Health Consultation

Evaluation of Community Exposures and Concerns Related to

FENIMORE LANDFILL

ROXBURY TOWNSHIP, NEW JERSEY

MAY 11, 2016

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
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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

The Agency for Toxic Substances and Disease Registry (ATSDR) evaluates community exposures and makes recommendations to prevent harmful exposures to hazardous substances in the environment. The goal of this health consultation is to give the people living near the Fenimore Landfill in Roxbury Township, New Jersey, trusted scientific information to protect their health.

Fenimore Landfill is a former private landfill that was reopened in 2011 and accepted construction and demolition waste until June 2013. In 2012, residents living near the landfill began complaining of odors coming from the landfill, mostly a rotten egg odor suggesting a hydrogen sulfide (H_2S) release. In 2013, ATSDR received two petitions from the community to evaluate potential health hazards associated with releases from the landfill.

In October 2013, the New Jersey Department of Environmental Protection (NJDEP) installed a gas collection and treatment system, which began operating full-time in December 2013. The New Jersey Department of Health (NJDOH) evaluated community exposures in a report dated February 2014 and concluded that exposure to H_2S in summer and fall 2013 (before the treatment system was installed) could harm community members, particularly sensitive populations, and recommended action to reduce odors. ATSDR agreed with this finding. This health consultation evaluates community exposures to H_2S before and after the treatment system became fully operational. We also address other community concerns about the landfill, such as exposure to other contaminants in air, explosion risk for methane from the landfill, and exposure to contaminants in groundwater.

ATSDR released a draft of this health consultation in September 2015 and accepted public comments on the report through October 30, 2015. This final version includes and addresses public comments received and includes discussion and evaluation of more recent data. ATSDR's major conclusions and recommendations have not changed from the draft health consultation.

Conclusions

ATSDR reaches seven important conclusions in this health consultation:

Conclusion 1

Before the landfill gas extraction and treatment system began operating in October 2013, concentrations of H_2S released from the landfill were high enough to cause harmful short-term health effects in community members**.** Lasting health effects are unlikely from the exposure.

Basis for Conclusion

- Community monitors around the landfill showed 30-minute H_2S concentrations that were consistently above ATSDR's acute minimal risk level (MRL) of 70 parts per billion (ppb), with those closest to the landfill regularly reaching hundreds of ppb. For even brief exposures, these levels are high enough to cause changes in lung function or headaches in people who are exposed. Potential respiratory health effects are more likely in people with pre-existing respiratory conditions, such as asthma. These short-term effects would be expected to resolve once the H_2S concentrations decreased, because H_2S is rapidly cleared from the body. The monthly average concentrations were all lower than ATSDR's intermediate MRL of 20 ppb. Therefore, longer-term health effects are unlikely.
- Offensive, pervasive odors were reported in summer and fall 2013. Some people are more sensitive to odors than others, but almost anyone in the nearby community who could smell the H_2S could have experienced general odor-related symptoms. These symptoms have been reported as the body's reaction to the odor rather than chemical irritant properties of a specific pollutant and could include eye, nose, and throat irritation; nausea; and headaches. Symptoms from odors could persist longer or aggravate existing medical conditions in sensitive groups (such as people with respiratory conditions like asthma, the very young, or the very old).

Next Steps

- ATSDR recommends that NJDEP continue operating the gas extraction and treatment system until components of the landfill gas are reduced to concentrations too low to cause any concern for safety or health.

Conclusion 2

After the gas extraction system was installed to remove landfill gases, short-term concentrations of H_2S were greatly reduced and are much less likely to cause harmful health effects. However, the toxicological and human health data indicate that some sensitive people in the community could continue to suffer harmful health effects from H_2S associated with odors or from stress caused by previous exposures to H_2S. Data quality issues beginning in late 2014 added uncertainty to this public health evaluation.

Basis for Conclusion

- When collection and treatment of landfill gases began in October 2013, community monitors registered an immediate reduction in the concentration of H_2S. H_2S concentrations, while still usually present above odor thresholds, were almost always below ATSDR's acute MRL of 70 ppb, and the monthly averages continued to be below ATSDR's intermediate MRL of 20 ppb. Harmful H_2S-related health effects would be unlikely from these concentrations.
- Beginning in late summer 2014, various monitors recorded more than 20 short-term elevations in H_2S concentration (up to tens of thousands of ppb) that were not obviously equipment-related but were also

reportedly not associated with odor events. We do not know if these measurements represented actual air concentrations of H_2S. Since January 2015, the frequency of these elevated readings has been greatly reduced.

- If these elevated readings represented actual air H_2S concentrations, the highest concentrations of H_2S could have caused changes in lung function or headaches in people with pre-existing respiratory conditions such as asthma, even for short exposures. These effects would have resolved once the H_2S concentrations decreased.
- Stress and possible health effects from previous exposures could have made community members more sensitive to odors. When odors are present, some people could continue to experience odor-related symptoms.

Next Steps

- ATSDR recommends that NJDEP continue operating the gas extraction and treatment system until components of the landfill gas are reduced to concentrations too low to cause any concern for safety or health.
- ATSDR recommends that NJDEP or the Township continue community monitoring near the landfill to confirm proper operation of the treatment system and to provide reassurance to community members that concentrations remain below acceptable levels.
- ATSDR recommends that NJDEP continue to investigate new odor complaints from the community and address offensive odors to the extent possible.
- ATSDR recommends that NJDEP or the Township verify data from existing community monitors by comparison or replacement with an alternate type of H_2S monitor (such as colorimetric tape meters). We recognize that operational improvements have reduced the frequency of equipment anomalies associated with the current monitoring system. Verification with an alternate measurement technology, not subject to such anomalies, would give community members even greater confidence in the results.

Conclusion 3

Past and current concentrations of sulfur dioxide (SO_2) produced from the landfill gas treatment process are not likely to have caused or be causing serious harmful health effects.

Basis for Conclusion

- Short-term concentrations (5-minute averages) of SO_2 above ATSDR's acute MRL of 10 ppb were infrequent (representing less than 0.25% of the time measured) and rarely reached levels that would harm health. In isolated incidents in April 2014 and July 2015, five-minute average SO_2 measured in one of the community monitors reached levels that have been associated with mild respiratory effects in some sensitive

people, such as those with asthma. The levels were unlikely to have caused lasting or serious effects.

- One-hour average SO_2 concentrations in any monitor were higher than the primary one-hour National Ambient Air Quality Standard only twice (during the incidents described above).

Next Steps

- ATSDR recommends that NJDEP conduct regular maintenance of the scrubber system to ensure its proper operation and the proper function of automatic controls. ATSDR also recommends that NJDEP continue real-time monitoring of SO_2 stack concentration to ensure against any unexpected releases.

Conclusion 4

Past releases of other volatile organic or reduced sulfur compounds potentially in the landfill gas were unlikely to result in serious, lasting harm to health. People could have had physical symptoms from the odors themselves. Current exposure to these compounds is unlikely as long as the treatment system is operating properly.

Basis for Conclusion

- Limited ambient air sampling near the landfill, while odors were present, showed that concentrations of volatile organic compounds were too low to cause any harmful health effects. Three compounds (benzene, trichloroethylene (TCE), and formaldehyde) were detected at concentrations that were within the range of typical ambient levels for the area, suggesting that the landfill was not the source of these compounds. These concentrations could contribute to a person's risk of developing cancer over a lifetime of exposures. However, estimating cancer risk is uncertain because of the limited number of samples.
- Reduced sulfur compounds such as mercaptans, sulfides, or disulfides could have been produced by the landfill and released. Testing for past concentrations is not possible. If these compounds were present at similar or lower concentrations than H_2S, they would be unlikely to cause serious lasting adverse health effects, though people could have had a reaction to the smell. If the compounds had been present at higher levels, a different characteristic odor would probably have been reported.
- Current exposure to volatile organic compounds or reduced sulfur compounds is unlikely because, if present, they will be collected by the landfill gas extraction system and destroyed along with the H_2S.

Next Steps

- ATSDR recommends that NJDEP continue operating the gas extraction and treatment system until components of the landfill gas are reduced to concentrations too low to cause any concern for safety or health.

Conclusion 5

Methane production from the landfill is unlikely to harm health by posing an explosion risk to nearby homes.

Basis for Conclusion

- Although high levels of methane were detected in one particular area of the landfill, further testing between that area and nearby homes showed that the methane was not moving toward homes. Methane is now collected by the landfill gas extraction system and burned along with other landfill gases.

Next Steps

- ATSDR recommends that NJDEP continue operating the gas extraction and treatment system until concentrations of methane and other components of the landfill gas are too low to cause any concern for safety or health.

Conclusion 6

Available data indicate that drinking water from municipal or private wells near the landfill is unlikely to harm health. However, we do not have data on metals in private wells. We also do not have enough information to determine whether H_2S released from private well water into indoor air could cause harmful health effects.

Basis for Conclusion

- No detections of volatile organic compounds were found in more than 40 private wells and municipal wells sampled near the landfill.
- No data were available on metals in private wells. Monitoring wells at the landfill boundary contained high levels of some metals.
- Sulfide concentrations in private and municipal wells could give water an unpleasant taste or smell but are unlikely to cause harmful health effects from drinking the water. H_2S would be quickly released from well water into air. If the H_2S builds up in unventilated areas, it could pose a potential risk, depending on the resulting concentration.
- A few private wells tested positive for indicators of microbial contamination, but further testing showed no indicators of pathogens.

Next Steps

- ATSDR recommends that NJDEP, the Township, or the entity responsible for the landfill sample private wells for metals and re-test representative private wells for sulfide to confirm that concentrations are not changing. ATSDR also recommends this sampling be accompanied by air monitoring for H_2S near the sample point to identify any significant releases of H_2S from the water sampled.
- ATSDR recommends that private well owners monitor their wells for microbial contamination and other water quality parameters, including metals. Residents concerned about sulfide or other odors from their private well water can ventilate their homes to reduce exposure or consider treating their water.

Conclusion 7

ATSDR cannot determine whether unidentified hazardous materials that could exist in the landfill could harm people's health.

Basis for Conclusion

- Historical reviews found no immediate environmental concern from the former solid waste landfill, and recent testing of private wells showed no detections of volatile organic compounds. However, some undocumented hazardous materials may have been added when the landfill was re-opened.
- Core sampling cannot disprove the presence of isolated pockets of hazardous materials and would compromise the integrity of the landfill cap, allowing gases to be released.
- If present, any unidentified materials could have released contaminants into groundwater when rainwater filtered through the landfill before it was capped. The above-waste liner, cap, and surface water runoff features recently added to the landfill will prevent further surface water infiltration and possible leaching of hazardous substances into the groundwater.

Next Steps

- ATSDR recommends that NJDEP or the entity responsible for the landfill regularly monitor groundwater at the landfill perimeter or downgradient locations for common landfill contaminants to verify that no harmful substances escape the landfill.
- ATSDR also recommends that NJDEP or the entity responsible for the landfill regularly monitor representative private wells downgradient from the landfill for sulfide and other common landfill contaminants to ensure they remain unaffected by the landfill.

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Background and Purpose

Fenimore Landfill (the landfill) is a former solid waste landfill located north of Mountain Road in Roxbury Township, Morris County, New Jersey. The landfill had been inoperative since 1979, but in 2011, a new owner began bringing in materials, including gypsum wallboard fines and debris, to level the site for reuse. In fall 2012, the community around the landfill began reporting a rotten egg odor emanating from the landfill. Community and New Jersey Department of Environmental Protection (NJDEP) air monitoring beginning in early 2013 showed high levels of hydrogen sulfide (H_2S), a known product of microbial decomposition of gypsum. In June 2013, the NJDEP took over the site to mitigate the odors. After a series of remediation efforts, a gas extraction and treatment system with 9 extraction wells was eventually installed and began operating continuously in December 2013.

The Agency for Toxic Substances and Disease Registry (ATSDR) evaluates community exposures and makes recommendations to prevent harmful exposures to hazardous substances in the environment. In fall 2013, ATSDR received two petitions asking for assistance with public health issues at the Fenimore Landfill site, especially related to community exposure to H_2S. The petitions were from the Township of Roxbury and from a private citizen associated with a local environmental group. ATSDR accepted the petitions and met with community members and involved agencies to understand the site, and has been providing informal input and recommendations on public health issues since summer 2014.

This health consultation is a formal evaluation of the public health implications of community exposures to H_2S near the Fenimore Landfill. The report summarizes the New Jersey Department of Health's (NJDOH's) evaluation of exposures occurring before December 2013 and provides an additional evaluation of exposures occurring before and after the gas extraction and treatment system began operating continuously in December 2013. This health consultation also evaluates community exposures to sulfur dioxide (SO_2), a product of the treatment process. Finally, this report addresses several additional health concerns related to the landfill that community members conveyed to ATSDR.

Public Comment

ATSDR released a draft of this health consultation for public comment on September 1, 2015. The draft health consultation was available for public review and comment at the Roxbury Public Library in Succasunna, New Jersey. The document was also available for viewing or downloading from the ATSDR web site and was provided electronically to residents and other interested parties on ATSDR's electronic mailing list for the site. The public comment period was open from September 1, 2015 through October 30, 2015. Public comments received are included in their entirety, with ATSDR responses, in Appendix C beginning on page 54 of this report.

The public comment period was announced to local media outlets. ATSDR discussed the findings of the draft health consultation with community members at three public availability sessions held September 15-16, 2015 at the Roxbury Recreation Meeting Room in Succasunna, New Jersey. Before the public availability sessions, ATSDR also met informally on September 14 and 15 with representatives of a local environmental group, Roxbury Township, Roxbury

Public Schools, and NJDEP. Copies of the draft report and a fact sheet summarizing the findings were provided to the community during the public availability sessions.

This final health consultation includes many changes made in response to public comments. Changes made are detailed in the responses in Appendix C. The major changes made to the body of the document include:

- H_2S Section: Updated charts, tables and discussion to include data from January 2015-November 2015 not evaluated in the public comment version. Updated discussion of data quality issues.
- SO_2 Section: Updated charts, tables, and discussion to include data from January 2015-November 2015 not evaluated in the public comment version.
- Added additional sections evaluating groundwater data collected from monitoring wells near the landfill and surface water data collected downstream of the landfill.

The main conclusions and recommendations of our evaluation are generally the same as in the public comment version.

Site Description and History

The information in the following history comes from several site reports and fact sheets [1-7]. Figure 1 shows the site, about 103 acres located north of Mountain Road in Roxbury Township, Morris County, New Jersey. The private landfill operated from the 1950s to 1979, accepting waste from numerous customers on approximately 60 acres of the property. NJDEP ordered the landfill to cease operating in 1979, but no formal closure or capping occurred.

In 2010, the site was purchased by a private company that obtained approval from NJDEP to cap a portion of the landfill to allow reuse of the facility. The company began accepting waste, including construction and demolition (C&D) fines containing gypsum wallboard materials, to level a 19-acre area planned for reuse. In fall 2012, the community around the landfill began reporting a rotten egg odor emanating from the landfill. H_2S has a distinctive odor of rotten eggs and is a known byproduct of the decomposition of C&D materials, particularly gypsum.

To address community odor concerns, the Township established H_2S monitoring stations around the landfill and measured H_2S in early 2013. The Township also established a respite center for community access during periods of high odors and worked with NJDEP and NJDOH to develop a protocol for notifying residents of high H_2S concentrations. NJDEP took over the site the following June. The Township set up more monitors to better measure H_2S releases into the community. During summer and fall 2013, NJDEP attempted to mitigate odors, but odors persisted. By October 2013 a gas extraction system and emergency scrubber were set up to gather and thermally treat landfill gases and scrub the resulting SO_2 from the treated gases coming out of the unit. SO_2 monitors were set up in the community to monitor releases of SO_2 in addition to H_2S. The thermal treatment and scrubber system operated intermittently for several weeks and became continuously operational in December 2013.

In June 2014, the piping system collecting gases for treatment was expanded to include additional extraction wells covering the entire 19-acre area of the landfill where the C&D material was added. In August 2014, NJDEP began preparing this area for installation of a liner and cap above the waste to prevent water infiltration and mitigate future production of H_2S by the landfill material. The cap was completed in winter 2015. A larger oxidizer system was installed in March 2015 to allow treatment of a greater volume of landfill gases.

Demographics

Figure 2 summarizes the characteristics of the population in the area surrounding Fenimore Landfill. Residences and park land immediately surround the landfill, with the nearest homes less than a quarter of a mile from the area where new material was added. The landfill sits midway up a mountain above the surrounding communities. Because the prevailing winds are generally from the west and H_2S is heavier than air, the communities most likely to be affected are those east of the landfill and lower in elevation, including Ledgewood and Succasunna. Communities such as Mount Arlington, Netcong, and Budd Lake are less likely to be affected because higher land blocks airflow and prevailing winds do not blow toward the north and west.

Figure 1. Location of Fenimore Landfill and Community H_2S and SO_2 Monitors, Roxbury Township, NJ

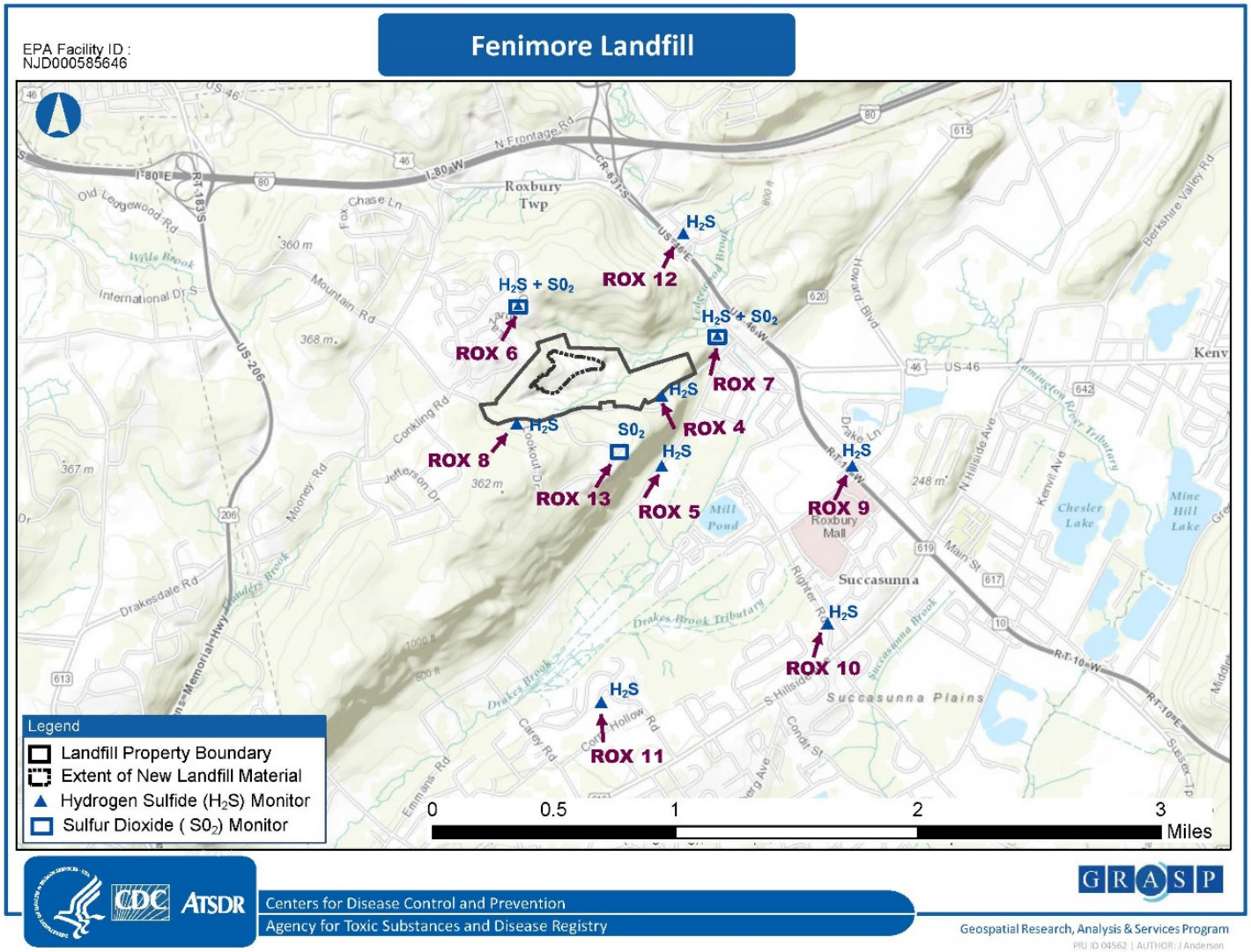
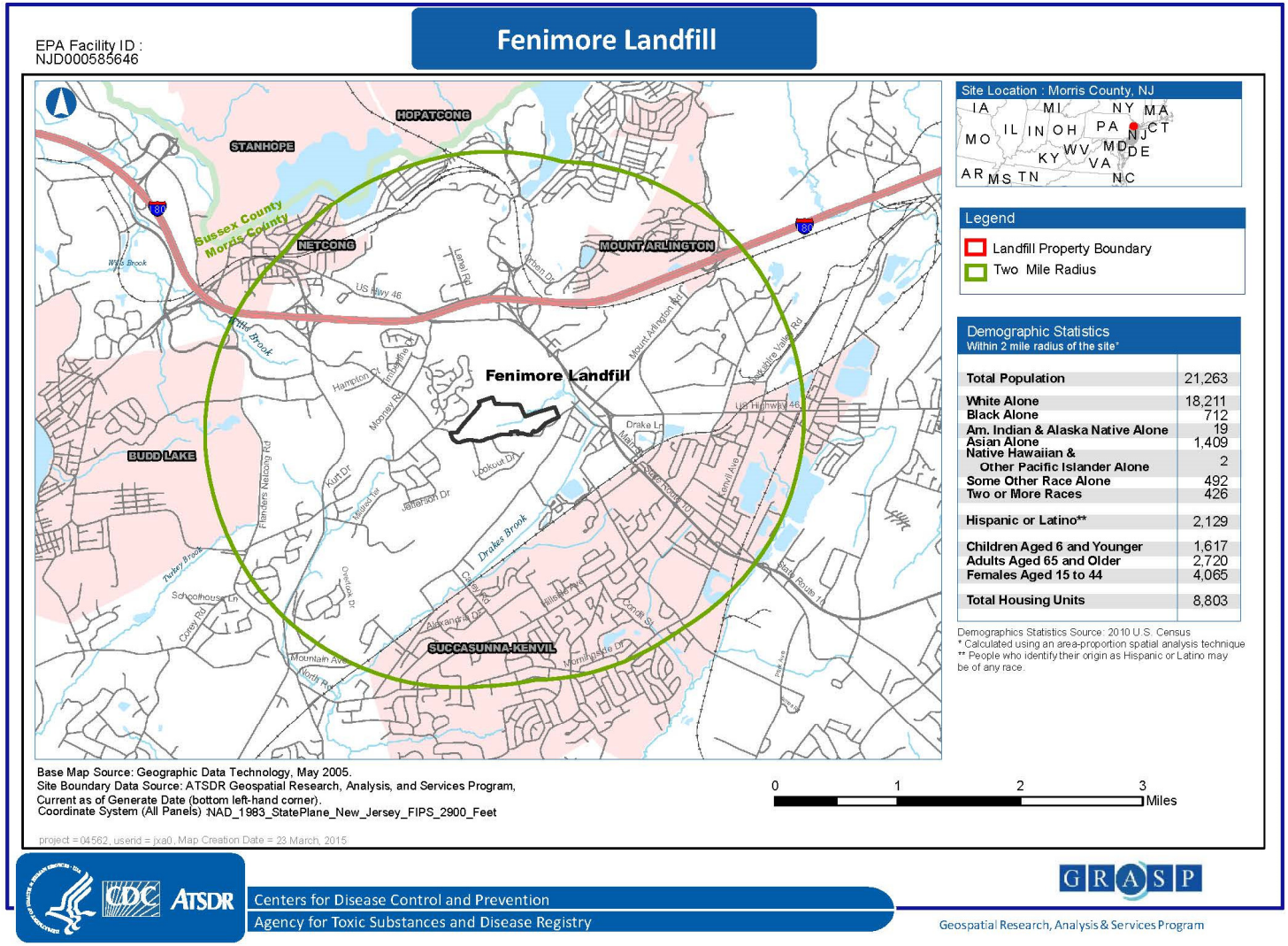


Figure 2. Demographic Statistics for the Population within a Two-Mile Radius of Fenimore Landfill, Roxbury Township, NJ



ATSDR Activities

After receiving the petitions for assistance from the community, ATSDR reviewed the February 2014 NJDOH health consultation and concurred with its conclusion that harmful health effects could occur from the H_2S exposure levels that were present in summer and fall 2013 [8]. ATSDR formally accepted the community petitions in April 2014 and wrote to the NJDEP to express the Agency's concern that exposure to H_2S from the landfill at the levels present in summer and fall 2013 could be harmful to public health. ATSDR contacted state and local agencies to begin obtaining site information. Since that time, ATSDR has conducted the following activities:

- May—June 2014: ATSDR developed a plan to gather information on health concerns from the community. For 2 weeks in June, ATSDR operated a toll-free telephone number for Roxbury area residents to contact ATSDR to express health concerns about the site. ATSDR informed residents of the toll-free line by a postcard mailed to residents within a one-mile radius of the site and by postings on Township and local community websites.
- June 2014: ATSDR visited Roxbury, met with state and local officials about the site, and participated in a tour of the landfill, treatment system, and monitoring stations located throughout Roxbury. ATSDR met with the local environmental group's officers to obtain their perspectives on landfill issues. ATSDR also met with small groups of community members randomly selected from callers to the toll-free line to hear health concerns in person.
- August—September 2014: ATSDR provided input to Roxbury Township and their contractors on using H_2S monitoring data results to better implement the Township's community notifications procedures.
- Fall 2014: ATSDR communicated with NJDEP, the Township, and contractors responsible for the community monitoring to obtain data, identify possible issues with monitoring, and clarify recommendations regarding public health and H_2S. ATSDR staff also provided Roxbury area school nurses with information about ATSDR, H_2S, environmental odors, and children's environmental health.
- September 2015: ATSDR released the public comment version of this report and met with community members and other stakeholders to discuss the draft findings. ATSDR accepted public comments on the draft report until October 30, 2015.

Community Concerns

ATSDR's discussions and interactions with the community revealed numerous health concerns and other environmental concerns related to the landfill. This health consultation addresses the following concerns:

- Continuing exposure to H_2S from the landfill, particularly long-term effects of high exposure to children and other sensitive groups and effects of chronic exposures to lower levels than those present in summer and fall 2013
- Exposure to SO_2 formed during the landfill gas treatment process
- Possible exposure to other compounds formed by the landfill that are not specifically measured and/or can't be smelled
- Possible sub-surface migration of methane gases formed in the landfill to nearby homes and resulting risks

- Possible landfill contamination of groundwater used by private homes and the municipality for drinking
- Possible risks from unidentified hazardous materials in the landfill

For each concern above, ATSDR will discuss the availability and quality of environmental sampling data to assess the public health implications of the concern. If data are not available, ATSDR will discuss the potential exposure and make recommendations for protecting public health.

Exposure Pathways and ATSDR's Evaluation Process

ATSDR evaluates whether people may have come into contact with chemicals from a site by examining *exposure pathways*. Exposure pathways consist of five elements: a contamination *source*; *transport* of the contaminant through an environmental medium like air, soil, or water; an *exposure point* where people can come in contact with the contaminant; an *exposure route* whereby the contaminant can be taken into the body; and an *exposed population* of people actually coming in contact with site contaminants [9].

Completed exposure pathways are those for which all five pathway elements are evident. If one or more elements are missing or have been stopped (for example, by preventing transport of the chemical from the source to the exposure point), the pathway is *incomplete*. Exposure cannot occur for incomplete exposure pathways. For *potential* exposure pathways, exposure appears possible, but one or more of the elements is not clearly defined.

At the Fenimore Landfill site, the following exposure pathways are considered to pose the greatest concern and have the potential to affect the greatest number of people:

- Air Pathway – The air pathway begins with gypsum materials in the landfill degrading to produce reduced sulfur compounds such as H_2S. The gases formed are either released from the land surface or collected and treated; after treatment, trace amounts of the gases or SO_2 formed in the treatment process are released from the stack. The gases then move through the air into the community, where residents can breathe them in. The air pathway is *complete* because the production of H_2S at the landfill and subsequent elevated concentrations in the community have been well documented and verified by monitoring and reports of odors from community members.
- Drinking Water Pathway –Drinking water in the community is obtained from municipal wells or from private wells drawing groundwater from areas near the landfill. Residents could be exposed through drinking the water, by breathing contaminants released from the water, or by getting contaminants on their skin. Limited information is available about contaminants released from the landfill into groundwater or groundwater flow in the area. Nearby wells have not been tested specifically for H_2S. Because the source and transport elements of the pathway are poorly defined, the drinking water pathway is considered *potential*.

