Public Health Assessment

Final Release

Evaluation of Environmental Concerns Related to the Shpack Landfill Superfund Site

SHPACK LANDFILL

NORTON AND ATTLEBORO, BRISTOL COUNTY, MASSACHUSETTS

EPA FACILITY ID: MAD980503973

Prepared by
Massachusetts Department of Public Health

APRIL 7, 2014

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

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR's Cooperative Agreement Partner pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 60-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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List of Abbreviations

ACS	American Cancer Society
ALI	Attleboro Landfill Incorporated.
ATSDR	Agency for Toxic Substances and Disease Registry
BEH	Bureau of Environmental Health
CAP	Community Assessment Program
CEL	Cancer Effect Level
CI	Confidence Interval
CREG	Cancer Risk Evaluation Guide
CT	Census Tract
DOC	Department of Commerce
EMEG	Environmental Media Evaluation Guide
GIS	Geographic Information System
HC	Health Consultation
IARC	International Agency for Research on Cancer
ICRP	International Commission on Radiological Protection
LOAEL	Lowest Observed Adverse Effect Level
LTHA	Lifetime Health Advisory
MG/KG	Milligrams per Kilogram
MTBE	Methyl Tert Butyl Ether
MCL	Maximum Contaminant Level
MCR	Massachusetts Cancer Registry
MDEP	Massachusetts Department of Environmental Protection
MDPH	Massachusetts Department of Public Health
MRL	Minimal Risk Level
mSv	Millisievert
NTP	National Toxicology Program
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PCB	Polychlorinated Biphenyls
PAH	Polycyclic Aromatic Hydrocarbons
pCi/L	Picocuries Per Liter
PPB	Parts Per Billion
PPM	Parts Per Million
RMEG	Reference Dose Media Evaluation Guide
ROD	Record of Decision
SIR	Standardized Incidence Ratio
SVOC	Semi-Volatile Organic Compound
TCE	Trichloroethylene
TEQ	Toxicity Equivalents
UG/M	Micrograms per Meter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound

I. SUMMARY

Introduction: This public health assessment was conducted because ATSDR is required to conduct health assessment activities for all sites that are on or proposed for the National Priorities List (NPL) and because residents of the communities of Norton and Attleboro, Massachusetts have been concerned about environmental contaminants, including chemical and radioactive waste, at the Shpack Landfill Superfund Site. The top priority of ATSDR/MDPH is to ensure that the community has the best information possible to safeguard its health.

Overview: The Massachusetts Department of Public Health (MDPH) reached two important conclusions about the Shpack Landfill Superfund Site in Norton and Attleboro.

Conclusion 1: Drinking tap water from private wells located in the vicinity of the Shpack Landfill Superfund Site or accidentally touching or eating soil, sediment, or surface water while occasionally visiting the Shpack Landfill is not expected to harm people's health.

Basis for Decision: Past activities at the Shpack Landfill Superfund Site resulted in radioactive materials and chemical contaminants in the soil, sediment, surface water, and groundwater. People can come into contact with chemical or radioactive contaminants in the soil, sediment, or surface water when they visit the site. People can come into contact with groundwater when it is pumped to the surface to be used for drinking, showering, bathing, dishwashing, and other activities.

Based on the available information, levels of chemical and radioactive contaminants that could get into a child's or an adult's body are below levels that would harm their health. Also, MDPH does not consider the levels of chemical and radioactive contaminants found in soil, sediment, surface water, or drinking water to present an unusually elevated cancer risk.

However, because some chemical contaminants exceed their respective regulatory guidelines [e.g., Maximum Contaminant

Level (MCLs)] and some chemicals are potential carcinogens, MDPH considers it prudent to reduce contact with chemicals in soil, sediment, surface water, and drinking water.

Conclusion 2: Without indoor air data, MDPH cannot conclude whether breathing radon in homes in the vicinity of the Shpack Landfill could harm people's health. While high levels of radon have been measured in drinking water at some homes, levels of radon in indoor air are unknown. Radon is naturally occurring and is not related to contamination at the Shpack Landfill.

Basis for Decision: In the 1980s, radon gas concentrations measured in residential private well water near the Shpack Landfill were below the screening level used at the time. However, several sample results were above U.S. Environmental Protection Agency (USEPA) current draft recommendations. The primary public health risk from radon is from breathing radon in indoor air; however, without indoor air data, no health impact determination can be made.

Next Steps:

- MDPH recommends that:
  - People safeguard their health by not visiting fenced portions of the Shpack Landfill Superfund Site.
  - Residents have their homes tested for radon. One out of four Massachusetts homes may have levels of radon above the USEPA action level. For advice on how to get your home tested and assistance with interpreting the results, call the MDPH Radiation Control Program toll free at (800) 723-6695. (See attached Radon Fact Sheet)
  - Residents in the immediate vicinity of the Shpack Landfill who use private well water follow USEPA and Massachusetts Department of Environmental Protection (MDEP) guidance that recommends testing initially for all contaminants, then at a minimum of once every 10 years (yearly for bacteria and nitrite/nitrate) (MDEP 2004).
  - Residents drinking private well water containing levels of arsenic above the USEPA MCL (10 ppb) take steps to reduce exposure to arsenic. This includes residents at Maple, House 7 and N. Worcester, House 1 in Norton, and

Peckham, House 3 and Peckham, House 4 in Attleboro (Note: Residents were notified of past private well sampling results by USEPA). These measures include treatment with point-of-use or point-of-entry devices to remove arsenic from tap water, connecting to the municipal water supply, or drinking bottled water.

- MDPH supports the USEPA's recommendation to connect the homes nearest to the Shpack Landfill on Union Road in Norton to the municipal water supply.

For More Information: If you have concerns about your health, you should contact your health care provider. You may also call ATSDR at 1-800-CDC-INFO or MDPH at 617-624-5757 and ask for information on the Shpack Landfill Superfund Site.

II. INTRODUCTION

The Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH), conducted an evaluation of possible environmental exposures in relation to the Shpack Landfill Superfund Site located on the border of the town of Norton and the city of Attleboro, Massachusetts. This evaluation was initiated based on community concerns about possible environmental contaminant exposures and potential adverse health effects for residents living near the landfill and due to the Shpack Landfill's designation as a National Priorities List (NPL) site. The Shpack Landfill, which operated from the 1940s to the 1970s, and surrounding neighborhoods are located on the border between Norton and Attleboro (see Figures 1 and 2). The site is now owned by the Town of Norton and Attleboro Landfill Incorporated (ALI), which also owns another 55-acre landfill immediately adjacent to the Shpack Landfill site at 179 Peckham Street, Attleboro. This public health assessment was conducted by MDPH under a cooperative agreement with the U.S. Agency for Toxic Substances and Disease Registry (ATSDR.

The communities of Norton and Attleboro are located in Bristol County approximately 30 miles southwest of Boston, Massachusetts. Norton is largely a residential community and has a total area of nearly 30 square miles with a density of 497 residents per square mile (DHCD 2008a). Attleboro is a small manufacturing city and has a total area of 28 square miles with a density of 1,395 residents per square mile (DHCD 2008b). The 2000 United States Census reports a total of 18,036 residents in the community of Norton and 42,068 residents in the community of Attleboro (U.S. DOC 2002). Census tract locations and boundaries in Norton and Attleboro are shown in Figure 2.

Available environmental contaminant data for the Shpack Landfill site were reviewed and potential pathways for residents to come into contact with contaminants detected in groundwater, surface water, soils, wetland sediment, and air were evaluated. Past MDPH investigations evaluated the pattern of cancer in the town of Norton and the city of Attleboro and examined cancer incidence in Norton and Attleboro neighborhoods closest to the site.

The full cancer incidence analysis was summarized in a health consultation (HC) released for public comment in 2007, *Evaluation of Cancer Incidence in Census Tracts of Attleboro and Norton, Bristol County, Massachusetts: 1982–2002* (MDPH 2007a). MDPH used data from the Massachusetts Cancer Registry (MCR) to review the incidence of 13 different cancer types in the communities of Norton and Attleboro during 1982–2002 and during four smaller time periods within this 21-year time period. Cancer incidence in smaller geographic areas of Norton and Attleboro, known as census tracts, was also evaluated. A census tract is a smaller geographic subdivision of a city or town that is designated by the United States Census Bureau and contains between 1,500 and 8,000 persons (U.S. DOC. 2000). The cancer incidence evaluation for the areas located closest to the Shpack Landfill demonstrated that two of the 13 cancer types [breast cancer and brain & central nervous system (CNS) cancer] were statistically significantly elevated above expected rates during one of the four time periods evaluated in one of the census tracts bordering the Shpack Landfill (MDPH 2007a).

During a public meeting conducted in conjunction with the release of the public comment draft of the HC, some residents expressed concern that the HC did not adequately evaluate the potential health impacts of the Shpack Landfill on residents in the immediate vicinity of the landfill. To address this concern, the BEH's Community Assessment Program (CAP) conducted additional evaluations using a one-mile radius area around the Shpack Landfill. The focused cancer incidence evaluation along with a discussion of the relationship between the contaminants of concern at the Shpack Landfill and the occurrence of particular cancer types within the one-mile radius surrounding the landfill is presented in a separate Health Consultation entitled *Focused Evaluation of Cancer Incidence Within One-Mile Radius Area of the Shpack Landfill Superfund Site and Response to Comments, Norton and Attleboro, Bristol County, Massachusetts* (MDPH 2011).

III. OBJECTIVES

The specific objectives of this PHA were to:

- Evaluate the extent to which contamination at the Shpack Landfill could result in exposure to people in the area and whether adverse health effects would be possible if exposure occurred.
- Evaluate opportunities for environmental exposure(s) of current and former nearby residents to contaminants identified at the Shpack Landfill.
- Discuss possible exposure pathways related to the Shpack Landfill.
- Evaluate opportunities for environmental exposure(s) of former recreational users to contaminants identified at the Shpack Landfill.

IV. BACKGROUND AND COMMUNITY ENVIRONMENTAL CONCERNS

The Shpack Landfill site is located on the town line between the Town of Norton and the City of Attleboro, Massachusetts. The site is bordered by residential roads (Union Road on the Norton side and Peckham Street on the Attleboro side) to the north and west; Attleboro Landfill Incorporated (ALI) Landfill (located at 179 Peckham Street) to the southwest; and a wetland area known as Chartley Swamp to the east. Other than residences on Union Road and Peckham Street, all residences are at least 1/3 mile from the Shpack Landfill property boundary. The site consists of a former domestic and industrial landfill occupying approximately 9.4 acres of land (Figure 1). Approximately 6 acres of the site in Norton were owned at one time by the Shpack family who operated a private landfill behind their home, formerly located at 68 Union Road. This residence, located approximately 100 feet from the Shpack Landfill site boundary, was demolished in 2007 and for purposes of this report is referred to as the former Shpack residence. Properties other than the former Shpack residence (68 Union Road) and the ALI Landfill (179 Peckham Street) will be referred to in this report using the naming scheme (e.g., Maple, House 7) presented in the Phase 1B Remedial Investigation Report (ERM 2004b).

The Shpack Landfill was reportedly active between about 1946 and the 1970s and received domestic and industrial waste, including low-level radioactive waste. The town of Norton now owns the Shpack family's portion of the site. The adjacent 3.4 acres are

located in Attleboro and comprise a small portion of an approximately 55-acre separate landfill currently owned by ALI. (ERM 1991, 2004a) The ALI Landfill, which is not evaluated in this PHA, is an unlined, private landfill and is listed as inactive by the Massachusetts Department of Environmental Protection (MDEP 2007a). From the 1940s to the 1970s, the city of Attleboro utilized the ALI property as a town dump. ALI assumed control of the landfill operations in 1975 and ran the landfill as a private operation. The ALI Landfill is not believed to contain significant radioactive waste (NUS 1985). A GHR Engineering Corporation report on the landfill suggests that it is "most probable" that the radionuclide concentrations measured at the ALI Landfill are of a natural origin (GHR 1980).

In the late 1970s, a resident concerned about the Shpack Landfill site reviewed records relating to wastes dumped at the property (NRC 1979). In 1978, the resident contacted the Nuclear Regulatory Commission (NRC) who then conducted an investigation including interviews with personnel involved in operations at Metals & Controls, Inc (now Texas Instruments) in Attleboro. The NRC investigation determined that burning of depleted uranium chips at the Texas Instruments (TI) property in Attleboro likely resulted in contamination of soil around open burning trays on the TI property. Materials associated with the cleanup of the burning area, including contaminated soil, were then disposed of at the Shpack Landfill (NRC 1979). Following the discovery of radioactivity at the site in 1978, the NRC, the Massachusetts Department of Environmental Protection, the Massachusetts Department of Public Health and the Norton Conservation Commission conducted a survey of the site and confirmed the presence of elevated levels of radiation above natural background (NRC 1979, MDEQE 1980, MDPH 1979). Subsequent investigations found uranium and radium, a decay product of uranium (Bechtel 1984, NUS 1985).

In 1981, the Shpack Landfill site was designated for inclusion in the Formerly Utilized Sites Remedial Action Program (FUSRAP), which is used to clean up or control sites where radioactive contamination remains from the early years of the nation's atomic energy program. In 1986, the United States Environmental Protection Agency (USEPA) added the site to the National Priorities List (NPL) under the federal Superfund Program

(USEPA 2004a). Since the late 1980s, extensive investigations of environmental media (e.g., soil, surface water, and groundwater) have been performed at the Shpack Landfill. Numerous reports have been written that summarize the type and extent of contamination associated with the site.

