Health Consultation

Methane Gas & Vapor Intrusion Concerns

BANK AVENUE LANDFILL SITE

ST. BERNARD, HAMILTON COUNTY, OHIO

Prepared by
Ohio Department of Health

JUNE 23, 2010

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

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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HEALTH CONSULTATION

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SUMMARY

Introduction

The Health Assessment Section (HAS) within the Ohio Department of Health (ODH), in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR), seeks to assist the community of St. Bernard, Ohio by providing the best information possible to safeguard its health from contact with hazardous chemicals.

Methane vapor levels continue to be measured above the lower explosive limit (LEL) near the northern boundary of the closed St. Bernard Landfill. Volatile organic compounds (VOCs) have also been identified in the landfill gas. The U.S. EPA, following up on requests from the Ohio EPA and ODH, conducted sampling to determine whether VOCs and methane are impacting nearby homes. This health consultation represents HAS's and ATSDR's evaluation of landfill gas sample results collected by U.S. EPA from homes near the former St. Bernard Landfill.

Conclusion 1

HAS concludes that the levels of methane and volatile organic compounds (VOCs) found in and under Bank Avenue homes at the Bank Avenue Landfill site are not expected to harm people's health at this time. The reason for this is that methane gas and VOC levels are below levels of health concern.

Basis for decision

The sub-slabs of six homes and the crawl spaces of two homes on Bank Avenue were sampled by the U.S EPA in December 2009 and February 2010. The chemicals of concern were detected at very low levels or not detected at all in residents' sub-slabs and crawl spaces and none were at levels above recommended health-based screening levels. The indoor air of one home that showed an increase in sub-slab VOC levels was sampled in March 2010, and the results did not show VOCs in the indoor air at levels of health concern. Based on sampling conducted by U.S. EPA in December 2009 and February 2010, HAS finds that the VOC and methane levels currently found in these homes are below levels known to result in non-cancer harmful health effects. Also, HAS does not consider the VOC levels found in these homes to present an elevated cancer risk. Trichloroethylene (TCE) and 1,2,4-trimethylbenzene were detected at levels just below sub-slab screening levels in one home. In another home, trimethylbenzene was detected in the subslab and also in the indoor air at levels just below the indoor air screening level.

Next steps

The migration of landfill gas into residences near the edge of the former landfill needs to be further delineated and monitored. Improved and continual operation of a more extensive and effective landfill gas extraction system is advised. Due to the detection of non-methane VOCs 1,2,4-trimethylbenzene and TCE at levels just below screening levels, HAS recommends an additional three quarters of sub-slab and indoor air monitoring.

Conclusion 2

HAS concludes that explosive levels of methane at the closed landfill boundary near properties on Bank Avenue could be a public health hazard in the future.

Basis for decision

Combustible gases are migrating from the closed landfill to the property line of homes near or at the landfill boundary on Bank Avenue. Monitoring data indicate explosive levels of methane at various subsurface locations near the property lines of residential yards. Conditions exist for a public health hazard based on migration of combustible gases into nearby residences and the potential for an explosion or fire. In addition, explosive gas alarms within the homes of affected property owners have been triggered on at least five separate occasions since 2005. Methane was not detected under homes and crawl spaces in samples collected by U.S. EPA in December 2009, and follow-up testing in February 2010 did not indicate that a hazard exists at this time. However, future public health hazard concerns exist due to the continued presence of explosive levels of methane at the property line of the landfill.

Next steps

The migration of landfill gas into residences near the edge of the former landfill needs to be mitigated or eliminated using a more extensive and effective landfill gas extraction system. The explosive gas alarms installed in the homes of adjacent properties should undergo periodic preventive maintenance and calibration to ensure the adequate protection of the safety of nearby residents.

For more information

For more information about hazardous substances identified in this report, including health effects, please see HAS chemical fact sheets available on-line at: http://www.odh.ohio.gov *(go to "H" and "Health Assessment Section")* or please see ATSDR ToxFAQs, available at: http://www.atsdr.cdc.gov/toxfaq.html. You may also call HAS at 614-466-1390 for more information on this site.

BACKGROUND AND STATEMENT OF ISSUES

Site Location and Description

The Bank Avenue Landfill Site is a closed waste disposal site located east of Interstate 75 and south of Bank Avenue in St. Bernard, Hamilton County, Ohio (Figure 1). The disposal facility operated from about 1950 through the late 1970s and closed in 1985. There is very little information available with regard to the types of waste disposed, the areal extent of the wastes, and the distribution of wastes within the site. The property is now a grassed over city park. The City of St. Bernard (the City) confirmed in 2008 that nine residences in the Bank Avenue Subdivision were within 200 feet of the presumed limit of buried waste at the closed landfill. An additional 234 occupied structures were reported to be within 1,000 feet of the limits of waste placement at the site.

In 1994, St. Bernard began annual sampling of six explosive gas monitoring probes (probes) at the site and reported methane gas levels above the lower explosive limit (LEL), or 5 percent methane in air, in 1994 and 1995. The City installed eight new probes in 2000 and reported that the LEL for methane was exceeded in six of them. In 2001, the City installed a passive venting system and provided potentially impacted residents at the northern landfill property boundary with explosive gas alarms inside their homes. Later in 2001, St. Bernard installed an active explosive gas extraction system by converting two probes to extraction wells and installing a blower and a vent. Despite these measures and adjustments, methane gas levels remained high in 2002, indicating to the Ohio EPA that explosive levels of the gas continued to move offsite from the facility.