This final report also includes discussion of data from surface water downstream from the site and groundwater collected at monitoring wells just downgradient from the landfill. We do not have sufficient data on soil contaminants to assess the potential for exposure to trespassers; we note that the capping materials now covering the C&D portion of the landfill were tested and

shown to be clean. If more information becomes available, ATSDR could consider exposures through other potential pathways in the future.

A completed exposure pathway does not necessarily mean that harmful health effects will occur. A chemical's ability to harm health depends on many factors, including how much of the chemical is present, how long and how often a person is exposed to the chemical, and how toxic the chemical is. Further evaluation of the specific exposure occurring is needed to determine whether the exposure could cause harmful effects.

The process by which ATSDR evaluates the potential for adverse health effects to result from exposure to contaminants is described briefly below, focusing on the air and water pathways evaluated for the community around Fenimore Landfill [9].

- ATSDR first screens air or water analytical results against chemical-specific comparison values (CVs). CVs are concentrations of chemicals in air or drinking water below which no harmful health effects are expected to occur, even with continual exposure. Concentrations higher than the corresponding CV do not necessarily result in harm but must be evaluated further. CVs may include values derived by ATSDR and values developed by other state, federal, or international organizations.
- For chemicals in air that exceed CVs, ATSDR compares the air concentrations with known health effect levels identified in ATSDR's toxicological profiles, the Environmental Protection Agency's (EPA's) Integrated Risk Information System, or other scientific literature. For cancer-causing substances, an estimate of the increased risk of developing cancer from the exposure is calculated by multiplying the air concentration by an appropriate inhalation unit risk.
- For chemicals in drinking water that exceed CVs, ATSDR calculates exposure doses—estimated amounts of a chemical that people could take up into their bodies, on an equivalent body weight basis. The estimated dose is compared to a corresponding health guideline representing a dose below which no harmful non-cancer health effects would be expected. Health guidelines include ATSDR minimal risk levels (MRLs) or EPA reference doses. The potential for doses that exceed health guidelines to cause harmful effects is determined by comparing the dose to known health effect levels identified in ATSDR's toxicological profiles, EPA's Integrated Risk Information System, or other scientific literature. For cancer-causing substances, an estimate of the increased risk of developing cancer from the exposure is calculated by multiplying the dose by an appropriate cancer slope factor.

Discussion

General Health Effects Associated with Environmental Odors

ATSDR's chemical-specific evaluation as described above relies on dose-effect relationships from the scientific literature to determine if exposure to a chemical could result in an irritant or toxic response. However, a substantial body of literature shows that offensive or objectionable odors themselves can cause health symptoms [10,11]. These symptoms may result from protective inborn or learned aversions to offensive odors, which may signal danger or threats to

health [11-13]. The presence of odors in a community can also lead to a diminished sense of well-being or quality of life for community members [14].

Health complaints reported from exposure to offensive odors (such as emanating from animal processing facilities, wastewater treatment plants, or landfills) include eye, nose, and throat irritation; headache; nausea; diarrhea; hoarseness; sore throat; cough; chest tightness; nasal congestion; palpitations; shortness of breath; stress; drowsiness; and alterations in mood [13]. Usually the symptoms occur at the same time as the odor and resolve when the odor goes away. But in sensitive people, such as those with asthma, the very young, or the very old, odors can result in symptoms that last longer and may aggravate existing medical conditions [12]. In addition, previous exposure to high levels of an irritating substance has been shown to make some people acutely sensitive to the substance in the future. If these people smell even very low levels of the substance, they might experience symptoms ranging from headaches and nausea to effects associated with panic attacks, such as lightheadedness or shortness of breath [13].

ATSDR has developed a website with information on environmental odors. The website (http://www.atsdr.cdc.gov/odors/index.html) contains additional reference information on effects of odors on health as well as resources for residents who are concerned about odors in their community.

Evaluation of Exposure to H_2S

The following sections will describe H_2S toxicity and monitoring for this substance that has occurred in the community surrounding the Fenimore Landfill. Following discussion of data quality issues related to the monitoring, ATSDR will evaluate implications of community exposure to H_2S.

H_2S Background and Health Effects

H_2S is a colorless, flammable gas with a distinctive "rotten egg" odor. It is formed by anaerobic (oxygen-free) degradation of sulfur-containing compounds and is a major concern for odors and exposures from C&D landfills, wastewater treatment facilities, and animal production operations. H_2S can be smelled at very low levels, with typical odor thresholds between 0.5 and 3 parts per billion (ppb). In addition to being a nuisance, H_2S can pose health risks at higher levels. Breathing in very high levels (hundreds of parts per million, or ppm) of H_2S can be life threatening, and breathing lower levels can cause symptoms such as reduced breathing function, eye and nasal irritation, headache, and nausea. H_2S can be particularly dangerous because at higher levels, the human nose becomes desensitized over time and may not detect the odor [15].

Community exposures to relatively low levels of H_2S have been associated with harmful health effects. For example, one study found that residents exposed to H_2S and other sulfur compounds from paper mill operations had 12 times the rate of eye irritation compared to residents in an unexposed town. In the exposed population, peak daily exposures of H_2S were up to 70 ppb, and the annual average was 4.3 ppb [16]. ATSDR investigated a community near several sources of H_2S and other sulfur compounds and found associations between asthma and other respiratory-related hospital visits and days with H_2S or total reduced sulfur compounds greater than 30 ppb in any 30-minute period [17]. Other studies have described headache, eye and nasal irritation, nausea, and other neurophysiological and respiratory effects from community exposures near

H_2S-releasing industries [18-20]. In most cases, other sulfur compounds and pollutants were present in addition to H_2S.

ATSDR has developed an acute (short-term) minimal risk level (MRL) for H_2S of 70 ppb [15]. This represents a concentration below which no harmful health effects are expected; higher concentrations do not necessarily result in harm but must be evaluated further. The acute MRL is based on a study of lung function of three male and seven female volunteers with bronchial asthma requiring medication. The ten volunteers were exposed to 2,000 ppb of H_2S for 30 minutes. The group as a whole did not show statistically significant changes in any lung function parameters. However, three volunteers complained of headaches, and two volunteers showed changes suggestive of bronchial obstruction. The 2,000 ppb concentration was used as the lowest effect level; this number was divided by uncertainty factors of 3 for use of a minimally adverse effect level, 3 for human variability, and 3 for the short exposure duration used in the study to obtain the acute MRL of 70 ppb.

ATSDR also developed an intermediate-duration MRL for H_2S of 20 ppb [15]. The intermediate MRL is based on a 10-week study of rats exposed to various levels up to 80,000 ppb H_2S for 6 hours a day, 7 days a week. Nasal lesions appeared in rats exposed to 30,000 or 80,000 ppb H_2S, but no lesions occurred in rats exposed to 10,000 ppb H_2S. The no-effect level of 10,000 ppb in rats exposed intermittently was adjusted to determine the human equivalent concentration for continuous exposure of 460 ppb. The 460 ppb concentration was divided by uncertainty factors of 3 for extrapolation from animals to humans and 10 for human variability to obtain the intermediate MRL of 20 ppb.

ATSDR has not derived a chronic MRL for H_2S. Chronic low level H_2S exposure studies have not been conducted in animals, and epidemiological exposure studies are limited. H_2S is rapidly processed and removed from the human body, and the early acute or intermediate effects caused by lower level exposures are generally reversible [15].

EPA developed an inhalation reference concentration (RfC) for H_2S. EPA defines the RfC as "an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." EPA developed the RfC for H_2S using the same 10-week rat study used by ATSDR to develop the intermediate MRL. The NOAEL was divided by uncertainty factors of 3 for animal to human extrapolation, 10 for sensitive populations, and 10 for using a study of sub-chronic exposure to obtain the RfC of 2 ppb [21].

H_2S is not known to cause cancer in humans, and its possible ability to cause cancer in animals has not been studied thoroughly. Neither the National Toxicology Program (NTP) of the Department of Health and Human Services nor the International Agency for Research on Cancer (IARC) have classified the carcinogenicity of H_2S [22,23]. EPA has determined that data for H_2S are inadequate to assess carcinogenicity [21].

Community H_2S Monitoring and Data Quality

Reports of rotten egg odors from the landfill began in fall 2012. In early 2013, the Township of Roxbury began monitoring at locations around the landfill to characterize H_2S releases using Jerome model 631-X monitors. These monitors work by sampling air and drawing it over a gold film. The concentration of H_2S in the sampled air is determined by the change in electrical resistance of the gold film as H_2S is deposited on the film [24]. The first monitor began recording data in February 2013, and additional monitors were added to the system in ensuing months. Figure 1 on page 8 shows the general locations of the monitors in relation to the landfill, and Table 1 indicates when sampling began for each monitor.

The monitors collect samples every 5 minutes and results are sent electronically to the Township contractor's central computer system and to the Township "Greenlight" system, which displays the previous 24 hours of results for each monitor and is available for public viewing on the internet (http://54.235.249.118/guests/greenlight.get.live.data.2a.php). Data summaries of 15-minute average H_2S readings for all monitors are also posted on the internet and updated regularly, generally on a weekly or biweekly basis.

Table 1. Information on Community Jerome H_2S Monitors

Monitor	Approximate Location (See Figure 1)	Date Jerome Meter Monitoring Began
ROX4	Near homes about ¼ mile east-southeast of the landfill	2/5/2013
ROX5	Near Emmans Park about ½ mile southeast of the landfill	3/18/2013
ROX6	Near homes less than ¼ mile northwest of the landfill	6/14/2013
ROX7	In public park less than ½ mile east-northeast of the landfill	9/3/2013
ROX8	At entrance to landfill, less than ¼ mile southwest of the landfill	9/3/2013
ROX9	At business located about 1 mile east-southeast of the landfill	10/9/2013
ROX10	At sports fields located about 1½ miles southeast of the landfill	10/9/2013
ROX11	In neighborhood about 1¼ miles south of the landfill	10/9/2013
ROX12	At business located about ¾ mile northeast of the landfill	10/9/2013

Data Quality Issues

In early 2014, several of the Jerome monitors began showing results that were unexpected. For example, occasionally a monitor which had been reading low H_2S levels would suddenly, for one sample reading, detect a very high H_2S concentration. The concentration measured in the next sample 5 minutes later would be low again. Odors were reportedly not associated with these readings. These spikes continued to occur, and eventually the operators of the monitors began postponing action while waiting to verify any high readings.

ATSDR recognizes that this type of spike is not uncommon using Jerome monitors. H_2S can slowly build up on the gold film over time and the buildup can suddenly be released all at once, resulting in a spike – a massive H_2S reading that does not really represent the concentration in air at that time [24]. However, at the time these high readings occurred, work was occurring at the landfill, and some H_2S was being released. Because even short exposures to elevated H_2S can have health effects, ATSDR made the following recommendations to the Township in August and September 2014 regarding implementing community alerts as specified in the Township's action plan:

- If real-time readings exceed action levels, take prompt action to protect the public from potentially harmful short-term exposures without waiting for complete investigation of the source of the readings.
- Notify community members in advance when work occurs at the landfill that could release H_2S.

Beginning in October 2014, the Township's contractor implemented a new software protocol to attempt to differentiate equipment spikes from actual readings of H_2S. This method has reportedly reduced the frequency of errant spikes. However, spikes continue to occur in various monitors.

To perform an independent analysis of the data, the Agency requested and obtained the complete data set of 5-minute H_2S readings sent directly to the contractor's computer system from the monitors [25]. ATSDR examined the raw data to determine how frequently the problem was occurring and whether any explanations for the spikes could be observed. ATSDR used its own criteria to identify spikes that were thought to be not representative of actual concentrations in the community and removed the spikes from the analysis of potential exposures.[1] Figures 3 through 6 show the H_2S concentrations over time for the community monitors as calculated using these procedures to remove spikes. Thirty-minute average concentrations are shown in the figures, since that is the exposure time period in the study used to develop ATSDR's acute (short-term) MRL.

Another data quality issue that began in early 2014 was a slight increase in the baseline H_2S levels, particularly evident in monitors farther from the landfill and closer to densely populated areas. Figure 6 shows this trend in the expanded data for monitors ROX 9, 10, 11, and 12. The increase was generally small; for example, monitors that typically read 7-9 ppb increased to 10-14 ppb. The reason for these increases is unknown, but it could be weather- or temperature-related, since the monitors returned to their previous levels during the summer months and trended upwards again in late 2014.

Except for the method described in the footnote on this page to account for equipment spikes, ATSDR considered and included all data points in this evaluation of exposure and made no attempt to determine whether the H_2S detections were actually released from the landfill or from some other source.

[1] ATSDR discounted as equipment spikes readings that were both greater than 50 ppb and more than 50 times the average of the two immediately preceding and two immediately following readings (instances where data immediately preceding or following were missing used only the available data). Using data through January 28, 2015, ATSDR identified and removed 109 spikes that were probably equipment-related. The removed spikes represent a very small fraction of the total readings (about 0.007%) and did not greatly affect the overall trends of H_2S measured over time. For the final release of this report, ATSDR evaluated additional data from January 29, 2015 through November 30, 2015. For these data, ATSDR identified and removed 10 spikes that were probably equipment-related.

Figure 3. H_2S concentrations in community monitors over time: ROX 4, 5, & 7 (monitors closest to and east of the landfill, generally downwind)

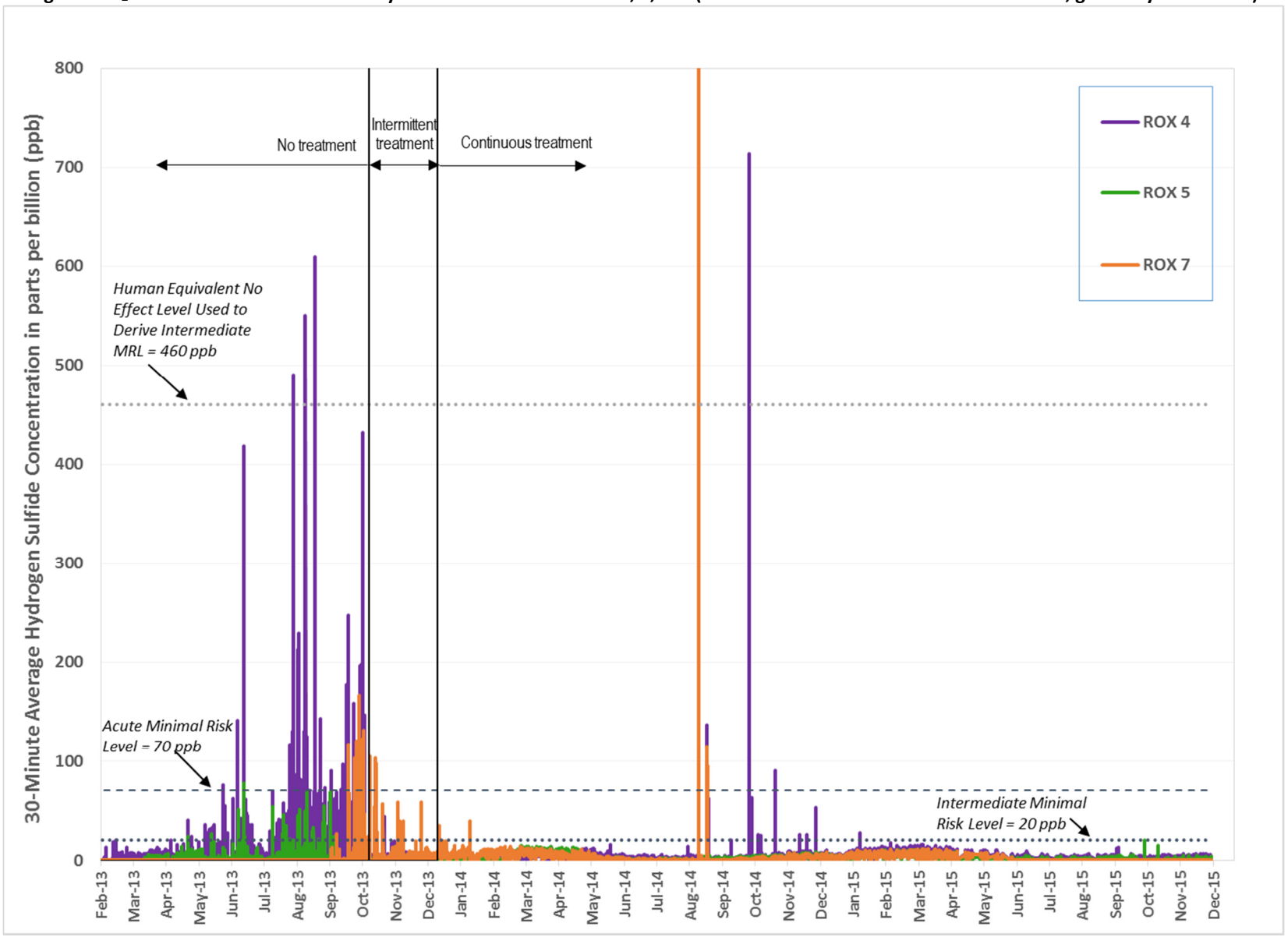


Figure 4. H_2S concentrations in community monitors over time: ROX 6 & 8 (monitors closest to and west of the landfill, generally upwind)

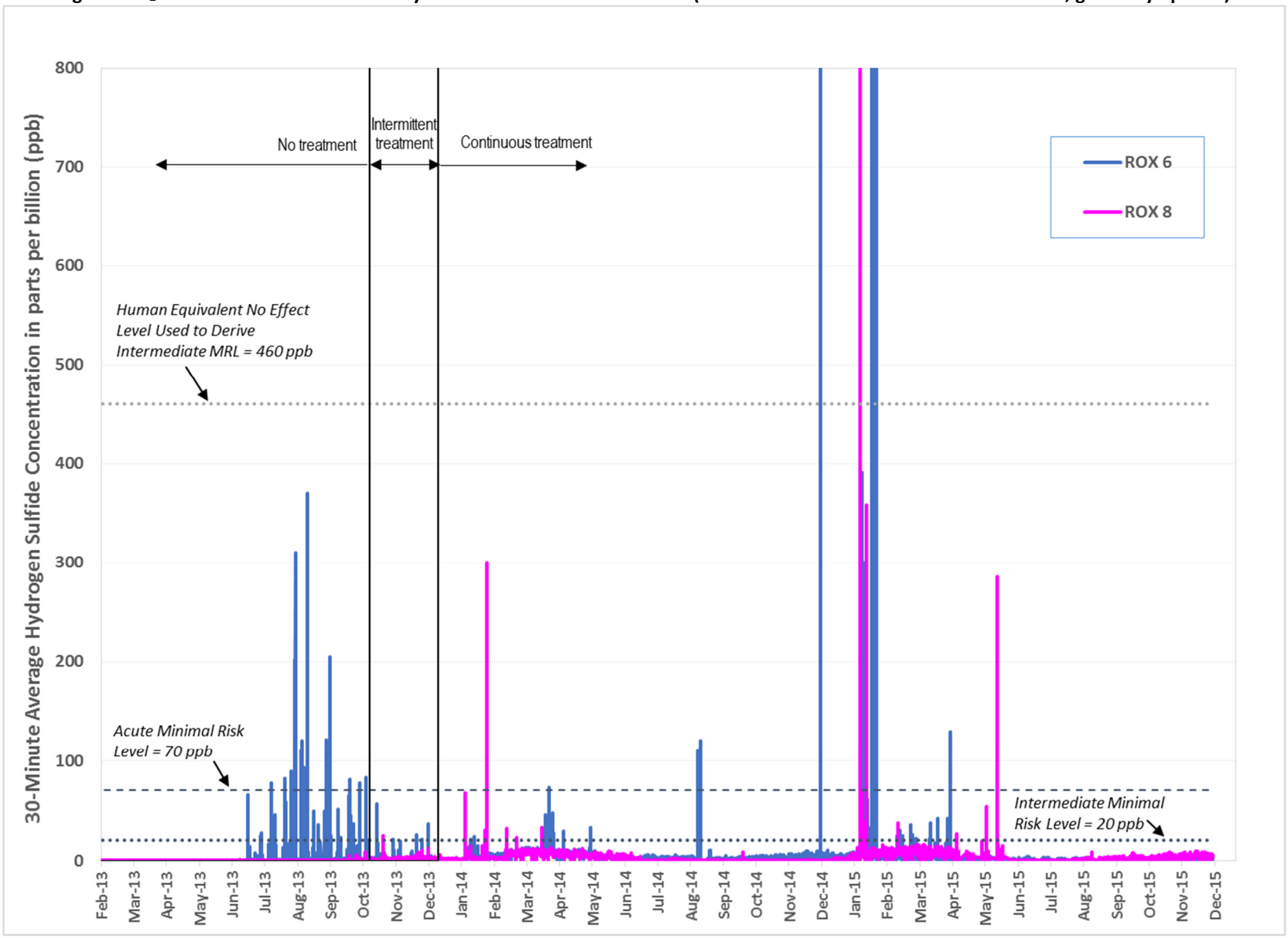


Figure 5. H_2S concentrations in community monitors over time: ROX 9, 10, 11, &12 (monitors furthest from the landfill, generally downwind)

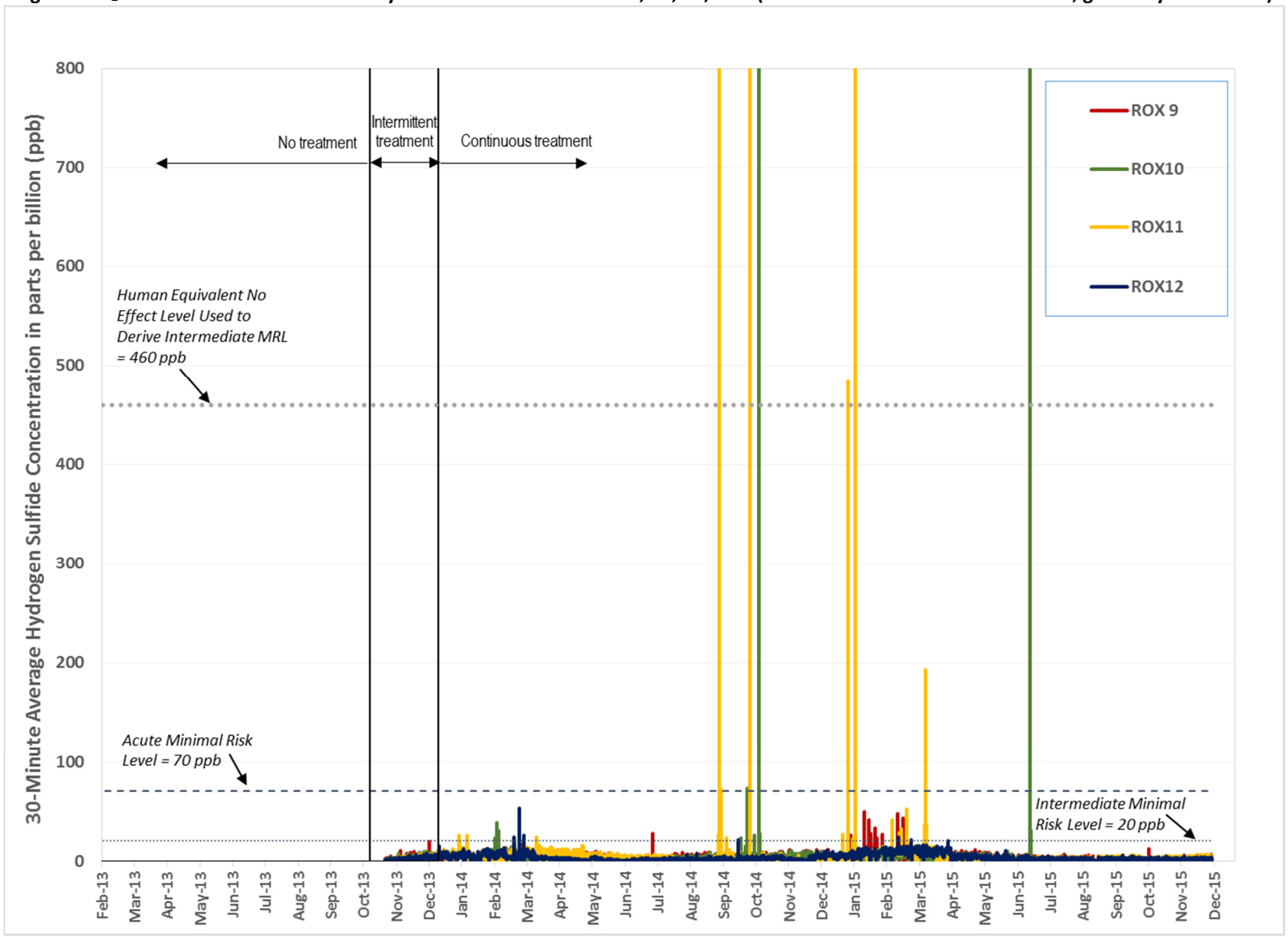
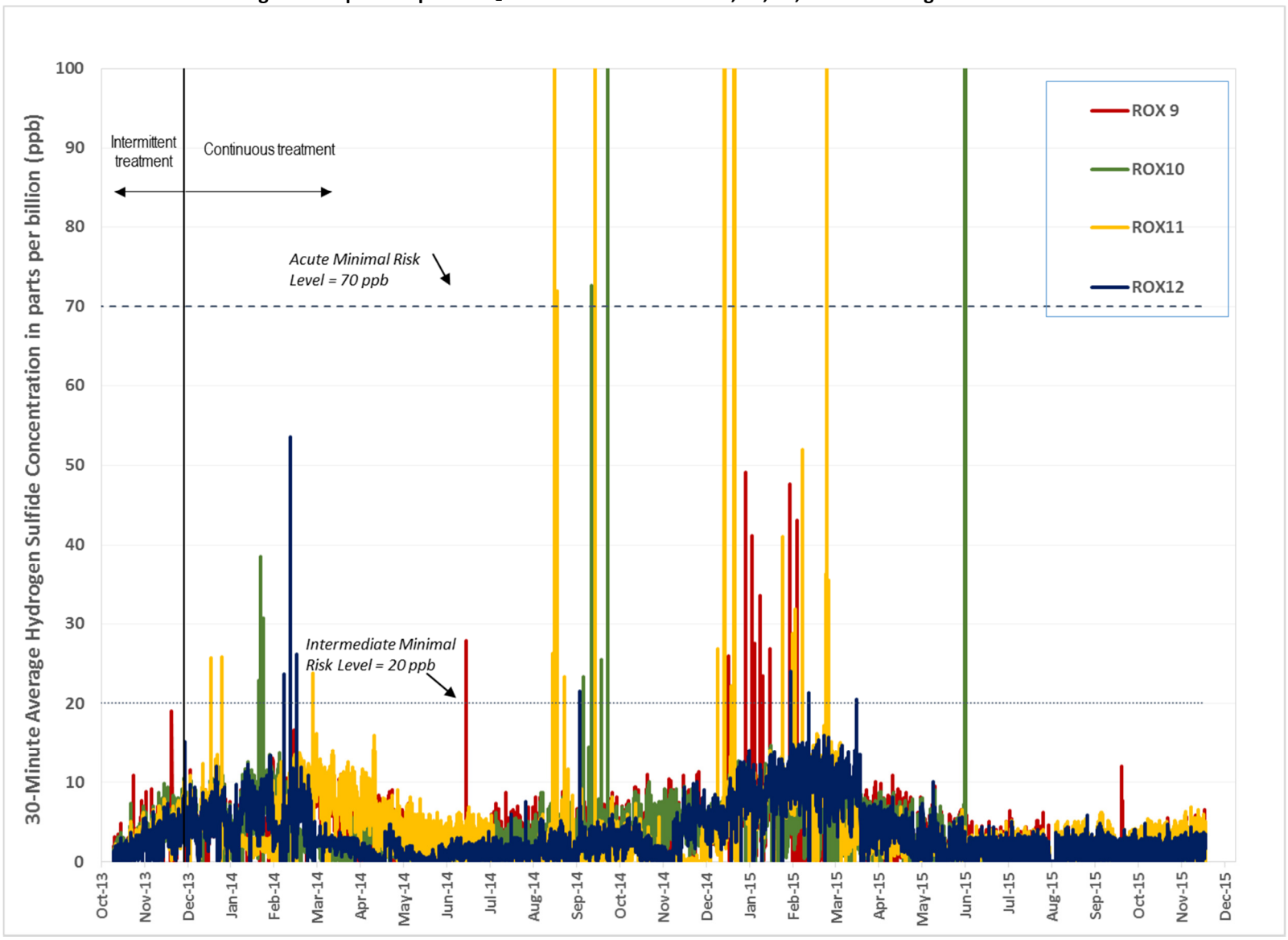


Figure 6. Expanded plot of H_2S concentrations in ROX 9, 10, 11, &12 to show greater detail



Tables 2a through 2c summarize the findings for H_2S since the monitoring began. To better understand the data, ATSDR split the monitoring into three periods:

- Before October 9, 2013 – when gases were not effectively controlled or treated. Only monitors ROX4, ROX5, ROX6, ROX7, and ROX8 collected data during this time period.
- Between October 9 and December 11, 2013 – when the gas treatment system and interim scrubber were operating intermittently, during the daytime hours. All ROX monitors collected data during this time period.
- After December 11, 2013 through January 28, 2015 – when the gas treatment system and scrubber were operated continuously. All ROX monitors collected data during this time period.