In July 1993, the Bureau of Environmental Health (BEH) within the MDPH issued a report on the Shpack Landfill entitled *Site Review and Update* (MDPH 1993). In this document, BEH reported the following possible human exposure pathways (identified initially in its 1989 Preliminary Health Assessment):

- Dermal absorption or ingestion of contaminants in soil, sediments, groundwater, and surface water
- Exposure to gamma radioactivity in the ambient air at the Shpack Landfill
- Dermal exposure to beta/gamma emissions near ground surface level at the Shpack Landfill

In June 2002, the Community Assessment Program (CAP), a division within BEH, released a report entitled *Phase I: Evaluation of Cancer Incidence in Attleboro and Norton, MA, 1994–1998* (MDPH 2002). In this report, the CAP reviewed available cancer incidence data from the Massachusetts Cancer Registry (MCR) *City and Town Supplement* for 23 different cancer types for Attleboro and Norton (MCR 2001). For both Norton and Attleboro, the majority of cancer types occurred approximately at or below expected rates for the 5-year period 1994–1998. However, in Attleboro, city-wide incidence rates for six cancer types were elevated among males and females combined compared to statewide rates for these cancers; the cancer types included colorectal cancer, Hodgkin's disease, laryngeal cancer, melanoma, multiple myeloma, and pancreatic cancer. The differences between the numbers of observed and expected cases were not statistically significant. In Norton, town-wide elevations were observed in the incidence of lung and bronchus cancer and pancreatic cancer. However, neither of these elevations was statistically significant.

In an earlier report issued by the MDPH in July 2001 entitled *Evaluation of Female Lung Cancer Incidence and Radon Exposure in Attleboro, MA 1982-1994* (MDPH 2001), MDPH reported that female lung cancer incidence occurred statistically significantly less often than expected during 1982-1986 and statistically significantly more often than expected during 1987-1994. In addition to an evaluation of cancer incidence data, this report also included a radon survey in which the radon concentrations measured in the homes (or former homes) of female lung cancer cases were compared to the concentrations measured in a group of randomly selected homes in the city. Although the median radon concentration in both the case and control homes was below the USEPA's recommended remediation level of 4 picocuries per liter, the median radon concentration in the case homes (2.4 picocuries per liter) was higher than the median concentration measured in the randomly selected control homes (1.9 picocuries per liter).

To respond to community concerns regarding cancer, the Community Assessment Program within the BEH conducted a health consultation, *Evaluation of Cancer Incidence in Census Tracts of Attleboro and Norton, Bristol County, Massachusetts: 1982–2002*, which evaluated the incidence of 13 different types of cancer within Norton and Attleboro, with particular focus on the census tracts nearest to the Shpack Landfill site (MDPH 2007a). In order to further address community concerns, the MDPH subsequently contacted the USEPA to obtain and review available environmental information pertaining to the Shpack Landfill site. MDPH also committed to conducting a Public Health Assessment for the site, however at that time, remedial investigations that provide data essential for review in a PHA had not been completed. This public health assessment analyzes environmental sampling data from the Shpack Landfill to determine opportunities for environmental exposures to nearby residents and former visitors to the Shpack Landfill.

In 2004, the USEPA published a Record of Decision for the site which called for the excavation and disposal of about 35,000 cubic yards of waste that exceeds cleanup standards. Site remediation is occurring in two phases. In the first phase, which began in 2005 and was completed in 2011, the U.S Army Corps of Engineers supervised the

removal of radioactive contamination (Figure 3). During the second phase, USEPA will supervise the removal of chemical contamination; this work is expected to begin in 2013.

In 1981, the U.S. Department of Energy installed a security fence to limit site access. In the fall of 1999, damage to the fence was discovered, including portions of missing fence along the ALI Landfill and near the southernmost fence corner, and there were small cuts in the fence along Union Road (Cabrera 2001). In June 2003, the fence was replaced along the ALI portion of the Shpack Landfill site (ERM 2004b). A new fence was also installed around the area referred to as the "Tongue Area" (ERM 2004b). Prior to 2003, access to the Tongue area, an un-vegetated area containing various wastes in the southern part of the landfill, was not restricted (ERM 2004b).

The public health assessment titled, *Evaluation of Environmental Concerns Related to the Shpack Landfill Superfund Site*, was released on July 15, 2011, for a 90-day public comment period. No public comments were received by the MDPH during the public comment period.

V. REVIEW OF ENVIRONMENTAL SAMPLING DATA

To address concerns about possible environmental exposures associated with the Shpack Landfill, MDPH reviewed information on file with USEPA. Environmental sampling data were available for drinking water, soil, air, surface water, and wetland sediment. Groundwater data were also available; however, this analysis focuses on drinking water data since it is a better indicator of actual exposure (a complete exposure pathway) than groundwater data. Volatile organic compounds (VOCs) in groundwater data in a densely populated area could impact indoor air quality levels; however, the groundwater data available for the Shpack Landfill are limited to areas within the site boundary or to areas that are not populated. Available environmental sampling data were reviewed, and a screening evaluation was conducted to identify those substances that may need to be considered for further analysis, to determine whether they may be of potential health concern. The screening analysis identified maximum concentrations of constituents detected in various types of environmental media (i.e., air, soil, water) and compared these concentrations to health-based comparison values established by the Agency for

Toxic Substances and Disease Registry (ATSDR) (ATSDR 2008a, 2008b, 2008c). If an ATSDR comparison value was not available for a specific chemical, USEPA's Regional Screening Levels for Chemical Contaminants at Superfund Sites (ORNL 2008), or the applicable groundwater and soil standards developed by the Massachusetts Department of Environmental Protection (MDEP 2007b, 2008), were used as comparison values in that order. For compounds detected in drinking water, maximum concentrations were compared with state and/or federal drinking water standards established for municipal drinking water supplies.

The ATSDR comparison values are specific concentrations of chemicals or radioactive materials for air, soil, or water that are used by health assessors to identify environmental contaminants that require further evaluation. Comparison values are developed based on health guidelines and assumed exposure situations that represent conservative estimates of human exposure. Comparison values are set well below levels that are known or anticipated to result in adverse health effects. Contamination levels detected in environmental media that are less than a comparison value are not likely to pose a health concern. Concentrations detected in environmental media above a comparison value do not necessarily indicate that a health threat is present, but rather indicate the need for further evaluation by assessing opportunities for exposures or possible health effects.

This PHA also makes use of "background" concentrations to aid in understanding the chemical contamination at the Shpack Landfill. Many metals are present in the earth's crust and hence have typical background concentrations. The United States Geological Society (USGS) has identified levels of metals that are considered typical for soil in the eastern United States (Shacklette and Boerngen 1984). ATSDR has compiled levels of polycyclic aromatic hydrocarbons (PAHs) and some metals (e.g., lead) that are considered typical for soil of urban and suburban communities due to centuries of human activities (ATSDR 1995). Thus, available typical background levels are used along with comparison values as screening methods for metals and PAHs in this analysis.

Several radioactive materials occur naturally in our environment. Some have existed in the earth's crust since it was formed, and some are cosmic ray induced in the earth's

atmosphere. In nature, uranium exists in the earth's crust as ^{238}U (99.284% by weight), ^{235}U (0.711% by weight), and a very small amount of ^{234}U (0.0058% by weight). Enriched uranium (enhanced by man) has a higher percent of ^{235}U and a lower percentage of ^{238}U. Depleted uranium has a lower percentage of ^{235}U and a higher percentage of ^{238}U. Uranium decays very slowly to another element (decay product) by emitting an alpha particle. Some of the products decay by emitting a beta particle (refer to Figures A and B below). Most of the decay products exist in solid or liquid form except radon which is an inert gas. Concentrations of these radioactive materials can vary due to local geological formations or due to actions by humans. In some cases, their concentrations in water or air can exceed ATSDR's health-based comparison values. Although elevated concentrations of radium in drinking water or radon in indoor air are usually naturally occurring, their concentrations can be at levels of potential health concern and are reviewed in this document.

Figure A. Uranium 238 decay scheme (Argonne 2005)

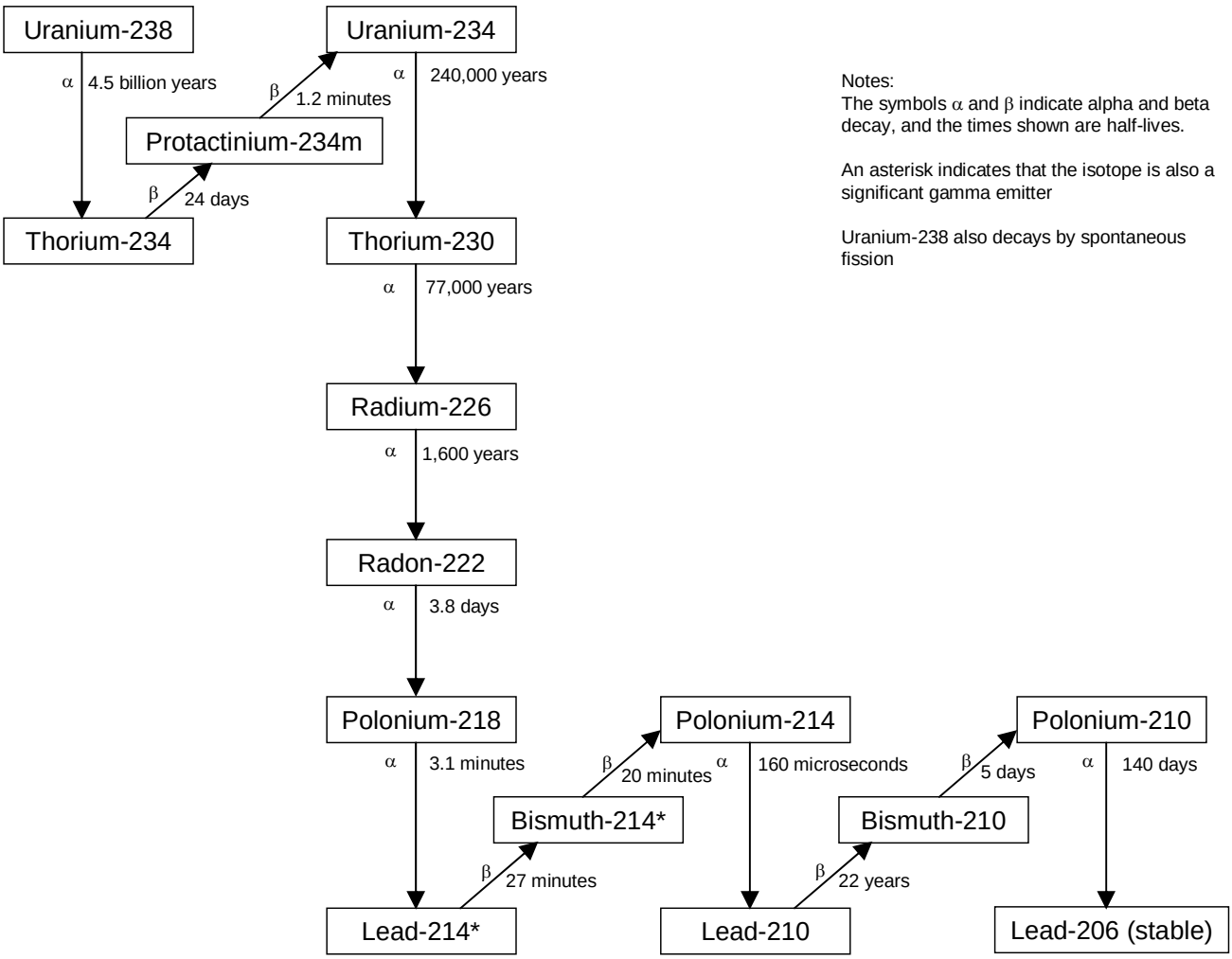
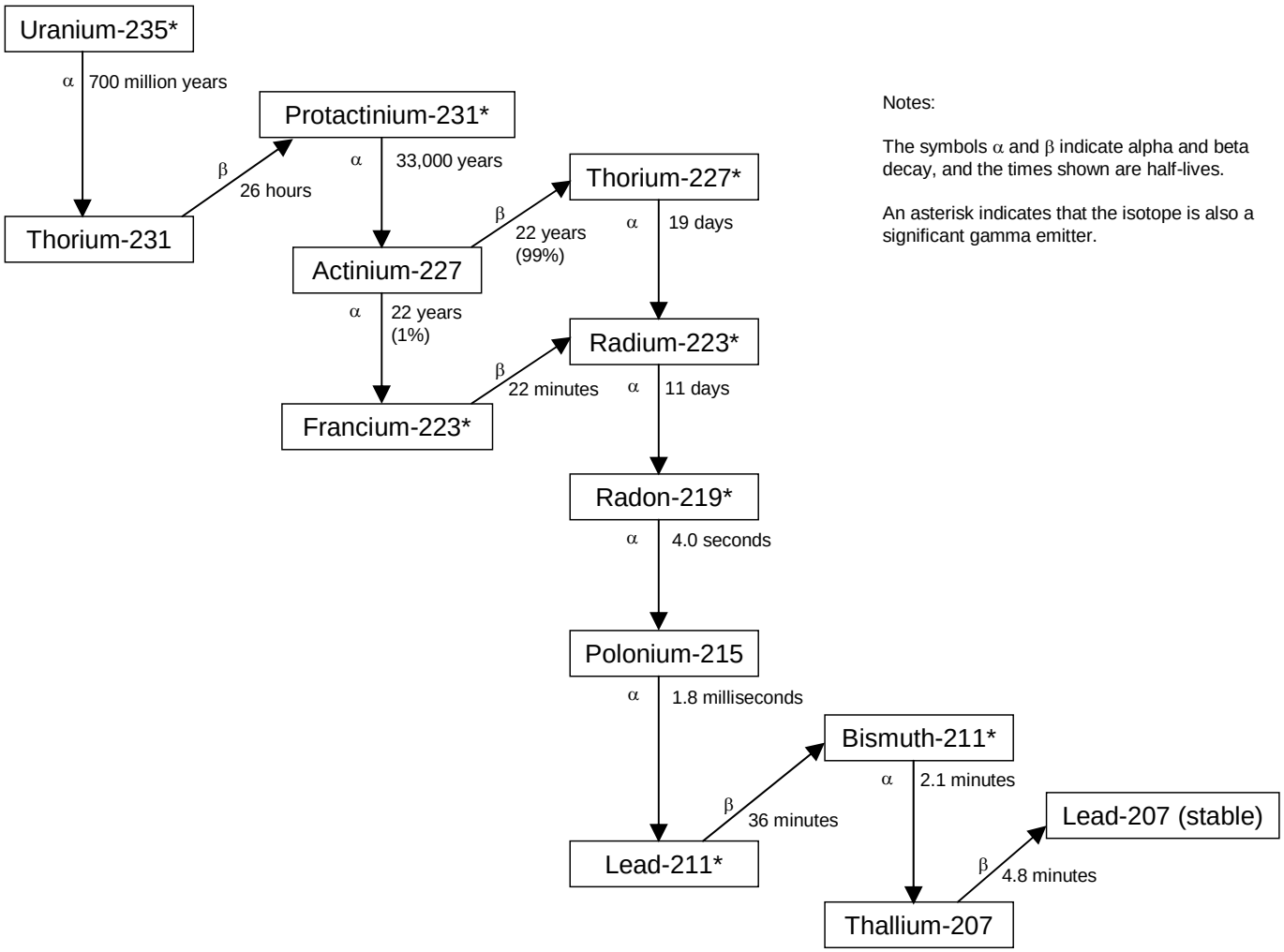