In 2003, Ohio EPA ordered St. Bernard to abate or minimize the formation or migration of explosive gas from the landfill. In 2004, the City stated that one probe, located less than two feet from the property boundary of a private residence, still routinely showed methane concentrations in excess of the 5 percent explosive threshold limit. Other probes located within 50 feet of individual homes on Bank Avenue continued to exceed the lower explosive limit. In December 2004, the City indicated that the data trends suggested that a source of explosive gas was located near or within a residential property on Bank Avenue. The City had converted a number of gas monitoring probes into active extraction wells in its efforts to address the explosive gas levels.

Despite remedial efforts by the City of St. Bernard, explosive levels of methane continue to be detected at the facility property line. In addition, the explosive gas alarms within the homes of adjacent property owners have sounded on at least five separate occasions since 2005. (Some of these episodes were attributed to calibration drift by the City's consultant.) [Ohio EPA 2009a]. In September 2009, Ohio EPA ordered the City to perform additional remedial measures in order to minimize the formation or migration of explosive gas at the landfill and from the landfill to adjacent properties

In addition to methane, non-methane organic compounds (NMOCs) were detected in the landfill gas. Samples taken from passive gas vents from four of five extraction wells near the property boundary in 2001 revealed the presence of NMOCs, including benzene, chlorobenzene, and trichloroethylene (CEC Inc. 2001). Upon learning of this information, the Health Assessment

Section (HAS) was asked in November 2009 to evaluate the sampling data and found that VOC levels in some cases exceeded soil vapor screening levels established for these chemicals by HAS and its cooperative agreement partner, the Agency for Toxic Substances and Disease Registry (ATSDR) at other U.S. EPA-lead vapor intrusion sites in Ohio (Table 1).

Ohio EPA requested U.S. EPA's assistance in sampling sub-slabs for methane and VOCs under the potentially impacted residences immediately adjacent to the former landfill (Ohio EPA 2009b). HAS stated that it would be prudent from a public health perspective to sample sub-slabs for methane and VOCs as soon as possible, given the levels of VOCs in the landfill gas and the geologic conditions, the increasing, often explosive levels of methane gas detected at the property line, and the proximity of the homes to the landfill (HAS 2009a).

Area Geology and Hydrogeology

The underlying geology in the area appears to be a mix of glacial soils at the edge of the Mill Creek valley, including sand and gravel stringers, silts and clays, and, at depth, thicker layers of lake-deposited clays (Walker 1986). Residents obtain their drinking water from the Greater Cincinnati Water Works, the local public water supply.

Impacted Community

The Bank Avenue Landfill site abuts an urban density, residential community of primarily single-family homes. Six homes on the south side of Bank Avenue in St. Bernard, Ohio are on the northern boundary of the closed landfill and are most likely to be impacted by gas migration. The City of St. Bernard installed explosive gas alarms (or combustible gas indicators or methane detectors) at the potentially impacted residences in 2001 (Ohio EPA 2009a). These residences are 1-story, multi-level, and 2-story homes built around 1983 and most have basements. One property on Bank Avenue had gas probes with elevated (explosive) levels of methane within 12 inches of the property line. Nine homes are within 200 feet of landfill waste, and 234 occupied structures have been reported to be within 1,000 feet of waste placement at the former landfill.

DISCUSSION

Exposure Pathways

Vapor Intrusion Pathway

> Vapor intrusion is the movement of gases and volatile chemicals from soil and groundwater into the indoor air of homes and commercial buildings.

Once gases are produced within a landfill, they can move or migrate through pore spaces within the soils and the waste. The natural tendency of landfill gases that are lighter than air, such as methane, is to move upward through the landfill soil and waste to the ground surface. If upward movement is inhibited by cover material, such as compacted clay soils or caps, the gases can migrate horizontally to other areas within the landfill or to areas outside the landfill. Studies indicate that landfill gas can migrate underground up to 1,000 feet or more (ATSDR 2001).

Methane gas is the main chemical of concern, with the health concern being the physical hazard due to the threat of explosion or fire. Explosive levels of methane gas have been detected at the property line of homes in close proximity to the St. Bernard landfill over the course of the past several years (Ohio EPA 2009a). Methane levels detected in landfill gas probes at the property appear to be increasing during this same time period.

Other landfill gases, called non-methane organic compounds (NMOCs), are also common byproducts of landfill waste decomposition. These chemicals may also move through the soil underground and enter homes or utility corridors on or adjacent to the landfill (ATSDR 2001). A number of volatile organic compounds, including benzene, chlorobenzene, and trichloroethylene have been identified in the landfill gas at the boundary of the former St. Bernard Landfill (Table 1).

U.S. EPA Soil-Gas/Indoor Air Investigation

Soil Gas Sampling

In December 2009, the U.S EPA sampled two landfill gas extraction wells and two monitoring probes near the perimeter of the landfill. Samples from the landfill extraction wells showed that the landfill gas source continued to have elevated levels of methane, benzene, chlorobenzene, and trichloroethylene (Table 2). Samples from the two monitoring probes near the perimeter of the site showed no detections of methane and no detections of many of the other chemicals of concern. Benzene, trichloroethylene, tetrachloroethylene, and chlorobenzene were detected in one or more of the monitoring probes; however, levels were far below screening values (Table 2).

Sub-slab and Indoor Air Sampling (Round 1)

The U.S. EPA sampled six sub-slabs and two crawl spaces from Bank Avenue residences in December 2009. The chemicals of concern were either not detected or detected at very low levels under residents' homes. None of the sub-slab samples were at levels above recommended sub-slab screening levels (Table 3A). However, one home on Bank Avenue had a TCE level near the sub-slab screening level (3.8 vs. 4.0 ppb). That home and another home also had 1,2,4-trimethylbenzene levels (7.5 and 7.1 ppb respectively) that were just below the sub-slab screening level of 12 ppb.

The indoor air of the two homes on Bank Avenue with crawl spaces had concentrations of the chemicals of concern below levels of health concern (below indoor air screening levels) or otherwise not detected in (Table 4A).

