Health Consultation

FORMER CHEVRON REFINERY
(U.S. EPA VAPOR INTRUSION INVESTIGATION)

HOOVEN, HAMILTON COUNTY, OHIO

EPA FACILITY ID: OHD004254132

Prepared by the
Ohio Department of Health

FEBRUARY 18, 2011

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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Agency for Toxic Substances and Disease Registry

FORWARD

The Agency for Toxic Substances and Disease Registry (ATSDR) was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. This law set up a fund to identify and clean up our country's hazardous waste sites. The U.S. Environmental Protection Agency (USEPA) and the individual states conduct or oversee the investigation and cleanup of the sites.

Since 1986, the ATSDR has been required by law to conduct public health assessment activities at each of the sites on the USEPA National Priorities List (NPL). The aim of these evaluations is to find out if people are being exposed to hazardous substances. If people are exposed, the assessment determines whether that exposure is harmful and recommends actions to reduce or eliminate the exposure. Since 1990, the Health Assessment Section (HAS) of the Ohio Department of Health (ODH) has maintained a cooperative agreement with the ATSDR and is tasked with completing the required Public Health Assessments. The HAS program has completed two Health Consultations with regard to the former Chevron Refinery site. The ODH has also completed a Community Cancer Incidence assessment for the Hooven area at the request of the Hooven residents.

Exposure

The HAS program reviews environmental data to determine how much contamination is at the site, where it is, and how people might come into contact with it. This information is provided by the USEPA, the Ohio EPA, other government agencies, businesses, and the public. When there is not enough environmental information available to make an assessment, the health assessment report will indicate what additional sampling is needed.

The route of a contaminant's movement is called the exposure pathway. This has five elements: (1) a source of contamination, (2) transporting environmental media (such as, soil, water, or air), (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. The source is the place where the chemical material was released. The environmental media transports the contaminants from the source to the local environment. The point of exposure is the place where persons come in contact with the contaminated media. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people actually exposed to the chemicals of concern are called the receptor population.

Health Effects

If there are potential or completed exposure pathways where people have or could come into contact with hazardous substances, the HAS evaluates whether these contacts may result in harmful effects. The HAS recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects than adults. Therefore, the health impact to the children is considered a priority when evaluating the health threat to a community.

The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during this evaluation.

The HAS uses existing scientific information, which can include the results of medical, toxicological, and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still evolving and sometimes scientific information on the health effects of certain substances is not available. The HAS identifies those types of information gaps and documents public health actions needed in public health assessment documents.

Conclusions

If appropriate, this report presents conclusions about the public health threat, if any, posed by a site. Any health threats that have been determined for high risk groups (such as children, the elderly, chronically ill people, and people engaging in high risk practices) are summarized in the Conclusions section of the report. Recommendations are presented on how to stop or reduce exposure. The public health action plan describes how those recommendations will be implemented.

The ATSDR is primarily a public health advisory agency, so its reports usually identify what actions are appropriate to be undertaken by federal and/or state EPAs, other responsible parties, or the research or education divisions of the ATSDR. However, if there is an urgent health threat, the ATSDR can issue a public health advisory warning people of the danger. The ATSDR can also authorize health education or pilot studies of health effects, full scale epidemiology studies, exposure registries, surveillance studies or research on specific hazardous substances.

Community

The ATSDR also needs to learn what people in the area know about the site and what concerns they may have about the site's impact on their health. Consequently, throughout the evaluation process, the ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups.

Comments

If, after reading this report, you have questions or comments, we encourage you to send them to us. Letters should be addressed as follows:

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Ohio Department of Health
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SUMMARY

PUBLIC HEALTH EVALUATION OF VAPOR INTRUSION POTENTIAL FOR THE VILLAGE OF HOOVEN, OHIO

U.S. EPA INVESTIGATION 2008-2009

Located 20 miles west of Cincinnati, in Hamilton County, the Former Chevron Refinery, when operational, produced gasoline, diesel, jet fuels, home-heating oils and sulfur. The refinery was immediately east of the Village of Hooven, across OH Route 128. The Village of Cleves is located ½ mile southeast of Hooven and the Former Chevron Refinery site.

In 1985, a report of gasoline seeping into the Great Miami River prompted the former owner, Gulf Oil, to begin a voluntary corrective action with the Ohio EPA. In May of 1993, the new refinery owner, Chevron, entered into an Administrative Order of Consent (AOC) with the U.S. Environmental Protection Agency (USEPA) to perform an environmental assessment and clean-up at the site. Environmental investigations revealed a very large plume of liquid phase hydrocarbons (mostly gasoline) floating on top of the groundwater beneath the facility and extending west, under the village of Hooven.

Chevron's pump and treat systems have treated more than 1 billion gallons of polluted ground water and have recovered 3.5 million gallons liquid-phase petroleum hydrocarbons since 1985 (USEPA, 2007). To control vapor migration, Chevron installed a soil vapor extraction (SVE) system beneath the village in 1999. In May of 2000, Chevron completed a human health risk assessment to estimate the risks posed to residents of Hooven from vapors migrating up from the underlying groundwater plume to the overlying residences. The company's consultants suggested that the groundwater plume that underlies the valley was not likely to impact the health of village residents.

In the fall of 2003, the Hamilton County General Health District (HCGHD) and the concerned community of Hooven asked the HAS to review the available environmental data and determine if the former Chevron refinery site poses a public health threat to the people who live in the Village of Hooven, Ohio. In May of 2004, the ODH HAS produced the first Former Chevron Refinery Public Health Consultation (PHC) for the residents of Hooven. At the time, ODH could not make conclusions about the potential for any public health hazard because critical environmental data were lacking or insufficient.

Prompted by the HAS recommendations made in the first HC, Chevron investigated the concentrations of vapor-phase petroleum chemicals under the village of Hooven, in the sub-slab, near-slab and from the nested vapor wells. The results of this sampling were reported in the *Subsurface Investigation Field Activities Report and Human Health Risk Assessment, Chevron Cincinnati Facility, Hooven, Ohio,* released in October, 2005.

In November of 2005, the HCGHD asked the HAS to update the first PHC and review the new data from the *Subsurface Investigation Field Activities Report*. In November of 2006, following extensive review, the ODH HAS produced the second PHC on the Former Chevron Refinery site for the residents of Hooven. Based on the data supplied to the ODH, it was again determined that no conclusions about the public health hazard could be made because the data supplied did not take into account the seasonal variability in groundwater production and vapor production scenarios, preferred pathways, and the influence of the soil vapor extraction system on the vapor levels under the village. A "worse-case" exposure scenario was not captured by the Chevron field sampling event in 2005 because of the time of the year the sample was collected and the resulting local hydrogeological conditions at the time of the sampling.

Due to concerns expressed by residents of Hooven to their Congressional Representative, the USEPA Emergency Response Branch of the Superfund Division, Ohio EPA, and Ohio Department of Health initiated an independent vapor intrusion investigation in Hooven in March of 2008. Groundwater, soil gas, sub-slab, and indoor air samples were collected periodically from March 2008 through November 2009. The following 2010 PHC evaluates the sample results collected during the USEPA vapor intrusion investigation.

<u>Notes:</u>

- The Village of Hooven residents obtain their drinking water from the Village of Cleves public water supply. The original Cleves well field was at risk for contamination from the site but Chevron paid to relocate the Cleves well field to the Whitewater River Valley, to the west, away from the contaminant plume. The new Cleves well field became operational in 2001. The Cleves public water supply is currently not at risk of being contaminated by the gasoline plume under the Chevron-Hooven site. Vapor Intrusion is the pathway of public health concern with regard to the site and the Village of Hooven.
- At the request of concerned Hooven residents, the Health Assessment Section (HAS) asked Ohio Department of Health's Chronic Disease and Behavioral Epidemiology Section to conduct a community cancer assessment to determine the incidence of cancer in the community. The Chronic Disease and Behavioral Epidemiology Section of the Ohio Department of Health produced a report on December 20, 2006, *Cancer Incidence Among Residents of Hooven, Hamilton County, Ohio, 1996-2003 (ODH, 2006).* This study was updated by the Chronic Disease and Behavioral Epidemiology Section at ODH in a letter to the HCGHD dated May 11, 2010. Cancer incidence in Hooven from 2004 to 2007 was tabulated. The additional cases did not change the results from the initial study.

Conclusion: The levels of vapor-phase petroleum hydrocarbons detected in the indoor air of area residences and the Hooven Elementary School as part of the USEPA quarterly sampling did not pose a public health hazard to residents, students or staff. The HAS concludes that the indoor air of area residences and the Hooven Elementary School is not expected to harm people's health at the current time because the levels of vapor-phase petroleum hydrocarbons detected in the sub-slab soil gas samples, with several isolated exceptions, did not exceed health-based sub-slab screening values.

Basis for Decision:

Indoor air and sub-slab levels from vapor intrusion: The HAS concluded that breathing indoor air contaminated with petroleum hydrocarbons at the levels detected by the USEPA sampling is not expected to harm people's health and currently does not represent a public health hazard. The HAS concluded that sub-slab levels of petroleum hydrocarbons detected in the USEPA sampling in both residential structures and at Hooven Elementary School did not exceed health-based sub-slab screening values (with several isolated exceptions). The levels of contaminants detected by the USEPA sampling are not expected to pose a significant increased risk of developing cancer or developing other adverse health effects among residents and school children. Although the concentrations of site-related contaminants were low, the HAS considers it prudent to reduce or eliminate any exposures to petroleum hydrocarbons in the indoor air.

Next Steps: To protect people:

- The HAS recommends the regular operation of the Horizontal Soil Vapor Extraction (HSVE) system under the village, installation of individual vapor abatement mitigation systems, or installation of some type of system to reduce vapors and levels in the soil gas to concentrations that do not pose an increased risk of health effects to residents. A HSVE or vapor abatement mitigation systems are interim actions to prevent possible exposures and do not address the long-term health threat posed by the contaminated soils and groundwater and the source of contamination.
- Soil gas in the area of Hooven overlying the gasoline plume should continue to be closely monitored to ensure that the operation of the HSVE system remains protective of the village residents.

Conclusion At the east end of the Village of Hooven, in the vicinity of monitoring wells VW-96 and VW-99, lowering the water table through operation of the High-Grade pumping system or during drought conditions will expose the smear zone and can generate significant levels of petroleum hydrocarbon vapors. These vapor concentrations can increase over a short period of time, approximately 4 weeks, in the soil gas beneath homes in the vicinity of monitoring wells VW-96 and VW-99 in the Village of Hooven to levels that can pose a potential health threat to residents via the vapor intrusion pathway.

Basis for Decision:

Vapor intrusion pathway: The HAS concluded that a completed exposure pathway via the vapor intrusion pathway can occur under specific environmental conditions at the Former Chevron Refinery. During the hydrogeologic conditions of a low water table and an exposed smear zone, vapor production will be higher, thus creating a potential for these vapors to make their way from the source to the surface. Although the concentrations of contaminants in the sub-slab and indoor air sampling are low, the HAS considers it prudent to reduce or eliminate this source of exposure to petroleum hydrocarbons. However, the levels detected in the USEPA sampling are not expected to pose to a significant increased risk of developing certain types of cancer or the development of other adverse health effects and do not currently represent a public health hazard.

Next Steps: To protect people, the HAS recommends:

- Operation of the Horizontal Soil Vapor Extraction (HSVE) system, installation of vapor abatement mitigation systems, or installation of some type of system to reduce soil gas vapors to concentrations that do not pose an increased risk of health effects to residents. HSVE or vapor abatement mitigation systems are interim actions to prevent possible exposures and do not address the long-term health threat posed by the contaminated soils and groundwater and the source of contamination.
- New construction in the area should be equipped with a vapor barrier or some type of vapor mitigation system.
- Sub-slab and indoor air levels in occupied structures without vapor barriers or some type of installed vapor mitigation system should be periodically monitored (at least twice a year with one sampling event occurring when the maximum exposure of the smear zone).

For More Information

If you have any concerns about your health, as it relates to exposure to petroleum hydrocarbons, you should contact your health care provider. You can also call the HAS at (614) 466-1390 and request information on the Former Chevron Refinery site.

BACKROUND

Site Location

The Village of Hooven is located twenty miles west of Cincinnati in Whitewater Township in Hamilton County, Ohio. Hooven is just northwest of the junction of US Route 50 and State Route 128. The Great Miami River is east of State Route 128 and north and south of US Route 50 and flows generally from the north to the southwest in the vicinity of Hooven.

In 1931, the Gulf Oil Corporation built an oil refinery on the floodplain between State Route 128 and the Great Miami River and just northeast of the Village of Hooven (Figure 1). Chevron-Texaco Products Company (Chevron) purchased the refinery in 1985 and operated it until it closed in 1986. The major products produced at the refinery were gasoline, jet fuels, diesel fuel, home-heating oils (i.e., kerosene and propane), and sulfur (Chevron Texaco, 2001).

Properties associated with the refinery site include the "Land Farm", the Southwest Quadrant, and the "Islands" (Figure 2). The five-acre Land Farm is located in a wooded area on top of a ridge west of and overlooking the refinery. The Land Farm was the disposal site for some of the refinery's semi-solid waste sludges. The Southwest Quadrant is on the floodplain of the river, just south of the Village of Hooven and was recently developed into a commercial shopping area. This area was also investigated due to potential vapor intrusion concerns. The "Islands" (Islands No. 1 and 2) are in the Great Miami River southeast of the refinery and north of US Route 50. In 1995, a soil vapor extraction (SVE) system began operations on the islands to address hydrocarbon contamination resulting from a series of pipeline spills on Islands No. 1 and 2 discovered in the early 1990's. In 2000, the SVE system was switched to bioventing (allowing vapors to vent to the atmosphere without inducing a vacuum on the soil vapor extraction system).

The main portion of the Former Chevron Refinery site is on the floodplain of the Great Miami River northeast of the Village of Hooven at an elevation of about 500 feet above mean sea level (msl). The Southwest Quadrant is on the same floodplain at an elevation of about 505-515 feet above msl. The nearby Village of Hooven is southwest of the former refinery and north of the Southwest Quadrant. The Village of Hooven's elevation ranges from about 525-545 feet msl, 25 to 45 feet above the level of the former refinery site on the Great Miami River floodplain. The Land Farm area is located northwest of the refinery on top of a nearby bedrock ridge at approximately 680-750 feet above msl.

The Village of Cleves is located on the east side of the Great Miami River and is about half a mile southeast of the Chevron facility and east of the Village of Hooven (Figure 2).

Demographics

The Village of Hooven is one of two unincorporated communities in the Whitewater Township of Hamilton County, Ohio. Whitewater Township has a total area of 26.3 square miles with 0.7 square miles of water. The population density of Whitewater Township is 217.4 people per square mile and, in the 2000 Census, the reported population was 5,564 people (for the cancer incidence assessment report by the ODH, 164 residents were determined to live in the Village of Hooven). Approximately 98 percent of the people in Whitewater Township are white and 2 percent other races. At the time of the 2000 Census, 72 percent of the people were 18 years of age or older, 61 percent were between the ages of 18 and 64, and 11 percent were 65 years of age or older. There was a total of 2,291 housing units with 2,133 households and an average of 2.60 persons per household. At the time of the 2000 Census, 67 percent of the housing units were owner-occupied, 33 percent were rented and 7 percent were vacant (Census, 2000). Also from the 2000 Census, but based on 1999 income, 8.7 percent of the people (of all ages) living in the Whitewater Township area were living with incomes below the poverty level (Census, 2000).

Land Use

The Village of Hooven is primarily a residential community with an elementary school located on the southeast end of the village on Chidlaw Street. The area fronting State Route 128 and US Route 50 is a mixture of commercial and industrial properties, with some agricultural areas west of the village. There are some sand and gravel mining areas along the Great Miami River north of the former refinery and south of the Village of Hooven. Gulf Community Park is the nearest public park located on the east side of the Great Miami River in Cleves, Ohio, and has soccer fields and a BMX track.

SITE HISTORY

Operational History

Gulf Oil Corporation built an oil refinery on the floodplain between State Route 128 and the Great Miami River and just northeast of the Village of Hooven. The refinery began operations in 1931 and the major products produced included gasoline, jet fuels, diesel fuel, home-heating oils (i.e., kerosene and propane), and sulfur. Chevron-Texaco Products Company (Chevron) purchased the refinery in 1985 and operated it until it closed in 1986.

Regulatory History

In 1985, a gasoline sheen was observed in the Greater Miami River, just south of the refinery. Investigations determined that the source of the sheen was seeping petroleum hydrocarbons from gasoline-contaminated groundwater coming from under the refinery. Fourteen groundwater extraction wells were installed and the pumped groundwater was treated to remove petroleum hydrocarbon contaminants.

On May 13, 1993, Chevron signed an Administrative Order of Consent (AOC) with the USEPA to perform a Resource Conservation and Recovery Act (RCRA) Facility Inspection (RFI) to identify the nature and extent of the contamination at the facility. A Corrective Measures Study (CMS) was performed to evaluate the long-term corrective measures necessary to protect human health and the environment. Phase I of the RFI investigated the extent of possible off-site contamination by examining groundwater at the site boundaries. Phase II addressed the groundwater and surface contamination on-site and also included a facility-wide risk assessment. The RFI was completed and approved by USEPA in 2000 (E & E, 2000a).

These investigations revealed a large, 263-acre plume of liquid-phase hydrocarbons (mostly gasoline) floating on top of the groundwater beneath the facility and extending west beneath the eastern portion of the Village of Hooven (E & E, 2000b) (Figure 3). Chevron first estimated that eight million gallons of "light non-aqueous phased liquids" (LNAPL) made up the plume. Subsequent Chevron reports have estimated approximately seven million gallons of gasoline product were floating on the water table. As of June 2004, Chevron had estimated that 3.5 million gallons of LNAPL still remained in subsurface soils and groundwater (USEPA, 2005a). The LNAPL consists primarily of 80% leaded gasoline and 20% diesel fuel (ChevronTexaco, 2003).

REGIONAL HYDROGEOLOGY AND GROUNDWATER RESOURCES

The ancestral Great Miami River cut deep wide valleys into the largely impermeable limestone and shale bedrock in the vicinity of the Former Chevron Refinery site. These bedrock valleys were later filled with outwash sand and gravel from glaciers. This highly permeable outwash material has filled the valley at the Former Chevron Refinery site to a depth of 70 to 120 feet (Durrell, 1961; Ohio Department of Natural Resources (ODNR), Well Logs). Large-diameter groundwater production wells at the Former Chevron Refinery site were drilled into the highly permeable sand and gravel deposits to depths of 80-90 feet and produced up to 2,000 gallons of water per minute (Walker, 1986; ODNR, Well Logs).