Figure B. Uranium 235 decay scheme (Argonne 2005)



For radioactive materials, the initial analyses of a sample may be for all radioactive materials emitting alpha particles (gross alpha) or beta particles (gross beta). These analyses do not identify the particular radioactive material but can indicate if further analysis needs to be performed. For instance, USEPA's Safe Drinking Water Standard does not require further analysis of a water sample if the gross alpha results are less than 15 picoCuries per liter (pCi/L) and the gross beta results are less than 50 pCi/L, except total radium cannot exceed 5 pCi/L.

The documents containing environmental data that were used in this assessment were selected for review from over 300 available documents because they provide the most

comprehensive site characterization data and discussion of conditions at the Shpack Landfill Superfund Site since the discovery of contamination. For example, both the Phase IA Initial Site Characterization Report, published in 1993, and the Phase 1B Remedial Investigation Report, published in 2004, contain comprehensive summaries of chemical and radioactive contaminants in soil, groundwater, and air as well as investigations of the meteorological and hydrogeological conditions around the Shpack Landfill. The 1993 report summarizes the results of earlier investigations and characterization activities (ERM 1993a, b, c). The 2004 report summarizes the investigative activities performed in 2002 (ERM 2004b). A full list of documents used in this assessment can be found in Section XII.

A. Drinking Water

According to the Massachusetts's Office of Geographic and Environmental Information (MassGIS), the Shpack Landfill site is located adjacent to a medium and high yield aquifer (MassGIS 2007). The nearest MDEP Zone II protection area lies approximately 3 miles to the northeast. A Zone II protection area is defined as the area of an aquifer that contributes water to a community drinking water well under the most severe pumping and recharge conditions that can be realistically anticipated (MDEP 1995). The nearest municipal drinking water wells are located in Norton, over 3 miles east and northeast of the site. The main sources of drinking water for Attleboro (Orr's Pond and Manchester Reservoir) are located over 4 miles from the site.

Depth to groundwater at the site is generally less than 5 feet below grade and has been measured as shallow as slightly more than 1 foot and as deep as approximately 16.5 feet below the ground surface in recent work conducted at the site (M&E 2004, ERM 2004b, Cabrera 2007). Shallow groundwater generally flows radially from the center of the landfill, meaning that groundwater flows from the landfill outward to the north, west, and east (GHR 1980, ERM 2004b). Deeper groundwater moves in a similar pattern, generally to the west, northwest, and east. Hydraulic testing also indicated that groundwater at the site has a strong vertical component resulting in downward groundwater flow in the area (ERM 2004b).

In 1980, reports from GHR Engineering Corporation (GHR) first noted chemical contamination of groundwater on the site (GHR 1980). Prior to that, data available for one private well was found free of contamination by organic solvents, chlorinated hydrocarbons, PCBs, or metals (MDEQE 1980). While GHR found groundwater contamination in monitoring wells located on the site, data from GHR and the Massachusetts Department of Environmental Quality Engineering (now the Massachusetts Department of Environmental Protection) did not show elevated levels of volatile organic compounds (VOCs), metals, or gross alpha (an indicator of radioactive materials) in private wells sampled at four nearby properties, including wells on Peckham Street, Maple Street, and Union Road during this time period (MDEQE 1980, GHR 1984). GHR also indicated that the public water supplies in Norton and Attleboro were not affected by contamination found beneath the landfill based on analysis of groundwater flow (GHR 1980).

In 1982, an unknown number of drinking water samples were taken from the former Shpack residence at 68 Union Road, the home located closest to the Shpack Landfill. The concentration of lead in drinking water (194 ppb) exceeded the U.S. EPA drinking water action level for lead (established for municipal drinking water supplies) [15 parts per billion (ppb)]. This was the maximum concentration of lead detected in drinking water at the former Shpack residence. U.S. EPA measured this maximum concentration of lead (194 ppb) in 1982 and recommended that additional sampling take place to determine whether the 1982 sample result was due to possible laboratory or sampling error. All subsequent drinking water samples at the former Shpack residence (68 Union Road) had lead concentrations well below the U.S. EPA drinking water action level (15 ppb). Therefore, it is possible that the concentration detected in 1982 was due to a laboratory or sampling error.

A residential well survey conducted in 1992 indicated that 56 private wells were located within a 1-mile radius of the Shpack Landfill site and that 23 of these private wells were potentially used for drinking water or personal uses (ERM 1993a, b). The closest private well is located at the former Shpack Residence, which is approximately 100 feet from the Shpack Landfill site boundary (see Figure 4). Past investigations have sampled a total of

22 private wells on North Worcester Road and Union Road to the northeast of the site, Walker Street to the north of the site, Maple Street to the east of the site, and Peckham Street to the southwest of the site. Also nearby was the private well located at Attleboro Landfill Incorporated (ALI) Landfill (179 Peckham Street), immediately adjacent to the Shpack Landfill.

Multiple rounds of private well sampling have occurred over the last 30 years, beginning in 1979 with the most recent round occurring in 2004. For this report, 188 samples from 22 private wells were reviewed for various chemical and radiological constituents over this time period. Of the chemicals detected in these private wells, the maximum concentrations of 10 compounds exceeded drinking water standards established for public water supplies, or if no standard was available, applicable comparison values, and these were further evaluated in this report. Nutrients, such as sodium, were also detected in private well water and are discussed in this report. Tables 2a and 2b summarize the maximum concentrations of each of these compounds as well as their MCLs or comparison values. Table 2a contains maximum concentrations measured in all nearby wells, while Table 2b focuses on data measured in the residential well located closest to the Shpack Landfill (i.e., the former Shpack residence).

Based on the review of the private well sampling data, the following compounds were selected as contaminants of concern (COCs) and will be discussed further in this report:

- **Arsenic:** Arsenic was measured at levels above the U.S. EPA drinking water standard of 10 ppb in residential well water of four homes since comprehensive sampling began in the 1980s. The range of concentrations of arsenic in well water of properties in the vicinity of the Shpack Landfill was ND (not detected) to 19 ppb and the average concentration was approximately 5.5 ppb. In the United States, the concentration of arsenic in groundwater is generally about 1 ppb (ATSDR 2007b). Surveys of drinking water in the U.S. indicate that about 80% of water supplies have less than 2 ppb of arsenic, but 2% of supplies exceed 20 ppb of arsenic (ATSDR 2007b).

- **Copper:** The maximum concentration of copper in private wells in the vicinity of the Shpack Landfill was 1,410 ppb and the average concentration was approximately 100 ppb. Copper occurs naturally in rock, soil, water, and sediment and is an essential element for humans at low levels (ATSDR 2004). The average concentration of copper in tap water in the United States ranges from 20–75 ppb, but many homes across the United States have copper concentrations over 1,000 ppb (ATSDR 2004). Copper is often found in tap water because it is dissolved from copper pipes and brass faucets when water sits in the pipes overnight (ATSDR 2004).

- **Manganese:** The maximum concentration of manganese in drinking water was 6,890 ppb (ERM 1993a). The concentration was measured during sampling in 1988 at 179 Peckham Street where the ALI Landfill is located. It was the maximum concentration of manganese detected in any private well sample from 1979 to 2004 and was above ATSDR comparison values, 500 ppb and 1,800 ppb for both children and adults, respectively. Manganese was consistently measured at levels above comparison values at 179 Peckham Street (ALI Landfill). Concentrations of manganese measured at other properties in the vicinity of the landfill ranged from not detected to 754 ppb. The average concentration of manganese in private well water in the vicinity of the landfill was 550 ppb.

- **Cadmium:** In 2003, cadmium (204 ppb) was detected once, at a concentration above the current EPA drinking water standard of 5 ppb at Maple, House 5. Cadmium was not detected at this home in seven sampling rounds conducted prior to 2003 (sampling rounds in 1986, 1987, 1988, 2001, and 2002) or during follow-up sampling in 2003. Investigators concluded that the single detection of cadmium was most likely the result of a laboratory error (ERM 2004b). Thus, this 2003 cadmium measurement will not be evaluated further.

- **Lead**: During the 1986 sampling rounds of 16 private wells, lead was detected above the USEPA drinking water action level of 15 ppb in drinking water from two private wells (Wehran 1987). The maximum concentration was 120 ppb,

which was the maximum concentration detected in private wells from 1979 to 2004. This lead concentration was above the action level of 15 ppb and the Maximum Contaminant Level Goal (MCLG) of 0 ppb for drinking water. (*Note: The maximum concentration of lead was detected in one sample [120 ppb] from a residential well, but lead was not detected in a duplicate sample, indicating a possible sampling error or laboratory error [MDEQE 1987]. Another elevated lead concentration [70 ppb detected at Maple, House 10] was also the result of a possible sampling or laboratory error because although the initial measurement was elevated, lead was not detected in six subsequent samples taken from this well [MDEQ 1987].*)

- **Methylene Chloride:** Methylene chloride was detected at Maple, House 8 and Maple, House 9 in 1986 at a maximum concentration of 11 ppb. The maximum concentration of methylene chloride exceeded the current drinking water standard (5 ppb). The concentration detected at Maple, House 8 was the maximum methylene chloride concentration detected in any private well sample from 1979 to 2004. Drinking water sampled at properties located closer to the landfill and at other properties on Maple Street did not show detectable levels of methylene chloride during 1986. Two detections of methylene chloride (2.1 ppb at Union, House 1 and 3.1 at Peckham, House 4) in 1990 were below the ATSDR Cancer Risk Evaluation Guide (CREG) of 18 ppb for methylene chloride. Methylene chloride is a chemical used as an industrial solvent and paint stripper. Possible household sources of methylene chloride include spray paints, automotive cleaners, and other household products (ATSDR 2000a). In addition to a number of household uses, methylene chloride is commonly used in laboratories; therefore, these isolated detections of the chemical may have resulted from contamination of the samples during laboratory testing.

- **Vinyl Chloride:** Between 1988 and 1990 vinyl chloride was detected above the current drinking water standard of 2 ppb in the private well water at 179 Peckham Street (where the ALI Landfill is located) (ERM 1993a). Vinyl chloride was not detected at this address during sampling in 1981–1987 or in any subsequent

sampling rounds (GHR 1984, ERM 1993a, ERM 2004b). Available data indicate that vinyl chloride was not detected in the well water of other properties sampled in the vicinity of the Shpack Landfill (ERM 1993a, ERM 2004b).

- **Aldrin:** There was a single detection of the pesticide aldrin (0.01 ppb) at 68 Union Road, the former Shpack residence (NUS 1985). Aldrin was detected below the ATSDR chronic Environmental Media Evaluation Guide (EMEG) for children (0.3 ppb) and adults (1.1 ppb), but above the CREG of 0.0021 ppb. It was not detected in any other private well in the vicinity of the Shpack Landfill.