Sub-slab and Indoor Air Sampling (Round 2)

In February 2010, the U.S. EPA repeated testing of the same Bank Avenue residences under conditions of heavy snow cover. In most cases, the chemicals of concern were not detected. PCE and TCE were detected below screening levels in a few of the sub-slab samples (Table 3B).

Chemicals of concern were not detected in the indoor air (crawl spaces of two homes), except for a detectable amount of toluene in one home (Table 4B).

The U.S. EPA selected two Bank Avenue residences for additional sampling. In one home, most of the VOCs previously detected in the sub-slab in the first and second rounds were not found in the third sample. The sub-slab of the other home showed VOCs at levels higher than the previous two samples. The reason for this increase in VOC levels in this residence as indicated by U.S. EPA may be due to a change in sampling location. The U.S. EPA collected an indoor air sample on March 8, 2010 at that residence to determine VOC levels in the indoor air. The sample results showed a 1,2,4-trimethylbenzene level of 1.1 ppb, which is below the HAS indoor air screening level of 1.2 ppb; and a benzene level of 2.4, which is below the HAS indoor air screening level of 3.0 ppb. 2-butanone, hexane and toluene were found at levels far below the indoor screening levels, and the other chemicals of concern were not detected or below laboratory reporting limits (Table 5).

Chemicals of Concern

Methane

Methane is a colorless, odorless, tasteless gas. It occurs in nature as natural gas and from coal gas and the decay of vegetation and other organic matter. It can be a significant fire and explosion hazard, forming explosive mixtures with air (Sax & Lewis 1987).

Methane is the component of landfill gas that is likely to pose the greatest explosion hazard. Methane is explosive between its lower explosive limit (LEL) of 5 percent methane by volume and its upper explosive limit (UEL) of 15 percent by volume. At these levels (between 5 and 15%), there is a proper ratio of methane to oxygen in air to allow for combustion to occur and an explosion hazard to exist if an ignition source is present. Because concentrations within the landfill are typically at 50 percent or greater, methane is unlikely to explode within the landfill boundaries. As methane migrates out of the landfill, it becomes diluted; allowing the methane gas/oxygen mixture to reach explosive levels (ATSDR 2001).

Samples from the landfill extraction wells showed that the landfill gas source has elevated levels of methane. Samples from two monitoring probes near the perimeter of the site showed no detections of methane. As of this report, methane was not detected in the eight Bank Avenue homes and crawl spaces that are potentially affected by landfill gas vapor intrusion. The exception was a methane level of 0.03% (just above the limit of detection of 0.01% but far below the lower explosive limit of 5 %) in one home in the second round of sampling.

Other Landfill Gases

Other common constituents of landfill gas: ammonia, hydrogen sulfide and non-methane organic compounds (NMOCs) are also flammable but usually are not present at concentrations above their explosive limits. Carbon dioxide is a major component of landfill gas, making up about 40-60 percent by volume. Carbon dioxide is colorless and odorless. HAS is not aware of any concerns due to carbon dioxide within homes at the Bank Avenue Landfill Site.

Non-methane organic compounds (NMOCs)

Non-methane organic compounds (NMOCs) typically make up less than one percent of landfill gas and can be stripped off and carried from waste material by methane, carbon dioxide, and other gases in landfill gas. The health effects of NMOCs are usually considered on a chemical-by-chemical basis, although it is also important to consider the possible effects of a mixture of compounds. Some of the typical NMOCs found in the landfill gas at St. Bernard include benzene, chlorobenzene, cis-1,2-dichloroethylene, hexane, methyl ethyl ketone (MEK), tetrachloroethylene (PCE), toluene, trichloroethylene (TCE), vinyl chloride, and xylenes.
As a first step in assessing potential health effects, HAS compared concentrations of the chemicals previously detected in the landfill gas vents against health-based screening values established for these chemical compounds. Based on the levels previously detected in soil gas at the property line, HAS does not expect that these non-methane volatile compounds will cause short-term (acute) health effects. The screening values presented for this site are based on a hypothetical exposure scenario that assumes a long-term (chronic) exposure of an individual for 24 hours a day, 350 days per year for 30 years. Most of the screening values are derived from the OSWER Subsurface Vapor Intrusion Guidance (U.S. EPA 2002). Screening levels listed for trichloroethylene, perchloroethylene, and vinyl chloride are calculated based on cancer risk at the 10^{-4} risk level. The benzene and toluene levels were derived from ATSDR's more conservative chronic-duration (more than 1 year) inhalation Minimal Risk Levels (MRLs) for these chemicals (HAS 2009b). MRLs are estimates of daily human exposure to a hazardous substance that are not expected to cause harmful (adverse) health effects (excluding cancer) over a specified period of time.

<u>Benzene</u>

Benzene is a colorless liquid with a sweet odor. It evaporates quickly into air and only slightly dissolves in water. It is less dense than water and tends to float on top of the groundwater table. Benzene is highly flammable and comes from both industrial and natural sources. Benzene is a common combustion product and can be found in landfill gas. Benzene is also present in crude oil and gasoline and tobacco smoke. Natural sources of benzene, such as gas emissions from volcanoes and forest fires can contribute to the presence of benzene in the environment. Most people can smell benzene in air at about 60,000 parts per billion (ppb). Benzene in outdoor air typically ranges from 0.02 to 34 ppb. In an EPA Region 5 study in 1999, benzene was found in all indoor and outdoor air samples with average concentrations of 2.25 ppb and 1.13 ppb, respectively. Long-term low-level exposure to benzene can harm the bone marrow, causing a decrease in red blood cells leading to anemia. Excessive exposure to benzene can be harmful to the immune system, increasing the chance for infection. Occupational studies of workers exposed to high levels of benzene in the air indicate that benzene is a known human carcinogen (cancer-causing chemical). Exposure to benzene is associated with the development of leukemia, especially acute myeloid leukemia (AML), a cancer of the blood and bone marrow [ATSDR 2007]. The EPA, the International Agency for Research on Cancer (IARC), and the National Toxicology Program (NTP) list benzene as a human carcinogen. ATSDR has established an MRL of 3 ppb for benzene for chronic (365 days and longer) duration for the inhalation route of

exposure based on immunological effects. A benzene concentration of 3 ppb was used by HAS as a screening level for indoor air, and 30 ppb was used as a screening level for sub-slab soil gas.