Historical Groundwater Contamination in Hooven

Since 1996, petroleum hydrocarbons, primarily constituents of gasoline, have been consistently detected in groundwater beneath the Village of Hooven at levels above the USEPA Maximum Contaminant Levels established for these chemicals in public drinking water supplies. The residents in the Village of Hooven obtain their drinking water from Village of Cleves public drinking water supply. The original Cleves well field was at risk for contamination but Chevron agreed to relocate the Cleves well field to the Whitewater River Valley, to the west, away from the contaminant plume (Figure 2). The new Cleves well field, operational in 2001, is currently not at risk of being contaminated by the gasoline plume under the Former Chevron Refinery site and Village of Hooven.

Natural Resource Use

Almost the entire population of the lower Great Miami River watershed in Southwest Ohio is dependent on groundwater for their drinking water supply (Miami Conservancy District, 2004). Their drinking water supply is obtained from wells in the buried valley sand and gravel aquifer, which the USEPA, in 1988, designated as the Miami Valley Sole Source Aquifer (SSA) system. The Village of Hooven and the Former Chevron Refinery site are located on top of this Sole Source Aquifer.

Evaluations of this buried valley aquifer system also indicate that the groundwater in these porous and permeable sand and gravel deposits is highly vulnerable to contamination from the ground surface (ODNR, Division of Water, 1989). The permeable sand and gravel soils in the area readily facilitate the seepage of chemical contaminants into the groundwater.

No residents of Hooven are known to be currently using private wells for drinking water. Residents in the Village of Hooven obtain their drinking water from Village of Cleves public drinking water supply. The production wells for the Cleves water supply were originally located on the east bank of the Great Miami River about ½ mile south-southeast of the former Former Chevron Refinery (Ohio EPA, 2001; USGS, 1996) (Figure 2).

After discovery of the gasoline contaminated groundwater under the Former Chevron Refinery site, concerns were expressed that contamination from the site might reach the Cleves well field. Monitoring wells were placed at the perimeter of the old Cleves well field in the early 1990's. Production wells and monitoring wells were regularly sampled for gasoline-related Volatile Organic Compounds (VOCs) throughout the latter half of the 1990's. There were detects of low levels of site-related chemicals in some of the outermost monitoring wells in 1994, 1997, and 1998 (Ohio EPA, 2004 personal communication Division of Ground and Drinking Water staff, March, 2004.). However, no site-related contaminants were detected in the Cleves public water supply wells during this time period (Ohio EPA, 2004). In 2000, an agreement was reached between the Village of Cleves and Chevron to relocate the water supply wells to a rural portion of Whitewater Township, west of the Village of Hooven. The new location is separated from the Former Chevron Refinery site groundwater contaminant plume by a 200-foot high, north-south trending bedrock ridge (Figure 2). Also, the new Cleves well field is not located in the same groundwater basin as the old well field and is not at risk of becoming contaminated by the gasoline plume under the Former Chevron Refinery site and the Village of Hooven now or in the future. The new Cleves water supply well field became operational in January, 2001.

Groundwater flow direction

Natural groundwater flow direction is parallel to surface water flow in the Great Miami River, which in the vicinity of Former Chevron Refinery, is to the south and southwest (ChevronTexaco, 2003). However, groundwater flow beneath the Village of Hooven and the Southwest Quadrant is controlled by Chevron's pumping of their extraction/production wells, causing groundwater to flow from the facility boundary and from the Great Miami River towards the extraction wells in the southern and southwestern portions of the Former Chevron Refinery site. Chevron's groundwater pumping has a greater influence on the flow direction when groundwater elevations are low. The extraction/production wells pull water radially into these wells. The groundwater flow is also being influenced by Chevron's recently installed sheet metal barrier wall along the west bank of the Great Miami River at the southwest edge of the refinery property.

Water Table

The depth to the top of the groundwater (the water table) ranges from 15 to 30 feet below the ground surface on the floodplain of the Great Miami River in the vicinity of the Former Chevron Refinery site and the Southwest Quadrant. The Village of Hooven, which sits atop a pile of sand and gravel at an elevation 25 to 45 feet above the level of Great Miami River flood plain and the Former Chevron Refinery site, has a depth to the groundwater surface that ranges from 40 to 60 feet below the ground surface (QST Environmental, 1998).

Water table fluctuations at the Former Chevron Refinery site reflect changes in groundwater levels due to seasonal recharge from precipitation, operation of groundwater production wells, and river level fluctuations. The river and the underlying groundwater aquifer are in direct contact with one another, with groundwater seasonally discharging to the river and at other times, the river water infiltrating into the groundwater. River level fluctuations create the most pronounced and widespread fluctuations in the groundwater surface or "water table" across the site (ChevronTexaco, 2003). Seasonal variations in water table elevation typically range between 2 and 5 feet, but have been up to18 feet as the river stage rises and falls throughout the year (USEPA, 2005a). River flooding has caused changes that have lasted from a week to a month in duration with a difference in elevation between the river and the aquifer ranging from 2 to 9 feet. Flood events have been known to occur at any time of the year but occur most often during the spring (ChevronTexaco, 2003).

When the water table is down, the layer of free product gasoline floating on the top of the groundwater, the light non-aqueous phase liquid (LNAPL), has its greatest thickness. When the water table is high, this layer of gasoline largely disappears. The influence of water table fluctuation on the LNAPL can result in repeated trapping and exposing of LNAPL to soil gas. Drought conditions may lower the water table and expose previously-trapped LNAPL product, greatly increasing the amount of the LNAPL released as a vapor to soil gas. These and other conditions may confound field data and need to be considered in order to determine under what conditions sampling should occur in order to provide a conservative, "worse-case" sampling event (USEPA, 2005b) (Figure 4).

Smear Zone and LNAPL Description

When petroleum hydrocarbons are spilled onto to the ground, they flow between the soil grains and seep downward towards the water table where they are held in the soil by capillary forces. The petroleum hydrocarbons in the gasoline plume are lighter than water and form a layer which floats on the groundwater surface known as light non-aqueous phase liquid (LNAPL). LNAPL continues to release dissolved contaminants to surrounding groundwater for an extended period of time. As the groundwater surface rises and falls seasonally, the LNAPL also rises and falls, creating a contaminant “smear zone” on the soil grains that is difficult to treat (USEPA, 2005a). The smear zone under the Former Chevron Refinery is where gasoline and diesel fuel from the refinery’s plume are adhering to the tiny spaces between the sand and gravel deposits at depth under the village. The highest elevation of the smear zone typically coincides with highest point the water table has risen. At the Former Chevron Refinery site the smear zone is up to 20 ft thick in some places and is estimated to cover an area of approximately 250 acres (ChevronTexaco, 2003). The approximate dimensions of the smear zone are 5,600 ft by 1,370 ft, with an average thickness of about 13 ft.

In the floodplain, the LNAPL “smear zone” extends from 12 to 30 feet bgs, and is present in intermixed gravely silts, fine sands, silty gravels, and small cobbles. At the time of the year when the groundwater is low (typically late summer-fall), most of the smear zone is present above the water table (Figure 4). The free-phase LNAPL layer typically ranges from 0.1 to 0.5 feet thick, but the LNAPL thickness during drought conditions in November 1999 was observed range from 0.1 to over 0.9 feet thick (ChevronTexaco, 2003). Approximately half of the groundwater plume has a layer of free-phase LNAPL with a thickness of greater than 0.5 feet (USEPA, 2005a). When the groundwater table is high (typically in the spring), most of the LNAPL smear zone is submerged and in some cases, no free product layer is present. When the groundwater is above an elevation of 465 feet msl under the Village of Hooven, the smear zone is thought to be below the water table (Civil & Environmental Consultants, Inc., CEC, 2001). The LNAPL was 2.7 feet thick in MW-96 in the northeast corner of the village in October 2007 when the High-Grade pumping was in operation (Chevron, 2009)

EXPOSURE PATHWAYS

For the public to be exposed to site-related contaminants from the Former Chevron Refinery site, they must first come into physical contact with the contaminated soil, sediment, groundwater, or air. The likely exposure route for the Hooven residents is from breathing site-related chemicals in outdoor and/or indoor air. The residential indoor air may have been contaminated by the vapors coming off the buried Former Chevron Refinery groundwater hydrocarbon plume. A **completed exposure pathway** consists of five main parts that must be present for a chemical exposure to occur. These include:

- **A source of chemicals**;
- **A route of environmental transport**, which is a way for the chemical to move away from its source (soil, air, groundwater, surface water);
- **A point of exposure**, which is a place where people come into physical contact with the chemical (on-site, off-site);
- **A route of exposure**, which is how people come into physical contact with the chemical (drinking, eating, touching); and

- **People who could be exposed**, which are people likely to come into physical contact with site-related chemicals.

Physical contact or exposure to a chemical contaminant, in and by itself, does not necessarily result in adverse health effects. A chemical's ability to affect a resident's health is also controlled by a number of factors including:

- How much of the chemical a person is exposed to (the dose).
- How long a person is exposed to the chemical (the duration).
- How often a person is exposed to the chemical (the frequency).
- The toxicity of the chemical of concern (how a chemical affects the body).

Other factors affecting a chemical's likelihood of causing adverse health effects upon contact include the resident's:

1. Past exposure
2. Smoking, drinking alcohol, or taking certain medications
3. Current health status, sensitivity to certain substances
4. Age
5. Family medical history

Past Exposures

The lack of extensive environmental data collected either by Chevron or the environmental protection agencies in the past makes it largely impossible to document past exposures. Chevron collected data from soil vapor wells and groundwater wells before the installation of the HSVE system, but did not collect sub-slab soil gas or indoor air data from residences. The operation of the HSVE system began in 1999 for HSVE #1 and 2001 for HSVE #2 and #3. The operation of the HSVE system for several years greatly reduced the levels of site-related contaminants in the soil gas and likely reduced or eliminated exposure of residents to contaminants during that time period. Sub-slab soil gas and indoor air samples were not collected by Chevron until the Spring of 2005. Unfortunately, at that time, the water table was high and the smear zone was submerged, limiting the levels of vapor phase product in the soils under the village. One of the primary objectives of the current/recently completed USEPA investigation was to provide vapor intrusion data for a "worst case scenario" when the water table was low and the smear zone under the village was fully exposed to the air generating the maximum amount of vapor-phase hydrocarbons from the site under the village (Figure 4).

VAPOR INTRUSION PATHWAY

The 2004 and 2006 HAS Public Health Consultations determined that the primary public health concern presented by the Former Chevron Refinery site in Hooven was the possibility that volatile chemicals associated with the underlying groundwater contamination plume (primarily gasoline) may be vaporizing off of the plume and moving as gases up through the overlying soils and into basements and crawl spaces of homes in Hooven (Figure 5). In the confined indoor air environments of a home, residents could be exposed to these chemicals through inhalation of these gases in the air. This potential exposure pathway is termed the *Vapor Intrusion Pathway* (see Appendix A, *Vapor Intrusion; Answers to Frequently Asked Health Questions,* Fact Sheet).

Gasoline is a mixture of refined hydrocarbon compounds: 150 simple to complex organic chemical compounds associated with crude oil. The "lighter" compounds in gasoline include a number of volatile organic compounds (VOCs); chemicals that are normally liquids but can readily vaporize into a gas when exposed to air. These include chemicals like benzene, toluene, ethylbenzene, xylenes (so-called BTEX compounds), plus naphthalene, trimethylbenzene (TMB total), 2,2,4-trimethylpentane (2,2,4-TMP), n-butane, isopentane, hexane, and methylcyclohexane. Upon being released as a gas to soils, these chemicals can migrate through soils as vapors from areas of high pressure at depth below the ground surface to areas of lower pressure at the ground surface. Vapor-phase hydrocarbons will tend to follow the path of the least resistance, seeking out soils that are more porous and permeable, allowing for the easy movement of the gases up through the soils to the ground surface. Upon reaching the surface, these gases discharge to the atmosphere, mixing with the air which effectively dilutes the concentrations of these chemicals and leading to their breakdown to simpler and less toxic compounds upon exposure to oxygen and sunlight.

However, if these gases migrate into and accumulate in homes and businesses, they undergo less mixing and dilution. Concentrations may remain high enough to pose a health threat to residents and workers if these accumulated gases are inhaled by these individuals. This is particularly true in the winter months when homes are typically closed up tight, trapping the air inside and allowing for little or no free exchange with the outside air. If indoor air concentrations are high enough and/or if people are exposed to these chemicals for a long enough period of time, these vapor-phase hydrocarbons can pose a health threat to people occupying the building. Benzene is a known human cancer-causing chemical through the inhalation route in occupational settings where workers were exposed to the chemical at high concentrations (parts per million range) in the indoor air for a number of years (ATSDR, 1997a). These exposures have been associated with the development of excess incidence of leukemia and other blood disorders in these workers (ATSDR, 2000). The other petroleum compounds pose primarily non-cancer health threats, usually targeting the central nervous system. Exposure to high concentrations of some of these other compounds in the air (several 10's of parts per million range) can result in dizziness, fatigue, sleepiness, headaches, and nausea (ATSDR, 1993). Prolonged exposures to these same high levels can lead to liver and kidney damage and anemia as well. It is unlikely, however, based on recent sampling data collected by Chevron and USEPA, that vapor levels associated with the gasoline plume beneath Hooven will be high enough to result in these acute adverse health effects.

Chevron Subsurface Investigation

The Chevron 2005 subsurface investigation collected samples in March, April, and May when the water table was high and the smear zone was submerged (Figure 4). This subsurface investigation based its conclusions on sampling conducted over the course of only one season and during the season (Spring) that would typically have the least amount of vapor generation from the hydrocarbon plume. Under these conditions, production of vapor phase hydrocarbons would have been limited or non-existent, leading to the reduced levels of these chemicals detected in soil gas under the village.

USEPA Emergency Response Branch 2008 Investigation

At the request of the Hamilton County General Health District (HCGHD), HAS reviewed Chevron's 2005 *Subsurface Investigation Field Activities Report* and produced a second public Health Consultation for the Former Chevron Refinery site. The 2006 Health Consultation concluded that the site posed an Indeterminate Public Health Hazard and that Chevron's data represented conditions in which the smear zone was covered by the groundwater and little vapor-phase hydrocarbons would be generated. HAS recommended that additional data was needed from "worst case scenario" conditions (when the groundwater elevation was below the smear zone and vapor generation was high) in order to assess the public health risk posed by the former Chevron refinery contamination. Hooven citizens expressed concerns regarding the potential vapor intrusion under the village during the drought in 2007 when very low groundwater levels had likely exposed a large portion of the smear zone for most of the summer. The concerned community contacted former Congressional Representative Steven Chabot's office in October 2007. In December 2007, Representative Chabot sent a letter to the USEPA Administrator, forwarding the health concerns of the residents of Hooven. In January 2008, the USEPA Emergency Response Branch (ERB) began their involvement at the *Former Chevron Refinery* site. At a February 26, 2008 public meeting, HAS introduced the USEPA ERB to the residents of Hooven. At this meeting, the HAS explained that worst-case scenario conditions were likely not met during Chevron's 2005 sampling events, as the groundwater elevation was above 463.5 ft and most of the smear zone was not exposed. The HAS and the USEPA asked residents to allow access to residential properties in order to conduct a four-quarter sub-slab soil gas and indoor air sampling investigation. The USEPA conducted an investigation that included sampling in:

- Quarter 1 – April 2008
- Quarter 2 – August 2008
- Quarter 3 – October-November 2008
- Quarter 4 – September 2009 (fourth quarter sampling was triggered when the groundwater elevation dropped below 463 ft)

Contaminant Levels in the groundwater

Groundwater was collected from the five soil probe locations in April 2008 and from four monitoring wells in November 2008 (Table 1 and Figure 7). Benzene, total trimethylbenzenes (TMB), and hexane concentrations exceeded the USEPA (USEPA, 2002) vapor intrusion screening levels for groundwater in one of the samples collected in April. Hexane was also exceeded in two of the other four samples in April. In November, three samples had at least one contaminant of concern that exceeded the screening level. Most samples had two contaminants of concern exceeding the screening levels. In addition to benzene, TMB (total), and hexane, two other contaminants of concern, ethylbenzene and naphthalene, were detected above the screening levels in November. All the contaminants of concern were also detected at high levels in the LNAPL found in on-site monitoring well MW-20S (Table 1).

Contaminant Levels in the soil gas

During the course of the USEPA subsurface vapor investigations, the concentration of the site-related contaminants of concern in vapor well VW-96 increased over time and increased in concentration with depth (See Table 2). Many of the contaminants of concern detected in the well exceeded the screening levels by November 2009, including, 2,2,4-TMP, isopentane, n-butane, and hexane (See Table 2). Some of these contaminant concentrations, such as 2,2,4-TMP, were at least fifteen times higher (up to 97 times higher for isopentane at 40 ft bgs) than the screening levels. 2,2,4-TMP was detected at all depth intervals sampled in VW-96, all the way up to the shallowest depth interval sampled - the 5 ft bgs interval (See Figure 5). These concentrations decreased significantly after the HSVE system under the village was turned back on in October 2009 as indicated by the results of the subsequent three sampling events approximately each a week apart (See Table 2). All concentrations of all the contaminants dropped well below screening levels at the three depths sampled (10 ft, 20 ft, and 30 ft bgs).

In Vapor Well VW-99, the concentration of the contaminants of concern increased over time when the HSVE system was temporarily shut down in 2008 and 2009. Not only did the concentration of contaminants increase with time, the contaminants also increased in concentration with depth. The largest increase in concentrations in VW-99 appears to have occurred when the groundwater elevation in nearby well MW-96 dropped below 463 ft msl. Many contaminants of concern such as, 2,2,4-TMP, n-butane, isopentane, and hexane (See Table 3), exceeded their screening levels by November 2009. Some contaminants, like 2,2,4-TMP, were at least fifteen times higher (up to 75 times higher for isopentane at 40 ft bgs) than the screening levels all the way up to the 20 ft bgs interval (See Table 3 and Figure 5).

There were seven additional soil gas probe sample locations that were each sampled at least twice, in April and August 2008 (See Table 4 and Figure 7). Soil gas locations GP-5 and GP-7 were sampled three times. Each location was sampled at ten-foot depth intervals, however, it was not possible to sample all depth intervals at all the locations. The limitations of the soil gas sampling device prevented more complete sampling at depth. At the GP-7 location, only the 10 ft bgs depth interval was sampled due to the shallow depth to the water table. 2,2,4-TMP was detected above the screening level at GP-7 at the 10 ft interval each time it was sampled (April, August, and September). 2,2,4-TMP was also detected above the screening level at the 47 ft bgs depth interval at the GP-5 location although it was not detected at the 30 ft and 10 ft bgs levels. No other contaminants of concern were detected above screening levels in these soil gas probe samples.

Levels in the sub-slab

Sub-slab samples were collected over four quarters, in April, August, November of 2008 and September of 2009, at twenty-two residential locations, two commercial locations, and at one school (Figure 7). Two contaminants of concern were detected above the screening levels at the commercial sub-slab locations in the Southwest Quadrant; 2,2,4 TMP and isopentane (See Table 5). A few contaminants were detected at levels slightly above the screening levels in the residential sub-slab samples, but were not found in the corresponding groundwater, deep soil gas, or indoor air at the same locality during the same quarter (Table 6). Chloroform was detected at one location in the sub-slab above screening level and naphthalene at another location in the Quarter 1. Chloroform was found above the screening level again in the Quarter 2, but at a different location. Trichloroethylene (TCE) was found at third location in the Quarter 3 above the screening level.