Radon: In the 1980s, radon gas concentrations measured in the well water of properties in the vicinity of the Shpack Landfill ranged from 180 to 7,580 pCi/L (MDEP 2001, ERT 1987, ERM-New England 1991). Levels of gross alpha and beta activity in private well water were not above regulatory limits. Radon, a naturally occurring radioactive gas, is a decay product in the uranium and thorium decay chains. Radon decays by emitting alpha particles. However, radon concentrations are not reflected in the gross alpha analyses. Since radon is a gas, it is not unusual for it to be released to air or water from geological formations even though its parent (radium) may not be present. Usually it enters homes through cracks in foundations but can also enter via groundwater use. The primary public health risk from radon is from breathing it in indoor air. When water containing elevated levels of radon is used for showering, cooking, and other household activities, the radon can be released from water to indoor air and increase air concentrations. Currently the USEPA has a two-option proposed radon drinking water standard for community water systems aimed primarily at reducing the radon risk in indoor air (USEPA 2007c). If a mitigation plan is developed to reduce and control the levels of indoor radon air concentrations, then the concentration of radon in the community water system could be up to 4,000 pCi/L. If no plan is developed, then the proposed drinking water standard is 300 pCi/L. Currently, the ATSDR comparison value for radon in water is 300 pCi/L. In 1986, four out of 16 wells had radon concentrations above 4,000 pCi/L, and 15 out of 16 had radon concentrations above 300 pCi/L. In 1987, three out of seven wells had radon concentrations above 4,000 pCi/L, but not all of the wells with elevated radon concentration in 1986 were tested in 1987. In early 1988, three out of 11 wells had

concentrations above 4,000 pCi/L. These wells were not the closest wells to the landfill and did not have elevated gross alpha/beta results or elevated levels of site-related chemical contaminants; therefore, the radon gas does not appear to be related to the landfill. No recent sampling results for radon in these wells were available, and it is unknown if any indoor radon concentrations have been measured in these homes.

B. Soil

Chemical Contamination

Multiple rounds of soil sampling have occurred over the last 30 years, beginning in 1978 with the discovery of radiological contamination in soil, and continuing with the most recent round occurring in 2002. For this report, 48 soil samples from 0 to 2 feet below ground surface (bgs) were reviewed for chemical contaminants. Sixteen of the 48 soil samples were collected from locations outside the fence line of the Shpack Landfill (i.e., nearby offsite locations). Twelve additional soil samples were taken for comparison to determine site-specific background concentrations of chemical constituents in soil. Background samples are taken to show typical amounts of substances that occur at a nearby off-site location not influenced by areas of contamination

In order to evaluate the significance of soil exposures, the highest levels of chemical constituents measured in soil on or near the site were compared to ATSDR comparison values to help determine if further evaluation was necessary. Of the chemicals detected in soil on or near the Shpack Landfill, 24 exceeded comparison values and, therefore, required further evaluation in this report. Tables 3a and 3b provide the maximum concentrations of each of the compounds detected in soil that exceeded comparison values. Table 3a contains maximum concentrations measured in all soil samples at the Shpack Landfill, while Table 3b focuses on data measured in soil samples located offsite at the former Shpack residence.

Investigations of chemical contamination in soil at the Shpack Landfill site began in 1991 (sediment sampling began in the 1980s and is discussed in Section C). Both the Phase IA Initial Site Characterization Report, published in 1993, and the Phase 1B Remedial Investigation Report, published in 2004, contain comprehensive investigations of

chemical and radioactive contaminants in soil, groundwater, and air as well as investigations of the meteorological and hydrogeological conditions around the Shpack Landfill. The 1993 report summarizes the results of earlier investigations and characterization activities (ERM 1993a, b, c). The 2004 report summarizes the investigative activities performed in 2002 (ERM 2004b). Soil samples for the 1993 and 2004 reports were collected from soil borings or test pits extending from 0 to 2 feet below the ground surface (bgs). Soil samples from more shallow depths were not available. Typically, MDPH prefers to evaluate surface soil samples that are taken from the top 0–3 inches of soil; these kinds of samples are of particular interest when evaluating possible exposure as it is likely that individuals would have more frequent contact with surface soil than with deeper soils. As part of the comprehensive site investigations at the Shpack Landfill, soil samples were also collected from deeper soils (approximately 2-14 feet below ground surface); however, these soils are not evaluated in this report as it is unlikely that individuals visiting the site would contact soils at this depth.

Soil samples (0-2 feet bgs) were analyzed for volatile organic compounds (VOCs) in 1992 and 2002. VOCs were detected in 19 of 37 soil samples (ERM 1993a, 2004b). All VOCs detected in soil were below comparison values except trichloroethylene. Trichloroethylene was detected above the soil comparison value (3.3 parts per million [ppm] vs. 0.91 ppm) at one location in the interior of the landfill (SB-04) in 2004 (Figure 4). No VOCs were detected in offsite samples (SB-22 or SB-23) across Union Road from the Shpack Landfill or at the offsite sampling location (SB-1) closest to the former Shpack residence at 68 Union Road. No VOCs were detected above comparison values at soil sampling locations northeast and east of the landfill and near Chartley Swamp (ERM 1993a, ERM 2004b). Soil sampling from these reports indicates that soil contaminated by VOCs appears to be localized and contained within the Shpack Landfill (ERM 1993a).

Soil samples (0-2 feet bgs) were analyzed for semi-volatile organic compounds (SVOCs) in 1992, 2002, and 2004. SVOCs were detected in 32 of 37 soil samples (ERM 1993a, b, c). Onsite soil sampling showed the presence of primarily polycyclic aromatic hydrocarbons (PAHs), as well as phenols, phthalates, chlorobenzenes, nitrobenzene, and

dibenzofuran. Of these, carbazole and PAHs, including benzo(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene, were detected above their respective comparison values and/or above background concentrations in onsite soil.

PAHs were also detected at offsite soil sampling locations and background soil sampling locations (i.e., sampling locations that indicate the expected amount of PAHs in this area). Four PAHs, (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene) were detected above comparison values at two offsite locations, SB-24 and SB-30, near the fence line with ALI Landfill. The concentrations at these two locations along the ALI fence line exceeded the site-specific background concentrations for these compounds, but fell within the range of PAHs considered normal for soil (ATSDR 1995). Low concentrations of PAHs are often detected in the environment because they are a product of incomplete combustion from sources such as cigarette smoke, asphalt roads, vehicle exhaust, coal burning, residential wood burning, and waste incineration (ATSDR 1995).

Pesticides were detected in 17 of 37 onsite and nearby offsite soil samples taken in 1992, 2002, and 2004 (ERM 1993a, 2004b). The maximum detected concentrations of all pesticides were below their respective comparison values in soil and will not be further evaluated.

Polychlorinated biphenyls (PCBs) were detected in 19 of 37 soil samples collected in 1992, 2002, and 2004. The specific PCBs detected in soil included Aroclor 1248, 1254, and 1260. Arochlor 1254 was detected at levels below comparison values at all on- and offsite sampling locations. Aroclor 1248 was detected above the residential soil screening level of 0.22 ppm at one sampling location in the interior of the landfill (SB-13), at a concentration of 2 ppm. Aroclor 1248 was detected below comparison values at all other onsite and offsite soil sampling locations. Aroclor 1260 was detected above the residential soil screening level of 0.22 ppm (ORNL 2008) at three onsite sampling locations in the interior of the landfill (ERM-105, SB-13, SB-16). Aroclor 1260 was detected in one of the 12 soil samples collected from nearby offsite locations and

analyzed for PCBs; it was detected below its comparison value at this location. Thus, no PCBs exceeded health-based comparison values at any offsite soil sampling location.

Some data for dioxins and furans measured in soil were also available for evaluation. Dioxins and furans were detected at two onsite soil locations (ERM-103B [only sampled in 1992] and ERM-105D) at the Shpack Landfill in 1992 and 2002. ERM 103B is located in the southern 'Tongue Area' of the landfill, approximately 700 feet from Union Road (see Figure 4). ERM-105D is located in the interior portion of the landfill, approximately 175 feet from Union Road. The term "dioxin" stands for a class of 210 organic compounds called chlorinated dibenzo-p-dioxins (CDDs) and dibenzofurans that exhibit a similar chemical structure. Seventeen of these compounds are considered to have dioxin-like toxicity. One of the most toxic of these is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). A toxicity equivalency factor (TEF) is assigned to each of the 17 dioxin-like compounds that depicts the relative toxicity of the compound compared to 2,3,7,8-TCDD. The concentration of each compound detected is multiplied by its respective TEF. All the products are then summed and expressed as a 2,3,7,8-TCDD toxic equivalent (TEQ). A TEQ can be derived if data for all 17 compounds are not available by combining the toxicity for those that were tested. The toxicity of all the 17 dioxin-like compounds combined is expressed as the dioxin TEQ. Because it is based on the relative toxicity of each compound with respect to 2,3,7,8-TCDD, the dioxin TEQ can be compared with health-based screening levels established for 2,3,7,8-TCDD. The dioxin and furan data from the Shpack Landfill in 1992 and 2002 were converted into 2,3,7,8-TCDD TEQ for evaluation. Typically, for individual dioxins and furans that are not detected, a value of one-half the detection limit is used when calculating the TEQ for that sample. However, because detection limits were not available for the Shpack Landfill dioxin and furan data, a value of zero was used when calculating the TEQ for each sample.

The dioxin TEQs for soil samples at the Shpack Landfill ranged from 0.00003 ppm to 0.0005 ppm. The dioxin TEQs measured in 1992 at sampling location ERM-103B (0.0001 ppm) and in 2002 at sampling location ERM-105D (0.0005 ppm) were above the chronic EMEG of 0.00005 ppm for children, but below the chronic EMEG value of

0.0007 ppm for adults. The dioxin TEQ measured in 1992 at sampling location ERM-105D (0.00003 ppm) was below both the child and adult EMEG values.

Metals were detected in all soil samples taken at the Shpack Landfill in 1992, 2002, and 2004. Of these, the maximum concentrations of antimony, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, and zinc measured onsite exceeded both comparison values and typical background concentrations in soil. No metal in any offsite location exceeded the range of typical background levels found in soil in the eastern U.S. (Shacklette and Boerngen 1984). The maximum concentration of arsenic (29.3 ppm) was measured onsite and is above the CREG (0.5 ppm). It is within the range of background concentrations of arsenic typically found in soil in the eastern U.S. (range of <0.1 – 73 ppm), but above the MDEP background level under the Massachusetts Contingency Plan (20 ppm) (MDEP 2002).

Radiological Contamination

Soil sampling for radiological contamination was conducted at the Shpack Landfill as early as 1978. The Nuclear Regulatory Commission (NRC) conducted the first radiological survey of the site and discovered three areas of soil contamination. Measurements of radiation in soil at these areas ranged from 4.0–5.0 milliroentgens/hr (mR/hr) up to 4 inches deep. A more extensive survey indicated that up to 50,000 square feet of soil toward the center of the landfill was contaminated with uranium-235 (^{235}U), uranium-238 (^{238}U) and radium-226 (^{226}Ra) (NRC 1979).

In 1981, Oak Ridge National Laboratory (ORNL) performed a radiological survey of the site designed as a follow-up to the 1978 NRC activities. As part of this survey, radiological surveys were performed and soil samples were collected between the ground surface and 5 centimeters (2 inches) depth at the center points of a 50-foot by 50-foot grid of the site. These 91 samples showed a range of concentrations for ^{226}Ra, ^{235}U, and ^{238}U contamination which were more typical of the soil contamination at the site. However, the maximum concentrations at the site were found by surveying the property with portable survey equipment and collecting soil samples where maximum exposure rates were recorded. These samples are referred to as “biased samples.” The average gamma

external exposure rate at the grid centers was within background range, but the maximum exposure rate at 1 meter (~3 feet) above the ground surface was 0.365 mR/hr and at the surface was 1.45 mR/hr (maximum background was 0.009 mR/hr) (ERM 1991). Systematic soil sampling from the grid and biased soil sampling revealed:

Radium-226: Range: <1 to 11 pCi/g (8 of 72 samples greater than background)
Maximum biased sample = 47,000 pCi/g
Uranium-235: Range: 0.03 to 51 pCi/g
Maximum biased sample = 7,080 pCi/g
Uranium-238: Range: <1 to 140 pCi/g
Maximum biased sample = 96,300 pCi/g

Sixty-three of the 91 surface soil samples contained uranium (5 depleted uranium, 21 natural uranium, and 37 enriched uranium). Subsurface soil sampling showed the same radioactive materials but at slightly lower maximum concentrations (ORNL 1981 as cited in ERM 1991).

Also, in 1981, the U.S. Department of Energy installed a security fence to limit access to the Shpack Landfill site. During fence construction, three "hot particles" were located along the fence line in the western corner of the landfill (Bechtel National, Inc 1982 as cited in ERM 1991). The particles were placed in tin cans and buried on the site; however, another area of contamination inside the fence line at the western corner of the landfill was identified and left in place (Bechtel National, Inc 1982 as cited in ERM 1991).

