Health Consultation

SUTTON BROOK: BEMIS CIRCLE RESIDENCE

CITY OF TEWKSBURY, MIDDLESEX COUNTY, MASSACHUSETTS

EPA FACILITY ID: MAD980520696

APRIL 29, 2005

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR 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 which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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TEWKSBURY, MIDDLESEX COUNTY, MASSACHUSETTS

EPA FACILITY ID: MAD980520696

Prepared by:
Environmental Toxicology Program
Center for Environmental Health
Massachusetts Department of Public Health
Under Cooperative Agreement with the
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BACKGROUND AND STATEMENT OF ISSUES

This is the second health consultation prepared by the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) for the same residence on Bemis Circle in Tewksbury, Massachusetts. The CEH programs that conducted this consultation included the Environmental Toxicology Program (ETP) and Emergency Response/Indoor Air Quality Program (ER/IAQ). The goal of this health consultation was to evaluate information gathered by MDPH during a site visit in 2004 aimed at advising residents on ways to reduce opportunities for exposure to contaminants identified in a previous ETP consultation.

The first health consultation, completed in July 2001, was requested by the United States Environmental Protection Agency (EPA) Region 1 to determine if levels of compounds found at a residence posed a health concern (see Appendix A). The residence is located approximately 1000 feet from the Sutton Brook Disposal Area (also known as Rocco's Landfill), which had been proposed for the National Priorities List (NPL) at the time MDPH had initiated the data review. The Disposal Area contains a former landfill used to dispose of municipal, commercial, and solid waste as well as a drum disposal area. In June 2001, EPA added the site to the NPL. Possible human exposures associated with this site were evaluated in the separate Sutton Brook Disposal Site Public Health Assessment, which was released in May 2003 (MDPH 2003).

In response to the EPA request, sampling data collected in 2000 by EPA from soil, soil gas, indoor air, groundwater, and nearby surface water at the residence were evaluated to assess the likelihood that contaminants at the property could pose health concerns for residents. Based on a review of the EPA data, MPDH conclusions included the following:

1. Several aldehyde chemicals found in indoor air, as well as other aldehydes, may have presented a health concern. Although levels of each chemical appeared to be lower than those at which health effects have usually been observed, total levels of the chemicals could have been irritating to very sensitive individuals. Individuals sensitized to formaldehyde may react at lower levels than the general population. Evaluation by a physician trained in environmental medicine may help determine whether formaldehyde or other aldehyde sensitization has occurred in any concerned residents.

2. Since the three aldehyde chemicals found exceeding their air comparison values indoors were not detected, or detected at lower levels, in outdoor air, and because these chemicals are commonly found in consumer products, it seemed likely that their source was within the home. Consumer products such as insulation, particleboard, and fabric preservative, contain formaldehyde. Gas stoves, fireplaces, and smoking are also common sources of aldehyde chemicals. MDPH recommended that further evaluation of the home (particularly indoor air tests with the windows closed) be conducted to help identify the sources of these chemicals.

3. Soil gas contained some volatile organic compounds. However, residents were unlikely to be exposed to soil gases, which disperse rapidly in ambient air, unless these gases concentrated in indoor air. Since these VOCs were at trace levels in the soil gas, and were not detected in air sampling, they were unlikely to present a health concern to residents of this home.

4. Nearby surface water and groundwater contained VOCs at levels below drinking water comparison values. In air testing outside and inside the residence, these chemicals were not detected at levels exceeding their comparison values. Therefore they were unlikely to present a health concern to residents at this location.

MDPH recommended that if residents felt they may have been experiencing health problems, they should pursue medical follow-up with an appropriate specialist to determine whether they may be sensitized to formaldehyde or other aldehyde compounds. MDPH also noted that at the request of the residents the Department would conduct a home visit to further evaluate potential sources of the chemicals detected in indoor air and if found, advise residents on ways to reduce opportunities for exposure.

In winter 2004, the resident contacted MDPH and requested a home visit to evaluate potential sources of the chemicals detected in indoor air and if found, to provide advice on ways to reduce opportunities for exposure. Hence, this health consultation contains results of the MDPH home visit. In addition, MDPH evaluated indoor air quality data generated by EPA in March 2001 and not previously evaluated by the department. MDPH prepared this health consultation under its cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

SITE DESCRIPTION

The residence is a single-family, wood frame, vinyl sided house originally built in the 1950s as a single-family home. The house has two floors. The upper floor contains the living room, bathroom, TV room, master bedroom, doll display room, and a kitchen. The lower floor is a partially finished basement that contains a room used to store a large quantity of art supplies (e.g., paints, glues), a laundry room, a furnace room, and an oil tank closet. The basement floor and foundation are made of cement. The foundation wall was found to be continuous, and upon visual inspection, free of cracks and moisture. Foundation and floor penetrations for drains and pipes were sealed and free of degradation. An unused washing machine that is connected to the sewer system is located in the unfinished section of the basement. An open-ended pipe that leads through the foundation is also located in this area.

The house is located approximately 20 feet from the curb of Bemis Circle, a dead-end street in Tewksbury, MA. The land behind the home contains an in-ground swimming pool. The land behind the swimming pool slopes away into a wetland area towards Sutton Brook and the Sutton Brook Disposal Area.

HOME VISIT

On April 14, 2004, the director of CEH's Emergency Response/Indoor Air Quality Program, and a senior environmental analyst with CEH's Environmental Toxicology Program performed a home visit. CEH staff were accompanied by Richard E. Doherty, P.E., L.S.P. from Engineering & Consulting Resources, Inc., an environmental consultant to the resident. The home visit was conducted according to a protocol developed specifically for the Bemis residence (see Appendix B).

ENVIRONMENTAL SAMPLING RESULTS AND REVIEW OF HOME VISIT

Indoor Air Sampling Data Collected by EPA

On March 9, 2001, EPA contractors collected their second round of air data from locations inside and outside the residence. This round of sampling was conducted as recommended in MDPH's first health consultation. EPA collected samples using three methods: carbon tubes, summa canisters, and a Trace Atmospheric Gas Analyzer (TAGA). Carbon tube samples, which sampled the air for 8 hours, were collected from the TV room, bottom of the basement stairs, the laundry room, and outside the home and analyzed for VOCs and aldehydes/ketones. Summa canister samples, which sampled the air for approximately 6 minutes during odor peaks as measured by the TAGA, were collected from outside the home and the bottom of the basement stairs and analyzed for VOCs. In addition, a mobile TAGA was operated for approximately 45 minutes and analyzed air samples collected in the driveway and inside the residence in the following 10 areas: living room, bathroom, TV room, master bedroom, doll display room, kitchen, basement, laundry room, washing machine drain, and the utility closet. The samples collected by the TAGA were analyzed for eight VOCs: benzene, dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, vinyl chloride, and xylene. Tables 1, 2, and 3 summarize contaminants detected and the methods used for collection.

Health assessors use a variety of health-based screening values, called comparison values, to help decide whether compounds detected at a site might need further evaluation. A description of comparison values is included in Appendix C of this health consultation.

Twenty-three VOCs were detected inside the residence, three of which (i.e., 1,3,5-trimethylbenzene, benzene, and methylene chloride) exceeded their comparison values (see Table 1). Several VOCs were analyzed for and not detected; however, the detection limit used was greater than the comparison value [e.g., Risk Based Concentrations (RBC), Cancer Risk Evaluation Guide (CREG)]. These VOCs are included in the Table for informational purposes only. Mesitylene, also known as1,3,5-trimethylbenzene, was detected in the TV room at 2.2 parts per billion (ppb), which is a concentration greater than its comparison value. Benzene was

detected in the three samples collected in the TV room and basement at estimated concentrations of 0.8 ppb, 0.9 ppb, and 0.9 ppb. Methylene chloride was detected once at an estimated concentration of 2 ppb.

Six aldehydes (i.e., acetaldehyde, benzaldehyde, 2-butanone, formaldehyde, hexanaldehyde, valeraldehyde, and propionaldehyde) and two ketones (i.e., 2-butanone and acetone) were detected inside the residence, two of which (i.e., acetaldehyde and formaldehyde) exceeded their comparison values (see Table 2). Acetaldehyde was detected in three samples in the TV room and basement at concentrations of 4 ppb, 4.4 ppb, and 8.6 ppb. Formaldehyde was detected in three samples in the TV room and basement at concentrations of 11 ppb, 12 ppb, and 22 ppb.

Of the five compounds that exceeded comparison values inside the residence, one (methylene chloride) exceeded its comparison value in outdoor air sampling (see Table 3). Methylene chloride was detected in an outdoor air sample, near the back of the driveway, with an estimated concentration of 3 ppb.

MDPH Home Visit and Sampling

Components of MDPH's evaluation included the following:

1. Visual observations (e.g., indoor sources of volatile organic compounds, mold)
2. Measurement of total volatile organic compounds (TVOCs) using a Photo Ionization Detector (PID).
3. Measurements of relative humidity and temperature. More details on the methods for these measurements are contained in Appendix B.

Although the protocol for the home visit included measuring for particulate matter, this sampling was not conducted. An examination of the house found that no equipment/machinery that could produce airborne particulate (e.g., the furnace) was operating. Based on these conditions, CEH staff believed that particle measurements would not reflect the normal conditions outside and inside the house and therefore did not take measurements as part of this assessment.

The day of the home visit was overcast with minimal wind, sporadic rain showers, and an outdoor temperature of 61° Fahrenheit. Observations were made during the home visit, including that the art storage room contained a large amount of art supplies and had an odor similar to that from an art supply store.

MPDH collected air data from inside and outside the residence. Environmental tests were taken during normal activities at the home. The air in thirteen areas inside and one area outside the residence was tested for TVOCs. The outdoor area sample was taken on the front porch and indoor air samples were taken in the living room (1 sample), the art storage room (5 samples), the furnace room (3 samples), the oil tank closet (3 samples), and the washing machine room (1 sample). The test results appear in Table 4. TVOCs were detected in each sample. TVOCs were detected in the outdoor air sample at a concentration of 400 ppb. The indoor air sample collected in the living room had a concentration of 400 ppb TVOCs. The air concentration of TVOCs in samples taken in the center of each of the four sections of the basement (i.e., art storage room, furnace room, washing machine room, and oil tank closet) ranged from 500-600 ppb. TVOC measurements were taken close to certain objects in order to identify potential sources. Indoor sources were found to be oiled materials in the furnace room and aerosol cans in the basement. For example, two air samples in the furnace room taken at less than 1-inch above oiled materials were 1,000 ppb and 1,100 ppb. Four air samples collected less than 1-inch above various aerosol cans in the main art work room in the basement had TVOC concentrations ranging from 800 to 2,200 ppb, with an average of 1,300 ppb.