Tables 2a through 2c summarize the 30-minute-averaged results for each time period and monitor compared to ATSDR's acute and intermediate duration MRLs for H_2S (70 ppb and 20 ppb, respectively).

For this final release, ATSDR evaluated additional community H_2S data collected from January 29, 2015 through November 30, 2015. The gas treatment system and scrubber were operated continuously and all ROX monitors collected data during this time period. These data are presented separately in a new Table 2d. **We have updated the following discussion to include discussion of these newer data.**

Note on Continuing Detections of H_2S

Several detections of H_2S occurring in late 2014 and early 2015 were not removed with the software algorithm to account for equipment spikes. However, these spikes were reportedly not accompanied by odors or consistent with wind directions that would indicate releases from the landfill. Such detections have continued in various monitors even with completion of the landfill cap. The source of these readings and their relationship to equipment issues are unknown. The detections were up to hour-long periods of intermittent H_2S concentrations in the tens of thousands of ppb.

The level and the time characteristics of the detections are different than H_2S detections from summer and fall 2013 when landfill gases were a recognized issue and odors were frequently reported by many people. Long-term operation of the monitors has possibly decreased their reliability. However, if accurate, the readings may indicate another source of potentially harmful levels of H_2S in the community.

In the public comment version of this health consultation, ATSDR recommended the Township or NJDEP investigate potential alternate sources of H_2S if these elevated readings continued. ATSDR also recommended the Township or NJDEP consider verifying results with a different H_2S monitoring technology. In response to these recommendations, NJDEP and Township officials stated that they intend to test alternate technologies. The Township also stated they had been working to reduce the frequency of equipment "spikes" and exploring equipment issues by placing co-located Jerome monitors near some of the ROX monitors.

These efforts appear to have been somewhat successful in producing more stable readings; Figures 3-6 and Tables 2a-2d show that H_2S readings in the monitors have been generally stable and low. Only a few apparent "spikes" were observed since late winter 2015.

In December 2015, the Township and its contractor provided ATSDR with H_2S data from Jerome meters co-located at three different locations [26]. The data were from Jerome meters placed near ROX6 and ROX8 starting in January 2015 and near ROX12 for a few weeks in April 2015. ATSDR's review of the data showed that none of the high readings for ROX6 or ROX8 were accompanied by elevated readings in the co-located monitor. No high readings occurred for ROX12. However, co-located monitors also exhibited "spikes" and highly elevated H_2S readings, even more frequently than the primary monitors, and we do not have co-located data to check all the spikes or longer duration elevated H_2S readings that occurred in all monitors. While it is very likely that the spikes are equipment-related and do not represent actual atmospheric H_2S concentrations, we continue to recommend an alternate technology for monitoring community H_2S to give more confidence in the data.

Table 2a. Summary of 30-Minute Average H_2S Concentrations in Roxbury Community near Fenimore Landfill, Data Prior to October 9, 2013, Before Operation of the Gas Extraction/ Treatment System

H_2S Monitor	Total Days Monitor in Operation	Number of Days with Any Reading > Acute MRL of 70 ppb	Percentage of Time Readings > Acute MRL	Number of Days with Any Reading > Intermediate MRL of 20 ppb	Percentage of Time Readings > Intermediate MRL	Highest 30-Min Average Concentration in ppb
ROX 4	249	36	1.1%	105	4.7%	610
ROX 5	209	1	0.0%	34	1.1%	78
ROX 6	120	14	0.5%	30	2.3%	370
ROX 7	39	11	2.1%	14	7.1%	167
ROX 8	39	0	0.0%	0	0.0%	8
ROX 9	No Monitor Operating					
ROX 10	No Monitor Operating					
ROX 11	No Monitor Operating					
ROX 12	No Monitor Operating					

Table 2b. Summary of 30-Minute Average H_2S Concentrations in Roxbury Community near Fenimore Landfill, Data from October 9 to December 11, 2013, During Intermittent Operation of the Gas Extraction/ Treatment System

H_2S Monitor	Total Days Monitor in Operation	Number of Days with Any Reading > Acute MRL of 70 ppb	Percentage of Time Readings > Acute MRL	Number of Days with Any Reading > Intermediate MRL of 20 ppb	Percentage of Time Readings > Intermediate MRL	Highest 30-Min Average Concentration in ppb
ROX 4	64	0	0.0%	5	0.5%	61
ROX 5	64	0	0.0%	3	0.2%	30
ROX 6	64	0	0.0%	6	0.3%	57
ROX 7	64	4	0.3%	9	1.4%	105
ROX 8	64	0	0.0%	1	0.1%	25
ROX 9	49	0	0.0%	0	0.0%	19
ROX 10	49	0	0.0%	0	0.0%	10
ROX 11	49	0	0.0%	0	0.0%	9
ROX 12	49	0	0.0%	0	0.0%	8

H_2S = hydrogen sulfide MRL = minimal risk level ppb = parts per billion

Table 2c. Summary of 30-Minute Average H_2S Concentrations in Roxbury Community near Fenimore Landfill, Data from December 12, 2013, to January 28, 2015, During Continuous Operation of the Gas Extraction/ Treatment System

H_2S Monitor	Total Days Monitor in Operation	Number of Days with Any Reading > Acute MRL of 70 ppb	Percentage of Time Readings > Acute MRL	Number of Days with Any Reading > Intermediate MRL of 20 ppb	Percentage of Time Readings > Intermediate MRL	Highest 30-Min Average Concentration in ppb
ROX 4	413	3	0.05%	12	0.06%	714
ROX 5	413	0	0.00%	0	0.00%	15
ROX 6	413	9	0.07%	21	0.11%	13,270
ROX 7	413	3	0.03%	5	0.07%	3,950
ROX 8	413	3	0.02%	10	0.05%	902
ROX 9	413	0	0.01%	8	0.01%	49
ROX 10	413	2	0.02%	8	0.03%	4,714
ROX 11	413	5	0.03%	14	0.04%	3,430
ROX 12	413	0	0.00%	4	0.01%	54

Table 2d. Summary of 30-Minute Average H_2S Concentrations in Roxbury Community near Fenimore Landfill, Data from January 29, 2015 through November 30, 2015, During Continuous Operation of the Gas Extraction/ Treatment System – (Data Collected After Those Evaluated in ATSDR's Public Comment Health Consultation)

H_2S Monitor	Total Days Monitor in Operation	Number of Days with Any Reading > Acute MRL of 70 ppb	Percentage of Time Readings > Acute MRL	Number of Days with Any Reading > Intermediate MRL of 20 ppb	Percentage of Time Readings > Intermediate MRL	Highest 30-Min Average Concentration in ppb
ROX 4	306	0	0.00%	0	0.01%	17
ROX 5	306	0	0.00%	1	0.01%	21
ROX 6	306	1	0.02%	12	0.04%	130
ROX 7	306	1	0.00%	1	0.00%	128
ROX 8	306	3	0.01%	8	0.04%	174
ROX 9	306	0	0.00%	2	0.01%	48
ROX 10	306	1	0.01%	2	0.01%	9,750
ROX 11	306	1	0.01%	6	0.02%	193
ROX 12	306	0	0.00%	3	0.02%	24

H_2S = hydrogen sulfide MRL = minimal risk level ppb = parts per billion

Public Health Implications of H_2S Exposure

Results of H_2S monitoring show that the community has been exposed to H_2S at least since monitoring began in 2013 (presumably, exposure began when odors were first reported in the community in fall 2012). H_2S concentrations have been reduced since treatment of the gases began.

Implications of H_2S Exposure before Gas Treatment

Before the landfill gas extraction and treatment system began operating, community monitors showed consistently high H_2S concentrations. Those closest to the landfill and downwind (ROX 4, 6, and 7) showed the highest concentrations, regularly reaching hundreds of ppb H_2S.

Virtually all people exposed to these concentrations of H_2S would be able to smell its unpleasant odor. As described earlier, people breathing air with offensive odors can experience symptoms such as eye, nose, and throat irritation; nausea; and headaches. These symptoms have been reported as the body's reaction to the odor rather than chemical irritant properties of a specific pollutant [10-13]. Some people are more sensitive to odors than others, but almost anyone in the nearby community who could smell the H_2S could have experienced odor-related symptoms.

Even the highest concentrations of H_2S measured were too low to cause life-threatening adverse effects like losing the sense of smell (typically occurring at more than 100,000 ppb) or losing consciousness (or "knockdown," occurring at exposure to 500,000 ppb or more) [27]. All monthly average H_2S concentrations for all monitors are lower than ATSDR's intermediate MRL of 20 ppb. Therefore, exposed people are unlikely to develop the nasal lesions found in the 10-week long rat study used as the basis for determining the intermediate MRL.

ATSDR's acute MRL of 70 ppb is based on a study in which two out of ten people with asthma exposed to 2,000 ppb of H_2S for 30 minutes had measurable changes in lung function parameters, and three complained of headaches afterwards [15]. People living near the landfill, primarily those with pre-existing respiratory conditions, could have had similar harmful effects from exposure to the levels of H_2S measured around the landfill – up to 610 ppb for a 30-minute average. Children and adults would have been affected equally. These effects would be expected to resolve when H_2S concentrations decreased.

In summary, before the landfill gases were being treated, the H_2S concentrations in the community were high enough to cause harmful health effects, even for short term exposures. Actions to mitigate harmful exposures were needed.

Implications of H_2S Exposure after Gas Treatment

When collection and treatment of landfill gases began in October 2013, community monitors recorded an immediate reduction in H_2S concentrations. Both the maximum concentrations detected and the number of detections over MRLs were reduced. City officials and community members also stated that the odors had declined. However, the monitoring indicated that H_2S was still present in the community. ATSDR was asked to evaluate the public health implications of H_2S exposure after the treatment began.

This evaluation is complicated by the data quality issues that began occurring in 2014 and were discussed earlier. Figures 3-6 indicate a significant reduction in H_2S from the consistently observed levels in summer and fall 2013; this reduction lasted through late summer 2014 (Note: ATSDR's spike detection procedure described on the footnote on page 11 removed several equipment-related spikes from this time period). However, in late summer 2014, additional elevations in concentration that were not obviously equipment-related began occurring. The elevations occurred at unrelated times, in several different monitors located in various directions from the landfill, and typically indicated H_2S concentrations an order of magnitude or more higher than were ever measured in summer and fall 2013. According to NJDEP and local officials, these high readings were not associated with odors or wind blowing from the landfill. The presence of these high readings increased the maximum reported 30-minute average in Table 2c compared to 2a before treatment, and it also increased the number of days with exceedances of ATSDR's MRL from what would be expected for continuous gas extraction and treatment. The elevated readings continued into early 2015 despite the completion of the landfill cap and continued extraction and treatment of landfill gases. ATSDR recommended the Township verify the readings or explore alternate technologies to measure H_2S. Table 2d indicates a decrease in the number and frequency of highly elevated H_2S readings in the monitors.

Due to the differences in timing, location, and concentration between the 2014-2015 elevated H_2S readings and detections of H_2S in summer/fall 2013 and based on review of the 2015 co-located data from 3 locations, ATSDR believes most of the elevations are equipment related. However, as discussed previously the continuing elevated readings, in both primary and co-located monitors, decrease confidence in the H_2S data. ATSDR recommends replacement or verification of the Jerome monitors with an alternate type of H_2S monitor (such as colorimetric tape meters) to give community members greater confidence in the results.

After extraction and treatment of landfill gases began, only a few instances of concentrations exceeding ATSDR's acute MRL of 70 ppb occurred. Some of these were apparent equipment-related elevated readings which might not represent actual air concentrations. If they did represent actual H_2S concentrations, the highest levels (up to 37,000 ppb) would be too low to cause immediate serious effects like losing the sense of smell or consciousness. During the relatively isolated times when H_2S concentrations exceeded ATSDR's MRL, sensitive populations may have experienced harmful health effects such as headache or changes in lung function, but the symptoms would resolve more quickly and occur less often because the exceedances were much less frequent. Similarly, the instances when concentrations exceeded the intermediate MRL of 20 ppb were greatly reduced. Data collected since January 2015 (not evaluated in ATSDR's report for public comment) indicate continued low H_2S concentrations in the community. Therefore, people exposed to the H_2S concentrations after treatment would be unlikely to develop health effects.

Chronic effects from breathing low levels of H_2S are considered unlikely. H_2S is rapidly processed and removed in the human body, and the early acute or intermediate effects caused by lower level exposures are generally reversible [15].

The potential for harmful effects from H_2S exposure was greatly reduced by collection and treatment of the landfill gases. However, even after treatment began, odors have occasionally occurred, and community monitors continue to detect low levels of H_2S. Stress and possible health effects from exposure in summer and fall 2013 could have made community members more sensitive to odors. People could still experience harmful health effects in reaction to H_2S odors, which are offensive and annoying [13]. Chronic exposure to unpleasant odors also reduces the quality of life of a community, so ATSDR recommends continued efforts to prevent odor releases from the landfill. We recognize that concentrations of H_2S have continued to go down in the past year, and the likelihood of any health effects from exposure is now minimal. However, residents have continued to report offensive odors. NJDEP informed ATSDR in September 2015 that they are investigating all new odor complaints separately from their landfill work. ATSDR supports NJDEP taking action to identify the source of odors and addressing offensive odors to improve residents' quality of life.

ATSDR anticipates releases of H_2S from the landfill to be further reduced now that the cap is in place. With the gas extraction and treatment system operating properly, exposures should not be at levels of health concern. However, we believe continued community monitoring is needed to both confirm proper operation of the treatment system and to provide reassurance to community members that the air is safe. The current monitoring system does not fully meet these goals. We recognize that improvements have been made in the frequency of equipment anomalies associated with the current monitoring system. However, we feel an alternate measurement technology, not subject to such anomalies, would more effectively meet the needs of the community.

Evaluation of Exposure to SO_2

SO_2 Background and Health Effects

SO_2 is a colorless gas with a pungent odor, formed when compounds containing the element sulfur are burned. Breathing in very high levels of SO_2 can be life threatening, and breathing lower levels for even short periods of time (5 minutes to 24 hours) can cause adverse respiratory effects, particularly in people with asthma, children, and the elderly [28].

EPA has developed National Ambient Air Quality Standards (NAAQS) to protect the public from certain harmful ambient air contaminants, including SO_2 [29]. A national network of ambient air quality monitors measures levels of the contaminants. Geographic areas that are not in attainment with standards are required to develop plans to address air quality issues. For SO_2, EPA has set a primary one-hour NAAQS of 75 parts per billion (ppb). An area is deemed in non-attainment with the standard if the 99^{th} percentile of one-hour daily maximum SO_2 concentrations, averaged over three years, exceeds 75 ppb. The EPA also set a secondary standard for SO_2: a three-hour average concentration of 500 ppb, not to be exceeded more than once per year.

ATSDR has developed an acute (short-term) minimal risk level (MRL) for SO_2 of 10 ppb [28]. This represents a concentration below which no harmful health effects are expected; higher concentrations do not necessarily result in harm but must be evaluated further. The acute MRL is based on a study of a group of people with mild to moderate asthma exposed to various levels of SO_2 through a mouthpiece for ten minutes while exercising. Concentrations of SO_2 as low as 100

ppb caused a slight, but statistically significant increase in airway resistance (bronchoconstriction) in two of the participants. Uncertainty factors of 3 for use of a minimal effect level and 3 for human variability were applied to the effect level of 100 ppb to obtain the acute MRL.

Short (5-minute) exposures to SO_2 greater than the MRL up to about 400 ppb may or may not result in adverse health effects. As concentration, frequency, and duration of exposure increase within this range (and sensitivity of the individual and/or intensity of exercise increase), a greater percentage of sensitive persons may be more likely to experience bronchoconstriction, eventually leading to symptoms such as wheezing or chest tightness. According to EPA's 2008 Integrated Science Assessment for Sulfur Oxides, exposures of greater than 400 ppb SO_2 have caused clearly decreased lung function accompanied by respiratory symptoms [30]. Therefore, exposures to SO_2 concentrations greater than 400 ppb could be expected to have more serious respiratory effects to a greater percentage of sensitive persons, requiring them to stop activity, take medication, or seek medical attention.

There are no studies that clearly show cancer-causing effects of SO_2 in people or animals. Neither NTP nor EPA has classified the carcinogenicity of SO_2 [22,21]. In addition, IARC lists the carcinogenicity of SO_2 as not classifiable [23].

Community SO_2 Monitoring and Results

The landfill gas treatment process produces SO_2 when H_2S burns. Most of the SO_2 is removed by the scrubber, but small amounts may leave the scrubber stack and enter the atmosphere. Malfunctions of equipment in the treatment process may result in greater amounts of SO_2 released. When gas treatment began in fall 2013, NJDEP began monitoring SO_2 in the community at three locations. The locations of the monitors surrounded the landfill as shown in Figure 1; the monitors operate continuously using the same methodology and equipment as in the National Ambient Air Quality network of monitors. This technology is accepted and produces data of sufficient quality for determining ambient SO_2 concentrations.

ATSDR obtained the complete set of SO_2 data, which was tabulated in 15-second intervals and covered over 24 months of data from November 1, 2013 through early 2016 (we used November 30, 2015 as an ending date for graphs and statistics) [31]. To compare with health guidelines and federal standards, ATSDR calculated 5-minute and 1-hour average concentrations of SO_2 for each monitor. The results are shown graphically in Figures 7 and 8.

Figure 7. Five-Minute Average SO_2 Concentrations in Roxbury Community Monitors near the Fenimore Landfill, November 1, 2013 – November 30, 2015.

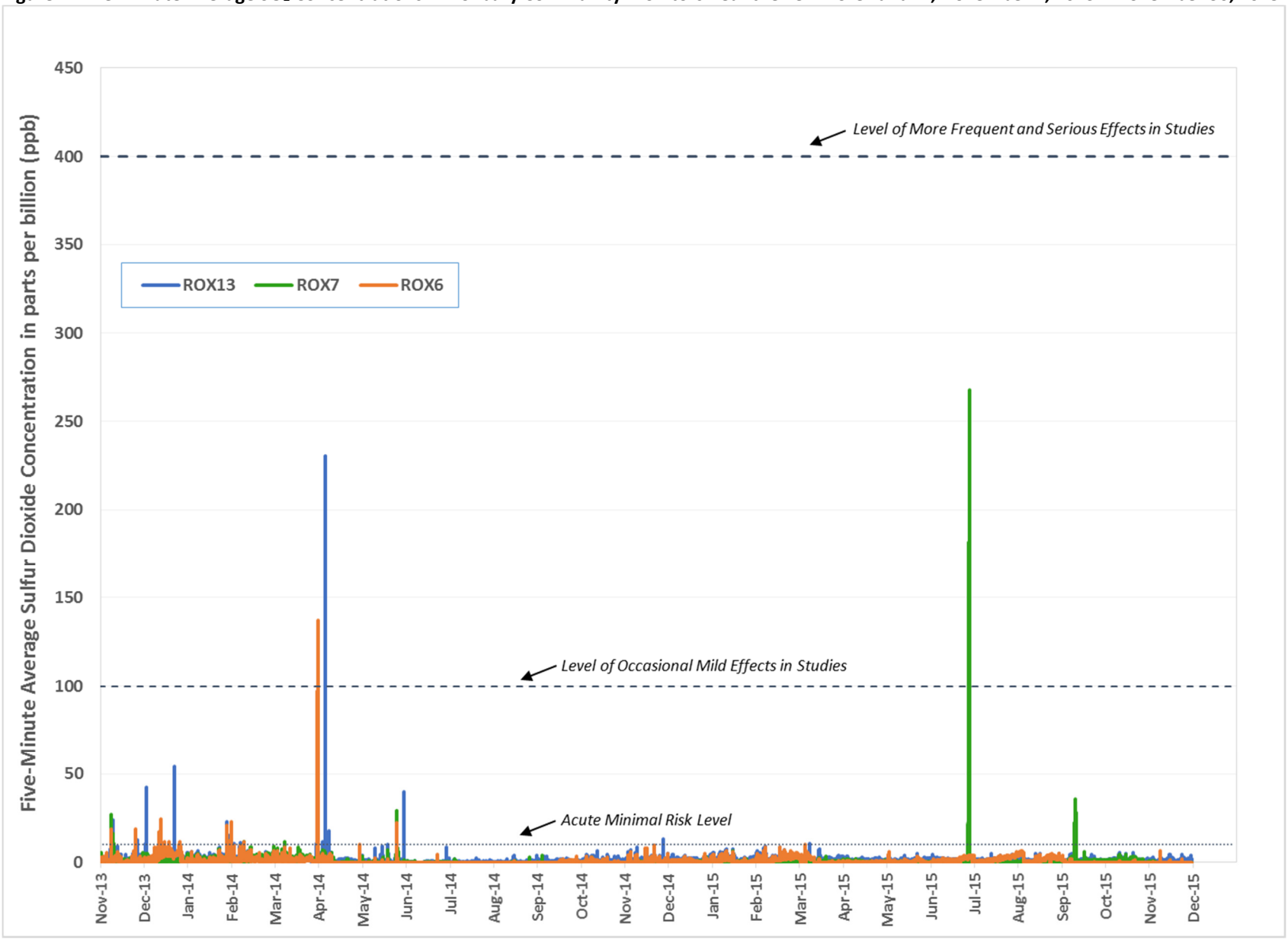
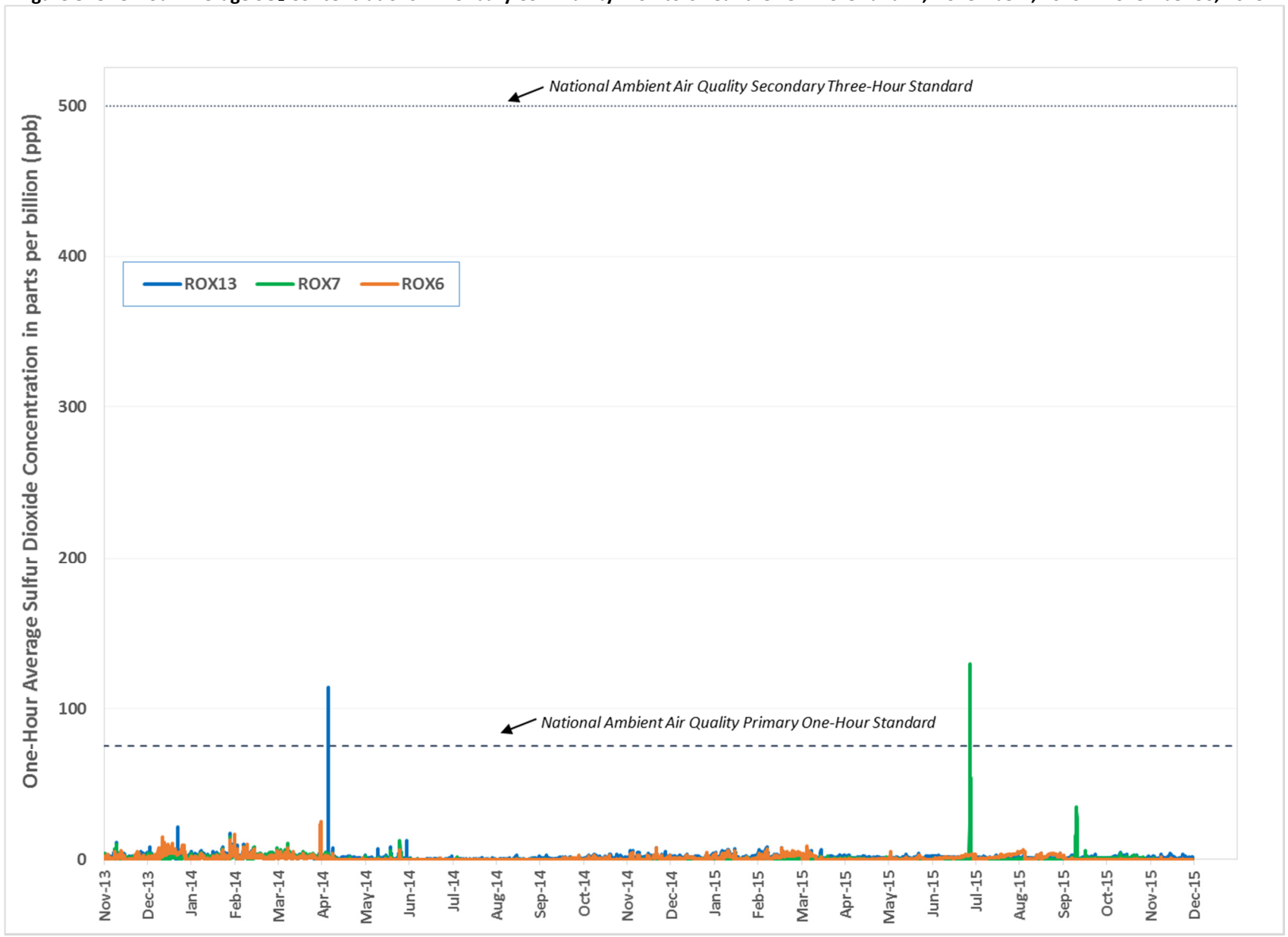


Figure 8. One-Hour Average SO_2 Concentrations in Roxbury Community Monitors near the Fenimore Landfill, November1, 2013 – November 30, 2015.



Public Health Implications of SO_2 Exposure

As illustrated in Figures 7 and 8, the community near the Fenimore Landfill has been exposed to detectable levels of SO_2 since the landfill gas treatment system began operation. Table 3 below summarizes the available monitoring data for SO_2 as compared with health guidelines and federal air quality standards discussed previously. ATSDR's acute MRL and the effect level forming the basis for the MRL are compared to short-term concentrations (5-minute averages). The study forming the basis for the MRL was of brief exposures (10-minute exposures to exercising asthmatics), and sensitive populations could experience health effects after very short exposures. The NAAQS primary standard is compared to one-hour averaged SO_2 concentrations, since the standard is based on a one-hour average concentration. We note that our comparison with the NAAQS standard is purely numerical and for perspective. Data were not available to calculate the 99th percentile of the one-hour daily maximum SO_2 concentration, averaged over three years, that is the official criteria determining whether an area meets or exceeds air quality standards.

Table 3. Summary of SO_2 Concentrations in Roxbury Community near Fenimore Landfill, Data from November 1, 2013 to November 30, 2015.

SO_2 Monitor	Highest 5-Minute Average Concentration in ppb	Number of 5-Minute Intervals (Percentage of Time) above Acute Minimal Risk Level of 10 ppb	Number of 5-Minute Intervals (% of Time) above Mild Effect Level of 100 ppb	Highest 1-Hour Average Concentration in ppb	Number of Hourly Intervals (% of Time) above National Ambient Air Quality Primary Standard of 75 ppb
ROX6	137	130 (0.06%)	2 (0.00%)	25	0 (0.00%)
ROX7	268	471 (0.22%)	19 (0.01%)	129	2 (0.01%)
ROX13	230	190 (0.09%)	6 (0.00%)	114	1 (0.01%)
Note: ATSDR removed some elevated SO_2 readings in 2015 (various monitors and times) from the raw data. The readings were researched and confirmed by NJDEP and/or the Township's contractor to be due to calibration of the monitors while they were inadvertently gathering data or weather-related equipment malfunctions that were promptly corrected. No equipment- or maintenance-related explanation for two readings in ROX 7 (6/28/15 and 9/11/15) could be identified; these readings are included in Figures 7 and 8 as well as this table.					

As shown in Table 3, the percentage of time SO_2 was higher than health guidelines or standards was very small, less than 0.25% in all cases. Before early June 2014, occasional releases of SO_2 occurred, and SO_2 concentrations higher than ATSDR's MRL were detected in the community monitors for short periods, from 5 minutes up to an hour. According to NJDEP personnel, these releases were due to treatment system equipment malfunctions that reduced the efficiency of SO_2 removal from the system; monitoring the stack for SO_2 was manual, so SO_2 sometimes was not detected right away. On July 3, 2014, the system was equipped with a continuous emissions monitoring system which monitors the stack every minute and automatically shuts the system down if SO_2 concentrations get too high [32,33]. SO_2 readings in community monitors were reduced after automation of these system controls: almost no readings above ATSDR's acute MRL occurred.

While updating the SO_2 data for this report, ATSDR removed some high SO_2 readings in the community monitors after receiving information from NJDEP and the contractors that the readings were due to brief malfunctions of the unit due to weather conditions (corrected), or due

to calibration of the system when it was still inadvertently collecting and storing data [34]. No equipment-related explanation was identified for two high SO_2 readings in the ROX 7 monitor (6/28/2015 and 9/11/15) [35]. ATSDR examined the continuous monitoring data for SO_2 concentration coming out of the treatment stack and the treatment system operator log sheet comments during these events [36]. No system problems that could have caused such high readings were identified. NJDEP also stated that records indicated wind was not blowing from the landfill towards the ROX7 monitor during these events [35].