In August and September 1982, Bechtel National, Inc. conducted a characterization survey of the site and found that the distribution of the onsite contamination was spotty and uneven, both horizontally and vertically. Although the average concentrations were not exceptionally elevated, "hotspot" concentrations of ^{226}Ra, ^{234}U, ^{235}U, and ^{238}U were found in surface soil with maximum detections of 166.8, 4200, 1500, and 7200 pCi/g, respectively. Subsurface soils also contained elevated concentrations of ^{226}Ra, ^{234}U, ^{235}U, and ^{238}U. The maximum gamma rate at 1 meter above the ground was 29.5 microroentgens/hr (μR/hr) with an average rate of 11.5 μR/hr for 36 measurements.

Background for this area averaged 7 μR/hr (Bechtel National, Inc 1984 as cited in ERM 1991)

The U. S. Army Corps of Engineers oversaw the 2002 radiological investigation for the Phase 1B Remedial Investigation Report (ERM 2004b). Although radionuclides were detected in soil at significant concentrations at the Shpack Landfill, most of the soil samples were taken deeper than 1 foot below the surface. Within the Shpack Landfill interior, localized areas contained concentrations of uranium and radium one to three orders of magnitude greater than the remainder of the Shpack Landfill interior. The two primary areas of elevated radium were not co-located with the three primary areas of elevated uranium; however, these compounds are co-located at low concentrations across the Shpack Landfill. The highest concentration of radium in a surface soil sample was located near the center of the site to the east of the swampy area. The radioactive materials with the highest concentrations for several radionuclides in this sample were americium-241 (11.1 pCi/g), bismuth-214 (1,230 pCi/g), cadmium-109 (1,350 pCi/g), lead-214 (1,230 pCi/g), radium-224 (2,220 pCi/g), and radium-226 (1,600 pCi/g). The uranium isotopes in this sample (not maximum for uranium) were elevated above normal background, but the concentrations were approximately 10 pCi/g for both ^{234}U and ^{238}U and 1 pCi/g for ^{235}U, indicating that it was not enriched or depleted. The highest concentrations for ^{234}U (5,340 pCi/g), ^{235}U (730 pCi/g), and ^{238}U (14,200 pCi/g) at 1-3 feet below ground surface were located to the southeast and north of this central swampy area; however, concentrations in surface soil samples appeared to be much lower. Surface soils were sampled at several locations around the perimeter of the site. The concentrations detected in these samples do not indicate that radium and uranium are migrating offsite.

C. Sediment

Testing of sediment for radioactive contamination at the Shpack Landfill site began in the 1980s. The Phase IA Initial Site Characterization Report and the Phase 1B Remedial Investigation Report contain comprehensive investigations of both chemical and radioactive contaminants in sediment (ERM 1993a, 1993b, 1993c; ERM 2004b).

Sediment samples for these reports were collected from onsite and offsite locations in 1992, 2002, 2003, and 2004.

In order to evaluate the significance of sediment exposures, the highest levels of VOCs, SVOCs, pesticides, polychlorinated biphenyls (PCBs), and metals measured in sediment on the entire site were compared to ATSDR's soil comparison values to help determine if further evaluation was necessary. Since ATSDR comparison values for sediment do not exist, soil comparison values were used as screening values. Sediment at the Shpack Landfill site had levels of VOCs, SVOCs, PAHs, polychlorinated biphenyls (PCBs), and metals that were above soil comparison values. Radiological surveys of the site also indicated that levels of radioactive isotopes and gross alpha/beta radiation in onsite sediment occasionally exceed background levels. Table 4 provides the maximum concentrations of each of the chemical compounds that exceeded comparison values as well as their comparison values and background concentrations, if available. Radioactive contaminants and their background levels are discussed in detail below.

Chemical Contamination

During sampling events in 1992 and 2002-2004, 14 sediment samples were collected from onsite locations and 8 sediment samples were collected from offsite locations (Chartley Pond and Chartley Swamp). In addition, 12 sediment samples were collected to evaluate site-specific background conditions in the area surrounding the landfill and were analyzed for chemical contaminants (ERM 2004b). The background samples were taken from locations approximately 1,500 feet southwest of the Shpack Landfill. Background samples are taken to show typical amounts of substances that occur at a nearby location not influenced by areas of contamination. The background samples showed detections of one VOC, 2-butanone (also known as methyl ethyl ketone or MEK), several SVOCs including benzaldehyde and PAHs, and 23 metals.

VOCs were detected in 7 of 10 onsite sediment samples (ERM 1993a, 2004b). Two VOCs (acetone and carbon disulfide) were detected in two of four offsite sediment samples, from areas near Chartley Pond and areas within Chartley Swamp. The VOCs at offsite locations were detected below their respective comparison values.

Trichloroethylene (TCE), was detected above comparison values in onsite sampling. TCE (10.45 ppm) was detected above the soil comparison value (0.91 ppm) in the interior of the landfill (SW-18) in 2003 (Table 4). TCE was not detected in background sediment samples.

SVOCs were detected in all ten onsite and four offsite sediment samples analyzed for these compounds (ERM 1993a, 2004b). Maximum concentrations of six PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(ah)anthracene] exceeded comparison values. The onsite and offsite sampling indicates that sediment contaminated by PAHs is primarily limited to the wetland areas in the central and northeastern areas of the site and is contained within the Shpack Landfill fence line. Maximum concentrations of benzo(a)anthracene, benzo(b)fluoranthene, and benzo(k)fluoranthene exceeded comparison values, but fall within the range of typical background concentrations observed in urban soils (ATSDR 1995) (see Table 4). The maximum concentrations of benzo(a)pyrene (15 ppm), chrysene (16 ppm), and dibenzo(ah)anhracene (2.55 ppm) exceeded their respective comparison values as well as the typical and site-specific background range observed in soils.

Pesticides were detected in 5 of 10 onsite sediment samples at the Shpack Landfill in 2003. Pesticides were not detected during sampling in 1992. None of the pesticides detected during 2003 exceeded comparison values.

PCBs were detected in 8 of 10 onsite sediment samples at the Shpack Landfill. Arochlor 1254 exceeded comparison values at one sediment sampling location, SW-18, located in an interior wetland. The concentration of Aroclor-1254 (84 ppm) exceeded the chronic EMEG for children (1 ppm) and adults (14 ppm) in soil and will be evaluated further later in this report.

Metals were detected in all 22 sediment samples taken in and around the Shpack Landfill. Nine metals (antimony, arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc) exceeded comparison values. The maximum concentration of arsenic (38 ppm) exceeded comparison values, but fell within the range of typical concentrations observed

for soil in the eastern United States (Shacklette and Boerngen 1984). The maximum concentration of the remaining eight metals exceeded the comparison values as well as the typical and site-specific background range observed in soil in the eastern United States and required further evaluation in this report.

Radiological Contamination

The 1981 ORNL radiological survey of the site included analyzing sediment samples from the onsite swamp area and the adjacent Chartley Swamp. The concentrations of ^{235}U and ^{238}U in all samples were above background. The concentrations of ^{226}Ra were also above background in several samples. This sampling event indicated that radioactive contamination had migrated from the dump site across the swamp and into the edge of Chartley Swamp (Figure 4). However, all stream sediment samples collected offsite showed concentrations at or near background levels (ORNL 1981 in ERM 1991).

In the August/September 1982 report, sediments from the landlocked portion of the swamp within the Shpack fenced border and from the wetlands east of the site were analyzed for radioactive materials and were reported to be within U.S. Department of Energy limits. Thirty sediment samples were collected with the following concentrations reported (Bechtel 1984, ERM 1991):

Radium 226:	maximum = 1.2 ± 0.1 pCi/g
	average = 0.4 ± 0.0 pCi/g
Uranium 235:	maximum = 0.364 pCi/g
	average = 0.087 pCi/g
Uranium 238:	maximum = 0.7 ± 0.1 pCi/g
	average = 0.3 ± 0.1 pCi/g

In 1984, measurements of gross alpha radiation in onsite sediment samples ranged from 12 ± 5 to 20 ± 6 pCi/g, and measurements of gross beta radiation ranged 17 ± 3 to 34 ± 4 pCi/g. Surface water samples and sediment samples were collected at the same locations. The location for the most elevated alpha concentrations in sediment did not correlate to the location for the most elevated alpha concentrations in surface water. This was not true for the most elevated beta concentrations. The maximum concentrations (in units of

pCi/g dry weight) of the major radionuclides detected in 1984 sediment samples include: actinium-228 (1.5 ± 0.2), bismuth-212 (2.1 ± 0.6), bismuth-214 (1.0 ± 0.2), cesium-137 (2.7 ± 0.6), lead-212 (2.2 ± 0.6), lead-214 (1.2 ± 0.2), and radium-226 (1.1 ± 0.2). Previous offsite surface water and sediment sampling were typically at or near background levels. These results indicate that some radioactive contaminants may be present at the edge of the swamp but do not extend into the swamp or to offsite drainage areas (NUS 1985).

During the sampling that occurred in 2002, eight sediment and surface water samples were collected at the same locations in or at the edge of Chartley Swamp and were analyzed for radioactive contaminants. The sediment samples were analyzed by both alpha and gamma spectroscopy with concentrations of ^{238}U and ^{235}U reported at or near background levels (ERM 2004b).

D. Surface Water

The Shpack Landfill is located at the western edge of the Taunton River Drainage Basin within the Narragansett Bay watershed (MassGIS 2007). Surface water potentially impacted by the landfill is located in wetlands in the central and northeastern portions of the landfill as well as in Chartley Swamp, to the east and southeast, and in Chartley Pond to the north (Figure 4) (ERM 2004b).

In order to evaluate the significance of surface water contaminants, the highest concentrations of each compound measured in surface water on the entire site were compared to drinking water comparison values to help determine if further evaluation was necessary. Drinking water comparison values are used because ATSDR comparison values for surface water do not exist; however, these comparison concentrations are very conservative because drinking water comparison values assume that an individual ingests 2 liters per day. Since it is very unlikely that an individual would routinely ingest 2 liters (more than eight 8-ounce glasses) of <u>surface water</u> from this site each day, exposure to contaminants in surface water would be expected to be considerably less than exposures to contaminants in drinking water.

Chemical Contamination

Of the contaminants detected in surface water, 26 exceeded comparison values or did not have comparison values and, therefore, required further evaluation. Table 5 summarizes the maximum concentrations of each of these contaminants as well as their comparison values.

In 1984, limited sampling of surface water in the vicinity of the Shpack Landfill found no VOCs (other than methane) in onsite surface water. This sampling also showed detections of manganese and zinc (NUS 1985 in ERM 1991). The most comprehensive evaluations of contaminants in surface water were conducted as part of the site characterization and remedial investigation activities during 1993 and 2004 (ERM 1993a, 2004b). Surface water samples for these investigations were collected from onsite and offsite locations in 1992, 2002, 2003, and 2004 (ERM 1993a, 2004b). VOCs, SVOCs, PAHs, pesticides, PCBs, metals, and radioactive contaminants were detected in surface water at the Shpack Landfill. Fourteen samples were collected and analyzed for VOCs, SVOCs, PAHs, pesticides, and PCBs. Twenty-two samples were collected and analyzed for metals. Twelve surface water samples were also collected to evaluate background conditions in the area surrounding the landfill and were analyzed for chemical contaminants (ERM 2004b). The background samples were taken from locations approximately 1,500 feet (0.25 miles) southeast of the Shpack Landfill. Background samples are taken to show typical amounts of substances that occur at a nearby location less likely to be influenced by areas of contamination.

VOCs were detected in 8 of 14 onsite and nearby offsite surface water samples (ERM 1993a, 2004b). Vinyl chloride (1.3 ppb) was detected above the drinking water comparison value (CREG of 0.025 ppb) at one location in the interior of the landfill (SW-19) in 2003. Vinyl chloride was not detected in the background surface water samples.

SVOCs were detected in 7 of 14 onsite and nearby offsite surface water samples at the Shpack Landfill (ERM 1993a, 2004b). Maximum concentrations of three PAHs [benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene] exceeded comparison

values. These three PAHs were only detected in the interior of the landfill and not detected at offsite locations outside of the fence line.

Pesticides were detected in 3 of 14 onsite and nearby offsite surface water samples at the Shpack Landfill (ERM 1993a, 2004b). Pesticides were not detected during sampling in 1992. One pesticide, alpha-BHC (0.015 ppb), was detected above the ATSDR CREG value (0.006 ppb). Pesticides were not detected in one background sample taken upgradient of both Shpack and ALI Landfills.

PCBs were detected in 1 of 14 onsite and nearby offsite surface water samples at the Shpack Landfill. The concentration of Aroclor-1254 (0.43 ppb) measured at sampling location SW-1 exceeded the chronic EMEG for children (0.2 ppb), but was below the chronic EMEG for adults (0.7 ppb). PCBs were not detected in the one background sample.

Metals were detected in all 22 onsite and nearby offsite surface water samples taken at the Shpack Landfill (ERM 1993a, 2004b). Sixteen metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc) exceeded comparison values in onsite and nearby offsite samples taken at the Shpack Landfill. The maximum concentration of arsenic (31.4 ppb) was measured in a background sample located upgradient of both Shpack and ALI Landfills. Concentrations of arsenic measured in the vicinity of the Shpack Landfill site ranged from not detected to 10.8 ppb. The second highest concentration of arsenic was located at SW-5, outside the fence line and adjacent to the "Tongue Area" in the southern portion of the site (Figure 4). The highest concentrations of 13 other inorganics (aluminum, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc) were also detected in the "Tongue Area." The highest concentrations of the remaining two metals, antimony and barium, were detected in the interior wetlands on the eastern portion of the Shpack Landfill. The nutrients calcium and sodium were also detected in surface water on the site. An additional 12 background samples were taken in the immediate vicinity of the Shpack Landfill to determine background concentrations of metals in areas less likely to be influenced by

site-related contamination. All 12 background samples also had detected concentrations of metals.