Levels in the indoor air

The USEPA collected indoor air samples during the second quarter, third quarter and fourth quarter of their vapor intrusion investigation over a 24 hour period in the basements at four residential locations (Table 7). No indoor air samples were collected the first quarter. The results from the two residential locations sampled during second quarter indicated three different chemicals above the ODH/ATSDR screening levels for indoor air (Appendix B). Two residential locations were sampled during third quarter and one home was sampled during fourth quarter. None of the contaminants of concern were above indoor air screening levels in the third and fourth quarters.

Hooven Elementary School

One groundwater sample was collected in the area of Hooven Elementary School. The groundwater sample from GP-2, collected in April 2008, detected several contaminants of concern but all concentrations were below screening levels (Table 8). Soil gas samples were collected near the school at GP-2, GP-3, and vapor well VW-128 (Figure 7). GP-2 and GP-3 were sampled in April and August 2008 at approximately the 10 ft, 20 ft, 30 ft and 50 ft bgs depths. The vapor well, VW-128, was sampled in November 2008 and September 2009 at the 10 ft, 20 ft, 30 ft, and 40 ft bgs depth intervals. A few contaminants of concern were detected in the soil gas samples, but all concentrations were below screening levels. No contaminants of concern were detected above the screening levels in the sub-slab samples during the four quarters of sampling. Total trimethylbenzene (TMB) was detected in a single indoor air sample collected in August 2008 at a concentration slightly above screening level. However, it was not detected in the sub-slab sample collected at the same time and could not be attributed to vapor intrusion pathway. Trichlorethylene (TCE) was also detected above the screening level in an indoor air sample collected in September 2009, but was not detected in the sub-slab and also could not be attributed to vapor intrusion pathway. As these exceedances appear to have been isolated one-time events and the screening levels they were compared to are based on a lifetime exposure scenario, they posed no health threat to school students or staff.

During USEPA's investigation, some sealed pipes in the basement of the school were discovered to contain elevated levels of VOCs. These pipes were feeder pipes supplying heating oil to the school's former heating system from an underground storage tank. This tank had been removed from beneath the parking area in front of the school at an earlier date.

Southwest Quadrant

One groundwater sample was collected from GP-7 in the southwest quadrant (Figures 2 and 7) in April 2008. Low levels of several contaminants of concern were detected, but no contaminants were found above the screening levels. Soil gas samples were collected at GP-7 at 10 ft level in April and August 2008 and September 2009 (Table 5). In each of these soil gas samples, the concentration of 2,2,4-TMP was above the screening level. Sub-slab samples were collected at one commercial location in each of the four quarters. Although TMB (total) was detected, the concentrations were all below the screening levels. No indoor air samples were collected.

DISCUSSION

Fall of 2007 Drought

The residents of Hooven expressed concerns about potential vapor intrusion into their homes and the local elementary school during the drought conditions in the summer and fall of 2007. The already low water table was further lowered by Chevron's High-Grade pumping. The High-Grade pumping exposed more of the smear zone in addition to developing a LNAPL on top of the groundwater. On October 1, 2007, the LNAPL was measured to be 2.7 feet thick in monitoring well MW-96S and 2.25 feet thick in MW-99S. The thickest off-site accumulation of LNAPL from the gasoline plume occurred under the northeast corner of the Village of Hooven (Figure 3). High-Grade pumping began on June 20, 2007 and continued through January 8, 2008. The HSVE system was also operated from July 17 through December 27, 2007 to remove petroleum hydrocarbon soil gas vapors. Typically, only one leg of HSVE is operated at a time. Unfortunately, volatile organic compound analytical data for soil gas, sub-slab soil gas, and indoor air under the Village were not collected during the late summer or fall following this unusual drought period.

USEPA Investigation

In March 2008, the USEPA ERB told Chevron that they would be collecting four quarters of soil gas and indoor air samples in the Hooven area and during that time Chevron was not to operate the HSVE system.

The USEPA ERB collected three quarters of samples in the village by December 2008. During these sampling events, the groundwater was either above the smear zone or only a small portion of the smear zone was exposed. The Hooven area had over 3 inches of precipitation above normal during the 2008 calendar year (NOAA, 2008). Groundwater in the Hooven area is recharged by the precipitation and during the USEPA's first three quarters of sampling, the groundwater elevation remained above the trigger level of 463 ft msl in well MW-96S. This trigger level was established so that at least one sampling event would coincide with the smear zone being exposed and would simulate a "worst case scenario" for vapor production. One of the main objectives of the USEPA investigation was to sample during a "worst case scenario" when the smear zone was exposed. In the Hooven area, the groundwater is typically at its lowest elevation in the fall and recharges in the winter and spring when there is usually more precipitation. As a result, the final quarter of sampling was postponed until September 2009 when the groundwater elevation finally dropped below the trigger level.

In August, 2009 the groundwater elevation was very close to the trigger level. Chevron restarted the High-Grade pumping on August 16th and the groundwater elevation dropped below the trigger level in MW-96. After allowing some time for the smear zone to generate vapors and for the soil gas to reach equilibrium, the USEPA conducted the fourth quarter sampling in mid September 2009 (Figure 4). The HSVE system had been shut down since December 27, 2007. It remained off until Chevron restarted operation on October 16, 2009, approximately 22 months later. Although the HSVE system was not operating when the USEPA collected the four quarters of samples, Chevron was operating the High-Grade pumping for a month prior to the USEPA collecting the last quarter's samples. The High-Grade pumping began on August 16, 2009 and the USEPA collected samples in Hooven from September 14th through September 29th. Although 2,2,4-TMP, isopentane, and n-butane were significantly above screening levels at the 10 ft depth interval, the concentrations were significantly below screening levels in these samples collected following a week of HSVE operation (compare Figures 5 and 6). Only the concentrations of 2,2,4-TMP at the 20 ft and 30 ft depth intervals remained above screening levels on October 23rd. All the contaminants of concern were below screening levels at all depth intervals, 10 ft, 20 ft, and 30 ft, in the samples collected on October 30th and November 9th (Tables 2 and 3).

Evidence of a Completed Exposure Pathway

Numerous contaminants of concern, all components of the gasoline plume, including, 2,2,4-TMP, isopentane, n-butane, and hexane, were detected at elevated levels and well above the soil gas screening levels at depths all the way to the surface in vapor wells VW-96 and VW-99 in September 2009 (Figure 5 and Tables 2 and 3). However, levels were significantly reduced when the HSVE system was restarted and the vapor monitoring wells were re-sampled again one week later. The concentration of 2,2,4-TMP at the 10 ft bgs depth interval in VW-96 dropped from 160,000 ppb to 23 ppb. All the contaminants of concern had similar reductions in concentrations at all the depth intervals sampled (10 ft, 20 ft, 30 ft and 40 ft bgs) within three weeks of the HSVE restarting operations (Figure 6).

Many of these same contaminants of concern, 2,2,4-TMP, isopentane, n-Butane, and hexane, were also detected at concentrations below screening levels in the sub-slab samples during the Quarter 1 sampling in April 2008. However, these contaminants of concern were seldom detected in the sub-slab samples for the succeeding three quarters. The concentrations of these contaminants detected in the Quarter 1 represented likely remnants the hydrocarbon vapors generated from the smear zone during the extended drought period and High-Grade pumping in fall of 2007.

Some of these same contaminants of concern, 2,2,4-TMP and hexane, were also detected at concentrations well below indoor air levels of concern during the Quarter 1 sampling in April 2008 by Chevron. These contaminants of concern were seldom detected in the indoor air samples in the remaining three quarters of sampling by the USEPA.

These contaminants of concern (COCs) were detected all the way to the ground surface only under “worst case scenario” conditions, when the HSVE system was not in operation and the groundwater elevation was below 463 ft msl. The concentration of contaminants increased at deeper soil gas sample intervals demonstrating a gradient from higher concentrations at the smear zone to lower concentrations near the ground surface (Figure 5). The data shows that only when the HSVE system was shut down and when the smear zone was exposed for about a month, did levels of certain contaminants of concern in the soil gas exceed screening levels. Indoor air concentrations of contaminants did not increase to above levels of concern under these specific conditions. However, the levels of these contaminants detected in the soil gas under the village indicate that under specific “worst case scenario” conditions, there can be a completed exposure pathway and a resulting vapor intrusion concern under the Village of Hooven.

Chevron soil gas data from vapor well VW-127 in April and September 2008 indicate that there were contaminants of concern detected at the ground surface (Chevron, 2009). Benzene, cyclohexane, hexane, and heptane were detected at the 5 ft, 10 ft, and 15 ft bgs depth intervals. In April 2008, these contaminants were detected only at the 5 ft depth interval and in September of that same year, contaminants were detected at all three depth intervals. The contaminants were higher in concentration at the surface and concentrations were lower or not detected at deeper depths. In September, benzene was detected at 40,000 ppb at the 5 ft bgs interval, 2,800 ppb at 10 ft bgs, 16 ppb at 15 ft bgs, and not detected at 20 ft bgs. This downward gradient indicates that the source of this contamination was at the ground surface, rather than coming up from the underlying plume. Additionally, the compounds detected (benzene, cyclohexane, and heptanes) were not the same as those found by the USEPA in VW-96 and VW-99 in September 2009 (2,2,4-TMP, isopentane, and n-Butane). The compound, 2,2,4-TMP is typically found in old gasoline plumes at higher concentrations because it is more resistant to biodegradation (Marchetti, 2001 and Solano-Serena, 2004). Since 2,2,4-TMP was detected at high levels in VW-96 and VW-99 and was below detection levels at similar depth intervals in VW-127, these contaminants were not derived from the same source.

CHEMICALS OF CONCERN

COCs Not Linked to the Former Chevron Refinery During the USEPA Investigation

Several contaminants were detected in indoor air samples collected by the USEPA at concentrations above the screening values. These contaminants were not linked to the plume because they were either not detected or were detected at lower concentrations in the sub-slab soil gas samples collected at the same time. When contaminants in the sub-slab have lower concentrations or are not detected compared to concentrations in the indoor air, the USEPA vapor intrusion guidance indicates that the indoor air contaminants cannot be attributed to vapor intrusion (USEPA, 2002). Contaminants such as 1,3-butadeine, naphthalene, and trimethylbenzene are known constituents of gasoline, however, they can also be found in household products such as certain paints, cleaners, and mothballs or they can be generated from activities such as burning wood or tobacco. Chloroform in the indoor air can be attributed to household cleaning products containing bleach or to chlorinated tap water.

1,3-Butadiene:

Second quarter results revealed one indoor air sample from one residential location that was slightly above the screening value for 1,3-butadiene. It is important to note that 1,3-butadiene was not found in the two sub-slab samples collected at this location (one in the second and one in the third quarter). Furthermore, the indoor air sample collected in the third quarter at this residence did not detect 1,3-butadiene. This residence has a wood burning stove that was in use at the time the second quarter indoor air sample was collected. The most common sources of exposure to 1,3-butadiene are from gasoline, automobile exhaust, cigarette smoke, and burning wood. Keeping in mind that 1,3-butadiene is a common by-product of burning wood, it is possible that the 1,3-butadiene detected may have originated from the wood burning stove rather than the Chevron plume.

Breathing low levels of 1,3-butadiene may cause irritation of the eyes, nose, and throat. Studies on workers who had long exposures with low levels have shown an increase in heart and lung damage, but these workers were also exposed to other chemicals. We do not know for sure which chemical or chemicals caused the heart and lung damage. We also do not know what levels in the air will cause these effects in people when breathed over many years. The Department of Health and Human Services (DHHS) has determined that 1,3-butadiene may reasonably be anticipated to be a carcinogen. This determination is based on animal studies that found increases in a variety of tumor types from chronic and elevated exposures to 1,3-butadiene.

Naphthalene:

Indoor air at another residential location was sampled twice during the second quarter and results revealed naphthalene above screening values in both samples. Although, naphthalene exceeded the screening values in an earlier sub-slab sample collected by Chevron (April 18, 2008), it was not detected in the second quarter sub-slab sample collected by the USEPA (when the indoor air level was above the screening value). If a contaminant is detected in the indoor air and not in the sub-slab, as in this case, the contamination is attributed to a source likely from within the home. Although, naphthalene is a known constituent of gasoline, it can also be found in household products such as mothballs and toilet deodorant blocks or can be generated when burning wood or tobacco.

Human health effects associated with breathing small amounts of naphthalene are not known. Rats and mice that breathed naphthalene vapors daily for a lifetime developed irritation and inflammation of their nose and lungs (ATSDR, 2005). It is unclear if naphthalene causes reproductive effects in animals; most evidence says it does not. Based on the results from animal studies, the DHHS concluded that naphthalene is reasonably anticipated to be a human carcinogen.

Total Trimethylbenzene (TMB):

The same residential location that detected naphthalene above the screening value in the indoor air also had TMB above the screening value for both the samples collected during the second quarter. Although TMB exceeded the screening values in the indoor air, it was not detected in sub-slab samples collected by the USEPA at the same time. If a contaminant is detected in the indoor air and not in the sub-slab, as in this case, the contamination can be attributed to source likely from within the home. Typical indoor air sources of TMB are certain paints and cleaners, although it is also a known constituent of gasoline.

Human health effects associated with breathing small amounts of TMB are not known. Long-term exposure to solvents containing TMB may cause nervousness, tension, and bronchitis. No information was found on the carcinogenicity of TMB (USEPA, 1994). Animals exposed to mixtures of petroleum industry chemicals, including TMB, in air had adverse effects of the reproductive system and developing fetus. The USEPA believes that exposure to individual chemicals from this mixture, like TMB, will have similar adverse effects.

Chloroform:

Chloroform was detected in the second quarter sub-slab sample from one home exceeding the sub-slab screening values. However, chloroform was not detected in the indoor air at levels above the screening values in the same house at the same time. Common sources of chloroform in the indoor air are from chlorinated drinking water and household cleaning products containing bleach. Although chloroform is not a petroleum hydrocarbon, it is one of the listed chemicals associated with refinery waste (USEPA, 1997).

Human health effects associated with breathing small amounts of chloroform are not known. The DHHS has determined that chloroform may reasonably be anticipated to be a carcinogen (ATSDR, 1997b). In research studies, rats and mice that ate food or drank water with large amounts of chloroform over a long period of time developed cancer of the liver and kidneys.

Plume-Related Vapor-Phase Hydrocarbons

A number of the volatile hydrocarbons, especially BTEX compounds, found in the Former Chevron Refinery's plume may also be found in a variety of household products, such as household cleaners, paints, glues, air fresheners, new carpeting, pressed wood products, personal care products, etc. However, other hydrocarbon compounds detected at the Hooven site seem to be associated only with gasoline and diesel fuel.

Hexane and Methylcyclohexane

Two compounds that are not commonly found in household products are hexane, and methylcyclohexane. When these contaminants are detected, it can be assumed that they have originated from the refinery plume (ATSDR, 2008). Hexane and methylcyclohexane were found in all the groundwater samples, with hexane exceeding the screening level in almost all samples. During certain sampling events, hexane also exceeded the screening levels in vapor wells VW-96 and VW-99 at depths of 30 ft, 40 ft, and 55 ft bgs. Hexane and methylcyclohexane were detected at low levels in sub-slab samples and hexane was detected in the indoor air at low levels in a few samples. Hexane in the indoor air can be attributed to vapor intrusion from the petroleum hydrocarbon plume.

2,2,4-Trimethylpentane (2,2,4-TMP)

2,2,4-Trimethylpentane is also called isooctane and is one of hundreds of hydrocarbon compounds found in gasoline. Refineries in the U.S. convert over half of the crude oil to gasoline. Refineries use a variety of processes to separate, break apart, and join together refinery compounds which are then blended to produce gasoline. A mixture of trimethylpentanes and dimethylhexanes are produced in one of these processes, alkylation, which joins together refinery gases such as isobutane to propylene, or butene. The product of alkylation is gasoline range liquids which have exceptionally high anti-knock qualities. Many of the compounds produced in alkylation fit into a group of hydrocarbons called branched alkanes. Twenty-five to forty percent of gasoline is made up of these branched alkanes. In general, these branched alkanes are considered to be resistant to biodegradation (Marchetti, 2001). Of the branched alkanes, 2,2,4-TMP may be more resistant to biodegradation due to its distinctive chemical structure (Solano-Serena, 2004). 2,2,4-TMP was produced and added to gasoline because of its exceptional anti-knock qualities and is not found in other common commercial products (Sanders, 2006).

The only information regarding human health effects from exposure to 2,2,4-TMP is with regard to spilling large amounts on the skin causing skin damage. When rodents were exposed to very high concentrations of TMP through inhalation and injection, it caused lung irritation, edema, and hemorrhage. Mice inhaling high concentrations had central nervous system depression. There is no information with regard to human reproductive, developmental, or carcinogenic effects resulting from exposure to low levels for long periods. Rats eating and inhaling 2,2,4-TMP for long periods had kidney and liver effects. The USEPA has not classified 2,2,4-TMP with respect to its ability to cause cancer.

In September 2009, shallow soil gas samples collected by the USEPA had 2,2,4-TMP concentrations above the screening level at 160,000 ppb from the 10 ft bgs level in VW-96, 213 times the screening level.

CHILD HEALTH CONSIDERATIONS

The HAS and the ATSDR both recognize that children are often inherently 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. To be protective of the health of children, the HAS has reviewed all data for this report as if children were the primary population being exposed. The HAS will also make recommendations that will provide for the highest level of protection for children in the Hooven area.

COMMUNITY CONCERNS

In late 2003, the Hamilton County General Health District (HCGHD) and concerned residents asked the Health Assessment Section (HAS) at the Ohio Department of Health (ODH) to evaluate available environmental data and determine if the Former Chevron Refinery site poses a public health threat to the people who live in the Village of Hooven, Hamilton County, Ohio. The ODH staff attended a Community Advisory Panel (CAP) meeting on October 1, 2003, to gain firsthand knowledge of the health concerns expressed by the residents.

- Residents were concerned about possible exposure to vapors from the gasoline plume beneath the village and about past exposures to pollutants released by the refinery when it was in operation.
- The HAS explained to the residents that it was necessary to document a completed exposure pathway to contaminants at levels that could cause adverse health effects in order to determine if any of their health concerns could be related to underlying groundwater contamination.

In light of the concerns voiced by the citizens of the Village of Hooven and the HCGHD Health Commissioner, the Health Assessment Section reviewed the available environmental data to determine if residents of Hooven were being exposed to environmental contaminants from the Former Chevron Refinery site. On May 6, 2004, the HAS released a Public Health Consultation on the Vapor Intrusion Issues in Hooven, Ohio, Former Chevron Refinery (HAS, 2004).