The past and current exposures of the community to SO_2 are not likely to have caused serious harmful health effects. Exposure to SO_2 at the concentrations measured in April 2014 and July 2015 may have increased the risk of mild respiratory effects (increased airway resistance, but probably without any respiratory symptoms) to sensitive populations when they occurred, but they were isolated incidents. The short-term concentrations during these releases did not reach levels that have been consistently associated with effects serious enough to cause affected people to take medication or seek medical assistance. Since automation of the treatment system, exposure to SO_2 has been reduced. Some SO_2 exposure may continue in the community as indicated by isolated, localized elevations in community monitor readings, but the frequency and level measured would not cause serious or lasting harmful effects.

Evaluation of Potential Air Exposure to Other Compounds from Landfill or Treatment Process

Available Data on Other Compounds Released

Only limited data are available on compounds other than H_2S and SO_2 released from the landfill into air. On August 16, 2013, NJDEP collected four ambient air samples in approximately the four compass directions from the C&D waste material at the tree line of the site [37,38]. The samples were collected over approximately 8 hours overnight in SUMMA canisters and were analyzed for volatile organic compounds using EPA Method TO-15.

A local environmental group (Roxbury Environmental Action Coalition, or R.E.A.C.T.) collected ambient samples on October 1, 2013, near the community monitoring station ROX4. Two SUMMA canisters and one vapor badge were used to collect air samples over approximately 8 hours. The samples were sent to laboratories for analysis by EPA Method TO-15 for volatile organic compounds, EPA Method TO-11A for formaldehyde, EPA Method 18 for methane, and ASTM Method D5504 for reduced sulfur compounds including H_2S, carbonyl sulfide, methyl mercaptan, ethyl mercaptan, and dimethyl sulfide [39].

Results and Public Health Implications of Exposure

The community group monitoring results did not show any detections of sulfur compounds. Some sulfur compounds are not very stable and may have been lost in the SUMMA canister sampling method. As demonstrated by community monitoring results included earlier in this document, H_2S was being released into the community when the ambient sampling was performed. Whether other sulfur compounds were also released in the past cannot be determined with certainty one way or the other. We discuss the possibility of exposure to other sulfur compounds later in this section.

A summary of the compounds detected in the ambient sampling by both groups is shown in Table 4. Highlighted concentrations indicate compounds detected at concentrations higher than health-based comparison values. Compounds detected above any comparison value are evaluated further to assess whether exposures could result in harmful health effects.

The data in Table 4 represent only a snapshot in time. Long-term concentrations of any compounds in ambient air may be significantly higher or lower than measured during the period sampled. However, the sampling was conducted during the period when odors from the landfill were frequent and high. Therefore, a reasonable assumption is that significant amounts of compounds released along with H_2S, other than the sulfur compounds discussed above, would have been detected.

Table 4. Compounds Detected in Ambient Air Sampling near Fenimore Landfill, Roxbury Township, NJ

Sample Date:	8/16/13				10/1/13	Comparison Value (CV) in ppb	Source
Direction from Landfill:	South	East	North	West	Southeast		
Group Collecting Sample:	DEP	DEP	DEP	DEP	REACT		
Compounds Detected, Concentrations in parts per billion (ppb):							
Acetone	18.5	1.9	3.7	3.8	1.1	13,000	MRL
Benzene	0.27	0.1 J	ND	ND	ND	3 /0.04	MRL /CREG
Chloromethane	0.59	0.54	0.62	0.54	ND	50	MRL
Dichlorodifluoromethane	0.5	0.5	0.49	0.49	0.43	20	RSL
Ethanol	0.87	0.73	1.4	1.4	0.57	none	
Ethyl Acetate	2.5	3.7	2.9	3.4	-	20	RSL
Freon 114	0.096 J	ND	0.14 J	ND	-	14,000	RfC (for Freon)
Hexane	0.12 J	ND	ND	ND	ND	200	RfC
2-Hexanone	0.17 J	ND	ND	ND	-	7.3	RfC
Isopropyl Alcohol	0.31	0.18 J	0.22	0.37	ND	85	RSL
Methylene chloride	0.38	0.3	0.26	0.23	0.28	170 /29	RfC /CREG
Methyl Ethyl Ketone	0.55	0.13 J	0.23	0.17 J	ND	1700	RfC
Propylene	0.4 J	0.36 J	0.44J	0.28J	-	1800	RSL
Tertiary Butyl Alcohol	0.77	ND	ND	ND	ND	10,000	RSL (for sec-butyl alcohol)
Tetrachloroethylene	0.14	ND	ND	ND	ND	5.9 /0.57	MRL /CREG
Toluene	0.28	0.22	0.5	0.25	ND	80	MRL
Trichloroethylene	0.07	ND	ND	ND	ND	0.37 /0.045	MRL /CREG
Trichlorofluoromethane	0.26	0.25	0.23	0.24	ND	130	RSL
m,p-Xylene	0.17 J	ND	ND	ND	ND	23	RfC (for total xylenes)
Xylenes (total)	0.17 J	ND	ND	ND	ND	23	RfC
Methane	-	-	-	-	3240 ppb (0.0003%)	explosive at >5%	
Formaldehyde	-	-	-	-	6.33	8 /0.063	MRL /CREG

NOTES: Shaded boxes indicate detection above ATSDR's lowest CV.
J = estimated value - = not analyzed, or not reported
ND = not detected MRL = ATSDR chronic Minimal Risk Level
RfC = EPA Reference Concentration RSL = EPA Regional Screening Level for Residential Air
CREG = Cancer Risk Evaluation Guide

Compounds Detected above Comparison Values

No compounds were detected above comparison values for noncancerous effects. As a result, exposure to any of the compounds detected would be unlikely to result in harmful non-cancer health effects. Only three compounds (benzene, TCE, and formaldehyde) exceeded their respective lowest ATSDR comparison value based on cancer effects.

To understand how the detections of these compounds compared to typical ambient concentrations, ATSDR examined air quality data maintained by the EPA for New Jersey and ambient air measurements discussed in ATSDR toxicological profiles for the compounds of

interest [40,41]. Table 5 below shows how the detected values at Fenimore compare to those listed in these databases.

Table 5. Contaminants Detected in Fenimore Ambient Sampling Compared to New Jersey and U.S. Ambient Air Monitoring

Compound	Highest Detected Concentration in Fenimore Ambient Sampling, ppb	1994-2012 Air Quality Monitoring Concentration Range (90th percentile)*, ppb	2013-2014 Air Quality Monitoring Concentration Range†, ppb	U.S. Locations, Outdoor Ambient Concentration Range‡, ppb
Benzene	0.27	0—11 (1.1)	0—0.9	0.8—6
Formaldehyde	6.33	0—78 (7.6)	0.4—37	0.15—47
Trichloroethylene	0.07	0—13 (0.04)	0—0.15	0.03—0.72

*Data from U.S. EPA Ambient Monitoring Archive for New Jersey, all available years (1994—2012) [41]. Data reported as ppb-carbon or µg/m^3 were converted to ppb.
†Data from U.S. EPA AirData website, New Jersey report, 2013 and 2014 [40]. Data reported as µg/m^3 converted to ppb.
‡Data summarized from "levels monitored or measured in the environment" reported in ATSDR Toxicological Profiles [42-44].

Although the concentrations of benzene, formaldehyde, and TCE all appear to be within typical ambient levels for this area of the country, they could contribute to the risk of cancer. EPA has developed inhalation unit risks for each of these compounds, which can be used to estimate the increased risk of cancer from breathing the detected concentrations [21]. Assuming a lifetime of exposure to the highest measured concentrations of benzene, TCE, and formaldehyde, the cumulative increased cancer risk is estimated as 1.09×10^{-4}. That is, out of 10,000 people exposed continuously for an entire lifetime, approximately one additional case of cancer might occur due to the exposure. To put this risk in perspective, based on U.S. cancer rates, the lifetime risk of cancer in the general population is about 1 in 2.5, or about 4,000 out of every 10,000 people [45]. Most of the increased estimated risk is contributed by formaldehyde. Please see the Appendix for details of the cancer calculations.

Potential for Exposure to Other Reduced Sulfur Compounds

The bacteria that degrade gypsum waste products in the landfill to form H_2S may also form other reduced sulfur compounds (from either incomplete metabolism, degradation of organic sulfur-containing wastes that may also be present, or other mechanisms). Reduced sulfur compounds (such as mercaptans, sulfides, or disulfides) have been measured in landfill gas from C&D landfills [46]. There are no data on other reduced sulfur compounds released from Fenimore Landfill.

H_2S exposure appears to have been the primary community exposure from the landfill when odors became a problem beginning in fall 2012. ATSDR reached this conclusion on the basis of reports from community members and officials describing the odor as of rotten eggs (characteristic of H_2S), elevated levels of H_2S measured in community monitors, and the fact that H_2S is generally the predominant gas produced by bacterial decomposition of C&D waste such as was deposited at Fenimore Landfill. Other reduced sulfur compounds could cause a response in the Jerome H_2S monitors, but the response would not be as great as for H_2S [24,47,48].

Potential Public Health Implications

Before the gas treatment system began operating continuously, other reduced sulfur compounds possibly made up some of the landfill gas released. There is no way to retrospectively determine what reduced sulfur compounds, at what levels, may have been present in the landfill gases released in the past. If compounds measured at other C&D landfills (such as mercaptans, sulfides, or disulfides) were present in landfill gases, they were probably at levels around or lower than the H_2S concentrations measured. At these concentrations, they would have been unlikely to cause harmful health effects, although people could have had reactions to their characteristic foul odors (described variously as rotten cabbage, skunk, garlic, or decayed vegetables) [49-51]. Based on the H_2S data trends, the possible durations and/or concentrations would unlikely have been great enough to desensitize the sense of smell.

Since the gas treatment system started operating, any other reduced sulfur compounds (and any other gases) produced in the landfill would be collected by the gas extraction system and would burn in the thermal treatment unit along with the H_2S. Therefore, exposure to any other compounds is not expected to cause any ongoing or future harmful effects as long as the extraction and treatment system is operating properly.

Potential for Migration of Methane Gas from Landfill to Nearby Homes

The gas methane is one of the major products of bacterial decomposition of organic matter in landfills. Typical landfill gas may contain high percentages of methane. Because methane is explosive at levels between 5% and 15%[2], methane can be a concern for safety reasons. It may also travel (migrate) underground. If the methane is released into the atmosphere, it will quickly dissipate. However, if the methane follows paths such as cracks into the basements of homes, it could potentially pose an explosion hazard in the home. Fenimore Landfill would be expected to produce methane, since solid waste was deposited there for many years and landfill gas continues to be produced for up to 50 years. Recent addition of organic material (from reported burial of downed trees when the landfill was reopened) could increase the amount or extend the duration of methane production from the landfill. A number of investigations examined methane concentrations at Fenimore and are summarized below. ATSDR has also compiled findings from these studies graphically in Figure 9. Figure 9 is only qualitative because coordinates of most sample points were not reported. Therefore, points on the figure are not exact, and several closely-spaced sample points are not shown because they would be difficult to see on the scale of the figure. Figure 9 gives a general idea of the extent of gas sampling performed and where elevated methane readings were detected.

Summary of Methane Monitoring at Fenimore

In 2004, a soil gas survey was conducted as part of the Immediate Environmental Concern Assessment [52]. Subsurface methane concentrations at 18 locations in the landfill were measured using a so-called “slam bar” method to obtain a gas sample from beneath the ground surface. According to the findings in the report, two sample points in the landfill area showed elevated levels of methane, one at more than 40% and one at slightly over 1% methane. The samples collected at the landfill perimeter did not reveal any elevated methane levels. The elevated methane concentration found in the highest sample is typical of that found in landfill

[2] These are referred to as the lower explosive limit (LEL) and upper explosive limit (UEL), respectively.

gas. Because none of the perimeter samples were elevated, the assessment concluded that offsite migration of the methane was not occurring and that methane did not pose an immediate environmental concern [52].

In 2012, the private company operating the landfill monitored methane concentrations in 30 gas wells that had been installed around the perimeter of the landfill and submitted findings in monthly reports to NJDEP [53]. In June 2012, elevated methane above the lower explosive limit was detected in two wells in the same area as the 2004 detection. To follow up on the elevated readings, additional measurements at the wells and at locations in between were taken in July 2012 using slam bars. These readings confirmed the high methane concentrations in the immediate vicinity of the two wells [53].

In September 2012, NJDEP performed slam bar testing in several locations between homes and the two landfill gas wells showing the highest methane levels. The two gas wells were confirmed to have methane concentrations higher than the lower explosive limit. But only trace concentrations of methane (less than a hundredth of 1%) were detected in the samples close to the homes [54]. Trace concentrations of methane are not considered hazardous.

The private company operating the landfill conducted further gas sampling reported monthly from January 2013 and April 2013. Methane continued to be localized around the two gas wells previously identified [53].

NJDEP took over the landfill in June 2013 and installed several gas extraction wells within the landfill material. The gas extraction system pulls landfill gas from underground to the thermal treatment unit and scrubber system. Methane collected by the extraction system will burn in the thermal treatment unit. In addition, the reduced volume of landfill gas means that the possibility of the gas migrating offsite is less likely. In June 2014, additional extraction wells were added to the system. The added extraction wells include some in the specific area of the high methane readings. Figure 10, developed from the landfill closure specifications, shows the locations of the gas extraction [1]. Comparing Figures 9 and 10 indicates that the gas extraction system pulls landfill gas from the area identified as having high levels of methane. NJDEP periodically tests the gases being extracted; the landfill gas continues to contain high concentrations of methane (30-50% in some wells) and of H_2S (1-5% in some wells) [55]. However, offsite migration of methane or other landfill gas is unlikely as long as the gas is extracted.

Potential Public Health Implications

Although high levels of methane are present beneath the landfill surface, previous testing indicated that the methane was localized in a particular area of the landfill and not migrating toward nearby homes. Now that the gas extraction system is operating, methane migration away from the landfill is even less likely. ATSDR considers that methane from the landfill was and will be unlikely to harm public safety or human health. ATSDR recommends that the gas extraction and treatment system continue operating until concentrations of methane and other components of the landfill gas are too low to cause any concern for safety or health.

Figure 9. General map showing area of elevated methane detections at Fenimore Landfill, Roxbury Township, NJ

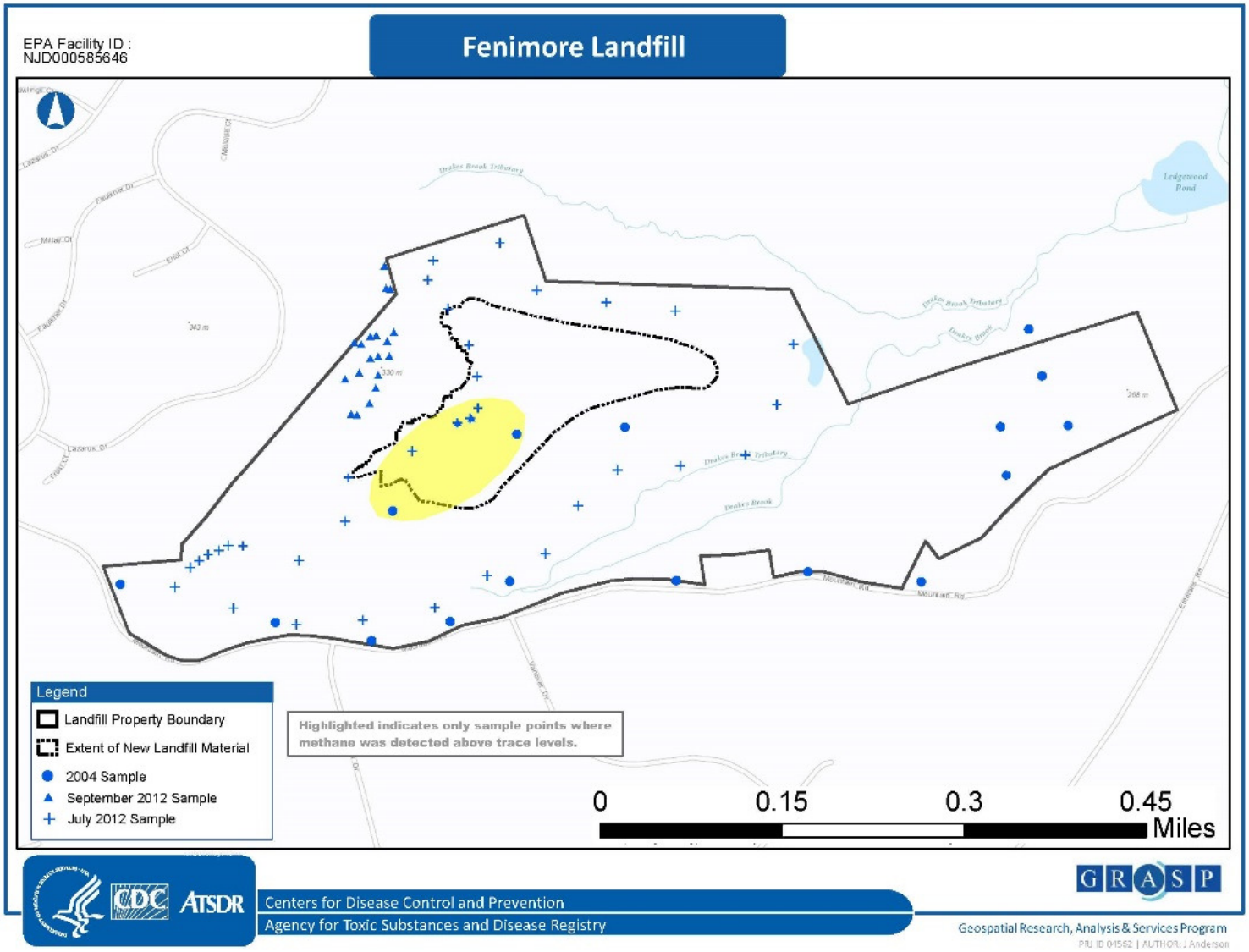
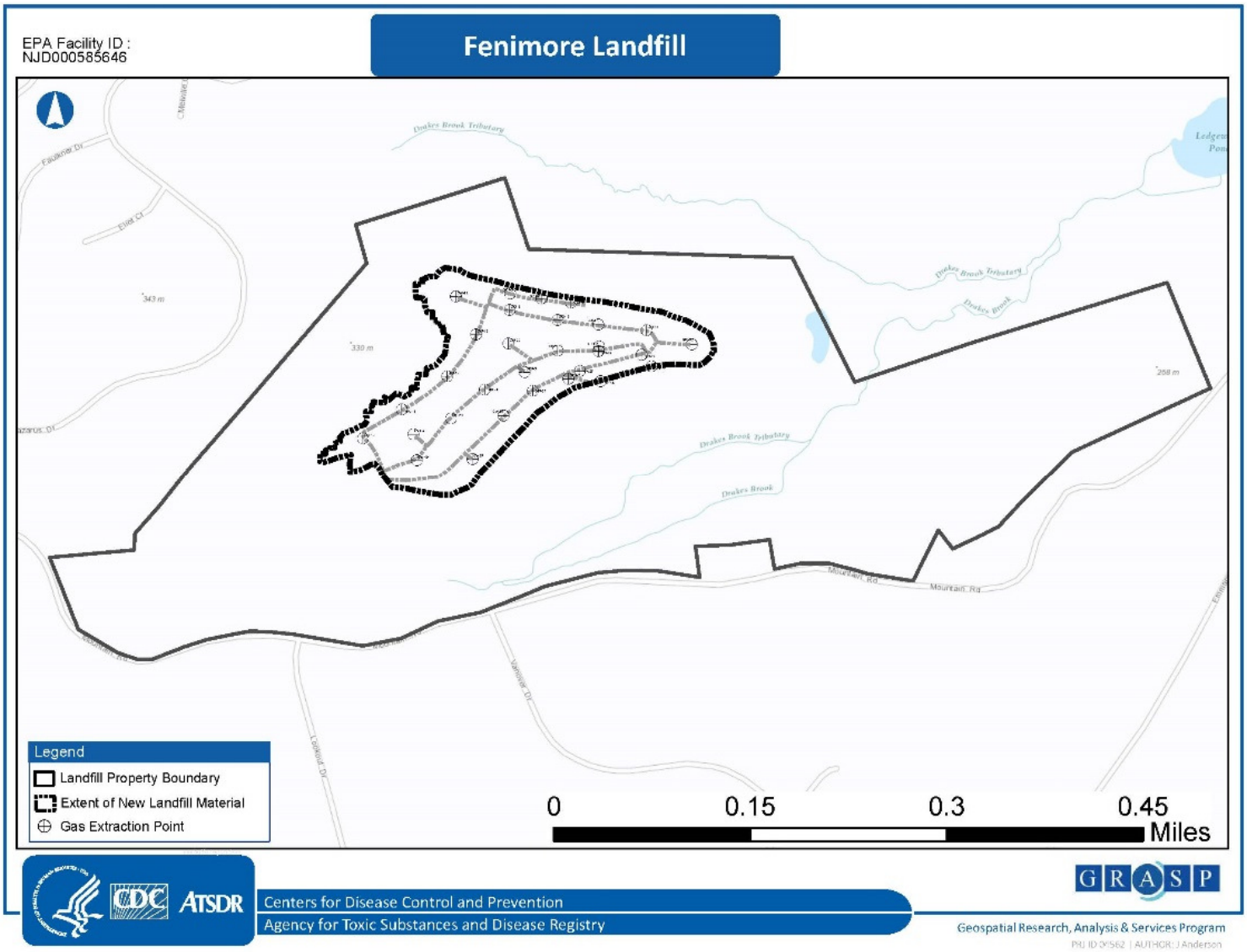


Figure 10. General map showing locations of gas extraction wells at Fenimore Landfill, Roxbury Township, NJ



Potential Contamination of Groundwater and Surface Water

Private Well (Groundwater) Monitoring and Representativeness

Residents expressed concern that groundwater could be contaminated by the site and travel to private wells or municipal wells downgradient. Residents cited the possibility of volatile organic compounds (VOCs) from old landfill materials and H_2S from newly deposited landfill material as of particular concern.

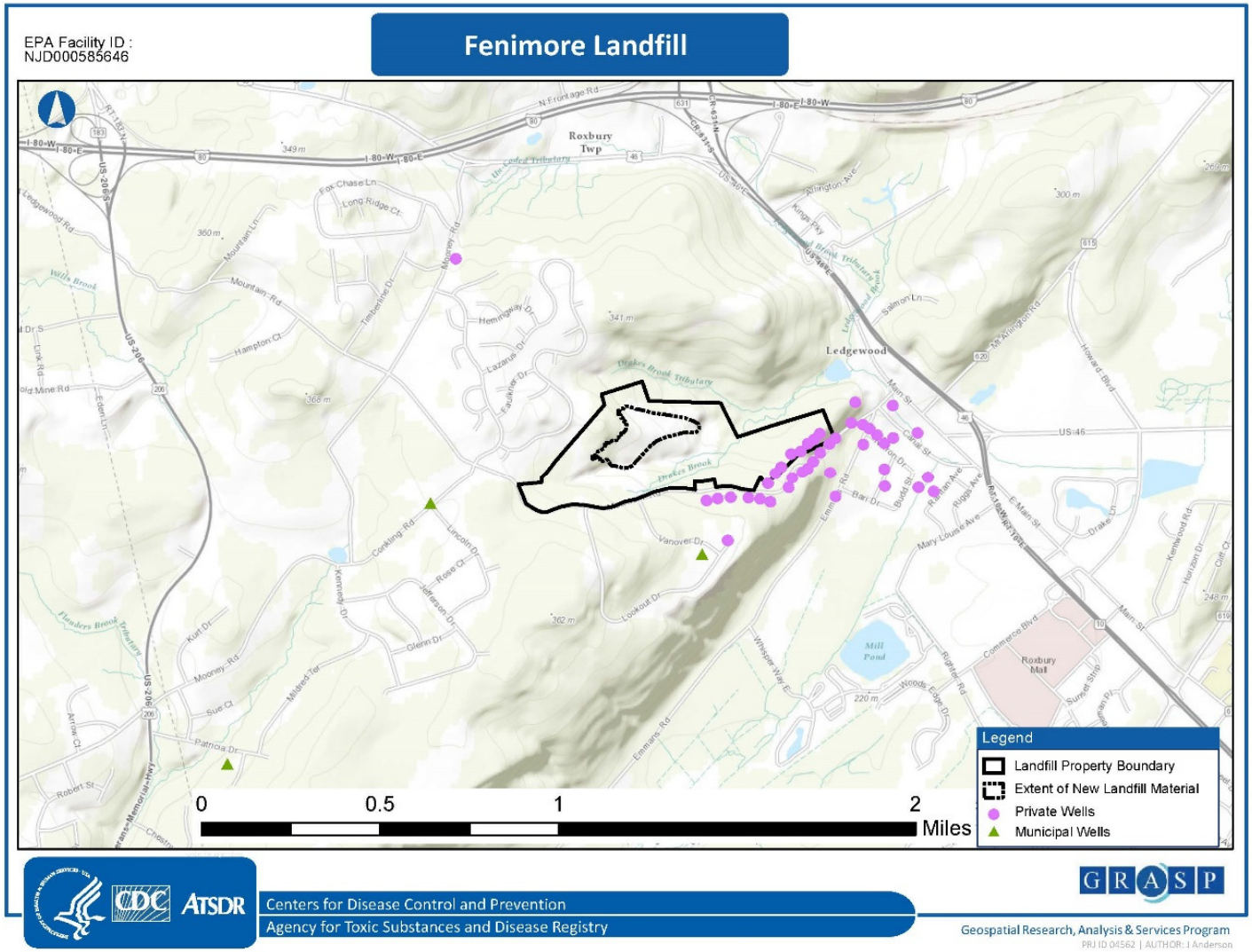
Roxbury Township provided ATSDR results of private well testing from 2012-2014 [56]. In July 2012, 25 private wells were tested for VOCs by EPA method 524.2, which analyzes for over 60 compounds. Between November 2013 and June 2014, three of the wells sampled in 2012 were resampled and an additional 14 private wells were sampled and tested for VOCs. Figure 11 shows the approximate locations of the private wells. The wells sampled represent the area of the Township not on municipal water. They also represent the groundwater most likely to be affected by the landfill because most of the wells are in the presumed general downgradient direction of groundwater flow, following surface topography.

Some of the private wells shown in Figure 8 were also sampled for sulfide and indicators of microbial contamination. Five private wells and three municipal wells were tested for sulfide in July or August 2013. Thirteen private wells were sampled and analyzed for indicators of microbial contamination in 2013 or 2014.

Roxbury Township obtains its drinking water from nine groundwater wells (three of which are relatively close to the landfill and shown in Figure 11) and from water purchased from a neighboring public water supply [57]. The Township is required to regularly monitor the public water supply for contaminants. These data are available on New Jersey's Drinking Water Watch website (https://www9.state.nj.us/DEP_WaterWatch_public) [58].

The municipal water supply is subject to regular monitoring for metals and other inorganics. However, no private well data on metals were available.

Figure 11. Approximate locations of private wells (purple dots) sampled and municipal wells (green triangles)



Results and Potential Implications

A summary of the available private and municipal well testing results is shown in Table 6.

Volatile Organic Compounds (VOCs)

VOCs were not detected in the 39 private wells sampled in 2012-2014. The detection limits for compounds in the method used were low enough to identify whether the compounds were present at harmful levels. The municipal system is required to test for VOCs every three years. Specific monitoring results (as recorded in New Jersey's Drinking Water Watch website referenced above) indicate no detections of VOCs in any of Roxbury's well systems in the last sampling performed in 2012. These findings for both private and municipal wells indicate that people are not being exposed to harmful levels of VOCs in their drinking water.

Table 6. Summary of Testing Results for Private and Municipal Wells near Fenimore Landfill, Roxbury Township, New Jersey

Test	# of Detections / # of Wells Sampled	Range of Detections
Volatile Organic Compounds*	0 / 42	No detections
Sulfide**	8 / 8	0.3—0.5 milligrams/liter
Total Coliform†	2 / 13	Positive Result
E. Coli†	0 / 2	No detections
Heterotrophic Count†	6 / 9	(5—more than 57,000 organisms/milliliter
* Results include samples collected from 2012-2014 ** Results include samples collected from 2013 † Results include samples collected from 2013-2014		

Sulfide

Sulfide was detected in the five private wells and three municipal wells tested for sulfide in 2013. The sulfide concentration in the wells ranged from 0.3 to 0.5 mg/L. ATSDR was not provided detailed information about the sampling procedures and preparation, but notes that samples should be properly preserved to detect H_2S, which is not stable in water under oxygenated conditions. The test method would detect all sulfide compounds in water, not only H_2S. The taste and odor threshold for sulfide in water is reported to be about 0.2 mg/L, while H_2S in particular can have a threshold as low as 0.05 mg/L in water [59].