DISCUSSION

In order to evaluate possible public health implications, estimates of opportunities for exposure to compounds (e.g., in air) must be combined with what is known about the toxicity of the chemicals. ATSDR has developed minimal risk levels (MRLs) for many chemicals. An MRL is an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse noncancer health effects over a specified duration of exposure. MRLs are derived based on no-observed-adverse-effect levels (NOAELs) or lowest-observed-adverse-effect levels (LOAELs) from either human or animal studies. The LOAELs or NOAELs reflect the actual levels of exposure that are used in studies. ATSDR has also classified LOAELs into “less

serious" or "serious" effects. "Less serious" effects are those that are not expected to cause significant dysfunction or whose significance to the organism is not entirely clear. "Serious" effects are those that evoke failure in a biological system and can lead to illness or death. When reliable and sufficient data exist, MRLs are derived from NOAELs or from less serious LOAELs, if no NOAEL is available for the study. To derive MRLs, ATSDR also accounts for uncertainties about the toxicity of a compound by applying various margins of safety, thereby establishing a level that is well below a level of health concern. For chemicals that do not have these comparison values available for the medium of concern, EPA Reference Concentrations (RfCs) or risk-based concentrations developed by EPA Regional Offices, are used.

These comparison values include cancer risk evaluation guides (CREGs) (see Appendix C). CREGs are developed by ATSDR using EPA's cancer slope factor (CsF) approach and provide information on the theoretical potential for carcinogenic effects in an exposed population.

If environmental contaminants are detected, residents must be exposed to these contaminants before adverse health effects can result. Five conditions must be met for exposure to occur. First, there must be a source of that chemical. Second, a medium (e.g., air) must be contaminated by either the source or by chemicals transported away from the source. Third, there must be a location where a person can potentially contact the contaminated medium. For example, if a person works in a garden with contaminants in soil, or if volatile chemicals are moving into a house from contaminated soil beneath the house. Fourth, there must be a means by which the contaminated medium could enter a person's body (ingestion, inhalation, or skin contact). Finally, the chemical must actually reach the target organ susceptible to the toxic effects from that particular substance at a sufficient dose for a sufficient time, for an adverse health effect to occur.

The results of the MDPH TVOC testing indicated that higher TVOC levels were present in the basement areas than on the upper level or outdoors. For TVOC measurements, it is important to evaluate differences between the background level outside and the levels detected inside. Air monitoring on the living room matched outdoor air levels for TVOCs (i.e., 400 ppb). Air monitoring taken in the basement ranged from approximately at the comparison levels to slightly exceeding them in the center of each area sampled in the basement (i.e., 600 ppb). Several

potential sources of TVOCs were identified by sampling at less than one inch above the point source: oil sludge from a valve on the furnace, granular absorbent material beneath the furnace oil leak, granular absorbent material beneath a leaking pipe from the oil tank; and the tops of four different spray cans of art supplies. TVOC concentrations from each point source rapidly dropped to comparison measurements detected outdoors as the PID probe was moved over 1-inch away from each of the point sources. These additional measurements were noted but not recorded. All other materials (i.e., house paint, bottles of water-based arts and crafts paints, tool drawer and other containers) had air sampling measurements that matched the levels measured in the basement (i.e., approximately 500-600 ppb).

There is no ATSDR or EPA comparison value for TVOCs. However, there is relevant information on possible health effects of opportunities for exposure to TVOCs in published literature. For example, one study found that for TVOC exposures ranging from 200 to 3,000 ppb, odors and irritant effects may result in temporary discomfort (Molhave 1990). The TVOC levels measured in the basement were higher than the level measured outdoors and within the range where temporary discomfort may be experienced.

Like most homes, the house was designed to use openable sash windows to provide ventilation and**,** besides the furnace itself**,** contains no mechanical heating, ventilating and air-conditioning (HVAC) system. Incidental air exchange (e.g., infiltration and exfiltration) through the building envelope would be expected to be minimized on a vinyl siding house. Without natural ventilation by infiltration/exfiltration or a mechanical ventilation system, air exchange within the home is minimized with the windows closed, which would make the basement area vulnerable to the accumulation of TVOCs. The basement had one window but due to its inaccessibility, it could not be determined if it was openable. On the day of the MDPH visit, all the windows in the house were closed.

Temperature measured outdoors on April 14, 2004 was 61^{o} F with a relative humidity of 69 percent. Indoor temperature on the first floor was 62^{o} F with a relative humidity of 40 percent and in the basement was 63^{o} F with a relative humidity of 42 percent. The difference between the outdoor and indoor relative humidity is likely caused by the use of an indoor heating system. Extremes in temperature and relative humidity indoors as well as variation between indoor and

outdoor measurements can influence air concentrations of TVOCs (e.g., increased TVOCs in hot, dry conditions; decreased TVOCs in moist, cold conditions). The temperature and relative humidity measurements indoors on the day of the MDPH visit were unlikely to have had a significant effect on the TVOC concentrations within the home.

MDPH also evaluated indoor air quality data generated by EPA in 2001 after MDPH recommended that this sampling be conducted while windows were closed to simulate the worst case conditions. Five compounds were found in indoor air at levels exceeding their cancer or non-cancer comparison values: 1,3,5-trimethylbenzene, benzene, methylene chloride, acetaldehyde and formaldehyde (see Tables 1 & 2). However, all compounds except 1,3,5-trimethylbenzene are reported to be widely present in ambient air or indoor air environments throughout the United States due to their widespread use in a variety of consumer products (e.g., paints, strippers, aerosols, fuels). Below is a brief discussion on the five compounds that exceeded their comparison values.

- With regard to 1,3,5-trimethylbenzene, there is no available information on levels commonly found in ambient or indoor air. It is a compound that is used in paint thinners, caulking compounds, and wall covering (EPA 1999, Etkin 1996). There is limited information on possible health effects from opportunities for exposure to this compound. The provisional EPA inhalation RfC of 1.2 ppb was derived from an occupational study done in 1958 in which workers who were exposed to airborne levels (i.e., 10,000-60,000 ppb) of a mixture containing 30% 1,3,5-trimethylbenzene reported various symptoms, including vertigo, headaches, and drowsiness. The study had several limitations, including that the workers were exposed to a mixture that contained only 30% 1,3,5-trimethylbenzene and the length of exposure was not well defined (i.e., approximately 10 years). However, the mixture contained over 50% of a similar trimethylbenzene (1,2,4-trimethylbenzene). There is some evidence that the trimethylbenzenes are similar enough that any effect could be cumulative. Using this assumption, the LOAEL, which is the lowest level at which an adverse effect was observed, for this study would be 10,000 ppb, which is much higher than the concentrations detected in the residence. A more recent study examined individuals after being exposed for two hours to airborne levels (i.e., 25,000 ppb) of 1,3,5-trimethylbenzene. The individuals reported no irritation, dizziness,

headaches, or fatigue (EPA 1999). Based on this information, it is unlikely that the opportunities for exposure to 1,3,5-trimethylbenzene in the indoor air (2.2 ppb) would result in health concerns.

- Concentrations of benzene were detected three times inside the residence: 0.9 ppb in the TV room, 0.9 ppb at the bottom of the basement stairs, and 0.8 ppb in the laundry room. It was not detected in the outdoor air sample. Benzene is commonly found in indoor air, with one study reporting a median level in over 185 homes without smokers as 2.2 ppb. Products such as paints, adhesives, marking pens, tape, and those that contain rubber can contain and release benzene into the air (ATSDR 1997). The levels detected in the residence exceed ATSDR's cancer comparison value but were well within typical background levels, and hence are unlikely to result in unusual cancer concerns. The levels detected were below the MRL of 4 ppb that ATSDR derived for benzene for intermediate inhalation exposure (exposure between 15 to 365 days) (no chronic inhalation MRL is available). This MRL was based on a LOAEL of 780 ppb, which was derived from an animal study in where animals showed neurological effects from benzene, specifically a decreased frequency of rapid response (ATSDR 1997).

- Methylene chloride was detected in the outdoor air sample at 3 ppb and in the basement at 2 ppb**,** both above ATSDR's cancer comparison value, but within typical background levels and hence are unlikely to result in unusual cancer concerns. Average ambient air concentrations in urban areas in the U.S. have been reported in the 0.2 to 2 ppb range, with concentrations ranging as high as 200 ppb in these areas. Common sources of methylene chloride in ambient air include facilities that manufacture methylene chloride and wastewater treatment plants, which emit it as a by-product from using chlorine as a disinfectant. Exposure in indoor air may be higher, depending on the use of spray painting, other aerosols, glues, paint thinners, etc. Estimated indoor air concentrations have been reported to range from 0.06 to 5,472 ppb. The levels detected in the residence are below the MRL of 300 ppb that ATSDR derived for methylene chloride for chronic

inhalation exposure (exposure greater than 365 days). This MRL was based on a NOAEL of 8,920 ppb, which was derived from an animal study where after being exposed to higher concentrations, the animals showed liver effects (ATSDR 2000).

- Acetaldehyde was detected in the TV room, in the laundry room, and at the bottom of the basement stairs with the maximum concentration at 8.6 ppb in the TV room. It was not detected in the outdoor air sample. Studies have indicated that indoor air concentrations can range from 0 to 35 ppb, depending on cooking, fireplace use, and whether cigarette smoking is present. Additional sources of acetaldehyde can be building materials such as rigid polyurethane foams, and consumer products such as adhesives, coatings, lubricants, inks, and nail polish remover (CARB 1993). The maximum concentration detected in the residence was greater than ATSDR's cancer comparison value as well as the RfC of 5 ppb that EPA derived for a lifetime inhalation exposure, but was well within typical background levels, and hence is unlikely to result in unusual cancer concerns. Also, the maximum concentration is much less than the NOAEL on which the RfC is based. The NOAEL of 4,828 ppb was derived from an animal study where animals showed degeneration of olfactory epithelium, which is tissue within the nasal cavity that is involved in the sense of smell (EPA 2004).

- Formaldehyde was detected in the TV room, in the laundry room, and at the bottom of the basement stairs, with the maximum concentration at 22 ppb in the TV room. It was not detected in the outdoor air sample. Studies have shown indoor air concentrations of formaldehyde to range from 10 to 100 ppb. Building and consumer products can be sources of formaldehyde. In particular, pressed wood products made with urea-formaldehyde resins (e.g., hardwood plywood, particle board, and medium-density fiberboard) can lead to elevated levels of formaldehyde in indoor air (CARB 1992). The maximum concentration detected in the residence was greater than ATSDR's cancer comparison value, but was well within typical background levels, and hence is unlikely to result in unusual cancer concerns. The levels detected in the residence also exceeded the noncancer comparison value **(**MRL of 8 ppb) that ATSDR derived for formaldehyde for chronic inhalation exposure (exposure greater than 365 days). However, the levels

detected were lower than the LOAEL on which the MRL is based. The LOAEL is 240 ppb, which was derived from an occupational study where after being exposed to higher concentrations, the workers showed liver effects (ATSDR 1999).

These data indicated that although these five compounds exceeded their health-based comparison values, nearly all of the concentrations were similar to typical levels found in indoor and outdoor air in the U.S. based on a review of the scientific literature. Hence, opportunities for exposure to these compounds at the measured levels are unlikely to produce unusual health concerns for most individuals.