The 2004 Public Health Consultation made the following Conclusions and Recommendations:

1. There is no evidence that the drinking water was ever contaminated or that the safety of drinking water was compromised by the Chevron gasoline plume.

2. The Health Assessment Section recommended Chevron collect new soil vapor data in the Village of Hooven from 5 to 10 feet below the ground surface to obtain an up-to-date picture of the soil vapor conditions in Hooven

3. Using the newly-collected soil vapor data, Chevron should complete a new human health risk assessment based upon the steps outlined in the USEPA vapor intrusion guidance

manual (USEPA, 2002. *Draft Guidance for the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*).

4. If the new risk assessment determines that residents could be exposed to contaminants from the groundwater plume via the vapor intrusion route at levels of concern, the HAS will recommend that Chevron collect indoor air samples from those residences most likely to be impacted.

Between March and May 2005, Chevron sampled 7 nested deep vapor wells (5 within the plume “footprint” and 2 outside the plume “footprint”), sub-slab vapor probes in 43 residences (21 inside plume and 22 outside plume), 50 near slab vapor probes at 5 and 10 foot depth, 18 groundwater wells, and 3 locations for ambient air samples. They determined, based on this sampling, that no completed vapor intrusion pathway existed at the Chevron Refinery site.

On November 27, 2006 the HAS released the second Public Health Consultation on the Soil Vapor Intrusion Issues in Hooven, Ohio, Former Chevron Refinery (HAS, 2006). The 2006 Public Health Consultation had the following recommendations:

1. Additional rounds of soil gas sampling in the area are recommended in order to capture season fluctuations in the vapor-phase hydrocarbons generated by the groundwater plume under the village, especially at times when the water-table is low and vapor production more likely to be at a maximum.

2. At least one of these soil gas sampling events needs to represent a “worst case scenario” (late summer and fall months) when the LNAPL production and vapor generation likely would be maximized.

3. Chevron should revise its conceptual site model to take into account the geologic heterogeneity of the subsurface soils under the village and include an evaluation of soil gas migration along preferential pathways.

4. Additional evaluation of the effectiveness of the Soil Vapor Extraction system under the village with regard to reducing vapor levels in soils under the village, particularly in conjunction with studies of the significance of natural biodegradation of vapor-phase hydrocarbons as a mitigating process at the site.

5. The installation and sampling of additional nested vapor wells in areas of the village that are not under the direct influence of the SVE system, but still close to the footprint of the underlying groundwater contaminant plume.

In 2007, residents of Hooven contacted the offices of US Representative Chabot of Cincinnati and the HAS to express concern about the safety of the students of the local elementary school and the residents of Hooven in light of the extreme drought conditions in the area during the summer of 2007. In response to the residents’ and Representative Chabot’s concerns, the

USEPA's Emergency Response Branch (ERB) was contacted, and in January of 2008 initiated sampling in the village as recommended by the HAS in the 2006 consultation. The USEPA and the ODH held a public meeting on February 26, 2008 to kick off the vapor intrusion investigation to be conducted by the USEPA and the Ohio EPA. This investigation collected samples over four quarters of the year and with at least one quarter's sampling to occur when the water table was below the smear zone. Four subsequent meetings were held with school officials and residents to provide them with data specific to their residence or school. These meetings were held on June 3, 2008 for Quarter 1, on October 9, 2008 for Quarter 2, and on February 5, 2009 for Quarter 3. On June 29, 2010, Quarter 4 results and summarized results of all of the USEPA's sampling events were presented to the residents at a public meeting in Hooven.

Community Health Outcome Data

In 2006, due to concerns about long-term exposure to site-related hydrocarbons, the residents of Hooven requested a community cancer incidence assessment for the village (ODH, 2006). The Chronic Disease and Behavioral Epidemiology Section and the Ohio Cancer Incidence Surveillance System (OCISS) of Ohio Department of Health reported in the *Cancer Incidence Among Residents of Hooven, Hamilton County, Ohio 1996-2003, December 20, 2006*, that there was a higher than expected incidence of cancer among the 164 residents of Hooven during the 8-year study period. It is difficult to determine the causes of each case of cancer due to the many risk factors and the interaction of these factors in developing cancer. The cancer assessment report concludes that;

> *"the twelve different sites/types of cancer diagnosed among Hooven residents differ with respect to risk factors, course of disease and probability of survival. For this reason, it is not likely a specific point source of exposure or single risk factor is playing a role in the increased cancer burden. Cigarette smoking is a major risk factor for two of the three significant cancer sites/types (lung and bronchus; and bladder)."*

CONCLUSIONS

Both the ATSDR and the HAS consider it a top priority to ensure that the residents of Hooven have the best information possible to safeguard their health. Based on the HAS's review and evaluation of the USEPA's four quarters of environmental sampling in the Village of Hooven the following determinations have been reached:

1. The levels of vapor-phase petroleum hydrocarbons detected in the indoor air of area residences and the Hooven Elementary School during the USEPA quarterly sampling did not pose a public health hazard to residents, students or staff. The HAS concludes that the indoor air of area residences and the Hooven Elementary School is not expected to pose a hazard to people's health as the levels of vapor-phase petroleum hydrocarbons detected in the sub-slab soil gas samples with several isolated exceptions, did not exceed health-based sub-slab screening values.

2. At the east end of the Village of Hooven, in the vicinity of monitoring wells VW-96 and VW-99, lowering the water table through operation of the High-Grade pumping system or during drought conditions will expose the smear zone and thus can generate significant levels of vapor-phase petroleum hydrocarbons. These vapor concentrations can increase to levels that pose a health threat due to vapor intrusion over a short period of time (approximately 4 weeks) in the soil gas beneath homes in the vicinity of monitoring wells VW-96 and VW-99 in the Village of Hooven. Under these conditions, there is a completed vapor intrusion pathway.

RECOMMENDATIONS

1. The HAS recommends continued operation of the Horizontal Soil Vapor Extraction (HSVE) system (Figures 3 and 8) to reduce vapors to ensure that concentrations that do not pose an increased risk of health effects when the groundwater elevation is below the smear zone or when Chevron is operating the High-Grade pumping system. A groundwater “trigger level” should be established to ensure that vapor levels do not exceed screening levels for soil gas. Operation of the HSVE system under the Village of Hooven appears to be quite effective in rapidly reducing or eliminating vapor levels under the village when these vapors are produced via drought conditions and/or operation of the high-grade pumping by Chevron.
2. The HAS recommends soil gas in the area of Hooven overlying the plume should also continue to be closely monitored to ensure the operation of the HSVE system remains protective of the village residents and students and staff at the school.
3. The HAS recommends new construction in the area should be equipped with a vapor barrier or some type of vapor mitigation system.
4. The HAS recommends groundwater and soil gas in the Southwest Quadrant should continue to be closely monitored to ensure the safety of workers and residents in this area.

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List of Acronyms:

AOC = Administrative Order of Consent
ATSDR = Agency for Toxic Substances and Disease Registry
bgs = Below Ground Surface
BTEX = benzene, toluene, ethylbenzene, xylene
CAP = Community Advisory Panel
CMS = Corrective Measures Study
COCs = Contaminants Of Concern
DHHS = Department of Health and Human Services
ERB = Emergency Response Branch (USEPA)
ft = Feet
HAS = Health Assessment Section
HC = Health Consultation
HCGHD = Hamilton County General Health District
HSVE = Horizontal Soil Vapor Extraction
LNAPL = Light Non-Aqueous Phased Liquids
MCL = Maximum Contaminant Level
msl = Mean Sea Level
MW = Monitoring Well
NPL = National Priority List
NOAA = National Oceanic and Atmospheric Administration
ODH = Ohio Department of Health
ODNR = Ohio Department of Natural Resources
ppb = Parts Per Billion
ppm = Parts Per Million
RFI = RCRA Facility Inspection
RCRA = Resource Conservation and Recovery Act
SSA = Sole Source Aquifer
SVE = Soil Vapor Extraction
TCE = Trichloroethylene
TMB = Trimethylbenzene
TMP = Trimethylpentane
USEPA = U.S. Environmental Protection Agency
VOCs = Volatile Organic Compounds
VW = Vapor Well

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TABLES

Table 1 - GROUNDWATER SAMPLE RESULTS

Chemical	Groundwater MCL Action Level (ppb)	Groundwater Screeining Level (ppb)	Groundwater Samples April 2008 (ppb)						Groundwater Samples November 2008 (ppb)					LNAPL (ppb)
			GP-1 (35.8' bgs)	GP-2 (53.6' bgs)	GP-4 (54.6' bgs)	GP-5 (52' bgs)	GP-5 (duplicate)	GP-7 (29.4' bgs)	MW-96S	MW-96S (duplicate)	MW-99S	MW-129	MW-20S	MW-20S
Benzene	5	140	11	0.47	150	47	45	20	660	690	9.3	0.12	2,100	310,000
Ethylbenzene	700	700	0.53	0.32	85	4.9	5.2	2.1	1,200	1,200	320	0.55 J	2,100	6,400,000
Toluene	1,000	1,500	1.1	1.1	7.8	1.5	1.6	2.9	22 J	24 J	11 J	0.13 J	120	100,000
Xylenes (total)	10,000	22,000	1.5	0.58	140	ND (10)	ND (10)	ND (2.0)	1,700	1,800	330	1.2	4,400	17,000,000
Butylbenzene	No MCL	250	16	ND (1.0)	25	15	15	1.7	20.1 J	22.6 J	18.9 J	ND (1.0)	70 J	2,406,000 J
Naphthalene	No MCL	150	ND (5.0)	ND (1.0)	2.5	ND (10)	ND (10)	0.24	420 B	460 B	150 B	0.63 JB U	600 B	3,300,000 B
Trimethylbenzene (total)	No MCL	24	0.63	0.228	57	1.73	1.81	0.43	900	990	310	0.96 J	1,840	22,300,000
Chloroform	No MCL	80	ND (5.0)	ND (1.0)	ND (10)	ND (10)	ND (10)	ND (2.0)	ND (50)	ND (50)	ND (20)	0.55 J	ND (120)	ND (500,000)
n-Butane	No MCL	None	ND	2.1	ND	ND	ND	4.8	ND	ND	ND	ND	ND	ND
Isopentane	No MCL	None	ND	1.4	25	ND	ND	47	240 NJ	280 NJ	110 NJ	ND	450 NJ	ND
Hexane	No MCL	2.9	0.69	0.5	17	6.7	7.6	3.8	58	69	27	ND (1.0)	200	5,600,000
Methylcyclohexane	No MCL	710	21	0.49	130	170	200	61	150	170	140	0.04 J	450	13,000,000

' - feet
not in household products (orange)
surrogates for exposure (blue)

MCL - Maximum Contaminant Level
ND - Not Detected
bgs - below ground surface

U - detected below required reporting level
J - estimated value
N - tentatively identified compound

B - analyte also detected in method blank
LNAPL - Light Non-Aqueous Phase Layer

Table 2 - Soil Gas from Vapor Well VW-96 (ppbv)

Chemical	Screening Level (ppbv)	VW-96 Chevron 9/6/2008	USEPA 11/10/2008	USEPA 9/15/2009	HSVE System Restart Operation October 16, 2009	USEPA 10/23/2009	USEPA 10/30/2009	USEPA 11/9/2009
		10-feet				10-feet		
2,2,4-Trimethylpentane	750	ND (1.1)	ND (0.78)	160,000		27	4.8	23
n-Butane	500	ND (4.6)	ND (3.1)	19,000		ND (3.2)	ND (2.9)	5.6
Isopentane	400	ND (4.6)	ND (3.1)	140,000		15	3	16
Hexane	570	ND (1.1)	ND (0.78)	3,300		ND (0.79)	ND (0.74)	ND (0.70)
Methylcyclohexane	7,500	ND (4.6)	ND (3.1)	ND (6,400)		ND (3.2)	ND (2.9)	4.2
		20-feet				20-feet		
2,2,4-Trimethylpentane	7,500	ND (1.2)	ND (0.79)	110,000		26,000	86	50
n-Butane	5,000	ND (4.9)	ND (3.2)	ND (3,300)		ND (370)	ND (2.8)	5.4
Isopentane	4,000	ND (4.9)	ND (3.2)	8,800		ND (370)	ND (2.8)	4.9
		30-feet				30-feet		
2,2,4-Trimethylpentane	7,500	1.6	ND (0.82)	300,000		12,000	600	190
n-Butane	5,000	ND (5.1)	ND (3.3)	36,000		230	13	27
Isopentane	4,000	ND (5.1)	ND (3.3)	260,000		2,000	84	120
Hexane	5,700	ND (1.3)	ND (0.82)	ND (3,500)		ND (41)	ND (1.7)	2.1
Methylcyclohexane	75,000	ND (5.1)	ND (3.3)	ND (14,000)		ND (160)	ND (6.9)	11
		40-feet						
2,2,4-Trimethylpentane	7,500	ND (1.2)	2,000	320,000				
n-Butane	5,000	ND (4.9)	35	56,000				
Isopentane	4,000	ND (4.9)	76	390,000				
Hexane	5,700	ND (1.2)	ND (5.4)	10,000				
		50-feet						
2,2,4-Trimethylpentane	7,500	27						
n-Butane	5,000	8.6						
Isopentane	4,000	7.4						
Hexane	5,700	10.0						
		55-feet						
2,2,4-Trimethylpentane	7,500	140,000						
n-Butane	5,000	8,800						
Isopentane	4,000	79,000						
Hexane	5,700	34,000						
Methylcyclohexane	75,000	38,000						

ND - Not Detected

Table 3 - Soil Gas from Vapor Well VW-99 (ppbv)

Chemical	Vapor Well Screening Level	Apr-08 Chevron	9/20/2008 Chevron	11/10/2008 USEPA	9/16/2009 USEPA
		VW-99			
10-feet					
2,2,4-Trimethylpentane	750	ND	ND (1.1)	3.3	84
Isopentane	400		ND (4.5)	ND (2.6)	39
Hexane	570		ND (1.1)	5.8	29
Methylcyclohexane	7,500		ND (4.5)	6.9	180
20-feet					
2,2,4-Trimethylpentane	**7,500**	ND	ND (1.3)	10	**110,000**
Isopentane	**4,000**		ND (5.2)	3.7	**50,000**
Hexane	5,700		ND (1.3)	18	ND (480)
Methylcyclohexane	75,000		ND (5.2)	21	4,000
30-feet					
2,2,4-Trimethylpentane	**7,500**	ND	ND (1.1)	4,500	**230,000**
n-Butane	**5,000**		ND (4.3)	170	**11,000**
Isopentane	**4,000**		ND (4.3)	300	**180,000**
Hexane	**5,700**		ND (1.1)	ND (9.2)	**6,200**
Methylcyclohexane	75,000		ND (4.3)	ND (37)	54,000
40-feet					
2,2,4-Trimethylpentane	**7,500**	3,500	5.7	**24,000**	**240,000**
n-Butane	**5,000**		ND (4.6)	720	**15,000**
Isopentane	**4,000**		ND (4.6)	2,500	**300,000**
Hexane	**5,700**		ND (1.1)	ND (80)	**29,000**
Methylcyclohexane	75,000		ND (4.6)	ND (320)	67,000
50-feet					
2,2,4-Trimethylpentane	**7,500**	**12,000**	**42,000**		
n-Butane	**5,000**		**6,100**		
Isopentane	**4,000**		**48,000**		
Hexane	5,700		2,500		
Methylcyclohexane	75,000		3,700		
55-feet					
2,2,4-Trimethylpentane	**7,500**	ND	**120,000**		
n-Butane	**5,000**		**21,000**		
Isopentane	**4,000**		**230,000**		
Hexane	**5,700**		**60,000**		
Methylcyclohexane	75,000		50,000		

ND - Not Detected

Table 4 Soil Gas from Soil Gas Vapor Probes (ppbv)

Chemical	Soil Gas Probe EPA Date Screening Level	GP-7 4/10/2008	GP-7 8/18/2008	GP-5 10/10/2008	GP-7 9/15/2009
		10-feet			
2,2,4-Trimethylpentane	**750**	**13,000**	**35,000**	ND (0.79)	**35,000**
n-Butane	**500**	**1,200**	**1,100**	ND (3.2)	**990**
Isopentane	**400**	**3,200**	**740**	ND (3.2)	**680**
				47-feet	
2,2,4-Trimethylpentane	**7,500**			**13,000**	
n-Butane	5,000			ND (130)	
Isopentane	4,000			2,800	

ND - Not Detected

Table 5 - Sample Results in the Southwest Quadrant Area

SUB-SLAB SOIL GAS (ppbv)

Chemical	Sub-Slab Soil Gas EPA Date Screening Level	4/14/2008 Sub-slab	8/18/2008 Sub-slab	11/19/2008 Sub-slab	9/14/2009 Sub-slab
2,2,4-Trimethylpentane	**750**	**3,100**	ND (0.5)	350	ND (0.8)
Trimethylbenzene (total)	12	ND (13)	1.1	ND (0.82)	ND (0.8)
Isopentane	**400**	**620**	ND (2.0)	20	ND (3.2)

SOIL GAS PROBE - GP-7 (ppbv)

Chemical	Soil Gas Date EPA Screening Level	GP-7 4/10/2008	GP-7 8/18/2008	GP-7	GP-7 9/15/2009
		10-feet			
2,2,4-Trimethylpentane	**750**	**13,000**	**35,000**		**35,000**
n-Butane	**500**	**1,200**	**1,100**		**990**
Isopentane	**400**	**3,200**	**740**		**680**

GROUNDWATER - GP-7 (ppb)

Chemical	Groundwater Action Level (ppb)	Apr-08 GP-7 (29.4' bgs)
Trimethylbenzene (total)	No MCL	0.43
n-Butane	No MCL	4.8
Isopentane	No MCL	47
Hexane	No MCL	3.8
Methylcyclohexane	No MCL	61

ND - Not Detected

' - feet

bgs - below ground surface

MCL - Maximum Contaminant Level

Table 6 - Residential Sub-Slab Soil Gas (ppbv)