Potential sources of sulfide in groundwater include dissolution from rocks and minerals and reduction of sulfates in groundwater by sulfate-reducing bacteria in low-oxygen conditions. H_2S can also be formed in home water systems, including the hot water heater, from microbial and chemical reactions. Theoretically, changes in groundwater sulfide composition could result from rainwater infiltrating the sulfate-containing material in the landfill. However, the private and municipal wells tested were in various directions (upgradient and downgradient) from the landfill, yet showed similar sulfide results. This suggests that wells were not significantly impacted by sulfides from the landfill when sampled in 2013. Sulfide levels could change seasonally, and groundwater sulfide levels might have increased before the landfill was capped in winter 2015. Re-sampling representative private or public wells would confirm sulfide levels have not increased.

According to the World Health Organization, at concentrations found in drinking water [concentrations not specified in the report], the H_2S will cause objectionable taste and odor, making water unpalatable. Therefore, ingestion exposures to H_2S are considered unlikely to occur or to cause any measurable health effects [59,60,15]. Oral toxicity of H_2S has not been extensively studied.

H_2S is a gas and if present in groundwater, will be released to air when the water is brought to the surface. H_2S could pose an inhalation risk if large amounts are released from water into air in a confined, unventilated space (during showering, for example). ATSDR could find few scientific reports on release of H_2S into air from contaminated groundwater. The state of Michigan recommends treating well water containing H_2S at concentrations greater than 1.3 mg/L [61]. The wells near Fenimore landfill had sulfide concentrations lower than this level. As stated earlier, the sulfide results may not reflect the H_2S concentration present in the collected sample; the actual H_2S concentration might be higher or lower than the sulfide concentration reported. ATSDR recommends further sampling of private wells for sulfide be accompanied by air monitoring near the sample point to identify any significant releases of H_2S from the water sampled.

In summary, the concentrations measured in private and municipal wells contain sulfide, but the concentrations do not appear to be high enough to result in harmful health effects from drinking the water. If large amounts of H_2S are released into the air from well water and build up in unventilated areas, the H_2S could pose an inhalation risk. Residents who are concerned about sulfide in their private well water or H_2S gas being released from well water could consider treating the well water with a whole-house treatment method to remove sulfide to minimize odor and the chances for H_2S to be released indoors. Ventilating the area by opening a window or using a ventilation fan will also help reduce potential exposures.

Microbial Indicators

In 2013 and 2014, thirteen private wells were sampled and analyzed for the presence of microbial contamination. Samples were analyzed for total coliform bacteria, which are an indicator that pathogenic bacteria could be present. If the total coliform result was positive, the samples were analyzed for E. coli, a subset of coliform bacteria more indicative of the presence of pathogenic bacteria. Of the 13 wells tested, two wells tested positive for total coliform bacteria, but negative for E. coli. Nine of the same private wells were also analyzed for heterotrophic bacteria, an indicator of the general bacterial level in the water. The results of this test provide information on the significance of coliform test results, since high concentrations of general bacteria may hinder the recovery of coliforms. Six of the wells showed detectable organisms in the heterotrophic bacteria test. None of those wells tested positive for total coliform bacteria.

The limited results suggest that the wells sampled did not contain disease-carrying bacteria. The presence of detectable levels of microorganisms, however, may indicate potential issues with the well construction or maintenance that could introduce microbial contamination into the system. The positive results for microbial indicator organisms are not likely related to the landfill, because several wells with negative microbial results were between the landfill and the wells

with positive results. Private well owners are advised to properly maintain their wells and continue to monitor for general water quality.

Monitoring Well (Groundwater) Data Evaluation

ATSDR reviewed groundwater data collected in 2015 from monitoring wells located at the downgradient edge of Fenimore Landfill. The results were included in documents downloaded from the Roxbury Township website. Analyses were performed for VOCs, SVOCs, metals, and pesticides/PCBs. Table 7 below lists the compounds detected in this sampling.

Table 7. Parameters Detected Above ATSDR Health Based Comparison Values in Groundwater from Monitoring Wells Near the Fenimore Landfill, Roxbury Township, NJ

Parameter	Range of Concentrations Detected in Monitoring Wells, µg/L		Drinking Water Comparison Value (CV) in µg/L	Source
	April 2015	August 2015		
Aluminum	ND (<20) – 65	ND (<200) – 22,000	10,000	EMEG
Arsenic	0.61J* – 5.8	ND (<3) – 5.4	3 / 0.023	EMEG / CREG
Aroclor-1221	ND (<0.095) – 0.3P	ND (<0.095)	0.0047	RSL
Benzene	ND (<0.5) – 15	ND (<0.24) – 3	3 / 0.64	LTHA / CREG
Bis(2-ethylhexyl) phthalate	0.51JB – 0.98JB	ND (<0.55) – 7.2B	6 / 2.5	MCL / CREG
1,4-Dioxane	0.19J – 3.2	ND (<0.72) – 5.5	200 / 0.35	LTHA / CREG
Iron	12J – 73,100	850 – 60,600	14,000 /300	RSL / Secondary MCL
Manganese	ND (<1) – 15,100	45.1 – 10,500	300 / 50	LTHA / Secondary MCL
Pentachlorophenol	ND (<9.4)	ND (<0.11) – 0.621	1 / 0.088	MCL / CREG
Sodium	6,700 – 53,100	12,100 – 66,400	20,000	DWA

Monitoring wells include 5 wells at toe of Fenimore Landfill; one duplicate collected for each sampling round.
Comparison values are for perspective; this groundwater is not used for drinking.

Darker pink shading indicates a detection above a drinking water non-cancer CV based on non-cancer effects.
Lighter pink shading indicates a detection above a drinking water CV based on cancer effects.
J, *, P, B not specifically defined in results available. Typically these qualifiers are defined as J-estimated quantity; *-duplicate sample not within control limits; P- percent difference greater than 25% for detected concentrations between two GC columns; and B- analyte found in associated method blank as well as in sample.

ND = not detected
RSL = EPA Regional Screening Level for Tap Water [64]
CREG = Cancer Risk Evaluation Guide
MCL = EPA Maximum Contaminant Level [63]
µg/L = micrograms per liter
LTHA = EPA Lifetime Health Advisory [62]
EMEG = Environmental Media Evaluation Guide
DWA = EPA Drinking Water Advisory [62]

For more information on CVs, please see Appendix B.

Several of the compounds listed in Table 7 were detected above drinking water comparison values; however this groundwater is not used for drinking. The high levels of manganese, iron, and other metals (which could be naturally occurring) could make the water look and taste bad and could harm health if the water were used for drinking. ATSDR recommends continuing to monitor this groundwater for changes. Monitoring of private wells in the area should include metals to identify any harmful levels in water used for drinking.

Surface Water Data Evaluation

ATSDR reviewed surface water sample data from Ledgewood Park from 2013-2015. The results were provided by Roxbury Township via mail or were downloaded from the Roxbury Township website. Analyses were performed for VOCs, SVOCs, metals, pesticides/PCBs, cyanide, and acrolein/acrylonitrile for most samples. Sulfide was analyzed for 3 samples. Most of the compounds analyzed for were not detected; Table 8 below lists the compounds detected in this sampling.

Table 8. Parameters Detected in Surface Water Samples Collected Near the Fenimore Landfill, Roxbury Township, NJ (includes samples labeled Ledgewood Brook, Ledgewood Pond, "Upstream" and "Downstream"*)

Parameter	Range of Concentrations Detected in Surface Water, µg/L	Drinking Water Comparison Value (CV) in µg/L	Source
Aluminum	ND – 121	10,000	EMEG
Barium	37 – 82	2,000	EMEG
Copper	ND – 1	100	iEMEG
Iron	180 – 734	14,000 / 300	RSL / Secondary MCL
Manganese	16 – 295	300 / 50	LTHA / Secondary MCL
Nitrate + Nitrite	2960**	10,000	MCL
Sulfide	300 – 400***	250,000	Secondary MCL for sulfate
Zinc	ND – 124	3,000	EMEG

*Exact sample location information not available.
** Only one sample analyzed for nitrate-nitrite.
***Sulfide analyzed in only 3 samples; results show similar concentrations as in private well testing (see page 38).

Comparison values are for perspective; this surface water is not used for drinking.

ND = not detected
µg/L = micrograms per liter
RSL = EPA Regional Screening Level for Tap Water [64]
LTHA = EPA Lifetime Health Advisory [62]
CREG = Cancer Risk Evaluation Guide
EMEG = Environmental Media Evaluation Guide
MCL = EPA Maximum Contaminant Level [63]
"i" denotes value based on intermediate exposure duration (2 weeks to one year)

For more information on CVs, please see Appendix B.

None of the detections were above ATSDR health based comparison values for drinking water. Two metals (iron and manganese) exceeded secondary drinking water standards indicating the water may taste or look bad. These two metals did not reach levels that would pose a risk to health. In addition, comparison to drinking water comparison values is overly protective because people do not drink this water. No harmful health effects are expected from exposure to water in Ledgewood Pond or creeks.

Potential Unidentified Hazardous Substances in the Landfill

Another concern of the community is the potential for unidentified hazardous substances in the landfill. This concern comes from historical reports of chemical drums found at the landfill, noted violations of past landfill operations, and reports of non-C&D waste deposited by the recent operators.

Previous studies of the old landfill did not find immediate environmental concerns [52]. If old landfill materials contained hazardous substances that were leaching into groundwater, some contaminants would likely have reached private wells by 2012-2014 when wells were tested. Results showed that private wells did not have any VOCs or excessive sulfide levels. To ATSDR's knowledge, only VOCs, sulfides, and microbial indicators were tested in the private wells; testing for other common landfill contaminants (metals, etc.) would help to confirm that groundwater has not been contaminated by old landfill leachate.

Hazardous materials could possibly have been added when the landfill re-opened. The above-waste liner and cap and surface water runoff features added recently are designed to prevent any leaching of materials into groundwater or surface water from now on. However, because some infiltration and leaching occurred during the time before the liner and cap were installed, groundwater could possibly have been affected by either the C&D waste or other unidentified materials.

ATSDR does not recommend core sampling to characterize buried landfill material. Core sampling cannot disprove the presence of hazardous materials, since finding isolated pockets of hazardous material with limited core samples would be difficult. Also, collecting samples would compromise the landfill cap and allow gases to escape. Instead, ATSDR recommends installing monitoring wells at the landfill perimeter and downgradient locations. These wells would be regularly monitored for common landfill contaminants to verify that no harmful substances escape the landfill. ATSDR also recommends regularly monitoring private wells downgradient from the landfill to ensure they remain unaffected by the landfill.

Children's Health Considerations

ATSDR recognizes that unique vulnerabilities of infants and children deserve special attention. Children may be at greater risk of exposure than adults because they play outdoors and breathe dust or heavy vapors closer to the ground. They are also smaller, resulting in higher doses of chemical exposure per body weight. Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at the site.

While preparing this health consultation, ATSDR considered these and other children's health issues. For example, ATSDR used minimal risk levels and other screening values designed to be protective of sensitive populations, including children. Children may be at greater risk of exposure to H_2S and SO_2, than adults; however, exposure is expected to result in similar health effects in children and adults.

Conclusions

ATSDR reached seven important conclusions in this health consultation.

Conclusion 1. Before the landfill gas extraction and treatment system began operating in October 2013, concentrations of H_2S released from the landfill were high enough to cause harmful short-term health effects in community members. Lasting health effects are unlikely from the exposure. This conclusion is based on the following information:

- Community monitors around the landfill showed 30-minute H_2S concentrations that were consistently above ATSDR's acute minimal risk level (MRL) of 70 parts per billion (ppb), with those closest to the landfill regularly reaching hundreds of ppb. For even brief exposures, these levels are high enough to cause changes in lung function or headaches in people who are exposed. Potential respiratory health effects are more likely in people with pre-existing respiratory conditions, such as asthma. These short-term effects would be expected to resolve once the H_2S concentrations decreased, because H_2S is rapidly cleared from the body. The monthly average concentrations were all lower than ATSDR's intermediate MRL of 20 ppb. Therefore, longer-term health effects are unlikely.
- Offensive, pervasive odors were reported in summer and fall 2013. Some people are more sensitive to odors than others, but almost anyone in the nearby community who could smell the H_2S could have experienced general odor-related symptoms. These symptoms have been reported as the body's reaction to the odor rather than chemical irritant properties of a specific pollutant and could include eye, nose, and throat irritation; nausea; and headaches. Symptoms from odors could persist longer or aggravate existing medical conditions in sensitive groups (such as people with respiratory conditions like asthma, the very young, or the very old).

Conclusion 2. After the gas extraction system was installed to remove landfill gases, short-term concentrations of H_2S were greatly reduced and are much less likely to cause harmful health effects. However, the toxicological and human health data indicate that some sensitive people in the community could continue to suffer harmful health effects from H_2S associated with odors or from stress caused by previous exposures to H_2S. Data quality issues beginning in late 2014 added uncertainty to this public health evaluation. This conclusion is based on the following information:

- When collection and treatment of landfill gases began in October 2013, community monitors registered an immediate reduction in the concentration of H_2S. H_2S concentrations, while still usually present above odor thresholds, were almost always below ATSDR's acute MRL of 70 ppb, and the monthly averages continued to be below ATSDR's intermediate MRL of 20 ppb. Harmful H_2S-related health effects would be unlikely from these concentrations.
- Beginning in late summer 2014, various monitors recorded more than 20 short-term elevations in H_2S concentration (up to tens of thousands of ppb) that were not obviously equipment-related but were also reportedly not associated with odor events. We do not

know if these measurements represented actual air concentrations of H_2S. Since January 2015, the frequency of these elevated readings has been greatly reduced.
- If these elevated readings represented actual air H_2S concentrations, the highest concentrations of H_2S could have cause changes in lung function or headaches in people with pre-existing respiratory conditions such as asthma, even for short exposures. These effects would have resolved once the H_2S concentrations decreased.
- Stress and possible health effects from previous exposures could have made community members more sensitive to odors. When odors are present, some people could continue to experience odor-related symptoms.

Conclusion 3. Past and current concentrations of sulfur dioxide (SO_2) produced from the landfill gas treatment process are not likely to have caused or be causing serious harmful health effects. This conclusion is based on the following information:

- Short-term concentrations (5-minute averages) of SO_2 above ATSDR's acute MRL of 10 ppb were infrequent (representing less than 0.25% of the time measured) and rarely reached levels that would harm health. In isolated incidents in April 2014 and July 2015, five-minute average SO_2 measured in one of the community monitors reached levels that have been associated with mild respiratory effects in some sensitive people, such as those with asthma. The levels were unlikely to have caused lasting or serious effects.
- One-hour average SO_2 concentrations in any monitor were higher than the primary one-hour National Ambient Air Quality Standard only twice (during the incidents described above).

Conclusion 4. Past releases of other volatile organic or reduced sulfur compounds potentially in the landfill gas were unlikely to result in serious, lasting harm to health. People could have had physical symptoms from the odors themselves. Current exposure to these compounds is unlikely as long as the treatment system is operating properly. This conclusion is based on the following information:

- Limited ambient air sampling near the landfill while odors were present showed concentrations of volatile organic compounds were too low to cause any harmful health effects. Three compounds (benzene, TCE, and formaldehyde) were detected at concentrations that were within the range of typical ambient levels for the area, suggesting that the landfill was not the source of these compounds. These concentrations could contribute to a person's risk of developing cancer over a lifetime of exposures. However, estimating cancer risk is uncertain because of the limited number of samples.
- Reduced sulfur compounds such as mercaptans, sulfides, or disulfides could have been produced by the landfill and released. Testing for past concentrations is not possible. If these compounds were present at similar or lower concentrations than H_2S, they would be unlikely to cause serious lasting adverse health effects, though people could have had a reaction to the smell. If the compounds had been present at higher levels, a different characteristic odor would probably have been reported.
- Current exposure to volatile organic compounds or reduced sulfur compounds is unlikely because, if present, they will be collected by the landfill gas extraction system and destroyed along with the H_2S.

Conclusion 5. Methane production from the landfill is unlikely to harm health by posing an explosion risk to nearby homes. This conclusion is based on the following information:

- Although high levels of methane were detected in one particular area of the landfill, further testing between that area and nearby homes showed that the methane was not moving toward homes. Methane is now collected by the landfill gas extraction system and destroyed along with other landfill gases.

Conclusion 6. Available data indicate that drinking water from municipal or private wells near the landfill is unlikely to harm health. However, we do not have data on metals in private wells. We also do not have enough information to determine whether H_2S released from private well water into indoor air could cause harmful health effects. This conclusion is based on the following information:

- No detections of volatile organic compounds were found in more than 40 private wells and municipal wells sampled near the landfill.
- No data were available on metals in private wells. Monitoring wells at the landfill boundary contained high levels of some metals.
- Sulfide concentrations in private and municipal wells could give water an unpleasant taste or smell but are unlikely to cause harmful health effects from drinking the water. H_2S would be quickly released from well water into air. If the H_2S builds up in unventilated areas, it could pose a potential risk, depending on the resulting concentration.
- A few private wells tested positive for indicators of microbial contamination, but further testing showed no indicators of pathogens.

Conclusion 7. ATSDR cannot determine whether unidentified hazardous materials that could exist in the landfill could harm people's health. This conclusion is based on the following information:

- Historical reviews found no immediate environmental concern from the former solid waste landfill, and recent testing of private wells detected no volatile organic compounds. However, some undocumented hazardous materials could possibly have been added when the landfill was re-opened.
- Core sampling cannot disprove the presence of isolated pockets of hazardous materials and would compromise the integrity of the landfill cap, allowing gases to be released.
- If present, any unidentified materials could have released contaminants into groundwater when rainwater filtered through the landfill before it was capped. The above-waste liner, cap, and surface water runoff features recently added to the landfill will prevent further surface water infiltration and possible leaching of hazardous substances into the groundwater.

Recommendations

- ATSDR recommends that NJDEP continue operating the gas extraction and treatment system until components of the landfill gas, including H_2S and methane, are reduced to concentrations too low to cause any concern for safety or health.
- ATSDR recommends that NJDEP or the Township continue community H_2S monitoring near the landfill to confirm proper operation of the treatment system and to provide reassurance to community members that concentrations remain below acceptable levels.
- ATSDR recommends that NJDEP continue to investigate new odor complaints from the community and address offensive odors to the extent possible.
- ATSDR recommends that NJDEP or the Township verify data from existing community monitors by comparison or replacement with an alternate type of H_2S monitor (such as colorimetric tape meters). We recognize that operational improvements have reduced the frequency of equipment anomalies associated with the current monitoring system. Verification with an alternate measurement technology, not subject to such anomalies, would give community members even greater confidence in the results.
- ATSDR recommends that NJDEP conduct regular maintenance of the scrubber system to ensure its proper operation and the proper function of automatic controls. ATSDR also recommends that NJDEP continue real-time monitoring of SO_2 stack concentration to ensure against any unexpected releases.
- ATSDR recommends that NJDEP, the Township, or the entity responsible for the landfill sample private wells for metals and re-testing representative private wells for sulfide to confirm that concentrations are not changing. ATSDR also recommends this sampling be accompanied by air monitoring for H_2S near the sample point to identify any significant releases of H_2S from the water sampled.
- ATSDR recommends that private well owners monitor their wells for microbial contamination and other water quality parameters, including metals. Residents concerned about sulfide or other odors from their private well water can ventilate their homes to reduce exposure or consider treating their water.
- ATSDR recommends that NJDEP or the entity responsible for the landfill regularly monitor groundwater at the landfill perimeter or downgradient locations for common landfill contaminants to verify that no harmful substances escape the landfill.
- ATSDR also recommends that NJDEP or the entity responsible for the landfill regularly monitor representative private wells downgradient from the landfill for sulfide, metals, and other common landfill contaminants to ensure they remain unaffected by the landfill. Residents concerned about sulfide or other odors from their private well water can ventilate their homes to reduce exposure or consider treating their water.

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Appendix A. Details of Ambient Air Cancer Risk Calculations

Table A1. Details of Cancer Calculations for Compounds Exceeding Cancer Comparison Values in Ambient Air Sampling

Compound	Highest Detection, ppb	Highest Detection, µg/m³	Inhalation Unit Risk, per µg/m³	Theoretical Increased Lifetime Cancer Risk
Benzene	0.27	0.86	7.8×10^{-6}	6.7×10^{-6}
Formaldehyde	6.33	7.77	1.3×10^{-5}	1.0×10^{-4}
Trichloroethylene	0.07	0.38	4.1×10^{-6}*	1.8×10^{-6}
Total (sum of each risk)				**1.1×10^{-4}**

Risk for benzene and formaldehyde (unitless) calculated by multiplying the concentration in µg/m³ by the Inhalation Unit Risk per µg/m³.
*Calculation of risk for trichloroethylene included appropriate age-dependent adjustment factors applied to kidney cancer component of the inhalation unit risk for ages birth to 16 years old [21].

Appendix B. ATSDR Comparison Values Used In This Report

In evaluating air and water data in this report, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are health-based contaminant concentrations used to screen contaminants for further evaluation. CVs for noncancer effects are set at a concentration below which no harmful human health effects are expected to occur, even with daily exposure to small children. CVs for cancer are set at concentrations corresponding to a predicted additional 1 in a million cancer risk for a lifetime of exposure. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

In this document, we used the following sources for CVs.

Minimal Risk Level (MRL) – concentration in air or dose in water below which no noncancer health effects are expected. MRLs are developed by ATSDR based on toxicological studies and can be specified for different exposure durations.

Cancer Risk Evaluation Guide (CREG) – concentration in air or water that would increase theoretical risk of cancer by no more than one out of one million persons exposed over a lifetime. CREGs are calculated by ATSDR from EPA cancer slope factors.

Regional Screening Level (RSL) – chemical specific concentration in air, drinking water, or soil that may warrant further investigation or site cleanup. RSLs are developed by EPA but are not cleanup standards.

Reference Concentration (RfC) – an estimate (within an order of magnitude) of a chemical's air concentration which would be unlikely to cause harm, even if sensitive people breathed it over a lifetime. EPA develops RfCs and lists them at http://www.epa.gov/iris.

Environmental Media Evaluation Guide (EMEG) – contaminant concentration in a water where noncancer health effects are unlikely. EMEGs are derived from the ATSDR minimal risk level.

Maximum Contaminant Level (MCL) – enforceable standard set by EPA for the highest level of a contaminant allowed in drinking water. MCLs are set as close to MCL goals (the level of a contaminant in drinking water below which there is no known or expected risk to health) as feasible using the best available treatment technology and taking cost into consideration.

Secondary MCL – non-mandatory water quality standards for 15 contaminants set by EPA as guidelines to ensure drinking water looks, smells and tastes okay. These contaminants are not health threatening at the secondary MCL.

Drinking Water Advisory (DWA) – EPA-derived non-regulatory concentration of a contaminant in water that is likely to be without harmful effects on health and aesthetics for the period it is derived.

Lifetime Health Advisory (LTHA) – EPA-derived non-regulatory concentration of a chemical in drinking water that is not expected to cause any harmful noncancer effects for a lifetime of exposure.

Appendix C. Public Comments Received and ATSDR Responses

A draft of this health consultation was available for public review and comment in fall 2015 at the Roxbury Public Library in Succasunna, New Jersey. The document and a fact sheet summary were also available for viewing or downloading from the ATSDR web site and were provided electronically to residents and other interested parties on ATSDR's electronic mailing list for the site. The public comment period was open from September 1, 2015 through October 30, 2015.

ATSDR shared the findings of the health consultation with state and federal partner agencies shortly before the public release. However, we requested all comments be submitted through the public comment process, so that comments could be part of the official record and to improve the transparency of the changes to be made to the document.

The public comment period was announced to local media outlets. ATSDR discussed the findings of the draft health consultation with community members at public availability sessions held September 15 and 16, 2015 at the Roxbury Recreation Meeting Room at Horseshoe Park in Succasunna. ATSDR met separately with state officials, local officials, and REACT to informally discuss the findings on September 14 and 15 before the public availability sessions. Copies of the draft report and a fact sheet summarizing the findings were also provided to the community during the public availability sessions.

ATSDR received written comments from private citizens, local stakeholders, and local and state agencies. The comments received are listed in their entirety below (with personal identifiers for private citizens removed). The comments were not changed but were split and numbered by ATSDR into specific comments that were responded to individually. In addition, we corrected some obvious typographical errors and made font changes to make the comments more readable and consistent throughout. ATSDR responses are inserted as italicized text. Notes and removed text are indicated in a different font. Page and figure numbers in comments refer to the public comment version of the health consultation, whereas those cited in ATSDR responses refer to this final version.

Comments from REACT (PC1):
PC1-1: Summary Section
Conclusion 1
a. In other ATSDR Health Consultations, it was stated that a study of children in Nebraska found an association with respiratory-related hospital visits after episodes when hydrogen sulfide concentrations were above 30 parts per billion (ppb) for longer than 30 minutes the previous day (Campagna et al. 2004). Also, a study of people living around a paper mill exposed to an annual average hydrogen sulfide concentration of 4.3 parts per billion (ppb) and daily maximum concentrations of up to 70 ppb, reported a 12-fold increase in eye and respiratory irritation (Kilburn 1997, Kilburn & Warshaw 1995). Why weren't these references included in the report in addition to the ATSDR MRL's?

ATSDR Response: ATSDR summarized H_2S's health effects in the original report, citing ATSDR's toxicological profile. In response to this comment, ATSDR added a paragraph to the H_2S background section briefly summarizing findings of studies of community H_2S exposures and

including additional references. We encourage those interested in more details on H_2S to consult our toxicological profile, available online at http://www.atsdr.cdc.gov/ToxProfiles/tp114.pdf.

PC1-2: b. New Jersey now has an air quality standard for H_2S of 30 ppb averaged over 30 minutes to be protective of human health and avoid nuisance odor. Why wasn't this referenced in the report?

ATSDR Response: The 2013 Landfill Legacy Act set a maximum air quality standard for H_2S. This act allows court action for relief to be taken against owners of legacy or closed sanitary landfills if the landfill causes the concentration of H_2S to be 30 ppb averaged over 30 minutes at or within 2 miles of the property boundary of the landfill. To ATSDR's knowledge, this is not a statewide ambient air quality standard for H_2S. In the health consultation, we used ATSDR's substance-specific minimal risk levels to screen and evaluate exposures. We recognize that H_2S concentrations in community monitors, particularly before the gas extraction and treatment system began operating, regularly exceeded the 30 ppb level (as well as the acute MRL of 70 ppb).

PC1-3: c. The ATSDR recommended that the gas extraction system and treatment system continue operating until components of the landfill gas are reduced to concentrations too low to cause any concern for safety or health, however, the ATSDR does not indicate what these target concentrations should be.

ATSDR Response: ATSDR is an advisory agency and cannot specify cleanup goals to regulatory authorities. We can comment on whether proposed goals are protective of public health, upon request.

PC1-4: Conclusion 2
a. Concentrations of hydrogen sulfide measured in the air around the Fenimore Landfill in summer and fall of 2013 were above concentrations, known to the scientific community to adversely affect the health of community members with pre-existing respiratory problems. Exposure to the concentrations measured around the Fenimore Landfill are also known to cause self-reported symptoms such as eye irritation, nasal irritation, congestions, coughing, breathlessness, wheezing, headaches, nausea and sore throats in community members without pre-existing respiratory problems. Hydrogen sulfide has an associated odor commonly described as rotten eggs which is detectible by humans at concentrations as low as 0.5 ppb. Concentrations of hydrogen sulfide measured in the air around the Fenimore Landfill starting in November 2012 through present day have been above concentrations known to the scientific community to have a detectible rotten egg odor. Exposure to hydrogen sulfide, at the concentrations measured around the landfill, and its associated odor are also known to cause psychological symptoms such as mood swings, nervousness, fatigue, irritability, confusion, and inability to concentrate. Exposure to hydrogen sulfide also creates a learned association effect which means the community members continue to be able to detect hydrogen sulfide at lower and lower concentrations and each detection of an odor associated with hydrogen sulfide can therefore trigger a self-reported symptom and/or psychological effect. These effects were not widespread in the community prior to H_2S emissions from Fenimore Landfill and should not be overlooked or understated.

ATSDR Response: The symptoms described by the commenter are all consistent with the conclusions of ATSDR's evaluation. We agree that harmful health effects such as described were possible in the community.

PC1-5: b. Fenimore Landfill has not totally eliminated objectionable odors. Citizens still complain. OPRA hotline complaints available per request.

ATSDR Response: The NJDEP informed ATSDR in September 2015 that it would investigate all new odor complaints. ATSDR recommends that NJDEP continue to investigate new odor complaints from the community and address offensive odors to the extent possible.

PC1-6: c. The peak levels of hydrogen sulfide that community members were exposed to prior to installation of the air monitors is unknown.

ATSDR Response: There are no H_2S data before the first monitoring in January 2013. From the information provided to ATSDR, complaints about the odors began shortly after Hurricane Sandy passed through in late October 2012. In January, preliminary monitoring showed intermittent detections of H_2S from 0.01-0.11 ppm, or 10-110 ppb. After Jerome monitors came online in early February, the readings were lower until the summer months, when H_2S concentrations became consistently high, often higher than ATSDR's acute minimal risk level of 70 ppb for hours at a time.

While there are no data, because the microbial populations creating the H_2S take time to develop, it is more probable that H_2S generation only became detectable in November 2012 and took some time to build up to harmful levels, rather than starting out very high and then reducing in concentration by the time monitoring began.