As of this report, measurements of benzene under people's homes did not exceed screening values. The results of indoor air samples collected from Bank Avenue homes indicated that levels of benzene in air were near background levels in air and below health-based screening levels.

Trichloroethylene

Trichloroethylene (TCE) is a clear, colorless, nonflammable liquid with a somewhat sweet odor, which readily volatilizes (vaporizes) in air. The primary use of trichloroethylene, a manufactured chlorinated solvent, has been the degreasing of metal parts. Its use has been closely associated with the automotive and metal-fabricating industries from the 1950's through the 1970's. Trichloroethylene is also released to the atmosphere through landfill gas emissions. The compound may occur as either an original contaminant or as a result of the decomposition of tetrachloroethylene, another chlorinated solvent. Very little trichloroethylene breaks down in the soil, and it can pass through the soil and contaminate groundwater. In surface soils, TCE will vaporize faster than many other volatile organic compounds. IARC has classified TCE as: *probably carcinogenic to humans (Group 2A).* Studies of TCE exposure in humans support the conclusion that TCE is a kidney carcinogen (ATSDR 1997). A TCE concentration of 4 ppb was used by HAS as a screening level for residential sub-slab soil gas and 0.4 ppb for indoor air. The screening level is based on an adult residential exposure scenario that assumes exposure of an individual for 24 hours per day for 350 days per year over a period of 30 years.

As of this report, TCE levels were detected in three out of six sub-slab samples - one home on Bank Avenue was very close to the sub-slab screening level (3.8 vs. 4.0 ppb). TCE was not detected in the indoor air of two homes on Bank Avenue with crawl spaces.

Chlorobenzene

Chlorobenzene is a colorless, flammable liquid with an aromatic, almond-like odor. The compound does not occur naturally in the environment. Chlorobenzene is used as a solvent for pesticide formulations, a degreaser for automobile parts, and a chemical intermediate to make other chemicals. It readily evaporates into air and is only moderately soluble in water. It adsorbs moderately to soil and biodegrades rapidly in soil. High concentrations of chlorobenzene affect the brain, liver and kidneys in animals (ATSDR 1990). Chlorobenzene is not classifiable as a human carcinogen (EPA Classification D) due to no human data, inadequate animal data, and predominantly negative genetic toxicity data in bacterial, yeast, and mouse cells. ATSDR has not established an inhalation MRL for chlorobenzene. HAS applied a target concentration of 13 ppb for indoor air and 130 ppb for shallow soil gas as screening values for chlorobenzene, based on OSWER Draft Vapor Intrusion Guidance (U.S. EPA 2002).

In the first round of sampling, chlorobenzene was not detected beneath five out of six homes sampled (sub-slabs). It was detected under one home at slightly above its detection limit;

however the level was far below the screening value. Chlorobenzene was not detected in the indoor air of the homes on Bank Avenue with crawl spaces.

1,2,4-Trimethylbenzene & 1,3,5-Trimethylbenzene

The trimethylbenzene isomers 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene are clear, colorless liquids with a distinctive, aromatic odor. Trimethylbenzenes are released directly to the environment as components of gasoline and as emissions from gasoline-powered vehicles, municipal waste-treatment plants, and coal-fired power plants. Trimethylbenzenes are found in coal tar, occur in some mineral oils, and are formed during the refining of crude oil. The general population may be exposed to trimethylbenzenes by breathing ambient air, particularly in areas with heavy traffic, eating food and drinking water, or dermal exposure to products such as gasoline which contain trimethylbenzenes. For example, 39% of the ambient air samples collected in Washington, DC contained 1,2,4-trimethylbenzene at an average concentration of 0.27 ppb (HSDB 2010).

ATSDR has not established minimal risk levels (MRLs) for 1,2,4- or 1,3,5-trimethylbenzene. ODH used generic screening levels for 1,2,4- and 1,3,5-trimethylbenzene that were established by the U.S. EPA in the OSWER 2002 Subsurface Vapor Intrusion Guidance Manual. These included target indoor air concentrations of 1.2 ppb for both trimethylbenzene isomers based on non-cancer health risks. The sub-slab screening levels were set at the target shallow soil gas concentration of 12 ppb (U.S. EPA 2002). High levels of uncertainty are incorporated into the development of screening values for some chemicals such as 1,2,4-trimethylbenzene. The screening level for trimethylbenzene has a relatively high margin of safety incorporated into it. No information or studies were found on the carcinogenicity of 1,2,4- or 1,3,5-trimethylbenzene.

As of this report, the sub-slab and indoor air sample results from homes along Bank Avenue were below the ODH health-based screening values. In one home, 1,2,4-trimethylbenzene was detected at 11 ppb, which was close to exceeding the sub-slab screening level of 12 ppb in February 2010. A follow-up sample of the indoor air at that home air in March 2010 showed the presence of 1.1 ppb of 1,2,4-trimethylbenzene, close to the indoor air screening level of 1.2 ppb. Given the high margin of safety used to develop the screening values for chemicals like 1,2,4-trimethylbenzene, chronic exposure to low ppb levels of trimethylbenzenes would not be expected to result in adverse health effects.