Chemical	Sceening Level (ppbv)	> First Quarter >	H1C 4/10/2008 Sub-slab	H3A Chevron 4/22/2008 Sub-Slab	H3B Chevron 4/18/2008 Sub-Slab	> Second Quarte >	H3A Chevron 8/21/2008 Sub-slab	H3B Chevron 9/4/2008 Sub-slab #2	> Third Quarter >	H1C 11/19/2008 Sub-slab	> Fourth Quarter >	H1C 9/14/2009 Sub-slab
Benzene	30		ND (0.84)	ND (1.0)	2.5		ND (0.80)	ND (0.79)		ND (0.88)		ND (0.84)
Ethylbenzene	510		ND (0.84)	ND (1.0)	2.5		ND (0.80)	ND (0.79)		ND (0.88)		ND (0.84)
Toluene	800		1.3	1.5	7.3		0.9	ND (0.79)		ND (0.88)		ND (0.84)
Xylenes (total)	500		ND (0.84)	ND (1.0)	10.8		ND (0.80)	ND (0.79)		ND (0.88)		ND (0.84)
2,2,4-Trimethylpentane	750		ND (0.84)	1.7	ND (1.2)		ND (0.80)	ND (0.79)		ND (0.88)		ND (0.84)
Trimethylbenzene (total)	12		ND (0.84)	ND (4.0)	11		ND (0.80)	ND (0.79)		ND (0.88)		ND (0.84)
2-Butanone (MEK)	3,400		1.9	1.9	18		1.6	ND (0.79)		ND (0.88)		ND (0.84)
Naphthalene	**5.7**		ND (3.4)	ND (4.0)	**19**		ND (3.2)	ND (3.2)		ND (3.5)		ND (3.4)
n-Butane	500		3.6	*	*		ND (3.2)	ND (3.2)		ND (3.5)		ND (3.4)
Hexane	570		0.87	1.6	2.1		ND (0.80)	ND (0.79)		ND (0.88)		ND (0.84)
Chloroform	**22**		ND (0.84)	**30**	ND (1.2)		ND (0.80)	**140**		ND (0.88)		ND (0.84)
Perchloroethylene (PCE)	120		ND (0.84)	ND (1.0)	ND (1.2)		ND (0.80)	ND (0.79)		ND (0.88)		0.86
Trichloroethylene (TCE)	**4**		ND (0.84)	ND (1.0)	ND (1.2)		ND (0.80)	ND (0.79)		**21**		ND (0.84)
1,2-Dichloroethane	23		ND (0.84)	3.4	ND (1.2)		ND (0.80)	ND (0.79)		ND (0.88)		ND (0.84)

* Not Ananlyzed

ND - Not Detected

TABLE 7 Hooven Residential Indoor Air and Corresponding Sub-Slab Soil Gas Results (ppbv)

		INDOOR AIR			INDOOR AIR			INDOOR AIR	INDOOR AIR		
		H3A			H3B			O1B	O1A		
Chemical	**EPA Date Screening Level**	NO SAMPLE	**8/21/2008**	**11/18/2008**	NO SAMPLE	**8/21/2008**	**9/4/2008**	**11/9/2009**	NO SAMPLE	NO SAMPLE	**9/29/2009**
Benzene	3		1	0.93		0.18	0.23	0.54			0.2
Ethylbenzene	51		0.27	ND (0.16)		ND (0.16)	0.13	0.19			ND (0.17)
Toluene	80		2.6	1.3		1.6	5.1	1.3			0.63
Xylenes (total)	50		1.24	0.33		0.79	0.79	0.69			0.3
2,2,4-Trimethylpentane	75		ND (0.74)	ND (0.79)		ND (0.82)	ND (0.67)	ND (0.86)			ND (0.17)
Trimethylbenzene (total)	**1.2**		0.82	0.27		**28.1**	**25.5**	0.26			ND (0.17)
2-Butanone (MEK)	340		2.2	0.72		0.45	0.78	0.36			0.41
Naphthalene	**0.57**		ND (0.74)	ND (0.79)		**3.1**	**5.3**	ND (0.86)			ND (0.84)
n-Butane	50		4.6	1.2		ND (0.82)	0.87	2.8			1.1
Isopentane	40		1.2	1.1		1.1	1.2	3.7			1
1,3-Butadiene	**1**		**1.3**	0.37		ND (0.16)	ND (0.13)	0.2			ND (0.17)
Hexane	57		0.18	ND (0.16)		ND (0.16)	ND (0.13)	0.2			0.25
Chloroform	2.2		0.26	ND (0.16)		0.42	0.41	ND (0.17)			ND (0.17)
Perchloroethylene (PCE)	12		ND (0.15)	ND (0.16)		ND (0.16)	ND (0.13)	ND (0.17)			ND (0.17)
1,2-Dichloroethane	2.3		0.3	ND (0.16)		ND (0.16)	ND (0.13)	ND (0.17)			ND (0.17)

		SUB-SLAB SOIL GAS			SUB-SLAB SOIL GAS				SUB-SLAB SOIL GAS		
		H3A			H3B				O1A		
Chemical	**EPA Date Screening Level**	**4/22/2008 Chevron**	**8/21/2008**	**11/18/2008**	**4/18/2008 Chevron**	NO SAMPLE	**9/4/2008**	NO SAMPLE	**4/9/2008**	**8/21/2008**	**9/29/2009**
Benzene	30	ND (1.0)	ND (0.80)	ND (0.84)	2.5		ND (0.79)		0.82	ND (0.72)	ND (0.78)
Ethylbenzene	510	ND (1.0)	ND (0.80)	ND (0.84)	2.5		ND (0.79)		1.2	ND (0.72)	ND (0.78)
Toluene	800	1.5	0.9	ND (0.84)	7.3		ND (0.79)		3.1	ND (0.72)	ND (0.78)
Xylenes (total)	500	ND (1.0)	ND (0.80)	ND (0.84)	10.8		ND (0.79)		1.2	ND (0.72)	ND (0.78)
2,2,4-Trimethylpentane	750	1.7	ND (0.80)	ND (0.84)	ND (1.2)		ND (0.79)		ND (0.8)	ND (0.72)	ND (0.78)
Trimethylbenzene (total)	12	ND (4.0)	ND (0.80)	ND (0.84)	11		ND (0.79)		ND (0.8)	ND (0.72)	ND (0.78)
2-Butanone (MEK)	3,400	1.9	1.6	ND (0.84)	18		ND (0.79)		2	ND (0.72)	0.78
Naphthalene	**5.7**	ND (4.0)	ND (3.2)	ND (3.4)	**19**		ND (3.2)		ND (3.2)	ND (2.9)	ND (3.1)
n-Butane	500	not analyzed	ND (3.2)	ND (3.4)	not analyzed		ND (3.2)		6.4	ND (2.9)	ND (3.1)
Isopentane	400	not analyzed	ND (3.2)	ND (3.4)	not analyzed		ND (3.2)		3.8	ND (2.9)	ND (3.1)
1,3-Butadiene	10	ND (1.0)	ND (0.80)	ND (0.84)	ND (1.2)		ND (0.79)		ND (0.8)	ND (0.72)	ND (0.78)
Hexane	570	1.6	ND (0.80)	ND (0.84)	2.1		ND (0.79)		1.8	ND (0.72)	ND (0.78)
Chloroform	**22**	**30**	ND (0.80)	ND (0.84)	ND (1.2)		**140**		ND (0.8)	ND (0.72)	ND (0.78)
Perchloroethylene (PCE)	120	ND (1.0)	ND (0.80)	ND (0.84)	ND (1.2)		ND (0.79)		ND (0.8)	1.2	0.78
1,2-Dichloroethane	23	3.4	ND (0.80)	ND (0.84)	ND (1.2)		ND (0.79)		ND (0.8)	ND (0.72)	ND (0.78)

ND - Not Detected

Table 8 - Sample Results in the Area of Hooven Elementary School

INDOOR AIR (ppbv)

Chemical	EPA Date Screening Level	3/25/2008	4/14/2008	8/19/2008	11/11/2008	11/11/2008	9/16/2009
		Indoor Air	Indoor Air	Indoor Air	Indoor Air	Ambient Air	Indoor Air
Trimethylbenzene (total)	1.2	ND (0.9)	ND (0.16)	1.53	ND (0.17)	ND (0.21)	ND (0.16)
n-Butane	50	2.4	1.4	2.1	1.9	1.3	22
Isopentane	40	3	1.2	1.9	1.5	0.82J	1
Hexane	57	0.22	0.19	0.48	0.19	ND (0.21)	ND (0.16)
		Indoor Air		Indoor Air	Indoor Air		Indoor Air
2,2,4-Trimethylpentane	75	ND (0.79)		0.78	ND (0.84)		ND (0.86)
Trimethylbenzene (total)	1.2	ND (0.79)		1.16	ND (0.17)		ND (0.17)
n-Butane	50	6.7		1.7	1.9		8.8
Isopentane	40	2.8		6.4	1.4		1.1
Hexane	57	0.19		0.59	0.22		ND (0.17)
Methylcyclohexane	750	ND (0.79)		0.96	ND (0.84)		ND (0.86)
		Indoor Air			Indoor Air		Indoor Air
Trimethylbenzene (total)	1.2	ND (1.9)			0.19		ND (0.18)
n-Butane	50	2.1			12		15
Isopentane	40	ND (1.9)			3.4		1
Hexane	57	ND (0.37)			0.39		ND (0.18)
					Indoor Air		
n-Butane	50				9		
Isopentane	40				2.3		
Hexane	57				0.3		
					Indoor Air		
n-Butane	50				3.9		
Isopentane	40				1.1		

SUB-SLAB SOIL GAS (ppbv)

Chemical	EPA Date Screening Level	3/25/2008	4/14/2008	8/19/2008	10/1/2008		9/16/2009
		Sub-slab	Sub-slab	Sub-slab	Sub-slab		Sub-slab
Trimethylbenzene (total)	12	ND (0.94)	ND (0.88)	ND (0.80)	3.74		ND (0.96)
n-Butane	500	ND (3.7)	6.2	7.7	6		ND (3.8)
Isopentane	400	ND (3.7)	ND (3.5)	3.8	ND (3.4)		ND (3.8)
Hexane	570	0.96	1.2	1.6	ND (0.84)		ND (0.96)
				Sub-slab	Sub-slab		Sub-slab
All Chemicals				ND	ND		ND
					Sub-slab		Sub-slab
All Chemicals					ND		ND
					Sub-slab		Sub-slab
All Chemicals					ND		ND

SOIL GAS PROBES - GP-2 & GP-3 (ppbv)

Chemical	Soil Gas Probe EPA Date Screening Level		GP-2 4/10/2008	GP-2 8/19/2008
		11-feet		
Trimethylbenzene (total)	12		1.1	ND (0.50)
n-Butane	500		48	ND (2.0)
Isopentane	400		32	ND (2.0)
Methylcyclohexane	7,500		6.5	ND (2.0)
		20-feet		
n-Butane	5,000		5.7	ND (2.0)
Isopentane	4,000		3.3	ND (2.0)
		50-feet		
All Chemicals			ND	ND

Chemical	Soil Gas Probe EPA Date Screening Level		GP-3 4/10/2008	GP-3 8/19/2008
		10-feet		
n-Butane	500		4.1	ND (2.8)
Isopentane	400		10	ND (2.8)
		32-feet		
n-Butane	5,000		17	ND (3.2)
Isopentane	4,000		4	ND (3.2)

VAPOR WELL - VW-128 (ppbv)

Chemical	Vapor Well EPA Date Screening Level	VW-128 11/10/2008	VW-128 9/17/2009
	10-feet		
All Chemicals		ND	ND
	20-feet		
All Chemicals		ND	ND
	30-feet		
All Chemicals		ND	ND
	40-feet		
n-Butane	5,000	70	14
1,3-Butadiene	100	2	ND (0.8)

GROUNDWATER - GP-2 (ppb)

Chemical	MCL	Apr-08 (53.6' bgs)
Trimethylbenzene (total)	No MCL	0.228
n-Butane	No MCL	2.1
Isopentane	No MCL	1.4
Hexane	No MCL	0.5
Methylcyclohexane	No MCL	0.49

ND - Not Detected
' - feet
bgs - below ground surface
MCL - Maximum Contaminant Level

FIGURES

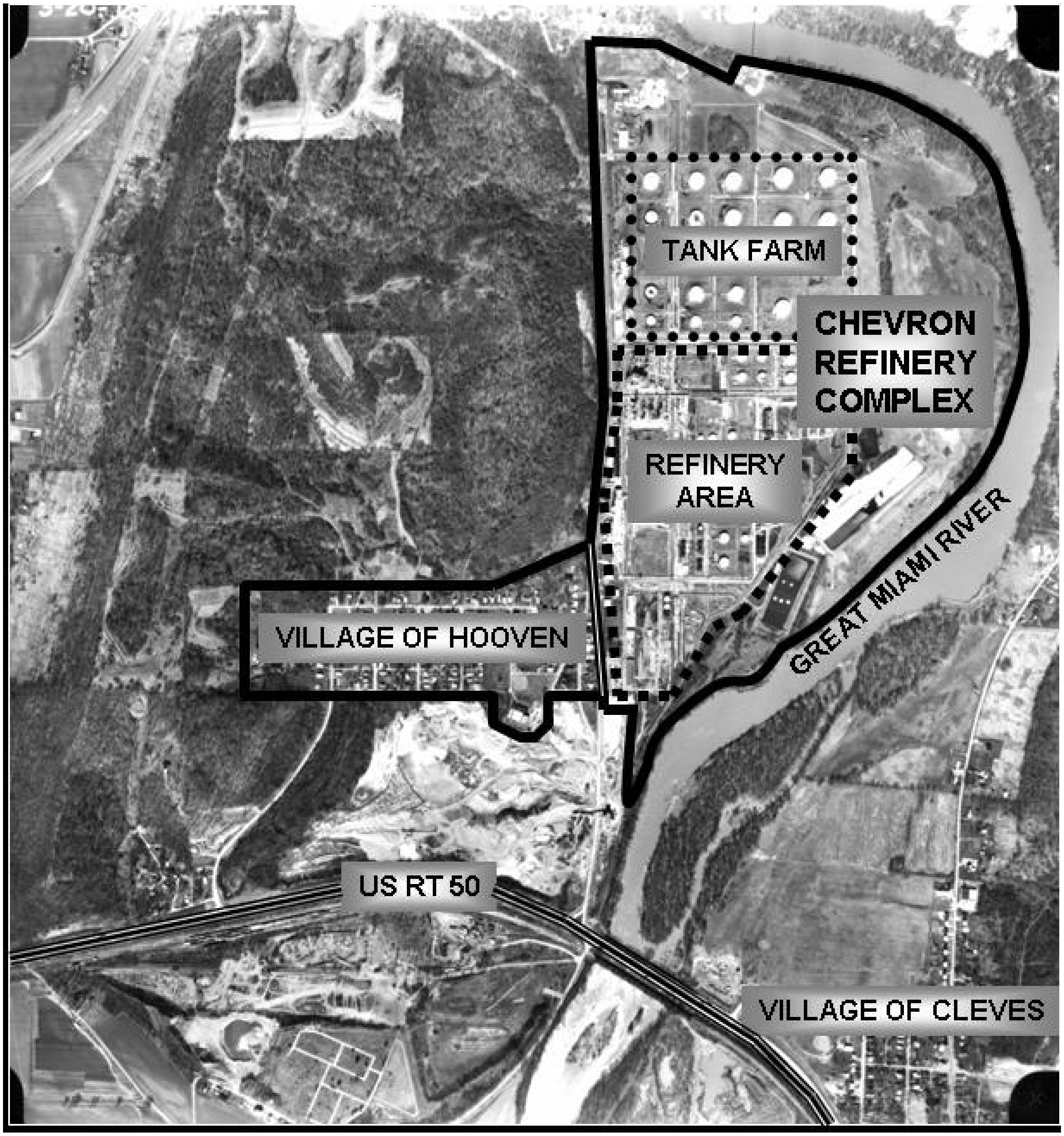


Figure 1. Chevron Refinery and Hooven Village Aerial Photograph 1975.

