental Ingestion of Soil</td></tr>
<tr><td>C_S</td><td>Concentration in Soil</td><td>mg/kg or pCi/gm</td><td rowspan="11">For trespassers on the smelter and bike riders on the WDA and Nature Conservancy Land:
$$\frac{C_S \times IR_S \times ET \times EF \times ED \times CF\text{-}C}{BW \times AT}$$
For visitors to the Nature Conservancy Land, the wetlands, and Ormond Beach:
$$\frac{C_S \times IR_S \times ET \times EF \times ED \times CF\text{-}C}{AT}$$</td><td rowspan="11">$$\frac{C_S \times IR_S \times BW \times ET \times EF \times ED \times CF\text{-}R \times (1 - e^{-\lambda t})}{t \times \lambda}$$
See External Exposure from Radionuclides below for explanation of parameters.</td></tr>
<tr><td>IR_S</td><td>Ingestion Rate for visitor</td><td>mg/kg-hour</td></tr>
<tr><td>IR_S</td><td>Ingestion Rate for trespasser and bike rider</td><td>mg/hour</td></tr>
<tr><td>ET</td><td>Exposure Time</td><td>hours/day</td></tr>
<tr><td>EF</td><td>Exposure Frequency</td><td>days/year</td></tr>
<tr><td>ED</td><td>Exposure Duration</td><td>years</td></tr>
<tr><td>CF-C</td><td>Conversion Factor for Chemical</td><td>kg/mg</td></tr>
<tr><td>CF-R</td><td>Conversion Factor for Radionuclides</td><td>gm/mg</td></tr>
<tr><td>BW</td><td>Body Weight</td><td>kg</td></tr>
<tr><td>AT_C</td><td>Averaging Time for carcinogens</td><td>days</td></tr>
<tr><td>AT_{NC}</td><td>Averaging Time for noncarcinogens</td><td>days</td></tr>
<tr><td colspan="5">Inhalation of Particulates</td></tr>
<tr><td>C_S</td><td>Concentration in Soil</td><td>mg/kg or pCi/gm</td><td rowspan="11">For trespassers on the smelter and bike riders on the Waste Disposal Area and Nature Conservancy Land:
$$\frac{C_S \times IR_A \times ET \times EF \times ED \times [(1/PEF)] \times CF}{BW \times AT}$$
For visitors to the Nature Conservancy Land, the wetlands, and Ormond Beach:
$$\frac{C_S \times IR_A \times ET \times EF \times ED \times [(1/PEF)] \times CF}{AT}$$</td><td rowspan="11">$$\frac{C_S \times IR_A \times BW \times ET \times EF \times ED \times (1 - e^{-\lambda t})}{PEF \times t \times \lambda}$$
See External Exposure from Radionuclides below for explanation of parameters.</td></tr>
<tr><td>IR_A</td><td>Inhalation Rate-trespasser & bike rider</td><td>m^3/hour</td></tr>
<tr><td>IR_A</td><td>Inhalation Rate- visitor</td><td>L/kg-hour</td></tr>
<tr><td>ET</td><td>Exposure Time</td><td>hours/day</td></tr>
<tr><td>EF</td><td>Exposure Frequency</td><td>days/year</td></tr>
<tr><td>ED</td><td>Exposure Duration</td><td>years</td></tr>
<tr><td>PEF</td><td>Particulate Emission Factor</td><td>m^3/kg</td></tr>
<tr><td>CF</td><td>Conversion Factor- Chemical</td><td>gm/kg</td></tr>
<tr><td>BW</td><td>Body Weight</td><td>kg</td></tr>
<tr><td>AT_C</td><td>Averaging Time for carcinogens</td><td>days</td></tr>
<tr><td>AT_{NC}</td><td>Averaging Time for noncarcinogens</td><td>days</td></tr>
</table>

Table D12. Assumptions Used for Calculations of Noncancer and Cancer Doses, Halaco Site, Oxnard, California

Exposure Parameter		Units	Intake Equation for Chemical Evaluation	Intake Equation for Radionuclide Evaluation
Incidental Ingestion of Water During Swimming				
C_W	Chemical Concentration in Water	µg/liter	$\frac{C_W \times IR_W \times ET \times EF \times ED \times CF}{BW \times AT}$	-
IR_W	Ingestion Rate water	liter/hour		
ET	Exposure Time	hours/day		
EF	Exposure Frequency	days/year		
ED	Exposure Duration	years		
CF	Conversion Factor	mg/µg		
BW	Body Weight	kg		
AT_C	Averaging Time for carcinogens	days		
AT_{NC}	Averaging Time for noncarcinogens	days		
Dermal Contact with Water During Swimming				
C_W	Chemical Concentration in Water	µg/liter	$\frac{C_W \times P \times SA \times ET \times EF \times ED \times CF}{BW \times AT}$	-
P	Permeability Factor	cm/hour		
SA	Exposed Surface Body Area	cm^2		
ET	Exposure Time	hours/day		
EF	Exposure Frequency	days/year		
ED	Exposure Duration	years		
CF	Conversion Factor	$mg\text{-}L/\mu g\text{-}cm^3$		
BW	Body Weight	kg		
AT_C	Averaging Time for carcinogens	days		
AT_{NC}	Averaging Time for noncarcinogens	days		

Table D12. Assumptions Used for Calculations of Noncancer and Cancer Doses, Halaco Site, Oxnard, California

Exposure Parameter		Units	Intake Equation for Chemical Evaluation	Intake Equation for Radionuclide Evaluation
External Exposure from Radionuclide				
C_S	Concentration in Soil	pCi/gm	Not relevant	$$\frac{C_S \times ET \times EF \times ED \times (1 - e^{-\lambda t})}{24 \text{ hours/day} \times 365 \text{ days/year} \times (t \times \lambda)}$$
ET	Exposure Time	hours/day		
EF	Exposure Frequency	days/year		
ED	Exposure Duration	years		
λ	Decay constant	$year^{-1}$		
t (top)	Time of exposure	year		
t (bottom)	Time of exposure average	year		
BW	Body Weight	kg		

Table D13. Noncancer Toxicological Evaluation of a Trespasser Exposed to the Maximum Level of Contamination Measured on the Smelter Surface Soil, Halaco Site, Oxnard, California

Contaminant	Maximum Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m³***	**µg/m³**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**
Aluminum	72,800	0.0000012	-	<0.01	0.0072	1.0 cMRL	<0.01	<0.01
Barium	5,960	0.000000099	-	<0.01	0.00059	0.2 cMRL	<0.01	<0.01
Beryllium	120	0.0000038*	0.007 cREL	<0.01	0.000012	0.002 cMRL	<0.01	<0.01
Cadmium	6	0.00000018*	0.02 cREL	<0.01	0.00000058	0.0002 cMRL	<0.01	<0.01
Chromium	318	0.0000000053	-	<0.01	0.000032	1.5 RfD	<0.01	<0.01
Copper	2,220	0.000000037	-	<0.01	0.00022	0.01 iMRL	0.022	0.022
Manganese	6,700	0.00021*	0.04 cMRL	<0.01	0.00066	0.047 RfD	0.014	0.019
Nickel	164	0.0000051*	0.09 cMRL	<0.01	0.000016	0.02 RfD	<0.01	<0.01
Silver	8	0.00000000014	-	<0.01	0.0000008	0.005 RfD	<0.01	<0.01
Zinc	3,260	0.000000054	-	<0.01	0.00032	0.3 cMRL	<0.01	<0.01
				Total Inhalation Hazard Index = **<0.01**			Total Ingestion Hazard Index = **0.057**	Total Hazard Index = **0.063**

mg/kg: milligram per kilogram; µg/m³: microgram per cubic meter; pCi/g: picoCuries per gram.
cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level.
†When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D14. Noncancer Toxicological Evaluation of a Dirtbike Rider Exposed to the Maximum Level of Contamination Measured in the Waste Disposal Area Surface Soil, Halaco Site, Oxnard, California

Contaminant	Maximum Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m³***	**µg/m³**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**
Aluminum	120,000	0.0026	-	<0.01	0.012	1.0 cMRL	0.012	0.015
Barium	49,000	0.0011	-	<0.01	0.0049	0.2 cMRL	0.024	0.030
Beryllium	27,000	1.1*	0.007 cREL	158.51	0.0027	0.002 cMRL	1.34	159.85
Cadmium	26	0.0011*	0.02 cREL	0.053	0.0000026	0.0002 cMRL	0.013	0.066
Chromium	1,700	0.000037	-	<0.01	0.00017	1.5 RfD	<0.01	<0.01
Copper	2,800	0.000061	-	<0.01	0.00028	0.01 iMRL	0.028	0.034
Manganese	8,500	0.35*	0.04 cMRL	8.73	0.00084	0.047 RfD	0.018	8.75
Nickel	610	0.025*	0.09 cMRL	0.28	0.000060	0.02 RfD	<0.01	0.28
Silver	62	0.0000014	-	<0.01	0.0000061	0.005 RfD	<0.01	<0.01
Zinc	2,500	0.000055	-	<0.01	0.00025	0.3 cMRL	<0.01	<0.01
				Total Inhalation Hazard Index = **168**			Total Ingestion Hazard Index = **1.44**	Total Hazard Index = **169**
			Modified Hazard Iadex	**0.35**			**0.10**	**0.45**

mg/kg: milligram per kilogram; µg/m³: microgram per cubic meter; pCi/g: picoCuries per gram.
cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level.
†When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D15. Noncancer Toxicological Evaluation of a Dirtbike Rider Exposed to the Average Level of Contamination Measured in the Waste Disposal Area Surface Soil, Halaco Site, Oxnard, California

Contaminant	Average Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m^3***	**µg/m^3**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**
Aluminum	78,500	0.0017	-	<0.01	0.0078	1.0 cMRL	<0.01	<0.01
Barium	15,100	0.00033	-	<0.01	0.0015	0.2 cMRL	<0.01	<0.01
Beryllium	6,785	0.28*	0.007 cREL	39.8	0.00067	0.002 cMRL	0.34	40.17
Cadmium	9	0.00038*	0.02 cREL	0.019	0.00000091	0.0002 cMRL	<0.01	0.023
Chromium	588	0.000013	-	<0.01	0.000058	1.5 RfD	<0.01	<0.01
Copper	1,580	0.000035	-	<0.01	0.00016	0.01 iMRL	0.016	0.019
Manganese	5,675	0.23*	0.04 cMRL	5.83	0.00056	0.047 RfD	0.012	5.84
Nickel	245	0.010*	0.09 cMRL	0.11	0.000024	0.02 RfD	<0.01	0.11
Silver	21	0.00000047	-	<0.01	0.0000021	0.005 RfD	<0.01	<0.01
Zinc	1,700	0.000037	-	<0.01	0.00017	0.3 cMRL	<0.01	<0.01
				Total Inhalation Hazard Index = **46**			Total Ingestion Hazard Index = **0.38**	Total Hazard Index = **46.2**
			Modified Hazard Iadex	**0.14**			**0.38**	**0.52**

mg/kg: milligram per kilogram; µg/m^3: microgram per cubic meter; pCi/g: picoCuries per gram.
cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level.
†When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D16. Cancer and Noncancer Toxicological Evaluation of an Adult (0-30 Years Old) Visitor Exposed to the Maximum Level of Contamination Measured in the National Conservancy Land Surface Soil, Halaco Site, Oxnard, California

Contaminant	Maximum Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or μg/m^3***	**μg/m^3**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	174,000	0.0000021	-	<0.01	0.018	1.0 cMRL	0.018	0.018	-
Barium	6,190	0.000000076	-	<0.01	0.00065	0.2 cMRL	<0.01	<0.01	-
Beryllium	15.9	0.00000050*	0.007 cREL	<0.01	0.0000017	0.002 cMRL	<0.01	<0.01	7.02×10^{-10}
Cadmium	6	0.00000019*	0.02 cREL	<0.01	0.00000063	0.0002 cMRL	<0.01	<0.01	4.73×10^{-10}
Chromium	363	0.0000000045	-	<0.01	0.000038	1.5 RfD	<0.01	<0.01	-
Copper	3,790	0.000000047	-	<0.01	0.00040	0.01 iMRL	0.040	0.040	-
Manganese	5,720	0.00018*	0.04 cMRL	<0.01	0.00060	0.047 RfD	0.013	0.017	-
Nickel	265	0.0000083*	0.09 cMRL	<0.01	0.000028	0.02 RfD	<0.01	<0.01	1.27×10^{-9}
Silver	0.5	0.0000000000061	-	<0.01	0.000000052	0.005 RfD	<0.01	<0.01	-
Zinc	5,950	0.000000073	-	<0.01	0.00062	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	6.73	-	-	-	-	-	-	-	2.55×10^{-6}
Thorium-230 isotope	6.17	-	-	-	-	-	-	-	4.19×10^{-8}
Thorium-232 isotope	5.44	-	-	-	-	-	-	-	4.08×10^{-8}
Total Inhalation Hazard Index = **<0.01**							Total Ingestion Hazard Index = **0.081**	Total Hazard Index = **0.086**	Total Cancer Risk = **2.64×10^{-6}**

mg/kg: milligram per kilogram; μg/m^3: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level.
†When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D17. Cancer and Noncancer Toxicological Evaluation of a Child (0-9 Years Old) Visitor Exposed to the Maximum Level of Contamination Measured in the National Conservancy Land Surface Soil, Halaco Site, Oxnard, California