Community Concerns

On December 10, 2009, U.S. EPA held a meeting with seven impacted residents along Bank Avenue in St. Bernard, Ohio, and included HAS staff. Discussions included the explosive levels of methane at the site boundary and the presence of non-methane VOCs, including known and probable human carcinogens, such as benzene and trichloroethylene, in soil gas in the landfill. ODH HAS discussed the chemicals of concern and their potential to impact the residents' health. The meeting facilitated U.S EPA's efforts to obtain access agreements which would allow them to collect soil gas, sub-slab soil gas, and indoor air samples from these properties. On March 30, 2010 another meeting was held with the impacted residents whose homes were sampled by the U.S. EPA to discuss the results of the U.S. EPA sampling. The U.S. EPA and HAS indicated that

based on sampling, there was no public health threat posed by the soil gas migration from the Bank Avenue Landfill at the current time.

Child Health Issues

Children can be at a greater risk of developing illness due to exposure to hazardous chemicals because of their smaller stature and developing body systems. Children are likely to breathe more air and consume more food and water per body weight than are adults. Children are also likely to have more opportunity to come into contact with environmental pollutants due to being closer to the ground surface and taking part in activities on the ground such as, crawling, sitting, and lying down on the ground.

CONCLUSIONS

1. The levels of methane and volatile organic compounds (VOCs) detected in and under Bank Avenue homes sampled by the U.S. EPA are not likely to harm people's health at the present time. The reason for this is that methane gas and VOCs were either not detected or below levels of health concern. The U.S EPA sampled the sub-slabs or crawl spaces of homes most likely to be affected by landfill gases migrating off of the former St. Bernard Landfill in December 2009 and again in February 2010. The chemicals of concern were either not detected or detected at very low levels. All VOC detections were below the recommended health-based screening levels, although in a few cases sub-slab and indoor air levels were very close to these screening values.

2. Explosive levels of methane in the closed landfill near properties on Bank Avenue in St. Bernard, Ohio could be a public health hazard in the future. Combustible gases are migrating from the closed landfill to the property line of homes near or at the landfill boundary on Bank Avenue. Monitoring data indicate explosive levels of methane at various subsurface locations near the landfill property line abutting nearby residences. Conditions exist for a public health hazard based on migration of combustible gases into nearby residences and the potential for an explosion or fire. Explosive gas alarms within the homes of affected property owners have sounded on at least five separate occasions since 2005. Methane was not detected under homes and crawl spaces in samples collected by U.S. EPA in December 2009, and follow-up testing did not indicate that a hazard currently exists. However, concerns about future health threats exist due to the unpredictable nature of methane vapor generation and migration, plus the close proximity of the residences to gas probes at the property line with the landfill that are recording explosive levels of methane gas.

RECOMMENDATIONS

1. The migration of landfill gas into residences near the edge of the former landfill needs to be further delineated and monitored. HAS supports an additional three quarters of sub-slab and indoor air monitoring at the sampled homes this coming spring, summer and fall in order to obtain four quarters of sampling data.

2. Operation of a more extensive and effective landfill gas extraction system is advised. Current landfill gas control measures in effect at the landfill property line do not appear to be successful in controlling the generation and migration of landfill gas at the property line.

3. The explosive gas alarms installed by the City of St. Bernard in homes of adjacent properties should undergo preventive maintenance and calibration as indicated in Ohio EPA's orders to ensure the protection of public health. Although methane was not detected under homes and crawl spaces in the recent sampling, the future generation and off-site migration of methane is possible.

PUBLIC HEALTH ACTION PLAN

1. The City of St. Bernard will conduct additional residential vapor intrusion sampling in July 2010 and October 2010 with U.S. EPA oversight. The City has already taken samples in April, 2010.

2. The City of St. Bernard submitted a Remedial Action Plan - Landfill Abatement work plan on April 21, 2010. The Landfill Gas Abatement work was initiated in May 2010 and includes: The installation of an enhanced condensate management system, an extension of the current vacuum extraction piping adjacent to residential yards, and the addition of four additional monitoring probes.

3. HAS will review additional data for the Bank Avenue Landfill Site as needed.

PREPARERS OF THE REPORT

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CERTIFICATION

This Public Health Consultation for the Bank Avenue Landfill site (Methane Gas & Vapor Intrusion Concerns) was prepared by the Ohio Department of Health under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement Partner.

Technical Project Officer, CAT, CAPEB, DHAC, ATSDR

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

for Alan Yarbrough

Team Lead, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

TABLES

Table 1. Chemicals Detected in Vent Gas at the St. Bernard Landfill Boundary in 2001

Chemicals of Concern	*Range of Detections (ppb*	*Average (ppb)*	*Frequency of Detections*	*# Above Comparison Value*	*Screening Value (ppb)*[1]
2-Butanone (MEK)	ND – 600	280	3/4	0	3,400
Benzene	ND – 97	24	1/4	1	30
Chlorobenzene	ND – 1,100	280	1/4	1	130
Cis-1,2-Dichloroethylene	ND – 25	10	2/4	0	88
Hexane	ND – 270	120	3/4	0	570
Tetrachloroethylene (PCE)	ND – 57	21	3/4	0	120
Toluene	ND – 35	9	2/4	0	800
Trichloroethylene (TCE)	ND – 6.8	3	2/4	1	4.0
1,2,4-Trimethylbenzene	ND – 5.8	2	1/4	0	12
Vinyl Chloride	ND – 68	28	3/4	0	110

Source: CEC Inc. 2001

ppb – parts per billion
ND – None detected
1 – Sub-slab soil vapor screening level: Most levels are taken from the U.S. EPA OSWER 2002 Vapor Intrusion Guidance manual at the 10^{-4} risk level. Benzene and toluene levels are derived from ATSDR Minimal Risk Levels (MRLs) for these chemicals.