PC1-7: Conclusion 4
a. The ATSDR states that if reduced sulfur compounds such as mercaptans, sulfides, or disulfides were present, a different characteristic odor would probably have been reported. Please note that many residents have reported odors ranging from rotting garbage /sewage, burnt bacon, fireworks, and burnt matches, which are consistent with various reduced sulfur compounds. These odors were not investigated by the NJDEP.

ATSDR Response: We recognize that before the treatment system began operating there may have been some fraction of gases other than H_2S present, but from the information we were provided, the predominant complaint then was of a rotten egg odor. We have heard that currently, residents are reporting different odors. If properly operated and maintained, the gas extraction and treatment system should destroy all gases being produced by the landfill. The NJDEP informed ATSDR in September 2015 that they would be investigating all new odor complaints separately from their Fenimore work. ATSDR recommends that NJDEP continue to investigate new odor complaints from the community and address offensive odors to the extent possible.

PC1-8: b. As stated in this report, other gases may be present that have not been monitored for. Grab samples should be regularly taken of the air in the vicinity and if other harmful gases are found they should also be monitored for and a corrective plan of action be activated.

ATSDR Response: Grab samples would help the community's confidence about the safety of the air around the landfill. ATSDR is an advisory agency and cannot require regulatory authorities to take samples. If data are collected, ATSDR would be available, upon request, to interpret the results as to their public health significance. Please see the response to comment PC1-9 below, which discusses limited vent sample results that showed only low concentrations of other VOCs in the landfill gas.

PC1-9: c. ATSDR is assuming that the cap and collection system is 100% efficient and any gases that are generated within the landfill are being collected and sent to the oxidizer. Further, ATSDR is assuming that the oxidizer / scrubber system is 100% efficient which has not been proven via a comprehensive and valid stack test by the NJDEP. Additional air testing for VOC's and other gases is warranted and should be recommended to establish a baseline and benchmark system performance.

ATSDR Response: ATSDR requested stack discharge monitoring reports from NJDEP and received the data in January 2016. The reports included daily data sheets of field monitoring performed by operators of the treatment system (including stack discharge monitoring) from October 2013—December 2015 and daily stack discharge data from the continuous emissions monitoring system (CEMS) from July 2014—December 2015. The CEMS data recorded SO_2 exiting the stack and the field monitoring stack reports recorded SO_2, oxygen, methane, H_2S, and other parameters collected 2-6 times a day during operation. H_2S exiting the stack was generally zero. In the last 3 months of 2015, H_2S was detected only about 2% of the time during stack field monitoring. The highest H_2S concentration measured was 1.5 ppm.

ATSDR also requested results from vent sampling of landfill gas entering the treatment system. NJDEP provided vent sampling data from August 2013—January 2016. NJDEP had concerns about the quality of vent data before June 2015; in that month they changed calibration methods and meters. Since June 2015, average H_2S concentrations in the extraction wells has ranged from zero to over 50,000 parts per million (ppm), with an average H_2S concentration into the treatment system of approximately 12,000 ppm. Given that the H_2S concentration exiting the stack is typically zero and the highest concentration measured was 1.5 ppm, the efficiency of H_2S removal is greater than 11,998.5/12,000 or more than 99.9%. Other gases would be consumed to a similar extent.

The vent sampling data provided by NJDEP included results of 8/20/2013 sampling from two gas extraction points (vent #1 and # 7) analyzed for VOCs using the EPA TO-15 method. Most VOCs were not detected; those detected were at relatively low levels summarized in Table A1 below. The concentrations of these substances would be reduced by treatment to levels too low to harm health.

If these results of landfill gas sampling are representative, it is unlikely that grab samples collected of ambient air near the landfill (as was suggested in the previous comment PC1-8) will

show concentrations of concern, since ambient samples would be much more diluted that vent samples.

Table A1. Results Summary - Limited Vent Sampling at Fenimore Landfill August 2013

Field Instrument Readings:	*Vent # 1*	*Vent # 7*		*Vent # 1*	*Vent # 7*
H_2S	*150,000,000*	*212,000,000*	*VOCs*	*16,200,000*	*28,200,000*
TO-15 Detected VOCs:	*Vent # 1*	*Vent # 7*		*Vent # 1*	*Vent # 7*
Acetone	*3,031*	*3,705*	*Isopropyl Alcohol*	*1,465*	*1,587*
Benzene	*1,315*	*407*	*Methylene chloride*	*141*	*144*
n-Butane	*1,683*	*3,996*	*4-Methyl-2-pentanone*	*159*	*ND*
2-Butanone	*814*	*1492*	*iso-Octane*	*135*	*156*
Carbon disulfide	*8,029*	*11,241*	*Tetrachloroethene*	*206*	*251*
Cyclohexane	*407*	*235*	*Tetrahydrofuran*	*1,255*	*5,087*
1,2-Dichloroethane	*205*	*ND*	*Toluene*	*2,654*	*1,964*
Ethanol	*584*	*637*	*Trichlorofluoromethane*	*ND*	*655*
Ethylbenzene	*322*	*214*	*1,2,4-Trimethylbenzene*	*244*	*ND*
4-Ethyltoluene	*144*	*ND*	*1,3,5-Trimethylbenzene*	*130*	*ND*
Heptane	*464*	*366*	*m,p-Xylene*	*576*	*369*
n-Hexane	*312*	*369*	*o-Xylene*	*253*	*143*
**All concentrations in parts per billion (ppb).*					

PC1-10: Conclusion 5

a. Methane testing has not been conducted since the cap has been installed. It's reasonable to assume that some of the methane is being generated by the historic waste, deep beneath the surface and below the header piping of the gas collection system. This gas has the potential to move uni-laterally as it tries to escape and vent off. Until additional testing is completed, it's speculation that the gas extraction system is collecting and destroying all methane being generated in the site. Also, methane has the potential to be generated in the remainder "uncapped" ~40 acres of the landfill and could migrate towards residential areas. Last, just because elevated levels of methane were not found in the few locations that were tested does not indicate there is no potential methane danger to residents living adjacent to the site. Additional testing is warranted and should be recommended.

ATSDR Response: The vent data provided by NJDEP shows that methane is being collected by the extraction system. Since June 2015, the methane level in each extraction well has been relatively stable; 21 of the 30 wells have less than 5% methane on average; 9 of the 30 wells have methane from 5-12%. All this methane is collected and destroyed in the treatment system. In addition, the gas extraction has created a vacuum in the subsurface of the landfill. Gases nearby, including any still being produced by old landfill material surrounding the C&D landfill area, would be drawn towards the vacuum and would not move away from the landfill.

In the 2012 testing, 19 subsurface samples were collected from in between the only area of high methane readings and the nearby homes, and all these showed no high methane concentrations. This was before the gas extraction began, which would draw methane towards the landfill. It is very unlikely that methane was or is moving towards these homes.

We recognize that additional testing for methane could help address remaining community concerns. ATSDR is available to evaluate any additional data that are collected and make further recommendations, if necessary.

PC1-11: Conclusion 6
a. In April 2015 DEP collected ground water samples on Fenimore landfill. Results showed that groundwater has been impacted by landfill operations, most notably by benzene and possibly by arsenic. Benzene exceeded its GWAQ (1.0 ppb) in three of the five well samples ranging up to 15 ppb. Arsenic exceeded its GWQS (3.0 ppb) in four of the five monitoring wells ranging up to 5.8 ppb. Additionally, SVOC's were detected at concentrations below the respective GWQS including bis(chloroethyl)ether and bis(2ethylhexyl)phthalate, 1,4 Dioxane, and various polynuclear aromatic hydrocarbons. Was this testing considered in ATSDR's conclusions regarding drinking water from groundwater wells near the landfill?

ATSDR Response: ATSDR did not consider these data in the public comment draft health consultation. We have added evaluation of these recent groundwater results to the document beginning on page 40. The concentrations of these contaminants exceeded drinking water comparison values, especially for metals such as iron and manganese, but no one is drinking water from the monitoring wells. We recommend ongoing monitoring of groundwater from these monitoring wells and including metals in any monitoring of private wells downgradient from the landfill. ATSDR is available to evaluate any additional data that are collected and make further recommendations, if necessary.

PC1-12: Conclusion 7
a. ATSDR stated that core sampling cannot prove or disprove the presence of hazardous materials and would compromise the integrity of the landfill cap allowing gases to be released. If core sampling was conducted and hazardous materials were found, how would this not prove that hazardous materials are present? In addition, there have been times when the landfill cap was compromised for maintenance and gases were not released so long as the extraction system was in operation. There are methods to safely obtain core samples without allowing gases to be released, but the ATSDR conclusion discourages this practice and incorrectly leads one to believe that the process would be impossible, and a guaranteed threat to public health.

ATSDR Response: We have changed the text so that it does not say core sampling could not "prove or disprove" presence of hazardous materials, since the commenter is correct that a positive result would prove the presence of such materials.

The monthly activity reports submitted by the landfill operator document volumes of waste accepted and the locations where each type of waste were disposed. The reports, which were available from June 2012—August 2012 and November 2012—May 2013, include C&D fines, construction site fill, crushed glass, recycled concrete and masonry, recycled asphalt, and clean material from regulated sites.[3] While we realize the community believes some hazardous

[3] Geosyntec Consultants. Review of hydrogen sulfide gas abatement options, Fenimore Landfill, Roxbury Township, New Jersey. Prepared for Environmental Enforcement Section, New Jersey Department of Law. Columbia (MD): March 2014. Reports available in Exhibit 10 of referenced report.

materials may have been wrongly disposed, there is no documentation of improper disposal, so determining exactly where to sample to find any hazardous materials would be very difficult. Negative core sample results would not prove there are no hazardous materials. ATSDR recommends ongoing monitoring of groundwater at the landfill perimeter to capture any releases of materials. If hazardous substances are found to be exiting the landfill in groundwater, we may recommend further investigation.

PC1-13: b. Conclusion 7 does not consider the high water table and streams running beneath the landfill that have the potential to keep the H_2S generating material wet, and also create a possible pathway of leaching hazardous substances into the groundwater. A full hydrological study of the site is warranted and should be recommended. This is also the probable cause on why the capped material is currently generating more H_2S than expected (because it's not drying).

ATSDR Response: H_2S formed in the landfill will be collected by the gas extraction system and treated. ATSDR does not have information on the water table. Historical site documents and NJDEP state that no streams run under the landfill; instead two streams run along either side of the landfill. Characterizing the groundwater beneath the site would help understand possible impacts of any substances being released by the landfill; however ATSDR's recommendation to monitor groundwater at the landfill perimeter will allow timely action to be taken, if necessary, to protect public health.

PC1-14: Site Description and History
The DEP explicitly allowed C&D material to be accepted from their approved recycling centers to be deposited on Fenimore Landfill, a dormant site that exhibited no environmental controls and is located adjacent to residential homes. The record should (correctly) reflect this with hope that stronger regulation, permit requirements, and project oversight is mandated in regards to wallboard recycling and disposal.

ATSDR Response: Your comment is noted.

PC1-15: ATSDR Activities
ATSDR clarified the following recommendations to the township after residents complained that the township was not sending out alerts to the public per guidelines of the Environmental Action Protocol that was created. "ATSDR provided the following recommendations in two conference calls this month with the Township, NJ DEP, and NJDOH. ATSDR recommended that all data readings be included in calculating the 60-minute running H_2S average for comparison with the action level of 100 ppb. Because some H_2S readings were high enough to result in harmful effects even with exposures of 30 minutes or less, action needs to be taken on real-time readings without waiting for complete investigation of the source of any high reading. ATSDR recommended preemptive alerts and opening the respite center when work occurs at the landfill that could reasonably be expected to release H_2S, such as scheduled power outages."

ATSDR Response: This comment accurately describes ATSDR's actions and recommendations provided to the Township in fall 2014.

PC1-16: Community H_2S Monitoring and Data Quality
Since H_2S exposures to the community have been ongoing for more than 2 years (subchronic), why haven't exposure comparisons been made to the EPA RfC of 2 ppb which is defined as the daily inhalation exposure of the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime, and also the only published chronic health based reference level. What should the long term exposure average be that will guarantee health and safety?

ATSDR Response: EPA's chronic RfC is based on the same study as ATSDR's intermediate minimal risk level of 20 ppb, with an additional factor of 10 to account for application of a subchronic study (10 weeks of exposure) to chronic (many years) exposure. ATSDR has not derived a chronic MRL for H_2S. Chronic low level H_2S exposure studies have not been conducted in animals, and epidemiological exposure studies are limited. H_2S is rapidly processed and removed from the human body, and the early acute or intermediate effects caused by lower level exposures are generally reversible. With continued operation of the landfill gas extraction and treatment system, the concentrations of H_2S in the community near Fenimore landfill are expected to be too low to cause any long-term health effects.

PC1-17: Sulfide in Well Water
The ATSDR should make the following recommendations regarding Sulfides in well water. "If you smell hydrogen sulfide coming from your water supply, you might be exposed to hydrogen sulfide. You can reduce exposure to hydrogen sulfide gas by practicing the following precautions:
While bathing or showering, try to ventilate the bathroom. This can be done with the use of bathroom ventilation fans, by cracking the door during showering or bathing or, during the warmer months, by opening a bathroom window.
Attempt to ventilate the basement or laundry room if, while washing or folding clothes, you notice a sulfur odor. This can be done with a fan or, when the weather is warm, by opening windows, doors or vents.
Residents who are concerned about hydrogen sulfide odors inside their homes should consult with a water-treatment professional. Water treatment can significantly reduce or eliminate hydrogen sulfide odors emitted from well water."

ATSDR Response: ATSDR has added language to the private well discussion and recommendations to include ventilation of the area to reduce potential exposures and possible water treatment.

PC1-18: Potential Unidentified Hazardous Substances in the Landfill
The report references an underliner. Note that the landfill does not have and has never had an underliner.

ATSDR Response: The commenter is correct that the waste at the landfill does not have a liner beneath the waste. The liner ATSDR mentions in the report is above the waste; its function is to prevent stormwater or moisture from flowing into the waste from above. We have modified language in the report to clarify that the liner is above the waste.

PC1-19: Children's Health Considerations
ATSDR has previously recognized that the unique vulnerabilities of infants and children demand special attention. Children may be at greater risk than are adults to certain kinds of exposure to hazardous substances. Because they play outdoors and because they often carry food into contaminated areas, children are more likely to be exposed to contaminants in the environment. Children are shorter than adults, which mean they breathe dust, soil, and heavy vapors closer to the ground (H_2S is heavier than air). They are also smaller, resulting in higher doses of chemical exposure per body weight. If toxic exposures occur during critical growth stages, the developing body systems of children can sustain permanent damage. Considering these facts, why did the report reference exposure to children to result in a similar health effects to adults?

ATSDR Response: ATSDR recognizes that exposure may be greater for children. The current scientific information suggests that for the same exposure to H_2S, children would experience the same types and degree of health effects as adults.

PC1-20: General Comments
The report should include the fact that that a group of concerned citizens, The Roxbury Environmental Action Coalition (R.E.A.C.T.), as well as other residents, asked the DEP and DOH to subsidize air purifiers to affected residents. DEP and DOH responded that they didn't have the funds to provide these, but somehow came up with 20 million dollars to remediate the site.

ATSDR Response: Your comment is noted. This information is beyond the scope of ATSDR's work at this site.

PC1-21: The ATSDR recommendations do not identify the specific governmental agencies or individual parties who are to implement the recommendations.

ATSDR Response: We have rewritten the recommendations to include the most appropriate parties to perform (or direct others to perform) the recommended actions. We recognize that ultimate control and regulatory authority at the landfill may be determined through the judicial system.

PC1-22: The report should include a recommendation for the DEP to continue to investigate future odor complaints. Although hotline complaints are still recorded, DEP no longer investigates them. As a result, residents in the immediate area have long since become discouraged and disillusioned with making complaints to local and state government and simply no longer do.

ATSDR Response: It is ATSDR's understanding that while mitigation work was occurring at the landfill, NJDEP did not investigate individual odor complaints, as odors were assumed to be caused by a problem that was actively being addressed. NJDEP informed ATSDR in September 2015 that they intend to investigate all new odor complaints. ATSDR added a recommendation that NJDEP continue to investigate new odor complaints from the community and address offensive odors to the extent possible. It's important for residents to continue reporting odors.

PC1-23: The report makes reference to "continuous" operation of the gas treatment system many times, which is not the case. In addition to downtime due to scheduled and unscheduled repairs and maintenance, the system is designed to automatically shut down if an elevated amount of SO_2 is detected. When this happens H_2S has the potential to and has escaped untreated, resulting in additional exposure to the community. The ATSDR should provide operational recommendations for additional safeguards and redundancy that should be built into the system that would eliminate downtime and any risk /threat of potential gas exposure.

ATSDR Response: The use of the word "continuous" was to differentiate the initial operation of the treatment system, which only ran during the day, to that of a 24-hour operation. Properly maintaining the treatment system (which by definition will include occasional downtime for maintenance) should prevent releases of H_2S or other gases into the community because the landfill is under vacuum and it would take several days for gases to build up enough to be released through the ground surface, if extraction ceased.

The system does shut down automatically if SO_2 levels are too high. ATSDR looked at the Continuous Emission Monitoring System data provided by NJDEP to see how often and for how long automatic shutdowns occurred. The table below summarizes these data. The total amount of time the system was shut down automatically was only about 0.2% of the time the system operated. In the last 6 months of 2015, the frequency and length of automatic shutdowns has been very low.

Table A2. Summary of System Shutdowns from Continuous Emission Monitoring System Data

Month and Year	*Total Number of Automatic Shutdowns of System**	*Total Minutes Shut Down During Month*	*% of Time Spent Automatically Shut Down*
July 2014	*6*	*39*	*0.09%*
August 2014	*49*	*168*	*0.4%*
September 2014	*29*	*292*	*0.7%*
October 2014	*12*	*79*	*0.2%*
November 2014	*10*	*129*	*0.3%*
December 2014	*34*	*82*	*0.2%*
January 2015	*1*	*10*	*0.02%*
February 2015	*87*	*461*	*1.1%*
March 2015	*35*	*140*	*0.3%*
April 2015	*22*	*25*	*0.06%*
May 2015	*18*	*24*	*0.05%*
June 2015	*24*	*48*	*0.1%*
July 2015	*1*	*3*	*0.00%*
August 2015	*14*	*21*	*0.05%*
September 2015	*1*	*2*	*0.00%*
October 2015	*0*	*0*	*0.00%*
November 2015	*0*	*0*	*0.00%*

**System automatically shuts down if SO_2 concentration is 40 ppm or higher; shutdowns were counted for stack readings greater than or equal to 40 ppm. Note stack readings continue even though the system is shut down.*

PC1-24: The report references H_2S emission data prior to and after the gas treatment system was implemented, however, there still remain odors and occasional emissions in excess of health based guidelines. At what point is the remediation method selected deemed insufficient to be protective of human health and safety? What other remediation options are there that may be less obtrusive to nearby residents (eliminate smoke stacks, etc.)? Section 4.7 of EPA recommended practices based on the Removal Action at the H_2S Emitting Warren Recycling /Warren Hills Landfill explicitly states that, "….active gas collection system be considered as one of the last control options to be implemented at a given site."

ATSDR Response: Because of the uncertainty with the monitoring results due to spikes in the data, discussed in depth in the health consultation, ATSDR is not sure that there are indeed occasional emissions above health screening levels. We recognize that odors may still cause health effects, particularly to people who have been sensitized; but the source of odors is not clear. NJDEP has informed ATSDR that it will investigate odor complaints. ATSDR recommends that NJDEP continue to investigate new odor complaints from the community and address offensive odors to the extent possible. Proper operation and maintenance of the treatment system should prevent releases of H_2S or other gases from the landfill into the community.

ATSDR also notes that the liner and capping materials installed above the waste and systems to divert stormwater and runoff from the landfill were designed to prevent moisture from entering the waste and should eventually reduce the gases being formed. When gases reach low enough levels, alternate treatments can be considered. ATSDR is available, upon request, to review and comment on proposed alternative treatment strategies being considered in the future.

ATSDR reviewed the EPA document mentioned in the comment [66].[4] ATSDR agrees that different management practices, if implemented when the C&D waste was deposited at Fenimore landfill, might have reduced the H_2S released. However, high levels of H_2S were already being released when NJDEP took control of the site. Installation of the active treatment system was a relatively quick way to address the H_2S and protect the public from harmful exposures.

PC1-25: DEP is operating under an "emergency order" and has not been obtaining otherwise required permits, including an air permit to operate a thermal oxidizer that has the potential to emit SO_2, or following NJ regulations for landfill closure, NJAC 7:26E. As a result, community involvement and environmental testing is lacking. ATSDR should recommend that the remediation and closure of Fenimore Landfill be in accordance with NJAC 7:26E and all required federal air permits via the Clean Air Act.

ATSDR Response: ATSDR is an advisory agency and does not have authority to set requirements for regulatory authorities.

[4] Durno M. Memorandum to Harris D and Snyder K of Ohio EPA RE: Recommended Management Practices based on the Removal Action at the Warren Recycling / Warren Hills Landfill Site. U.S. Environmental Protection Agency Region 5. August 22, 2006. Accessed on December 9, 2015 at http://www.epa.ohio.gov/portals/34/document/newsPDFs/cdd_h2s_bmps.pdf

PC1-26: What are the ATSDR recommendations for the remainder 40 acres of uncapped landfill? Is an environmental investigation warranted? What testing is recommended to insure public safety?

ATSDR Response: ATSDR recommends ongoing groundwater monitoring at the landfill perimeter for common landfill contaminants. We noted in the report that private wells, presumably downgradient from the landfill, did not show contaminant concentrations at levels of concern; however, ongoing monitoring of private wells is recommended to ensure the water remains safe to drink.

PC1-27: ATSDR should recommend the correct standards that ground water, surface waters, and residential wells are tested to. There has been discrepancy on testing methods and contaminants tested for.

ATSDR Response: ATSDR typically recommends EPA analytical methods to assess quality of groundwater or surface water. Depending on the purpose of the testing and the water's intended use, different methods and standards might be applicable.

PC1-28: ATSDR should list the data they requested from the Township, DOH, and DEP and never received, such as air quality readings from redundant monitors.

ATSDR Response: ATSDR received data requested from NJDEP (vent composition data, continuous emissions monitoring system (CEMS) data of SO_2 releases from the scrubber stack, stack discharge reports describing releases from the scrubber stack) in January 2016. ATSDR received data requested from the Township and its contractor (updated H_2S and SO_2 data from community monitors and H_2S data from co-located monitors) in late 2015. NJDOH had provided data it collected at schools before the release of the public comment version of this report.

PC1-29: Community Involvement
The DEP and DOH have been unresponsive to resident's concerns regarding H_2S emissions from Fenimore Landfill. The Township issued a resolution asking the DOH and DEP to come to Roxbury and hold a public meeting. It wasn't until over a year later that the DEP held a public meeting. During the public meeting the DEP presented the remediation plan with little to no input from the public. Resident's concerns were not addressed, and the selected remediation strategy of incorporating a smoke stack in a residential area has diminished property values. In addition, no updates have been given to the public in several months, including what the final remediation design will consist of. It's important that the ATSDR continue to recognize and recommend the importance of community involvement for a remediation of this magnitude. EPA recommended practices based on the Removal Action at the H_2S Emitting Warren Recycling /Warren Hills Landfill site further support this.

ATSDR Response: As an advisory agency, ATSDR has no authority to dictate other agencies' communication strategies. Unfortunately, we don't know when the landfill gases might be reduced enough that alternate treatments could be considered, so it might be some time before final remediation plans are developed. ATSDR is available to answer the public's health

questions about exposures from the site and evaluate new data or plans that may come available, upon request.

PC1-30: 4.9.1 Community Outreach
Good community relations are part of every successful odor control program. Humans can detect the odor of H_2S gas at very low concentrations (as low as 0.0005 ppm). Even at low concentrations, H_2S gas can be offensive and complaints may occur, especially during unfavorable weather conditions. Therefore, we recommend that the owner or operator maintain effective communication with the surrounding community and encourage involvement.

ATSDR Response: ATSDR agrees that effective communication with the surrounding community is important at any site.

PC1-31: ATSDR should request that that Roxbury Township disseminate the final ATSDR report on their website and social media sites to spread awareness and increase circulation. The Township did not post the draft report on their website and indicated that the ATSDR did not ask them to.

ATSDR Response: The public comment version of the health consultation was available on ATSDR's web site, and the final version will be also. ATSDR will request the Township post the final version of the health consultation (or a link to it on ATSDR's web site) when we release it. We did not specifically ask them to post the document when it was released for public comment.

Comments from a Roxbury Township Council Member (PC2):

PC2-1: I wanted to thank the agency for Toxic Substance and Disease Registry (ATSDR) for accepting our application petition to review the impacts of the reopening of the Fenimore landfill. The health and well-being of our residents is the highest priority. The detailed review, results, and recommendations have gone a long way in providing the public with a trusted understanding of the past and present conditions of the landfill and the impacts on our residents in that area. The report date September 1, 2015 provides extensive detail and I believe overall provides a thorough understanding of the conditions through a specific date. Thank you for all your work on this document.

ATSDR Response: Thank you for your comment. No response is necessary.

PC2-2: I do have some questions that I would like to raise for consideration.
1. General Reporting Period. The report itself does a fine job of evaluating the conditions through 2014. In that time there have been a series of improvements made to the collections system (oxidizer / scrubber) to enhance the operation of the gas extraction system. Many of these changes were made in the spring of 2015. I would ask, if possible that the latest reporting, let's say through October 2015 be included. The Township can supply this information.

ATSDR Response: We have updated the H_2S and SO_2 charts and evaluation to include data through the end of November 2015. The general conclusions and recommendations remain the same.

PC2-3: 2. Page iii, first bullet, indicates the odors were reported in the summer of 2012. Honestly, they occurred just after superstorm sandy when the materials were deposited to that site. The summer is not correct, November 2012 is correct.

ATSDR Response: Page iii states that the offensive odors were pervasive in summer and fall of 2013 (almost a year after the odors were first reported). We agree with the commenter that odors were first reported shortly after Hurricane Sandy passed through the area at the end of October 2012. We have checked timelines in the report to ensure the dates we have listed are accurate.

PC2-4: 3. Page iii, under basis of conclusion, first bullet, I would request that it be stated that the monitors were installed by the Township.

ATSDR Response: ATSDR has clarified that the Township installed the monitors in the body of the report on pages 1-2. We do not provide this level of detail in our Executive Summaries.

PC2-5: 4. Page v, recommendation, agree with the conclusion but it would be helpful to add a parameter for when the concentrations are low enough to possible retire the use of this system (i.e. 1 ppb over a 3 month period). This is repeated in other recommendations.

ATSDR Response: ATSDR is an advisory agency and cannot specify cleanup goals to regulatory authorities. We can comment on whether proposed goals are protective of public health, upon request.

PC2-6: 5. Page VI, Reference private wells, it would be helpful to set parameter for testing of local wells (i.e. 1x per year/ 2x per year in an area ¼ mile radius from landfill).

ATSDR Response: As an advisory agency, ATSDR leaves decisions about frequency and extent of testing to local or state agencies performing the work. We are available to provide technical assistance on evaluating sampling plans, upon request.

PC2-7: 6. Conclusion 6, basis of conclusion, states a few private wells tested for indicators of microbial contamination. Perhaps a statement indicating that this may or may not be caused by the landfill may be appropriate.

ATSDR Response: Microbial indicators in private wells are discussed in detail on page 35 of the report, where we state, "The positive results for microbial indicator organisms are not likely related to the landfill, because several wells with negative microbial results were between the landfill and the wells with positive results."

PC2-8: 7. Conclusion 7, basis for conclusion, second bullet, states that the core samplings could not prove or disprove presence of hazardous materials. I agree, but it would help, and that is why the township took a very aggressive position to obtain core samples during the process of digging the additional 20 extraction wells. The Township asked for but did not receive permission to test samples in multiple locations.

ATSDR Response: Your comment is noted. We have changed the text so that it does not say core sampling could not "prove or disprove" presence of hazardous materials, since a positive result would prove the presence of such materials. ATSDR concluded that ongoing monitoring of the groundwater at the landfill boundary will indicate whether any hazardous substances are being released from the waste. This will allow prompt action to protect public health, should any contaminants be detected at levels of concern.

PC2-9: 8. Page vii, next steps, recommends that the groundwater be monitored regularly. If we can establish some parameters (i.e. 2x a year at wells x, y, z) it would be helpful.

ATSDR Response: As an advisory agency, ATSDR leaves decisions about frequency of testing to local or state agencies performing the work. We are available to give informal technical assistance on designing sampling plans, upon request.

PC2-10: 9. In general, would you recommend a further site assessment be conducted prior to any further capping operations on the site and if so you can add this to your report?

ATSDR Response: As an advisory agency, ATSDR cannot set requirements for future work. However, we are available, upon request, to give input on public health questions that might come up in the future related to the landfill.