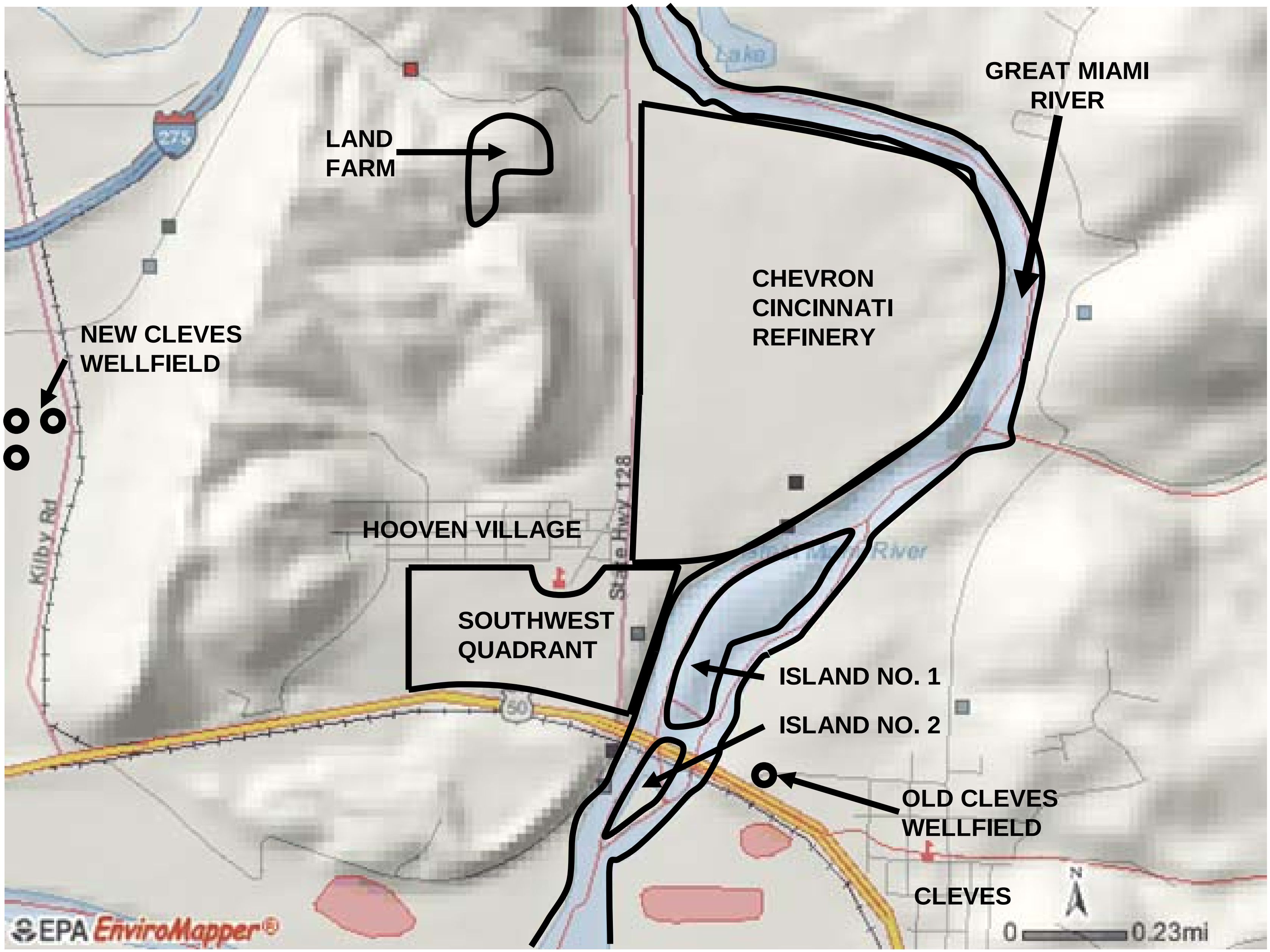


Figure 2. Site Location Map

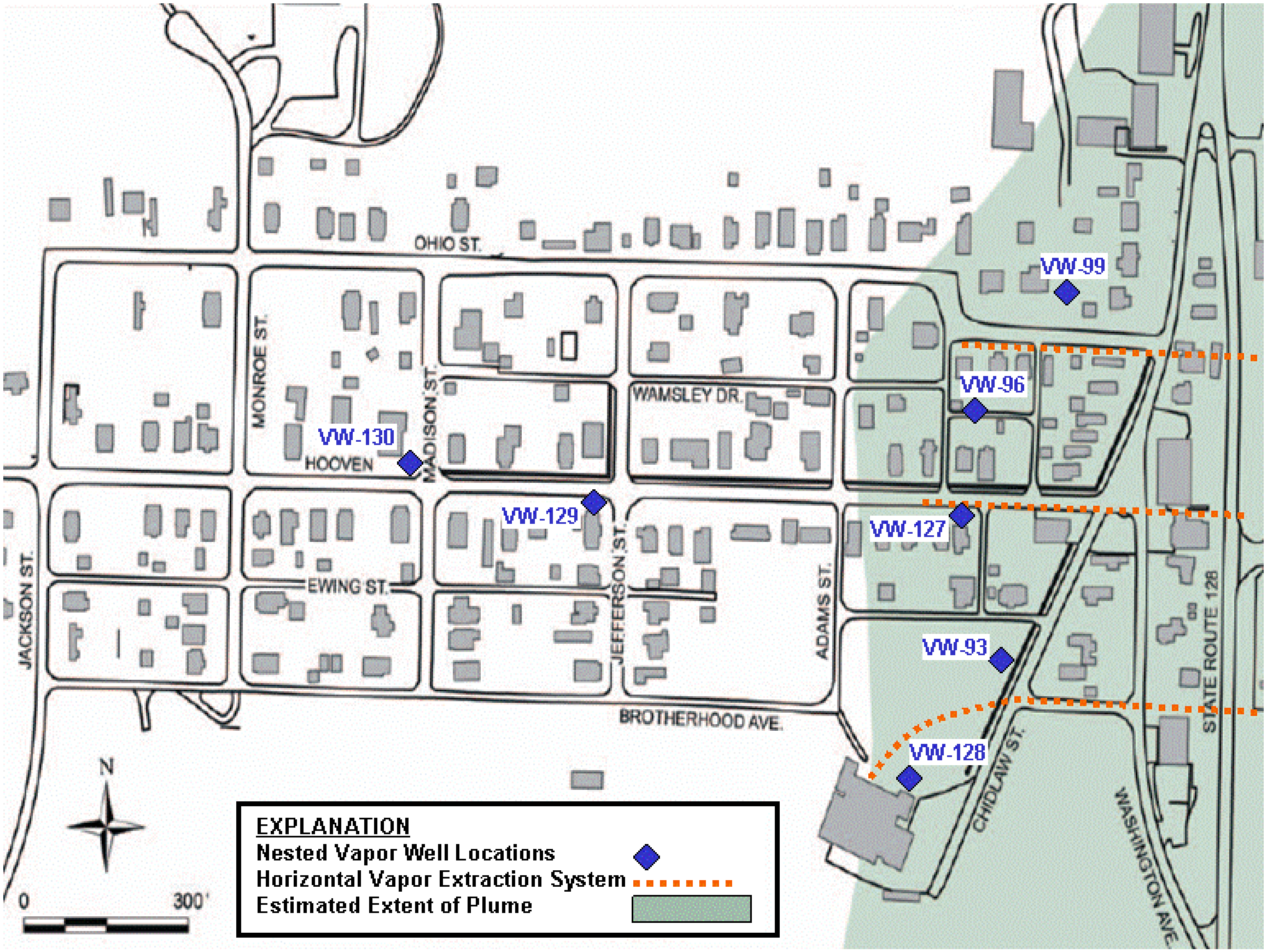


Figure 3. The Estimated Extent of the LNAPL Plume Under Hooven Village

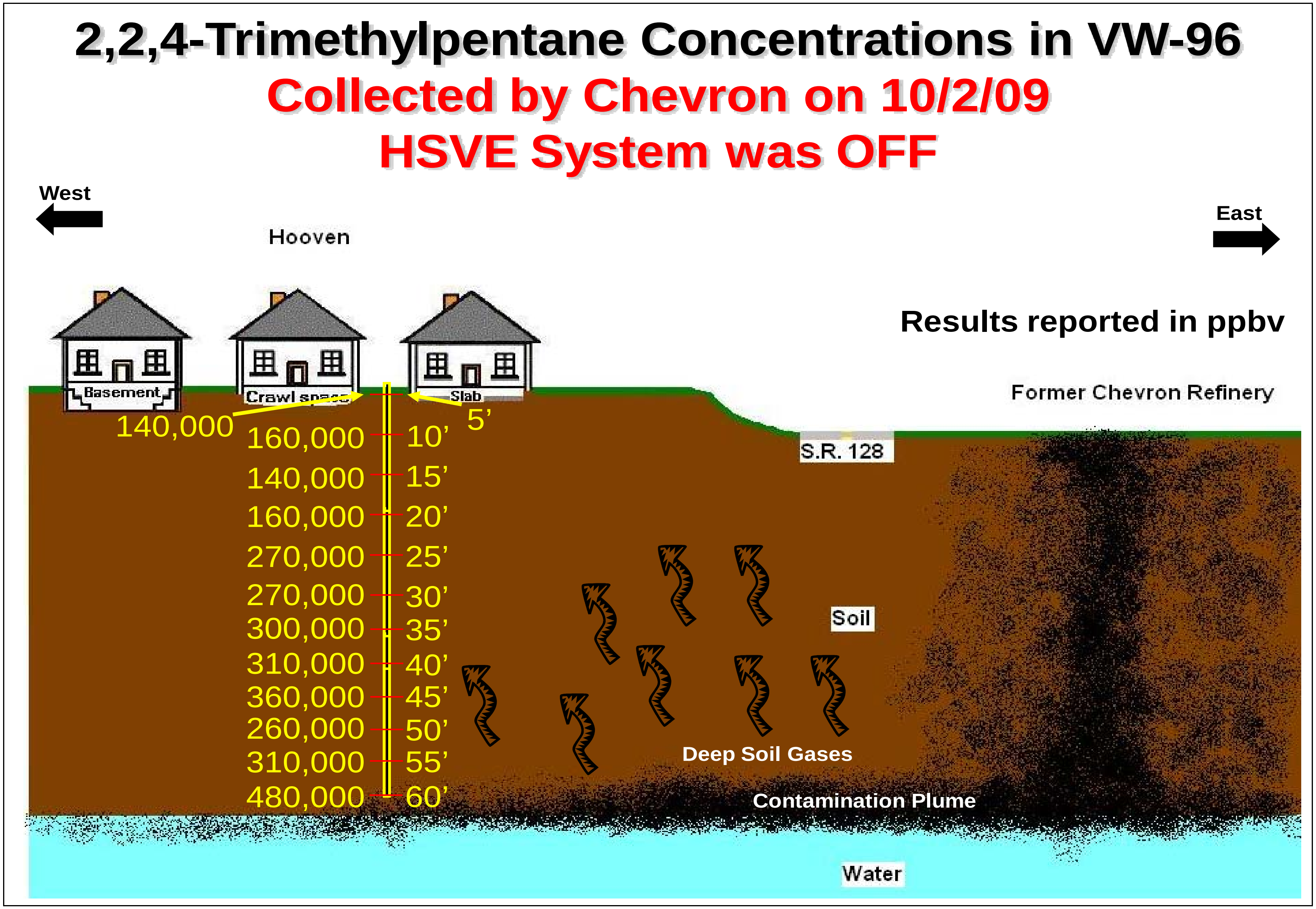


Figure 4 – Trimethylpentane Concentrations in Vapor Well VW-96 in October 2009 When HSVE System was Off

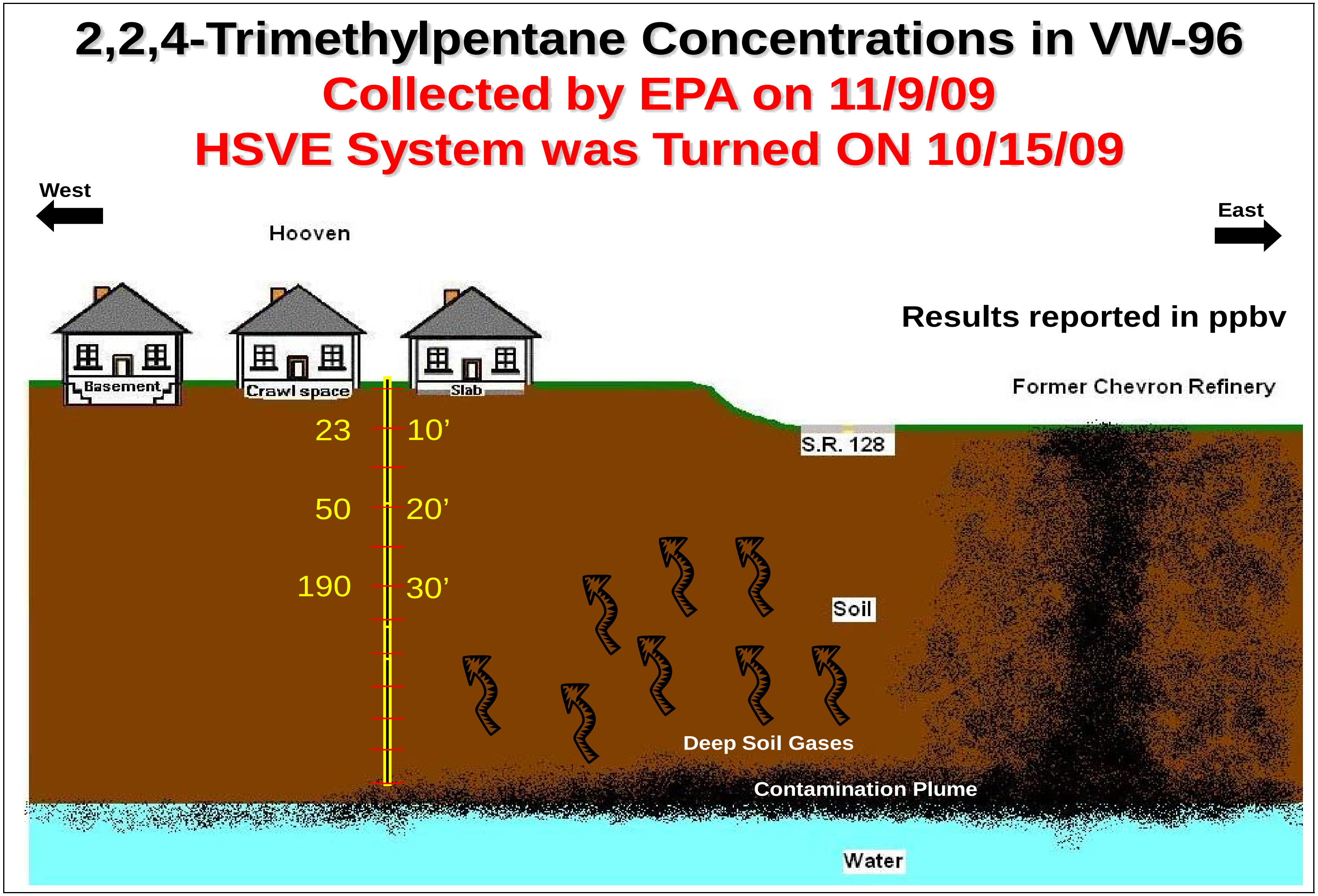


Figure 5 – Trimethylpentane Concentrations in Vapor Well VW-96 in November 2009 When HSVE System was On

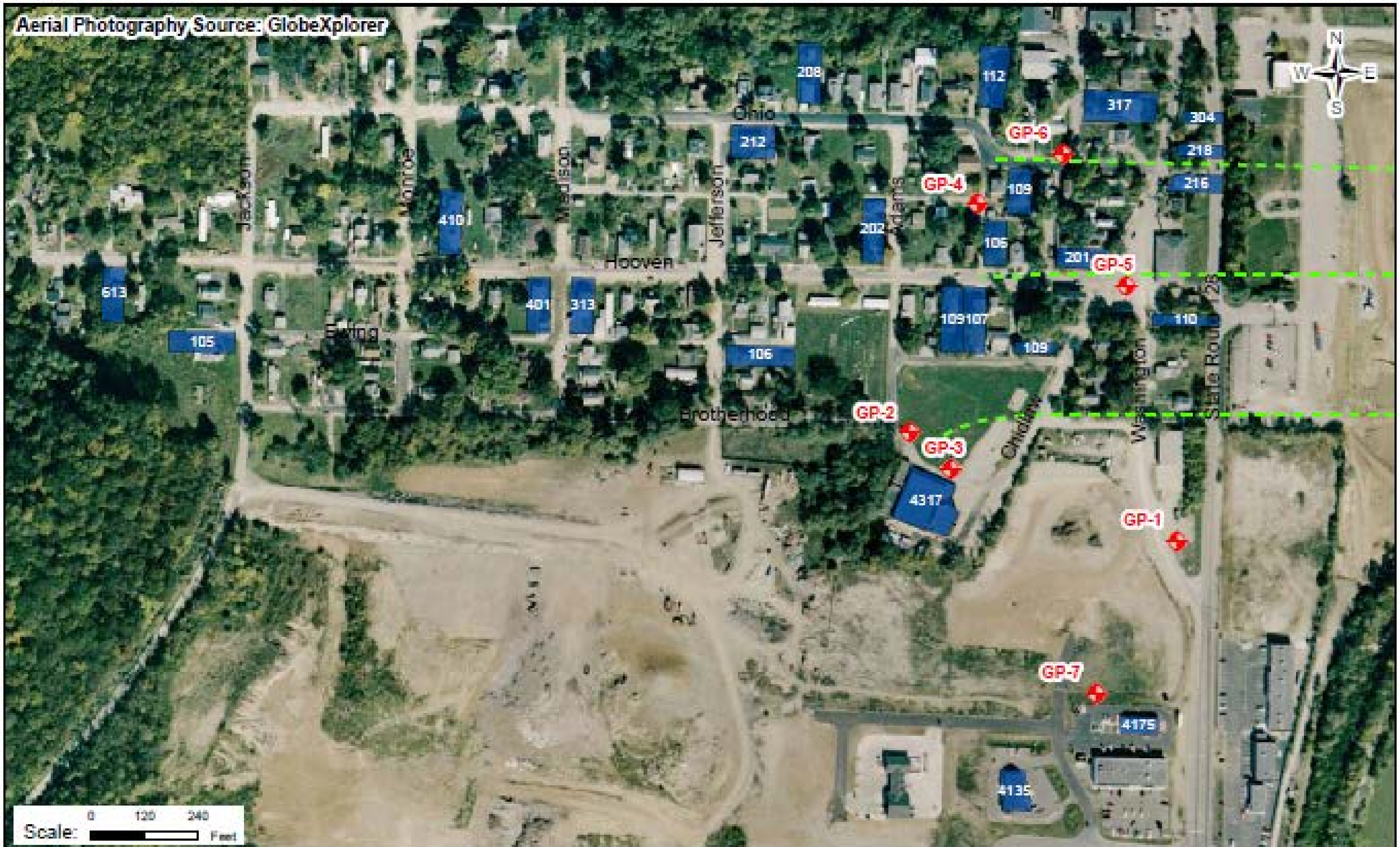


Figure 1

Soil Gas Probe Location Horizontal SVE System (Chevron) Sub-Slab Sample Location	Prepared for: **U.S. EPA REGION V** Contract No: EP-S5-06-04	Prepared by: **WESTON SOLUTIONS, INC.** 10200 Alliance Road, Suite 150 Cincinnati, OH 45242	U.S. EPA VAPOR INTRUSION SAMPLE LOCATION MAP CHEVRON-HOOVEN SITE HOOVEN, HAMILTON COUNTY, OHIO April 11, 2008

Figure 6 U.S. EPA Vapor Intrusion Sample Locations Hooven, OH First Quarter April 2008 Soil Gas Probe Locations

Gas Probe ID	Probe Depth (ft)	Depth to Groundwater
GP-1	10	35.8' bgs
	20	
	30	
GP-2	11	53.6' bgs
	20	
	50	
GP-3	10	Dry hole to 56', refusal, broken rods
	32	
GP-4	10	54.6' bgs
	19	
	50	
GP-5	10	52' bgs
	30	
	47	
GP-6	10	unknown (rods broken at 50')
	19	
GP-7	10	29.4' bgs

Figure 1

Soil Gas Probe Location
Chevron Monitoring Well Location
Horizontal SVE System (Chevron)
Sub-Slab Sample Location

Prepared for:
U.S. EPA REGION V
Contract No: EP-S5-06-04

WESTON
Prepared by:
WESTON SOLUTIONS, INC.
10200 Alliance Road, Suite 150
Cincinnati, OH 45242

U.S. EPA VAPOR INTRUSION
SAMPLE LOCATION MAP
CHEVRON-HOOVEN SITE
HOOVEN, HAMILTON COUNTY, OHIO
September 19, 2008

Figure 7 U.S. EPA Vapor Intrusion Sample Locations Hooven, OH August/September 2008 Monitoring Well Locations

Figure 1

Legend

Vapor Well Sample Location

Sub-Slab Sample Location

Prepared for:
U.S. EPA REGION V
Contract No: EP-S5-06-04

Prepared by:
WESTON SOLUTIONS, INC.
4710-A Interstate Drive
Cincinnati, OH 45246

Quarter 4 Vapor Intrusion
Sample Location Map
Chevron-Hooven Site
Hooven, Hamilton County, Ohio
September 23, 2009

Figure 8 U.S. EPA Vapor Intrusion Sample Locations Hooven, OH September 2009 Vapor Well Locations