Contaminant	Maximum Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m^3***	**µg/m^3**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	174,000	0.000011	-	<0.01	0.093	1.0 cMRL	0.093	0.093	-
Barium	6,190	0.00000038	-	<0.01	0.0033	0.2 cMRL	0.017	0.017	-
Beryllium	15.9	0.00000050*	0.007 cREL	<0.01	0.0000085	0.002 cMRL	<0.01	<0.01	3.12×10^{-10}
Cadmium	6	0.00000019*	0.02 cREL	<0.01	0.0000032	0.000011 chRD	0.29	0.29	2.10×10^{-10}
Chromium	363	0.000000022	-	<0.01	0.00020	1.5 RfD	<0.01	<0.01	-
Copper	3,790	0.00000023	-	<0.01	0.0020	0.01 iMRL	0.20	0.20	-
Manganese	5,720	0.00018*	0.04 cMRL	<0.01	0.0031	0.03 chRD	0.10	0.11	-
Nickel	265	0.0000083*	0.09 cMRL	<0.01	0.00014	0.01 chRD	0.013	0.013	5.63×10^{-10}
Silver	0.5	0.000000000030	-	<0.01	0.00000027	0.005 RfD	<0.01	<0.01	-
Zinc	5,950	0.00000036	-	<0.01	0.0032	0.3 cMRL	0.011	0.011	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	6.73	-	-	-	-	-	-	-	2.44×10^{-6}
Thorium-230 isotope	6.17	-	-	-	-	-	-	-	4.05×10^{-9}
Thorium-232 isotope	5.44	-	-	-	-	-	-	-	3.71×10^{-9}
Total Inhalation Hazard Index = **<0.01**							Total Ingestion Hazard Index = **0.74**	Total Hazard Index = **0.74**	Total Cancer Risk = **2.45×10^{-6}**

mg/kg: milligram per kilogram; µg/m^3: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level; chRD: Child-specific Reference Dose. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D18. Cancer and Noncancer Toxicological Evaluation of a Dirt bike Rider Exposed to the Maximum Level of Contamination Measured in the National Conservancy Land Surface Soil, Halaco Site, Oxnard, California

Contaminant	Maximum Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m³***	**µg/m³**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	174,000	0.0039	-	<0.01	0.016	1.0 cMRL	0.016	0.019	-
Barium	6,190	0.00014	-	<0.01	0.00055	0.2 cMRL	<0.01	<0.01	-
Beryllium	15.9	0.00065*	0.007 cREL	0.093	0.0000014	0.002 cMRL	<0.01	0.093	1.29×10^{-6}
Cadmium	6	0.00025*	0.02 cREL	0.012	0.0000005	0.0002 cMRL	<0.01	0.015	8.66×10^{-7}
Chromium	363	0.0000082	-	<0.01	0.0003	1.5 RfD	<0.01	<0.01	-
Copper	3,790	0.000085	-	<0.01	0.00034	0.01 iMRL	0.034	0.042	-
Manganese	5,720	0.24*	0.04 cMRL	5.9	0.00051	0.047 RfD	0.01	5.89	-
Nickel	265	0.011*	0.09 cMRL	0.12	0.00002	0.02 RfD	<0.01	0.12	2.32×10^{-6}
Silver	0.5	0.000000011	-	<0.01	0.000000045	0.005 RfD	<0.01	<0.01	-
Zinc	5,950	0.00013	-	<0.01	0.00053	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	6.73	-	-	-	-	-	-	-	3.14×10^{-6}
Thorium-230 isotope	6.17	-	-	-	-	-	-	-	1.16×10^{-6}
Thorium-232 isotope	5.44	-	-	-	-	-	-	-	1.54×10^{-6}
				Total Inhalation Hazard Index = **6.12**			Total Ingestion Hazard Index = **0.069**	Total Hazard Index = **6.19**	Total Cancer Risk = **1.0×10^{-5}**
			Modified Hazard Iadex	**0.24**			**0.069**	**0.31**	

mg/kg: milligram per kilogram; µg/m³: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D19. Cancer and Noncancer Toxicological Evaluation of a Dirt bike Rider Exposed to the Average Level of Contamination Measured in the National Conservancy Land Surface Soil, Halaco Site, Oxnard, California

Contaminant	Average Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m³***	**µg/m³**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	91,850	0.0021	-	<0.01	0.0082	1.0 cMRL	<0.01	0.01	-
Barium	2,365	0.000053	-	<0.01	0.00021	0.2 cMRL	<0.01	<0.01	-
Beryllium	9.5	0.00039*	0.007 cREL	0.056	0.00000085	0.002 cMRL	<0.01	0.056	7.68×10^{-7}
Cadmium	4	0.00016	0.02 cREL	<0.01	0.00000036	0.0002 cMRL	<0.01	0.01	5.77×10^{-7}
Chromium	207	0.0000047	-	<0.01	0.000019	1.5 RfD	<0.01	<0.01	-
Copper	2,086	0.000047	-	<0.01	0.00019	0.01 iMRL	0.019	0.023	-
Manganese	2,438	0.1*	0.04 cMRL	2.5	0.00022	0.047 RfD	<0.01	2.51	-
Nickel	122	0.005*	0.09 cMRL	0.056	0.000011	0.02 RfD	<0.01	0.057	1.07×10^{-6}
Silver	0.5	0.000000011	-	<0.01	0.000000045	0.005 RfD	<0.01	<0.01	-
Zinc	2,455	0.000055	-	<0.01	0.00022	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	3.06	-	-	-	-	-	-	-	1.43×10^{-6}
Thorium-230 isotope	2.91	-	-	-	-	-	-	-	5.47×10^{-7}
Thorium-232 isotope	2.57	-	-	-	-	-	-	-	7.28×10^{-7}
				Total Inhalation Hazard Index = **2.63**			Total Ingestion Hazard Index = **0.036**	Total Hazard Index = **2.67**	Total Cancer Risk = **3.57×10^{-6}**
			Modified Hazard Iadex	**0.13**			**0.036**	**0.16**	

mg/kg: milligram per kilogram; µg/m³: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D20. Cancer and Noncancer Toxicological Evaluation of an Adult (0-30 Years Old) Visitor Exposed to the Maximum Level of Contamination Measured in the Wetlands Surface Soil, Halaco Site, Oxnard, California

Contaminant	Maximum Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m³***	**µg/m³**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	205,000	0.0000025	-	<0.01	0.022	1.0 cMRL	0.021	0.021	-
Barium	4,620	0.000000057	-	<0.01	0.00048	0.2 cMRL	<0.01	<0.01	-
Beryllium	19.7	0.00000062*	0.007 cREL	<0.01	0.0000021	0.002 cMRL	<0.01	<0.01	8.70×10^{-10}
Cadmium	17	0.00000053*	0.02 cREL	<0.01	0.0000018	0.0002 cMRL	<0.01	<0.01	1.34×10^{-9}
Chromium	503	0.0000000062	-	<0.01	0.000053	1.5 RfD	<0.01	<0.01	-
Copper	5,960	0.000000073	-	<0.01	0.00063	0.01 iMRL	0.062	0.062	-
Manganese	2,980	0.000093*	0.04 cMRL	<0.01	0.00031	0.047 RfD	<0.01	<0.01	-
Nickel	244	0.0000076*	0.09 cMRL	<0.01	0.000026	0.02 RfD	<0.01	<0.01	1.17×10^{-9}
Silver	0.5	0.0000000000061	-	<0.01	0.000000052	0.005 RfD	<0.01	<0.01	-
Zinc	5,210	0.000000064	-	<0.01	0.00055	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	2.55	-	-	-	-	-	-	-	9.67×10^{-7}
Thorium-230 isotope	1.61	-	-	-	-	-	-	-	1.09×10^{-8}
Thorium-232 isotope	2.46	-	-	-	-	-	-	-	1.84×10^{-8}
				Total Inhalation Hazard Index = **<0.01**			Total Ingestion Hazard Index = **0.11**	Total Hazard Index = **0.11**	Total Cancer Risk = **1.0×10^{-6}**

mg/kg: milligram per kilogram; µg/m³: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D21. Cancer and Noncancer Toxicological Evaluation of a Child (0-9 Years Old) Visitor Exposed to the Maximum Level of Contamination Measured in the Wetlands Surface Soil, Halaco Site, Oxnard, California

Contaminant	Maximum Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m^3***	**µg/m^3**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	205,000	0.000012	-	<0.01	0.11	1.0 cMRL	0.11	0.11	-
Barium	4,620	0.00000028	-	<0.01	0.0025	0.2 cMRL	0.012	0.012	-
Beryllium	19.7	0.00000062*	0.007 cREL	<0.01	0.000011	0.002 cMRL	<0.01	<0.01	3.86×10^{-10}
Cadmium	17	0.00000053*	0.02 cREL	<0.01	0.0000091	0.000011 chRD	0.83	0.83	5.95×10^{-10}
Chromium	503	0.000000030	-	<0.01	0.00027	1.5 RfD	<0.01	<0.01	-
Copper	5,960	0.00000036	-	<0.01	0.0032	0.01 iMRL	0.32	0.32	-
Manganese	2,980	0.000093*	0.04 cMRL	<0.01	0.0016	0.03 chRD	0.053	0.056	-
Nickel	244	0.0000076*	0.09 cMRL	<0.01	0.00013	0.01 chRD	0.012	0.012	5.18×10^{-10}
Silver	0.5	0.000000000030	-	<0.01	0.00000027	0.005 RfD	<0.01	<0.01	-
Zinc	5,210	0.00000032	-	<0.01	0.0028	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	2.55	-	-	-	-	-	-	-	9.26×10^{-7}
Thorium-230 isotope	1.61	-	-	-	-	-	-	-	1.56×10^{-9}
Thorium-232 isotope	2.46	-	-	-	-	-	-	-	1.68×10^{-9}
				Total Inhalation Hazard Index = **<0.01**			Total Ingestion Hazard Index = **1.35**	Total Hazard Index = **1.35**	Total Cancer Risk = **9.30×10^{-7}**

mg/kg: milligram per kilogram; µg/m^3: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level; chRD: Child-specific Reference Dose. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D22. Cancer and Noncancer Toxicological Evaluation of a Child (0-9 Years Old) Visitor Exposed to the Average Level of Contamination Measured in the Wetlands Surface Soil, Halaco Site, Oxnard, California

Contaminant	Average Soil Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or $\mu g/m^3$***	**$\mu g/m^3$**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	154,400	0.0000093	-	<0.01	0.083	1.0 cMRL	0.083	0.083	-
Barium	2,713	0.00000016	-	<0.01	0.0015	0.2 cMRL	<0.01	<0.01	-
Beryllium	10.9	0.00000034*	0.007 cREL	<0.01	0.0000059	0.002 cMRL	<0.01	<0.01	2.14×10^{-10}
Cadmium	7.1	0.00000022*	0.02 cREL	<0.01	0.0000038	0.000011 chRD	0.35	0.35	2.48×10^{-10}
Chromium	325	0.000000020	-	<0.01	0.00017	1.5 RfD	<0.01	<0.01	-
Copper	3,850	0.00000023	-	<0.01	0.0021	0.01 iMRL	0.21	0.21	-
Manganese	1,813	0.000057*	0.04 cMRL	<0.01	0.00097	0.03 chRD	0.032	0.034	-
Nickel	167	0.0000052*	0.09 cMRL	<0.01	0.00009	0.01 chRD	<0.01	<0.01	5.18×10^{-10}
Silver	0.5	0.000000000030	-	<0.01	0.00000027	0.005 RfD	<0.01	<0.01	-
Zinc	3,050	0.00000018	-	<0.01	0.0016	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	1.34	-	-	-	-	-	-	-	4.86×10^{-7}
Thorium-230 isotope	0.756	-	-	-	-	-	-	-	1.09×10^{-9}
Thorium-232 isotope	0.975	-	-	-	-	-	-	-	6.64×10^{-10}
				Total Inhalation Hazard Index = **<0.01**			Total Ingestion Hazard Index = **0.70**	Total Hazard Index = **0.70**	Total Cancer Risk = **4.89×10^{-7}**

mg/kg: milligram per kilogram; $\mu g/m^3$: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level; chRD: Child-specific Reference Dose. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D23. Cancer and Noncancer Toxicological Evaluation of an Adult (0-30 Years Old) Visitor Exposed to the Maximum Level of Contamination Measured in the Ormond Beach Surface Sand, Halaco Site, Oxnard, California