Fourteen detected compounds in indoor air did not have comparison values available from ATSDR or EPA (e.g., EMEG, LOAEL, NOAEL) and have not been adequately studied for possible health concerns. Ten of these compounds (i.e., n-decane, n-dodecane, n-heptane, n-hexadecane, n-nonanal, n-nonane, n-pentadecane, n-tetradecane, n-tridecane, and n-undecane) are called aliphatic hydrocarbons. Mixtures of aliphatic hydrocarbons are used in a variety of fuels, lubricants, paint solvents, and plastics (Clayton and Clayton 1981). D-limonene is found in citrus fruit and consumer products, like paint, adhesives, and chipboard (Clayton and Clayton 1981; Etkin 1996). The other three compounds (i.e., hexanaldehyde, propionaldehyde, and valeraldehyde) are types of aldehydes, which are commonly found in solvents and rubbers (Clayton and Clayton 1981).

Two of the three aldehydes detected during the EPA sampling in 2000 that exceeded their air comparison values indoors (i.e., acetaldehyde and formaldehyde) were detected at lower values during the 2001 sampling event. The other aldehyde (i.e., acrolein) was not detected during the more recent sampling event.

Environmental sampling data reviewed for the Sutton Brook Disposal Area Public Health Assessment did not indicate the presence of a clearly delineated off-site groundwater plume, although the groundwater beneath the Disposal Area had not been completely characterized. Contaminants detected in the groundwater included several that were also detected in the indoor air (e.g., acetone, benzene, methylene chloride, toluene). Additional investigations at the

Disposal Area are ongoing and need to better characterize the extent of groundwater contamination and the potential for off-site migration and volatilization into nearby residences.

People's sensitivity to chemicals can vary widely, and because several different compounds are present, the levels of various related-compounds may increase the potential effect. Six aldehydes were detected in the indoor air (i.e., acetaldehyde, benzaldehyde, formaldehyde, hexanaldehyde, propionaldehyde, and valeraldehyde). Acetaldehyde and formaldehyde are both irritating to the eyes and upper respiratory passages, and it is possible that the other aldehydes could contribute to any possible irritating effect (Sittig 1985). It is possible that residents of this home might experience reactions at the levels of formaldehydes or other aldehydes detected in the indoor air if previously sensitized. Repeated exposures to formaldehyde are believed to promote allergic contact dermatitis, which is a type of hypersensitivity reaction. It has been estimated that up to 5% of the population suffers dermal reactions to formaldehyde (Ford 2001). There are environmental medical tests that can determine if such sensitization has occurred.

CHILD HEALTH CONSIDERATIONS

ATSDR and MDPH recognize that in communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health. Currently, there are no children that live at this residence. This public health consultation evaluated opportunities for exposure to all residents, including children.

CONCLUSIONS

1. The concentration of TVOCs in the basement was greater than the outdoor comparison concentrations. Several sources in the basement may be contributing to TVOC levels measured in this area and should be eliminated. Levels of TVOCs similar to those found in the basement may result in temporary discomfort for residents during the time they are inside the house.
2. Five compounds were detected in the indoor air that exceeded health-based comparison values but were generally within typical background levels measured in the indoor air or outdoor air in the U.S. (data on background levels for one compound were not available). For most individuals, the concentrations of the five compounds are unlikely to result in health concerns. However they might be of health concern to some individuals that may be more sensitive to certain compounds and the presence of various related-compounds may increase the potential effect. Low levels of aldehydes can irritate the eyes and upper respiratory tract of individuals who have become sensitized to them.
3. Due to insufficient data, it is unclear what impact contaminated groundwater from the Sutton Brook Disposal Area may have on the indoor air until further characterization of the Sutton Brook Disposal Area is completed by the EPA.

ATSDR requires assignment of one of five conclusion categories to describe current site conditions. These categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

A category is selected from site-specific conditions such as the degree of public health hazard based on the presence and duration of human exposure, contaminant concentration, the nature of toxic effects associated with site-related contaminants, presence of physical hazards, and

community health concerns. Using established ATSDR criteria, and based on the data and information reviewed and discussed in this health consult regarding opportunities for exposure to contaminants from identified sources (e.g., art material) located inside the residence, ATSDR would classify the Bemis Circle residence as "No Apparent Public Health Hazard" for most people. However, it is possible that contaminants not identified and/or fully characterized may be impacting the current resident. Additional data are needed to better characterize the nature and extent of contamination at the Sutton Brook Disposal Area and any possible subsequent impact on the residence.

RECOMMENDATIONS

1. The residents of this home should work to increase the ventilation of the basement area. Under present conditions, a fire hazard may exist in the basement with the large amounts of clothes and art supplies. In addition, the TVOC containing art materials listed in Table 4, as well as other similar material (e.g., aerosol cans) should be stored in a place outside the home.
2. The leak from the furnace and the oil tank should be repaired.
3. The oil contaminated granular absorbent material located beneath the oil tank should be removed and disposed of during a local household hazardous waste disposal event.
4. MDPH supports the plans by environmental regulatory agencies to conduct additional sampling to further characterize the nature and extent of contamination at the Sutton Brook Disposal Area. MPDH recommends that this sampling include off-site groundwater samples. If this information suggests that certain exposure pathways may exist, MDPH will re-evaluate the indoor air data summarized in this consultation.

PUBLIC HEALTH ACTION PLAN

Upon request, MDPH will review any additional environmental data that would be helpful in improving the characterization of opportunities of exposure.

PREPARER OF HEALTH CONSULTATION:

The Center for Environmental Health of the Massachusetts Department of Public Health prepared this health consultation. If you have any questions about this document, please contact Suzanne K. Condon, Associate Commissioner, 7th Floor, 250 Washington Street, Boston, Massachusetts 02108.

CERTIFICATION

The health consultation for the Bemis Circle Residence, Tewksbury, Massachusetts was prepared by the Massachusetts Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedures existing at the time this health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Tammie McRae
Technical Project Officer
Division of Health Assessment and Consultation (DHAC)
ATSDR

The Division of Public Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

Cooperative Agreement Team Leader
CAT, DHAC, ATSDR

Table 1: Indoor Air Samples Tested for VOCs on March 9, 2001 using carbon tubes, summa canisters, and TAGA.

VOC	Number of Detects/ Samples	Minimum (ppb)	Mean (ppb)	Maximum (ppb)	Comparison Values (ppb)
1,1,1-Trichloroethane	14/15	ND (4)	2.4	3.2	Int. EMEG - 700
1,1,2,2-Tetrachloroethane	0/5	ND (4)	ND (4)	ND (4)	Int. EMEG – 400 CREG – 0.003
1,1,2-Trichloroethane	0/2	ND (4)	ND (4)	ND (4)	CREG – 0.01
1,2,4-Trichlorobenzene	0/3	ND (1)	ND (1)	ND (1)	RBC – 0.5
1,2-Dichloroethane	0/2	ND (4)	ND (4)	ND (4)	Chronic EMEG – 600 CREG – 0.01
1,3,5-Trimethylbenzene/ Mesitylene	3/5	ND (4)	1.52	2.2	RBC – 1.3
1,4-Dioxane	0/3	ND (1.4)	ND (1.4)	ND (1.4)	RBC – 0.16
Benzene	3/15	ND (3.5)	1.6	0.9J	Int. EMEG – 4 CREG – 0.03
Benzyl chloride	0/3	ND (1.3)	ND (1.3)	ND (1.3)	RBC – 0.01
Bromodichloromethane	0/2	ND (4)	ND (4)	ND (4)	RBC – 0.01
Bromoform	0/3	ND (0.6)	ND (0.6)	ND (0.6)	CREG – 0.09
Carbon Tetrachloride	0/5	ND (2)	ND (2)	ND (2)	Chronic EMEG - 30 CREG – 0.01
D-limonene	2/3	ND (0.8)	1.6	2.4	NA
Ethylbenzene	1/5	ND (2.5)	2.1	0.4J	Int. EMEG - 1000
m & p-Xylenes	1/2	ND (4)	2	1J	Chronic EMEG - 100
Methylcyclohexane	1/3	ND (1)	0.4	0.3J	RBC - 772
Methylene chloride	1/2	ND (4)	2	2J	Chronic EMEG – 300 CREG – 0.86
Naphthalene	0/3	ND (5)	ND (5)	ND (5)	Chronic EMEG - 0.7
n-Decane	3/3	1.3	1.9	2.2	NA
n-Dodecane	3/3	0.8	0.9	1	NA
n-Heptane	1/3	ND (1.2)	0.6	0.5J	NA
n-Hexadecane	3/3	0.4J	0.4	0.5J	NA
n-Nonanal	1/3	ND (2.6)	2.0	3.5	NA
n-Nonane	3/3	0.5J	0.7	0.8J	NA
n-Pentadecane	3/3	0.7	0.7	0.8	NA
n-Tetradecane	3/3	1.1	1.2	1.2	NA
n-Tridecane	3/3	0.9	1.2	1.3	NA
n-Undecane	1/3	ND	NC	1.9	NA
ortho-Xylene	2/5	ND (3)	2.0	0.5J	Chronic EMEG - 100
para-Xylene	3/3	1.3	1.4	1.5	Chronic EMEG - 100
Tetrachloroethene/	12/15	ND (2.8)	1.4	4.3	Chronic EMEG - 40

VOC	Number of Detects/ Samples	Minimum (ppb)	Mean (ppb)	Maximum (ppb)	Comparison Values (ppb)
Tetrachloroethylene					
Toluene	4/15	ND (27)	12	8.7	Chronic EMEG - 80
Trichloromethane	0/2	ND (4)	ND (4)	ND (4)	Chronic EMEG – 20 CREG – 0.01
Vinyl Chloride	0/12	ND (33)	ND (33)	ND (33)	Int. EMEG - 30 CREG – 0.04
Xylene	7/10	ND (2.7)	2.9	4.5J	Chronic EMEG - 100

ND- Non-detect; mean detection limit in parentheses
NA- Not Available
NC- Not Calculable
J – Estimated value below the method detection limit

Mean values were calculated using one-half the method detection limit for samples in which the compound was below detection. Mean values may exceed maximum values due to high detection limits.

Table 2: Indoor Air Samples Tested for Aldehydes/Ketones on March 9, 2001 using carbon tubes.

Compound	Number of Detects/ Samples	Minimum (ppb)	Mean (ppb)	Maximum (ppb)	Comparison Values (ppb)
Acetaldehyde	3/3	4	5.7	8.6	CREG – 0.28 RfC – 2.8
Acetone	3/3	16	17	18	Chronic EMEG - 13,000
Acrolein	0/3	ND (0.45)			Int. EMEG - 0.009
Benzaldehyde	2/3	ND (0.24)	0.45	0.8	RBC – 85
2-Butanone (MEK)	3/3	0.49	0.55	0.68	RBC – 1,729
Formaldehyde	3/3	11	15	22	Chronic EMEG – 8 CREG – 0.07
Hexanaldehyde	3/3	0.66	1.1	1.9	NA
Valeraldehyde	1/3	ND (0.3)	0.29	0.57	NA
Propionaldehyde	1/3	ND (0.44)	0.376667	0.69	NA

ND- Non-detect; mean detection limit in parentheses
NA- Not Available

Mean values were calculated using one-half the method detection limit for samples in which the compound was below detection. Mean values may exceed maximum values due to high detection limits.