In 2000, water quality sampling was performed offsite at Chartley Pond in Norton, Massachusetts; specifically, the surface water at the pond outlet on South Worcester Street was sampled (USEPA 2000). The arsenic concentration (3.6 ppb) exceeded the ATSDR CREG value for drinking water (0.023 ppb). It is important to note that drinking water comparison values are used to screen surface water concentrations and, as discussed above, exposure to contaminants in surface water would be expected to be considerably less.

Radiological Contamination

In 1982, surface water from swamp areas located onsite, within the fence line, and from Chartley Swamp east of the site were sampled for ^{234}U, ^{235}U, and ^{238}U. Fifteen surface water samples were analyzed and all results were within Department of Energy limits and the USEPA's current drinking water standard of 30 pCi/L for total uranium.

In 1984, measurements of gross alpha and/or gross beta radiation in two of six surface water samples exceeded USEPA's drinking water standards (15 pCi/L for gross alpha and 50 pCi/L for gross beta): SW-02, located on the swamp edge south of the ALI Landfill, measured at 22 ± 8 pCi/L gross alpha, and SW-03, located at the corner of Fire Pond at the swamp edge between the Shpack Landfill and the ALI Landfill, measured at 31+/- 20 pCi/L gross alpha and 160 ± 20 pCi/L gross beta (Table 5). ^{226}Ra measurements in all five surface water samples tested were less than USEPA's drinking water standard of 5 pCi/L (NUS 1985 in ERM 1991).

In 1989, six surface water samples were collected from the landfill and analyzed for gross alpha and gross beta concentrations. The locations where these samples were collected were not indicated in the report. One sample (68 ± 7 pCi/L) exceeded USEPA's drinking water standard for gross beta, and one sample (27.5 pCi/L) exceeded USEPA's drinking water standard for gross alpha.

Comprehensive surface water sampling for remedial investigation activities were collected from onsite and offsite locations in 1992, 2000, 2002, 2003, and 2004 (ERM 1993a, 2004b; USEPA 2000; Cabrera 2003). Sampling for radioactive contaminants was described in the 1993, 2003, and 2004 reports (ERM 1993a, ERM 2004b, Cabrera 2003). Nine surface water samples were collected in 1992 and analyzed for gross alpha activity. Two samples contained gross alpha activity (44.3 ± 23.3 pCi/L and 44.0 ± 25.3 pCi/L) in exceedance of USEPA's drinking water standard; however, these samples were not filtered, which makes their results not useful (ERM 1993c). For the 2003 report, eight surface water samples were collected and analyzed for gross alpha and gross beta activity. One sample contained gross alpha activity (44.1 ± 8.9 pCi/L) in exceedance of the USEPA drinking water standard for gross alpha (Cabrera 2003). None of the results exceeded USEPA's drinking water standards for gross beta. While radioactive contaminants have been occasionally detected in the surface water, access to this site has been limited; the likelihood that anyone would ingest large quantities of surface water from this area is small given the restricted access to the site.

E. Air

Limited air monitoring was conducted at the Shpack Landfill in 1982 and 1992 (Bechtel 1984, ERM 1993a). In August and September 1982, continuous air monitoring was conducted at two stations, one near the wood frame building next to the former Shpack residence and one at the corner of the site near Peckham Road and the Norton town line (Bechtel 1984). Samples showed that concentrations of ^{226}Ra, ^{234}U, ^{235}U, and ^{238}U were all within U.S. Department of Energy limits; however, exposure to these concentrations will be considered when calculating potential offsite and onsite exposure doses. ^{226}Ra concentrations ranged from 7.1×10^{-4} to 1.2×10^{-3} picocuries per cubic meter (pCi/m^3). ^{234}U concentrations ranged from less than 7.1×10^{-5} to 3.9×10^{-4} pCi/m^3. ^{235}U concentrations ranged from less than 3.5×10^{-5} to less than 1.1×10^{-4} pCi/m^3. ^{238}U concentrations ranged from 1.4×10^{-4} to 1.7×10^{-4} pCi/m^3. Background levels for uranium and uranium decay products (including radium) are generally very low and vary by site. These radioactive contaminants will be evaluated further by calculating exposure doses in Section VI.

Additional onsite air quality screening reported in the Final Site Response Assessment Report showed no detections of VOCs (NUS 1985). Methane gas concentrations measured in ambient air ranged from 100 to 1,000 ppm.

Six onsite air samples (20-minute grab samples) for chemical contaminants were taken in 1992 at a time when the wind was blowing from south to north (ERM 1993a). Of the six onsite air samples, two samples were taken from the southeast border of the landfill, along the ALI Landfill boundary (the upwind location); two samples were taken from the interior of the Shpack Landfill; and two samples were taken from the northeast border of the Shpack Landfill (the downwind location). The air samples were analyzed for VOCs, some SVOCs and inorganic compounds (except mercury). One SVOC, 1,1-dichloroethene, was detected in all six samples at a maximum concentration of 2.2 ppb, which was below the intermediate EMEG of 20 ppb. Metals were not detected in any of the six air samples.

VI. EVALUATION OF POTENTIAL EXPOSURE PATHWAYS

An evaluation of potential exposure pathways was conducted to determine whether contamination identified at Shpack Landfill could be impacting nearby residents of Norton or Attleboro or recreational users of the Shpack Landfill in the past, present, or future. Exposure to a chemical or a radioactive material must first occur before any potential adverse health effects can result. Five conditions must be present for exposure to occur. First, there must be a source of that chemical or radioactive material. Second, an environmental medium must be contaminated by either the source or by contaminants transported away from the source. Third, there must be a location where a person can potentially contact the contaminated medium. Fourth, there must be a means by which the contaminated medium could enter a person's body, such as ingestion, inhalation, and dermal absorption. Fifth, there must be a potentially exposed population. Examples of exposed populations might include recreational users, nearby residents, or workers. Even if all five elements of an exposure pathway are present, adverse health effects will not necessarily occur. The chemical or radioactive material must actually reach the target organ susceptible to the toxic effects caused by that particular substance at a sufficient

dose and for a sufficient exposure time for an adverse health effect to occur (ATSDR 2005a). For radioactive substances, released radiation may also cause an external exposure depending on the type of radiation, the distance from the source of the radiation, and shielding between the source and the individual recipient.

A completed exposure pathway indicates that exposure to humans occurred in the past, is occurring in the present, or will occur in the future. A completed exposure pathway exists when all of the five elements are present. A potential exposure pathway exists when one or more of the five elements is missing or uncertain and indicates that exposure to a contaminant could have occurred in the past, could be occurring in the present, or could occur in the future. An exposure pathway can be eliminated if at least one of the five elements is missing and will not likely be present in the future.

To evaluate the potential for health effects for potential or completed pathways, ATSDR Minimal Risk Levels (MRLs) were compared to exposure estimates for the contaminants of concern at the Shpack Landfill. The MRL is an estimate of daily exposure to a contaminant below which noncancer, adverse health outcomes are unlikely to occur. In addition, exposure estimates for contaminants of concern were combined with USEPA cancer slope factors provided by ATSDR to evaluate a theoretical cancer risk. Refer to Table 1 for a summary of exposure pathways discussed in this section.

A. Exposure to Contaminants in Drinking Water

i) Municipal Water

According to MassGIS, the nearest municipal drinking water wells and associated MDEP Zone II protection areas are located in Norton and lie approximately 3.5 miles east of the Shpack Landfill; therefore, groundwater beneath the Shpack Landfill is not expected to contribute to the municipal drinking water in Norton, even under the most severe pumping and recharge conditions (MassGIS 2007). The main sources of drinking water for Attleboro, Orr's Pond and Manchester Reservoir, are located over 4 miles west of the site. Additional sources of Attleboro's municipal drinking water are located over 5 miles from the Shpack Landfill in North Attleboro and Plainville, Massachusetts (MassGIS 2007, Attleboro Water Department 2007). Municipal drinking water in both Norton and

Attleboro is tested and treated on a routine basis in accordance with state and federal laws. More information on Attleboro's water supply, including testing results, can be found at www.cityofattleboro.us/water or by contacting the Attleboro Water Department at 508-222-0019. For more information on Norton's water supply, contact the Norton Water Department at 508-285-0280.

ii) Private Well Water – 68 Union Road (Former Shpack Residence)

A number of homes in the vicinity of the Shpack Landfill rely on groundwater (private wells) as a source of drinking water. The nearest private well is located at the former Shpack residence, immediately adjacent to the Shpack Landfill. This home was demolished and the private well closed in 2007 and is therefore considered a pathway for past exposures only (M. Taylor, USEPA Region 1, personal communication, 2008, 2013).

In the past, residents living at the former Shpack residence might have been exposed to low levels of one pesticide or several metals in residential well water via ingestion and dermal contact. The maximum concentrations of aldrin, lead, manganese, and nickel detected in well water at 68 Union Road exceeded comparison values (Table 2b) and were retained for further evaluation in this report. Past exposures for both adult and child residents of 68 Union Road consuming well water regularly and showering in well water regularly were examined for each compound detected above comparison values in drinking water. A typical exposure scenario assumes that a child resident ingests 1 liter of drinking water containing the average concentration of a contaminant for 7 days a week, each week of the year, for 10 years. Using this exposure scenario to evaluate

aldrin in the well water at 68 Union Road, exposure to aldrin is not expected to result in an unusual cancer risk or adverse non-cancer health effects for residents[1].

Exposure doses were also calculated for the metals (lead, manganese, and nickel) that exceeded comparison values in well water at 68 Union Road. Using the typical exposure scenario discussed above to evaluate a child resident ingesting tap water containing manganese and nickel, exposure to manganese or nickel is not expected to result in adverse non-cancer health effects for residents; however, MDPH took into consideration the evaluation approach used in a New York State Department of Health (NYSDOH) report evaluating manganese in drinking water and conducted a more detailed assessment described below.

Lead

In humans, the main target for lead toxicity is the nervous system. Lead exposure is of greatest concern for young children because children exposed to lead, primarily due to the presence of lead paint in housing, may experience neurological damage (including learning disabilities) and behavioral changes. Lead was detected above the U.S. EPA drinking water action level of 15 ppb at 68 Union Road in one well water sample taken in 1982. All subsequent samples of this well (1984-2003) were below the U.S. EPA drinking water action level. Therefore, it is possible that the concentration detected in 1982 was due to a laboratory or sampling error. The home was demolished and the

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$$\text{Cancer Effects Exposure Factor} = \frac{(7\text{ days/week})(52\text{ weeks/year})(10\text{ years})}{(70\text{ years})(365\text{ days/year})} = 0.14$$

$$\text{Cancer Effects Exposure Dose(Child)} = \frac{(\text{avg aldrin concentration})(\text{ingestion rate})(\text{exposure factor})}{\text{body weight}}$$

$$= \frac{(0.00001\text{mg/L})(1\text{L/day})(0.14)}{30\text{kg}} = 4.7x10^{-8}\text{ mg/kg/day}$$

$$\text{Cancer Risk} = (\text{Cancer Effects Dose})(\text{Cancer Slope Factor})$$

$$= (4.7 \text{ x } 10^{-8}\text{ mg/kg/day})(17\text{ mg/kg/day}^{-1})$$

$$= 8.1 \text{ x } 10^{-7}$$

private well closed in 2007, therefore, current and future exposures would not be possible.

Manganese

Manganese is a naturally occurring element found in rock, soil, water, and food and is an essential nutrient for humans at certain levels (ATSDR 2012). The human body can control the amount of absorbed manganese. If large amounts of manganese are ingested, then the body excretes large amounts in the feces.

In 1986, manganese was detected above comparison values (500 ppb and 1,800 ppb for both children and adults, respectively) at a level of 2,110 ppb in one sample of well water collected from 68 Union Road. All five of the subsequent samples collected from 68 Union Road (1992-2003) and analyzed for manganese were below health-based comparison values (ERM 2004b).

The NYSDOH published a report in 2009 that discussed manganese in drinking water. People who drank water for 10 years or more with manganese at levels similar to those found historically in the well at 68 Union Road had a slightly higher frequency of symptoms such as weakness, stiff muscles and trembling of the hands (NYSDOH 2009). However, they also reported that these symptoms are not specific to manganese and might have been caused by other factors. Although this evaluation is limited, it provides evidence (along with studies in animals and humans) that high levels of manganese in drinking water may increase the risk for non-cancer health effects, particularly after long-term exposure (NYSDOH 2009).

MDPH evaluated whether adverse health effects could have been possible if a resident living at 68 Union Road consumed water containing high levels of manganese, in order to be conservative. To evaluate the risk of non-cancer health effects for a resident living at 68 Union Road and consuming the water, exposure calculations were performed using a typical exposure scenario assuming that a resident ingested 1 liter (child) or 2 liters (adult) of well water containing the average concentration of a contaminant for 7 days a week, each week of the year, for 10 years (child) or 30 years (adult). Based on this typical exposure scenario, the estimated exposure doses for adult and child residents

living at 68 Union Road are 0.012 mg/kg/day and 0.014 mg/kg/day, respectively. The estimated exposure doses for adult and child residents were below the health-based guideline of 0.16 mg/kg/day[2]. Therefore, although the previously discussed study indicates that adverse health effects could have been possible if residents consumed water containing high levels of manganese for many years, exposure calculations specific to residents at 68 Union Road indicate that non-cancer health effects due to manganese ingestion are not expected.