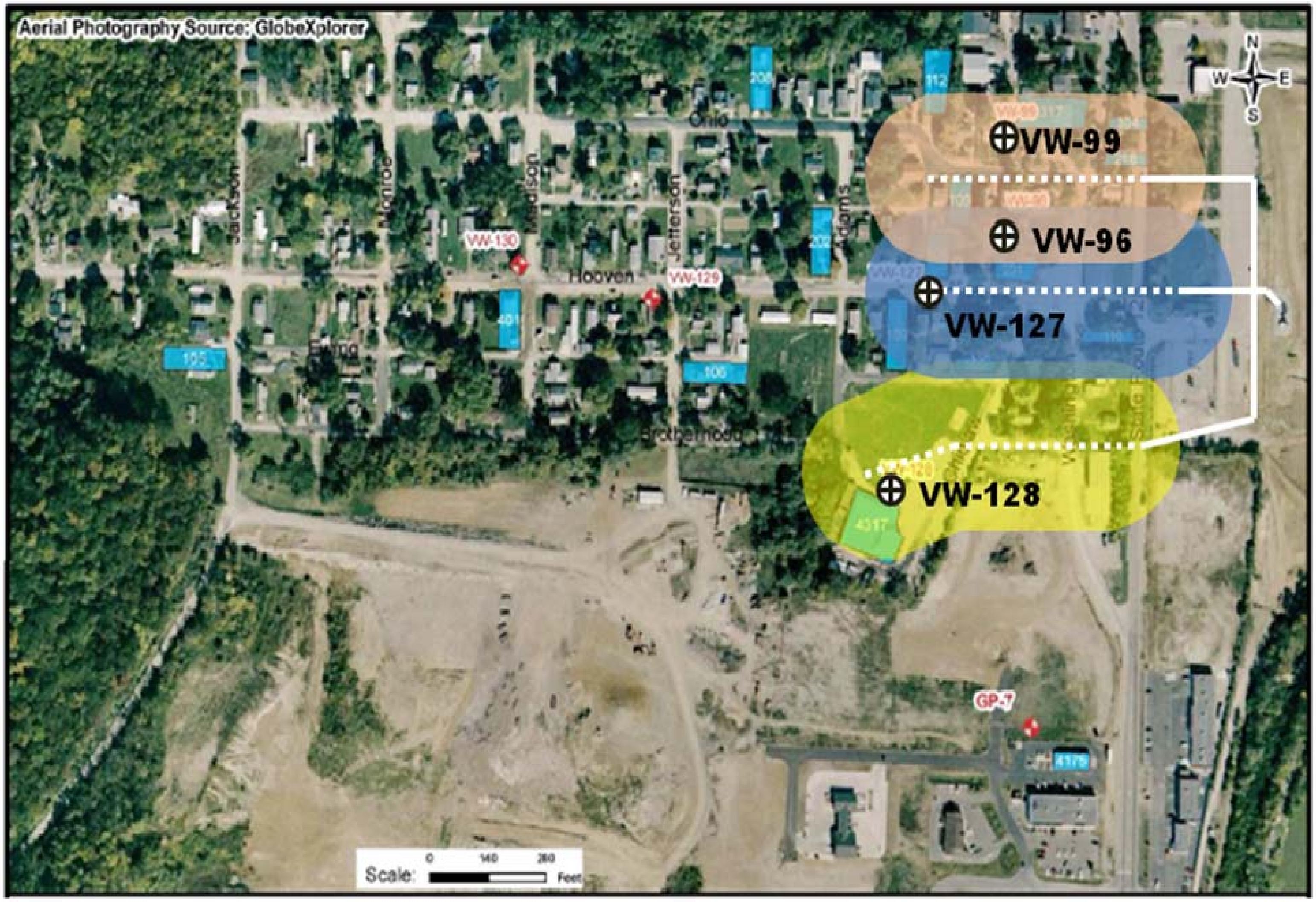


Figure 9 Estimated Zone of Influence of the Horizontal Soil Vapor Extraction (HSVE) System And Vapor Monitoring Well Locations

APPENDIX A

Vapor Intrusion; Answers to Frequently Asked Health Questions, Fact Sheet
http://www.odh.ohio.gov/ASSETS/E26C5AB6C94F402A896325AC3CB7B831/VapIntru.pdf

Benzene; *Answers to Frequently Asked Health Questions*, Fact Sheet
http://www.odh.ohio.gov/ASSETS/B50DD769DEAF483D84C7A06756121521/benzen.pdf

BTEX; *Answers to Frequently Asked Health Questions*, Fact Sheet
http://www.odh.ohio.gov/ASSETS/489EA8FB630C4AB49269A95FB2975DC4/BTEX%20Fact%20Sheet.pdf

Exposure to Toxic Chemicals and Cancer, Fact Sheet
http://www.odh.ohio.gov/ASSETS/BE98561F7DAD454698D12FCBB53A51C7/chemexp.pdf

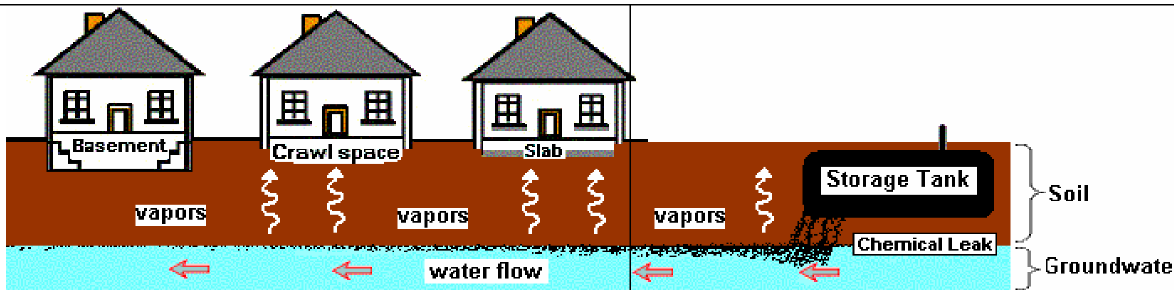
Cancer; *Answers to Frequently Asked Health Questions*, Fact Sheet
http://www.odh.ohio.gov/ASSETS/CF8D9E9718E14C94902C77A1856B07D6/Cancer.pdf

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Vapor Intrusion

Answers to Frequently Asked Health Questions



What is vapor intrusion?

Vapor intrusion refers to the vapors produced by a chemical spill/leak that make their way into indoor air. When chemicals are spilled on the ground or leak from an underground storage tank, they will seep into the soils and will sometimes make their way into the groundwater (underground drinking water). There are a group of chemicals called volatile organic compounds (VOCs) that easily produce vapors. These vapors can travel through soils, especially if the soils are sandy and loose or have a lot of cracks (fissures). These vapors can then enter a home through cracks in the foundation or into a basement with a dirt floor or concrete slab.

VOCs and vapors:

VOCs can be found in petroleum products such as gasoline or diesel fuels, in solvents used for industrial cleaning and are also used in dry cleaning. If there is a large spill or leak resulting in soil or groundwater contamination, vapor intrusion may be possible and should be considered a potential public health concern that may require further investigation.

Although large spills or leaks are a public health concern, other sources of VOCs are found in everyday household products and are a more common source of poor indoor air quality. Common products such as paint, paint strippers and thinners, hobby supplies (glues), solvents, stored fuels (gasoline or home heating fuel), aerosol sprays, new carpeting or furniture, cigarette smoke, moth balls, air fresheners and dry-cleaned clothing all contain VOCs.

Can you get sick from vapor intrusion?

You can get sick from breathing harmful chemical vapors. But getting sick will depend on:
How much you were exposed to (dose).
How long you were exposed (duration).
How often you were exposed (frequency).
How toxic the spill/leak chemicals are.
General Health, age, lifestyle: Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

VOC vapors at high levels can cause a strong petroleum or solvent odor and some persons may experience eye and respiratory irritation, headache and/or nausea (upset stomach). These symptoms are usually temporary and go away when the person is moved to fresh air.

Lower levels of vapors may go unnoticed and a person may feel no health effects. A few individual VOCs are known carcinogens (cause cancer). Health officials are concerned with low-level chemical exposures that happen over many years and may raise a person's lifetime risk for developing cancer.

How is vapor intrusion investigated?

In most cases, collecting soil gas or groundwater samples near the spill site is done first to see if there is on-site contamination. If soil vapors or groundwater contamination are detected at a spill site, environmental protection and public health officials may then ask that soil vapor samples be taken from areas outside the immediate spill site and near any potential affected business or home. The Ohio Department of Health (ODH) does not usually recommend indoor air sampling for vapor intrusion before the on-site contamination is determined.

(continued on next page)

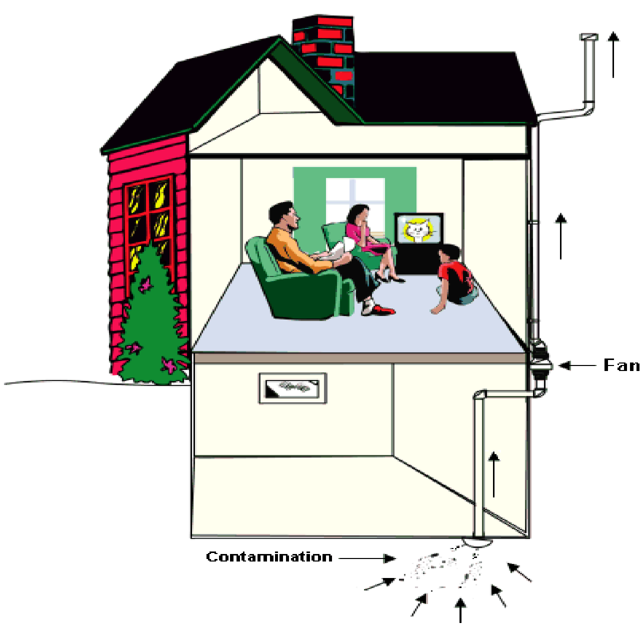
How is vapor intrusion investigated? (continued)

Because a variety of VOC sources are present in most homes, testing will not necessarily confirm VOCs in the indoor air are from VOC contamination in soils at nearby spill site. But if additional sampling is recommended, samples may be taken from beneath the home's foundation (called sub-slab samples), to see if vapors have reached the home. Sub-slab samples are more reliable than indoor air samples and are not as affected by other indoor chemical sources. If there was a need for additional sampling on a private property, homeowners would be contacted by the cleanup contractor or others working on the cleanup site and their cooperation and consent would be requested before any testing/sampling would be done.

What happens if a vapor intrusion problem is found?

If vapor intrusion is having an effect on the air in your home, the most common solution is to install a *radon mitigation system*. A radon mitigation system will prevent gases in the soil from entering the home. A low amount of suction is applied below the foundation and the vapors are vented to the outside. The system uses minimal electricity and should not noticeably affect heating and cooling efficiency. This mitigation system also prevents radon from entering the home, an added health benefit. Usually, the party responsible for cleaning up the contamination is also responsible for paying for the installation of this system. Once the contamination is cleaned up, the system should no longer be needed. In homes with on going radon problems, ODH suggests these systems remain in place permanently.

Radon Mitigation System



What can you do to improve your indoor air quality?

As stated before, the most likely source of VOCs in indoor air comes from the common items that are found in most homes. The following helpful hints will help improve air quality inside your home:

- Do not buy more chemicals than you need and know what products contain VOCs.
- If you have a garage or an out building such as a shed, place the properly stored VOC-containing chemicals outside and away from your family living areas.
- Immediately clean and ventilate any VOC spill area.
- If you smoke, go outside and/or open the windows to ventilate the second-hand, VOC-containing smoke outdoors.
- Make sure all your major appliances and fireplace(s) are in good condition and not leaking harmful VOC vapors. Fix all appliance and fireplace leaks promptly, as well as other leaks that cause moisture problems that encourage mold growth.
- Most VOCs are a fire hazard. Make sure these chemicals are stored in appropriate containers and in a well-ventilated location and away from an open pilot light (flame) of a gas water heater or furnace.
- Fresh air will help prevent both build up of chemical vapors in the air and mold growth. Occasionally open the windows and doors and ventilate.
- Test your home for radon and install a radon detector.

References:

Wisconsin Department of Health and Family Services, Environmental Health Resources, Vapor Intrusion, electronic, 2004.

New York State Department of Health, Center for Environmental Health, April 2003.

Ohio Department of Health, Bureau of Environmental Health, Indoor Environment Program, 2004.

For more information contact:

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Bureau of Environmental Health
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Columbus, Ohio 43215
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Fax: (614) 466-4556

Created September 2004

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Benzene (ben' zeen)

Answers to Frequently Asked Health Questions

What is benzene?

Benzene, also known as benzol, is a colorless liquid with a sweet odor. It is highly flammable and evaporates in the air quickly.

Where do you find benzene?

Most everyone is exposed to low levels of benzene in their every day activities. People are exposed to small amounts of benzene in the air outside, at work and in the home.

Benzene is a natural part of crude oil, gas and cigarette smoke. Auto exhaust and industrial emissions account for about 20% of the total nationwide exposure to benzene. About 50% of the entire nationwide exposure to benzene results from smoking tobacco or from 2nd hand exposure to tobacco smoke. Other natural sources of benzene include volcanoes and forest fires.

The outdoor air has low levels of benzene that come from the car exhaust, gas fumes and cigarette smoke. Indoor air usually contains higher levels of benzene that can be found in cigarette smoke, glues, paints, furniture wax and detergents.

Benzene is widely used in U.S. industry. Some industries use benzene to make other chemicals which are used to make plastics, resins, nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs and pesticides.

How do you come in contact with unhealthy levels of benzene?

In the air:

- Higher levels of benzene can be released in the air around industries that make or use benzene.

In the underground drinking water:

- If underground storage tanks containing benzene leak, benzene could get into the underground well water and pollute it.

Occupation (job):

- Working in an industry that makes or uses benzene.

Can benzene make you sick?

Yes, you can get sick from benzene. Getting sick will depend on:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- General Health, Age, Lifestyle
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How does benzene affect health?

Breathing benzene:
Breathing high levels of benzene can cause rapid heart rate, dizziness, headaches, tremors (shaking), confusion, drowsiness (sleepy), and unconsciousness (passing out). Breathing extremely high levels of benzene can result in death.

Eating or drinking benzene:
Eating foods or drinking water containing high levels of benzene can cause an irritated (upset) stomach, vomiting, rapid heart rate, dizziness, convulsions (severe shaking), sleepiness and death.

Long-term exposure to benzene:
Long-term exposure (365 days or longer) to high levels of benzene causes serious problems with the production of blood. Benzene harms the bone marrow which produces the body's red and white blood cells. Red blood cells carry oxygen and white blood cells fight infection. A decrease in red blood cells leads to anemia. A decrease in white blood cells affects the immune system and increases the chance for infection.

Women exposed to benzene:
Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. It is not known whether benzene exposure affects the developing fetus in pregnant women or fertility in men.

Does benzene cause cancer?

Yes, the Department of Health and Human Services (HHS) has determined that benzene is a known human carcinogen (causes cancer).

Long-term exposure to high levels of benzene in the air can lead to leukemia and cancers of the blood-forming organs.

Is there a medical test to show whether you have been exposed to benzene?

Several tests can show if you have been exposed to benzene. However, all these tests must be done shortly after exposure because benzene leaves the body quickly. These tests include testing the breath, blood and urine. However, the urine test may not be as effective to measures benzene levels.

Note that all these tests will show the amount of benzene in your body but cannot tell you whether you will have any harmful health problems. They also do not tell you where the benzene came from.

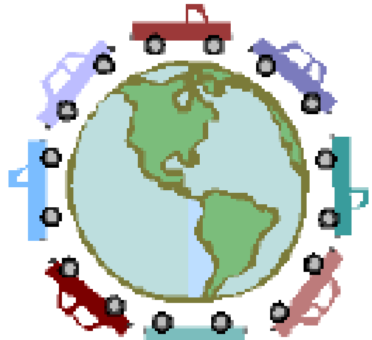
What has been done to protect human health?

The Occupational Safety and Health Administration (OSHA) has set a permissible 1 ppm exposure limit of air in the workplace during an 8-hour workday, 40-hour week.

The Environmental Protection Agency (EPA) has set the maximum permissible level of benzene in drinking water at 0.005 parts per million (ppm).

The EPA requires benzene spills or accidental releases into the environment of 10 pounds or more of be reported to the EPA.

Most people can begin to smell benzene in air at 1.5 - 4.7 parts of benzene parts per million (ppm) and smell benzene in water at 2 ppm. Most people can begin to taste benzene in water at 0.5 - 4.5 ppm.



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Reference:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for benzene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2006.

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

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Revised 08/07/09

Bureau of Environmental Health
Health Assessment Section
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BTEX

Benzene, Toluene, Ethylbenzene, and Xylenes

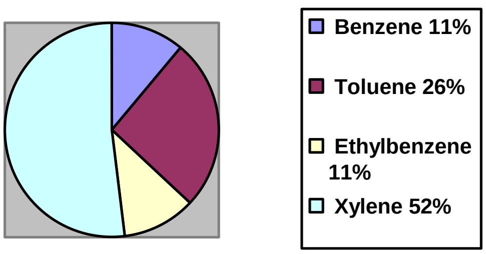
What is BTEX?

BTEX is not one chemical, but are a group of the following chemical compounds:

Benzene, **T**oluene, **E**thylbenzene and **X**ylenes.

BTEX are made up of naturally-occurring chemicals that are found mainly in petroleum products such as gasoline. Refineries will change the amounts of these chemical compounds to meet vapor pressure and octane standards for gasoline. Besides gasoline, BTEX can be found in many of the common household products we use every day.

BTEX Breakdown



BTEX typically make up about 18% of gasoline.

What are some products that contain BTEX?

Benzene can be found in gasoline and in products such as synthetic rubber, plastics, nylon, insecticides, paints, dyes, resins-glues, furniture wax, detergents and cosmetics. Auto exhaust and industrial emissions account for about 20% of the total nationwide exposure to benzene. Benzene can also be found in cigarette smoke. About 50% of the entire nationwide exposure to benzene results from smoking tobacco or from 2^{nd} hand exposure to tobacco smoke.

Toluene occurs naturally as a component of many petroleum products. Toluene is used as a solvent for paints, coatings, gums, oils and resins.

Ethylbenzene is used mostly as a gasoline and aviation fuel additive. It may also be present in consumer products such as paints, inks, plastics and pesticides.

There are three forms of **Xylene:** ortho-, meta-, and para-. Ortho-xylene is the only naturally-occurring form of xylene; the other two forms are man-made. Xylenes are used in gasoline and as a solvent in printing, rubber and leather industries.

BTEX are in a class of chemicals known as volatile organic compounds (VOCs). VOC chemicals easily vaporize or change from a liquid to a vapor (gas). The VOC vapors can travel through the air and/or move through contaminated groundwater and soils as vapors, possibly impacting indoor air quality in nearby homes or businesses.

Where do you find BTEX?

Most people are exposed to small amounts of BTEX compounds in the ambient (outdoor) air, at work and in the home. Most everyone is exposed to low levels of these chemicals in their everyday activities. People who live in urban areas (cities) or by major roads and highways will likely be exposed to more BTEX than someone who lives in a rural (country) setting.

Besides common everyday exposures, larger amounts of BTEX can enter the environment from leaks from underground storage tanks, overfills of storage tanks, fuel spills and landfills. BTEX compounds easily move through soils and can make their way into the groundwater, contaminating public and private water systems and the soils in between.

Can exposure to BTEX make you sick?

Yes, you can get sick from exposure to BTEX. But getting sick will depend on:

- <u>How much</u> you were exposed to (dose).
- <u>How long</u> you were exposed (duration).
- <u>How often</u> you were exposed (frequency).
- <u>General Health, Age, Lifestyle</u>
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How are you exposed to BTEX?

Exposure can occur by either drinking contaminated water (ingestion), by breathing contaminated air from pumping gas or from the water via showering or laundering (inhalation) or from spills on your skin (dermal).

How does BTEX affect health?

Acute (short-term) exposure to gasoline and its components benzene, toluene and xylenes has been associated with skin and sensory irritation, central nervous system-CNS problems (tiredness, dizziness, headache, loss of coordination) and effects on the respiratory system (eye and nose irritation).