Contaminant	Maximum Sand Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m³***	**µg/m³**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	2,510	0.000000031	-	<0.01	0.00026	1.0 cMRL	<0.01	<0.01	-
Barium	297	0.0000000036	-	<0.01	0.000031	0.2 cMRL	<0.01	<0.01	-
Beryllium	0.2	0.0000000062*	0.007 cREL	<0.01	0.000000021	0.002 cMRL	<0.01	<0.01	8.84×10^{-12}
Cadmium	0.5	0.000000016*	0.02 cREL	<0.01	0.000000052	0.0002 cMRL	<0.01	<0.01	3.94×10^{-11}
Chromium	18.3	0.00000000023	-	<0.01	0.0000019	1.5 RfD	<0.01	<0.01	-
Copper	4	0.000000000044	-	<0.01	0.00000038	0.01 iMRL	<0.01	<0.01	-
Manganese	120	0.0000037*	0.04 cMRL	<0.01	0.000013	0.047 RfD	<0.01	<0.01	-
Nickel	6.6	0.00000021*	0.09 cMRL	<0.01	0.00000069	0.02 RfD	<0.01	<0.01	3.16×10^{-11}
Silver	0.5	0.0000000000061	-	<0.01	0.000000052	0.005 RfD	<0.01	<0.01	-
Zinc	16	0.00000000019	-	<0.01	0.0000017	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	2.72	-	-	-	-	-	-	-	1.03×10^{-6}
Thorium-230 isotope	0.886	-	-	-	-	-	-	-	6.02×10^{-9}
Thorium-232 isotope	3.67	-	-	-	-	-	-	-	2.75×10^{-8}
				Total Inhalation Hazard Index = **<0.01**			Total Ingestion Hazard Index = **<0.01**	Total Hazard Index = **<0.01**	Total Cancer Risk = **1.06×10^{-6}**

mg/kg: milligram per kilogram; µg/m³: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D24. Cancer and Noncancer Toxicological Evaluation of a Child (0-9 Years Old) Visitor Exposed to the Maximum Level of Contamination Measured in the Ormond Beach Surface Sand, Halaco Site, Oxnard, California

Contaminant	Maximum Sand Concentration	Inhalation Dose or Adjusted Air Concentration*	Inhalation Health Comparison Value	Inhalation Hazard Quotient†	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant	Total Risk for Each Contaminant
Metals	**mg/kg**	**mg/kg/day or µg/m³***	**µg/m³**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**	**Unitless**
Aluminum	2,510	0.00000015	-	<0.01	0.0014	1.0 cMRL	<0.01	<0.01	-
Barium	297	0.000000018	-	<0.01	0.00016	0.2 cMRL	<0.01	<0.01	-
Beryllium	0.2	0.0000000062*	0.007 cREL	<0.01	0.00000011	0.002 cMRL	<0.01	<0.01	3.92×10^{-12}
Cadmium	0.5	0.000000016*	0.02 cREL	<0.01	0.00000027	0.000011 chRD	0.024	0.024	1.75×10^{-11}
Chromium	18.3	0.0000000011	-	<0.01	0.0000098	1.5 RfD	<0.01	<0.01	-
Copper	4	0.00000000022	-	<0.01	0.0000019	0.01 iMRL	<0.01	<0.01	-
Manganese	120	0.0000037*	0.04 cMRL	<0.01	0.000064	0.03 chRD	<0.01	<0.01	-
Nickel	6.6	0.00000021*	0.09 cMRL	<0.01	0.0000035	0.01 chRD	<0.01	<0.01	1.40×10^{-11}
Silver	0.5	0.00000000003	-	<0.01	0.00000027	0.005 RfD	<0.01	<0.01	-
Zinc	16	0.00000000097	-	<0.01	0.0000085	0.3 cMRL	<0.01	<0.01	-
Radionuclides	**pCi/g**								
Thorium-228 isotope	2.72	-	-	-	-	-	-	-	9.87×10^{-7}
Thorium-230 isotope	0.886	-	-	-	-	-	-	-	1.16×10^{-9}
Thorium-232 isotope	3.67	-	-	-	-	-	-	-	2.50×10^{-9}
				Total Inhalation Hazard Index = **<0.01**			Total Ingestion Hazard Index = **0.029**	Total Hazard Index = **0.029**	Total Cancer Risk = **9.92×10^{-7}**

mg/kg: milligram per kilogram; µg/m³: microgram per cubic meter; pCi/g: picoCuries per gram. cREL: Office of Environmental Health Hazard Assessment's chronic Reference Exposure Level; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Reference Dose; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level; chRD: Child-specific Reference Dose. †When an inhalation health comparison value was available for a contaminant, the exposure adjusted air concentration was compared to the inhalation health comparison value. When there was no inhalation health comparison value, the inhalation dose was compared to the ingestion health comparison value.

Table D25. Cancer and Noncancer Toxicological Evaluation of an Adult (18-30 Years of Age) Swimmer Exposed to the Maximum Level of Contamination Measured in the Oxnard Industrial Drain Water, Halaco Site, Oxnard, California

Contaminant	Maximum Water Concentration	Dermal Dose	Dermal Health Comparison Value†	Dermal Hazard Quotient	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant
Metals	**mg/L**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**
Aluminum	534	0.000033	0.1 RfDd	<0.01	0.000092	1.0 cMRL	<0.01	<0.01
Barium	153	0.0000095	0.014 RfDd	<0.01	0.000026	0.2 cMRL	<0.01	<0.01
Beryllium	0.25	0.000000016	0.00002 RfDd	<0.01	0.000000043	0.002 cMRL	<0.01	<0.01
Cadmium	0.37	0.000000023	0.000005 RfDd	<0.01	0.000000064	0.0002 cMRL	<0.01	<0.01
Chromium	ND	-	-	-	-	-	-	-
Copper	67.1	0.0000042	0.012 RfDd	<0.01	0.000012	0.01 iMRL	<0.01	<0.01
Manganese	1,100	0.000068	0.00184 RfDd	0.037	0.00019	0.047 RfD	<0.01	0.041
Nickel	5.2	0.00000032	0.0054 RfDd	<0.01	0.00000089	0.02 RfD	<0.01	<0.01
Silver	ND	-	-	-	-	-	-	-
Zinc	47.5	0.0000018	0.06 RfDd	<0.01	0.0000082	0.3 cMRL	<0.01	<0.01
				Total Dermal Hazard Index = **0.044**			Total Ingestion Hazard Index = **<0.01**	Total Hazard Index = **0.050**

mg/kg: milligram per kilogram; ND: not detected.
RfDd: U.S. Environmental Protection Agency's Dermal Reference Dose; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Oral Reference Dose
†RfDds obtained from http://rais.ornl.gov/tox/tox_values.shtml

Table D26. Cancer and Noncancer Toxicological Evaluation of a Child (8-18 years) Swimmer Exposed to the Maximum Level of Contamination Measured in the Oxnard Industrial Drain Water, Halaco Site, Oxnard, California

Contaminant	Maximum Water Concentration	Dermal Dose	Dermal Health Comparison Value†	Dermal Hazard Quotient	Ingestion Dose	Ingestion Health Comparison Value	Ingestion Hazard Quotient	Total Hazard Quotient for Each Contaminant
Metals	**mg/L**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**mg/kg/day**	**mg/kg/day**	**Unitless**	**Unitless**
Aluminum	534	0.000023	0.1 RfDd	<0.01	0.00014	1.0 cMRL	<0.01	<0.01
Barium	153	0.0000064	0.014 RfDd	<0.01	0.00004	0.2 cMRL	<0.01	<0.01
Beryllium	0.25	0.000000011	0.00002 RfDd	<0.01	0.000000065	0.002 cMRL	<0.01	<0.01
Cadmium	0.37	0.000000016	0.000005 RfDd	<0.01	0.000000096	0.000011 chRD	<0.01	0.012
Chromium	ND	-	-	-	-	-	-	-
Copper	67.1	0.0000028	0.012 RfDd	<0.01	0.000018	0.01 iMRL	<0.01	<0.01
Manganese	1,100	0.000046	0.00184 RfDd	0.025	0.00029	0.03 chRD	<0.01	0.035
Nickel	5.2	0.00000022	0.0054 RfDd	<0.01	0.0000014	0.01 chRD	<0.01	<0.01
Silver	ND	-	-	-	-	-	-	-
Zinc	47.5	0.0000012	0.06 RfDd	<0.01	0.000012	0.3 cMRL	<0.01	<0.01
				Total Inhalation Hazard Index = **0.030**			Total Ingestion Hazard Index = **0.021**	Total Hazard Index = **0.051**

mg/kg: milligram per kilogram; ND: not detected.
RfDd: U.S. Environmental Protection Agency's Dermal Reference Dose; cMRL: Agency for Toxic Substances and Disease Registry's chronic Minimal Risk Level; iMRL: Agency for Toxic Substances and Disease Registry's intermediate Minimal Risk Level; RfD: U.S. Environmental Protection Agency's Oral Reference Dose
†RfDds obtained from http://rais.ornl.gov/tox/tox_values.shtml

Table D27. Asthma Prevalence in Ventura County and California Overall, Halaco Site, Oxnard, California

	Ventura County		California Overall	
	%*	95% Confidence Interval	%*	95% Confidence Interval
2005				
All Ages	10.3	**8.0-12.7†**	13.6	**13.2-14.0†**
Children 1-17	14.9	9.3-20.5	16.1	15.2-17.1
2003				
All Ages	12.1	9.2-14.9	13.1	12.7-13.5
Children 1-17	11.9	6.0-17.7	15.4	14.5-16.4
2001				
All Ages	12.0	9.8-14.2	12.0	11.7-12.3
Children 1-17	11.8	7.7-15.8	14.0	13.3-14.8

Source: California Health Interview Survey.
*Percentage of people interviewed who reported ever being diagnosed with asthma by a health care provider.
†Figures in bold indicate a statistically significant difference in asthma prevalence between Ventura County and California overall, using a p-value that is less than 0.05.
A p-value of less than 0.05 means that there is a less than 5% chance that the difference in asthma prevalence between the groups is due to chance alone. Therefore, we conclude that there is an important difference in asthma prevalence between the groups, and not just a random difference.

Table D28. Comparison of Selected Risk Factors for Asthma for ZIP Code 93033 (Next to Halaco) and ZIP Code 93030 (Not Next to the Halaco Site), Halaco Site, Oxnard, California

	93033	93030	% Difference between 93033 and 93030
	Southern Oxnard	Northeastern Oxnard	
	Next to Halaco	Not Next to Halaco	
	% of Population	% of Population	
Age			
Under 5	9.3	9	0.3
18 and over	66.1	68.3	-2.2
65 and over	7	8.4	-1.4
Race			
White	35.6	43.1	-7.5*
Black	3.4	3.7	-0.3
Asian	9	5.2	3.8
Other (one race)	45.5	41.4	4.1
Hispanic	73.9	68.7	5.2
Proxy for indoor allergens			
Owner-occupied	58.9	54.5	4.4
Renter-occupied	41.1	45.5	-4.4
Proxy for income			
High school graduate	50.3	59.1	-8.8*
Individuals below poverty	18	15.3	2.7

Source [10]
*Indicates a difference in percentage of people in the study and control ZIP codes is larger than 5%.

Table D29. Comparison of Selected Risk Factors for Asthma for ZIP Code 93041 (Next to the Halaco site) and ZIP Code 93454 (Not Next to the Halaco site), Halaco Site, Oxnard, California

	93041	93454	% Difference between 93041 and 93454
	Port Hueneme	Santa Maria	
	Next to Halaco	Not Next to Halaco	
	% of Population	% of Population	
Age			
Under 5	9.4	7	2.4
18 and over	71.3	73.7	-2.4
65 and over	10	14.7	-4.7
Race			
White	58.2	74.7	-16.5*
Black	6.5	2.2	4.3
Asian	6.8	4	2.8
Other (one race)	20.1	13	7.1*
Hispanic	38.4	40.9	-2.5
Proxy for indoor allergens			
Owner-occupied	45.4	57.8	-12.4*
Renter-occupied	54.6	42.2	12.4*
Proxy for income			
High school graduate	76.7	76.8	-0.1
Individuals below poverty	12.3	14.6	-2.3

Source [10]

*Indicates a difference in percentage of people in the study and control ZIP codes is larger than 5%.

Table D30. Comparison of Selected Risk Factors for Asthma for ZIP Code 93041 (Next to the Halaco Site) and ZIP Code 93103 (Not Next to the Halaco Site) According to 2000 U.S. Census, Halaco Site, Oxnard, California

	93041	93103	% Difference between 93041 and 93103
	Port Hueneme	Santa Barbara	
	Next to Halaco	Not Next to Halaco	
	% of Population	% of Population	
Age			
Under 5 years	9.4	6.2	3.2
18 years and over	71.3	77.4	-6.1*
65 years and older	10	11.3	-1.3
Race			
White	58.2	65.4	-7.2*
Black	6.5	2.4	4.1
Asian	6.8	1.9	4.9
Other (one race)	20.1	25.2	-5.1
Hispanic	38.4	50.8	-12.4*
Proxy for indoor allergens			
Owner-occupied	45.4	46.1	-0.7
Renter-occupied	54.6	53.9	0.7
Proxy for income			
High school graduate	76.7	73.6	3.1
Individuals below poverty	12.3	14.4	-2.1

Source [10]
*Indicates a difference in percentage of people in the study and control ZIP codes is larger than 5%.

Table D31. Asthma Hospitalizations per 10,000 Residents (Crude Rate), for ZIP Code 93033 (Next to the Halaco Site) and ZIP Code 93030 (Not Next to the Halaco Site) for 1990 to 2006, Halaco Site, Oxnard, California

Year	Next to Halaco 93033 Southern Oxnard Number of Asthma Hospitalizations	Crude Rate of Asthma Hospitalizations (per 10,000)	Not Next to Halaco 93030 Northeastern Oxnard Number of Asthma Hospitalizations	Crude Rate of Asthma Hospitalizations (per 10,000)
1990	110	16.7	164	24.8
1991	96	14.3	161	23.8
1992	95	13.9	136	19.7
1993	84	12.1	129	18.4
1994	93	13.1	144	20.1
1995	119	16.5	155	21.2
1996	71	9.7	133	17.9
1997	85	11.4	142	18.8
1998	78	10.3	153	19.9
1999	131	17.1	129	16.5
2000	101	13.0	105	13.2
2001	83	9.2	104	11.2
2002	72	7.8	106	11.3
2003	69	7.4	126	13.2
2004	53	5.6	83	8.6
2005	61	6.4	65	6.6
2006	56	5.8	58	5.8

Source: California Office of Statewide Health Planning and Development.