Table 3: Outdoor Air Samples Tested for VOCs and Aldehyde/Ketones on March 9, 2001 using carbon tubes, summa canisters, and TAGA.

Compound	Number of Detects/ Samples	Minimum (ppb)	Mean (ppb)	Maximum (ppb)	Comparison Values (ppb)
1,1,1-Trichloroethane	1/4	ND (0.8)	1.1	2J	Int. EMEG – 700
1,1,2,2-Tetrachloroethane	0/2	ND (2.4)	ND (2.4)	ND (2.4)	Int. EMEG – 400 CREG – 0.003
1,1,2-Trichloroethane	0/1	ND (4)	ND (4)	ND (4)	CREG – 0.01
1,2,4-Trichlorobenzene	0/1	ND (1)	ND (1)	ND (1)	RBC – 0.5
1,2-Dichloroethane	0/1	ND (4)	ND (4)	ND (4)	Chronic EMEG – 600 CREG – 0.01
1,3,5-Trimethylbenzene/ Mesitylene	0/2	ND (2.5)	ND (2.5)	ND (2.5)	RBC – 1.26
1,4-Dioxane	0/1	ND (1.4)	ND (1.4)	ND (1.4)	RBC – 0.16
Benzene	0/4	ND (3.1)	ND (3.1)	ND (3.1)	Int. EMEG – 4 CREG – 0.03
Benzyl chloride	0/1	ND (1.3)	ND (1.3)	ND (1.3)	RBC – 0.01
Bromodichloromethane	0/1	ND (4)	ND (4)	ND (4)	RBC – 0.01
Bromoform	0/1	ND (0.6)	ND (0.6)	ND (0.6)	CREG – 0.09
Carbon Tetrachloride	0/2	ND (2.4)	ND (2.4)	ND (2.4)	Chronic EMEG - 30 CREG – 0.01
m & p-Xylenes	1/1	1J	1J	1J	Chronic EMEG - 100
Methylene chloride	1/1	3J	3J	3J	Chronic EMEG – 300 CREG – 0.86
Naphthalene	0/1	ND (5.1)	ND (5.1)	ND (5.1)	Chronic EMEG - 0.7
Toluene	1/4	ND (20)	16.5	6	Chronic EMEG - 80
Trichloromethane	0/1	ND (4)	ND (4)	ND (4)	Chronic EMEG – 20 CREG – 0.01
Vinyl Chloride	0/3	ND (27)	ND (27)	ND (27)	Int. EMEG – 30 CREG – 0.04
Acetaldehyde	0/1	ND (0.58)	ND (0.58)	ND (0.58)	CREG – 0.28 RfC – 2.8
Acrolein	0/1	ND (0.45)	ND (0.45)	ND (0.45)	Int. EMEG - 0.009
Formaldehyde	0/1	ND (0.85)	ND (0.85)	ND (0.85)	Chronic EMEG – 8 CREG – 0.07

ND- Non-detect; mean detection limit in parentheses
J – Estimated value below the method detection limit

Mean values were calculated using one-half the method detection limit for samples in which the compound was below detection. Mean values may exceed maximum values due to high detection limits.

Table 4: Total Volatile Organic Chemicals (TVOCs) Detected in Indoor Air on April 14, 2004 using a Photo Ionization Detector (PID).

Area Sampled	TVOCs (ppb)
Outdoors on front porch	400
Living Room 1st Floor	400
Main work room, basement	500-600
Washing machine room, basement	500-600
Oil tank closet, basement	500-600
Oil tank closet, basement <1 inch above oil contaminated granular material	500
Oil tank closet, above oil tank	500
Furnace room, basement	500-600
Furnace room, basement, <1 inch above oily sludge on pipe	1000
Furnace room, basement, <1 inch above oil contaminated granular material	1100
Webbing spray aerosol can, <1 inch from spray cap	1100
Blair Clear Spray aerosol can, <1 inch from spray cap	2200
Myco Colors Super Gloss spray aerosol can, <1 inch from spray cap	800
Grambacher Spray Fix aerosol can, <1 inch from spray cap	1200

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APPENDIX A

Health Consultation

BEMIS CIRCLE RESIDENCE
LOCATED NEAR SUTTON BROOK DISPOSAL AREA:
Tewksbury, Massachusetts

CERCLIS NO: MAD980520696

Conducted by

Environmental Toxicology Program
Bureau of Environmental Health Assessment
Massachusetts Department of Public Health
Boston, Massachusetts

Under Cooperative Agreement with the

Agency for Toxic Substances and Disease Registry
Atlanta, Georgia

STATEMENT OF ISSUES

The Massachusetts Department of Public Health (MDPH) received a request from the U.S. Environmental Protection Agency (EPA) Region 1 to complete a health consultation in order to determine if levels of contaminants found at a residence on Bemis Circle in Tewksbury, Massachusetts, posed a health concern. The residence is located approximately 1000 feet from the Sutton Brook Disposal Area (also known as Rocco's Landfill), which has recently been listed on the National Priorities List (see Figure 1). An ongoing removal action is taking place at the Sutton Brook site, consisting of excavation of containers and contaminated soil. Possible human exposures associated with this site are being evaluated in the separate Sutton Brook Disposal Site Public Health Assessment. Sampling data collected from the soil, soil gas, indoor air, groundwater, and nearby surface water at the residence were analyzed to evaluate the likelihood that contaminants at the property could contribute to health effects for residents. This residence is on a municipal water supply. This health consultation was performed by MDPH, under a cooperative agreement with the U.S. Agency for Toxic Substances and Disease Registry (ATSDR). A glossary of environmental health terms can be found at the end of this document for further explanation of technical terms used in this consult.

DISCUSSION

Environmental Sampling Data

Sampling data reviewed for this health consultation include indoor and outdoor air sampling data collected by the EPA Environmental Response Team (EPA-ERT) in June 2000 (EPA 2000a), soil samples collected by EPA contractor Roy F. Weston in September 2000 (Weston 2000), and soil gas samples (along with one ambient grab sample) also collected in September 2000 (EPA 2000b). The Massachusetts Department of Environmental Protection (MA DEP) also collected a surface water sample from Sutton Brook, approximately 250 feet from the Bemis Circle property, and a groundwater sample from a monitoring well on the property (MA DEP 2000a and b). Another, earlier groundwater sample was collected close to the property adjacent to and on the Bemis Circle side of Sutton Brook. Earlier data collected from the property and nearby areas in conjunction with evaluations of the Sutton Brook Disposal Site are evaluated in the Public Health Assessment for that site.

The indoor and ambient air samples collected in June 2000 were analyzed for volatile organic compounds (VOCs), aldehydes and ketones. For aldehydes and most VOCs, two samples were collected outside the house, two were collected in the living area, and four were collected in the basement. For some VOCs, five samples were collected outdoors, two in the living area, and seven in the basement. The soil data were analyzed for VOCs, semi-volatile organic compounds (SVOCs), metals, polychlorinated biphenyls (PCBs) and pesticides. The soil gas samples, the ambient air grab sample, and the surface water and groundwater sample were analyzed for VOCs.

A variety of methods were used for the environmental analyses. Indoor and outdoor air samples were sampled and analyzed using modified gas chromatography/mass spectrometry (GC/MS). Samples collected in tubes were analyzed using National Institute of Occupational Safety and Health (NIOSH) Method 1500 for hydrocarbons with a boiling point between 36-126 ºC; Method 1501 for aromatic hydrocarbons; and Method 1003 for halogenated hydrocarbons. The grab SUMMA samples were analyzed for VOCs using EPA Method TO-14A: Determination of Mass Spectrometric (GC/MS) Analysis. Aldehydes/ketones, were sampled and analyzed using the EPA Method TO-11A: Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Performance Liquid Chromotography (HPLC) (EPA 2000c, Lockheed Martin 2000).

Soil gas sampling was done at the 14 locations on the property at three to four foot depths using a probe. In addition, one ambient air sample was taken during the soil gas sampling event. These analyses were performed using EPA's standard screening method, Ambient Air Grab Samples Analyses for VOCs. Samples were analyzed on-site by GC with photoionization and electron capture detectors. Based on results from these, additional soil gas samples were collected using SUMMA canisters and were analyzed for VOCs using EPA Method T015: Detection of VOCs in Air Collected in Specially Prepared Canisters and Analyzed by GC/MS.

Soil and surface water samples were sampled and analyzed for: VOCs using EPA Method 624 and Modified SW-846 Method 5035; SVOCs using EPA Method 625, SW-846 Method 3541 (Revision 0, September 1994), and SW-846 Method 3545 (Revision 0, December 1996); pesticide/PCBs using EPA Method 608, SW-846 Method 3541 (Revision 0, September 1994), and SW-846 Method 3545 (Revision 0, December 1996); and inorganics using EPA Method 200.7 Contract Laboratory Program-Modified (CLP-M), mercury using EPA Method 245.5 CLP-M, and cyanide using EPA Method 335.2 CLP-M (EPA 1999a, EPA 1999b).

The groundwater sample was analyzed for VOCs using DEP Northeast Regional Office GC Screening Method for VOCs (Immerman 2001).

Comparison Values

Target analytes detected in the indoor air samples are shown in Table 1, those detected in soil (from the surface to two feet below ground surface), are shown in Table 2, those detected in soil gas are shown in Table 3a, and those detected in an ambient air grab sample are shown in Table 3b. VOC results from the surface water and groundwater samples are shown in Table 4. In addition to the sampling data, the tables include chemical-specific comparison values for the relevant medium (e.g., soil, air). Because ATSDR comparison values are not available for surface water, comparison values for drinking water are used as screening values. This is a conservative evaluation because health risks from exposure to surface water would be expected to be less than those from drinking water. Comparison values are health-based screening values used by health assessors to help decide whether compounds detected at a site may need further

evaluation. These comparison values include environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and cancer risk evaluation guides (CREGs). These comparison values have been scientifically peer-reviewed and published by ATSDR and/or EPA. For chemicals that do not have these comparison values available for the medium of concern, EPA reference concentrations (RfCs) or risk-based concentrations (RBCs) developed by EPA regional offices, are used. For lead, EPA has developed a hazard standard for residential soil (Federal Register 2001).

If the concentration of a chemical exceeds its comparison value, adverse health effects are not necessarily expected. Rather, these comparison values help in selecting compounds for further consideration. For example, if the concentration of a chemical in a medium (e.g., soil) is greater than the EMEG for that medium, the potential for exposure to the compound should be further evaluated for the specific situation to determine whether noncancer health effects might be possible. Conversely, if the concentration is less than the EMEG, it is unlikely that exposure would result in noncancer health effects. EMEG values are derived for different durations of exposure according to ATSDR's guidelines. Acute EMEGs correspond to exposure lasting fourteen days or less. Intermediate EMEGs correspond to exposures lasting longer than fourteen days to less than one year. Chronic EMEGs correspond to exposures lasting one year or longer. CREG values are derived assuming lifetime duration of exposure. RMEG values also assume chronic exposure. All comparison values are derived assuming opportunities for exposure in a residential setting. Table 2 also lists the range of background values for Eastern United States soils for some chemicals (Shacklette 1984). In some cases, natural background concentrations may be higher than health-based screening values.