PC2-11: 10. Page 1, second sentence, I would like to request we make this more accurate, perhaps state, "but in 2011, at the direction of the NJDEP to cap the landfill, a new owner…

ATSDR Response: ATSDR has opted to only briefly summarize events leading to our involvement at the site because we don't have first-hand knowledge of the exact sequence and reasons for all events and actions. The focus of this report is on public health and not the legal responsibilities for the contamination.

PC2-12: 11. Page 1, first paragraph ….the NJDEP took over the site to mitigate odors. A series of remediation efforts followed, including a posishell covering, followed by a flare system to burn landfill gases, followed by the installation of a temporary scrubber (LODI scrubber) to further burn landfill gases." A gas extraction system with 9 extraction wells was eventually installed…

ATSDR Response: We have added the following underlined phrases. "<u>After a series of remediation efforts,</u> a gas extraction and treatment system <u>with 9 extraction wells</u> was eventually installed and began operating…"

PC2-13: 12. Page 1. second to last paragraph, the site was purchased by a private company that received approvals from the NJDEP to cap the landfill…

ATSDR Response: We have added the phrase "from NJDEP," as suggested.

PC2-14: 13. Page 2, first sentence, more monitors were set up by the Township to characterize the release to the community.

ATSDR Response: Thank you for this information. We modified the text on page 2 to reflect this.

PC2-15: 14. Page 2, second paragraph, first sentence, where the C&D materials was added, along with additional Township recommended extraction wells. In 2014, work began by the NJDEP on preparing the site….

ATSDR Response: We have reworded the text to read "In June 2014, the piping system collecting gases for treatment was expanded to include additional extraction wells covering the entire 19-acre area of the landfill where the C&D material was added. In August 2014, NJDEP began preparing this area…"

PC2-16: 15. Page 8, after first paragraph, it could be noted that the Township established , in connection with the NJDEP and NJDOH, a notification protocol to alert residents as well as establishment of a community respite center.

ATSDR Response: We added this note in the Site Description & History section (pages 1-2).

PC2-17: 16. Page 25 change the last sentence to read "Therefore, a reasonable assumption "is".

ATSDR Response: Thank you for identifying this error. The correction has been made.

PC2-18: 17. Could you recommend that if any additional capping is required that an appropriate flow topology study be required?

ATSDR Response: As an advisory agency, ATSDR cannot set requirements for future work. However, we are available, upon request, to give input on public health questions that might come up in the future related to the landfill.

PC2-19: 18. Finally, I agree with your statements regarding the new monitors to validate the existing monitors for spikes. Perhaps a bit more detail regarding the testing of a second monitor, such as at the site of the monitor with the most spike conditions, concurrently for a set period of time would be helpful.

ATSDR Response: As an advisory agency, ATSDR leaves decisions about how to set up such validation to local or state agencies performing the work. However, we are available to provide technical assistance and review monitoring plans, upon request.

PC2-20: Again, I would like to thank you for accepting our petition and for your thorough analysis of the past and present conditions of the Fenimore landfill. I would also like to thank you for spending as much time as you did explaining the report in detail to me, [another Council Member,] as well as the general public. Your insight and knowledge were extremely helpful and your conclusion put a lot of fears of our residents to rest. Thank you so much for what you have

done for Roxbury. As changes occur at this site we would be very appreciative if we can utilize your expertise in the future to assist us in making positive decisions for our residents.

ATSDR Response: Thank you for this comment. ATSDR is available, upon request, to answer the public's health questions about exposures from the site and assist the Township or other involved groups in evaluating new data or plans that may come available.

Comments from the Roxbury Township Manager (PC3):

PC3-1: Once again thanks to you and the ATSDR Team in developing the Health Consultation Report. Furthermore, your outreach to the public in informative sessions is appreciated.

ATSDR Response: Thank you for this comment. No response necessary.

PC3-2: As per the team directions, I am providing the following comments on the report. Page Number ii; Paragraph 2. Fenimore was never a municipal landfill, it was a private landfill that accepted waste from numerous customers.

ATSDR Response: Thank you for this information. We modified statements about the landfill on pages ii, vi, 1, 28, and 39 to reflect this.

PC3-3: Page Number 1,2; Paragraph 6. The Township maintains responsibility for the monitors. The NJDEP did not take over the monitors.

ATSDR Response: Thank you for this information. We modified the text on page 2 to reflect this.

PC3-4: Figures 3/4/5/6. Updating the charts with data through August 2015 will demonstrate lower H_2S levels.

ATSDR Response: Roxbury Township and Emilcott provided H_2S monitoring data through the end of November 2015. The document includes the recent data in charts and applicable discussion.

PC3-5: Page Number 24; Paragraph 1. The report should address SO_2 exposure levels in the area prior to the construction of the landfill gas treatment system.

ATSDR Response: We do not know the exact levels of SO_2 around Fenimore Landfill before the treatment system began operating and community monitors began collecting data in November 2013.

To address National Ambient Air Quality Standards, New Jersey conducts ambient air monitoring at 8 locations in the state. The monitoring station in Chester, NJ is less than 10 miles south of Roxbury Township. The table below summarizes annual one-hour average SO_2 data from 2009-2015 for the Chester ambient monitoring location, and the range of 99^{th} percentile one-hour average concentrations at the other New Jersey locations. Available data for ROX6, ROX7, and ROX13 are shown for comparison in Table C1.

Table C1. SO_2 Ambient Air Data for New Jersey from EPA AirData Website* compared with Fenimore Community Monitoring Data

Year	Highest One-Hour Average SO_2 Concentration, ppb: Chester NJ Location (Fenimore ROX Monitors)	99th Percentile of All One-Hour SO_2 Concentrations for Year, ppb: Chester NJ Location (Fenimore ROX Monitors)	Range of 99th Percentile One-Hour SO_2 Concentrations, ppb: All Eight NJ Monitor Locations
2009	40	29	14—34
2010	49	26	9—183
2011	67	25	7—125
2012	14	11	5—66
2013	12	6	6—81
2014	20 (ROX6/7/13 = 25/15/114)	12 (ROX6/7/13 = 11/9/12)	7—78
2015**	7 (ROX6/7/13 = 9/129/9)	7 (ROX6/7/13 = 6/12/7)	5—17

*Data Downloaded from http://www3.epa.gov/airquality/airdata/ad_rep_mon.html - Last accessed on December 17, 2015 [67]
**Annual statistics for 2015 are not final until May 1, 2016; ROX data includes December 2015 data not presented in graphs

PC3-6: Page Number 27; Paragraph Last. First sentence conflicts with the finding of the report. Presently there is no community exposure to H_2S.

ATSDR Response: We have modified the sentence (which appears in the section beginning on page 31 of the final report) to read, "H_2S exposure appears to have been the primary community exposure from the landfill when odors became a problem beginning in fall 2012".

PC3-7: Lastly, in my opinion the report fails to adequately detail the efforts of the Township in establishing a continuous monitoring system and operation of a respite center.

ATSDR Response: We have clarified the Township's operation of the monitoring system and added mention of the respite center on pages 1-2 of the report.

PC3-8: I would be remiss in closing this letter without acknowledging the efforts and contributors of the ATSDR in reassuring residents that the abatement effort of the NJDEP has effectively improved the health and safety of Roxbury Residents.

ATSDR Response: Thank you for this comment. No response is needed.

Comments from Emilcott Technologies, the Township's contractor (PC4):

PC4-1: "ATSDR recommends verification of existing community monitors, replacement with new units, or installation of an alternate type of H_2S monitor (such as colorimetric tape meters)."

We feel it is important to note that the community air monitoring program, using the Jerome 631x Hydrogen Sulfide monitor, has produced over 2 million H_2S readings since beginning in early 2013. The air monitoring program has been extremely reliable and has provided accurate data to support the goals of this project and protect the surrounding community. We do acknowledge that there have been infrequent recorded spikes of extremely short duration (with a frequency of less than 0.01%). These spikes are related to sensor anomalies, electrical surges, or localized particulate interferences not related to emissions from the Fenimore landfill. As acknowledged in the report, we have significantly reduced the occurrences of these spikes but have not eliminated them entirely. We will continue to make improvements to the Greenlight™ air monitoring system to further reduce the frequency of spikes and other false positive readings. Emilcott Technologies has been working with NJDEP to automatically identify these infrequent spikes and remove them from the time weighted averages. It is our goal to continue to ensure the public is not unnecessarily alarmed without compromising the air monitoring program's ability to accurately measure real landfill H_2S emissions.

ATSDR Response: We recognize that the Jerome meters are generally reliable instruments. In this case the isolated data spikes add to the community's uncertainty about the H_2S levels in the community, and we feel an instrument that does not exhibit these spikes would add to confidence that the H_2S levels remain low.

PC4-2: Monitoring ambient H_2S with real-time results (measurements every 5 minutes) at parts per billion levels requires instrumentation that is both accurate and robust. The Jerome 631x H_2S monitor is well suited for the continuous duty cycles required by this project. It also has the accuracy and resolution needed at levels as a low as 3 ppb. The occurrence of isolated data spikes does not deter from the instrumentation's accuracy or resolution. Other instrumentation can be evaluated for its ability to meet the accuracy and durability (relative to duty cycle and temperature / humidity) requirements of the project. If a suitable device can be identified it may be used to verify the results of the Jerome monitors.

ATSDR Response: We recognize that the Jerome meters are generally reliable instruments. In this case the isolated data spikes add to the community's uncertainty about the H_2S levels in the community, and we feel an instrument that does not exhibit these spikes would add to confidence that the H_2S levels remain low.

PC4-3: We appreciate the efforts of ATSDR and the hard work of the team in evaluating the effects of the landfill emissions at Fenimore.

ATSDR Response: Thank you for this comment. No response is needed.

Comments from New Jersey Department of Environmental Protection (PC5):

PC5-1: Thank you for the opportunity to comment on the draft Health Consultation prepared by the Agency for Toxic Substances and Disease Registry (ATSDR) for the Fenimore Landfill site. The New Jersey Department of Environmental Protection (NJDEP) concurs with ATSDR's conclusion that NJDEP's installation of a gas extraction system in October 2013 has greatly reduced hydrogen sulfide (H_2S) concentrations and the likelihood of harmful health effects. Upon review of additional information provided to ATSDR by NJDEP and Roxbury Township, NJDEP believes that ATSDR will be able to state conclusively in the final document that the threat of fugitive emissions from the site has been eliminated.

ATSDR Response: NJDEP provided continuous monitoring data of SO_2 releases from the scrubber stack, treatment system operator log sheets, and data on composition of gases in vent sampling dating from when NJDEP took over operations at the landfill. Roxbury Township and their contractor provided H_2S data from co-located Jerome monitors and additional H_2S and SO_2 data collected from community monitors through late 2015 and into 2016. ATSDR appreciates the cooperation shown by these agencies in providing data and answering inquiries related to the data. ATSDR's review of these data helped confirm our conclusion that, with continuing operation and proper maintenance of the gas collection and treatment system, community exposures will remain at low levels and are unlikely to result in lasting health effects.

PC5-2: NJDEP concurs with ATSDR's conclusion that methane production from the landfill does not pose a risk to nearby homes and that drinking water from groundwater wells near the landfill is unlikely to harm health.

ATSDR Response: Thank you for this comment. We note that our conclusion is based on currently available data and the continued proper operation of the gas treatment system; we recommend ongoing monitoring of groundwater and continued operation of the gas treatment system to ensure public health is protected in these areas.

Groundwater from monitoring wells just downgradient of the landfill was tested twice in 2015. A discussion of these results and their implications for the conclusion is in the final document beginning on page 40.

PC5-3: NJDEP will continue to operate and properly maintain the gas extraction and treatment system and will continue to monitor for H_2S and SO_2. Consistent with ATSDR's recommendation, NJDEP will be investing in new H_2S monitors to address the data quality issues identified in the draft report.

ATSDR Response: Thank you for committing to these actions. ATSDR is available, upon request, to evaluate and comment on public health implications of additional data that become available in the future.

PC5-4: NJDEP's actions at the site beginning in June 2013 were initiated in response to citizen complaints during months of uncontrolled H_2S emissions from one portion of the landfill. NJDEP's actions at the landfill are limited to abating the H_2S gas emissions, and were neither

designed nor intended to address any other issues at the facility. The landfill owner remains responsible for proper closure and post-closure monitoring of the landfill itself.

ATSDR Response: We recognize that the NJDEP's Site Remediation Program responding at the landfill was limited in scope to the area receiving C&D waste. We recommend the organization within NJDEP with authority over landfill closure issues enforce requirements to properly close and monitor the landfill. ATSDR is willing, upon request, to evaluate and comment on public health implications of any monitoring data that may come available in the future.

Comments from a private citizen (PC6):

PC6-1: I respectfully submit my response to the ATSDR report.
Introduction
This report was supposed to respond to a specific request for information about health risks related to the Fenimore landfill. It was supposed to provide an objective evaluation of what health risks can be identified as a result of the dumping of materials in the landfill. The most important conclusions I have, after studying this document have nothing to do with health risks. The major problems I have with this document is the politically motivated nature of what is written.

If it were not for the smell, the Fenimore issue probably would not exist in the public mind. The smell was a spectacular wakeup call indicating issues of a lethal nature. Having done many searches I have discovered that Fenimore seems to be the worst case of hydrogen [sulfide] poisoning within a community in history. I have not found a case where hydrogen sulfide has been generated on a larger scale anywhere in the world, ever.

Hydrogen sulfide is a dangerous, highly toxic neurological agent. There has been a consistent effort to minimize this fact in all the actions of public officials since 2011. The early court case centered on the fact that the smell was a nuisance. Newspapers still talk mainly about the problem being the smell. This report falls right in line with this denial of the serious issue of hydrogen sulfide's lethal properties.

ATSDR Response: The section entitled "H_2S Background and Health Effects" describes the toxicological properties of H_2S, including the fact that breathing high levels of H_2S can be life threatening. The National Institute for Occupational Safety and Health has determined that breathing 100,000 parts per billion (ppb) of H_2S is immediately dangerous to life or health of workers. Breathing more than 100,000 ppb of H_2S can result in a loss of the sense of smell, and exposure to 500,000 ppb or more can cause "knockdown" or a loss of consciousness. If a person recovers from this exposure, there can be long-lasting neurological impairment. Exposure to lower concentrations of H_2S can cause other effects. Rats exposed to 30,000 ppb H_2S for ten weeks developed nasal lesions, and 2 of ten people with asthma who volunteered for an experiment in which they breathed 2,000 ppb of H_2S for half an hour showed small changes in lung function parameters. ATSDR used these studies to develop the minimal risk levels used in the report.

The levels of H_2S measured in community monitoring near Fenimore Landfill were high, but they were not as high as the concentrations that were examined in toxicological studies or that we know can cause life-threatening effects. During the period of time when odors were strongest, the highest 30-minute average H_2S concentration measured in monitors was less than 700 ppb. While the highest levels of H_2S measured at Fenimore were of concern, especially for sensitive populations like people with asthma or other respiratory conditions, the general population would not have experienced long-lasting impairment from the toxic effects of H_2S. Instead, the symptoms experienced by nearby residents could have been caused by the offensive odor of H_2S since we know odors themselves can result in health symptoms.

PC6-2: My direct experience with hydrogen sulfide and Fenimore began when I was walking in the area to see for myself what the problem was. At one point I walked into a hydrogen sulfide cloud. At first it was impossible to know how big the cloud is, so I continued to walk in the same direction, hoping to walk right through it. After two minutes I realized I might be walking into a large cloud and be overcome by the gas, so I turned round and attempted to exit the cloud. Two minutes later, the smell was still very strong, so I tried to find higher ground and luckily escaped the cloud. Only after, did I realize how lucky I had been. The area where I was walking is still open to the public and is an area where children still play. The area is unlike any open area I have ever walked in. There is almost no sound of life. There are very few birds. It is quite eerie.

ATSDR Response: H_2S can be smelled at very low concentrations, as low as 0.5 ppb, and the smell would be very strong at the concentrations measured near Fenimore Landfill. The concentrations near the landfill itself would have been much higher than those measured in the community monitors. The concentrations of H_2S that were being released before the gas treatment system began operating could have resulted in harmful health effects, which would be expected to resolve once the exposure stopped.

PC6-3: In this report the word “odor” is mentioned 89 times, odor-related 5 times and offensive odors 7 times. This is a prime example of the degree to which the all the public officials don’t get it. As political creatures they live in the world of appearances, not reality. Hence their focus on the smell, and not the health of the community. The use of the word “smell” shows the report’s non-scientific bias, characterizing and minimizing the problem as an aesthetic one, rather than using the words “toxic gas”. This points to the report’s downplaying of the health hazard by implying that the hydrogen sulfide is a nuisance and not potentially deadly. Odor-related symptoms should be changed to say, toxic gas poisoning symptoms.

ATSDR Response: The concentrations of H_2S measured in the community around Fenimore before the treatment system was installed were high enough to cause short-term health effects, particularly in people with pre-existing respiratory conditions. Our conclusion was meant to highlight the fact that health effects could occur at even lower concentrations and in the general population due to the offensive odor. We recommend any persisting odors be addressed as they are a remaining cause for concern.

PC6-4: Here is one of the deceptive quotes from the report: “People could still experience harmful health effects in reaction to H_2S odors, which are offensive and annoying.”

This document is very cleverly worded. It takes advantage of the lack of understanding of scientific issues in the minds of the public. Many of the points made in this report are non-scientific, and therefore do not belong in such a document, except to serve as a political move to let the people who are supposed to protect us off the hook for their failures.

ATSDR Response: ATSDR tries to write in plain language to improve readability. We attempted to explain the difference between health effects caused by odors versus health effects caused by toxicological irritant properties of a substance. Both types of health effects are real and we recommend action be taken to reduce all exposures than could result in harmful effects.

PC6-5: In the following text I have placed all direct quotes from the report in quotation marks. Some major points that show how poor this report is are:
Hydrogen sulfide is a neurological agent. That is its major characteristic. This is not mentioned anywhere in this report. Why?
"Chronic effects from breathing low levels of H_2S are considered unlikely." Since H_2S is a neurological agent that affects us all even in minute amounts, how can the above statement be true?

ATSDR Response: Exposure to high concentrations of H_2S can result in neurological effects, which can be lasting if the exposure is very high, such as high enough to cause a loss of consciousness or "knockdown." The concentrations of H_2S in the community near Fenimore Landfill were never high enough to cause lasting neurological effects. Lower levels of exposure could result in less severe respiratory and neurological effects. The minimal risk levels used by ATSDR for screening are based on the most sensitive respiratory effects, which were the first effects seen for low levels of exposure studied.

PC6-6"Because none of the perimeter samples were elevated, the assessment concluded that offsite migration of the methane was not occurring and that methane did not pose an immediate environmental concern [42]." This is not true. It does not indicate there is no methane danger. They simply did not find methane in the few places where they searched.

ATSDR Response: The above quote from our report describes the conclusion reached in the historical assessment being described. The sampling included areas along the perimeter of the landfill in all directions.

PC6-7: This report makes conclusions that it admits are based on what we do not know. It is not scientifically permissible to say you do not know the effect of a poison, and therefore decide not control exposure to it. Some major errors are:
"ATSDR recommends that the gas extraction and treatment system continue operating until concentrations of methane and other components of the landfill gas are too low to cause any concern for safety or health." No. We simply do not know what other toxic gases are present. If we do not know what they are, how will their concentration levels be decreased and how will we know when they become too rare to cause harm?

ATSDR Response: H_2S is the major gas being produced by the landfill, with methane present as well. Other combustible gases will be destroyed in the treatment system and will not be released

to the atmosphere. When the H_2S and methane levels being generated by the landfill are reduced to very low levels and authorities are considering whether to cease treatment, we would recommend fully characterizing the components of the landfill gas to evaluate any potential health concerns. ATSDR can evaluate such sample results at that time, if requested.

PC6-8: "Drinking water from groundwater wells near the landfill is unlikely to harm health. However, there is not enough information to determine whether H_2S released from private well water into indoor air could cause harmful health effects." The issue is, are there poisons in groundwater that cause health issues? If so, what are they, and what effect do they have on us. A completely un-scientific, political statement.

ATSDR Response: The available private well results showed no contaminants present that would harm health. However, because H_2S does not remain in water but is quickly released into air, it's possible that the sampling method did not capture H_2S that was present. That's why we recommend any further sampling be accompanied by air sampling to make sure the levels of H_2S released into the air near private taps are not too high. People would probably smell the H_2S if it was being released from their well water.

This final report includes a new section evaluating testing of groundwater from monitoring wells at the landfill boundary. This testing included comprehensive analyses including volatile organic compounds, semi-volatile organic compounds, metals, and pesticides/polychlorinated biphenyls. ATSDR recommends continued monitoring of this groundwater, which could eventually reach private wells downgradient from the landfill.

PC6-9: "Methane is now collected by the landfill gas extraction system and burned along with other landfill gases." No. Methane is collected only from the areas where hydrogen sulfide gas is collected, which is about 19 acres, out of 60 acres at Fenimore. Only a small percentage of the methane is collected.

ATSDR Response: The gas extraction system was designed to draw gases from the entire C&D portion of the landfill and covers all areas where high methane readings were detected in previous monitoring. The previous monitoring showed only trace levels of methane in other areas of the old landfill, as shown in Figures 9 and 10 of the report.

PC6-10: "Past and current concentrations of sulfur dioxide (SO_2) produced from the landfill gas treatment process are not likely to have caused or be causing serious harmful health effects." No. Anyone who has emphysema and is exposed to sulfur dioxide is in a precarious position. What is the likelihood that this report statement holds true for these poor individuals? Who is protecting their health?

ATSDR Response: ATSDR reached its conclusion by looking at the levels of SO_2 measured in the community and comparing that to known effect levels, including those for sensitive groups. The levels of SO_2 were too low to cause harmful effects.

PC6-11: The effect of the hydrogen sulfide is evaluated as if there were no other factors that affect public health. The combined effects of exposure to the toxic gas and other factors that

adversely affect public health is not considered at all. If the exposure to hydrogen sulfide was the last straw in a series of health hazards, the exposure would be the deciding factor in any number of individual casualties. This is precisely why zero tolerance for emission of a toxic gas is so important. Any one of the dangerous emissions of hydrogen sulfide since the installation of the gas removal system at Fenimore would have a serious effect on some people. Had the hydrogen sulfide not been released into the air in these cases, many people who suffered health problems would not have suffered them. Any time there is an emission of hydrogen sulfide, some people do suffer as a direct result of that emission. We know that such emissions occur and have no reason to expect them to stop any time in the next twenty years.

ATSDR Response: ATSDR did conclude that the H_2S exposures were high enough to cause harmful health effects in the population and that the actions to reduce exposure were needed.

PC6-12: "Before the landfill gas extraction and treatment system began operating in October 2013, concentrations of H_2S released from the landfill were high enough to cause harmful short-term health effects in community members. Lasting health effects are unlikely from the exposure." Not true. Is use of the word "unlikely" sufficient reason not to monitor these effects? Are they being monitored?

ATSDR Response: Studies have shown that the short-term health effects possible from exposure to the levels of H_2S near Fenimore Landfill are reversible. The report discusses possible lasting health effects in people who have become sensitized to the odor of H_2S (or any offensive odor). People who continue to experience health effects should consult their personal medical provider.

PC6-13: "ATSDR recommends that the gas extraction and treatment system continue operating until components of the landfill gas are reduced to concentrations too low to cause any concern for safety or health." It has been the experience to date at Fenimore that it is impossible to keep hydrogen sulfide levels too low to cause concern for safety or health. That is precisely why this recommendation is extremely inappropriate.

ATSDR Response: The treatment system is effective at reducing H_2S to levels too low to harm health. The treatment system needs to be maintained and continue operating until the landfill stops producing H_2S. Full characterization of the landfill gas and further evaluation would be needed to make sure it is safe to stop treating landfill gas when that time comes.

PC6-14: A gas extraction and treatment system was eventually installed and began operating continuously in December 2013. The thermal treatment and scrubber system operated intermittently for several weeks and became continuously operational in December 2013." No. It did not operate continuously. It was shut down on several occasions. The system automatically shuts down if there is too much sulfur dioxide detected. This means that the hydrogen sulfide that would otherwise be collected, is now released into the atmosphere. This is completely unacceptable. It is a major system design flaw.

ATSDR Response: The use of the word "continuous" was to differentiate the initial operation of the treatment system, which only ran during the day, to 24-hour operation. Properly maintaining the treatment system (which by definition will include occasional downtime for maintenance)

should prevent releases of H_2S or other gases into the community because the landfill is under vacuum and it would take several days for gases to build up enough to be released through the ground surface, if extraction ceased. The total amount of time the system was shut down automatically was only about 0.2% of the time the system operated. In the last 6 months of 2015, the frequency and length of automatic shutdowns has been very low. Please see our response to public comment PC1-23 above for more details about the amount of time the system was automatically shut down.

PC6-15: "In August 2014, work began on preparing this area for installation of a liner and cap to prevent water infiltration and mitigate future production of H_2S by the landfill material." No. There are streams running under Fenimore. Water infiltration has not been prevented. Hydrogen sulfide production was not mitigated by this procedure because the gas would travel horizontally, as hydrogen sulfide gas is known to do in landfills such as Fenimore.

ATSDR Response: Stormwater infiltration is prevented by a liner installed above the waste and by drainage culverts routing stormwater away from the waste. Historical reports and NJDEP stated that no streams run under the landfill. If the landfill dries out eventually the microbes producing the H_2S will die out.

PC6-16: "Because the source and transport elements of the pathway are poorly defined, the drinking water pathway is considered potential." No. When there is an admitted lack of knowledge concerning a pathway, it is not possible to declare that the drinking water pathway is considered potential. The correct answer is that chemical testing is required, before a proper determination can be made. This is a criminally irresponsible and negligent conclusion.

ATSDR Response: The path of contaminants from landfill to drinking water has not been measured at this time, so ATSDR considers the pathway potential. That does not prevent us from recommending testing be done to characterize groundwater at the landfill perimeter and assessing whether drinking water in the area shows harmful levels of any contaminants. We made both these recommendations.

PC6-17: "Limited information is available about contaminants released from the landfill into groundwater or groundwater flow in the area. Nearby wells have not been tested specifically for hydrogen sulfide." This is a shocking admission of professional negligence

ATSDR Response: ATSDR is an advisory agency and makes recommendations to protect public health based on available data, recognizing limitations of the data appropriately. When appropriate, we recommend collecting additional data.

PC6-18: "Other potential exposure pathways, such as trespassers exposed to contaminated soil on site or others exposed to surface water downstream from the site, are not evaluated in this report because contaminants present in these locations have not been well characterized." What if a child falls into the leachate pond? Do they know how easily this could happen? When there is heavy rain and the leachate is flowing down the mountain, and a child comes into contact with this liquid, what happens? Why is this pathway discounted in this report? Why was this critically important evaluation not done?

ATSDR Response: ATSDR limited the scope of the evaluation to answer the most important community concerns about exposure to H_2S and other gases released from the landfill. ATSDR has added a brief evaluation of surface water and groundwater data in the final report beginning on page 40.

PC6-19: "Methane collected by the extraction system will burn in the thermal treatment unit. In addition, the reduced volume of landfill gas means that the possibility of the gas migrating offsite is less likely." Not true. The gas collection area is only 19 acres. The complete area is 60 acres. 41 acres release methane where there is no gas collection.

ATSDR Response: The gas extraction system was designed to draw gases from the entire C&D portion of the landfill and covers all areas where high methane readings were detected in previous monitoring. The previous monitoring showed only trace levels of methane in other areas of the old landfill, as shown in Figures 9 and 10 of the report. Operation of the gas extraction system creates a vacuum in the subsurface of the landfill, so any nearby gases would be drawn towards the vacuum and would not move away from the landfill.

PC6-20: "In addition, the reduced volume of landfill gas means that the possibility of the gas migrating offsite is less likely. In June 2014, additional extraction wells were added to the system. The added extraction wells include some in the specific area of the high methane readings. Figure 10, developed from the landfill closure specifications, shows the locations of the gas extraction [1]." Not true. Figure 10 shows all gas extraction wells inside the 19 acre area, leaving the remaining 41 acres releasing methane into the atmosphere.

ATSDR Response: The gas extraction wells cover the areas where % levels of methane were measured in subsurface sampling, indicated by the yellow area shown on Figure 9. Other areas of the old landfill had no or trace levels of methane. The vacuum created by operation of the extraction system will draw nearby gases towards the system, so the gases won't move away from the landfill.

PC6-21: "However, offsite migration of methane or other landfill gas is unlikely as long as the gas is extracted." Not true for the reasons stated above.

ATSDR Response: Please see previous responses.

PC6-22: "Previous studies of the old landfill did not find immediate environmental concerns [42]." Not true. There are several reports that clearly state there are environmental concerns.

ATSDR Response: The site was assessed in the late 1980s and did not score sufficiently high to warrant listing on the National Priorities List (Superfund) [65].[5] A 2005 Immediate Environmental Concern Assessment showed no need for immediate action [52].[6]

PC6-23: "Children may be at greater risk of exposure to H_2S and SO_2, than adults; however, exposure is expected to result in similar health effects in children and adults." This is a meaningless statement. The exposure is expected to result in a greater effect in children than adults, for the very reasons cited in the quoted statement.