Table 2. Chemicals Detected in the Soil Gas at Bank Avenue Landfill Site in 2009

Chemicals of Concern	*Extraction Well EW8B*	*Extraction Well EW3*	*Monitoring Probe MP8*	*Monitoring Probe MP10*	*Screening Value (ppb)*
2-Butanone (MEK)	0.93	ND (2.0)	ND (2.0)	ND (2.0)	3,400
Benzene	24	120	0.19	ND (1.0)	30
Chlorobenzene	290	2,400	7.6	2	130
Cis-1,2-Dichloroethylene	1.8	9.4	ND (1.0)	ND (1.0)	88
Hexane	58	97	ND (1.0)	ND (1.0)	570
Tetrachloroethylene (PCE)	ND (1.0)	0.8	ND (1.0)	1.6	120
Toluene	5.2	24	ND (1.0)	ND (1.0)	800
Trichloroethylene (TCE)	0.85	10	ND (0.4)	2	4.0
1,2,4-Trimethylbenzene	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	12
1,3,5-Trimethylbenzene	2.6	3.8	ND (1.0)	ND (1.0)	12
Vinyl chloride	5.6	ND (1.0)	ND (1.0)	ND (1.0)	110
% Methane	2.2%	10%	ND (0.01)	ND (0.01)	5%

Source: U.S. EPA 2009

Results reported in ppb (parts per billion), except for % Methane
ND – None detected (Detection Limit)

Table 3A. Chemicals Detected in Sub-slabs of Six Bank Avenue Homes (Round 1)

Chemicals of Concern	*Range of Detections (ppb)*	*Frequency of Detections*	*# Above Screening Value*	*Screening Value (ppb)*
2-Butanone (MEK)	ND – 7.6	3/6	0	3,400
Benzene	ND – 7.3	5/6	0	30
Chlorobenzene	ND – 0.56	1/6	0	130
Cis-1,2-Dichloroethylene	ND – 0.62	1/6	0	88
Hexane	ND – 17	5/6	0	570
Tetrachloroethylene (PCE)	ND – 7.8	3/6	0	120
Toluene	ND – 22	6/6	0	800
Trichloroethylene (TCE)	ND – 3.8	3/6	0	4.0
1,2,4-Trimethylbenzene	ND – 7.5	5/6	0	12
1,3,5-Trimethylbenzene	ND – 2.2	3/6	0	12
Vinyl chloride	ND (1.0)	0/6	0	110
% Methane	ND (0.01%)	0/6	0	5%

Source: U.S. EPA 2009

Results reported in ppb (parts per billion), except for % Methane
ND – None detected (Detection Limit).

Table 3B. Chemicals Detected in Sub-slabs of Six Bank Avenue Homes (Round 2)

Chemicals of Concern	*Range of Detections (ppb)*	*Frequency of Detections*	*# Above Screening Value*	*Screening Value (ppb)*
2-Butanone (MEK)	ND – 21	1/8	0	3,400
Benzene	ND – 8.6	1/8	0	30
Chlorobenzene	ND (1.0)	0/8	0	130
Cis-1,2-Dichloroethylene	ND (1.0)	0/8	0	88
Hexane	ND – 51	1/8	0	570
Tetrachloroethylene (PCE)	ND – 6.8	2/8	0	120
Toluene	ND – 20	2/8	0	800
Trichloroethylene (TCE)	ND – 3.8	3/8	0	4.0
1,2,4-Trimethylbenzene	ND – 11	1/8	0	12
1,3,5-Trimethylbenzene	ND – 2.9	1/8	0	12
Vinyl chloride	ND (1.0)	0/8	0	110
% Methane	ND – 0.03%	1/8	0	5%

Source: U.S. EPA 2009

Results reported in ppb (parts per billion), except for % Methane
ND – None detected (Detection Limit).

Table 4A. Chemicals Detected in Crawl Spaces of Two Bank Avenue Homes (Round 1)

Chemical of Concern	*Sample 1*	*Sample 2*	*Frequency of Detections*	*# Above Screening Value*	*Screening Value[1] (ppb)*
2-Butanone (MEK)	ND (0.5)	ND (0.5)	0/2	0	340
Benzene	0.18	0.65	2/2	0	3
Chlorobenzene	ND (0.5)	ND (0.5)	0/2	0	13
Cis-1,2-Dichloroethylene	ND (0.5)	ND (0.5)	0/2	0	8.8
Hexane	ND (0.5)	1.2	1/2	0	57
Tetrachloroethylene (PCE)	ND (0.5)	ND (0.5)	0/2	0	12
Toluene	0.53	3.3	2/2	0	80
Trichloroethylene (TCE)	ND (0.4)	ND (0.4)	0/2	0	0.4
1,2,4-Trimethylbenzene	0.21	0.36	2/2	0	1.2
1,3,5-Trimethylbenzene	ND (0.5)	ND (0.5)	0/2	0	1.2
Vinyl chloride	ND (0.5)	ND (0.5)	0/2	0	11
% Methane	ND (0.01%)	ND (0.01%)	0/2	0	5%

Source: U.S. EPA 2010

Results reported in ppb (parts per billion), except for % Methane
ND – None detected (Detection Limit)
1 – Indoor air screening level: Most levels are taken from the U.S. EPA OSWER 2002 Vapor Intrusion Guidance manual at the 10^{-4} risk level. Benzene and toluene levels derived from ATSDR Minimal Risk Levels (MRLs) for these chemicals.