Former residents of 68 Union Road may have been exposed to aldrin, lead, manganese, and nickel; however levels of exposure are not expected to result in adverse health effects. Present and future exposures to contaminants in residential well water at 68 Union Road are not possible because the home was demolished and the well closed in 2007.

iii) Private Well Water – Other Nearby Residences

Some nearby residents on Maple Street, Peckham Street, Union Road, and North Worcester Street relied on private well water as a source of drinking water in the past or present. In 1992, a well survey sent to residents within a 1-mile radius of the Shpack Landfill site indicated that 56 residences had a private well on their property. Of the 56 private wells reported, 23 were potentially used for drinking water or personal uses; 16 were used only as a supplementary source for gardening, livestock, swimming pools; and 17 were currently not in use or abandoned (ERM 1993a, 1993b, 1993c). A 1992 report states that a number of residents who previously used private well water, including six homes on Maple Street, are now connected to Town of Norton water (ERM 1992). Owners of Maple, House 8 and N. Worcester, House 2 reported abandoned wells on their property that are no longer in use (ERM 1993c). Owners of 179 Peckham Street (the location of the ALI Landfill) reported that the primary use of their private well was irrigation and that the well had not been used since approximately 1990; it was closed by

[2] An interim guidance value of 0.16 mg manganese/kg/day, based on the Tolerable Upper Intake Level for 70 kg adults of 11 mg manganese/day (established by the U.S. Food and Nutrition Board/Institute of Medicine [FNB/IOM 2001]) is recommended to be used for ATSDR public health assessments of oral exposure to inorganic forms of manganese (ATSDR 2008e)

the City of Attleboro Health Department in the mid 1990s (James Mooney, City of Attleboro Health Department, personal communication, 2009). It is clear that drinking water from private wells represents a completed exposure pathway in the past, although details on years of use for a specific address were not always known. It is our belief that at least some of these wells continue to be used for drinking water.

According to USEPA's Record of Decision for the Shpack Landfill site, they have determined that a sufficient threat exists at the site to support the installation of a waterline to provide municipal water to homes adjacent to the landfill (Union, House 1; and 68 Union Road) (USEPA 2004a). The home referred to as Union, House 1 is currently not connected to the municipal water supply and, as noted above, the former Shpack residence at 68 Union Road was demolished and the well was closed in 2007 (Jim Mooney, Attleboro Health Department, personal communication, 2008; M. Taylor, USEPA Region 1, personal communication, 2008).

In the past, present, and future, residents living in properties in the vicinity of the landfill (properties on Maple Street, Union Road, Peckham Street, and North Worcester Road) who consumed water from residential wells may have been exposed to drinking water containing levels of contaminants that exceeded comparison values. Exposure scenario dose calculations were conducted for all contaminants (except nutrients) detected in well water that exceeded comparison values (methylene chloride, vinyl chloride, arsenic, cadmium, copper, lead, manganese) at area properties. Exposure calculations using a typical exposure scenario assumes that a resident ingests 1 liter (child) or 2 liters (adult) of well water containing the average concentration of a contaminant for 7 days a week, each week of the year, for 10 years (child) or 30 years (adult). Calculations indicate that neither unusual cancer risk nor adverse non-cancer health effects would be expected from a majority of the contaminants detected in drinking water including methylene chloride, vinyl chloride, arsenic, cadmium, copper, and lead.

Contaminants requiring detailed evaluation are discussed below including cadmium, manganese, and sodium (a nutrient). Exposure to arsenic and lead at the Shpack Landfill is discussed in detail below because of the complexity of the evaluation conducted.

Because the community has expressed special concern about radiological contaminants at the Shpack Landfill, these exposures are also discussed in detail.

Arsenic

Arsenic can occur naturally in our environment and can be found in rocks, soil, water, and air. Concentrations of arsenic measured in the residential well water of all properties in the vicinity of the Shpack Landfill ranged from 0.74 ppb to 19 ppb, with an average concentration of 5.5 ppb. Arsenic was detected above the current U.S. EPA drinking water standard (MCL of 10 ppb applicable to public drinking water supplies in the U.S.) in the residential well water of four properties in the vicinity of the Shpack Landfill. Data from approximately 20 years of drinking water sampling indicated that arsenic concentrations at three of the four residential wells fluctuated above and below the current MCL (See Table 2c). At Peckham, House 3, ten of 13 samples showed detections ranging from 7 – 15 ppb. At Peckham, House 4, two of 24 samples showed detections ranging from 8 – 12 ppb. At N. Worcester, House 1, ten of ten samples showed detections ranging from 7 – 16 ppb. Over time, the average concentration, a typical estimate of what a resident might consume over the long-term, was equal to or below the U.S. EPA drinking water standard in each of these three homes (8.6 ppb, 2.9 ppb, and 10 ppb, respectively). For the remaining home, Maple, House 7, only two water samples from 1986 (19 ppb) and 1988 (19 ppb) were available; therefore, the data necessary to assess long-term health effects are unavailable. This particular home was connected to the municipal water supply following sampling in the late 1980s or early 1990s (ERM 1993a, 1993b, 1993c).

An analysis of arsenic concentrations measured in groundwater and background monitoring wells in the vicinity of the Shpack Landfill indicated that arsenic concentrations were similar at private drinking water wells and monitoring wells in the area and indicated that arsenic in drinking water may result from background levels of arsenic in rock, soil, and water.

Cadmium

With the exception of one sample, all cadmium concentrations measured in the well water of properties in the vicinity of the Shpack Landfill were below the EPA MCL of 5 ppb. On April 30, 2003, one sample (204 ppb) was collected from Maple, House 5 that exceeded the MCL. Drinking water samples were collected from this house a total of nine times, six times prior to this sample between 1986 and 2002, and two times after this sample in July and August 2003. Cadmium was not detected in eight out of the nine samples collected from Maple, House 5. The next highest concentration of cadmium (4 ppb) detected in any drinking water wells near the Shpack Landfill was below comparison values and was measured at 179 Peckham Street, where the ALI Landfill is located. Investigators concluded that the single detection of cadmium at Maple, House 5 was most likely the result of a laboratory error (ERM 2004b). Thus, the sample collected from Maple, House 5 on April 30, 2003, was considered anomalous and was excluded from evaluation.

Exposure calculations for cadmium were completed using a typical exposure scenario, assuming that a resident ingests 1 liter (child) or 2 liters (adult) of well water containing the average concentration of a contaminant for 7 days a week, each week of the year, for 10 years (child) or 30 years (adult). Calculations indicate that no unusual cancer risk or adverse non-cancer health effects would be expected.

Lead

In humans, the main target for lead toxicity is the nervous system. Lead exposure is of greatest concern for young children because children exposed to lead, primarily due to the presence of lead paint in housing, may experience neurological damage (including learning disabilities) and behavioral changes.

In general, lead concentrations measured in the residential well water of most properties in the vicinity of the Shpack Landfill were below the USEPA drinking water action level of 15 ppb. The average concentration of lead in well water was 7 ppb, which is less than the U.S. EPA drinking water action level for lead of 15 ppb for municipal drinking water supplies. Residential well water occasionally exceeded the action level at Union, House

1 and Maple, House 10 (past exposures only were assessed for Maple, House 10 because the home is currently connected to town water, therefore current and future exposures would not be possible). At Union, House 1, lead was detected in one sample (120 ppb) from the residential well, but lead was not detected in a duplicate sample collected at the same time, indicating a possible sampling error or laboratory error (MDEQE 1987). The average concentration of lead in well water from Union, House 1 was 10 ppb, which is less than the action level for lead of 15 ppb for municipal drinking water supplies and above the USEPA Maximum Contaminant Level Goal (MCLG) of 0 ppb. At Maple, House 10, lead was detected in one sample (70 ppb) from the residential well. Lead was not detected in six subsequent samples taken from this well and the initial measurement could have resulted from an error (MDEQ 1987).

Manganese

Manganese was detected above health-based comparison values in private well water in the vicinity of the Shpack Landfill. Manganese in the private well water ranged from not detected (ND) to 6,890 ppb. Maximum concentrations measured in background monitoring wells in the vicinity of the Shpack Landfill had manganese in groundwater ranging from 2,590 ppb to 10,900 ppb. Therefore, since levels detected in offsite monitoring wells were generally higher than levels in private well water, it is possible that manganese is naturally occurring in offsite groundwater.

The maximum concentration of manganese (6,890 ppb) in private well water was measured at 179 Peckham Street where the ALI Landfill is located. This well served a home located at the ALI Landfill and was installed in 1936 (ERM 1993c). Because this home was last occupied in the late 1970s or early 1980s and the private well was closed by the Attleboro Health Department in the mid 1990s, the exposures at 179 Peckham Street are considered as a past exposure and are not continuing in the present or future (James Mooney, City of Attleboro Health Department, personal communication, 2009). Further, during a well survey in 1992, owners of 179 Peckham Street indicated that the well water was used for irrigation only at that time (ERM 1993c). It is unknown whether the well could have been used for drinking water from the time it was installed in 1936.

Although the former owners indicated that the well water was used only for irrigation, MDPH evaluated whether adverse health effects could have been possible if a resident living at 179 Peckham consumed water containing high levels of manganese, in order to be conservative. To evaluate the risk of non-cancer health effects for a resident living at 179 Peckham Street (ALI Landfill) and consuming the water, exposure calculations were performed using a typical exposure scenario assuming that a resident ingested 1 liter (child) or 2 liters (adult) of well water containing the average concentration of a contaminant for 7 days a week, each week of the year, for 10 years (child) or 30 years (adult). Based on this typical exposure scenario, the estimated exposure doses for adult and child residents living at 179 Peckham Street (ALI Landfill) are 0.08 mg/kg/day and 0.10 mg/kg/day, respectively. The estimated exposure doses for adult and child residents were below the health guideline of 0.16 mg/kg/day[3]. Therefore, although the previously discussed document (NYSDOH 2009) indicates that adverse health effects could have been possible if residents consumed water containing high levels of manganese for many years, exposure calculations specific to residents at 179 Peckham Street indicate that non-cancer health effects due to manganese ingestion are not expected.

In general, the concentrations of manganese measured in the well water of other properties in the vicinity of the Shpack Landfill were much lower than the concentrations measured at 179 Peckham Street (ALI Landfill). Concentrations of manganese measured at other properties in the vicinity of the landfill ranged from not detected (ND) to 754 ppb. Based on a conservative exposure scenario, the estimated exposure doses for adults and children are 0.021 mg/kg/day and 0.047 mg/kg/day, respectively. The estimated exposure doses for adult and child residents are also below the health guideline of 0.16 mg/kg/day, therefore, adverse health effects would not be expected to result from regular manganese exposure due to drinking water from other properties near the landfill.

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[3] An interim guidance value of 0.16 mg manganese/kg/day, based on the Tolerable Upper Intake Level for 70 kg adults of 11 mg manganese/day (established by the U.S. Food and Nutrition Board/Institute of Medicine [FNB/IOM 2001]) is recommended to be used for ATSDR public health assessments of oral exposure to inorganic forms of manganese (ATSDR 2008e)

Sodium (a nutrient)

Sodium was detected at elevated concentrations in the residential well water of some properties in the vicinity of the landfill. A maximum concentration of 42.5 ppm of sodium was measured in these wells. This concentration exceeds the Massachusetts guideline for sodium in drinking water of 20 ppm. Sodium is a naturally occurring element found in water and soil. It is an essential mineral, which is necessary for the normal functioning of the body and maintenance of body fluids. The Massachusetts guideline of 20 ppm in drinking water represents a level of sodium in water that physicians and sodium-sensitive individuals should be aware of in cases where sodium exposures are carefully controlled. People who have difficulty regulating fluid volume as a result of several diseases such as hypertension and kidney failure are particularly affected by elevated levels of sodium (MDPH 2007b). BEH's "Sodium in Drinking Water Fact Sheet" is included in Appendix B.

Radioactive Contaminants

In the past and present, residents living in the vicinity of the landfill and consuming groundwater from residential wells have not been exposed to site-related radioactive contaminants above comparison values. However, most of the wells tested in 1986 and 1987 had concentrations of radon gas in water (naturally occurring; not site-related) that did not exceed USEPA's recommendations at the time of sampling but exceed ATSDR's current health-based comparison value of 300 pCi/L and USEPA's proposed MCL [see Environmental Data Section (Section V) for USEPA's approach to regulating radon in drinking water]. No recent sampling results for radon in water from these wells were available. Radon is classified as a carcinogen, and the primary public health risk is associated with breathing radon in indoor air. When water containing radon is used for showering, cooking, and other household chores, the radon can be released from the water to the air. There can also be other contributors to the level of radon in indoor air, and there can be mitigating conditions that can reduce the concentrations. It is unknown if any indoor radon concentrations have been measured in these properties. Without indoor air sampling results and the knowledge of where, when, and how any potential samples were collected, no health impact determination can be made.