Table D32. Asthma Hospitalizations per 10,000 Residents (Crude Rate), for ZIP Code 93041 (Next to the Halaco Site), ZIP Codes 93103 and 93454 (Not Next to the Halaco Site) for 1990 to 2006, Halaco Site, Oxnard, California

Year	Next to Halaco 93041 Port Hueneme Number of Asthma Hospitalizations	Crude Rate of Asthma Hospitalizations (per 10,000)	Not Next to Halaco 93103 Santa Barbara Number of Asthma Hospitalizations	Crude Rate of Asthma Hospitalizations (per 10,000)	Not Next to Halaco 93454 Santa Maria Number of Asthma Hospitalizations	Crude Rate of Asthma Hospitalizations (per 10,000)
1990	38	21.9	15	8.2	67	11.1
1991	48	26.4	11	6.0	57	10.0
1992	35	18.4	8	4.3	66	12.2
1993	42	21.2	10	5.3	78	15.2
1994	36	17.4	8	4.2	52	10.8
1995	39	18.2	5	2.6	68	15.0
1996	37	16.6	9	4.5	74	17.5
1997	32	13.8	8	4.0	77	19.5
1998	25	10.4	8	3.9	69	18.9
1999	38	15.3	9	4.4	63	18.8
2000	26	10.1	4	1.9	49	16.1
2001	28	3.2	11	1.4	33	7.3
2002	40	4.6	5	0.6	36	8.5
2003	28	3.2	6	0.7	39	9.9
2004	24	2.7	6	0.7	34	9.4
2005	22	2.4	8	1.0	32	9.6
2006	15	1.6	11	1.3	26	8.6

Source: California Office of Statewide Health Planning and Development.

Table D33. Observed and Expected Number of Cases of Selected Cancers by Time Period and Sex Within Selected Census Tracts*, Halaco Site, Oxnard, California

Year	Observed Cases Among Males	Expected Cases Among Males	99% Confidence Interval for Expected Among Males	Observed Cases Among Females	Expected Cases Among Females	99% Confidence Interval for Expected Among Females	Observed Total Cases	Expected Total Cases	99% Confidence Interval for Expected Total Cases
All Cancers Combined									
1988-2006	574	618.5	556.3-685.5	**574**	**646.7**	582.9-714.9	1148	1265.3	1062.6-1238.2
1988-1992	165	143.5	114.5-177.3	142	144.8	115.4-178.5	307	288.3	246.2-334.7
1998-2002	143	171.0	139.2-207.7	**146**	**181.1**	148.2-218.6	289	352.1	305.6-403.3
Breast Cancer									
1988-2006	0	1.2	0.0-7.4	**159**	**204.6**	169.5-244.3	159	205.8	181.4-258.5
1988-1992	0	0.2	0.0-5.3	35	45.6	30.0-65.9	35	45.8	30.0-65.9
1998-2002	0	0.4	0.0-5.3	41	57.4	39.4-79.5	41	57.7	39.4-79.5
All Leukemia Combined									
1988-2006	15	22.2	11.8-37.2	14	15.8	7.2-28.8	29	38.0	24.0-57.0
1988-1992	<5	5.0	0.9-13.4	<5	4.2	0.7-12.6	<10	9.1	3.1-20.0
1998-2002	<5	6.2	1.5-15.7	<5	4.2	0.7-12.6	<10	10.4	3.7-21.4
Melanoma									
1988-2006	17	24.9	13.6-40.4	14	15.8	7.2-28.8	31	44.4	28.8-64.2
1988-1992	<5	4.5	0.9-13.4	5	3.9	0.5-11.8	6	8.4	2.6-18.6
1998-2002	<5	7.4	2.0-17.1	**<5**	**5.7**	1.3-14.9		13.1	5.6-25.5
Cancer of the Nasal Sinuses									
1988-2006	<5	1.3	0.0-7.4	<5	0.9	0.0-6.4 5	<10	2.2	Not included (see footnote)
1988-1992	<5	0.3	0.0-5.3	<5	0.2	0.0-5.3	<10	0.6	Not included (see footnote)

Table D33. Observed and Expected Number of Cases of Selected Cancers by Time Period and Sex Within Selected Census Tracts*, Halaco Site, Oxnard, California

Year	Observed Cases Among Males	Expected Cases Among Males	99% Confidence Interval for Expected Among Males	Observed Cases Among Females	Expected Cases Among Females	99% Confidence Interval for Expected Among Females	Observed Total Cases	Expected Total Cases	99% Confidence Interval for Expected Total Cases
1998-2002	<5	0.4	0.0-5.3	<5	0.2	0.0-5.3	<10	0.6	Not included (see footnote)
Thyroid Cancer									
1988-2006	<5	5.8	1.3-14.9	22	23.0	12.52-38.48	<27	28.8	16.6-45.4
1988-1992	<5	1.5	0.0-7.4	<5	4.8	0.87-13.38	<10	6.3	1.5-15.7
1998-2002	<5	1.6	0.0-8.4	5	6.6	1.78-16.40	<10	8.2	2.6-18.6
Bladder Cancer									
1988-2006	37	34.4	20.9-52.1	7	12.8	5.3-24.8	44	47.2	31.2-67.7
1988-1992	18	8.5	2.6-18.6	**<5**	**3.4**	0.3-11.0	<23	11.8	4.6-23.5
1998-2002	5	9.3	3.1-20.0	<5	3.4	0.3-11.0	<10	12.7	5.3-24.8
Cancers of Lung and Bronchus									
1988-2006	**102**	**73.9**	53.3-98.6	78	66.6	47.4-90.5	180	140.5	111.4-173.5
1988-1992	24	20.6	10.7-35.3	16	15.8	7.2-28.8	40	36.3	22.4-54.5
1998-2002	22	19.0	9.3-32.7	20	18.3	9.0-32.1	42	37.3	23.2-55.7
Leiomyosarcoma									
1988-2006	1	1.31	0.0-7.4	4	2.54	0.0-10.1	5	3.85	0.0-11.8
1988-1992	0	0.34	0.0-5.3	0	0.54	0.0-6.4	0	0.88	0.0-6.4
1998-2002	0	0.35	0.0-5.3	0	0.72	0.0-6.4	0	1.07	0.0-7.4

*These census tracts are located within a 1-mile radius of the Halaco site, Oxnard, Ventura County. They include census tracts 44, 45.01, 45.02, and 47.02 for the 1990 U.S. Census and census tracts 44, 45.01, 45.03, and 47.02 for the 2000 U.S. Census.

Bold values indicate a statistically significant difference between observed and expected numbers of cases, using a p-value that is less than 0.01.
The 99% confidence interval for the expected number of nasal sinuses cancer cases was not included here. The number of observed cases was so small that a comparison between the observed and expected numbers of cases was not applicable.

The concept of control charts used in the field of statistical process control was used to compare the number of observed cases with the number of expected cases over the study time period from 1988-2006. Control charts are frequently used in industrial processes to detect whether or not the fluctuations in the production quality of a product is within normal range, or outside of this range. In this case, a control chart was used to detect unusual changes in the incidence of cancer over time. Unusual changes may be due to exposure the pollutants from the Halaco site, or other factors that warrant further investigation.

A control chart is set up by establishing a reference line, which describes when the normal, expected behavior of a process, and upper and lower control limits, which theoretically capture almost all observations when a process is within normal fluctuation [163]. When using control charts, generally a significant change is defined as three or more consecutive data points outside the control limits [108].

In the control charts created for the selected census tracts near the Halaco site, the reference line includes point estimates for the expected number of cases over the time period 1988-2006. There control limits are given by the 99% confidence interval for expected number of cases, which is 2.58 standard deviations from the point estimate for expected cases. The number of observed cases is examined over the time period of 1988-2006 to see whether it is greater than the upper limit for the 99% confidence interval. In this comparison, a significant change in pattern of cancer incidence is defined as when the number of observed cases is greater than the 99% confidence interval value for three or more consecutive years.

Table D34. Observed and Expected Number of Cases of Cancers of Lung and Bronchus by Time Period and Sex Among Specific Racial/Ethnic Groups within Selected Census Tracts*, Halaco Site, Oxnard, California

Year	Observed Cases Among Males	Expected Cases Among Males	99% Confidence Interval for Expected Cases Among Males	Observed Cases Among Females	Expected Cases Among Females	99% Confidence Interval for Expected Cases Among Females
All races						
1988-2006	**102**	**73.9**	53.3-98.6	78	66.6	47.4-90.5
1988-1992	24	20.6	10.7-35.3	16	15.8	7.2-28.8
1998-2002	22	19.0	9.3-32.7	20	18.3	8.9-32.1
Non-Hispanic White						
1988-2006	**66**	**42.3**	27.2-61.8	**62**	**39.3**	24.8-58.2
1988-1992	20	14.1	0.0-26.8	14	12.2	0.0-24.1
1998-2002	11	9.9	0.0-20.7	16	9.8	0.0-20.7
Hispanic						
1988-2006	14	17.6	8.6-31.4	**<5**	**14.9**	6.6-27.5
1988-1992	<5	2.7	0.2-10.1	<5	1.9	0.0-8.4
1998-2002	<5	5.3	1.1-14.2	<5	4.7	0.9-13.4

Bold values indicate a statistically significant difference between observed and expected numbers of cases, using a p-value that is less than 0.01.
*These census tracts are located within a 1-mile radius of the Halaco site, Oxnard, Ventura County. They include census tracts 44, 45.01, 45.02, and 47.02 for the 1990 U.S. Census and census tracts 44, 45.01, 45.03, and 47.02 for the 2000 U.S. Census.

Table D35. British Pediatric Association (BPA) Codes and their Descriptions for Neural Tube and Limb Reduction Defects Included in Review of 1-Mile Radius to Halaco Site, Oxnard, California

Type of Birth Defect	BPA Code	Description of Code
Neural tube	740.000-740.080	Anencephalus
	740.100	Craniorachischisis
	740.200-740.290	Iniencephaly
	741.000-741.999	Spina bifida
	742.000-742.099	Encephalocele
Limb reduction	755.200-755.299	Upper limb reductions
	755.300-755.399	Lower limb reductions
	755.400-755.499	Limb reductions, unspecified limb

Table D36. Comparing Numbers of All Birth Defects for ZIP Codes Next to Halaco (93033, 93041) and Reference Areas (Ventura County, Excluding ZIP Codes Next to Halaco, and California, Excluding Ventura County) for All Races, Using Relative Risk and Mantel-Haenszel Chi-Square Test, Halaco Site, Oxnard, California

Area	Exposure Status	Birth Defects Cases	Total Number of Births	Number of All Birth Defects per 100 Births	Relative Risk of Birth Defects Comparing ZIP Codes Next to Halaco to Reference Area	95% Confidence Interval for Relative Risk	Chi-Square Value	P-Value
ZIP Codes Next to Halaco	Potentially Exposed	45	1,760	2.56	-	-	-	-
Ventura	Reference	222	10,335	2.15	1.19*	0.9-1.6	1.16	0.28
California	Reference	10,322	359,601	2.87	0.89	0.7-1.2	0.62	0.43

*A relative risk greater than 1 indicates evidence of an association between exposure and disease.

Table D37. Comparing Numbers of Limb Reduction Defects for ZIP Codes Next to Halaco (93033, 93041) and Reference Areas (Ventura County, Excluding ZIP Codes Next to Halaco, and California, Excluding Ventura County) for All Races, Using Relative Risk and Mantel-Haenszel Chi-Square Test, Halaco Site, Oxnard, California

Area	Exposure Status	Birth Defects Cases	Total Number of Births	Number of Limb Reduction Defects per 100 Births	Relative Risk of Birth Defects Comparing ZIP Codes Next to Halaco to Reference Area	95% Confidence Interval for Relative Risk	Chi-Square Value	P-Value
ZIP Codes Next to Halaco	Potentially Exposed	1	1,760	0.06	-	-	-	-
Ventura	Reference	8	10,335	0.08	0.73	0.1-4.5	0.09	0.77
California	Reference	224	359,601	0.06	0.91	0.2-5.2	0.01	0.92

Table D38. Comparing Numbers of Neural Tube Defects for ZIP Codes Next to Halaco (93033, 93041) and Reference Areas (Ventura County, Excluding ZIP Codes Next to Halaco, and California, Excluding Ventura County) for All Races, Using Relative Risk and Mantel-Haenszel Chi-Square Test, Halaco Site, Oxnard, California

Area	Exposure Status	Birth Defects Cases	Total Number of Births	Number of Neural Tube Defects per 100 Births	Relative Risk of Birth Defects Comparing ZIP Codes Next to Halaco to Reference Area	95% Confidence Interval for Relative Risk	Chi-Square Value	P-Value
ZIP Codes Next to Halaco	Potentially Exposed	5	1,760	0.28	-	-	-	-
Ventura	Reference	6	10,335	0.06	4.89*	1.6-15.1	8.46	0.004†
California	Reference	399	359,601	0.11	2.56*	1.1-6.1	4.70	0.030†

*A relative risk greater than 1 indicates evidence of an association between exposure and disease.
†A p-value of less than 0.05 is considered statistically significant.

Table D39. Comparing Numbers of Neural Tube Defects for ZIP Codes Next to Halaco (93033, 93041) and Reference Areas (Ventura County, Excluding ZIP Codes Next to Halaco, and California, Excluding Ventura County) for Hispanics, Using Mantel-Haenszel Chi-Square Test, Halaco Site, Oxnard, California

Area	Exposure Status	Birth Defects Cases	Total Number of Births	Number of Neural Tube Defects per 100 Births	Relative Risk of Birth Defects Comparing ZIP Codes Next to Halaco to Reference Area	95% Confidence Interval for Relative Risk	Chi-Square Value	P-Value
ZIP Codes Next to Halaco	Potentially Exposed	5	1,097	0.46	-	-	-	-
Ventura	Reference	4	3,389	0.12	3.86*	1.1-13.3	4.72	0.03†
California	Reference	170	108,318	0.16	2.90*	1.2-6.9	6.07	0.01†

*A relative risk greater than 1 indicates evidence of an association between exposure and disease.
†A p-value of less than 0.05 is considered statistically significant.

Table D40. Comparing Observed and Expected Numbers of Neural Tube Defects for ZIP Codes Next to the Halaco Site (93033, 93041) and Reference Areas (Ventura County, Excluding ZIP Codes Next to Halaco, and California, Excluding Ventura County) for Non-Hispanics, Halaco Site, Oxnard, California

Area	Total Number of Births in ZIP Codes Next to the Halaco site	Number of Neural Tube Defects per 100 Births in Reference Area	Expected Number of Neural Tube Defects in ZIP Codes Next to Halaco	Observed Number of Birth Defects in ZIP Codes Next to Halaco
Ventura	663	0.03	0.19	0
California	663	0.09	0.60	0

Table D41. Comparing Numbers of Neural Tube Defects for ZIP Codes Next to Halaco (93033, 93041) and Reference Areas (Ventura County, Excluding ZIP Codes Next to Halaco, and California, Excluding Ventura County) for Non-Hispanics, Halaco Site, Oxnard, California

Area	Exposure Status	Birth Defects Cases	Total Number of Births	Number of Neural Tube Defects per 100 Births	Relative Risk of Birth Defects Comparing ZIP Codes Next to Halaco to Reference Area	95% Confidence Interval for Relative Risk
ZIP Codes Next to Halaco	Potentially Exposed	0	663	0	-	-
Ventura	Reference	2	6,946	0.03	0	0-20.1
California	Reference	229	251,283	0.09	0	0-6.4

Table D42. Comparing Number of Neural Tube Defects among Hispanics and Non-Hispanics Living in ZIP Codes Next to Halaco (93033, 93041), Using Mantel-Haenszel Chi-Square Test, Halaco Site, Oxnard, California

Maternal Race/Ethnicity	Births Defect Cases	Total Births	Number of Neural Tube Defects per 100 Births	Chi-Square Value	P-Value
Hispanic	5	1,097	0.46	-	-
Non-Hispanic	0	663	0	3.03	0.08

Table D43. Comparing Number of Neural Tube Defects among Hispanics and Non-Hispanics Living in Ventura County, Excluding ZIP Codes Next to Halaco (93033, 93041), Using Relative Risk and Mantel-Haenszel Chi-Square Test, Halaco Site, Oxnard, California

Maternal Race/Ethnicity	Births Defect Cases	Total Births	Number of Neural Tube Defects per 100 Births	Relative Risk of Birth Defects Comparing Hispanics to Non-Hispanics	Chi-Square Value	P-Value
Hispanic	4	3,389	0.12	-	-	-
Non-Hispanic	2	6,946	0.03	4.10*	3.13	0.08

*A relative risk greater than 1 indicates evidence of an association between exposure and disease.

Table D44. Comparing Number of Neural Tube Defects among Hispanics and Non-Hispanics Living in California, Excluding Ventura County, Using Relative Risk and Mantel-Haenszel Chi-Square Test, Halaco Site, Oxnard, California

Maternal Race/Ethnicity	Births Defect Cases	Total Births	Number of Neural Tube Defects per 100 Births	Relative Risk of Birth Defects Comparing Hispanics to Non-Hispanics	Chi-Square Value	P-Value
Hispanic	170	108,318	0.16	-	-	-
Non-Hispanic	229	251,283	0.09	1.72*	29.58	<0.001†

*A relative risk greater than 1 indicates evidence of an association between exposure and disease.
†A p-value of less than 0.05 is considered statistically significant.

Table D45. Comparing Percentage of Low Birth Weight (LBW) Births in Ventura County (Reference Area), and ZIP Code 93033 (Next to Halaco) for 1982-2006, Halaco Site, Oxnard, California

Year	Ventura County (Reference Area)					ZIP Code 93033 (Next to Halaco)				
	LBW Count	Total Births	% LBW	Lower Limit % LBW	Upper Limit % LBW	LBW Count	Total Births	% LBW	Lower Limit % LBW	Upper Limit % LBW
1982	471	9,872	4.77	4.37	5.21	30	891	3.37	2.37	4.77
1983	485	9,903	4.9	4.49	5.34	50	1,026	4.87	3.72	6.37
1984	455	9,849	4.62	4.22	5.05	52	1,173	4.43	3.4	5.77
1985	539	10,584	5.09	4.69	5.53	87	1,330	6.54	5.33	8
1986	505	10,362	4.87	4.48	5.31	64	1,202	5.32	4.19	6.74
1987	523	10,858	4.82	4.43	5.24	65	1,171	5.55	4.38	7.01
1988	566	11,447	4.94	4.56	5.36	76	1,190	6.39	5.13	7.92
1989	703	12,007	5.85	5.45	6.29	94	1,383	6.8	5.59	8.25
1990	640	12,719	5.03	4.67	5.43	83	1,470	5.65	4.58	6.95
1991	678	12,827	5.29	4.91	5.69	94	1,584	5.93	4.87	7.21
1992	690	12,510	5.52	5.13	5.93	112	1,657	6.76	5.65	8.07
1993	679	12,180	5.57	5.18	6	108	1,656	6.52	5.43	7.81
1994	677	11,872	5.7	5.3	6.13	102	1,563	6.53	5.4	7.86
1995	644	12,068	5.34	4.95	5.75	81	1,528	5.3	4.29	6.54
1996	609	11,712	5.20	4.81	5.62	68	1,548	4.39	3.48	5.53
1997	659	11,362	5.80	5.38	6.24	99	1,539	6.43	5.31	7.77
1998	622	11,519	5.40	5.00	5.83	77	1,660	4.64	3.73	5.76
1999	653	11,444	5.71	5.30	6.15	102	1,700	6.00	4.97	7.23
2000	694	11,768	5.90	5.49	6.34	118	1,680	7.02	5.90	8.35
2001	676	11,329	5.97	5.55	6.42	90	1,696	5.31	4.34	6.48
2002	692	11,533	6.00	5.58	6.45	100	1,743	5.74	4.74	6.93
2003	764	11,938	6.40	5.97	6.85	106	1,856	5.71	4.74	6.86
2004	836	11,943	7.00	6.56	7.47	131	1,966	6.66	5.64	7.85
2005	789	12,138	6.50	6.08	6.95	115	2,052	5.60	4.69	6.68
2006	842	12,382	6.80	6.37	7.26	121	2,086	5.80	4.88	6.89

Table D46. Comparing Percentage of Low Birth Weight (LBW) Births in Ventura County (Reference Area), and ZIP Code 93041 (Next to Halaco) for 1982-2006, Halaco Site, Oxnard, California

Year	Ventura County (Reference Area)					ZIP Code 93041 (Next to Halaco)				
	LBW Count	Total Births	% LBW	Lower Limit % LBW	Upper Limit % LBW	lLBW Count	Total Births	% LBW	Lower Limit % LBW	Upper Limit % LBW
1982	471	9,872	4.77	4.37	5.21	17*	390	4.36*	2.74	6.87
1983	485	9,903	4.9	4.49	5.34	23*	413	5.57*	3.74	8.22
1984	455	9,849	4.62	4.22	5.05	19*	371	5.12*	3.3	7.86
1985	539	10,584	5.09	4.69	5.53	18*	351	5.13*	3.27	7.96
1986	505	10,362	4.87	4.48	5.31	23	352	6.53	4.39	9.61
1987	523	10,858	4.82	4.43	5.24	17*	340	5*	3.14	7.86
1988	566	11,447	4.94	4.56	5.36	18*	334	5.39*	3.44	8.36
1989	703	12,007	5.85	5.45	6.29	17	361*	4.71*	2.96	7.41
1990	640	12,719	5.03	4.67	5.43	22	452	4.87	3.24	7.26
1991	678	12,827	5.29	4.91	5.69	30	481	6.24	4.4	8.76
1992	690	12,510	5.52	5.13	5.93	25	453	5.52	3.77	8.02
1993	679	12,180	5.57	5.18	6	20	425	4.71	3.07	7.16
1994	677	11,872	5.7	5.3	6.13	33	483	6.83	4.91	9.44
1995	644	12,068	5.34	4.95	5.75	33	520	6.35	4.55	8.78
1996	609	11,712	5.20	4.81	5.62	26	484	5.37	3.69	7.75
1997	659	11,362	5.80	5.38	6.24	25	486	5.14	3.51	7.48
1998	622	11,519	5.40	5.00	5.83	38	469	8.10	5.96	10.90
1999	653	11,444	5.71	5.30	6.15	28	509	5.50	3.83	7.84
2000	694	11,768	5.90	5.49	6.34	30	512	5.86	4.13	8.24
2001	676	11,329	5.97	5.55	6.42	23	469	4.90	3.29	7.25
2002	692	11,533	6.00	5.58	6.45	40	484	8.26	6.13	11.10
2003	764	11,938	6.40	5.97	6.85	30	481	6.24	4.40	8.76
2004	836	11,943	7.00	6.56	7.47	29	500	5.80	4.07	8.21
2005	789	12,138	6.50	6.08	6.95	30	501	5.99	4.23	8.42
2006	842	12,382	6.80	6.37	7.26	40	486	8.23	6.10	11.00

*There were less than 20 cases for this year. Therefore, the rates based on these counts may be unreliable and subject to significant variability from year to year.

Table D47. Comparing Percentage of Preterm Births in Ventura County (Reference Area), and ZIP Code 93033 (Next to Halaco) for 1982-2006, Halaco Site, Oxnard, California

Year	Ventura County (Reference Area)					ZIP Code 93033 (Next to Halaco)				
	Preterm Count	Total Births	% Preterm	Lower Limit % Preterm	Upper Limit % Preterm	Preterm Count	Total Births	% Preterm	Lower Limit % Preterm	Upper Limit % Preterm
1982	699	9,877	7.08	6.59	7.6	60	892	6.73	5.26	8.56
1983	712	9,895	7.2	6.7	7.72	77	1,026	7.5	6.05	9.28
1984	715	9,849	7.26	6.76	7.79	97	1,175	8.26	6.81	9.97
1985	824	9,855	8.36	7.83	8.92	113	1,225	9.22	7.73	10.97
1986	837	9,719	8.61	8.07	9.19	94	1,114	8.44	6.95	10.22
1987	914	10,071	9.08	8.53	9.65	109	1,044	10.44	8.73	12.44
1988	922	10,600	8.7	8.18	9.25	107	1,032	10.37	8.65	12.38
1989	1,054	11,670	9.03	8.53	9.57	139	1,309	10.62	9.06	12.4
1990	978	12,507	7.82	7.36	8.3	138	1,444	9.56	8.15	11.18
1991	1,120	12,541	8.93	8.44	9.44	162	1,551	10.44	9.02	12.07
1992	1,184	12,156	9.74	9.23	10.28	184	1,611	11.42	9.96	13.07
1993	1,118	11,919	9.38	8.87	9.92	173	1,607	10.77	9.34	12.38
1994	1,057	11,282	9.37	8.84	9.92	154	1,430	10.77	9.27	12.48
1995	1,148	11,429	10.04	9.51	10.61	173	1,425	12.14	10.55	13.94
1996	1,022	10,383	9.84	9.28	10.43	170	1,535	11.07	9.60	12.74
1997	1,090	10,190	10.70	10.11	11.31	186	1,534	12.13	10.59	13.85
1998	996	10,478	9.51	8.96	10.08	162	1,660	9.76	8.42	11.28
1999	1,046	11,444	9.14	8.63	9.68	172	1,700	10.12	8.77	11.64
2000	1,141	11,154	10.23	9.68	10.81	165	1,679	9.83	8.49	11.34
2001	1,083	10,844	9.99	9.44	10.57	183	1,696	10.79	9.40	12.36
2002	1,159	11,086	10.45	9.90	11.04	183	1,742	10.51	9.15	12.03
2003	1,279	11,307	11.31	10.74	11.91	211	1,856	11.37	10.00	12.89
2004	1,325	11,387	11.64	11.06	12.24	252	1,966	12.82	11.41	14.37
2005	1,268	11,916	10.64	10.10	11.21	187	2,052	9.11	7.94	10.44
2006	1,201	12,346	9.73	9.22	10.26	195	2,086	9.35	8.17	10.67

Table D48. Comparing Percentage of Preterm Births in Ventura County (Reference Area), and ZIP Code 93041 (Next to Halaco) for 1982-2006, Halaco Site, Oxnard, California