Table 4B. Chemicals Detected in Crawl Spaces of Two Bank Avenue Homes (Round 2)

Chemical of Concern	*Sample 1*	*Sample 2*	*Frequency of Detections*	*# Above Screening Value*	*Screening Value[1] (ppb)*
2-Butanone (MEK)	ND (2.0)	ND (2.0)	0/2	0	340
Benzene	ND (1.0)	ND (1.0)	0/2	0	3
Chlorobenzene	ND (1.0)	ND (1.0)	0/2	0	13
Cis-1,2-Dichloroethylene	ND (1.0)	ND (1.0)	0/2	0	8.8
Hexane	ND (1.0)	ND (1.0)	0/2	0	57
Tetrachloroethylene (PCE)	ND (1.0)	ND (1.0)	0/2	0	12
Toluene	ND (1.0)	1.3	1/2	0	80
Trichloroethylene (TCE)	ND (0.4)	ND (0.4)	0/2	0	0.4
1,2,4-Trimethylbenzene	ND (1.0)	ND (1.0)	0/2	0	1.2
1,3,5-Trimethylbenzene	ND (1.0)	ND (1.0)	0/2	0	1.2
Vinyl chloride	ND (1.0)	ND (1.0)	0/2	0	11
% Methane	ND (0.01%)	ND (0.01%)	0/2	0	5%

Source: U.S. EPA 2010

Results reported in ppb (parts per billion), except for % Methane
ND – None detected (Detection Limit)
1 – Indoor air screening level: Most levels are taken from the U.S. EPA OSWER 2002 Vapor Intrusion Guidance manual at the 10^{-4} risk level. Benzene and toluene levels derived from ATSDR Minimal Risk Levels (MRLs) for these chemicals.

Table 5. Chemicals Detected in Indoor Air of One Bank Avenue Home

Chemical of Concern	*Sample 2*	*Screening Value[1] (ppb)*
2-Butanone (MEK)	5.6	340
Benzene	2.4	3
Chlorobenzene	ND (0.085)	13
Cis-1,2-Dichloroethylene	ND (0.076)	8.8
Hexane	2.4	57
Tetrachloroethylene (PCE)	0.25	12
Toluene	6.1	80
Trichloroethylene (TCE)	ND (0.15)	0.4
1,2,4-Trimethylbenzene	1.1	1.2
1,3,5-Trimethylbenzene	0.31	1.2
Vinyl chloride	ND (0.05)	11
% Methane	NA	5%

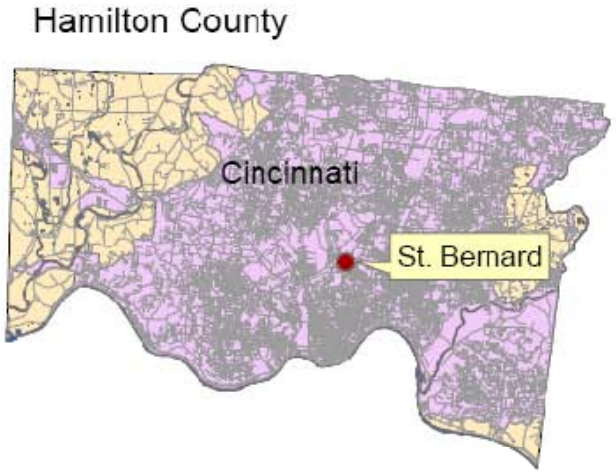
Source: U.S. EPA 2010

Results reported in ppb (parts per billion), except for % Methane
ND – None detected (Detection Limit)
1 – Indoor air screening level: Most levels are taken from the U.S. EPA OSWER 2002 Vapor Intrusion Guidance manual at the 10^{-4} risk level. Benzene and toluene levels derived from ATSDR Minimal Risk Levels (MRLs) for these chemicals.
NA – Not analyzed

FIGURES

Figure 1. Bank Avenue Landfill Site Location Map

Residential area in St. Bernard, Ohio (aerial view).



Appendix A. Fact Sheet

Bureau of Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Landfill Gas

Answers to Frequently Asked Health Questions

Municipal Solid Waste Landfills (MSWLF):

Private homes, business and industry all produce waste. The wastes we create are regulated as either hazardous waste or solid waste. It is the non-hazardous solid wastes that are often sent to a municipal solid waste landfill (MSWLF). Commonly called trash or garbage, the non-hazardous waste accepted at MSWLF include items such as paper products, food items, plastics, metals, glass and household items such as old furniture, appliances and household hazardous wastes. **Note:** For a listing of the common household hazardous wastes that can be taken to your local household hazardous waste collection events, visit the Ohio EPA household hazardous waste web site at: www.epa.ohio.gov/dhwm/recycpro.aspx

Ohio Environmental Protection Agency (OEPA) regulations require Ohio landfills to be designed and operated to prevent contamination from moving into the environment. The landfill design and operation system include a liner and a leachate (landfill water) collection systems. Landfills also monitor for methane gas and have gas collection systems.

What are landfill gases?

Landfill gases are colorless vapors that are produced at solid waste landfills and other waste disposal sites where trash and garbage are buried in the ground and covered with dirt. Over time, the bacteria in the soils will break down (decompose) the organic wastes in the landfill. The by-product of these bacteria breaking down the garbage will produce gases, just as humans produce carbon dioxide gas when we breathe out the oxygen we take in. Volatile organic compound (VOC) gases can also be produced in a landfill when common household chemical products vaporize (turn from a solid or liquid into a gas).

The amount and type of gases created by a landfill depends on the amount of garbage buried in the landfill, the type of garbage buried, the age of the landfill, the size and depth of the landfill and the chemical environment within the landfill.

The gases created in a landfill will try to move through the landfill to reach the surface air. Once in the outdoor air, landfill gases will mix with the air and be carried by the surface winds. Wind speed, wind direction and barometric pressure can affect whether residents will come in contact with these landfill gasses. Because wind speed and wind direction change, the degree of the exposure to odors will be different from day to day. At locations near a landfill, landfill gases tend to be most noticeable in the early morning, when winds tend to be most gentle, providing the least mixing of air and dilution of the gas. Landfill gas production tends to be highest when the weather is hot and dry; it decreases with cooling temperatures or frequent rainfall.

