# Health Consultation

Evaluation of Community Exposure to Lead and Sulfur Dioxide in Air

HAYDEN AND WINKELMAN COMMUNITIES

GILA AND PINAL COUNTY, ARIZONA

**Prepared by:**
**Arizona Department of Health Services**

MAY 25, 2018

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

**Health Consultation: A Note of Explanation**

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or 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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# Summary


**INTRODUCTION**

This report was written in response to a request to the Arizona Department of Health Services (ADHS) by the Arizona Department of Environmental Quality (ADEQ) to evaluate whether exposure to detected levels of sulfur dioxide ($SO_2$) and lead in outdoor air in Hayden and Winkelman, AZ could harm the health of nearby residents. Both $SO_2$ and lead have been found in the area at levels exceeding the U.S. Environmental Protection Agency's (EPA) National Ambient Air Quality Standards (NAAQS) and the World Health Organizations Air Quality Guidelines (AQGs).

ADHS evaluated ambient air data collected from 8 area monitoring stations—three ADEQ monitoring stations (1 for $SO_2$ and 2 for lead) and 5 EPA monitoring stations measuring lead in the assessment. $SO_2$ data were collected from 2010 to 2016. Lead data were collected from 2011 to 2016.

**CONCLUSION**

Based on the available information, ADHS reached the following conclusion: *Currently and in the past, breathing air containing the concentrations of $SO_2$ and lead measured in the Hayden and Winkelman area could harm people's health*.

**BASIS FOR CONCLUSION**

$SO_2$:

- Between 2014 and 2016, 10-minute average $SO_2$ measurements in Hayden were occasionally as high as 1,000 parts per billion (ppb). People breathing $SO_2$ at those levels for short periods could experience increasing airway resistance, exacerbation of pre-existing respiratory conditions, and wheezing, particularly when performing an activity that raises their breathing rate. At $SO_2$ levels above 500 ppb, they could have needed to take their medication more frequently, gone to the doctor, or had to stop physical activity (ATSDR 1998).

- $SO_2$ measurements were found to exceed the Agency for Toxic Substances and Disease Registry's (ATSDR's) acute Minimal Risk Level (MRL) or EPA's NAAQS more than 600 times during the initial screening analysis. Between 2014 and 2016, 10-minute $SO_2$ measurements exceeded the World Health Organization's (WHO's) guideline of 190.8 ppb more than 100 times each year. Sensitive groups such as people with asthma and other respiratory conditions, could have experienced coughing, wheezing, and chest tightness during those events.

Lead:

- Between 2011 and 2016, lead levels at three of the five monitoring locations (or five of the seven monitors) exceeded the NAAQS (0.15

micrograms per cubic meter, µg/$m^3$, rolling three-month average). Two of these monitoring locations were in non-residential areas and one was in a residential area.

- EPA established the NAAQS for lead to prevent children from experiencing cognitive neurological effects from air-related lead exposure such as IQ decrement [EPA 2014b].

- Children breathing air contaminated with lead in Hayden and Winkelman could have an increased chance for neurocognitive or neurobehavioral effects.

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**RECOMMENDATIONS**

ADHS supports ongoing efforts by ADEQ and EPA to reduce SO2 and lead levels in air and other environmental media. Such actions include implementation of the EPA/ASARCO 2015 Consent Decree, ADEQ state implementation plan revisions to bring the area into attainment with the SO2 and lead NAAQS, and remedial actions taken through EPA's Superfund Alternative Approach process.

Because children can experience health effects at low blood lead levels (BLLs), ADHS recommends that ADEQ, EPA, and local health departments use ADHS and CDC fact sheets to help educate families, health care providers, advocates, and public officials on primary prevention of lead exposure in homes and other child-occupied facilities, so that lead hazards are eliminated before children are exposed.

ADHS recommends that health care providers notify the family of all children with a confirmed blood lead level (BLL) greater than or equal to (≥) 5 micrograms per deciliter (µg/dL) in a timely and appropriate manner. In addition, conduct follow-up blood lead testing using CDC's recommendations available at: https://www.cdc.gov/nceh/lead/acclpp/actions_blls.html.

ADHS recommends that health care providers monitor the health status of all children with a confirmed BLL ≥5 µg/dL for subsequent increase or decrease in BLL until recommended environmental investigations and mitigation strategies are complete.

ADHS recommends that community members take steps to protect themselves from exposure to lead:

- Participate in the home lead-based paint testing and abatement project ASARCO is funding through the EPA/ASARCO Consent Decree.

- Subscribe to the ADEQ lead in air forecast using the following link: http://www.azdeq.gov/programs/air-quality-programs/air-forecasting.

Follow ADHS' recommendations, such as washing your child's hands often and keeping their toys clean, to reduce exposures to lead. Additional information is available at: http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/childhood-lead/poisoning-flyer.pdf

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**NEXT STEPS**

ADHS will notify ADEQ regarding the findings of this report.

ADHS will continue to review and evaluate data provided for this site upon request.

ADHS will provide support for public meetings to discuss this health consultation upon request. ADHS will make presentations, develop handouts, and provide additional assistance as necessary to notify residents of the findings of this health consultation.

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**FOR MORE INFORMATION**

If you have concerns about your health, you should contact your health care provider. Please call ADHS at 602-364-3118 if you have questions about this report.

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# Purpose

The Arizona Department of Environmental Quality (ADEQ) Air Quality Division requested that the Arizona Department of Health Services (ADHS) prepare a health consultation to address the frequent exceedances of the U.S. Environmental Protection Agency's (EPA) National Ambient Air Quality Standards (NAAQS) for sulfur dioxide ($SO_2$) and lead in the adjacent towns of Hayden and Winkelman located in Gila and Pinal Counties, AZ. ADEQ expressed their concerns for residents living near the ASARCO Hayden Plant site. This health consultation evaluates whether exposure to detected levels of $SO_2$ and lead in ambient air may harm the health of nearby residents under current land use conditions.

# Background and Statement of Issues

*Location*: Hayden and Winkelman, Arizona are about 100 miles southeast of Phoenix and about 50 miles northeast of Tucson, AZ. The ASARCO Hayden copper smelter plant site sits between the two small towns (Figure 1). According to the 2015 American Community Survey, Hayden has a population of about 600 and Winkelman has a population of about 330. The nearby industrial areas include the ASARCO smelter, concentrator, former Kennecott smelter and all associated tailings facilities in the area. Figure 1 shows the population density for Hayden and Winkelman.

Hayden and Winkelman are positioned near the San Pedro River drainage. The area has a southeast to northwest gradient, with elevation decreasing toward the northwest. The complex terrain creates localized daily wind patterns. In general, during the day, winds tend to move toward Hayden (from south to north and from southeast to northwest). At night winds move the opposite direction, towards Winkelman (from north to south and from northwest to southeast). A detailed description of the wind complexity can be found at EPA's Remedial Investigation/Feasibility Study (RI/FS) Work Plan [EPA 2012].

*EPA and ADEQ's Involvement:* EPA and ADEQ have taken several actions to understand and reduce environmental contamination in Hayden and Winkelman.

Superfund Alternative Approach Actions: In 2008, EPA performed a Phase I Remedial Investigation (RI) and the results indicated the current and former ASARCO operations resulted in measurable impacts to soils, ambient (outdoor) air, and indoor dust, and to a lesser extent, impacts to groundwater, surface water and sediment. An EPA contractor, CH2M Hill, used data reported in the RI to prepare a Human Health Risk Assessment for EPA [CH2M Hill 2008 a,b]. Between 2008 and 2014, contaminated soil was removed and replaced from over 260 residential properties in Hayden and Winkelman [EPA 2015b]. EPA is conducting another remedial investigation to evaluate contamination in non-residential soils, air, and ground and surface water [EPA 2017]. Data and information gathered from this investigation will be used to develop additional cleanup options.

Air Quality Actions: Since 2010, EPA and ADEQ have installed numerous air monitoring stations on the smelter property and throughout the Hayden-Winkelman area to collect air data to characterize air contamination, and sources. These data show that emissions from the ASARCO plant contribute to lead and $SO_2$ levels in ambient air [EPA 2015a; ATSDR 2017].

EPA designated the Hayden, AZ area as a nonattainment area for the $SO_2$ and lead NAAQS in 2013 and 2014, respectively [EPA 2013, 2014c]. ADEQ is revising Arizona's $SO_2$ and lead state implementation plans to reduce $SO_2$ and lead levels in the area and bring the area into attainment with both NAAQS [ADEQ 2017a,b].

In 2015, EPA and ASARCO settled alleged Clean Air Act violations through a Consent Decree. Implementation of the Consent Decree will reduce emissions from the smelter plant. It requires the company to install new equipment and pollution control technology at the Hayden smelter, fund local environmental health projects (including a lead-based paint testing and abatement program for homes and public buildings), replace a diesel locomotive with a cleaner model, and pay a civil penalty [EPA 2015c].

*ATSDR and ADHS Involvement*:

- 1999: The University of Arizona conducted a biomonitoring survey [Burgess et al. 2000] under an ADHS contract to evaluate arsenic and lead exposures and potential health effects among residents of Hayden and Winkelman. The study reported no elevated blood lead levels (≥ 10 µg/dL) in a small group of 14 children who participated in blood lead testing.

- 2002: ADHS completed a public health assessment (PHA) [ATSDR 2002] of the ASARCO Hayden Smelter Site in Hayden. Residents of the town expressed concerns that metals from smelter emissions over the years had been causing health problems. ADHS was made aware of the concerns by EPA Region IX. The PHA evaluated water, soil, and air data. The report concluded that exposure to $SO_2$ in air occasionally posed a short-term public health hazard to sensitive populations such as children, elderly, and individuals with respiratory disease. Episodes of higher levels of $SO_2$ in air were reported to be infrequent. The report concluded that breathing $SO_2$ was not a public health hazard for non-sensitive people (i.e. healthy individuals) and that other environmental exposures did not pose a public health hazard.

- 2015: EPA requested that the Agency for Toxic Substances and Disease Registry (ATSDR) conduct an exposure investigation in Hayden and Winkelman to better understand residents' exposure to lead and arsenic. ATSDR offered blood and urine testing for eligible residents to measure lead and arsenic exposure. Lead testing was done for 83 residents from 29 households and test results were sent to participants in June 2015. Blood lead levels (BLLs) for two children exceeded the exposure investigation blood lead follow-up level (5 micrograms per deciliter, µg/dL) at 5.9 µg/dL (1–5 year old age group) and 5.3 µg/dL (6–11 year old age group). Additionally, two children in the 1-5 year old

age group had blood lead levels between 4 and 5 µg/dL. ATSDR's exposure investigation blood lead follow-up level is consistent with the 2012Centers for Disease Control and Prevention's reference level [CDC 2012b].

- 2016: ADHS' Childhood Lead Poisoning Prevention Program reviewed available blood lead data for Hayden and Winkelman, Arizona. Blood lead results are reported to the ADHS per Arizona Administrative Code R9-4-302. Blood lead testing is not universal in Arizona. Arizona utilizes a targeted screening plan with high-risk zip codes across the state for recommended blood lead testing. If children live outside the high-risk zip codes, a questionnaire is recommended to assess risk and testing is ordered when appropriate. The intent of a targeted screening approach is to increase screening rates in specific geographical locations, which limits the ability to establish a state average or compare rates to a state average. By design, more children likely to be exposed to lead will be tested, which may artificially raise the state rate if it were compared to a universal screening approach. The Hayden and Winkelman area was identified as high-risk in the 2014 Targeted Lead Screening Plan for Lead Poisoning Prevention, which has been in use since 2014.

  Between 2014 and 2016, there were 110 children under the age of 16 tested in Hayden and Winkelman. Among those children tested, 8 (7.3%) children had venous-confirmed BLLs greater than or equal to the CDC reference value of 5 µg/dL established in 2012, compared to 1,468 (0.9%) children with elevated BLLs statewide in the same time period. Among children with elevated BLLs, 271 of 1,468 (18.5%) children statewide had blood lead levels above 10 µg/dL, while zero Hayden and Winkelman children had results above 10 µg/dL between 2014 and 2016. Arizona counts include children tested from both inside and outside of high-risk zip codes.

- 2017: ADHS offered blood lead testing to all Hayden and Winkelman residents on April 28-29, 2017 as a two year follow-up to ATSDR's Exposure Investigation and to address some community members concerns about the limited eligibility criteria during ATSDR's 2015 testing. There were 13 children (less than 16 years of age) and 79 adults (16 years and older) who provided the 92 blood samples. Participants ranged in age from 15 months to 86 years. ADHS defined an elevated BLL for children and adults, respectively, when BLLs are greater than or equal to 5 µg/dL and 10 µg/dL. Two children (5.9 and 16.2 µg/dL) had BLLs at or above the ADHS follow-up levels. Participants were sent their results by mail and provided educational materials to reduce exposures to lead. ADHS provided further recommendations by phone for participants who were identified with elevated BLLs. The source of lead poisoning was found to be lead-based paint.

# Discussion

## General Assessment Methodology

ADHS conducted a three-step process to evaluate the public health implications of the $SO_2$ and lead in ambient air in this community (ATSDR 2005). ADHS evaluated ongoing and past exposures. First, ADHS conducted an exposure pathway analysis to identify how people are likely exposed. Second, ATSDR conducted a screening analysis by comparing the ambient air monitoring data to the EPA Air Quality Index (AQI), ATSDR Minimal Risk Level (MRL), World Health Organization (WHO) Air Quality Guidelines (AQGs), and NAAQS. Third, ADHS conducted a more detailed public health evaluation of contaminants of concern identified in the screening analysis.

## Available Environmental Data

ADHS received ambient air data on $SO_2$ and lead from ADEQ. The data were collected at 8 monitors—three ADEQ monitors (1 for $SO_2$ and 2 for lead) and five EPA monitors measuring lead (Figure 2). Generally, all ambient air monitors in Hayden, AZ are located in areas to collect ASARCO emissions, either from fugitive sources or stacks (personal communication with Craig Pearson at ADEQ). After consulting with ADEQ, ADHS assumed that adequate quality assurance/quality control (QA/QC) procedures were followed. ADEQ has a standard procedure to ensure that the data meets QA/QC guidelines.

Sulfur dioxide levels were collected continuously from 2010 to 2016 at one ADEQ monitoring station in Hayden (Figure 2). Lead levels were collected every 6 days between 2011 to 2016 from a network of 12 monitoring stations in Hayden and Winkelman. ADEQ's stations measured lead concentration in total suspended particles (TSP). TSP are airborne particles having diameters less than 100 micrometers (µm). EPA's stations measured lead concentrations in TSP and/or particulate matter 10 µm's in diameter or less ($PM_{10}$). All $PM_{10}$ lead concentrations were below the NAAQS. ADHS used only TSP concentrations in this evaluation because it contains total lead and is the more health-protective fraction. ADHS did not include in this analysis data from 5 EPA air monitoring stations that collect $PM_{10}$, but not TSP, concentrations. In addition, ADHS treated Hayden and Winkelman as a single town since the area is relatively small. The driving distance is about 2.5 miles (less than 4 km) from the farthest edge of Hayden to the farthest edge of Winkelman (Figure 3).

This health consultation evaluated potential health risks associated with exposures to $SO_2$ and lead in the air through inhalation. Table 1 presents an assessment of the inhalation exposure pathway and concludes that residents and visitors in Hayden and Winkelman can inhale $SO_2$ and lead released from smelter operations into ambient air while they are doing indoor and outdoor activities. ADHS concludes that inhalation is a completed exposure pathway. ADHS further evaluated the completed inhalation exposure pathway to determine whether realistic exposures were at high enough concentrations, often enough, and for a long enough period of time, to result in adverse health effects.

## Screening Analysis: Comparison to Health-based Comparison Values

Following identification of a completed/potential exposure pathway, ADHS conducted a screening analysis of detected chemicals against health-based comparison values (CVs). These comparison values are conservative, and include uncertainty factors that account for the most sensitive populations. Adverse health effects are not expected to occur if an exposure concentration is below a CV. However, an exposure concentration at or above the CV does not automatically mean adverse effects will occur. Rather, it means that there is a need to conduct a site-specific exposure evaluation. The health risk for an individual depends on individual human factors (e.g. personal habits, occupation, and/or overall health), and site-specific environmental exposure factors (e.g. duration and amount of exposure). Therefore, the CVs are not used to predict the occurrence of adverse health effects without looking at site-specific conditions.

ADHS used EPA's AQI and NAAQS, ATSDR's MRL, and WHO's AQGs, as comparison values in the screening analysis. ADHS used 1-hour and 24-hour averages for the $SO_2$ screening analysis and 3-month rolling averages for the lead screening analysis.

*Sulfur Dioxide ($SO_2$)*: ATSDR has developed an acute (14 days or less) MRL for $SO_2$ at 10 ppb (ATSDR 1998). An MRL is a concentration below which no harmful health effects are expected. Between 2010 and 2016, the $SO_2$ 24-hour average in Hayden exceeded acute MRL 705 times.

EPA's air quality index (AQI) is an index for rating local air quality and its effects on the health. The AQI scale ranges from 0 to 500, with higher AQI values indicating worse air quality. In general, an AQI value of 100 corresponds to the NAAQS for the pollutant [EPA 2014a]. EPA's one-hour $SO_2$ NAAQS is 75 parts per billion (ppb). Thus, the AQI indicates that air is unhealthy for sensitive groups if the 1-hour average $SO_2$ level is 76 ppb (AQI=101). Between 2010 and 2016, the $SO_2$ 1-hour average in Hayden exceeded 75 ppb (AQI = 100) more than 90 times each year (Table 2a).

*Lead*: Neither ATSDR nor the EPA has developed a MRL or reference dose (RfD) for exposure to lead. Therefore, ADHS cannot use the usual approach of estimating human exposure to an environmental contaminant and then comparing that dose to a health based comparison value (such as an MRL or RfD). Instead ADHS used the NAAQS for lead. The NAAQS for lead requires that lead concentrations in TSP for any 3-month rolling average not exceed 0.15 microgram per cubic meter ($\mu g/m^3$). As seen in Table 3, lead concentrations in TSP measured at 3 locations, Globe Highway (ADEQ monitor), Hillcrest (both ADEQ and EPA monitors), and Smelter Parking Lot (EPA monitor), were above the NAAQS.

## Public Health Implications

### Sulfur Dioxide

Sulfur dioxide ($SO_2$) is formed during the burning of sulfur-containing substances (e.g. coal), metal smelting, and other industrial processes. Oxidation of $SO_2$ can form sulfurous and sulfuric acids. Neutralization (by ammonia) leads to the formation of bisulfates and sulfates. $SO_2$ is a colorless gas with a strong odor and is readily soluble in water [ATSDR 1998]. $SO_2$ is highly reactive with the mucous membranes of the nose and upper respiratory tract due to its high solubility, and is considered a respiratory irritant [WHO 2000].

#### *$SO_2$ sub-acute 10-minute exposures*

Short-term $SO_2$ exposures can have health effects. For the initial screening process for $SO_2$, ADHS used the 1-hour average based on EPA's approach to determine whether the 1-hour values may be a concern. The result provided evidence that there were shorter-term $SO_2$ exposures of potential health concern. Based on this evaluation, ADHS then choose to use 10-minute average $SO_2$ data to further evaluate the public health implications and to determine the possible severity of the short-term exposures. As reviewed by the WHO [WHO 2000], most of the short-term exposure studies were done with volunteers in controlled chamber experiments (mostly 10-15 minute exposures). Decreased lung function was the most commonly observed short-term effect, with studies noting that their severity was influenced by individual sensitivity. Some people were not affected by concentrations that lead to severe bronchoconstriction (narrowing of airways in the lungs) in others. Asthmatics were particularly sensitive to the exposure [ATSDR 1998]. When $SO_2$ reaches lower lung regions as often occurs with exercise due to deeper, more frequent breathes, the effect on lung function is worse [ATSDR 1998]. The maximum effects were usually reached within a few minutes and the effects were generally short-lived for healthy adults [ATSDR 1998].

General Public: Clinical study results showed lung function alternation did not occur in healthy individuals when they were exposed to $SO_2$ concentration less than 1,000 ppb [ATSDR 1998; EPA 2008a; WHO 2000]. Based on the available data from 2010-2016, 4 out of 143,652 $SO_2$ 10-minute concentrations in Hayden (roughly ~0.003% of all readings) exceeded 1,000 ppb (Table 2b). During these infrequent events, people in Hayden may have been exposed to $SO_2$ at these levels for a short time. Figure 4 shows the concentrations of $SO_2$ measured at ADEQ's Hayden Old Jail station. No specific daily- or seasonal-patterns were identified. When $SO_2$ concentrations exceed 1,000 ppb, some people may have experienced differing degrees of $SO_2$-related respiratory symptoms, depending on their existing respiratory health, physical activity levels.

Sensitive Populations: Sensitive populations such as those with asthma or other respiratory issues/diseases respond in a similar way to most people except that the respiratory effects happen at lower concentrations. According to published clinical studies, respiratory effects were observed in asthmatic adults when exposed to $SO_2$ levels < 1,000 ppb [ATSDR 1998; EPA

2008a]. These clinical studies did not include children or individuals with severe asthma. The clinical studies were conducted under controlled exposure conditions, such as humidity and temperature. Studies showed that real-world exposure conditions, for example cold and dry air, could induce effects at lower $SO_2$ concentrations [ATSDR 1998].

Studies showed that fairly large changes in lung functions took place when asthmatics were exposed to 600 ppb during heavy exercise [ATSDR 1998], and at 500 ppb during moderate or severe exercise [ATSDR 1998]. Asthmatics experienced effects at less than 200 ppb of $SO_2$ delivered by mouthpiece. The lowest observed adverse effect level (LOAEL)[1] found was 100 ppb. The primary effects from exposure between 100 to 200 ppb was asymptomatic bronchoconstriction to moderately exercising asthmatics [ATSDR 1998]. However, studies in free-breathing exposures[2] have not been conducted below 200 ppb. Thus, we do not know whether sensitive people with increased breathing rates would experience the same effects when exposed to $SO_2$ less than 200 ppb under normal environmental conditions.

WHO recommends that $SO_2$ concentrations should not exceed 190.8 ppb (500 $\mu g/m^3$) over an averaging period of 10 minutes [WHO 2005]. Available studies on exercising asthmatics showed that some participants had respiratory symptoms and experienced changes in lung function after exposure to $SO_2$ for as little as 10 minutes [WHO 2005]. In the past 3 years, 10-minute $SO_2$ readings in Hayden showed more than 100 exceedances of the WHO guideline each year (Table 2b). Individuals who lived in Hayden and Winkelman likely experienced exposures above the WHO guideline regularly. Sensitive individuals, like asthmatics could have experienced respiratory effects due to these short-term exposures. Those effects could have included the exacerbation of asthma as well as coughing, wheezing, and chest tightness. When exposed to $SO_2$ levels above 500 ppb, these sensitive individuals may need to stop physical activity, take their medication more frequently, or seek medical attention.

The International Agency for Research on Cancer [IARC 1992] has classified $SO_2$ as Group 3, not classifiable as to human carcinogenicity. No study clearly showed cancer-causing effects from exposure to $SO_2$ in human or animals [ATSDR 1998]. Workers were studied in the copper smelting and pulp and paper industries, but the results were inconclusive since the workers were also exposed to arsenic and other chemicals [ATSDR 1998]. The one available animal study suggests that $SO_2$ may be a carcinogen in mice [ATSDR 1998].

## Lead

Lead is a naturally occurring metal and is typically found at low levels in soils. Lead is processed for many industrial and manufacturing applications, and is found in many metallic alloys. On a national level, many different sources emit lead, including boilers, electricity-generating

[1] The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

[2] In free-breathing exposure studies, participants breathe the air while isolated in a large chamber. In some other studies exposures are delivered by mouthpiece breathing. Individuals exposed to $SO_2$ through a mouthpiece are likely to experience greater respiratory effects from a given $SO_2$ exposure.

facilities, and incinerators [ATSDR 2007; EPA 2006]. The most common ways people are exposed to lead are by swallowing dust or dirt, drinking water, eating foods, or breathing air contaminated with lead.

Elevated blood lead levels can cause serious, irreversible damage to the nervous system. Children's nervous systems are still developing and are more susceptible to long-term damage than adults'. Unborn children can be exposed to lead through their pregnant mothers. In addition to cognitive effects, lead exposure could cause weakness in fingers, wrists, or ankles, small increases in blood pressure, anemia, kidney damage, and seizures [ATSDR 2007].

Lead affects children more than other age groups because young children are more likely to absorb lead through their gastrointestinal tract than adults and to exhibit the types of nutritional deficiencies, such as anemia, that facilitate the absorption of lead [ATSDR 2007; Hegazy et al. 2010]. In addition, this age group is likely to have more contact with lead because they like to play in dirt and place their hands and other contaminated objects in their mouths [ATSDR 2007]. In 2012, CDC adopted the 97.5 percentile of blood lead levels for children aged 1 through 5 years in the National Health and Nutrition Examination Survey as the reference value for identifying children and environments associated with lead-exposure hazards. The 97.5 percentile is currently 5 µg/dL [CDC 2012a,b].

Children who are exposed to lead might have increased chances for slower growth and development, developing hearing damage, and attention and learning problems [ATSDR 2007]. The lead NAAQS was established to prevent neurocognitive effects (i.e. loss of 1-2 IQ points) due to air related exposures [EPA 2014b]. It was determined by an evidence-based framework using a quantitative exposure/risk assessment process that relied on an air-to-blood ratio of 1:7, with 1 representing air lead in µg/$m^3$ and 7 representing blood lead in µg/dL [EPA 2008b; EPA 2014b].

Air monitors at three of five locations exceeded the lead NAAQS:

- Globe Highway (non-residential area, Winkelman),
- Smelter parking lot (non-residential area, Hayden), and
- Hillcrest Avenue (residential area, Hayden).

The available data showed that ADEQ's Globe Highway monitor exceeded the NAAQS 9 times from 2011 to 2016. EPA's Globe Highway monitor exceeded the NAAQS 4 times from 2013 to 2015. ADEQ's Hillcrest monitor exceeded the NAAQS once in 2016. EPA's Hillcrest Avenue monitor exceeded NAAQS 12 times from 2013 to 2015. EPA's smelter parking lot monitor exceeded the NAAQS 18 times from 2013 to 2015 (Table 3).

Figure 5 shows the concentrations of lead in TSP measured at monitors in Hayden and Winkelman. As expected, the airborne concentration of lead is much higher near the smelter source. No specific daily- or seasonal-patterns were identified. The highest lead annual average concentrations in TSP were similar (~0.130 to 0.199 µg/$m^3$) at the Globe Highway, Hillcrest, and

Post Office ambient air monitors in Hayden and Winkelman. The highest lead annual average concentration measured was much higher at the smelter parking lot (0.919 µg/$m^3$), and much lower at the Hayden High School (0.029 µg/$m^3$). In the evaluation, ADHS treated Hayden and Winkelman as a town because the community is fluid between the two towns and they are geographically proximate. Based on the ambient air concentrations measured, breathing air contaminated with lead in this area could potentially increase childhood risk for cognitive deficits such as IQ decrements.

### Limitations

One of the limitations of this study is that $SO_2$ conclusions are based on one $SO_2$ monitor, located in Hayden. According to ADEQ, the monitor was sited to collect ASARCO emissions from fugitive sources and stacks. It is assumed that this monitor is representative of pollutant concentrations within 4 km. The monitor may not be representative of concentrations outside of that radius, which includes some areas of the broader Hayden and Winkelman communities.

It is assumed that the measured $SO_2$ and lead concentrations are representative of the exposure point concentrations. Lead was sampled every 6 days. In addition, lead tends to fall out closer to the source and be more localized. $SO_2$ tends to be more uniform across areas, however, the actual exposure point concentrations are affected by meteorology, topography, and the source characteristics. Also, the air monitoring data cannot predict future concentrations given anticipated projects at the facility.

## Conclusions

This health consultation evaluated the potential health risks associated with exposure to $SO_2$ and lead in ambient air. The ambient air sampling results were provided by ADEQ. Based on the available information, ADHS reached the following conclusion:

*Breathing air contaminated with $SO_2$ and lead in the Hayden and Winkelman area may harm people's health*.

### Sulfur Dioxide:

- Between 2014 and 2016, 10-minute average $SO_2$ measurements were occasionally measured in Hayden as high as 1,000 parts per billion (ppb). People breathing $SO_2$ at those levels for short periods could experience increasing airway resistance, exacerbation of pre-existing respiratory conditions, and wheezing, particularly when performing an activity that raises their breathing rate. At $SO_2$ levels above 500 ppb, they could have needed to take their medication more frequently, gone to the doctor, or had to stop physical activity.
- $SO_2$ measurements were found to exceed the Agency for Toxic Substances and Disease Registry's (ATSDR's) acute Minimal Risk Level (MRL) or EPA's NAAQS more than 600

times during the initial screening analysis. Between 2014 and 2016, 10-minute $SO_2$ measurements exceeded the World Health Organization's (WHO's) guideline of 190.8 ppb more than 100 times each year. Sensitive groups such as people with asthma and other respiratory conditions, could have experienced coughing, wheezing, and chest tightness during those events.

### Lead:

- Between 2011 and 2016, lead levels at three monitoring locations exceeded the NAAQS (0.15 micrograms per cubic meter, $\mu g/m^3$, rolling three-month average). Two of these monitoring locations were in non-residential areas and one was in a residential area.

- EPA established the NAAQS for lead to prevent children from experiencing cognitive neurological effects from air-related lead exposure such as IQ decrement [EPA 2014b].

- Children breathing air contaminated with lead in Hayden and Winkelman could have an increased chance for neurocognitive or neurobehavioral effects.

## Recommendations

- ADHS supports ongoing efforts by ADEQ and EPA to reduce $SO_2$ and lead levels in air and other environmental media. Such actions include implementation of the EPA/ASARCO 2015 Consent Decree, ADEQ state implementation plan revisions to bring the area into attainment with the $SO_2$ and lead NAAQS, and remedial actions taken through EPA's Superfund Alternative Approach process.

- Because children can experience health effects at BLLs, ADHS recommends that ADEQ, EPA, and local health departments use ADHS and CDC fact sheets to help educate families, health care providers, advocates, and public officials on primary prevention of lead exposure in homes and other child-occupied facilities, so that lead hazards are eliminated before children are exposed.

- ADHS recommends that health care providers notify the family of all children with a confirmed BLL ≥5 micrograms per deciliter (µg/dL) in a timely and appropriate manner. In addition, conduct follow-up blood lead testing using CDC's recommendations available at: https://www.cdc.gov/nceh/lead/acclpp/actions_blls.html.

- ADHS recommends that health care providers monitor the health status of all children with a confirmed BLL ≥5 µg/dL for subsequent increase or decrease in BLL until recommended environmental investigations and mitigation strategies are complete.

- ADHS recommends that community members take steps to protect themselves from exposure to lead:
  - Participate in the home lead-based paint testing and abatement project ASARCO is funding through the EPA/ASARCO Consent Decree.
  - Subscribe to the ADEQ lead in air forecast using the following link: http://www.azdeq.gov/programs/air-quality-programs/air-forecasting.
  - Follow ADHS' recommendations, such as washing your child's hands often and keeping their toys clean, to reduce exposures to lead. Additional information is available at: http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/childhood-lead/poisoning-flyer.pdf.

## Public Health Action Plan

- ADHS will notify ADEQ regarding the findings of this report.
- ADHS will continue to review and evaluate data provided for this site upon request.
- ADHS will provide support for public meetings to discuss this health consultation upon request. ADHS will make presentations, develop handouts, and provide additional assistance as necessary to notify the property owners and residents in the area of the findings of this health consultation.

# References

ADEQ, 2017a. Arizona Department and Environmental Quality. Public Notice: Proposed Hayden Sulfur Dioxide Nonattainment Area State Implementation Plan (SIP) Revision. Available at: http://www.azdeq.gov/public-notice-proposed-hayden-sulfur-dioxide-nonattainment-area-state-implementation-plan-sip. Last accessed March 23, 2018.

ADEQ, 2017b. Arizona Department and Environmental Quality. Public Notice: Proposed Hayden Lead Nonattainment Area State Implementation Plan (SIP) Revision. Available at: http://www.azdeq.gov/public-notice-proposed-hayden-lead-nonattainment-area-state-implementation-plan-sip-revision. Last accessed March 23, 2018.

ATSDR, 1998. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Sulfur Dioxide. Agency for Toxic Substances and Disease Registry, Public Health Service, United States Department of Health and Human Services, Atlanta, GA.

ATSDR, 2002. Public Health Assessment: ASARCO Hayden Smelter Site, Hayden, Arizona. Atlanta, Georgia: US Department of Health and Human Services. Available at: http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/environmental-toxicology/asarco-hayden.pdf. Last accessed March 23, 2018.

ATSDR, 2005. Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual (Update). Atlanta, Georgia: US Department of Health and Human Services/

ATSDR, 2007. Agency for Toxic Substances and Disease Registry. Toxicological profile for lead (update). Atlanta, Georgia: US Department of Health and Human Services.

ATSDR, 2017. Agency for Toxic Substances and Disease Registry. Health Consultation: Exposure Investigation, Biological Testing for Exposure to Lead and Arsenic near ASARCO Hayden Smelter Site, Hayden and Winkelman, AZ. Atlanta, Georgia: US Department of Health and Human Services.

Burgess JL, Carter DE, O'Rourke MK. (2000). Hayden-Winkelman Arsenic and Lead Survey, 1999. Available at: https://assets.documentcloud.org/documents/267080/hayden-winkelman-arsenic-and-lead-survey.pdf. Last accessed March 23, 2018.

CDC, 2012a. Centers for Disease Control and Prevention. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. A Report of the Advisory Committee on Childhood Lead Poisoning Prevention. Atlanta: Department of Health and Human Services.

CDC, 2012b. Centers for Disease Control and Prevention. CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "*Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention*". June 7, 2012. Available at:

http://www.cdc.gov/nceh/lead/ACCLPP/CDC_Response_Lead_Exposure_Recs.pdf. Last accessed March 23, 2018.

CH2M Hill, 2008a. "Draft Report, Remedial Investigation Report for the ASARCO LLC Hayden Plant Site, Hayden, Gila County, Arizona," August.

CH2M Hill, 2008b. "Draft Report, Baseline Human Health Risk Assessment for the ASARCO LLC Hayden Plant Site, Hayden, Gila County, Arizona (HHRA)," Prepared for U.S. Environmental Protection Agency Region IX, San Francisco, CA. August.

EPA, 2006. U.S. Environmental Protection Agency. Air Quality Criteria for Lead: Volume I of II. EPA/600/R-5/144aF. October, 2006. Available at: http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=158823. Last accessed March 23, 2018.

EPA, 2008a. U.S. Environmental Protection Agency. Integrated Science Assessment for Sulfur Oxides—Health Criteria. EPA/600/R-08/047F. September, 2008. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=198843. Last accessed March 23, 2018.

EPA, 2008b. U.S. Environmental Protection Agency. National Ambient Air Quality Standards for Lead. General Overview. Available at: https://www.epa.gov/sites/production/files/2016-03/documents/finalrule_20081015presentation.pdf. Last accessed March 23, 2018.

EPA, 2012. U.S. Environmental Protection Agency. ASARCO Final Phase II Remedial Investigation/Feasibility Study (RI/FS) Work Plan.

EPA, 2013. U.S. Environmental Protection Agency. Air Quality Designations for the 2010 Sulfur Dioxide (SO2) Primary National Ambient Air Quality Standard. Available at: https://www.gpo.gov/fdsys/pkg/FR-2013-08-05/pdf/2013-18835.pdf. Last accessed March 23, 2018.

EPA, 2014a. U.S. Environmental Protection Agency. AQI. Air Quality Index: A guide to air quality and your health. Retrieved from: https://www3.epa.gov/airnow/aqi_brochure_02_14.pdf. Last accessed March 23, 2018.

EPA, 2014b. U.S. Environmental Protection Agency. Policy Assessment for the Review of the Lead National Ambient Air Quality Standards. EPA-452/R-14-001. Office of Air Quality Planning and Standards Health and Environmental Impacts Division Research Triangle Park, North Carolina.

EPA, 2014c. U.S. Environmental Protection Agency. Designation of Areas for Air Quality Planning Purposes: State of Arizona; Pinal County and Gila County; Pb. Available at: https://www.regulations.gov/document?D=EPA-R09-OAR-2014-0266-0041. Last accessed March 23, 2018.

EPA, 2015a. U.S. Environmental Protection Agency. EPA Requires ASARCO to Cut Toxic Emissions at 103-Year-Old Arizona Copper Smelter. Available at: https://www.epa.gov/pacific-

southwest-media-center/epa-requires-asarco-cut-toxic-emissions-103-year-old-arizona-copper. Last accessed March 23, 2018.

EPA, 2015b. U.S. Environmental Protection Agency. Residential Soil Removal Action Report, Towns of Hayden and Winkelman, Arizona.

EPA, 2015c. U.S. Environmental Protection Agency. ASARCO LLC Settlement. Available at: http://www.epa.gov/enforcement/asarco-llc-settlement. Last updated on May 9, 2017. Last accessed March 23, 2018.

EPA, 2017. U.S. Environmental Protection Agency. Superfund Site: Asarco Hayden Plant Hayden, AZ. Available at: https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0900497. Last accessed March 23, 2018.

Hegazy AA, Zaher MM, El-Hafez MA, Morsy AA, Saleh RA. (2010). Relation between anemia and blood levels of lead, copper, zinc and iron among children. BMC Research Notes, 3, 133. http://doi.org/10.1186/1756-0500-3-133. Last accessed March 23, 2018.

IARC 1992. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Agents Classified by the IARC Monographs, Volume 54. Available at: http://monographs.iarc.fr/ENG/Classification/. Last accessed March 23, 2018.

WHO, 2000. World Health Organization. Air quality guidelines for Europe. 2nd ed. Copenhagen, WHO Regional Office for Europe.

WHO, 2005. World Health Organization. WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005. Summary of risk assessment.

## REPORT PREPARATION

This Health Consultation*: Hayden and Winkelman Communities, Gila and Pinal County, Arizona, Evaluation of Community Exposure to Lead and Sulfur Dioxide in Air* was prepared by the Arizona Department of Health Services under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database.

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# Tables

## Table 1. Exposure pathway analysis

| Source | Media | Point of exposure | Route of exposure | Potentially exposed population | Time Frame | Type of Exposure Pathway |
|---|---|---|---|---|---|---|
| Emissions from smelter operations | Air | Ambient Air | Inhalation | Residents/ Visitors | Past | Completed |
| | | | | | Current | Completed |
| | | | | | Future | Potential |

## Tables 2a and 2b. Summaries of sulfur dioxide levels in ambient air. Data received from ADEQ.

*Table 2a. Air Quality Index (AQI) for sulfur dioxide monitoring data in parts per billion (ppb), 2010 – 2016. The count and percentage (%) of 1-hour and 24-hour average sulfur dioxide levels in Hayden are shown for each year by AQI category.*

| AQI Category (AQI Value) (Corresponding $SO_2$ concentration in ppb) | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| Good (AQI 0—50) (1 hour average from 0—35 ppb) | 7,975 (93.3%) | 8,084 (95.4%) | 8,049 (92.2%) | 8,049 (95.1%) | 8,032 (95.1%) | 8,284 (95.2%) | 5,645 (91.4%) |
| Moderate (AQI 51—100) (1 hour average from 36—75 ppb) | 371 (4.3%) | 299 (3.5%) | 456 (5.2%) | 289 (3.4%) | 275 (3.3%) | 320 (3.7%) | 356 (5.8%) |
| Unhealthy for Sensitive Groups (AQI 101—150) (1 hour average from 76—185 ppb) | 177 (2.1%) | 87 (1.0%) | 204 (2.3%) | 106 (1.3%) | 134 (1.6%) | 94 (1.1%) | 149 (2.4%) |
| Unhealthy for all groups (AQI 151—200) (1 hour average from 186—304 ppb) | 23 (0.3%) | 4 (0.0%) | 24 (0.3%) | 20 (0.2%) | 7 (0.1%) | 13 (0.1%) | 25 (0.4%) |
| Very Unhealthy (AQI 201—300)* (24-hour average from 305—604 ppb) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hazardous (AQI 301—500)* (24-hour average from 604—1004 ppb) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Note: AQI values of 201 or greater are calculated with 24-hour $SO_2$ concentrations (https://airnow.gov/index.cfm?action=airnow.calculator)

Table 2b. Maximum 10-minute average sulfur dioxide monitoring data in parts per billion (ppb), 2014 – 2016.

| Year | Number of total data points | Number of samples exceeding 1,000 ppb | Number of samples exceeding 190.8 ppb (WHO 10-min guideline) | Maximum reading (ppb) |
|---|---|---|---|---|
| 2014 | 38,702 | 0 (0%) | 111 (0.29%) | 717 |
| 2015 | 52,516 | 0 (0%) | 105 (0.24%) | 959 |
| 2016 | 52,434 | 4 (0.008%) | 345 (0.66%) | 1,079 |

## Table 3. Summary of lead levels in ambient air received from ADEQ

Lead air monitoring data in micrograms per cubic meter (µg/m$^3$) measured in total suspended particles (TSP), 2011–2016. TSP measures airborne particles having diameters less than 100 micrometer (µm). Lead concentrations in TSP measured at 3 locations, Globe Highway (both ADEQ and EPA monitors), Hillcrest (both ADEQ and EPA monitors), and Smelter Parking Lot (EPA monitor) were above the NAAQS.

| Air Monitoring Station (Monitor scale) | Owner | Air Sampling Time Frame | # of Samples | Highest 3-month Rolling Average (µg/m$^3$); (# of 3-month average >0.15 µg/m$^3$) | Highest Annual Average (µg/m$^3$) |
|---|---|---|---|---|---|
| Globe Highway | ADEQ | 01/15/2011 – 08/28/2016 | 346 | 0.27; (9) | 0.14 (2011) |
| ST-05: Globe Highway | EPA | 08/23/2013 – 05/12/2015 | 94 | 0.24; (3) | 0.13 (2014) |
| Hillcrest | ADEQ | 01/01/2016 – 08/28/2016 | 41 | 0.22; (2) | 0.13 (2016) |
| ST-23: Hillcrest Avenue | EPA | 07/03/2013 – 05/12/2015 | 108 | 0.29; (13) | 0.20 (2015) |
| ST-14: Smelter Parking Lot | EPA | 08/08/2013 – 05/12/2015 | 100 | 1.19; (18) | 0.92 (2015) |
| ST-02: Hayden High School | EPA | 07/03/2013 – 05/12/2015 | 87 | 0.04; (0) | 0.03 (2014) |
| ST-26: Concentrator/ Post Office | EPA | 08/02/2013 – 05/12/2015 | 104 | 0.15; (0) | 0.14 (2015) |

# Figures

Figure 1. Location and population density of ASARCO Hayden Plant Superfund Alternative Site.

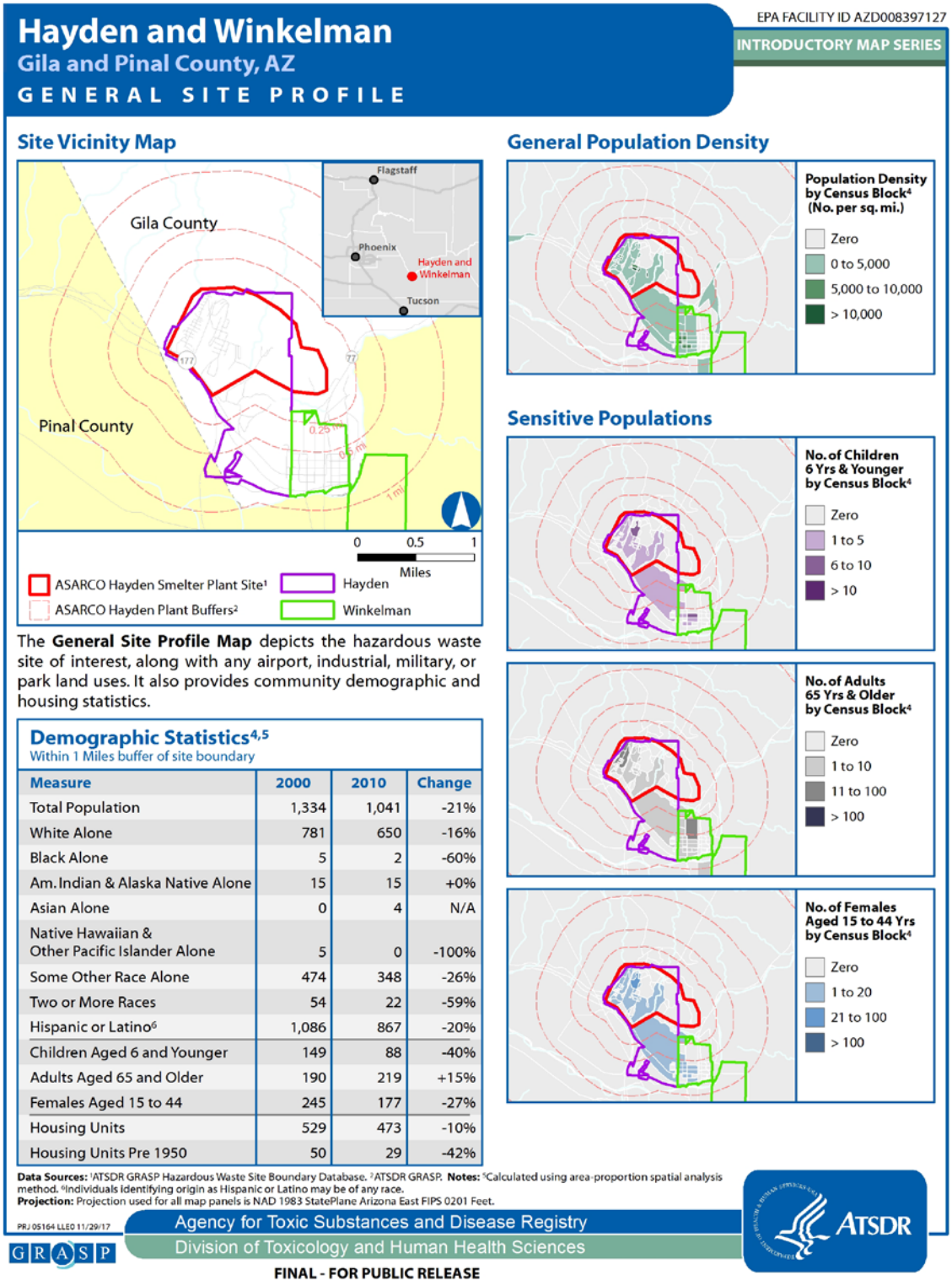


Figure 2. Map with air and meteorology monitoring stations.

Figure 3. Google map shows the driving and walking distances between the edges of Hayden and Winkelman.

## Figures 4a-c. 10-minutes $SO_2$ concentrations measured at Hayden Old Jail.

Figure 4a. April to December 2014 data. No data are available prior to April 2014.

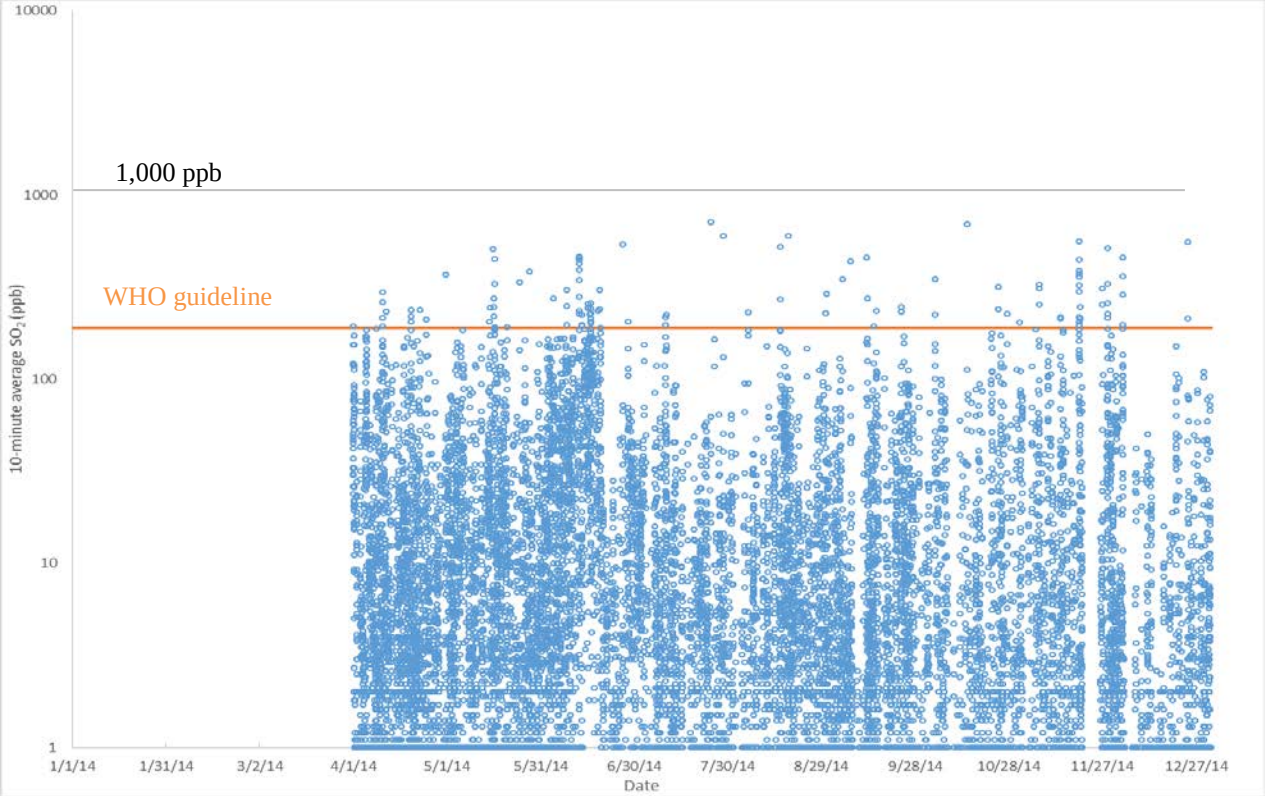


Figure 4b. 2015 data. ASARCO was shut down from April, 26 2015 to May 21, 2015. During this time no elevated $SO_2$ concentrations were observed.

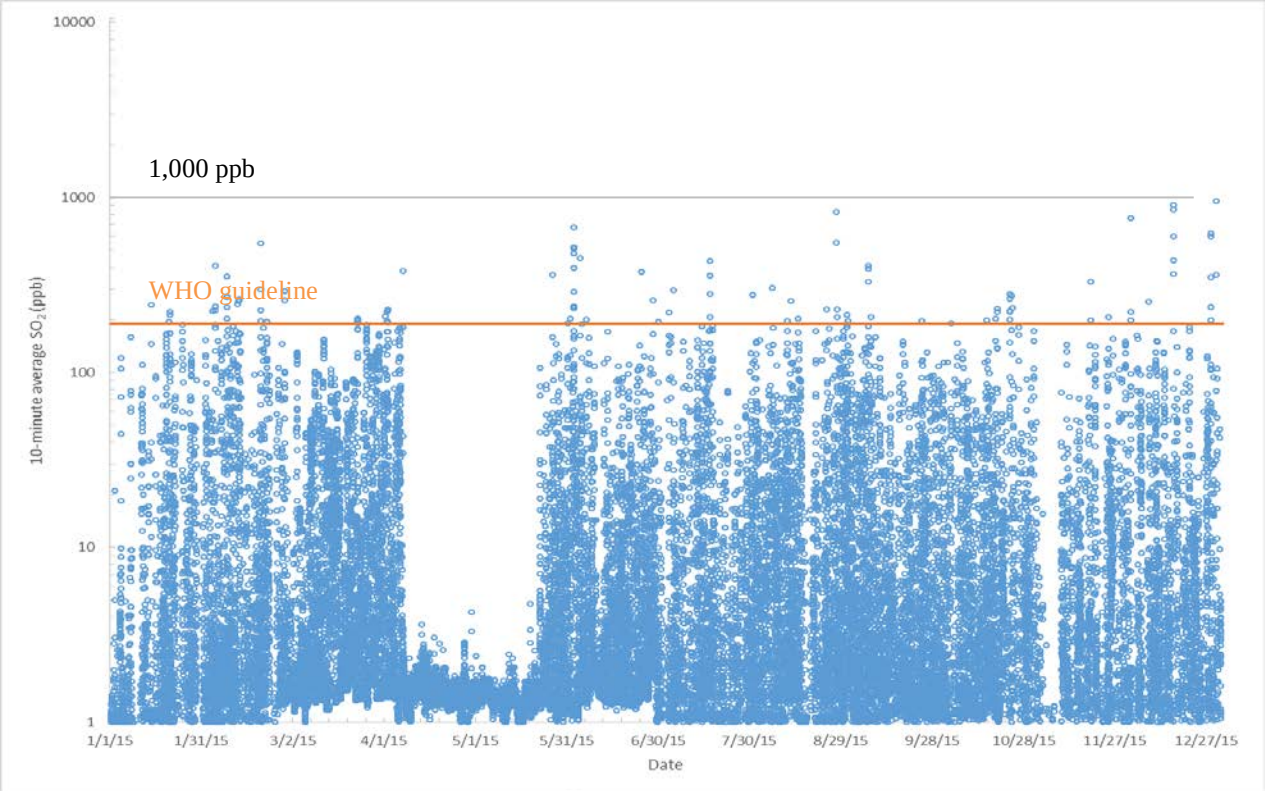


Figure 4c. 2016 data. ASARCO was shut down from November 2016. During this time no elevated $SO_2$ concentrations were observed.

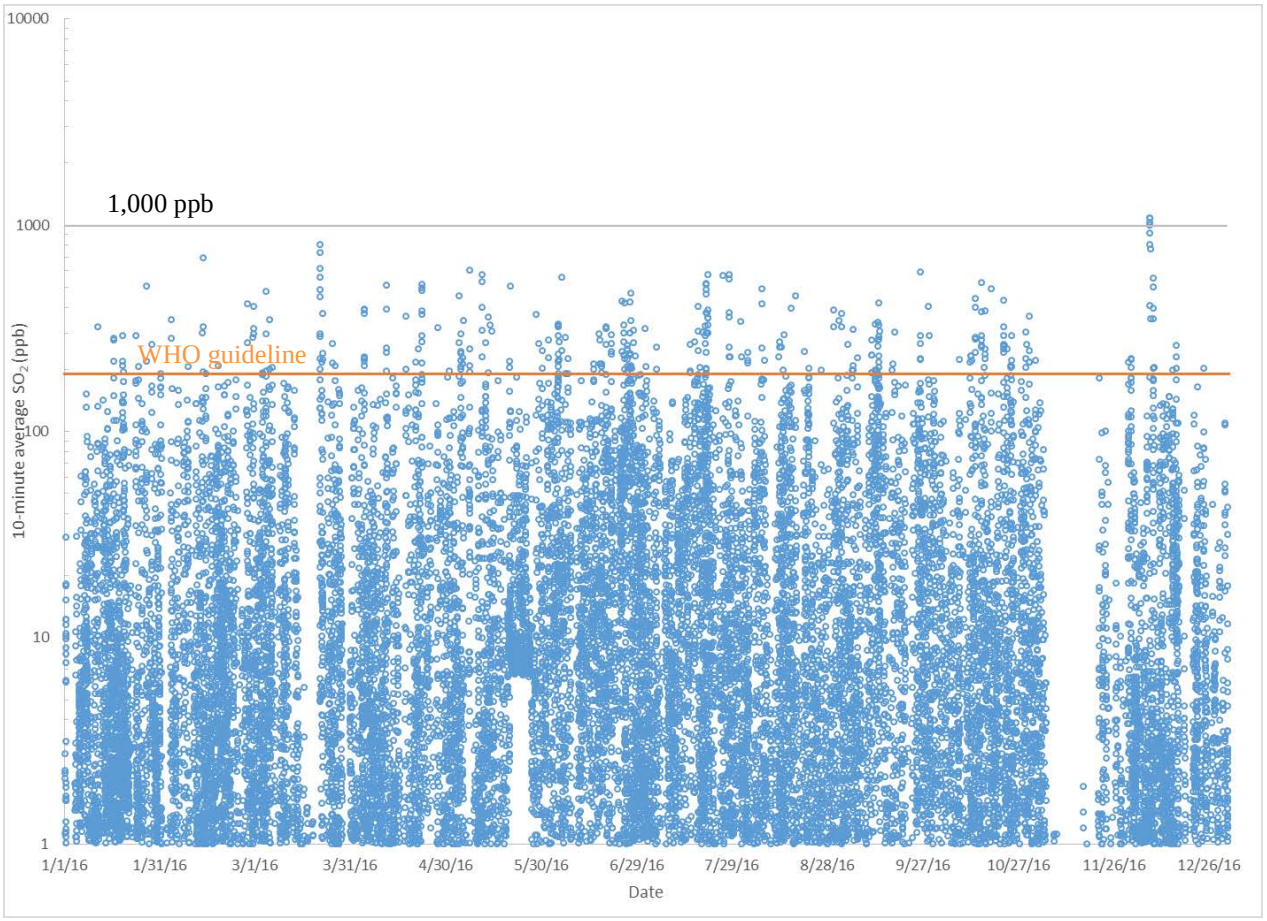
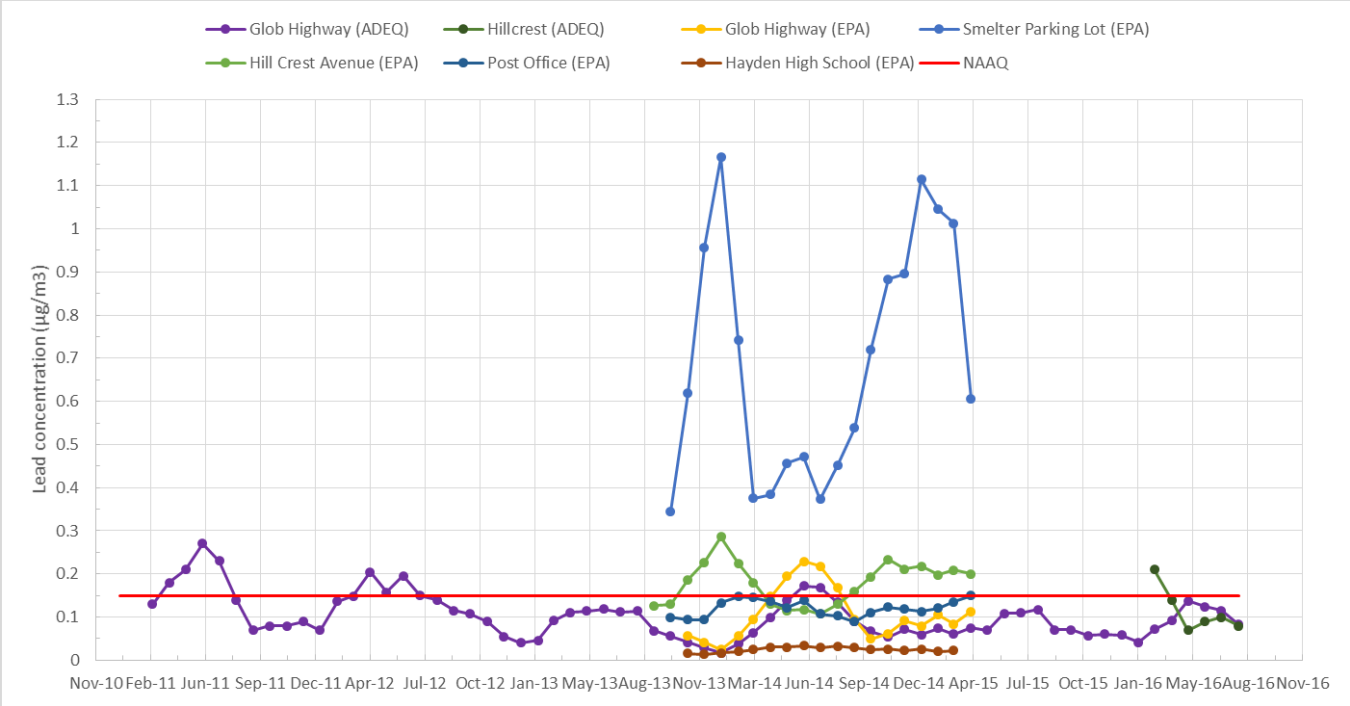


Figure 5. 3-month rolling average lead concentrations in total suspended particles (TSP) measured at stations in Hayden and Winkelman.



# Appendix A: Description of Ambient Air and Meteorological Monitoring Stations Used in this Evaluation

**ST-02: Hayden High School (EPA)**: This southernmost station is located at the northern edge of the town of Winkelman and is situated on the roof of Hayden High School. A middle school and elementary school are located immediately to the south. Undeveloped desert is located immediately to the west and east. The active slag dump is approximately 1,200 feet to the north-northeast. The station is used to collect lead data.

**ST-05: Globe Highway (EPA)**: This easternmost station is located adjacent to AZ State Highway 77. It is surrounded by undeveloped desert and the Gila River. The closest active portion of Hayden Operations is the slag dump, approximately 900 feet to the west-southwest. The station is used to collect lead data.

**ST-10: Meteorology Station (EPA)**: The station is located on Camera Hill (aka Smelter Hill) and is used to collect meteorological data representative of the entire Study Area.

**ST-14: Smelter Parking Lot (EPA)**: This station is located within an active portion of Hayden Operations, at the southwestern end of an employee parking lot. Numerous portions of active smelter facility operations are nearby to the southeast, east, and northeast, including significant lengths of high-traffic facility roads. The station is used to collect lead data.

**ST-23: Hillcrest Avenue (EPA)**: This station is located along an unpaved road just east of Hillcrest Avenue and adjacent to residential property. Conveyor #9, which is used to convey crushed ore, is located approximately 90 feet to the northwest. The station is used to collect lead data.

**ST-26: Concentrator/Post Office (EPA)**: This station is located approximately 200 feet west of active portions of concentrator operations and just east of the Hayden post office. Residential property is located about 150 feet to the west. The Hayden public swimming pool is located about 200 feet to the south-southwest. The station is used to collect lead data.

**Globe Highway (ADEQ)**: This easternmost station is located adjacent to AZ State Highway 77. It is surrounded by undeveloped desert and the Gila River. The closest active portion of Hayden Operations is the slag dump, approximately 900 feet to the west-southwest. It is located in a separate fence directly south on the same property as EPA's Globe Highway station. The station is used to collect lead data.

**Hillcrest (ADEQ)**: This station is located along an unpaved road just east of Hillcrest Avenue and adjacent to residential property. Conveyor #9, which is used to convey crushed ore, is located approximately 90 feet to the northwest. It is located in a separate fence directly north on the same property as EPA's Hillcrest Avenue station. The station is used to collect lead data.

**Hayden Old Jail (ADEQ)**: This westernmost station is located on the corner of Canyon Dr. and Kennecott Avenue. The surrounding area consists mainly of residential and commercial buildings. The furnace stack is approximately 3,300 feet to the east. The station is used to collect sulfur dioxide data.