Year	Ventura County (Reference Area)					ZIP Code 93041 (Next to Halaco)				
	Preterm Count	Total Births	% Preterm	Lower Limit % Preterm	Upper Limit % Preterm	Preterm Count	Total Births	% Preterm	Lower Limit % Preterm	Upper Limit % Preterm
1982	699	9,877	7.08	6.59	7.6	28	390	7.18	5.01	10.18
1983	**712**	**9,895**	**7.2**	**6.7**	**7.72**	**43**	**413**	**10.41**	**7.82**	**13.73**
1984	715	9,849	7.26	6.76	7.79	35	370	9.46	6.88	12.87
1985	824	9,855	8.36	7.83	8.92	36	323	11.15	8.16	15.04
1986	837	9,719	8.61	8.07	9.19	38	325	11.69	8.64	15.64
1987	914	10,071	9.08	8.53	9.65	33	296	11.15	8.05	15.24
1988	922	10,600	8.7	8.18	9.25	24	285	8.42	5.72	12.22
1989	1,054	11,670	9.03	8.53	9.57	35	353	9.92	7.22	13.48
1990	978	12,507	7.82	7.36	8.3	43	445	9.66	7.25	12.76
1991	1,120	12,541	8.93	8.44	9.44	45	466	9.66	7.3	12.68
1992	1,184	12,156	9.74	9.23	10.28	48	440	10.91	8.33	14.17
1993	1,118	11,919	9.38	8.87	9.92	40	420	9.52	7.07	12.71
1994	1,057	11,282	9.37	8.84	9.92	47	467	10.06	7.65	13.13
1995	1,148	11,429	10.04	9.51	10.61	48	496	9.68	7.38	12.6
1996	1,022	10,383	9.84	9.28	10.43	39	449	8.69	6.42	11.65
1997	1,090	10,190	10.70	10.11	11.31	50	458	10.92	8.38	14.10
1998	**996**	**10,478**	**9.51**	**8.96**	**10.08**	**64**	**452**	**14.16**	**11.25**	**17.68**
1999	1,046	11,444	9.14	8.63	9.68	45	480	9.38	7.08	12.31
2000	1,141	11,154	10.23	9.68	10.81	46	489	9.41	7.13	12.32
2001	1,083	10,844	9.99	9.44	10.57	46	451	10.20	7.73	13.34
2002	1,159	11,086	10.45	9.90	11.04	56	458	12.23	9.54	15.55
2003	1,279	11,307	11.31	10.74	11.91	48	446	10.76	8.21	13.98
2004	1,325	11,387	11.64	11.06	12.24	49	479	10.23	7.82	13.27
2005	1,268	11,916	10.64	10.10	11.21	50	496	10.08	7.73	13.04
2006	1,201	12,346	9.73	9.22	10.26	56	486	11.52	8.98	14.67

Bold values indicate 95% confidence limits for reference area and exposed areas do not overlap indicating a significant difference, and confidence interval for the exposed areas was higher than the reference area.

Table D49. Comparison of Percentage of Low Birth Weight Births during Halaco Facility Operation (1982-2004) and after Halaco Closure (2005-2006) in ZIP Code 93033 (Next to Halaco), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Years	Status of Halaco Facility	Number of Low Birth Weight Births	Total Number of Births	Percentage of Low Birth Weight Births	Relative Risk of Low Birth Weight Births Comparing "Operating" to "Closed" Years	Chi-Square Value	p-Value
1982-2004	Operating	1,989	34,212	5.81	-	-	-
2005-2006	Closed	236	4,138	5.70	1.02*	0.08	0.77

*A relative risk greater than 1 indicates evidence of an association between exposure and disease.

Table D50. Comparison of Percentage of Low Birth Weight Births during Halaco Facility Operation (1982-2004) and after Halaco Closure (2005-2006) in ZIP Code 93041 (Next to Halaco), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Years	Status of Halaco Facility	Number of Low Birth Weight Births	Total Number of Births	Percentage of Low Birth Weight Births	Relative Risk of Low Birth Weight Births Comparing "Operating" to "Closed" Years	Chi-Square Value	p-Value
1982-2004	Operating	584	10,120	5.77	-	-	-
2005-2006	Closed	70	987	7.09	0.81*	2.83	0.09

*A relative risk of less than 1 indicates that the risk is lower during the time period when people were exposed.

Table D51. Comparison of Percentage of Low Birth Weight Births during Halaco Facility Operation (1982-2004) and after Halaco Closure (2005-2006) in Ventura County (Reference Area), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Years	Status of Halaco Facility	Number of Low Birth Weight Births	Total Number of Births	Percentage of Low Birth Weight Births	Relative Risk of Low Birth Weight Births Comparing "Operating" to "Closed" Years	Chi-Square Value	p-Value
1982-2004	Operating	14,460	263,605	5.49	-	-	-
2005-2006	Closed	1,631	24,521	6.65	0.82*	57.84	<0.0001†

*A relative risk of less than 1 indicates that the risk is lower during the time period when people were exposed.
†A p-value of less than 0.05 is considered statistically significant.

Table D52. Comparison of Percentage of Preterm Births during Halaco Facility Operation (1982-2004) and after Halaco Closure (2005-2006) in ZIP Code 93033 (Next to Halaco), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Years	Status of Halaco Facility	Number of Preterm Births	Total Number of Births	Percentage of Preterm Births	Relative Risk of Preterm Births Comparing "Operating" to "Closed" Years	Chi-Square Value	p-Value
1982-2004	Operating	3,464	33,253	10.42	-	-	-
2005-2006	Closed	382	4,138	9.23	1.13*	5.61	0.02†

*A relative risk greater than 1 indicates evidence of an association between exposure and disease.
†A p-value of less than 0.05 is considered statistically significant.

Table D53. Comparison of Percentage of Preterm Births during Halaco Facility Operation (1982-2004) and after Halaco Closure (2005-2006) in ZIP Code 93041 (Next to Halaco), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Years	Status of Halaco Facility	Number of Preterm Births	Total Number of Births	Percentage of Preterm Births	Relative Risk of Preterm Births Comparing "Operating" to "Closed" Years	Chi-Square Value	p-Value
1982-2004	Operating	986	9,651	10.22	-	-	-
2005-2006	Closed	106	982	10.79	0.95*	0.32	0.57

*A relative risk of less than 1 indicates that the risk is lower during the time period when people were exposed.

Table D54. Comparison of Percentage of Preterm Births during Halaco Facility Operation (1982-2004) and after Halaco Closure (2005-2006) in Ventura County (Reference Area), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Years	Status of Halaco Facility	Number of Preterm Births	Total Number of Births	Percentage of Preterm Births	Relative Risk of Preterm Births Comparing "Operating" to "Closed" Years	Chi-Square Value	p-Value
1982-2004	Operating	23,423	251,643	9.31	-	-	-
2005-2006	Closed	2,469	24,262	10.18	0.91*	19.62	<0.0001†

*A relative risk of less than 1 indicates that the risk is lower during the time period when people were exposed.
†A p-value of less than 0.05 is considered statistically significant.

Table D55. Percentage of Preterm Births by Relative Likelihood of Exposure to Halaco Emissions (Defined by Proximity to and Operating Status of the Halaco Facility) for Ventura County for 1982-2006, Halaco Site, Oxnard, California

Relative Likelihood of Exposure	Preterm Births	Total Births	% Preterm
More likely exposed[1]	4,415	41,216	10.7
Less likely exposed[2]	20,677	223,254	9.3

[1] ZIP codes next to Halaco facility when Halaco operated.
[2] ZIP codes next to Halaco facility when Halaco was closed and Ventura County, excluding ZIP codes next to Halaco facility, both when Halaco operated and was closed.

Table D56. Percentage of Preterm Births by Type of Birth and Relative Likelihood of Exposure to Halaco Emissions (Defined by Proximity to and Operating Status of the Halaco Facility) for Ventura County for 1982-2006, Halaco Site, Oxnard, California

Type of Birth	Preterm Births	Total Births	% Preterm
Singleton			
More likely exposed[1]	3,999	40,320	9.9
Less likely exposed[2]	17,706	217,475	8.1
Multiple			
More likely exposed[1]	416	896	46.4
Less likely exposed[2]	2,971	5,779	51.4

[1] ZIP codes next to Halaco facility when Halaco operated.
[2] ZIP codes next to Halaco facility when Halaco was closed and Ventura County, excluding ZIP codes next to Halaco facility, both when Halaco operated and was closed.

Table D57. Percentage of Preterm Births by Maternal Race and Relative Likelihood of Exposure to Halaco Emissions (Defined by Proximity to and Operating Status of the Halaco Facility) for Ventura County for 1982-2006, Halaco Site, Oxnard, California

Maternal Race	Preterm Births	Total Births	% Preterm
Hispanic			
More likely exposed[1]	2,951	27,137	10.9
Less likely exposed[2]	9,363	91,369	10.2
Non-Hispanic White			
More likely exposed[1]	702	7,516	9.3
Less likely exposed[2]	9,101	110,536	8.2
Non-Hispanic Black			
More likely exposed[1]	200	1,414	14.1
Less likely exposed[2]	446	3,291	13.6
Non-Hispanic Asian/Pacific Islander			
More likely exposed[1]	323	3,083	10.5
Less likely exposed[2]	1,015	10,321	9.8
Non-Hispanic Other			
More likely exposed[1]	18	190	9.5
Less likely exposed[2]	87	803	10.8

[1] ZIP codes next to Halaco facility when Halaco operated.
[2] ZIP codes next to Halaco facility when Halaco was closed and Ventura County, excluding ZIP codes next to Halaco facility, both when Halaco operated and was closed.

Table D58. Percentage of Preterm Births by Maternal Age and Relative Likelihood of Exposure to Halaco Emissions (Defined by Proximity to and Operating Status of the Halaco Facility) for Ventura County for 1982-2006, Halaco Site, Oxnard, California

Maternal Age	Preterm Births	Total Births	% Preterm
Below 20			
More likely exposed[1]	741	5,792	12.8
Less likely exposed[2]	2,222	20,072	11.1
20-24			
More likely exposed[1]	1,245	12,457	10.0
Less likely exposed[2]	4,558	51,333	8.9
25-29			
More likely exposed[1]	1,124	11,776	9.5
Less likely exposed[2]	5,388	65,151	8.3
30-34			
More likely exposed[1]	782	7,325	10.7
Less likely exposed[2]	4,986	55,061	9.1
35-39			
More likely exposed[1]	419	3,181	13.2
Less likely exposed[2]	2,769	26,097	10.6
40 and over			
More likely exposed[1]	103	679	15.2
Less likely exposed[2]	751	5,509	13.6

[1] ZIP codes next to Halaco facility when Halaco operated.
[2] ZIP codes next to Halaco facility when Halaco was closed and Ventura County, excluding ZIP codes next to Halaco facility, both when Halaco operated and was closed.

Table D59. Investigating Association Between Type of Birth and Relative Likelihood of Exposure to Halaco Emissions (Defined by Proximity to and Operating Status of the Halaco Facility), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Type of Birth	Number of Births in More Likely Exposed Areas[1]	Total Births
Singleton	40,320	257,795
Multiple	896	6,675
Chi-square value = 24.3		
p-value = <0.0001*		

*A p-value of less than 0.05 is considered statistically significant.
[1] ZIP codes next to Halaco facility when Halaco operated.

Table D60. Investigating Association Between Type of Birth and Preterm Births, Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Type of Birth	Number of Preterm Births	Total Births
Singleton	3,387	6,675
Multiple	21,705	255,795
Chi-square value = 13,571.1		
p-value = <0.0001*		

*A p-value of less than 0.05 is considered statistically significant.

Table D61. Investigating Association Between Maternal Race and Relative Likelihood of Exposure to Halaco Emissions (Defined by Proximity to and Operating Status of the Halaco Facility), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Maternal Race	Number of Births in More Likely Exposed Areas[1]	Total Births
Hispanic	27,137	118,506
Non-Hispanic White	7,516	118,052
Non-Hispanic Black	1,414	4,705
Non-Hispanic Asian/Pacific Islander	3,083	13,404
Non-Hispanic Other	190	993
Chi-square value = 1,783		
p-value = <0.0001*		

*A p-value of less than 0.05 is considered statistically significant.
[1] ZIP codes next to Halaco facility when Halaco operated.

Table D62. Investigating Association Between Maternal Race and Preterm Births, Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Maternal Race	Number of Preterm Births	Total Births
Hispanic	12,314	118,506
Non-Hispanic White	9,803	118,052
Non-Hispanic Black	646	4,705
Non-Hispanic Asian/Pacific Islander	1,338	13,404
Non-Hispanic Other	105	993
Chi-square value = 38.5		
p-value = <0.0001*		

*A p-value of less than 0.05 is considered statistically significant.

Table D63. Investigating Association Between Maternal Age and Operating Status of and Proximity to the Halaco Facility Status, Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Maternal Age	Number of Births in More Likely Exposed Areas[1]	Total Births
Below 20	5,792	25,864
20-24	12,457	63,790
25-29	11,776	76,927
30-34	7,325	62,386
35-39	3,181	29,278
40 and over	679	6,188
Chi-square value = 2,760		
p-value = <0.0001*		

*A p-value of less than 0.05 is considered statistically significant.
[1] ZIP codes next to Halaco facility when Halaco operated.