If environmental contaminants are detected, residents must be exposed to these contaminants before adverse health effects can result. Five conditions must be met for exposure to occur. First, there must be a source of that chemical. Second, a medium (e.g., soil) must be contaminated by either the source or by chemicals transported away from the source. Third, there must be a location where a person can potentially contact the contaminated medium. (For example, if a person works in a garden with contaminants in soil, or if VOCs are moving into a house from contaminated soil beneath the house.) Fourth, there must be a means by which the contaminated medium could enter a person's body (ingestion, inhalation, or skin contact). Finally, the chemical must actually reach the target organ susceptible to the toxic effects from that particular substance at a sufficient dose for a sufficient time, for an adverse health effect to occur.

Soil Results

Results, as shown in Tables 1 through 4, indicate levels of several chemicals exceeding their comparison values. In soil, one sample of the chemical heptachlor epoxide, a degradation product of the organochlorine pesticide heptachlor, was detected at a concentration greater than its cancer screening value. However, the sample was at a depth of 1.5 to 2 feet, which reduces the likelihood that a resident would come in

contact with it. Also, the elevated level was found in one out of twelve soil samples. Since residents would have opportunities for exposure to all of the surface soil, it is appropriate to look at the mean level of heptachlor epoxide across the yard in screening for cancer and other long-term health effects. Since the mean level, as shown in Table 2, did not exceed the screening value, heptachlor epoxide is unlikely to present a cancer concern for residents who may have contact with the soil. Arsenic also was detected above its cancer screening value. However, arsenic occurs naturally in many soils, and the levels detected were well within normal background levels found in Eastern U.S. soils (Shacklette 1984). Likewise, benzo(a)pyrene was detected in soil samples above its comparison value. However, benzo(a)pyrene and other polyaromatic hydrocarbons are widely found in soils throughout the U.S. Typical background levels of benzo(a)pyrene in soils range from 0.06-14 ppm. The maximum detected concentration of this compound was 0.4 ppm or within typical background concentration.

Soil Gas Results

In soil gas, chloroform, carbon tetrachloride, tetrachloroethene, and bromodichloromethane were detected above their health-based screening values, but it should be noted that these screening values are intended to apply to exposures to chemicals in air that people regularly breathe. Soil gas is gas in the pore spaces of soil below the ground surface. Once emitted into outdoor (i.e., ambient) air, gases would quickly disperse, so that the concentration of these chemicals in ambient air would likely be far lower than in soil gas. Unless soil excavation is taking place, people would not have opportunities for exposure to the soil gas directly, but only when vapors leave the soil and are released into the air. If vapors from the soil concentrated in the air inside the house, this could be a source of concern. However, all of these compounds were either not detected in indoor air (i.e., chloroform and bromodichloromethane) or they were detected at levels at or less than these detected in soil gas (i.e., carbon tetrachloride and tetrachloroethene). No other VOCs were detected in soil gas samples at levels exceeding health-based comparison values. In addition, there was no consistent pattern in concentration between soil gas and indoor air (e.g., some compounds [i.e., methylene chloride, toluene] were slightly higher indoors while another [i.e., 1, 1, 1-trichloroethane] was slightly higher in soil gas). Hence, the levels detected in soil gas seem unlikely, based on the data available, to present a health concern to residents of this home. However, because the indoor air sampling was conducted with the windows open, the representativeness of these data for conditions when windows are closed is unclear. For that reason, MDPH recommended to EPA that more sampling be conducted under worst case conditions (e.g., with windows closed). EPA did

return to the residence to take additional samples in March 2001. Review of data from the March 2001 sampling will be included in a follow-up health consultation by MDPH.

Surface Water and Groundwater Results

The surface water sample collected from Sutton Brook, approximately 250 feet from the residence on Bemis Circle, contained some VOCs (see Table 4); however, none exceeded drinking water screening levels. While elevated levels of VOCs have been found in groundwater and other media of the Sutton Brook Disposal site itself, a groundwater sample taken along the bank of Sutton Brook near the residence did not have detectable concentrations of VOCs, and the groundwater sample from the Bemis Circle residence (see Table 4) contained trace levels of a few VOCs (i.e., xylenes, toluene, 1,2,4-trimethylbenzene, benzene, and ethylbenzene) that were all below drinking water screening levels. The compounds detected in groundwater are typical petroleum products. The direction of groundwater flow in the area is currently being evaluated as part of the Sutton Brook Disposal Area Site investigation. However, based on data reviewed as part of this health consultation, it does not appear that residents at the location of the Bemis Circle home have opportunities for exposure to VOCs from the groundwater or surface water at levels which could pose a health concern.

Air Results

Formaldehyde was the only compound detected (i.e., 4.3 ppb) in the June 2000 outdoor air samples. Several compounds were detected in the September 2000 ambient air grab sample, with carbon tetrachloride being the only compound exceeding its comparison value.

Eight chemicals were found at levels exceeding their screening values in indoor air. These were acrolein, acetaldehyde, and formaldehyde, which are all aldehyde chemicals; tetrachloroethene, carbon tetrachloride, benzene, methylene chloride, and bromoform. Five compounds (i.e., benzene, tetrachloroethene, methylene chloride, bromoform, carbon tetrachloride) were detected in at least one indoor air sample at levels that exceeded health-based guidance values that are all based on each chemical's potential for carcinogenic effects. However, all these compounds are reported to be widely present in ambient air or indoor air environments throughout the United States due to their widespread use in a variety of consumer products (e.g., paints, strippers, aerosols, fuels). Comparisons between levels detected in indoor air samples at Bemis Circle versus those reported in outdoor or indoor air samples measured in the US follow:

- Benzene was detected in most indoor air samples (7 of 9 samples) in the Bemis Circle residence, with a maximum detected concentration of 1.3 ppb. Benzene was not detected in soil gas samples or in ambient air samples. Typical average background levels in outdoor air samples from around the U.S. have been reported as usually between about 2-12 ppb (ATSDR 1997a). Benzene is also commonly found in indoor air, with one study reporting a median level in over 185 homes without smokers as 2.2 ppb (ATSDR 1997a).

- Carbon tetrachloride was detected in one indoor air sample at an estimated concentration of 0.2 ppb. Carbon tetrachloride was also detected in three soil gas samples, with a maximum concentration of 0.12 ppb, and in the ambient air grab sample at 0.12 ppb. Based on over 2,000 indoor air samples in the US, the average concentration of carbon tetrachloride was 0.4 ppb, and results from nearly 5,000 outdoor air samples throughout the US found an average concentration of 0.168 ppb (ATSDR 1994).
- Tetrachloroethene was detected in five indoor air samples, with a maximum estimated concentration of 0.6 ppb. This compound was also detected in four of five soil gas samples at a maximum concentration of 15 ppb. It was not detected in ambient air samples. Outdoor air data from various locations around the US showed average concentrations of tetrachloroethene ranging from about 0.06-0.77 ppb. In addition, analysis of indoor and outdoor air concentrations in six regions of the US showed that indoor air concentrations were generally greater than outdoor concentrations (ATSDR 1997b).
- Bromoform was detected in one indoor air sample at an estimated concentration of 0.5 ppb. Bromoform was not detected in soil gas samples or in ambient air samples. Bromoform is not typically detected in outdoor or indoor air. It is unclear what the source of this single estimated concentration of bromoform is, although it is possible that it may be the result of volatilization from drinking water in the home, which is from the chlorinated supply of Tewksbury.
- Methylene chloride was detected in three indoor air samples at a maximum concentration of 5 ppb. It was detected in two soil gas samples at a maximum concentration of 0.56 ppb. Methylene chloride was not detected in ambient air samples. Average ambient air concentrations in urban areas in the US have been reported in the 0.2 to 2 ppb range, with concentrations ranging as high as 200 ppb in these areas (ATSDR 1997c).

These data indicate that four of the five compounds discussed here were detected at concentrations that are similar to typical background levels reported in the U.S. Bromoform is not typically found in air samples but is a common constituent in public chlorinated drinking water supplies throughout the U.S. Thus, the data reviewed for this health consultation indicate that levels of these compounds are similar to typical background levels. However, as noted earlier, because testing was conducted with windows open, the representativeness of these data for worst case conditions (e.g., windows closed) is unclear. MDPH will conduct a follow-up health consultation that will include more recent indoor air data generated in March 2001.

The screening values for acrolein, acetaldehyde, and formaldehyde were exceeded in both the basement and the living area, and there was no significant variation in levels between the basement and living area (e.g., acetaldehyde ranged from 5.4 to 14 parts per billion [ppb] in the basement and 9.6 to 15 ppb in the living area; acrolein ranged from 0.5 to 3.1 ppb in the basement and was 1.5 ppb in the living area; and formaldehyde ranged from 16 to 27 ppb in the basement versus 29 to 31 ppb in the living area). It should be noted that the windows of the residence were open during one of the two days of air sampling, and air conditioning was running on the other day

(Lipson 2001). These conditions may have resulted in an underestimate of the levels of any chemicals inside the home. Formaldehyde was also detected in one outdoor air sample at 4.3 ppb.

Several detected chemicals in indoor air did not have screening values available from ATSDR or EPA. One of these chemicals, d-limonene, is found in citrus fruit, food additives, and consumer products. Although it has fairly low toxicity to most people, it can be associated with hypersensitivity reactions (Pearson 2001). It is not known if such reactions could be additive with aldehyde chemicals. The other chemicals without screening values are aldehydes (i.e., hexanaldehyde, isobutyraldehyde, pentanal, and propanal). These chemicals, which were each detected at 2.5 ppb or less, are structurally similar to acetaldehyde but have longer carbon chains. They are likely to have similar toxicity to acetaldehyde, and therefore could add to any effect that may be induced by the other aldehydes.

Aldehyde Compounds

Mean and maximum values of acrolein and acetaldehyde both exceeded available screening values. Inside the house, formaldehyde's maximum level exceeded its cancer and intermediate-term noncancer screening values, but not its acute (short-term) screening value. The mean formaldehyde level in the house exceeded the cancer screening value but not the noncancer screening values (see Table 1). The concentration of formaldehyde in outside air (i.e., 4.3 ppb) was approximately four-fold lower than the lowest indoor air concentrations. The outside concentrations exceeded the cancer but not the noncancer screening values. Possible health effects associated with these three chemicals are summarized below. Following this information is a discussion about the possible health effects that could plausibly occur at the residence as a result of possible exposures to the aldehydes.

- Acrolein, which is formed during burning of gasoline and tobacco products and cooking certain foods, is a strong respiratory irritant. Irritation of eyes, nose, and throat has been observed in humans at concentrations greater than 50 ppb. Animal studies indicate that acrolein may also be associated with chronic respiratory damage. There are no significant findings of dermatological, reproductive, developmental, neurological, or immunologic effects from exposure to acrolein. Acrolein is considered a possible human respiratory carcinogen, primarily based on structural similarity to other carcinogenic chemicals. Acrolein levels in outdoor air in urban areas have been measured as high as 9 ppb, but in rural areas are much lower. Indoor air concentrations can be as high as 100 ppb when smoking is present. Levels above 50 ppb have been shown to cause irritation in humans (ATSDR 1990, NRC 1984).

- Acetaldehyde is present in cigarette smoke and urban smog, and is found in some fruits and vegetables. It is also used in the chemical industry. Acetaldehyde is an acute respiratory irritant, and has also caused chronic respiratory damage in animal studies. Skin contact can cause dermal irritation, but it is not clear if skin reactions can result from inhalation exposure. Some evidence from animal studies indicates

that acetaldehyde may be a developmental toxicant. Acetaldehyde does not appear to cause other systemic toxicological effects, though few studies have been done. Acetaldehyde is also considered a probable human nasal and respiratory tract carcinogen, based on studies that found tumors in the respiratory tracts of animals exposed for long periods of time (EPA 1994). Studies have indicated that outdoor acetaldehyde concentrations are typically 1.5-3 ppb in urban areas, but less than 0.8 ppb in rural areas, while indoor air concentrations can range from 0-35 ppb, depending on cooking, fireplace use, and whether cigarette smoking is present. There are no studies indicating that ambient levels have caused acute health effects in humans (CARB 1993).

- Formaldehyde, which is found in products including insulation, preservatives, resins, fertilizers, dyes, and medicines, is irritating to the eyes, nose, and throat. The respiratory tract is the area most affected by formaldehyde; both acute and chronic respiratory illnesses have been observed in humans and animals. Acute health effects can include nausea, headaches, and irritation of the skin, eyes, and mucous membranes. Some evidence suggests formaldehyde may be a neurological toxicant, and it is considered a probable human nose, throat, and lung carcinogen, with some evidence of respiratory tract cancers in exposed workers and supporting evidence from studies in animals. Furthermore, there is evidence that formaldehyde can induce long-term allergic sensitization in humans. Some individuals who have been previously exposed to formaldehyde (usually by dermal contact) have developed specific antibodies to the chemical. Upon subsequent exposure of these individuals to the chemical, even to small amounts which would otherwise not be harmful, inflammatory responses can result. Some research also suggests that formaldehyde sensitization could increase immune responses to other respiratory allergens (ATSDR 1999). Studies have shown indoor concentrations of formaldehyde to range from 10 to 100 ppb, while outdoor concentrations are usually much lower, from 3-5 ppb. For most individuals the lowest observed level of health effects occurs at exposures above 100 ppb; however, for sensitive individuals the effects may occur at exposure to levels from 30 to 70 ppb (CARB 1992).

  Regarding the carcinogenic potential of formaldehyde, scientific reviewers concur that cancer of the upper respiratory tract is more biologically plausible from inhalation exposure than cancer at distant sites, because formaldehyde is highly reactive and respiratory tissues can metabolize formaldehyde. Although formaldehyde is the most well-studied of the three aldehydes discussed here, the chemicals are structurally similar and it is reasonable to conclude they may act by similar mechanisms.

SUMMARY

At the Bemis Circle residence, formaldehyde was found at a lower concentration outside than inside the house (4.3 ppb versus 31 ppb). Also, available data do not indicate significant variation in levels of detected chemicals between the basement and living area. For these reasons, and because aldehyde chemicals are typically associated

with household products (e.g., particleboard, plywood, fabric) and combustion, it appears, based on available data, the source at this residence may be within the home. The aldehydes do not appear to be present at atypical indoor concentrations (e.g., total aldehydes can average 40 to 400 ppb in indoor air [Moschandreas 1978]), and the chemicals individually appear to be present at levels below those which have been normally associated with health effects. However, levels of these compounds inside this residence may have been underestimated, since windows in the home appear to have been open during the first of two days of air sampling, and air conditioning was running on the second day (Lipson 2001). As noted above, this could have resulted in an underestimate of the levels of any chemicals whose source is inside the home.

People's sensitivity to chemicals can vary widely, and, because several different irritants are present, the levels of total aldehydes may be elevated enough to cause irritation to sensitive individuals. Particularly if any residents of this home are sensitized to formaldehyde or other aldehydes, it is possible that they might experience reactions to formaldehyde at the concentrations (i.e., 16 to 31 ppb) detected in the indoor air of the house. There are medical tests that can determine if such sensitization has occurred.

ATSDR'S CHILD HEALTH INITIATIVE

ATSDR and MDPH, through ATSDR's Child Health Initiative, recognize that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their environment. Children are at a greater risk than adults from certain kinds of exposure to hazardous substances emitted from waste sites. They are more likely to be exposed because they play outdoors and because they often bring food into contaminated areas. Because of their smaller stature, they may breathe dust, soil, and heavy vapors close to the ground. Children are also smaller, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if certain toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care. This Health Consultation evaluated opportunities for exposure to all individuals, including children.

CONCLUSIONS

Sampling data from the Bemis Circle property indicated certain chemicals were present at levels exceeding their health-based screening values. Based on the data reviewed, MDPH concludes:

1. The three aldehyde chemicals found exceeding their screening values in indoor air, as well as other aldehydes which did not have screening values, may present a health concern to residents of the property. Although levels of each chemical appear to be lower than those at which health effects have usually been observed,

total levels of these chemicals could be irritating to very sensitive individuals. Individuals sensitized to formaldehyde may react at lower levels than the general population. Evaluation by a physician trained in environmental medicine may help determine whether formaldehyde or other aldehyde sensitization has occurred in any concerned residents.

2. Since the three aldehyde chemicals found exceeding their air screening values indoors were not detected in outdoor air, and because these chemicals are commonly found in consumer products, the possibility that their source is within the home warrants further investigation. Consumer products such as insulation, particleboard, and fabric preservative, contain formaldehyde. Gas stoves, fireplaces, and smoking are also common sources of aldehyde chemicals. Further evaluation of the home (particularly indoor air tests with the windows closed) may help to identify the potential sources of these chemicals.

3. One of 12 soil samples contained elevated levels of heptachlor epoxide, but the mean level of heptachlor epoxide in the soil was below screening values. Because elevated levels were found in one location on the property, frequent contact with high levels is unlikely and exposures to average levels found in soil are unlikely to pose a health concern.

4. Soil gas contained some VOCs. Two VOC compounds (i.e., chloroform and bromodichloromethane) that were above health-based screening levels in soil gas were not detected in outdoor or indoor air. Two other compounds, tetrachloroethene and carbon tetrachloride, were detected in soil gas and in at least one indoor air sample at levels exceeding health-based guidance values. However, the soil gas and indoor air concentrations of carbon tetrachloride were similar to each other and to typical background levels reported in the literature for indoor or outdoor air concentrations of this compound. Tetrachloroethene concentrations in indoor air were lower than in soil gas and at levels typical of this reported as background indoor and outdoor air. Thus, based on these data, residents of this home are unlikely to experience opportunities for exposure to soil gases that would be of health concern. However, because indoor air testing was conducted with windows open, the representativeness of these data for worst case conditions (e.g., windows closed) is unclear.

5. Groundwater and surface water on or in very close proximity to this residence contained VOCs at levels below drinking water screening values.

6. ATSDR requires that one of five conclusion categories be used to summarize findings of health consultations and health assessments. These categories are: 1) Urgent Public Health Hazard, 2) Public Health Hazard, 3) Indeterminate Public Health Hazard, 4) No Apparent Public Health Hazard, 5) No Public Health Hazard. A category is selected from site-specific conditions such as the degree of public health hazard based on the presence and duration of human exposure, contaminant concentration, the nature of toxic effects associated with site-related contaminants,

presence of physical hazards, and community health concerns. Based on ATSDR criteria, ATSDR would classify the conditions at Bemis Circle residence as an indeterminate health hazard. While chemicals have been detected over their screening values in the indoor air of the home, and the mixture of aldehyde chemicals (e.g., formaldehyde, etc.) may be sufficient to cause adverse health effects in some individuals (i.e., those who may have been previously sensitized to these types of compounds), additional investigation is needed as described, in the recommendations below to determine health concerns more specifically.

RECOMMENDATIONS

1. If residents of this home feel they may be experiencing health problems, MDPH recommends that they pursue medical follow-up with an appropriate specialist to determine whether they may be sensitized to formaldehyde or other aldehyde compounds. MDPH can provide referral assistance upon request.

2. Upon request, MDPH will conduct a home visit to evaluate potential sources of the chemicals detected in indoor air, particularly those exceeding health-based screening values. If sources can be identified, MDPH can advise residents on ways to reduce opportunities for exposure.

3. MDPH will conduct a follow-up health consultation based on the data collected in March 2001 that will include a determination of the representativeness of sampling data generated in 2000.

PUBLIC HEALTH ACTION PLAN

1. MDPH will, upon request, provide assistance with an environmental medical consultation if any residents are concerned that they may be experiencing adverse health effects or chemical sensitization.

2. MDPH will, upon request, conduct a home visit to advise residents on possible sources of aldehydes and other irritants in the home.

3. MDPH will conduct a follow-up health consultation.

This document was prepared by the Bureau of Environmental Health Assessment of the Massachusetts Department of Public Health. If you have any questions about this document, please contact Suzanne K. Condon, Assistant Commissioner, 7th Floor, 250 Washington Street, Boston, Massachusetts 02108.

Certification

The Health Consultation for Sutton Brook Disposal Area: Bemis Circle Residence, Tewksbury, Massachusetts was prepared by the Massachusetts Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated. The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

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Table 1: Chemicals Detected in Indoor Air[1] at the Bemis Circle Residence Tewksbury, Massachusetts

Compound[2]	Number of Detects/Samples	Units	Minimum	Mean	Maximum	Comparison Values	
						Value	Type
1,1,1-Trichloroethane	9/9	ppb	1.1 J	3.3	5	700	Int. EMEG
Toluene	9/9	ppb	5 J	11	13	80	Chr. EMEG
D-Limonene	6/6	ppb	0.7 J	9.7	29	NA	
Methylene Chloride	3/3	ppb	3 J	3.5	5	0.9 300	CREG Chr. EMEG
Carbon Tetrachloride	1/9	ppb	ND	1.7[3]	0.2 J	0.01	CREG
Benzene	7/9	ppb	ND	1.3	1.3 J	0.3	CREG
n-Heptane	2/6	ppb	ND	1.8	0.8 J	NA	
Methylcyclohexane	3/6	ppb	ND	1.4	0.4 J	772	RBC (residential)
n-Octane	1/6	ppb	ND	1.2	0.6 J	NA	
Tetrachloroethene	5/9	ppb	ND	1.2	0.6 J	0.5	RBC (residential)
Ethylbenzene	5/9	ppb	ND	1.3	0.7 J	NA	
m-, p-, and o-xylenes	8/9	ppb	ND	1.7	2.2 J	560	Chr. EMEG
Bromoform	1/6	ppb	ND	1.0	0.5 J	0.09	CREG
n-Nonane	6/6	ppb	0.2 J	1.3	2.6 J	NA	
Mesitylene	2/6	ppb	ND	1.5	0.3 J	NA	
1,4-Dichlorobenzene	5/6	ppb	ND	1.9	2.9 J	100	Chr. EMEG
n-Decane	5/6	ppb	ND	2.2	5.2	NA	
n-Undecane	5/6	ppb	ND	2.2	3.8	NA	
n-Dodecane	5/6	ppb	ND	1.4	1.7 J	NA	
n-Tridecane	6/6	ppb	0.4 J	1.4	2.0 J	NA	
n-Tetradecane	6/6	ppb	0.4 J	1.2	1.7 J	NA	
n-Pentadecane	6/6	ppb	0.3 J	0.7	1.0 J	NA	
n-Hexadecane	6/6	ppb	0.2 J	0.6	0.5 J	NA	
Acetaldehyde	6/6	ppb	5.4	11.0	15	0.3 2.8	CREG RfC
Acrolein	3/6	ppb	ND	1.0	3.1	0.009 0.05	Int. EMEG Acute EMEG
Benzaldehyde	6/6	ppb	0.56	0.8	1	85.2	RBC (residential)
Formaldehyde	6/6	ppb	16	24.5	31	0.06 30 40	CREG Int. EMEG Chr. EMEG

1 In the two outdoor air samples, there was one detection of formaldehyde at 4.3 ppb; no other chemicals were detected.
2 Compounds which were not detected in any sample are not shown on the table.
3 Some mean levels are higher than maximum levels because of variation in detection limits.

Compound[2]	Number of Detects/Samples	Units	Minimum	Mean	Maximum	Comparison Values	
						Value	Type
Hexanaldehyde	6/6	ppb	1.1	1.9	2.5	NA	
Isobutyraldehyde	5/6	ppb	ND	0.6	0.98	NA	
o-Tolualdehyde	1/6	ppb	ND	0.1	0.32	85.2	Benzaldehyde[4]
Pentanal	6/6	ppb	0.44	0.7	0.99	NA	
Propanal	6/6	ppb	0.8	1.6	2.3	NA	

J: The value is below the method detection limit and is estimated.
NA: Not available. No screening levels were found for this chemical. See text.
ND: Not detected.

See text and glossary for more information on comparison values.
CREG: Cancer Risk Evaluation Guide;
RMEG: Reference Dose Media Evaluation Guide;
Chr. EMEG, Int. EMEG, Acute EMEG: Chronic, Intermediate and Acute Environmental Media Evaluation Guides
RBC: EPA Region III Risk-Based Concentration;

4 Benzaldehyde is used as a surrogate for this chemical, because of its structural similarity.

Table 2: Chemicals Detected in Soil at the Bemis Circle Residence, Tewksbury, Massachusetts

Compound[5]	# Detects/ # Samples	Units	Minimum	Mean	Maximum	Comparison Values	
						Value	Type
Aluminum	12/12	ppm	3020	5464.2	8700	100000	Int. EMEG (child)
Arsenic	8/12	ppm	ND	4.9	8.7	0.1 – 73 0.5 20 200	Background[6] CREG Cr EMEG (child) Cr EMEG (adult)
Barium	11/12	ppm	ND	19.1	42.4	4000	RMEG (child)
Beryllium	10/12	ppm	ND	0.3	0.4 J	50	RMEG (child)
Calcium	12/12	ppm	290	1273	4250 J	NA	
Chromium	12/12	ppm	6.2	9.5	15.1	200	RMEG (child)
Cobalt	7/12	ppm	ND	2.2	3.4 J	4700	RBC (residential)
Copper	12/12	ppm	2.4	10.6	30.8	3100	RBC (residential)
Cyanide	3/12	ppm	ND	0.11	0.64	1000	RMEG (child)
Iron	12/12	ppm	4050	5708.3	8050	23000	RBC (residential)
Lead	12/12	ppm	2.2	28.2	97.3	400	EPA soil std (res.)
Magnesium	12/12	ppm	752 J	1192	1410 J	NA	
Manganese	12/12	ppm	49	107.3	202	3000	RMEG (child)
Mercury	2/12	ppm	ND	.02	0.1 J	20	MA DEP S-1
Nickel	11/12	ppm	ND	5.7	6.9	1000	RMEG (child)
Potassium	12/12	ppm	224	401	560	NA	
Silver	5/12	ppm	ND	1.2	2.4	300	RMEG (child)
Vanadium	12/12	ppm	5.9	8.7	13.8	200	Int. EMEG (child)
Zinc	5/12	ppm	ND	22.2	77 J	20000	Cr EMEG (child)
Methyl Acetate	5/12	ppb	ND	497	1800	78000	RBC (residential)
Caprolactam	1/5	ppb	ND	718	51 J	39,000,000	RBC (residential)
Di-n-butylphthalate	1/12	ppb	ND	403	43 J	5,000,000	RMEG (child)
Bis(2-ethylhexyl)phthalate	3/12	ppb	ND	342	200 J	46000	RBC (residential)
4,4'-DDE	6/12	ppb	ND	19	74	2000	CREG
4,4'-DDT	5/12	ppb	ND	28	110	2000	CREG
Heptachlor Epoxide	2/11	ppb	ND	12	110	80 700	CREG RMEG (child)
alpha-Chlordane	3/11	ppb	ND	78	770	2000 30000	CREG Cr EMEG (child)
Heptachlor	1/12	ppb	ND	12	130	200	CREG
gamma-Chlordane	5/12	ppb	ND	71	790	2000 30000	CREG Cr EMEG (child)

5 Compounds which were not detected in any sample are not shown on the table.
6 Natural background levels of arsenic in the eastern United States from Shacklette and Boerngen (1984).

Compound[5]	# Detects/ # Samples	Units	Minimum	Mean	Maximum	Comparison Values	
						Value	Type
Endrin aldehyde	1/12	ppb	ND	4	11 J	NA	
PCBs (Aroclor 1254)	1/12	ppb	ND	50	230 J	320	RBC (residential)
Phenanthrene	3/12	ppb	ND	300	440 J	100,000	CREG
Fluoranthene	5/12	ppb	ND	320	1000 J	100,000 2,000,000	CREG RMEG (child)
Pyrene	5/12	ppb	ND	238	820 J	1000 2,000,000	CREG RMEG (child)
Benzo(a)anthracene	3/12	ppb	ND	298	430 J	1000	CREG
Chrysene	4/12	ppb	ND	252	620 J	10000	CREG
Benzo(b)fluoranthene	3/12	ppb	ND	301	450 J	1000	CREG
Benzo(k)fluoranthene	3/12	ppb	ND	285	340 J	1000	CREG
Benzo(a)pyrene	3/12	ppb	ND	295	400 J	100	CREG
Ideno(1,2,3-cd)pyrene	3/12	ppb	ND	270	250 J	1000	CREG
Benzo(g,h,i)perylene	1/12	ppb	ND	353	200 J	10000	CREG

J: The value is below the method detection limit and is estimated.
NA: Not available. No screening levels were found for this chemical. See text.
ND: Not detected.

See text for more information on comparison values.
CREG: Cancer Risk Evaluation Guide;
RMEG: Reference Dose Media Evaluation Guide;
Chr. EMEG, Int. EMEG, Acute EMEG: Chronic, Intermediate and Acute Environmental Media Evaluation Guides
RBC: EPA Region III Risk-Based Concentration;

Table 3a: Chemicals Detected in Soil Gas at the Bemis Circle Residence, Tewksbury, Massachusetts

Compound[7]	Number of Detects/Samples	Units	Minimum	Mean	Maximum	Comparison Values	
						Value	Type
Dichlorodifluoromethane	5/5	ppb	0.69	0.8	0.85	36.3	RBC (residential)
Acetone	1/5	ppb	ND	0.3	0.46	13000	Chr. EMEG
Trichlorofluoromethane	4/5	ppb	ND	0.3	0.31	130	RBC (residential)
Methylene Chloride	2/5	ppb	ND	0.2	0.56	0.9 300	CREG Chr. EMEG
1,1,2-Trichloro-1,2,2-trifluoroethane	5/5	ppb	0.13	0.3	0.79	4036	RBC (residential)
Hexane	1/5	ppb	ND	0.03	0.061	600	Chr. EMEG
Chloroform	3/5	ppb	ND	2.8	9.8	.002 20	CREG Chr. EMEG
1,1,1-Trichloroethane	5/5	ppb	0.054	46.6	230	700	Int. EMEG
Carbon Tetrachloride	3/5	ppb	ND	0.1	0.12	0.011	CREG
Bromodichloromethane	1/5	ppb	ND	0.4	2	0.02	RBC (residential)
Toluene	2/5	ppb	ND	0.05	0.13	80	Chr. EMEG
Tetrachloroethene	4/5	ppb	ND	7.4	15	0.5 40	RBC (residential) Chr. EMEG[8]

ND: Not detected.

See text for more information on comparison values.
CREG: Cancer Risk Evaluation Guide;
RMEG: Reference Dose Media Evaluation Guide;
Chr. EMEG, Int. EMEG, Acute EMEG;
RBC: EPA Region III Risk-Based Concentration

7 Compounds which were not detected in any sample are not shown on the table.
8 ATSDR does not have a cancer risk level for tetrachloroethene; however, since USEPA considers it a probable carcinogen, the Region IX PRG is included here.

Table 3b: Chemicals Detected in Ambient Air Grab Sample at the Bemis Circle Residence, Tewksbury, Massachusetts

Compound[9] (one sample)	Units	Concentration	Comparison Values	
			Value	Type
Dichlorodifluoromethane	ppb	0.79	36.3	RBC (residential)
Acetone	ppb	0.46 J	13000	Chr. EMEG
Trichlorofluoromethane	ppb	0.30	130	RBC (residential)
Hexane	ppb	0.061	600	Chr. EMEG
1,1,1-Trichloroethane	ppb	0.054	700	Int. EMEG
Carbon Tetrachloride	ppb	0.12	0.01	CREG
Toluene	ppb	0.13	80	Chr. EMEG

J: The value is below the method detection limit and is estimated.

See text for more information on comparison values.
CREG: Cancer Risk Evaluation Guide;
RMEG: Reference Dose Media Evaluation Guide;
Chr. EMEG, Int. EMEG, Acute EMEG;
RBC: EPA Region III Risk-Based Concentration

9 Compounds which were not detected in any sample are not shown on the table.

Table 4: Chemicals Detected in Surface Water and Groundwater Near the Bemis Circle Residence, Tewksbury, Massachusetts

Compound[10]	**Surface Water**[11] (ppb)	**Ground-water**[12] (ppb)	**Comparison Values (ppb)**	
			Value	Type
Acetone	14	NA	1000	RMEG
Chloroethane	2.7	NA	3600	RBC
Ethylbenzene[13]	4.6	0.44	700	LTHA
1,1-Dichloroethane	2	ND	5	MMCL
Xylenes	18.2	4.0	2000	Int. EMEG (child)
cis-1,2-Dichloroethylene	1.1	ND	70	LTHA
1,1,1-Trichloroethane	2.8	ND	200	LTHA
2-Butanone	18	NA	350	ORSG
Methyl isobutyl ketone	22	NA	350	ORSG
Toluene	33	5.7	200	Int. EMEG (child)
Benzene[14]	ND	0.35	0.6	CREG
1,2,4-Trimethylbenzene	ND	5.1	12	RBC
Tetrahydrofuran	58	NA	1300	ORSG

NA: Not analyzed
ND: Not detected.

See text for more information on comparison values.
CREG: Cancer Risk Evaluation Guide;
RMEG: Reference Dose Media Evaluation Guide;
Chr. EMEG, Int. EMEG, Acute EMEG: Chronic, Intermediate and Acute Environmental Media Evaluation Guides
RBC: EPA Region III Risk-Based Concentration;
MMCL: Massachusetts Maximum Contaminant Level for Drinking Water
LTHA: Lifetime health advisory for drinking water (EPA)
ORSG: Massachusetts Office of Research and Standards Guideline (for chemicals lacking MCLs)

10 Compounds which were not detected in either medium are not shown on the table.
11 One surface water sample was collected from Sutton Brook.
12 One groundwater sample was collected from the Bemis Circle Residence.
13 Detected at a trace level.
14 Detected below its minimum detect limit.

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ATSDR PLAIN LANGUAGE GLOSSARY OF ENVIRONMENTAL HEALTH TERMS

Revised –15 Dec 1999

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

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

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

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

Antagonistic Effect: A response to a mixture of chemicals or combination of substances that is less than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

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

Biota: Used in public health, things that humans would eat – including animals, fish and plants.

CAP: See **C**ommunity **A**ssistance **P**anel**.**

Cancer: A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See Comprehensive Environmental Response, Compensation, and Liability Act.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathway: See **Exposure Pathway**.

Community Assistance Panel (CAP): A group of people from the community and health and environmental agencies who work together on issues and problems at hazardous waste sites.

Comparison Value (CVs): Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): CERCLA was put into place in 1980. It is also known as Superfund. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

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

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

Contaminant: See **Environmental Contaminant**.

Delayed Health Effect: A disease or injury that happens as a result of exposures that might have occurred far in the past.

Dermal Contact: A chemical getting onto your skin. (see Route of Exposure).

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

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

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

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

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

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology: The study of the different factors that determine how often, in how many people, and in which people will disease occur.

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

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

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having five parts:

1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all five parts of an exposure pathway are present, it is called a Completed Exposure Pathway. Each of these five terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

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

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

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

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

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

LOAEL: Lowest Observed Adverse Effect Level. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

Malignancy: See Cancer.

MRL: Minimal Risk Level. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The National Priorities List. (Which is part of Superfund.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: No Observed Adverse Effect Level. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals might have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

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

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

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

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

PRP: Potentially Responsible Party. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

Public Health Assessment(s): See PHA.

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

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

Reference Dose (RfD): An estimate, with safety factors (see safety factor) built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause harm to the person.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:

- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

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

SARA: The Superfund Amendments and Reauthorization Act in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.

Sample Size: The number of people that are needed for a health study.

Sample: A small number of people chosen from a larger population (See Population).

Source of Contamination: The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an Exposure Pathway.

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

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See NPL.

Survey: A way to collect information or data from a group of people (population). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

Synergistic Effect: A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together are greater than the effects of the chemicals acting by themselves.

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

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

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See Safety Factor.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

APPENDIX B

Protocol for Assessing Indoor Air Quality at Bemis Circle Residence

Massachusetts Department of Public Health
Center for Environmental Health
April 13, 2004

Background

The Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) released a Health Consultation, entitled Bemis Circle Residence Located Near Sutton Brook Disposal Area, in July 2001. The consultation evaluated data (i.e., indoor/outdoor air, soil, and soil gas) collected by the United States Environmental Protection Agency (EPA) and an EPA contractor in June and September 2000. One of the recommendations in the consultation was that upon request by the resident(s), MDPH would conduct a home visit to evaluate potential sources of the chemicals detected in the indoor air, particularly those exceeding health-based screening values. If sources could be identified, MDPH would advise residents on ways to reduce opportunities for exposure.

Additional air sampling was conducted by an EPA contractor in March 2001. However, MDPH was only recently contacted by a resident on behalf of the occupant to pursue a follow-up home visit. Hence, the purpose of this brief protocol is to describe the MDPH approach to conducting an indoor air quality assessment at the Bemis Circle residence.

Methods

The site visit will include both visual observations (e.g., indoor sources of volatile organic compounds, mold) and some limited indoor air testing, using equipment that measures total volatile organic compounds (TVOCs), fine particulate matter, relative humidity, and air temperature. The following is a description of the indoor air testing equipment.

Total Volatile Organic Compounds

A Photo Ionization Detector (PID) equipped with a 10.6 (eV) electronic volt lamp is used to detect TVOCs with an ionization potential less than or equal to 10.6 (eV). To obtain a comparison sample, outdoor measurements are recorded in a location away from the building and potential volatile organic compound (VOC) generating sources. Air samples are taken in a neutral airflow area (e.g., center of the room, outside the air stream of the ventilation system). If a detectable measurement is obtained, the monitoring equipment is moved to other locations to identify the source of TVOCs. These sources of TVOCs can be any material that contains petroleum-derived products. These materials can be included but are not limited to office products (e.g., permanent markers, rubber cement), fuels (e.g., gasoline, heating oil), science chemicals, and materials used during renovations/construction/arts (e.g., paints, adhesives, caulking).

Fine Particulate Matter

Airborne particle measurements are obtained with a TSI Dust-Trak. To obtain a comparison sample, an outdoor measurement is recorded in a location away from the building and operating motor vehicles. Indoor measurements are made in a neutral airflow area in each room (e.g., center of classroom outside the direct air stream of the

ventilation system). These measurements are generally taken within the breathing zone of building occupants (2 ½ to 5 feet in height above the floor), away from doors and windows. If a detectable measurement is obtained in comparison to outdoor measurements, the monitoring equipment is moved to other locations to identify the sources of airborne particles. These sources consist of the location of motor vehicles outside the area sampled as well as combustion sources, such as boiler/furnace chimney/exhaust vents, non-vented cooking stoves, propane heaters, boiler/furnaces, gas-fueled air handling units or water heaters. Other sources can include renovation activities, tobacco smoke, carpentry/grinding, brazing of file tire and other maintenance activities.

Relative Humidity

Relative humidity readings will be obtained with a TSI, Q-Trak, IAQ Monitor Model 8551. Indoor relative humidity measurements are taken in a neutral airflow area in each room. These measurements are generally taken within the breathing zone of the building occupants (2 ½ feet to 5 feet in height above the floor), away from doors and windows. Relative humidity samples are taken in as many rooms/areas as feasible under normal operating conditions. The number of room occupants is recorded and the statuses of portals that allow for airflow are denoted (e.g., open windows, doors or transoms). These factors can greatly affect relative humidity measurements. Other non-human sources of airborne water vapor are noted. These non-human sources consist of non-vented bathrooms, water penetration into crawlspaces/foundations, non-vented kitchens, non-vented clothes driers, non-vented pottery kilns, and/or water heaters. Outdoor relative humidity measurements are recorded in a location away from the building and in a shaded area away from direct sunlight at the same time as the temperature readings.

Temperature

Temperature readings will be obtained with a TSI, Q-Trak, IAQ Monitor Model 8551. Indoor temperature measurements are taken in a neutral airflow area in each room (e.g., center of room outside the direct air stream of the ventilation system). These measurements are generally taken within the breathing zone of the building occupants (2 ½ feet to 5 feet in height above the floor), away from doors and windows. Temperature samples are taken in as many rooms/areas as feasible under normal operating conditions. The number of room occupants is recorded and the statuses of portals that allow for airflow are denoted (e.g., open windows, doors or transoms). These factors can greatly affect temperature measurements. Other non-human sources of heat are noted. These non-human sources consist of computer CPUs and monitors, electrical appliances, and combustion sources, such as motor vehicles, gas stoves, propane heaters, or water heaters. Outdoor temperature measurements are recorded in a location away from the building and in a shaded area away from direct sunlight.

Interpretation of Results

MDPH will prepare a written report on the indoor air quality including an analysis of the data collected by an EPA contractor in 2001. For the indoor air parameters that MDPH will be measuring, comparisons will be made between outdoor and indoor measurements as well as ideal ranges. MDPH will interpret the EPA data using health-based comparison values developed by the United States Agency for Toxics Substances and Disease Registry (ATSDR). If no ATSDR comparison values are available, MDPH will use comparison values from other sources. For example, a scientific paper published in the journal Proceedings of Indoor Air found that for TVOC exposures ranging from 0.2 to 3 ppm, odors and irritant effects may result in temporary discomfort.

APPENDIX C

Comparison Values

Health assessors use a variety of health-based screening values, called comparison values, to help decide whether compounds detected at a site might need further evaluation. These comparison values include environmental media evaluation guides (EMEG), reference dose media evaluation guides (RMEG), cancer risk evaluation guides (CREG), and maximum contaminant levels for drinking water (MCL). These comparison values have been scientifically peer reviewed or were derived from scientifically peer-reviewed values and published by the Agency for Toxic Substances and Disease Registry (ATSDR) and/or EPA. The MA DEP has established Massachusetts's maximum contaminant levels (MMCL) for public drinking water supplies. EMEG, RMEG, MCL, and MMCL values are used to evaluate the potential for noncancer health effects. CREG values provide information on the potential for carcinogenic effects. For chemicals that do not have comparison values available for the medium of concern, EPA risk-based concentrations (RBCs) developed by EPA regional offices, are used.

If the concentration of a compound exceeds its comparison value, adverse health effects are not necessarily expected. Rather, these comparison values help in selecting compounds for further consideration. For example, if the concentration of a chemical in a medium (e.g., soil) is greater than the EMEG for that medium, the potential for exposure to the compound should be further evaluated for the specific situation to determine whether noncancer health effects might be possible. Conversely, if the concentration is less than the EMEG, it is unlikely that exposure would result in noncancer health effects. EMEG values are derived for different durations of exposure according to ATSDR's guidelines. Acute EMEGs correspond to exposures lasting 14 days or less. Intermediate EMEGs correspond to exposures lasting longer than 14 days to less than one year. Chronic EMEGs correspond to exposures lasting one year or longer. CREG values are derived assuming a lifetime duration of exposure. RMEG values also assume chronic exposure. All the comparison values (i.e., CREGs, EMEGs, RMEGs, and RBCs) are derived assuming opportunities for exposure in a residential setting.

CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed during their lifetime (70 years). ATSDR's CREGs are calculated from EPA's cancer slope factors for oral exposures or unit risk values for inhalation exposures. These values are based on EPA evaluations and assumptions about hypothetical cancer risks at low levels of exposure.