ATSDR Response: As discussed in the report, exposure may be greater for children because they are closer to the ground and may breathe a higher concentration. However, if a child and an adult received the same exposure, they would experience the same types and degree of health effects.

PC6-24: "Methane production from the landfill is unlikely to harm health by posing an explosion risk to nearby homes." What about the risks of explosion at the Fenimore site? A 2006 report cites this risk, specifically.

ATSDR Response: With the gas extraction and treatment system operating, the risk of explosion of methane gas is very small.

PC6-25: "If present, any unidentified materials could have released contaminants into groundwater when rainwater filtered through the landfill before it was capped. The liner, cap, and surface water runoff features recently added to the landfill will prevent further surface water infiltration and possible leaching of hazardous substances into the groundwater." Not true. There are streams underneath Fenimore. Simply putting a lid on Fenimore does little to solve this problem.

ATSDR Response: Historical reports and NJDEP stated that no streams run under the landfill.

PC6-26: Dangers that are omitted from this report:
Methane gas is a greenhouse gas many, many times more damaging than the global warming effect of carbon dioxide. This is a global risk that Fenimore is contributing to.

ATSDR Response: The focus of our report was on health of the community near Fenimore Landfill. Global risks are beyond the scope of the report. The gas treatment system is preventing release of methane and other gases produced by the landfill to the atmosphere.

PC6-27: This report makes conclusions that it says are based on what we do not know. It is not scientifically permissible to say you do not know the effect of a poison, and therefore decide not

[5] H2M Group. Background Investigation Report, Fenimore Sanitary Landfill, Roxbury Township, Morris County, New Jersey, Facility No. 1436A. Prepared for New Jersey Department of Environmental Protection, Bureau of Site Management. Totowa (NJ): June 2001.
[6] Louis Berger Group, Inc. and Sadat Associates, Inc. Immediate Environmental Concern Assessment Report, Fenimore Sanitary Landfill, Morris County, New Jersey. Trenton (NJ): November 2005.

control exposure to it. Nowhere are there any quantitative data relating to the poisoning of drinking water.

ATSDR Response: The report summarizes data available on private drinking water wells and municipal wells near the landfill in Table 6 on page 38. The data show no indication that drinking water has been contaminated, though we note that no data on metals in private wells were available. ATSDR recommends ongoing monitoring, including metals analysis, of groundwater near the landfill as well as nearby drinking water wells.

PC6-28: Issues raised and unanswered:
"Data quality issues have added uncertainty to this public health evaluation." What does this mean? Who is not doing his job? We deserve to have good quality data provided by public officials.

ATSDR Response: The continuing spikes in H_2S are reportedly common in the type of monitor used, but they cause uncertainty in reassuring the community that H_2S releases are low or have been stopped. We recommended the monitors be replaced with another type of monitor to confirm the H_2S concentrations. NJDEP and at least one Township official stated verbally that they intend to test/implement another type of monitor. ATSDR has not been provided with any status update on this.

PC6-29: "A larger oxidizer system was installed in March 2015 to allow treatment of a greater volume of landfill gases." This indicates the most significant admission of under-engineering the Fenimore solution by deploying a system that under-serves the health needs of the community.

ATSDR Response: According to the information provided to ATSDR, NJDEP used an available lower volume oxidizer system while the larger custom system was being fabricated. The original oxidizer was able to treat some of the gases, reducing community exposure, and would be preferable to having no treatment at all during that time period.

PC6-30: "According to NJDEP personnel, these releases were due to equipment malfunctions that reduced the efficiency of sulfur dioxide removal from the system; monitoring the stack for sulfur dioxide was manual, so sulfur dioxide sometimes was not detected right away." Sulfur dioxide was a risk from the beginning of hydrogen sulfide treatment at Fenimore. Why was it not being monitored 24*7 from the beginning, and only after a system failure?

ATSDR Response: Spreadsheets containing field data collected by scrubber system technicians were provided to ATSDR by NJDEP in January 2016. SO_2 was being monitored regularly (every several hours) by personnel until the automated system was installed. Before an automated system was available, regular manual monitoring would have been preferable to no monitoring at all.

PC6-31: "Further evaluation of the specific exposure occurring is needed to determine whether the exposure could cause harmful effects." Will this evaluation be done? Was it done?

ATSDR Response: This quote is taken from the section describing ATSDR's evaluation process. ATSDR's health consultation followed the process described to evaluate exposures to H_2S, SO_2, and other chemicals from Fenimore Landfill.

PC6-32: Question: do the health authorities collect data on lesions, asthma, etc. in the Roxbury community? If so, where are the data?

ATSDR Response: The evaluation ATSDR performs looks at exposure to determine if any adverse health effects would be possible. We try to document and address the community's health concerns. But we do not typically collect statistical data on actual medical conditions in the community in our evaluation. For example, ATSDR's evaluation found that the exposures to H_2S were high enough to cause harmful health effects and that actions to reduce exposures were needed. ATSDR does not need to count or survey the population to prove those health effects are actually occurring to make its recommendations. People who have experienced health effects should talk to their doctors or medical providers for personal advice.

PC6-33: "The current monitoring system does not fully meet these goals because of recurring anomalies and data quality issues." What has been done to remedy this? What happens when the equipment is shut down for maintenance, repair or upgrade? What happens when there is too much sulfur dioxide detected and the system automatically shuts down?

ATSDR Response: ATSDR recommended the monitors be replaced with another type of monitor to confirm the H_2S concentrations. NJDEP and at least one Township official stated verbally that they intend to test/implement another type of monitor. ATSDR has not been provided with any status update on this.

According to information provided by NJDEP, if the system shuts down, it will take several days for any gases beneath the landfill to overcome the current vacuum and build up to a pressure where gases would be released from the landfill surface. This seems reasonable, as ATSDR did not observe a relationship between recorded system shutdowns in the last year and higher H_2S readings in community monitors. Proper operation and maintenance to minimize any unplanned outages will further reduce the chances of gases being released.

PC6-34: "Instead, ATSDR recommends installing monitoring wells at the landfill perimeter and downgradient locations. These wells would be regularly monitored for common landfill contaminants to verify that no harmful substances escape the landfill. ATSDR also recommends regularly monitoring private wells downgradient from the landfill to ensure they remain unaffected by the landfill." Has this been done?

ATSDR Response: Monitoring wells downgradient from the landfill were sampled in April and August 2015. We have evaluated these data in a new section beginning on page 40 of the final report. The Township has offered continued private well testing to local residents.

PC6-35: "ATSDR cannot determine whether unidentified hazardous materials that could exist in the landfill could harm people's health." This is the vast unknown. Scientific integrity would

require testing to evaluate Fenimore for all materials known to exist in landfills. This has not been done.

ATSDR Response: ATSDR recommended groundwater downgradient from the landfill be monitored to detect the release of any landfill contaminants. We are available, upon request, to evaluate any additional data that become available.

PC6-36: "To ATSDR's knowledge, only VOCs, sulfides, and microbial indicators were tested in the private wells; testing for other common landfill contaminants (metals, etc.) would help to confirm that groundwater has not been contaminated by old landfill leachate." What is the status of this recommendation?

ATSDR Response: The Township has offered private well testing to local residents; it is up to the individual well owner to take advantage of this offer or perform their own testing. The Township or private well owners would maintain data on private wells.

PC6-37: Why is this report so incomplete?

ATSDR Response: ATSDR tried to balance the need for providing timely information on health with the limited data available at the time. In this final report, we have updated the H_2S and SO_2 community monitoring data and added evaluation of data from co-located community H_2S monitors, groundwater, and surface water.

PC6-38: Political and un-scientific statements:
"odors were reportedly pervasive." The truth is that odors WERE pervasive. This is an indisputable fact. We are not liars! This is an attempt, just like focusing on the nuisance smell, to minimize the health danger.

ATSDR Response: We have reworded the statement to read "Offensive, pervasive odors were reported in summer and fall 2013." ATSDR does not doubt that odors were pervasive in the area.

PC6-39: "Short-lived" effects of hydrogen sulfide. This is very misleading. They are not "short-lived" if the person dies from respiratory problems, where poisoning from hydrogen sulfide was the straw that broke the camel's back. Every death certificate must have a cause of death associated with it. It is often impossible to be accurate in determining the cause of death. If hydrogen sulfide is the last straw in the list of health issues leading to death, it is extremely unlikely that hydrogen sulfide would be listed as the reason for death. However, if the person had not been exposed to hydrogen sulfide, they might well not have died following exposure to the toxic gas. This is precisely why the material producing hydrogen sulfide at Fenimore must be removed. We should not be prepared to take this risk with our public health.

ATSDR Response: ATSDR agrees that some people are more sensitive than others to chemicals' toxic effects. ATSDR's evaluations are designed to be protective of the health of the entire public, including sensitive people. The highest concentrations of H_2S measured in community monitoring at Fenimore were not high enough to cause irreversible health effects. With the

current treatment system operating, the concentrations of H_2S are currently very low and not likely to cause any harmful effects.

PC6-40: "Some people are more sensitive to odors than others, but almost anyone in the nearby community who could smell the H_2S could have experienced general odor-related symptoms, These symptoms have been reported as the body's reaction to the odor rather than chemical irritant properties of a specific pollutant and could include eye, nose, and throat irritation; nausea; and headaches. Symptoms from odors could persist longer or aggravate existing medical conditions in sensitive groups (such as people with respiratory conditions like asthma, the very young, or the very old)." A scientific report would read: Some people are more sensitive to toxic hydrogen sulfide than others, but almost anyone in the nearby community who could smell the H_2S could have experienced general toxic gas related symptoms. These symptoms include neurological disorders, eye, nose, and throat irritation; nausea; and headaches. Symptoms from exposure to hydrogen sulfide could persist longer or aggravate existing medical conditions in sensitive groups (such as people with respiratory conditions like asthma, the very young, or the very old).

ATSDR Response: According to the toxicological literature on H_2S and odors, the levels of H_2S in the community could have caused short term harmful effects in sensitive people such as those with pre-existing respiratory conditions, etc. The general public's response to the levels of H_2S measured would be a negative response to the offensive odor rather than a toxicological response. ATSDR is concerned about preventing harmful health effects from any exposure, be it toxicological or odor-related.

PC6-41: "After the gas extraction system was installed to remove landfill gases, short term concentrations of H_2S were greatly reduced and are much less likely to cause harmful health effects." This is an extremely vague statement and is not a scientific one. The collection system is designed to capture an unknown percentage of the hydrogen sulfide from areas where the material that produces the gas were initially dumped. It is a well-known fact that hydrogen sulfide gas can travel laterally and this gas would not be collected by the Fenimore gas collection system. Methane gas is known to be a gas emitted by Fenimore. The very limited area of hydrogen sulfide gas collection would have very little impact on methane gas collection at Fenimore. We simply do not know how many other toxic gases are generated and emitted at Fenimore.

ATSDR Response: ATSDR's statement is supported by the specific data on H_2S as presented in Tables 4-6. The gas extraction system's operation creates a vacuum in the subsurface that will draw gases from the surrounding area, so the gases don't move offsite. The gas extraction system was designed to draw gases from the entire C&D portion of the landfill and covers all areas where high methane readings were detected in previous monitoring. The previous monitoring showed only trace levels of methane in other areas of the old landfill, as shown in Figures 9 and 10 of the report.

PC6-42: "More monitors were set up to characterize the releases into the community." No. Not "characterize", "quantify". A scientific report would not use the word "characterize." A political report would.

ATSDR Response: The monitors were set up to not only quantify the concentration of H_2S, but to observe how the H_2S traveled to multiple areas in the community.

PC6-43: "Communities such as Mount Arlington, Netcong, and Budd Lake are less likely to be affected because higher land blocks airflow and prevailing winds do not blow toward the north and west." What about the areas that are more likely to be affected? This is part of the non-scientific, political under-stating of the health hazards. If health was the object of interest, why does this statement "accentuate the positive", rather than address the danger?

ATSDR Response: Because of the fact that air from the landfill is unable to reach these communities, they would not be affected to the extent that other areas would. The report's conclusions and recommendations apply to the communities that are more likely to be affected.

PC6-44: Cavalier response: "Therefore, exposure to any other compounds is not expected to cause any ongoing or future harmful effects as long as the extraction and treatment system is operating properly." We cannot know this unless we begin to test thoroughly for "any other compounds."

ATSDR Response: ATSDR recognizes that there is distrust in the community. In this report we evaluated data available on other compounds possibly released from the landfill. Other combustible gases would be extracted and destroyed, along with H_2S and methane, in the gas extraction and treatment system. ATSDR is an advisory agency and can recommend but cannot require further testing. We are available, upon request, to evaluate any additional data that becomes available and to update our conclusions based on newly acquired data, if necessary.

PC6-45: Here are some of my issues from having read this report:
We must identify those who are vulnerable and monitor their health. The generic problem with a reducing gas such as hydrogen sulfide is that it is the opposite of oxygen. It "sucks life out of human beings", whereas oxygen puts life into human beings*.
*Otto Warberg received the Nobel Prize for discovering that cancer cannot exist in a cell which is electrically neutral. Simply put, adequate oxygen, adequate breathing helps stop cancer. Hydrogen sulfide renders cells vulnerable to cancer.

ATSDR Response: People who feel they have been affected by this issue should speak to their personal physicians or health care providers. Upon request, ATSDR can facilitate a consultation between residents' personal physicians and medical specialists in environmental health.

PC6-46: The issue is not whether or not symptoms were experienced, it is whether or not exposure to hydrogen sulfide caused medical damage, with or without symptoms.

ATSDR Response: The H_2S concentrations in the community were below those shown to cause permanent harmful health effects. H_2S is not known to cause delayed effects.

PC6-47: The report makes a significant number of recommendations in the body of the report that are excluded from the recommendations summarized at the end of the report. Why?

ATSDR Response: ATSDR summarized its recommendations for the executive summary and recommendations sections.

PC6-48: Why has the leachate pond not been tested?

ATSDR Response: The leachate pond was tested by NJDEP in 2013. ATSDR did not evaluate the results in the public comment health consultation to focus on air and drinking water issues that were expressed as the most important concerns of the community. In this final report, ATSDR evaluated 2015 sampling data from monitoring wells at the downgradient edge of the landfill. These data included analysis for a wider range of contaminants than the limited leachate pond testing. The results from monitoring wells were consistent with the limited results from the leachate pond.

PC6-49: Cancer
The report confirms the existence of cancer producing materials in Fenimore. We know that cancer is not just the result of one poison, but a cumulative result of many poisons. The report twists the truth by claiming, for example, that hydrogen sulfide is not known to cause cancer, and that Fenimore does not give them cause for alarm. This denial of the truth is prevalent throughout the report and is its most distinctive message, and is wrong.

ATSDR Response: The levels of cancer-causing substances (benzene, formaldehyde, and trichloroethylene) found in limited ambient sampling near the landfill could contribute to the risk of cancer, as discussed in the report on page 31. However, the levels were similar to typical ambient concentrations, so the estimated increased risk from these compounds is likely similar to other places. Hydrogen sulfide exposure is not known to cause cancer.

The exposures occurring from Fenimore Landfill were of concern to ATSDR because they could cause harmful noncancer health effects in community members. The mitigation actions and gas extraction and treatment system have reduced the exposures to levels that are not harmful. Vigilance in monitoring and maintenance to ensure these fixes remain protective is essential for making sure exposures do not become a problem again.

Comments from a private citizen (PC7):

PC7-1: We need more frequent water test and NEW and improved water test equipment... Many area landfills tested there waters and there programs failed. Many area residents found out to late. DEP and EPA had to spend millions of dollars 15 to 20 years later... I say SPEND it now and take this out. It was not here and NOW it is.

ATSDR Response: ATSDR is an advisory agency. ATSDR does not have authority to specify what actions are taken by regulatory agencies to mitigate harmful exposures.

PC7-2: We need to have all request for core testing and stack testing taken and reported. We deserve to have clean air to breathe. SO_2 is NOT our only problem here.

ATSDR Response: ATSDR recommends groundwater monitoring to detect any contaminants that might be released into groundwater. NJDEP provided ATSDR with stack testing data in January 2016. We evaluated these data in this final version of the report.

PC7-3: We need new monitors. The equipment on site [is] not sufficient and have given false readings.

ATSDR Response: ATSDR recommended the community monitors be replaced with another type of monitor to confirm the H_2S concentrations. NJDEP and at least one Township official stated verbally that they intend to test/implement another type of monitor. ATSDR has not been provided with any status update on this.

PC7-4: We are dealing with many new odors and this is becoming a daily exposure as work is done on the landfill.

ATSDR Response: ATSDR cannot speculate on the identity or source of new odors. NJDEP informed ATSDR in September 2015 that they are investigating all new odor complaints. ATSDR recommends that NJDEP continue to investigate new odor complaints from the community and address offensive odors to the extent possible.

PC7-5: The landfill equipment has had many breakdowns and repairs

ATSDR Response: According to information provided by NJDEP, if the system shuts down, it will take several days for any gases beneath the landfill to overcome the current vacuum and build up to a pressure where gases would be released from the landfill surface. This seems reasonable, as ATSDR did not observe a relationship between recorded system shutdowns in the last year and higher H_2S readings in community monitors. Proper operation and maintenance to minimize any unplanned outages will further reduce the chances of gases being released.

PC7-6: We need to review the system of water waste treatment procedures at the landfill. (toxic) Trucks and water removal questions [related to the] scrubber. This is a toxic area so we need to update you.

ATSDR Response: ATSDR is available to discuss further concerns or questions raised by the community.

PC7-7: We need to truck this fill OUT of Roxbury. Money should NOT be the reason why this cannot be done. This was trucked in here to our town. It can be trucked out.

ATSDR Response: ATSDR is an advisory agency. ATSDR does not have authority to specify what actions are taken by regulatory agencies to mitigate harmful exposures.

PC7-8: We need to have town post all reports on their websites. ATSDR reports as well. This community has to have all [the] updates on problems and issues.

ATSDR Response: The final version of the health consultation will be available on ATSDR's web site. ATSDR will request the Township post the final health consultation (or a link to it on ATSDR's web site) when we release it.

PC7-9: We need support to have the entire landfill reviewed as the only response to our call for clean up from the DEP dumping was [response to] odors [and] SO_2.

ATSDR Response: We recognize that the NJDEP's Site Remediation Program responding at the landfill was limited in scope to the area receiving C&D waste. However, the landfill owner submitted closure plans for the entire landfill in 2011 to the NJDEP, and approval was granted by the Bureau of Landfill and Hazardous Waste Permitting in the Solid and Hazardous Waste Management Program in November 2011. We recommend this group, or another group within NJDEP with authority over landfill closure issues, enforce requirements for the owner to monitor the landfill and assess the quality and implications of said monitoring.

PC7-10: WE still have the contaminated material.

ATSDR Response: We recognize that this situation was not anticipated or deserved by the community. ATSDR's goal is to prevent or reduce exposures that could harm a community's health. ATSDR's evaluation of exposures found that the gas extraction and treatment system is preventing harmful releases of landfill gases.

PC7-11: NO ONE has addressed the old landfill. It is there feet from the 2nd dumping from DEP.

ATSDR Response: The site was assessed in the late 1980s and did not score sufficiently high to warrant listing on the National Priorities List (Superfund) [65].[7] A 2005 Immediate Environmental Concern Assessment showed no need for immediate action [52].[8] ATSDR recommends that groundwater at the landfill perimeter or downgradient locations, and private wells downgradient from the landfill, be monitored regularly for common landfill contaminants to verify that no harmful substances escape the landfill.

Comments from a private citizen (PC8):

PC8-1: "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

[7] H2M Group. Background Investigation Report, Fenimore Sanitary Landfill, Roxbury Township, Morris County, New Jersey, Facility No. 1436A. Prepared for New Jersey Department of Environmental Protection, Bureau of Site Management. Totowa (NJ): June 2001.
[8] Louis Berger Group, Inc. and Sadat Associates, Inc. Immediate Environmental Concern Assessment Report, Fenimore Sanitary Landfill, Morris County, New Jersey. Trenton (NJ): November 2005.

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."

Your above description of a health consultation would lead someone to believe that your agency does the things that our group, REACT Roxbury, contacted you to investigate. That would include data withheld by the NJDEP and the NJDOH, relating to the recontamination of the former Fenimore landfill. REACT Vice President Bill Morrocco, initially contacted you to begin an investigation of the NJDEP handling of the Fenimore Landfill. The Township of Roxbury belatedly jumped on board only to save face for failing to do so first. We, the concerned citizenry of Roxbury, believe that the Official Leadership of Roxbury has been complicit in undermining the health and well being of our community by having advance knowledge of the landfill being reopened to deposit more than a million cubic feet of contaminated material coming from areas of concern but ignored the common sense solution, to just say no to the project, and to use whatever legal steps necessary to insure the residents would not be subjected to the risky contaminated material that was to be brought into the township, All of the damage done to our health and well-being, not to mention the toll this horrible blight has done to the property values of everyone on or near the Ledgewood section or the Mountain section, was unnecessary and it was allowed to happen to please Chris Christie and his attempt to have someone else pay for the landfill clean up that is his responsibility to pay. He used the money dedicated to landfill clean up in the general fund and put together this scheme to advance his brother's and his Lieutenant Governor's investment in solar power.

ATSDR Response: The evaluation ATSDR performs looks at community members' exposures to environmental contaminants to determine if any adverse health effects would be possible and makes recommendations to reduce harmful exposures and protect public health. ATSDR does not have authority to investigate or comment on legal aspects of the responsibility for or source of the contamination.

PC8-2: Poet's Peak lived through the unbearable stench for one full year, as did everyone else in Ledgewood. Now those houses are selling at a loss, but they have been selling, because unlike my section, Lookout Mountain, they do not have to look at the landfill sitting at the bottom of their street. Nothing has sold in my development because the landfill hits you right in the face as soon as you crest the hill. You can't get in or out of my development without looking into the landfill. Even if it were not a dangerous site, it would still be a blight on the neighborhood and it would bring down my property values by half. We paid [a large amount] for our house in August, 2009. Were it not for the landfill, our house would have been worth at least [20% more] today. Instead, if we could sell it, it would only get [less than half of what we paid] because of the landfill being 1200 feet away and visible every time you crest the hill on my street.

ATSDR Response: We are sorry this happened to your community and recognize the stress it has put many people under. ATSDR's mission is to prevent any further harmful exposures to the extent our advisory capacity allows and to provide the best scientific information on the health effects of past exposures to the community.

PC8-3: Image your anguish over being robbed of your health and your property because of an unscrupulous governor and township council and its attorney, who has an obvious conflict of interest by serving as the Township Attorney while also serving as the State Assemblyman for our district and having a father who is our State Senator. While both he and his father, together and apart, are always photographed hugging the governor, he continuously told the residents that he can't get a meeting with or a return phone call or email from him.

ATSDR Response: Your comment is noted. ATSDR does not have authority to investigate or comment on legal aspects of the responsibility for or source of the contamination. .

PC8-5: Now our federal government ray of hope, the ATSDR, has spent a full year to come up with this sham investigation result. If your idea of an investigation into the unpublished and secret dealings of State Government Agencies is to simply use the published and available data that was handed to you by the agencies that we asked you to investigate, then you are a waste of taxpayers' money, and should find real jobs in the private sector. The REACT group worked tirelessly to get some of the information through OPRA requests that we delivered to you. We were informed that the report would take 6 months to a year to be published. What we were not made aware of was the fact that the report would imply that it was studied and finished. Instead, the report's conclusion is published in the newspapers before the stakeholders, the residents, were given a copy. The whole process is deceptive and bass ackwards.

ATSDR Response: The evaluation ATSDR performs looks at community members' exposure to contaminants to determine if any adverse health effects would be possible and makes recommendations to reduce harmful exposures and protect public health. We have no authority to investigate other agencies' actions beyond public health implications. In the report, ATSDR used data provided by NJDEP and NJDOH, data in the OPRA request provided by REACT, data collected by REACT, and data provided by the Township of Roxbury. ATSDR issued the press release announcing the public comment release at the same time the report was posted to the ATSDR web site and sent to the community email list, Township, REACT, and other stakeholders. As with most sites ATSDR works on, we provided telephone briefings and courtesy copies of the report the day before the release to NJDEP, NJDOH, and EPA. These agencies did not have any input into ATSDR's findings, and they were requested to not share the report before the official release.

PC8-6: You denied the residents the opportunity to share with you our medical records, doctors' letters, or any kind of proof as to the deterioration of our health once we were subjected to the landfill. The yearlong stench was definitely an ordeal that no citizen of the USA should have had to endure. Not only did it make people throw up but in many cases it was a 24/7 ordeal. The workers at Macy's had to go to the bathroom to throw up during their work day. Imagine living in that environment and while paying full property taxes for the duration. What we received from the Township and the State agencies was complete indifference, pretense of disbelief, and aggravation. The NJDOP never got involved with us at all. Nor did the Township BOH bother to make any contact with any of us, individually or as a group.

ATSDR Response: ATSDR's evaluation found that the exposures to H_2S or odors were high enough to cause harmful health effects and that actions to reduce exposures were needed. ATSDR did not need people's medical information to prove those health effects are actually occurring to make its recommendations. People who have experienced health effects should talk to their doctors or medical providers for personal advice.

PC8-7: Like the township and state agencies, you did nothing to arrange independent tests from reputable medical agencies or hospitals. I contacted Senator Menendez Health Advisor, Magda Schaler Haynes, who recommended that we contact Rutgers Robert Wood Johnson to take advantage of their environmental medicine department. We told her that those of us that went there didn't even have our temperature taken and were sent home with the information to move away from the landfill. All of us would do so were it not financially impossible to do so. There are residents who are native Roxburians, whose families have lived here for generations, who would find leaving the township a heartbreaking loss of identity but would do so if the State would be forced to buy out the contaminated community with fair market value of the properties before the landfill debacle.

ATSDR Response: ATSDR does not provide individual medical testing or treatment. Our recommendations to reduce harmful exposures are based on a general assessment of exposures occurring at the site and whether exposures are high enough to cause harm. Exposures to H_2S from the landfill were high enough to result in harmful effects. Now, mitigation actions have reduced exposures to levels that are not harmful.

PC8-8: The Township Council and Attorney allowed this all to happen to impress the bully governor, Chris Christie. We have all seen the corrupt hold that Christie has had on the State, even including the Democratic Senate and the Democratic Mayors, and as was demonstrated by the honest Mayors of Hoboken and of Fort Lee. Intimidation and promises of denied State funds were threatened to insure compliance to the governor's demands were met. Thus, the closure of crucial entrance lanes on the George Washington Bridge to punish the Mayor of Fort Lee for non-compliance to the governor's demands occurred. Hoboken, which was inundated with flood water that ruined even the transit systems there, was given an allotment for damages, in the same numbers as Roxbury Twp. was given. There was plenty of damage in Roxbury Twp. but Hoboken sits on the river, so, of course, their flooding was major but because the Mayor had refused to help Christie spot zone a plot in the middle of a block to one of his many fat-cat donors, the Rockefeller Group, Hoboken got the same State allocated storm damage money as an inland township. Revenge for the intimidation and publicity generated by the Bridge scandal. As to the Fenimore Landfill scandal, the governor cut all red tape to have this boondoggle rushed through the fake process, even going so far as to appoint the Mayor of Roxbury to the Head of the Highlands Commission to insure that the passage of the exception would be without question. When the project blew up in their faces and members of REACT questioned the Governor at two Town Hall meetings, he blamed the Township council and past councils for improprieties that they committed years ago in allowing residential housing to be built around an unclosed and uncapped landfill. Christie is a bully and a squealer, the worst of both worlds.

ATSDR Response: Your comment is noted. The evaluation ATSDR performs looks at exposure to determine if any adverse health effects would be possible and makes recommendations to reduce

harmful exposures and protect public health. Our evaluation process is based on exposure assessment and toxicological science. We attempt to do an objective evaluation without regard for political issues.

PC8-9: I am writing this account at the last minute without bothering to reread the report that you presented because it was meaningless to the residents health and well being. It was pretty much a whitewash of the harm, past, present and future, that has and will continue to befall the innocent residents of Mooney Mountain, Ledgewood, Roxbury Township, Morris County, New Jersey.

ATSDR Response: Thank you for sharing your opinion. We did not intend to minimize the stress this incident has caused local residents.

Greetings,

You are receiving a document from the Agency for Toxic Substances and Disease Registry (ATSDR). We are very interested in your opinions about the document you received. We ask that you please take a moment now to complete the following ten question survey. You can access the survey by clicking on the link below.

Completing the survey should take less than 5 minutes of your time. If possible, please provide your responses within the next two weeks. All information that you provide will remain confidential.

The responses to the survey will help ATSDR determine if we are providing useful and meaningful information to you. ATSDR greatly appreciates your assistance as it is vital to our ability to provide optimal public health information.

https://www.surveymonkey.com/r/ATSDRDocumentSatisfaction

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