Characteristics of landfill gases:

- Landfill gases try to move from higher pressure areas (areas deep within the landfill) to lower pressure areas (areas such as ground surface and off-site areas)
- Landfill gases easily move through loose sand or gravel soils and will be released to the air through any cracks it can find
- Landfill gases will take the path of least resistance, often following buried utility lines (water, electrical, or gas lines)
- At older, unlined landfills, the landfill cover (cap) will often cause gas to move out sideways under ground from the landfill. **Note:** A landfill cover or cap is usually made of clay or some other rainproof (impermeable) material
- Gases will usually move away from the decaying garbage, but it is difficult to predict the specific directions the gas will follow

What kinds of gases are found in a MSWLF?

Landfill gases are typically made up of hundreds of different types of gases. The main gases produced by a MSWLF are usually methane at 40-65% and carbon dioxide (CO_2) at 40-60%. CO_2 and methane are colorless and odorless gasses. Methane, at certain levels, can be flammable or even explosive and can pose a physical hazard. Since methane is lighter than air, it can pose a physical hazard if trapped in confined spaces of buildings, such as basements and crawl spaces

Other landfill gases are produced by bacteria breaking down organic material and are called reduced sulfur gases or sulfides (examples: hydrogen sulfide (H_2S), dimethyl sulfide and mercaptans). These gases *do* have odors and they give the landfill that familiar "rotting" smell. But hydrogen sulfide (H_2S) and non-methane VOCs make up a much smaller proportion of the landfill gas at less than 1%.

- **Methane** **40-65%**
- **Carbon dioxide (CO_2)** **40-60%**
- **Hydrogen sulfide (H_2S) and non-methane VOCs** **<1%**

How can we detect landfill gas?

Landfill gases are mostly invisible, but they can be detected in the environment by:

- ***Odors:*** Landfill gases commonly contain hydrogen sulfide (H_2S) gas which produces a foul, rotten egg odor. This H_2S odor can be detected at very low levels, levels much lower than those at which this chemical can cause toxic health problems. In contrast, potentially harmful VOCs have a distinctive, sweet, ether-like smell, but you cannot usually smell them in landfill gases because they are present at such low concentrations.
- ***Stressed or dead vegetation:*** Landfill gases will reduce the amount of oxygen in the soils. The lack of oxygen affects deep root growth and often results in the death of deep-rooted plants, especially trees. Soils with high levels of landfill gases will not grow vegetation or the vegetation will be stunted and limited to shallow-rooted plants.
- ***Landfill gas-monitoring probes:*** Landfill gas probes are narrow, hollow tubes inserted in the ground. There are holes in the sides of these tubes that allow gas vapors to flow into the tube. The tubes are then sealed to trap the gas. These sample results can show the type and amount of gas and whether it is at a level that can create a public health threat.

How can landfill gases affect my health and safety?

Under the right set of environmental conditions, landfill gas can be a potential health hazard to residents living close to a landfill. However, a person must be exposed to specific concentrations of chemicals and over a specific period of time before health effects can occur. The two types of health hazards include:

- ***Physical Hazard:*** The methane gas that typically makes up 40-65% of landfill gas is not toxic, but it can ignite and cause an explosion under specific conditions. The specific conditions include the right combination of methane and oxygen, plus a source of ignition (spark-fire). Methane can be explosive at concentrations that range from 5-15% methane per volume of air. At concentrations below 5%, methane levels are too low to ignite. At concentrations above 15%, methane levels are too rich and oxygen levels are too low to combust.
- ***Toxic Chemical Hazard:*** H_2S and VOCs like benzene, perchloroethylene (PCE), trichloroethylene (TCE) and vinyl chloride can be toxic to people if they are inhaled at certain concentrations. If concentrations are high enough, breathing these gases can cause breathing difficulties, nausea (upset stomach), dizziness, headaches and central nervous system problems. Breathing these gases at high concentrations for extended periods of time (years) can cause the development of specific types of cancer and other serious health problems.

How can we reduce landfill gas hazards?

Under state law, landfill owners and operators must monitor (methane) gas levels at their property boundaries and take action to protect occupied structures, such as homes, that are located within 1,000 feet of landfill waste placement (OAC Rule 3745-27-12). Containment and abatement can reduce the possible health hazards due to the movement of landfill gases off-site into nearby properties. Containment simply means to contain the landfill gasses on-site and not allow them to move off-site. Abatement means to remove, subtract from or completely stop the production of landfill gasses.

- ***Containment:*** Ohio landfills are required to contain the landfill waste and gases through impermeable bottom liners and an engineered cap or cover.
- ***Abatement:*** Landfill gas is vented from the interior of the landfill to the outside. This reduces gas pressure within the landfill and limits the ability of the gas to move off-site. Gas abatement can be done passively or actively, through:
  - Simple vents installed at points around the landfill, or
  - A pipe system that pumps the gas from the landfill to a central collection area.
  - The collected gasses can be simply released to the air, burned off in a flare, or collected to be used as a fuel resource (natural gas).

References:

ATSDR. Landfill Gas Primer, An Overview for Environmental Health Professionals. November, 2000.

Georgia Division of Public Health, Environmental Health and Injury Prevention Branch, Chemical Hazards Program. Landfill Gases and Odors. 2000.

U.S. EPA. Municipal Solid Waste web site. www.epa.gov/osw/nonhaz/municipal/msw99.htm Accessed 2009.

For information on Ohio landfills:

Ohio Environmental Protection Agency web site at: www.epa.ohio.gov/dsiwm

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ATSDR AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY