Health Consultation

Public Comment Release

REVIEW OF SOIL SAMPLING DATA FROM OCTOBER 2002 TO NOVEMBER 2003

BAY STREET STUDY AREA SITE

TIVERTON, NEWPORT COUNTY, RHODE ISLAND

JUNE 15, 2005

Comment Period End Date: July 18, 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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Prepared by:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Table of Contents

Summary and Statement of Issues

United States Senator Jack Reed requested that the Agency for Toxic Substances and Disease Registry (ATSDR) review soil-sampling data collected from contaminated soil in Tiverton, Rhode Island. Senator Reed further requested that ATSDR provide recommendations in a public health consultation regarding the potential health impacts from exposure to that contaminated soil. ATSDR evaluated the available environmental sampling information for potential exposure to contaminants found in residential soil as well as in non-residential soils. The information includes data collected from October 2002 to November 2003 by EA Engineering Science and Technology, Inc. (EA) and Vanase Hangen Brustlin, Inc.(VHB).

In 2002 soil contamination was discovered during the installation of a Bay Street sewer main. The Rhode Island Department of Environmental Management (RIDEM) started the initial investigation and oversaw further investigation by the Town of Tiverton and by New England Gas Company (NEGC). Soil samples have been collected from roadways, from residential properties, and from the Bay View Recreation Area. For this health consultation ATSDR reviewed and evaluated the available environmental data — approximately 465 surface soil samples and 216 subsurface soil samples. ATSDR identified arsenic, lead, mercury, and PAHs as potential contaminants of concern for the site. Analysis of exposure pathway indicated that

1. For general activities, soil arsenic levels at tested properties are unlikely to cause adverse, noncancer health effects in children and adults. Residents who have a continuous lifetime exposure to the highest levels of arsenic observed at this site via ingestion have no apparent increased risk (i.e., one to two extra cancer cases per every 10,000 people exposed) of developing cancer.
2. Several properties have concentrations of lead above 400 milligram per kilogram (mg/kg). If those are in areas where contact with soil is frequent, such as play areas with bare surface soil, they might present a health hazard for children.
3. Except for one property, soil mercury concentrations of tested properties are below soil screening values. That property has one hotspot containing a maximum mercury concentration of 3,890 mg/kg. If residents are exposed to those levels, a potential public health hazard exists.
4. Concentrations of six polycyclic aromatic hydrocarbons (PAHs) exceeded their respective Cancer Risk Evaluation Guidelines (CREGs) or Risk-Based Concentrations (RBCs). Conservative risk evaluation indicated that residents who have a continuous lifetime exposure to those chemicals via ingestion have no apparent increased risk (i.e., 2 extra cancer cases per 10,000 people exposed) of developing cancer.
5. The analysis includes some environmental data limitations: 1) data are not available for more than half of the properties at the site, 2) existing surface soil samples might not provide an accurate measure of property-wide levels of contaminations, and 3) data are lacking for all U.S. Environmental Protection Agency (EPA) target compounds and other potential contaminants of concern.

Because of the environmental data limitations for the site, ATSDR has categorized this site as an “Indeterminate Public Health Hazard.” ATSDR recommends additional environmental sampling, additional biological monitoring to evaluate lead exposures in the community, and health education activities. It should be noted that the purposes of the health consultation are to identify possible exposures and to recommend actions needed to protect public health. Remedial decisions concerning soil on the site are based on the RIDEM Remediation Regulations, as amended, with EPA risk assessment methodology.

Background

In November 2003, United States Senator Jack Reed requested that ATSDR investigate potential health impacts from exposure to contaminated soil in Tiverton, Rhode Island. The soil contamination was discovered in summer 2002, during the installation of a sewer main in Bay Street [1]. The soil stockpiles excavated at this site consist of blue-colored soil with a petroleum odor — indicative of coal gasification waste materials.

The site covers approximately 36 acres and is located in a mixed residential, industrial, and undeveloped area. Demographic statistics from the 2000 Census indicate that approximately 156 housing units and 400 residents are at the site. The site boundaries are the Mount Hope Bay and a petroleum terminal to the west, Church Street to the east, State Avenue to the north, and Lepes Road to the south. Demographic statistics, again based on 2000 Census data, are presented in Figure 1.

The Rhode Island Department of Environmental Management (RIDEM) started the initial investigation in 2002. In 2003, RIDEM requested and oversaw further investigation by the Town of Tiverton and by the former Fall River Gas Company, now owned by Southern Union Company/New England Gas Company (NEGC). The historical disposal practices of the former manufactured gas plant (MGP) could have contributed to the contamination.

From the 1800s to the 1900s manufactured gas plants were the major energy provider in the United States [2]. MGPs produced gas from coal, oil, and other feedstocks. From 1850 to 1960, 50,000 manufactured gas plants operated in the United States [3]. The gas production and purification processes at MGPs generated byproducts and residues that included two principal waste materials: coal-tar and purifier waste. Coal tar is the most common contaminant at MGP sites. Purifier waste is a dark mixture of wood chips with a very strong and unpleasant burnt odor. Purifier waste often contains significant quantities of cyanide compounds and coal tar residue. Although the composition of waste materials varies, it is usually a mixture of the following [4]:

- Polycyclic aromatic hydrocarbons (PAHs), such as benzopyrene, naphthalene, anthracene, acenaphthene, and phenathrene;
- Volatile organic compounds, such as benzene, toluene, ethyltoluene, and xylenes, also referred to as light aromatic compounds; and
- Inorganic compounds, such as iron, lead, copper, zinc, sulfides, cyanides, and nitrates.

Since October 2002, soil samples have been collected from roadways, residential properties, and the Bay View Recreation Area. Laboratory analysis of soil samples revealed the presence of cyanide, metals, polycyclic aromatic hydrocarbons (PAHs), and other substances. The following is a summary of environmental activities at the site [5–13]:

- September 2002, soil contamination discovered during sewer main installation;
- October 2002, EA Engineering, Science, and Technology, Inc.(EA) under contract with Town of Tiverton, conducted roadway soil testing;
- March 2003, RIDEM issued letter of responsibility to NEGC;
- April 2003, EA conducted additional soil testing for roadways and the Bay View Recreation Area;
- June to August 2003, Vanasse Hangen Brustlin, Inc. (VHB) under contract with NEGC, conducted site investigation including 352 soil borings and 515 soil samples;

- September 2003, the Tiverton Town Council issued an Excavation Moratorium covering approximately 150 properties;
- October 2003, VHB released Site Investigation Report (SIR) for 58 properties and Environ Health Sciences Institute, under contract with NEGC, released a Human Health Risk Assessment;
- November 2003, Senate Jack Reed requested that ATSDR review the health impact of exposure to soil contamination;
- December 2003, VHB released additional SIRs for nine properties not covered in the previous SIR;
- January 2004, ATSDR accepted Senate Reed's petition and started gathering environmental data and public health information;
- March 2004, VHB removed two small areas of contaminated soil;
- May 2004, ATSDR site team conducted a site visit to meet with community members, local government agencies, and to observe the area of concern;
- July 2004, NEGC released the Phase II site investigation work plan and supplemental site investigation work plan; and
- August 2004, EPA Region 1 collected additional soil samples for mercury contamination at one property and its adjacent area. December 2004, EPA started a removal operation on the property.

Community Health Concerns

As part of response to RI Senator Jack Reed's petition for investigation of Tiverton soil contamination, ATSDR staff conducted a site visit May 17–20, 2004. During the visit, ATSDR site team members met with representatives of the RIDEM, the Rhode Island Department of Health (HEALTH), Senator Reed's office, the Town of Tiverton, and the Environmental Neighborhood Action Committee of Tiverton (ENACT). In addition, ATSDR held a public availability session for all community members. Approximately 40–50 people came to the session. Community members expressed their concerns regarding the contamination, investigation, and remediation of the site. Major environmental health issues include the following:

- Lead exposures for children — health effects for past, present, and future exposures;
- Arsenic exposures for adults and children — health effects for past, present and futures exposures;
- PAHs exposures for adults and children — cancer effects for long-term exposure;
- Long-term health effects for general activities in the yards such as playing, digging, mowing, and gardening;
- Gardening issues — uptake of contaminants by plants, consuming home-grown vegetables, and potential exposures during gardening activities;
- Environmental sampling issues — representative sampling locations, methods (e.g., composite vs. discrete soil samples, deeper soil borings), results confirmation, related federal/state regulations on remediation; and

- Diseases and symptoms mentioned — various cancers, brain tumours, allergies, skin corns and warts, skin rashes, sensitive skin, autism, asthma, chronic obstructive pulmonary disease, learning disabilities and behaviour issues in children, and dementia.

Others issues include surface water (e.g., streams, sump pump water, and bay water) and issues such as contamination on local school property and other areas, animal tumours and diseases, increase in home insurance prices, and difficulties in mortgage refinancing.

In this health consultation ATSDR will address some of the community concerns, will make recommendations for future activities to address other issues by ATSDR and other agencies such as RIDEM, HEALTH, NEGC, and ENACT.

ATSDR's Evaluation Process

ATSDR provides site-specific public health recommendations on the basis of toxicologic literature, levels of environmental contaminants detected at a site compared to accepted comparison values, an evaluation of potential exposure pathways and duration of exposure, and the characteristics of the exposed population. Whether a person will be harmed by exposure to hazardous substances depends upon several factors, including the type and amount of the contaminant, the manner in which the person was exposed, the duration of the exposure, the amount of the contaminant absorbed by the body, site conditions, genetic factors, and individual lifestyle factors.

Ingestion of soil and dust is the primary exposure of concern for residents who live on the site. A chemical can be present in the soil and dust — both as a result of natural causes and human activities. The exposure pathway associated with soil is presented below.

Soil ingestion

The accidental ingestion (i.e., swallowing) of contaminated soil by both children and adults is a potential exposure pathway. This exposure occurs when people have direct contact with soils in their environment. When children play outside or crawl on floors, or when adults work in yards and gardens, contaminated soil or dust particles cling to their hands. Children or adults might accidentally swallow the contaminated soil when they put their hands on or into their mouths. Because both people and pets track contaminated soils from outdoors into their homes, exposures can occur while people are in their homes and in their yards. Factors affecting whether people have contact with contaminated soil include the amount of grass cover, weather conditions, the amount of time spent outside, and personal habits.

The amount of chemicals to which people are exposed via ingestion depends on many factors, such as the level of contamination in soil and the type of activities engaged in while at home. Although people might not be aware of it, everyone ingests some soil or dust every day. Preschool children often have close contact with soil and dust when they play. Because these children tend to engage frequently in hand-to-mouth activity, their chance for exposure is increased. Children in elementary school, teenagers, and adults are also exposed to soil and dust, but generally less frequently and in smaller amounts.

When evaluating exposures, ATSDR also considers a wide range of human activities that might increase exposure to contaminants in soil. One activity of potential concern — particularly in preschool children — is a behavior called soil-pica (i.e., the eating or ingestion of large amounts of soil). Various studies have reported that this behavior occurs in as few as 4% of children or in as many as 21% of children [14–17]. For this health consultation, ATSDR used a range of soil intakes from 600 to 5000 milligrams (about 1/8 teaspoon to 1 teaspoon) of soil to estimate soil exposure for soil-pica children [18–21]. General pica behavior is greatest in 1- and 2- year old children and decreases as children age [20, 22–23].

Eating home-grown produce

Eating fruits, vegetables, herbs, or other produce grown locally in gardens with contaminated soil can cause exposure. This type of exposure occurs because many plants slowly absorb small amounts of the chemicals found in soils, or because contaminated soil can adhere to the exterior surface of produce. Some of these absorbed chemicals are essential nutrients and are actually good for people to eat. Other chemicals, however, can present health hazards if they are found at high enough levels and are consumed on a regular basis.

ATSDR's approach to evaluating a potential health concern has two components. The first component involves a screening process that could indicate the need for further analysis. The second component involves a weight-of-evidence approach that integrates estimates of likely exposure with information about the toxicology and epidemiology of the substances of interest.

Screening is a process of comparing appropriate environmental concentrations and doses to ATSDR or EPA comparison values. These comparison values include but not limited to

- ATSDR Environmental Media Evaluation Guides (EMEGs)
- Reference Media Evaluation Guides (RMEGs)
- Minimum Risk Levels (MRLs)
- Cancer Risk Evaluation Guidelines (CREGs)
- EPA Reference Doses (RfDs)
- EPA Risk-Based Concentrations (RBCs) or Preliminary Remediation Goals (PRGs)

When determining what environmental guideline value to use, this health consultation followed ATSDR's general hierarchy and used professional judgment to select CVs that best apply to the site conditions. For example, Hierarchy 1 environmental guidelines (such as CREGs and chronic EMEGs),were used. In the absence of these values, Hierarchy 2 intermediate EMEGs or RMEGs, were selected. When environmental guidelines listed in the ATSDR hierarchy are unavailable, those from other sources (e.g., EPA RBCs, RIDEM) were consided.

These health-based comparison values (CVs) are media-specific concentrations considered safe using default conditions of exposure. Default conditions are typically based on estimates of exposure in most (i.e., the 90th percentile or more) of the general population. Comparison values are not thresholds of toxicity. When a level is above a comparison value, it does not mean that health effects could be expected — it does, however, represent a point at which further evaluation is warranted.

After identifying potential chemicals of concern through the screening process, ATSDR evaluates a number of parameters depending on the contaminant and site-specific exposure conditions. Such parameters can include biological plausibility, mechanisms of action, cumulative interactions, health outcome data, strength of epidemiological and animal studies, and toxicological and pharmacological characteristics. It should be noted that the purposes of the health consultation are to identify possible exposures and to recommend actions needed to protect public health. Remedial decisions concerning soil on the site are based on the RIDEM Remediation Regulations, as amended, with EPA risk assessment methodology.

Discussion

For this health consultation, ATSDR reviewed and evaluated all available soil data for the site. Evaluation of data on historic or current disease incidence in the area is outside the scope of this health consultation. ATSDR will assist, as needed, in further evaluations of additional environmental data and other health information when they become available. Discussed below are available environmental data, data evaluation, and public health implications.

Available Environmental Data for the Site and Data Quality Evaluation

ATSDR evaluated the available environmental sampling information for potential exposure to contaminants found in residential soil as well as non-residential soils. The information includes data collected by EA, under contract with Town of Tiverton, and VHB, under contract with NEGC from October 2002 to November 2003.

Samples included approximately 465 surface soil samples (samples with sampling depths of 0 to 2 feet below ground surface, including samples with sampling depths of 0 to six inches) and 216 subsurface soil samples (samples with sampling depths of equal to or greater than 2 feet below ground surface). Table 1 is a summary of all available soil sampling information. VHB collected soil samples from 67 properties among the approximately 150 properties at the site. Using an averaged-sized lot in the area, VHB collected four or more surface soil samples from each property. The surface samples characterized levels of contamination at particular points at each property. They might not provide an accurate measure of property-wide levels of contamination. Multi-point composite samples or additional surface soil samples (at different depths including 0 to 2 inches for surface exposure) are needed to provide a useful indicator of the property-wide contamination levels. In addition, more than half of the properties at the site were not sampled during the site investigation. Therefore, no data are available to make public health decisions for those properties.

Soil samples were analyzed for semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), 13 Priority Pollutant Metals (PPM13), total cyanide, and total petroleum hydrocarbons (TPHs). Environmental sampling data were, however, limited to selected chemicals only. Information on other potential contaminants of concern related to MGP and some EPA targeted compounds are not available.

The laboratory analysis methods selected by EA were EPA Method 8270 for SVOCs, EPA method 9010 for total cyanide, EPA Method 6010 and 7471 for metals, and EPA Method 8260B/5053 for VOCs. The laboratory analysis methods selected by VHB were EPA Method 8270 for SVOC, EPA method 9010 for total cyanide, and metals, EPA Method 8021 for VOCs, and EPA method 8100m for TPHs.

ATSDR also reviewed information on Quality Assurance (QA)/Quality Control (QC) specifications for field data quality and laboratory data quality to verify the acceptability and adequacy of data. For example, ATSDR reviewed available Chain of Custody sheets, project narratives, and laboratory certifications. The laboratory analysis methods and the QA/AC procedures were appropriate.

Environmental data evaluation and public health implications

Environmental data are grouped in to three categories (residential surface soil samples, Bay View Recreation Area surface soil samples, and subsurface soil samples) and discussed in the following sections.

Residential surface soil samples

The most likely exposure to contaminants in surface soil is occasional ingestion or infrequent dermal contact with contaminated soil by residents who are conducting general activities in the yards such as playing, digging, mowing, and gardening. Ingestion is the primary pathway of concern in those general activities.

Approximately 440 residential soil surface samples were taken at this site between June and August 2003. Of the 89 substances analyzed, 46 different substances (52%) were detected (Table 2). ATSDR compared the levels found in residential surface soil with comparison values to identify potential contaminants of concern (COCs). All VOCs, total cyanide, and total petroleum hydrocarbons were either not detected or found at levels below the ATSDR soil screening values and were thus eliminated from the list of potential COCs. Potential COCs are discussed below.

Metals

Several metals were not detected or found at levels below the ATSDR soil screening values (antimony, beryllium, cadmium, chromium, copper, nickel, selenium, silver, thallium, and zinc). The other metals found in residential surface soil include arsenic, lead, and mercury.

Arsenic

Arsenic is a naturally occurring element, present at low levels in soil, water, food, and air. The U.S. Geological Survey reports the background range of arsenic in soil and other surficial materials as less than 0.1 mg/kg to 97 mg/kg, with a mean value of 7.2 mg/kg [24].

Four hundred-forty surface soil samples were taken from the site. Arsenic concentrations ranged from 0.85 to 131 mg/kg, with an average of 6.06 mg/kg (Table 2).

To determine whether harmful effects might be possible, ATSDR reviewed for acute and chronic exposures to arsenic the findings from numerous studies that have documented the effects of arsenic on humans and that have established health guideline values. The several factors that should be considered when evaluating the health hazard associated with arsenic in soil include bioavailability of arsenic in soil, pica-like behavior in children, and carcinogenic effect. Children and children with soil-pica behavior are a special concern for acute exposures because ingesting high amounts of soil could lead to significant arsenic exposure.

ATSDR has developed a provisional acute and chronic oral MRL for arsenic of 0.005 mg/kg/day and 0.0003 mg/kg/day, respectively. MRL is an exposure level below which non-cancerous harmful effects are unlikely. The acute MRL is based on several transient (i.e., temporary) effects including nausea, vomiting, and diarrhea. When an estimated acute dose of arsenic is below 0.005 mg/kg/day, non-cancerous harmful effects are unlikely. It should be noted that 1) the acute MRL is 10 times below the levels that are known to cause harmful effects in humans, 2) the acute MRL is based on people being exposed to arsenic dissolved in water instead of arsenic in soil — a fact that might influence how much arsenic can be absorbed, and 3) the MRL applies to non-cancerous effects only and is not used to determine whether people could develop cancer [25].

The ATSDR chronic EMEGs for adults and children are 200 and 20 mg/kg, respectively [25]. The chronic EMEGs are soil arsenic concentrations unlikely to be associated with any appreciable risk of adverse noncancer effects for exposures of more than 1 year. ATSDR based this EMEG on a Taiwanese drinking water study and determined the lowest intake amount most likely to result in an adverse non-cancerous effect (or LOAEL). In this case, the LOAEL is a daily intake of about 800 micrograms of arsenic a day. Because arsenic is more bioavailable in drinking water than in soil, the soil EMEGs for arsenic — which are not adjusted for bioavailability in soil — are more conservative than the drinking water EMEGs.

For cancer effects, the Department of Health and Human Services, the International Agency for Research on Cancer, the National Toxicology Program, and EPA have all independently determined that arsenic is carcinogenic to humans.

To consider the bioavailability of arsenic in soil, pica-like behavior in children, and the carcinogenic effect, the ATSDR interim guidance for public health assessment evaluations of arsenic-contaminated soils for residential scenarios recommended a lower screening level of 30 mg/kg [26]. Of the 440 surface soil samples, 10 (2%) were detected containing arsenic above 30 mg/kg, with one location having the highest arsenic concentration of 131 mg/kg. Nine of the 10 samples with arsenic concentrations above 30 mg/kg were located in two properties. Recently, NEGC contractors removed soil from two properties and replaced it with clean fill material. The remaining one property had one sample with arsenic concentration slightly above the lower screening level.

To estimate arsenic exposure doses for different exposure scenarios at the site, ATSDR used the maximum soil arsenic concentration of 131 mg/kg to calculate and then compare the doses to the acute and chronic MRLs. In addition, for cancer risk evaluation, ATSDR used the EPA region 3 ingestion cancer slope factors (CSFo) for oral exposures (Appendix B). The cancer risk evaluation is based on conservative assumptions such as fixed level of risk (i.e., a 1-in-1 million cancer risk) and a lifetime exposure (i.e., 365 days per year for 70 years). Using the available data and the conservative exposure dose estimation, ATSDR concludes that it is unlikely that adults and children at any of the properties at the Bay Street Study Area sampled from October 2002 to November 2003 will experience non-cancerous harmful effects from arsenic in soil. That said, however, children who eat soil excessively (more than 1,000 mg a day), and who play in and ingest soil from that part of the yard with the highest arsenic level (131 mg/kg) might have a dose exceeding the acute MRL but below the dose in a human study that caused temporary harmful effects. For cancer effects, using the conservative risk evaluation (Appendix B), residents who have a continuous lifetime exposure to those chemicals via ingestion have no apparent increased risk (i.e., one to two extra cancer cases per 10,000 people exposed) of developing cancer. Nevertheless, because more than half of the properties at the site were not sampled during the site investigation, data are needed to make public health decisions for those properties. When possible, it is prudent public health practice to avoid and reduce exposures to contaminants that could cause cancer.

To address the community concern on plant uptake of contaminants from soil, ATSDR reviewed literature on the issue. Arsenic is largely immobile in agricultural soils. Arsenic tends to concentrate and remain in upper soil layers indefinitely [27]. Terrestrial plants can accumulate arsenic by root uptake from the soil or by absorption of airborne arsenic deposited on the leaves [28]. But the arsenic level taken up by the plants is comparatively low [29–30]. A study revealed that the dominating pathway for transport of arsenic from the incineration facility to the leafy vegetables (kale) was by direct atmospheric deposition, while arsenic in the root crops (potatoes and carrots) was a result of both soil uptake and atmospheric deposition [31]. Although data are not available for arsenic concentration in garden produce, based on the soil arsenic levels found at the site, ATSDR does not expect significant uptake of arsenic by garden produce.

Lead

Lead is another naturally occurring element found in small amounts in the earth's crust. The general population is exposed to lead in air, food, drinking water, soil, and dust. Multimedia contamination of lead at residential areas results from many different sources, such as lead-based paint, old plumbing fixtures, soil, dust contaminated by combustion of leaded gasoline, and other industrial sources [32].

Health effects of lead exposures depend on the concentration of lead, amount of lead absorbed by the body, duration of exposure, age, and a person's nutrition status. The main target for lead toxicity is the nervous system [32]. Many studies on the toxicity of lead have shown that children are most susceptible to adverse health effects following exposures, and environmental exposures among adults generally do not result in as serious effects. As a result, the remainder of this section focuses on non-cancer effects that might occur in children following exposures to lead.

Four hundred-forty surface soil samples were taken from the site for lead analysis. Lead concentrations ranged from nondetect to 5600 mg/kg, with an average of 103 mg/kg (Table 2).

ATSDR considers residential soil levels above 400 mg/kg as needing further evaluation because of childrens' unique susceptibility [32]. Of the 440 surface soil samples, 10 (2%,) were detected containing lead above 400 mg/kg. The 10 samples were located in 7 properties of the community. Three properties had average lead concentrations above 400 mg/kg. If those sample hot spots are in areas where contact with soil is frequent, such as play areas with residential bare surface soil, they might present a health hazard for children. In accordance with state law, HEALTH recommends that all parents with children over 9 months and under 6 years of age have them screened for lead. ATSDR supports HEALTH's universal lead screening recommendation and recommends sampling of blood-lead levels in children less than 6 years of age who live at the properties where soil lead exceeded 400 mg/kg. It should be noted that in addition to lead coming from soil, children could be exposed to lead from other sources. For example, lead in a child's diet, lead in drinking water, lead from lead paint, lead from lead-glazed pottery, and other unidentified sources. Therefore, to minimize any possible lead exposure from multimedia sources, the appropriate federal, state, and local agency and any potential responsible parties should establish a comprehensive approach to reduce or eliminate lead exposure. Examples include health education, community involvement, surveillance programs, and remediation of contaminated areas.

Lead can be taken up in edible plants from the soil via the root system, by direct foliage uptake and translocation within the plant, and by surface deposition of particulate matter. Still, the uptake is small. The bioavailability of lead in soil to plants is limited because of the strong absorption of lead to soil organic matter. Lead is not biomagnified in aquatic or terrestrial food chains [32]. Prudent public health practice recommends washing fruits and vegetables thoroughly, especially low-growing vegetables such as collard greens, spinach, and lettuce. Although data are not available for lead concentration in garden produce, based on the soil lead levels found at the site, ATSDR considers if the fruits and vegetables are cleaned properly, the exposure to lead through eating homegrown produce is minimal.

Mercury

Mercury also occurs naturally in the environment and exists in several forms (e.g., metallic, inorganic, and organic mercury). The U.S. Geological Survey reports the background range of mercury in soil and other surficial materials as less than 0.01 mg/kg to 4.6 mg/kg, with a mean value of 0.09 mg/kg [33]. Because most of the mercury found in soil is in the form of metallic mercury (i.e., elemental mercury) and inorganic mercury (i.e., elemental mercury combined with elements such as chlorine, sulfa, or oxygen), health-related comparison values used in this document are for inorganic mercury.

Approximately 400 surface soil samples were taken for mercury analysis. Mercury concentrations ranged from not detected to 42 mg/kg, with an average of 0.947 mg/kg (Table 2).

In addition, one soil sample taken at one property was analyzed three times for a different combination of materials. The results showed that the portion consisting of felt material and surrounding soil had a mercury concentration of 892 mg/kg; the portion consisting of felt and leather material had a mercury concentration of 3,890 mg/kg; and the portion consisting only of the surrounding soil had a mercury concentration of 1,290 mg/kg. This hot spot will be discussed in the following section.

EPA has established a soil screening value of 23 mg/kg for mercury. ATSDR also has MRLs for mercury exposures [34]. For noncancer effects, the ATSDR acute and intermediate oral MRLs for inorganic mercury are 0.007 and 0.002 mg/kg/day respectively. These MRLs are based on no-observed-adverse-effect levels (NOAELs) for renal effects in rats, with an uncertainty (safety) factor of 100 for extrapolation from animals to humans and human variability. For the site-specific exposure scenario, assume that if a 70-kg adult ingested 100 mg of soil per day containing 42 mg/kg (maximum concentration in Table 2) of mercury, the soil ingestion dose would be 0.00006 mg/kg/day. A 10-kg child ingesting 200 mg of soil containing 42 mg/kg (maximum concentration) of mercury would receive doses of 0.00084 mg/kg/day. The estimated mercury dose for adults and children ingesting mercury-contaminated soil were far below the MRLs. In addition, the mercury contamination in soil at the site was reportedly in the form of elemental mercury. This form of mercury is poorly absorbed from the gastrointestinal tract, so the actual absorbed dose of mercury would be much less than the calculated amount. Therefore, no adverse health effects would result from ingesting the surface soil for mercury exposures. Still, for the hot spot identified above, the estimated doses from incidental soil ingestion based on the maximum concentration (3,890 mg/kg) approached (for adult) or exceeded (for children) the NOAEL. Therefore, a potential public health hazard is present if people are exposed to those levels. Additional soil samples are needed for the property and other unsampled properties at the site to ensure that mercury levels in soil are at a safe level.

Because of high mercury concentration in soil, there is another possible exposure pathway for residents who live on the property. That potential pathway is vapor intrusion — the migration of mercury from contaminated soil through the pore spaces of soil into the buildings above. Mercury vapor can enter residences through foundation cracks and gaps, mechanical ventilation systems, and leakage areas (for example, utility entry points, construction joints, and drainage systems). Therefore, indoor air mercury levels need to be verified. RIDEM conducted preliminary indoor air mercury test for the property in early November, 2004 and did not detect any mercury vapor in the basement. The U.S. Environmental Protection Agency (EPA) collected soil samples in August 2004 on the property and started a removal operation in December 2004.

Polycyclic aromatic hydrocarbons (PAHs)

PAHs are a group of chemicals formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. More than 100 different PAHs are known. PAHs generally occur as complex mixtures (e.g., as part of combustion products such as soot), not as single compounds. Several PAHs have caused tumors in laboratory animals when the animals breathed these substances in the air, when they ate them, or when they had long periods of skin contact with them. Studies of people show that individuals exposed to mixtures containing PAHs and other compounds for long periods by breathing or by skin contact can also develop cancer. ATSDR and EPA have established CREGs and RBCs for cancer effects. The CREG or RBC is an estimated PAH concentration in soil that would be expected to cause no more than one excess cancer in 1 million persons exposed over a lifetime.

For PAHs analysis, 411 surface soil samples were taken from the site. Concentrations of seven PAHs [benzo(a)anthracene, benzo(a)pryene, benzo(b) fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a, h)anthracene and indeno (1,2,3-cd)pyrene] exceeded their respective CREGs or RBCs. That said, however, using the conservative risk evaluation (Appendix C), residents who have a continuous lifetime exposure to those chemicals via ingestion have no apparent increased risk (i.e., two extra cancer cases per every 10,000 people exposed) of developing cancer. Still, because of the lack of data for untested properties on the site, the uncertainties involved with the mathematic cancer risk evaluation, and the concept of nonthreshold effects for carcinogenesis, ATSDR recommends prudent public health practice to avoid and reduce exposures to contaminated soil at the site.

Some terrestrial plants can take up PAHs from soil via the roots or from air via the foliage. Uptake rates are dependent on the concentration, solubility, and molecular weight of the PAH, and on the plant species [35]. As a route of PAH accumulation, atmospheric deposition on leaves often greatly exceeds uptake from soil by roots [36]. The uptake of PAHs from soil to plants and the subsequent biomagnification is generally quite low [37]. After reviewing the soil levels, ATSDR does not expect significant uptake of PAHs by plants in home gardens at the site.

Bay View Recreation Area Surface Soil Samples

Approximately 15 surface soil samples were taken at the Bay View Recreation Area between April and November 2003. Of the 28 substances analyzed, 27 substances (96%) were detected. Only two chemicals — arsenic and benzo(a)pryene — were found above their respective CVs. All Bay View Recreation Area surface soil analytical results are summarized in Table 3.

Arsenic was found in all 15 samples, with concentrations ranging from 2.92 to 10.3 mg/kg. As discussed in the previous section, those concentrations were below the ATSDR screening value of 30 mg/kg. Therefore ATSDR does not expect adverse health effects in children from exposure to the levels of arsenic found in the area.

Benzo(a)pryene found in seven samples with maximum concentration of 0.279 mg/kg. Although the maximum concentration was higher than the CREG of 0.1 mg/kg, exposure to the maximum level is unlikely to cause any adverse health effects. The CREG is based on lifetime exposure (i.e., 365 days per year for 70 years), which is not plausible for the area-specific exposure scenarios.

Subsurface Soil Samples

From October 2002 through November 2003 EA and VHB collected about 216 subsurface soil samples from residential properties and roadways at the site. Subsurface soil samples were taken with sampling depths of equal to or greater than 2 feet below ground surface from residential properties and under roadway pavement. Of the 94 substances analyzed, 15 different substances (16%) were detected above their representative comparison values (Table 4). In general, the levels of metals found in subsurface soil samples were less than the levels found in surface soil samples, but the PAH levels found in subsurface soil samples were higher than the levels found in surface soil samples. Residents are not directly exposed to the contaminated soil during regular daily activities. It is however possible that future exposure to contaminated soil might happen if activities occur (e.g., basement or utility work excavation) that could result in contacting contaminated subsurface soil. At the contamination levels found on tested properties at the site, short-term exposures to subsurface soil during such events are unlikely to cause adverse health effects. Still, in September 2003 the Tiverton Town Council issued an Excavation Moratorium. ATSDR supports actions by appropriate authorities to implement additional administrative controls that will prevent prolonged exposures to subsurface soil. For example, notify residents of activities, restrict access to worksite, proper disposal of spoils, and implement work health and safety plan for workers.

Child Health Considerations

ATSDR considers children in its evaluations of all exposures , and we use health guidelines that are protective of children. In general, ATSDR assumes that children are more susceptible to chemical exposures than are adults.

For arsenic and lead exposures, ATSDR has taken into account that children are at a greater risk for poisoning than are adolescents or adults because

- The normal behavior of children might result in higher rates of ingestion of arsenic and lead- contaminated soil and dust,
- Children might also receive a higher dose of arsenic and lead because following ingestion they absorb more lead into their blood and they have lower body weights than do adults,
- Some children might eat soil excessively (called pica behavior) and therefore have a higher exposure dose to arsenic and lead in soil, and
- The Centers for Disease Control and Prevention (CDC) and ATSDR report that blood levels in young children have been raised, on average, 5 micrograms per deciliter of blood for every 1,000 mg/kg of lead in residential soil or dust [38–39]. CDC recommends that young children be tested for lead poisoning if they have been in contact with lead-contaminated soil or dust [38].

ATSDR has considered these factors in the development of conclusions and recommendations for this site. CVs used for this health consultation are intended to represent exposures that could be continued for a lifetime for the general population — including potentially susceptible subgroups such as children — without appreciable health risks. To account for human variability, ATSDR derived comparison-value MRLs by using an uncertainty factor of 10. ATSDR considers this uncertainty factor to include the variability related to age (children and elderly) when no data indicate a need for special metabolic or sensitivity considerations. Therefore, ATSDR considers the MRLs to include age-related variability and thus to be protective of children.

Conclusions

After reviewing available environmental data, ATSDR identified arsenic, lead, mercury and PAHs as potential contaminants of concern for the site. The accidental ingestion of contaminated soil by both children and adults is the most important exposure pathway. Residents at the Bay Area Study Area site could have exposed to the soil contaminants in the past and present. Environmental data evaluation and analysis indicated

1. Soil arsenic levels of tested properties at the site ranged from 0.85 mg/kg to 131 mg/kg, with an average of 6.06 mg/kg. These levels are unlikely to cause adverse, noncancer health effects for acute, intermediate, and chronic exposures for children and for adults who experience typical soil intake levels during general activities.
2. Children who eat soil excessively (i.e., more than 1,000 mg a day), and play in and ingest soil from part of the yard with the highest arsenic level (131 mg/kg) might have a dose exceeding the acute MRL but below the dose in a human study that was identified as causing temporary harmful effects.
3. Conservative cancer risk assessment indicates that residents who have a continuous lifetime exposure to the highest levels of arsenic observed at this site via ingestion have no apparent increased risk of developing cancer.

4. Soil lead concentrations of tested properties ranged from nondetect to 5600 mg/kg, with an average of 103 mg/kg. Seven properties had lead concentration above 400 mg/kg. If those sample hot spots are in areas where contact with soil is frequent, such as play areas with bare surface soil, they might present a health hazard for children.
5. Soil mercury concentrations of tested properties are below the soil screening values except in one property. The property has one hotspot containing the maximum mercury concentration of 3,890 mg/kg. If people are exposed to those levels a potential public health hazard could exist. EPA is, however, in the process of removing the contaminated surface soil from the property.
6. Concentrations of seven PAHs exceeded their respective CREGs or RBCs of tested properties. Nevertheless, conservative risk evaluation indicated that residents who have a continuous lifetime exposure to those chemicals via ingestion have no apparent increased risk of developing cancer.
7. The analysis includes some environmental data limitations: 1) no data on more than half properties at the site, 2) existing surface soil samples might not provide an accurate measure of property-wide levels of contaminations, and 3) the lack of data for all U.S. Environmental Protection Agency (EPA) target compounds and other potential contaminants of concern.
8. Because of the environmental data limitations for the site, ATSDR has categorized this site as an “Indeterminate Public Health Hazard.”

Recommendations

1. Per RIDEM requirements, NEGC should collect representative soil samples at the site to characterize fully the soil contamination.
2. HEALTH will identify and screen children under age 6 to evaluate the potential exposure to lead in the identified properties.
3. ATSDR will work with HEALTH, RIDEM, Town of Tiverton, and ENACT to evaluate the needs and strategies for community health education.
4. The Tiverton Town Council should consider implementing administrative controls to prevent potential long-term exposures to subsurface soil. For example, notify residents of activities, restrict access to worksite, and implement work health and safety plans for affected workers.

Public Health Action Plan

Actions Taken:

1. May 2004, an ATSDR site team conducted a site visit to meet with community members, local government agencies, and to observe the area of concern;
2. July 2004, NEGC released phase 2 site investigation work plan and supplemental site investigation work plan;
3. August 2004, Weston Solutions, on behalf of EPA Region 1 Removals Program, took soil samples on the property for mercury contamination;
4. October and November 2004, RIDEM took indoor air samples on the property for VOCs and mercury contamination; and
5. November 2004, EPA started a removal operation for the property with high soil mercury concentrations.

Actions Planned:

1. HEALTH is planning to identify and conduct blood lead screening for children under age 6 who live on properties where soil lead exceeded 400 mg/kg;
2. ATSDR will assist, as needed, in further evaluations of additional environmental data to better characterize the exposure and the extent of soil contamination;
3. ATSDR will continue to work with HEALTH, RIDEM, Town of Tiverton, and ENACT to respond to public health questions and concerns and to develop health education strategies.
4. RIDEM will verify the indoor air mercury levels after the EPA removal operation is completed to ensure that mercury levels in the living spaces on the property are at safe levels.

Authors, Technical Advisors

Jane Zhu

Environmental Health Scientist
Consultation Section
Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry (ATSDR)

Jamie Mutter

Environmental Health Scientist
Consultation Section
Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry (ATSDR)

Technical Assistance

Steve Martin

FFIMS Data Manager
Information Resources Management Branch
Office of Program Operations and Management
NCEH/ATSDR

Reviewers

Susan Moore

Chief, Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation
ATSDR

Peter Kowalski

Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation
ATSDR

Katherine Robbins

Regional Representative
Division of Regional Operations
ATSDR

Rose Jackson

Health Communication Specialist
Community Involvement Branch
Division of Health Assessment and Consultation
ATSDR

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