On top of skin, sensory and CNS problems, prolonged exposure to these compounds can also affect the kidney, liver and blood systems.

Do BTEX compounds cause cancer?

In the absence of data on the cancer-causing nature of the whole mixture (benzene, toluene, ethylbenzene and xylenes), possible health hazards from exposures to BTEX are assessed using an individual component-based approach of the individual chemicals.

Benzene: The Department of Health and Human Services (HHS) has determined that benzene is a known human carcinogen (causes cancer). Workers exposed to high levels of benzene in occupational settings were found to have an increase occurrence of leukemia. Long-term exposure to high levels of benzene in the air can lead to leukemia and cancers of the blood-forming organs.

Ethylbenzene: According to the International Agency for Research on Cancer (IARC), ethylbenzene classified as a Group 2B, possibly carcinogenic to humans, based on studies of laboratory animals.

Toluene, and Xylenes have been categorized as not classifiable as to human carcinogenicity by both EPA (IRIS 2001) and IARC (1999a, 1999b), reflecting the lack of evidence for the carcinogenicity of these two chemicals.

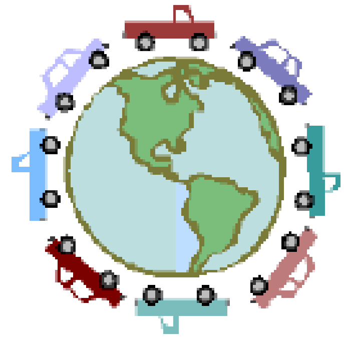
Is there a medical test to show whether you have been exposed to BTEX?

Several tests can show if you have been exposed to BTEX. Components of BTEX can be found in the blood, urine, breath and some body tissues of exposed people. However, these tests need to be done within a few hours after exposure because these substances leave the body very quickly. The most common way to test for ethylbenzene is in the urine. However, the urine test may not be as effective to measures benzene levels.

Note these tests will perhaps show the amount of BTEX in your body, but they cannot tell you whether you will have any harmful health problems. They also do not tell you where the benzene came from.

How can families reduce the risk of exposure to BTEX?

- Use adequate ventilation to reduce exposure to BTEX vapors from consumer products such as gasoline, pesticides, varnishes, paints, resins-glues and newly installed carpeting.
- Household chemicals should be stored out of reach of children to prevent accidental poisoning. Always store household chemicals in their original containers; never store them in containers that children would find attractive to eat or drink from, such as old soda bottles. Gasoline should be stored in a gasoline can with a locked cap.
- Volatile chemicals should be stored outside the home if possible – in a separate garage or shed.
- Don't smoke indoors with doors and windows closed.



For more information contact:

Ohio Department of Health
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Health Assessment Section
246 N. High Street
Columbus, Ohio 43215
Phone: (614) 466-1390
Fax: (614) 466-4556

References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for benzene. U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological profile for ethylbenzene. U.S. Department of Health and Human Services, Public Health Service.

Maryland Department of the Environment (MDE). 2007. BTEX.

Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Interaction Profile for Benzene, Toluene, Ethylbenzene and Xylene (BTEX). U.S. Department of Health and Human Services, Public Health Service.

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

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Revised 08/07/09

Comprehensive Cancer Program
Division of Prevention

"To protect and improve the health of all Ohioans"

Exposure to Toxic Chemicals and Cancer

How are we exposed to chemicals in our environment?

We come in contact with many different chemicals every day that generally do not cause health problems. But any chemical can become toxic if a person comes into contact with large enough doses. For example: aspirin will cure a headache, but too much aspirin becomes toxic and can cause serious health problems. Contact with toxic chemicals does not always cause adverse (negative) health effects. Whether you get sick as a result of a chemical exposure depends on:

- How toxic the chemicals are;
- How much you were exposed to (dose);
- How long you were exposed (duration);
- How often you were exposed (frequency);
- Your general health, age and lifestyle. Young children, the elderly and people with chronic (ongoing) health problems are more at risk to health problems following exposures to chemicals.

What is a completed exposure pathway?

Chemicals must have a way to get into a person's body in order to cause health problems. Environmental scientists work to show the five links between a chemical source and the people who are exposed to a chemical. In order for a person to get sick from contact with chemicals, a "Completed Exposure Pathway" must be present.

The five links that make a completed exposure pathway include:

(1) Source (where the chemical came from);
(2) Environmental Transport (the way the chemical moves from the source to the public. This can take place through the soil, air, underground drinking water or surface water);
(3) Point of Exposure (where contact with the chemical is made. This could be where chemical contamination occurred or off-site if the contamination has moved);
(4) Route of Exposure (how people came into physical contact with the chemical. This could occur by drinking, eating, breathing or touching the chemical);
(5) People Who Might be Exposed (those who are most likely to come into physical contact with a chemical).

Documenting a completed exposure pathway:

Documenting a completed exposure pathway can link a chemical exposure with a health problem such as cancer. But it is difficult to study communities living near chemical contamination sites and link their health problems with exposure to a chemical. A few of the difficulties include:

- Not knowing the exact level of a person's exposure to a cancer-causing chemical. This is especially true if the exposure to chemicals occurred years ago and there is no information to prove the exposure;
- Chemical contamination sites often contain more than one chemical. This makes it difficult to link a health problem to a single exposure or chemical;
- Scientists who study communities will also look at other factors before linking a disease to an exposure from a site. Cancer often takes a long time to develop and getting information on the type of past behaviors that increase the risk of getting cancer (such as tobacco use, alcohol consumption and diet) are often difficult or sometimes impossible to collect.

Do toxic chemicals cause cancer?

Yes, some chemicals are known to be carcinogenic (cause cancer). But it is important to know that less than 5% of all cancers are believed to be due to factors in the environment such as environmental pollution (2%), industrial products (1%) or food additives (1%).

Toxic chemicals are cancer risk factors. A risk factor is anything that could increase a person's chance of getting a disease. Cancer risk factors, such as tobacco use, drinking a lot of alcohol, having a poor diet, lack of physical activity and unprotected exposure to the sun, can be changed. Other cancer risk factors such as a person's age, sex and family medical history (genetics) cannot be changed.

The Ohio Department of Health works closely with the Agency for Toxic Substance and Disease Registry (ATSDR), the U.S. EPA and Ohio EPA, local health departments and concerned communities to investigate and prevent harmful exposures and disease related to toxic substance in the environment.

IMPORTANT FACTS: Cigarette smoke contains 43 known cancer-causing chemicals. In 2003, the U.S. EPA Superfund program prepared a list of the 275 chemicals found at chemical contamination sites throughout the nation. Six of the top 10 chemicals found at chemical contamination sites are also found in cigarette smoke.

A List of Known[1] and Possible[2] Human Carcinogenic (cancer-causing) Agents by Organ

Organ	Known Human Carcinogen	Possible Human Carcinogen
Bladder	* Arsenic * Benzidine * Cadmium * Tobacco smoke	* Tetrachloroethylene (PERC or PCE)
Blood Diseases (leukemia, lymphoma)	* Benzene * Ionizing Radiation	* Trichloroethylene (TCE) * Vinyl chloride
Brain		* Vinyl chloride
Colon	* Arsenic	
Kidney	* Arsenic * Coke oven emissions	* Tetrachloroethylene (PERC or PCE) * Chloroform * Trichloroethylene (TCE)
Liver	* Alcoholic drinks * Vinyl chloride	* Chlordane * Chloroform * Dieldrin * Polychlorinated Biphenyls (PCBs) * Trichloroethylene (TCE)
Lung	* Arsenic * Asbestos * Beryllium * Cadmium * Chromium (Hexavalent) * Coke oven emissions * Tobacco smoking * Uranium - Radon	* Benzo(a)pyrene * Polycyclic aromatic hydrocarbons (PAHs) * Vinyl chloride
Mouth, Pharynx, Larynx, Esophagus	* Alcoholic drinks * Chewing tobacco (mouth only) * Tobacco smoke	
Skin	* Arsenic * Overexposure to the sun	* Benzo(a)pyrene * Polycyclic aromatic hydrocarbons (PAHs) * Tetrachloroethylene (PERC or PCE)

[1] The category *"known human carcinogen"* requires evidence from human studies.

[2] The category *"possible human carcinogen"* gathers evidence mainly from animal studies. There may be limited human studies or there may be no human or animal study evidence to support carcinogenicity; but the agent, substance or mixture belongs to a well-defined class of substances that are known to be carcinogenic.

Note: Due to limited space, the above table is not a complete listing of all the known and possible human carcinogens. The top 20 chemicals listed in this table can be found in the 2003 U.S. EPA Superfund, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) listing of chemicals found at chemical contamination sites placed on the National Priorities List (NPL).

- To see a full listing of known and possible carcinogens, you can review the National Toxicology Program, Report on Carcinogens, Eleventh Edition or visit online (see below reference).
- To see a full listing of the chemicals found at National Priorities List (NPL) sites, you can review the 2003 CERCLA Priority List of Hazardous Substances report or visit online (see below reference).

References:

- American Cancer Society, 2004.
- Ohio Department of Health, Comprehensive Cancer Program, 2004.
- Agency for Toxic Substances and Disease Registry, 2003 CERCLA Priority List of Hazardous Substances (2005 electronic at **www.atsdr.cdc.gov/cercla/**).
- Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2005 (2005 electronic at **http://ntp.niehs.nih.gov/ntp/roc/toc11.html**).

For more information contact:

Ohio Department of Health
Bureau of Environmental Health
Health Assessment Section
(614) 466-1390

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Toll-free at 1-888-422-8737

Revised January 2007

Comprehensive Cancer Program
Division of Prevention

"To protect and improve the health of all Ohioans"

Cancer

Answers to Frequently Asked Health Questions

What is cancer?

Cancer is the irregular growth of abnormal cells. In the human body, normal cells grow, divide and die in a normal process. Cancer cells outlive normal cells and continue to grow and make new abnormal cells.

Cancer cells will clump together and form tumors. These tumors can invade and destroy normal cells and tissue. Tumors can be malignant (cancerous) or benign (non-cancerous).

Cancer cells can travel (metastasize) through the blood or the lymph system to other areas of the body where they can settle and form new tumors. Some cancers, such as leukemia, do not form tumors but invade the blood and blood-forming organs. Benign (non-cancerous) tumors do not spread to other parts of the body and are usually not life-threatening.

In many cases, the exact cause of cancer is not known. We know certain changes in our cells can cause cancer to start but we don't yet know exactly how this happens. Many scientists and health professionals study cancer in the hope they can discover the causes and a cure. But, there are a lot things we **do** know about cancer.

Who gets cancer?

Cancer may strike at any age. However, cancer is mostly a disease of middle and old age. In Ohio, about 86% of cancers were diagnosed in people age 50 and older in 2000.

Cancer is the second-leading cause of death in the United States. It is estimated that <u>half of all men</u> and <u>one-third of all women</u> in the United States will develop cancer during their lifetimes.

In 2003, about 60,300 Ohioans – or 165 Ohioans per day – were diagnosed with cancer. More than 25,200 Ohioans – or about 69 people each day – died from it.

What are cancer risk factors?

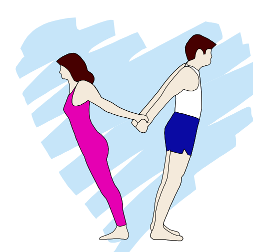
A risk factor is anything that increases a person's chance of getting a disease. Some risk factors, such as tobacco use, can be changed, and others, such as age, cannot.

Having a risk factor for cancer means a person is more likely to develop the disease at some point in his or her life. However, having one or more risk factors does not always mean a person will get cancer. Some people with one or more risk factors never develop the disease, while other people who develop cancer have no apparent risk factors. Even when a person who has a risk factor is diagnosed with cancer, there is no way to prove the risk factor actually caused the cancer. In reality, getting cancer is probably due to the combination of risk factors rather than one single factor.

Risk factors for cancer include a person's age, sex and family medical history (genetics). Other major factors are related to lifestyle choices such as using tobacco, drinking a lot of alcohol, eating a poor diet, lack of physical activity and unprotected exposure to the sun. Occupational (work) exposures can be another risk factor.

Using tobacco products, a poor diet and lack of physical activity account for about 65% of cancer deaths. Less than 5% of cancers are believed to be due to factors in the environment such as environmental pollution (2%), industrial products (1%) or food additives (1%).

The risk of developing most types of cancers can be reduced by changes in a person's lifestyle. By quitting smoking, eating healthier and exercising, you can reduce your risk of developing cancer.



Risk factors (continued)

Different kinds of cancer have different risk factors. Some of the common cancers and their risk factors include the following:

- Lung cancer: **Tobacco smoking is responsible for 80 to 85 percent of lung cancers.** Note: Tobacco use (including cigarettes, cigars, chewing tobacco and snuff) is also related to cancers of the mouth, larynx, cervix, bladder, kidney, esophagus and pancreas. Other important risk factors for lung cancer include exposure to radon and asbestos; a history of tuberculosis and some types of pneumonia; and family history.
- Breast cancer risk factors include: Increasing age; hormone-related factors such as early age at first menstruation, fewer number of pregnancies and late age at menopause; obesity; and lack of physical activity. Also, women with a mother or sister who have had breast cancer are more likely to develop the disease themselves (genetics). **All women 40 years and older should get a yearly mammogram and perform monthly self-examinations.**
- Prostate cancer: All men are at risk for prostate cancer. Prostate cancer is more common among African-American men compared to white men. Also, men with a father or brother who have had prostate cancer are more likely to get prostate cancer themselves (genetics). **All men 50 years and older should talk with their doctor about being tested.**
- Colon and Rectum cancer risk factors include: Increasing age (persons 50 years and older); a diet high in animal fat; lack of exercise; and obesity. **Women and men should be screened for colorectal cancer beginning at age 50.**
- Skin cancer is related to unprotected exposure to strong sunlight and severe sunburns as a child**. To protect against skin cancer use sunscreen, wear protective clothing and avoid direct sunlight between 10 a.m. and 4 p.m.**
- Cervical cancer risk factors include: infection with a certain sexually transmitted disease (STD) called the Human Papilloma Virus (HPV); smoking; and being HIV positive. **It is important for women to receive regular Pap tests because they can detect HPV and pre-cancerous cells.**

How is cancer treated?

Cancer is a group of diseases that behave very differently. For example, lung cancer and breast cancer develop and grow at different rates and respond to different treatments. That is why people with cancer need treatment that is aimed at their particular kind of cancer.

The patient is a vital part of his or her cancer care team. Patients and families should talk with their health care providers about which treatment choices are best. Today, millions of people are living with cancer or have been cured of the disease. **The sooner a cancer is found and the sooner treatment begins, the better a patient's chances are of a cure.** That is why early detection is such an important weapon in the fight against cancer.

Learn more about cancer:

Cancer is the second-leading cause of death among adults in Ohio following heart disease.

According to a survey released at the 11th Annual Research Conference of the American Institute for Cancer Research (AICR), cancer is the No. 1 day-to-day health concern in America. Additionally, half of all Americans believe it is impossible or next to impossible to prevent cancer. But this is not true and in many cases, cancer can be prevented.

The Ohio Department of Health wants to help Ohioans learn more about cancer, including how to prevent it, how to find it early and how to get treatment if needed.

Through coordination and working together we will make a difference in the health and quality of life in our state.

References:

American Cancer Society, http://www.cancer.org, 2003.

Winauer SJ, Shike M. Cancer Free: The Comprehensive Cancer Prevention Program. New York: Simon and Shuster, 1995.

Ohio Department of Health, Comprehensive Cancer Program, 2003.

American Institute for Cancer Research, July, 2001.

For more information:

If you have questions or if you need information that is not available on this fact sheet, please contact one of the following organizations:

Ohio Department of Health
(614) 728-7418
American Cancer Society
1-800-ACS-2345 or 1-800-227-2345
Ohio Radon Program
1-800-523-4439
National Cancer Institute
1-800-422-6237

APPENDIX B

Recommended Screening Levels for VOCs in Residential Structures
Chevron Hooven Site, Hooven, Hamilton County, Ohio
With comparison column with Hartford, IL site

Chemical	Short-term Action Level Indoor Air (ppb)	Short-term Action Level Sub-slab (ppb)	Long-term Screening Level Indoor Air (ppb)	Long-term Screening Level Sub-slab (ppb)	Hartford Indoor Air CV (ppb)
Benzene	6 (Intermediate)	60	3	30	3 chronic 9 acute
Toluene	1,000 (Acute)	10,000	110	1,100	80
Ethylbenzene	1,000 (Intermediate)	10,000	51	510	Removed 230
m,p-Xylene	600 (Intermediate)	6,000	1,600	16,000	Total Xylene 100
o-Xylene	600	6,000	1,600	16,000	
1,3,5-Trimethylbenzene	NA	---	1.2	12	Total Trimethylbenzene 1.2
1,2,4-Trimethylbenzene	NA	---	1.2	12	
2,2,4-Trimethylpentane (isooctane)	NA	---	NA	NA	-
Naphthalene	0.7 (Chronic)	7	0.57	5.7	-
MTBE	700 (Intermediate)	7,000	700	7,000	Removed 700
Acetone	13,000 (Intermediate)	130,000	150	1,500	-
2-Butanone (MEK)	NA	---	340	3,400	-
Carbon tetrachloride	30	3,000	2.6	26	-
TCE	100 (Intermediate)	1,000	0.4	4	-
PCE	200 (Acute)	2,000	12	120	-
Butylbenzene	NA	---	26	260	-
Chloroform	50 (Intermediate)	500	2.2	22	-
Cyclohexane	NA		NA	NA	-
Methylcyclohexane					750
n-Hexane					55
1,3-Butadiene					1

- Units: Concentration is in parts per billion (ppb).
- Short–term Action Levels: ATSDR Intermediate MRL if available; otherwise, the ATSDR Acute MRL. Air Comparison Values in ppb (for VOC Compounds Only). February 20, 2007.
- Long-term Screening Levels: US EPA Draft Vapor Intrusion Guidance document (2002)
- [Target Indoor air concentration at the 10^{-4} Risk Level]
- Note: The screening level for benzene was based on the US EPA Integrated Risk Information System (IRIS) inhalation unit risk value for benzene calculated for a 1 in 10,000 lifetime risk. The air concentration of 13.0 $\mu g/m^3$ (4 ppb) was applied as a screening value, instead of using the 2002 US EPA vapor intrusion target concentration of 9.8 ppb (Risk = 1×10^{-4}). The sub-slab screening value (98 ppb) was taken from the OSWER table.
- The screening levels for known or suspected human carcinogens (benzene, carbon tetrachloride, TCE, PCE and chloroform) were based on cancer risk of 1×10^{-4}.

CERTIFICATION

The Ohio Department of Health prepared this Public Health Consultation, for the Former Chevron Refinery site, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). At the time this Public Health Consultation was written, it was in accordance with approved methodology and procedures. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

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

Team Leader, Cooperative Agreement Team, CAPEB, DHAC, ATSDR