Table D64. Investigating Association Between Maternal Age and Preterm Births, Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Maternal Age	Number of Preterm Births	Total Births
Below 20	2,963	25,864
20-24	5,803	63,790
25-29	6,512	76,927
30-34	5,768	62,386
35-39	3,188	29,278
40 and over	854	6,188
Chi-square value = 14.3		
p-value = <0.0002*		

*A p-value of less than 0.05 is considered statistically significant.

Table D65. Logistic Regression Analysis Results for Preterm Births for Crude, Unadjusted Model and Full, Adjusted Model, Halaco Site, Oxnard, California

Model Term	Coefficient			Odds Ratio	
	Point Estimate	Standard Error	p-Value	Point Estimate	95% Conference Interval (Lower Limit, Upper Limit)
Model 1: Crude, Unadjusted					
(Intercept)	-2.28	0.01	<0.0001	-	-
X_1 (exposed vs. unexposed)	0.16	0.02	<0.0001	1.18	(1.14, 1.22)
Model 2: Full, Adjusted					
(Intercept)	-2.69	0.02	<0.0001	-	-
X_1 (exposed vs. unexposed)	0.09	0.02	<0.0001	1.09	(1.05, 1.13)
X_2 (multiple vs. singleton)	2.46	0.03	<0.0001	11.72	(11.13, 12.34)
X_3 (Hispanic vs. Non-Hispanic White)	0.30	0.02	<0.0001	1.35	(1.31, 1.39)
X_4 (Non-Hispanic Black vs. Non-Hispanic White)	0.54	0.05	<0.0001	1.71	(1.56, 1.87)
X_5 (Non-Hispanic Asian/Pacific Islander vs. Non-Hispanic White)	0.25	0.03	<0.0001	1.29	(1.21, 1.37)
X_6 (Non-Hispanic Other vs. Non-Hispanic White)	0.30	0.11	0.01	1.35	(1.09, 1.66)
X_7 (Below 20 vs. 25-29)	0.33	0.02	<0.0001	1.39	(1.33, 1.46)
X_8 (20-24 vs. 25-29)	0.07	0.02	0.0005	1.07	(1.03, 1.11)
X_9 (20-34 vs. 25-29)	0.08	0.02	<0.0001	1.09	(1.05, 1.13)
X_{10} (35-39 vs. 25-29)	0.24	0.02	<0.0001	1.28	(1.22, 1.34)
X_{11} (40 and Over vs.25-29)	0.45	0.04	<0.0001	1.57	(1.44, 1.70)

Table D66. Comparison of Percentages of Preterm Births in ZIP Codes 93033 and 93041 vs. the rest of Ventura County after Halaco Closure (2005-2006), Using Mantel-Haenszel Chi-Square Analysis, Halaco Site, Oxnard, California

Area	Number of preterm births	Total number of births	Percentage of preterm births	Relative risk of preterm births comparing ZIP codes next to Halaco and rest of Ventura County	Chi-Square Value	P-Value
ZIP codes next to Halaco	478	5030	9.5	-	-	-
Rest of Ventura County (excluding ZIP codes next to Halaco)	1800	17734	10.1	0.94	1.82	0.18

Appendix E. Toxicological Summaries

This appendix provides background information from toxicological profiles published by the Agency for Toxic Substances and Disease Registry (ATSDR), information developed by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA), and the U.S. Environmental Protection Agency (EPA) [164]. It highlights the toxicological effects of contaminants exceeding background levels in soil around the Halaco site.

Acronyms and units of measure used in this appendix:

IARC—International Agency for Research on Cancer
DHHS—Department of Health and Human Services
mg/kg/day—milligram per kilogram per day
µg/m^3—microgram per cubic meter
µg/dL—microgram per deciliter
pCi—picocuries

Aluminum [110]

- Is ubiquitous; the third most common element of the earth's crust.
- Naturally released to the environment from the weathering of rocks and volcanic activity. Human activities such as mining also result in the release of aluminum to the environment.
- Found in over-the-counter medicinals, such as antacids and buffered aspirin; used as a food additive; found in a number of topically applied consumer products such as antiperspirants, and in first aid antibiotic and antiseptics, diaper rash and prickly heat, insect sting and bite, sunscreen and suntan, and dry skin products.
- Numerous studies have examined aluminum's potential to induce toxic effects in humans exposed via inhalation, oral, or dermal exposure. Most of these findings are supported by a large number of studies in laboratory animals. Occupational exposure studies and animal studies suggest that the lungs and nervous system may be the most sensitive targets of toxicity following inhalation exposure. The nervous system may be the primarily organ affected by ingestion.
- Exposure to most people is through the consumption of food items, although minor exposures may occur through ingestion of aluminum in drinking water and inhalation of ambient air.
- ATSDR intermediate and chronic oral Minimal Risk Level = 1 mg/kg/day (developmental effect in offspring, decreased limb strength and decreased thermal sensitivity).

Carcinogenicity Classification

- Aluminum production is carcinogenic to humans and pitch volatiles have fairly consistently been suggested in epidemiological studies as being possible causative agents (IARC).
- Not evaluated (DHHS).

Barium [165]

- Naturally occurring element found in rocks, food, and water.
- An important factor affecting the development of adverse health effects in humans is the solubility of the barium compound to which the individual is exposed. The insoluble, nontoxic nature of barium sulfate has made it practical to use this particular barium compound in medical applications as a contrast media for x-ray examination of the gastrointestinal tract.
- One study showed that people who drank water containing as much as 10 parts per million of barium for 4 weeks did not have increased blood pressure or abnormal heart rhythms. In another study, significantly higher mortality rates, particularly among individuals 65 years of age and older, for cardiovascular disease and heart disease (arteriosclerosis) were found in a community with elevated barium drinking water levels (0.06-0.3 mg barium/kg/day) as compared to a community with low barium levels (0.006 mg barium/kg/day).
- The potential for barium to induce reproductive and developmental effects has not been well investigated.
- ATSDR chronic oral Minimal Risk Level = 0.2 mg/kg/day (increased risk of cardiovascular disease).

Carcinogenicity Classification

- Not likely to be carcinogenic to humans following oral exposure and its carcinogenic potential cannot be determined following inhalation exposure (Group D) (EPA).

- No data (DHHS and EPA).

Beryllium [79,166]

- Naturally occurring element found in rocks, coal and oil, soil, and volcanic dust.
- Most beryllium alloys are used in making electrical and electronic parts or as constructions materials for machinery and molds for plastic.
- Emissions from burning coal and oil increase beryllium levels in the air.
- In air, beryllium compounds are presently mostly as fine dust particles. Extremely small beryllium particles may remain in the air for about 10 days.
- Inhalation is the route of greatest concern because beryllium and its compounds are poorly absorbed after ingestion or skin contact.
- The respiratory tract in humans and animals is the primary target of toxicity after breathing beryllium.
- No studies were located regarding respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, hepatic, renal, or dermal, and ocular effects in humans after oral exposure to beryllium or its compounds.
- In dogs, ingestion of beryllium has caused ulcerative gastrointestinal lesions.
- OEHHA Reference Exposure Level = 0.007 $\mu g/m^3$ (chronic beryllium disease in workers).
- OEHHA Inhalation Slope Factor = 8.4 $(mg/kg\text{-}day)^{-1}$.
- ATSDR chronic oral Minimal Risk Level and EPA chronic Reference Dose = 0.002. mg/kg/day (ulcerative gastrointestinal lesions in dogs).

<u>Carcinogenicity Classification</u>

- Beryllium and beryllium compound carcinogenic to humans (IARC).
- Probable human carcinogen (inhalation) (EPA).
- Listed on State of California Proposition 65 Reproductive/Developmental Toxicants (OEHHA).

Cadmium [112]

- Naturally occurring element (metal); also occurs as a result of industrial processes.
- Not usually found as a pure metal, but as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide).
- Enters the body primarily through inhalation and ingestion; people are exposed to cadmium mostly from food and cigarette smoke.
- Inhalation of high levels of cadmium can severely damage the lungs and cause death.
- Chronic exposure (inhalation) to low levels can cause kidney (renal) damage.
- The absorption of cadmium in the intestinal tract by children, from early infancy through 8 years of age, is much greater than later in life.
- There is very little human data on developmental effects from exposure to cadmium; animal studies have shown developmental effects (reduced birth weight and altered locomotor activity).
- Evidence is insufficient to determine an association between inhalation exposure to cadmium and reproductive effects in humans; an animal study has shown decreased sperm count in rats.

- Listed on State of California Proposition 65 Reproductive/Developmental Toxicants (OEHHA).
- The relationship between occupational exposure to cadmium and increased risk of cancer (specifically lung and prostate cancer) has been explored in a number of epidemiologic studies which are not convincing.
- ATSDR chronic oral Minimal Risk Level = 0.0002 mg/kg/day (kidney damage in humans).
- OEHHA chronic Reference Exposure Level = 0.02 µg/m^3 (kidney and respiratory damage in humans).
- OEHHA child-specific Reference Dose = 0.000011 mg/kg/day (kidney effects and greater absorption from the gastrointestinal tract in children).
- OEHHA Inhalation slope factor = 15 $(mg/kg\text{-}day)^{-1}$.

<u>Carcinogenicity Classification</u>
- Probable human carcinogen (limited human, sufficient animal evidence) (EPA).
- Human carcinogen (sufficient human evidence) (IARC).
- Reasonably anticipated to be a human carcinogen (DHHS).
- Listed on State of California Proposition 65 Reproductive/Developmental Toxicants (OEHHA).

Chromium [113]

- Naturally occurring element found in soil and in volcanic dust and gases.
- Different forms (valence states) of chromium; most common form in soil is trivalent chromium.
- Trivalent chromium is an essential nutrient that plays a role in glucose, fat, and protein metabolism by potentiating the action of insulin.
- U.S. EPA chronic oral Reference Dose for trivalent chromium = 1.5 mg/kg/day (reduced liver weight in rats).

<u>Carcinogenicity Classification for trivalent and total chromium</u>
- Not classifiable (EPA).
- Not classifiable (IARC).
- Not classified (DHHS).

Copper [126]

- Naturally occurring metal found in rocks, soil sediment, and water.
- Essential element for humans, plants, and other animals.
- Long-term exposure to copper dust can irritate nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea.
- Common effects from ingestion of higher than normal levels of copper include nausea, vomiting, stomach cramps, or diarrhea.
- ATSDR acute and intermediate oral Minimal Risk Level = 0.01 mg/kg/day (gastrointestinal effects in humans).

<u>Carcinogenicity Classification</u>
- Not classifiable due to a lack of studies (EPA).
- Not reviewed (IARC).

Lead [167]

- Naturally occurring metal found in small amounts in the earth's crust; most of the high levels of lead found in the environment are from human activities.
- People may be exposed to lead by eating foods or drinking water that contains lead, spending time in areas where leaded paints have been used or are deteriorating, lead pipes, and drinking from leaded-crystal glassware.
- People who live near hazardous waste sites may be exposed to lead and chemicals containing lead by breathing the air, swallowing dust and dirt containing lead, or drinking lead-contaminated water.
- Lead affects the nervous system, the blood system, the kidneys, and the reproductive system.
- Low blood levels (30 µg/dL) may contribute to behavioral disorders; lead levels in young children have been consistently associated with deficits in reaction time and with reaction behavior. These effects on attention occur at blood lead levels extending below 30 µg/dL, and possibly as low as 15-20 µg/dL; the developing nervous system of a young child can be adversely affected at blood lead levels below 10 µg/dL.
- Health effects associated with lead are not based on an external dose, but on internal dose that takes into account total exposure.
- Federal agencies and advisory groups have defined childhood lead poisoning as a blood lead level of 10 µg/dL.
- Occupational Safety and Health Administration requires workers with a blood lead level above 50 µg/dL be removed from the workroom where lead exposure is occurring.

<u>Carcinogenicity Classification</u>

- Probable human carcinogen (renal tumors in mice) (EPA).
- Possibly carcinogenic to humans (limited evidence of kidney, brain, and lung cancer) (IARC).
- Listed on State of California Proposition 65 Reproductive/Developmental Toxicants (OEHHA).

Manganese [82]

- Naturally occurring substance found in many types of rock.
- Released into the air from iron- and steel- producing plants, power plants, coke ovens, burning of fossil fuels, and erosion of soil containing manganese.
- Is an essential nutrient.
- Workers exposed to high levels of manganese dust in the air may experience mental and emotional disturbances, slow and clumsy body movements, and impotence.
- People whose water supply contained high levels of manganese showed symptoms of lethargy, increased muscle tone, tremor, and mental disturbances. In another community with high manganese in the drinking water, the children's academic performance was affected.
- There is indirect evidence that reproductive outcomes might be affected (decreased libido, impotence, and sexual dysfunction have been observed in manganese-exposed men); however, the available studies on the effect manganese has on fertility is inconclusive.
- Developmental data in humans exposed to manganese are limited. Animal studies indicate that manganese is a developmental toxin when administered orally and intravenously, but inhalation data concerning these effects are scarce and not definitive.

- Newborns and infants absorb more manganese from the intestinal tract, are less able to excrete it in the feces once taken up, the absorbed manganese passes more easily through the neonatal blood brain barrier, and greater number of transferrin molecules that carry manganese into the brain.
- EPA chronic oral Reference Dose = 0.05 mg/kg/day in water or soil (highest intake for nutritional value without toxicity).
- ATSDR chronic inhalation Minimal Risk Level = 0.04 $\mu g/m^3$ (neurobehavioral changes in workers).
- OEHHA child-specific Reference Dose = 0.03 mg/kg/day (highest intake for nutritional value without toxicity, children have greater potential for toxicity (see above).

<u>Carcinogenicity Classification</u>

- Not classifiable (EPA).

Nickel [125]

- Hard metal that occurs naturally in soils and volcanic dust.
- Released to the atmosphere by windblown dust, volcanoes, combustion of fuel oil, municipal incineration, and industries involved in nickel refining, steel production, and other nickel alloy production.
- The most commonly reported adverse health effect associated with nickel exposure is contact dermatitis. Contact dermatitis is the result of an allergic reaction to nickel that has been reported in the general population and workers exposed via dermal contact with airborne nickel, liquid nickel solution, or prolonged contact with metal items such as jewelry and prosthetic devices that contain nickel. After an individual becomes sensitized to nickel, dermal contact with a small amount of nickel or oral exposure to fairly low doses of nickel can result in dermatitis. Approximately 10–20% of the general population is sensitized to nickel.
- Adverse noncancer respiratory effects have been reported in humans and animals exposed to nickel compounds at concentrations much higher than typically found in the environment.
- The potential for nickel compounds to induce reproductive effects (male reproductive effects and decreased fertility) has not been firmly established but some animal studies have shown such effects (changes in the male reproductive system and impaired fertility) while other studies have not.
- Nickel refinery dust caused lung and nasal tumors in sulfide nickel matte refinery workers in several epidemiologic studies in different countries, and on animal data in which carcinomas were produced in rats by inhalation and injection.
- EPA Reference Dose = 0.02 mg/kg/day (decreased body weight in offspring).
- EPA Inhalation Slope Factor = 0.91 $(mg/kg\text{-}day)^{-1}$ (lung and nasal cancer).
- OEHHA child-specific Reference Dose = 0.011 mg/kg/day (offspring mortality in 3 rat studies).

<u>Carcinogenicity Classification</u>

- Metallic nickel may reasonably be anticipated to be a human carcinogen and nickel compounds are known to be human carcinogens (DHHS).
- Metallic nickel classified in group 2B (possibly carcinogenic to humans) and nickel compounds in group 1 (carcinogenic to humans) (IARC).

- Nickel refinery dust and nickel subsulfide classified in Group A (human carcinogen); other nickel compounds not classified (EPA).
- Listed on State of California Proposition 65 Reproductive/Developmental Toxicants (OEHHA).

Silver [168]

- Since at least the early part of this century, doctors have known that silver compounds can cause some areas of the skin and other body tissues to turn gray or blue-gray. Doctors call this condition "argyria." Argyria occurs in people who eat or breathe in silver compounds over a long period (several months to many years). A single exposure to a silver compound may also cause silver to be deposited in the skin and in other parts of the body; however, this is not known to be harmful. It is likely that many exposures to silver are necessary to develop argyria. Once you have argyria, it is permanent. However, the condition is thought to be only a "cosmetic" problem.
- EPA Reference Dose = 0.005 mg/kg/day (development of argyria).

Carcinogenicity Classification

- Not classified (EPA).

Thorium

- Naturally occurring radioactive metal; 99.99% of natural thorium exists in form (isotope) thorium-232.
- When mined, thorium becomes thorium dioxide or another chemical form.
- Everyone gets exposed to naturally occurring thorium, primarily in food.
- The decay (breakdown) of thorium-232 occurs very slowly; it takes 14 billion years for half of thorium-232 to change into its new forms.
- The decay (breakdown) of thorium-232 results in new products and gives off alpha and beta particles and gamma radiation.
- Used as a fuel in the generation of nuclear energy, and in the manufacture of refractory applications, lamp mantles, aerospace alloys, and welding electrodes.
- Studies of thorium workers have shown that breathing thorium dust may cause an increased chance of developing lung disease and cancer of the lung or pancreas many years after exposure.
- EPA soil ingestion slope factor for thorium-282 and daughters = 8.09×10^{-10} risk/pCi; thorium-230 = 2.02×10^{-10} risk/pCi; thorium-232 = 2.31×10^{-10} risk/pCi.
- EPA inhalation slope factor for thorium-282 and daughters = 1.43×10^{-7} risk/pCi; thorium-230 = 2.85×10^{-8} risk/pCi; thorium-232 = 4.33×10^{-8} risk/pCi.
- EPA external slope factor for thorium-282 and daughters = 7.76×10^{-6} risk/year per pCi/gm soil; thorium-230 = 8.19×10^{-10} risk/year per pCi/gm soil; thorium-232 = 3.42×10^{-10} risk/year per pCi/gm soil.

Carcinogenicity Classification

- All radionuclides classified as Group A (known human) carcinogens (EPA).

Zinc [124]

- One of the most common elements in the earth's crust; can be found in air, soil, water, and all foods.
- Released into the environment as the result of mining, smelting of zinc, lead, and cadmium ores, steel production, coal burning, and burning of wastes.
- An essential nutrient for humans and animals.
- Following inhalation of high levels of zinc oxide, and to a lesser extent, zinc metal and many other zinc compounds, the most commonly reported effect is the development of "metal fume fever." Metal fume fever is characterized by chest pain, cough, dyspnea, reduced lung volumes, nausea, chills, malaise, and leukocytosis. Symptoms generally appear a few hours after exposure, and are reversible 1-4 days following cessation of exposure.
- Following longer-term exposure to lower doses (~0.5-2 mg zinc/kg/day) of zinc compounds, the observed symptoms generally result from a decreased absorption of copper from the diet, leading to early symptoms of copper deficiency. The most noticeable manifestation of the decreased copper levels is anemia, manifesting as decreased erythrocyte number or decreased hematocrit.
- Available studies have not presented evidence of reproductive or developmental effects in humans or animals following inhalation of zinc compounds.
- ATSDR intermediate Minimal Risk Level and EPA Reference Dose = 0.30 mg/kg/day (zinc-induced copper deficiency).

<u>Carcinogenicity Classification</u>

- Inadequate information to assess carcinogenic potential of zinc, because studies of humans occupationally exposed to zinc are inadequate or inconclusive; adequate animal bioassays of the possible carcinogenicity of zinc are not available; and results of genotoxic tests of zinc have been equivocal (EPA).

Appendix F. California Department of Public Health's Responses to Public Comments

On March 9, 2009, this Public Health Assessment (PHA) for the Halaco Engineering Company was released in draft for public comment. The comment period was extended to April 30, 2009, to ensure that the community would have enough time to review the PHA.

As part of the release of the PHA, CDPH held a joint public availability meeting with the Environmental Protection Agency (EPA) on March 11, 2009. EPA sent the meeting announcement to their mailing list of interested parties. CDPH sent the meeting announcement to 4,100 mailing addresses located within 1.25 mile radius of the facility and to the stakeholder mailing list. The PHA was placed in two libraries, one in Oxnard and one in Port Hueneme, for public review and comment. The document is viewable on EHIB's website at www.ehib.org.

CDPH received two sets of comments, which are provided in the following pages. When appropriate, a response from CDPH is provided in italics.

Comments from Cameron Yee, Researcher, Central Coast Alliance United for a Sustainable Economy (CAUSE)

CAUSE makes the following comments on the Public Health Assessment for Evaluation of Exposure to Contaminants at the Halaco Engineering Company.

1. Limitations of the data greatly affected the validity of the conclusions of the assessment. The data used to assess health conditions and disease was far too large of a geographic area to properly conclude what impacts Halaco had on the community of South Oxnard's health.

***CDPH Response*:** *We agree that the large size of the geographic area for our data made it difficult to assess the health impact of the Halaco site. We are limited by the type of data that are collected by the various sources of health outcome data. We performed analysis utilizing the smallest geographic areas available for the data that we could obtain.*

2. Again limitations of the data for the time period from which the data was available affected the analysis as the data did not stretch far enough back to lead to any hard conclusions on health impacts for South Oxnard.

***CDPH Response*:** *It is true that the time period for the available data was often inadequate. Data was not always collected for all health outcomes of interest over the entire time period that Halaco operated. However, we included data in our analysis for the longest time period available.*

3. In analyzing exposure from the current site, the cumulative impacts from the Halaco site as well as other pollution sources in the community such as Aluminum Precision Products, Cook Composites and Polymers, the Hueneme Paper Mill, and the Ormond Beach Power Plant are important in understanding how the health of South Oxnard is affected. CAUSE believes that cumulative impacts from pollution sources should be part of public health assessments,

especially for assessments in low income neighborhoods and communities of color where environmental justice is such an important issue.

__CDPH Response__: *We concur that it is important to look at the cumulative impacts of multiple exposures. However, CDPH is mandated by its Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) to look at the health impacts of specific contaminated sites, particularly superfund sites. In this case, CDPH was assigned to look at the health impacts of the Halaco Superfund Site, not the other sites that you mentioned. Therefore, the exposure pathway analysis of the PHA focuses on Halaco; however, the health outcome data review by its very nature does not look at the impacts from only the site. The health endpoints that were reviewed could have been impacted by other pollution sources in the area.*

Models and techniques for exploring cumulative impacts are still being developed. CDPH referred CAUSE to EPA's efforts to explore cumulative impacts. The EPA has been actively working with community members to develop tools and resources that are relevant to cumulative risk assessment. In addition, the EPA has put together several guidance documents that explain specific approaches and techniques to consider when conducting a cumulative risk assessment. However, there are still a significant gaps in knowledge about the cumulative risk assessment process including: 1) how to quantitatively measure the impact of multiple pollution sources on exposed populations, including interactions of chemicals together, and 2) how to measure the impact of non-chemical stressors, such as socioeconomic and demographic characteristics, on modifying an individual's health risk when exposed to chemicals.

4. A clear distinction needs to be made for vulnerable populations in the analysis of health impacts, especially workers, the elderly, low income, people of color, and the young such as specified by the President Clinton's 1994 Executive Order 12898 on "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations". Long term exposure to a variety of pollutants for these populations should be analyzed.

__CDPH Response__: *CDPH did not look at health outcome data for the vulnerable populations mentioned by CAUSE separately. Due to the way that health outcome data are collected, it was not possible to look at the separate groups within the population for all health outcomes. In addition, when we look at smaller segments within the general population, we have smaller sample sizes for our data review. This gives us a lessened ability to see an association between a specific exposure and particular health outcome.*

However, SAS took into account the presence of vulnerable populations in the analysis of health impacts in a manner that was compatible with the format and limitations of each type of exposure and health outcome data. In our risk assessment calculations for different exposure pathways, we included factors that consider the special vulnerability of children. These factors resulted in more conservative, and therefore more protective, estimations of the health risk due to activities of the Halaco site.

Comments from Senator Fran Pavley, Senate District 23

I am writing to express my concerns about the possible harm to the health of South Oxnard residents from the Halaco metal recycling plant operations nearby, and the California Department of Public Health study released earlier this year. While I appreciate the effort CDPH officials put into the study, I question the conclusion that there were no major health problems associated with Halaco besides a more frequent incidence of preterm births.

As the state senator representing this area, cleaning up of this eyesore and community health hazard is a top priority. The negative impacts to the recently state-owned Ormond Beach property, which is being planned for environmental education and wetland restoration, is also of concern. I want to make sure the voices of my constituents there are heard and their issues addressed. The 240-page CDPH study, though exhaustive in its research of documentation and statistics, seems to fall short in basic community outreach.

The study notes:

CDPH officials "gathered community health concerns in person, via telephone, and by email beginning in June of 2007. CDPH coordinated outreach activities with EPA. EPA included an announcement about CDPH outreach in an EPA fact sheet distributed to English- and Spanish-speaking residents by mail and in person. CDPH carried out a series of coordinated community presentations with EPA, providing joint presentations to the community and elected officials in September and October 2007. CDPH met with key leaders from local community-based organizations to identify outreach strategies for different segments of the community. Based on this feedback, CDPH staff met in person with workers of neighboring facilities, performed in-person canvassing of the shopping strip near the Halaco site, and explored future outreach ideas with local school and community health center staff. In addition, some community members contacted CDPH when local newspapers announced CDPH's involvement at the Halaco site."

But there is no indication in the study how many people were actually interviewed. At the March 11 community meeting about the study, one CDPH official told the South Oxnard gathering that about 30 people were questioned. That sounds like a very small number for such a large and important effort chronicling 40 years of contamination.

One man at the meeting said he had worked in the area for decades and now has cancer. Was he interviewed? There were other community members present who clearly were disappointed in the study's findings and outreach efforts, some of whom left the meeting early.

I understand the challenges of finding everyone who might have been affected by Halaco's operations. But only finding 30 or so people falls way short.

Going forward, I will be closely monitoring the Halaco cleanup to make sure this neighborhood is not neglected.

<u>CDPH Response</u>*: It seems that Senator Pavley got some misinformation about the CDPH outreach effort. CDPH spoke with quite a bit more than 30 individuals about the Halaco site.*

For instance, CDPH met with the staff of the Oxnard Wastewater Treatment facility and there were almost 50 staff in attendance at that one meeting. CDPH met with 10-15 workers from the former Weyerhauser plant. CDPH went door to door and talked with about 40 different retail businesses located along West Hueneme Road. CDPH heard concerns from a number of community members when they participated in an EPA meeting about the site in September 2007, which had been advertised to a large part of Port Hueneme and Oxnard and to the Port Hueneme City Council in October 2007. CDPH also received a number of community concerns via email and via the telephone.