B. Exposure to Contaminants in Soil

Past exposure to contaminants in soil from the mid-1940s, when the landfill began accepting waste, to 1981 was possible. In November 1981, an 8-foot high barbed wire fence was erected to restrict access to the Shpack Landfill (ERM 1991). During the time period from the mid-1940s until the fencing of the landfill in 1981, adults and children may have visited the Shpack Landfill for recreational purposes, including collecting items disposed of as refuse. Individuals may have also gained access to the site through missing sections of fencing or holes in the fence discovered during site work in 1999 and subsequently repaired in 2003. This public health assessment evaluates potential soil exposures for past visitors to the Shpack Landfill, former residents of the Shpack residence, and past and present visitors to areas surrounding the Shpack Landfill (i.e., offsite).

At the Shpack Landfill, soil samples were collected from 0 to 2 feet below the ground surface (bgs). Typically, surface soil samples are taken from the top 0–3 inches of soil for public health evaluation. This is because it is likely that individuals would have more frequent contact with surface soil than with deeper soils. Because there are no data available for soil at more shallow depths, this public health assessment considers potential exposures to the shallowest soil samples available (0-2 ft bgs). As mentioned, soil samples were also taken for 2 to 14 feet below the ground surface, but it is unlikely that visitors would be exposed to soil at these depths.

In the past, visitors to the site may have been exposed through incidental ingestion of or dermal contact with contaminants such as volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), dioxins, PCBs, and metals detected in onsite soil (0-2 feet bgs) at levels above comparison values (Table 3a). However, it is important to consider that comparison values are based on a residential exposure scenario, and it is unlikely that an occasional visitor would have had contact with onsite surface soil for a comparable frequency and duration of time. Visitors may have been exposed through ingestion of and external exposure to radioactive contaminants at levels that may exceed the ATSDR MRL for non-cancer health effects or at levels that may cause an increase risk of developing cancer.

Past and current exposure calculations were conducted for chemical contaminants. Future exposures were not predicted because site remediation for chemical contaminants is expected to begin in 2013 following radiological material removal, which was completed in 2011 (Figure 3).

For the Shpack Landfill, the exposure scenario used assumes that a resident visits the site 1 day each week, for 52 weeks each year, for 10 years as a child or 30 years as an adult. This is based on community reports that area residents may have dropped off refuse at the landfill, and these residents and their children may have spent time collecting salvageable items from the landfill. While this scenario is assumed to be typical, it may overestimate the actual exposure of an individual because it is unlikely that residents would be visiting the landfill as frequently during the colder months of the year. This exposure scenario also assumes that incidental ingestion of soil occurs at a rate of 100 milligrams (mg) per day for adults and 200 mg per day for children. Exposure scenario calculations using these exposure assumptions were conducted for all contaminants detected in soil (0-2 feet bgs) that exceeded comparison values and typical background levels [i.e., trichloroethylene (TCE), carbazole, six PAHs, dioxins, 11 metals, and the PCBs Aroclor 1248 and Aroclor 1254] at the landfill. Exposure calculations, using similar exposure assumptions, were also conducted separately for radioactive contaminants detected in onsite soil.

For example, assuming that a child visited the Shpack Landfill site and incidentally ingested soil containing the <u>maximum</u> concentration of benzo(a)pyrene (a PAH) detected

in soil (54 ppm) for 1 day every week for 52 weeks over 10 years would not result in an unusual cancer risk[4].

Exposure calculations, as discussed for benzo(a)pyrene, were conducted for all chemical contaminants detected in soil (0-2 feet bgs) that exceeded comparison values and typical background levels in soil. Exposure calculations indicate that for a majority of contaminants (TCE, carbazole, six PAHs, dioxins, nine metals, and the PCBs Aroclor 1248 and Aroclor 1254), ingestion of even the maximum concentration measured in soil (0-2 feet bgs) at the Shpack Landfill would not be expected to result in either adverse non-cancer health effects or elevated cancer risk based upon exposure assumptions. Two contaminants (copper and nickel), may produce adverse non-cancer health effects if soil containing the maximum concentration of each contaminant was ingested on a regular basis. However, evaluation of copper and nickel using more realistic assumptions of a child visiting different areas of the Shpack Landfill and ingesting soil containing an average concentration of each contaminant, showed that non-cancer health effects would not be expected. Offsite soil results showed no exceedances of both comparison values and typical background soil concentrations and hence would not be expected to result in health concerns.

For lead, the main target of toxicity is the nervous system. Lead exposure is of greatest concern for young children because children exposed to lead, primarily due to the

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[4] $$\text{Cancer Effects Exposure Factor} = \frac{(1\ \text{days/week})\,(52\ \text{weeks/year})\,(10\ \text{years})}{(70\ \text{years})\,(365\ \text{days/year})} = 0.020$$

$$\text{Cancer Effects Exposure Dose(Child)} = \frac{(\text{maximum benzo(a)pyrene concentration})\,(\text{ingestion rate})\,(\text{exposure factor})\,(\text{conversion factor})}{\text{body weight}}$$

$$= \frac{(54\ \text{mg/kg})\ (200\ \text{mg/day})\ (0.020)\ (1\text{kg}/10^{6}\ \text{mg})}{30\ \text{kg}} = 7.3x10^{-6}$$

$$\text{Cancer Risk} = (\text{Cancer Effects Dose})\,(\text{Cancer Slope Factor})$$

$$= (7.3 \times 10^{-6}\ \text{mg/kg/day})\ (7.3\ \text{mg/kg/day}^{-1})$$

$$= 5.3 \times 10^{-5}$$

presence of lead paint in housing, may experience neurological damage (including learning disabilities) and behavioral changes. Although lead was detected in some areas at the Shpack Landfill well above typical background levels, the likelihood that a young child (particularly, under age 7) regularly visited the site, particularly the landfill interior with the highest lead levels, and played in the soil is very low. Lead exposure is of greatest concern for young children under age 7; the hand-to-mouth behavior typical of young children represents the greatest exposure potential to lead in surface soil. Children who may have visited the landfill were most likely older children or teenagers.

Exposures Specific to Individuals Living in the Former Shpack Residence

In the past, residents of the former Shpack house, located at 68 Union Road, may have been exposed through incidental ingestion of or dermal contact with arsenic (maximum of 4.9 ppm) detected in soil (0-2 feet bgs) at levels above the CREG (0.47 ppm) but below the chronic EMEG for adults (210 ppm) and children (15 ppm) (Table 3b). This type of exposure was not evaluated for present or future exposures because this residence was demolished in 2007 (M. Taylor, USEPA Region 1, personal communication, 2008). All other contaminants detected in the immediate vicinity of the former Shpack residence were below comparison values at the sampling locations closest to the home. While arsenic concentrations detected closest to the home were above a comparison value, it is important to note that the maximum concentration detected in soil near the residence was well within the range of concentrations of metals typically measured in soils in the eastern United States (<0.1–73 ppm) (Shacklette and Boerngen 1984). In addition, exposure dose calculations indicated that adverse health effects would not be expected.

Offsite Exposures

Sampling conducted in 1992 at offsite locations opposite the Shpack Landfill and in 1992 and 2002 at locations outside of the fence line (i.e., offsite) showed that soil (0-2 feet bgs) did not have elevated levels of contaminants. Arsenic was the only metal detected above comparison values outside of the fence line. Arsenic (10.5 ppm) was detected above the CREG (0.47 ppm) but below the chronic EMEG for adults (210 ppm) and children (15 ppm). Concentrations of arsenic detected at offsite soil sampling locations were within

the range of background concentrations of arsenic (<0.1–73 ppm) typically found in soil in the eastern US (Shacklette and Boerngen 1984) and, based upon exposure assumptions, would not be expected to result in health concerns. Four polycyclic aromatic hydrocarbons (PAHs) were occasionally detected slightly above comparison values at offsite soil sampling locations. This is not considered unusual because PAHs are common in our environment as a result of residential wood burning, forest fires, and exhaust from automobiles and trucks (ATSDR 1995). ATSDR has compiled levels of PAHs that are considered normal for soil of urban and suburban communities (ATSDR 1995). Levels of PAHs detected at offsite locations surrounding the Shpack Landfill fall within the range of PAHs considered normal for soil. For example, benzo(a)pyrene was detected in offsite soil (0-2 feet bgs) at 1.0 ppm, which is above the CREG (0.096 ppm), but within background levels for urban soil (0.169-59 ppm).

Radioactive Contaminants

Past and current exposure calculations were conducted for radioactive contaminants. Future exposures were not predicted because the site remediation for radioactive materials was completed in 2011.

As mentioned earlier, many of the soil samples were collected deeper than what is normally considered surface soil. Typically, surface soil samples are taken from the top 0–3 inches of soil; however, the shallowest available soil samples for the Shpack Landfill incorporated the top 0–2 feet of soil. However, some conclusions can be made from the available data for the Shpack Landfill. There appear to be two primary areas of elevated ^{226}Ra contamination not co-located with the three primary areas of elevated uranium contamination even though lower concentrations of radium and uranium appear to be co-located across the site (ERM 2004b). There are two swampy areas located onsite: one in the east-northeast area of the site and a larger one centrally located. One primary area of elevated ^{226}Ra is on the west side of the central swamp near the Town of Norton property line. The other primary area of elevated ^{226}Ra is located on the east side of the central swamp. The three primary areas of elevated uranium contamination are on the southeast corner of the central swamp and to the north of the central swamp on the tail of the east-northeast swamp, not far from the former Shpack residence. To determine a conservative

exposure scenario, maximum concentrations were used in a calculation for one of the ^{226}Ra contaminated sites and another calculation for one of the uranium contaminated areas. Exposure calculations were conducted to evaluate the risk of adverse non-cancer health effects and elevated cancer risk.

For the Shpack Landfill, a typical exposure scenario assumes that a 10 year-old child visits the site 1 day each week, for 52 weeks each year and that the child incidentally ingests 200 mg of soil per day. In order to evaluate potential non-cancer health concerns, exposure calculations for potential ingestion of contaminated soil were performed using the International Commission on Radiological Protection (ICRP) Publication 72 methodology and conversion factors along with assumptions for a typical exposure scenario at the landfill (ICRP 1996)[5]. For the maximum radium contaminated area, the annual exposure to americium-241, bismuth-214, cadmium-109, lead-214, radium-224, and radium-226 would be a total of 72 millirem/year (mrem/year) (0.72 millisievert/year) which is less than ATSDR's MRL of 100 mrem/year [1 millisievert/year (mSv/yr)]; however, exposures from other media and routes must also be considered. For the maximum uranium contaminated area, the annual exposure for a 10 year-old child would be 55 mrem/year (0.55 mSv/yr), which is also less than ATSDR's MRL. The potential exposure for an adult from both of these areas would be less than half the exposure for this child. External exposures should also be added to the exposure from soil ingestion. Using the maximum gamma exposure rate at 1 meter above the ground from ORNL's grid survey of 0.365 mR/hr (ORNL 1981 as cited in ERM 1991) and assuming that a child or an adult were on the site for 1 hour per day for 52 days per year, the external

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[5] Non-cancer adverse health effects from radioactive contaminants (isotopes):

Exposure from each isotope is calculated and summed for total exposure for each scenario:

Isotopic concentration in soil (Bq/mg) x ingestion rate (200 mg/day) x 52 days/year x CF (Sv/Bq)

Note: Bq = Becquerel (1 Bq = 27 picocuries)

mg = milligram (of soil)

Sv = sievert (1 Sv = 100 rem; 1 mSv = 100 mrem)

CF = conversion factor from activity ingested to exposure dose (unique for each isotope)

exposure would add an additional 19 mrem/yr (0.19 mSv/yr). This additional exposure would not make the potential exposures exceed ATSDR's MRL. Because estimated exposure doses for radioactive contaminants in soil are below health guidelines (i.e. ATSDR's MRL), adverse health effects would not be expected.

In order to evaluate potential elevated cancer risk, exposure calculations were performed using the USEPA's Federal Guidance 13 (USEPA 1999). As with the calculations for a child's exposure to benzo(a)pyrene, a child consistently visiting the maximally contaminated area of the site could have been exposed to radioactive contaminants at a level that could present an increased cancer risk (1.4×10^{-4}). However, these exposure assumptions are conservative, and it is very unlikely that a weekly visitor would have had consistent contact with surface soil containing the highest concentrations. It is more likely that a site visitor would be exposed to a range of concentrations similar to the samples collected during the ORNL grid survey (maximum of 11 pCi/g ^{226}Ra, 140 pCi/g ^{238}U, and 51 pCi/g ^{235}U). Under a more realistic assumption that a child who regularly visited the site could have been exposed to a range of concentrations, an increased cancer risk would not have been likely.

C. Exposure to Sediment

Sediment is present at the Shpack Landfill site in wetland and swampy areas located within the fence line in the interior of the landfill and also beyond the fence line (i.e., offsite) in nearby areas such as Chartley Swamp and Chartley Pond. There are two swampy areas located in the interior of the landfill: one in the east-northeast area of the site and a larger one centrally located. In the past, from the mid-1940s when the landfill began accepting waste until 1981 when a fence was constructed to restrict access, exposure to onsite sediment was possible. During that time period, adults and children may have come into contact with these wetland and swampy areas if they visited the Shpack Landfill for recreational purposes, including collecting items disposed of as refuse. Individuals may have also gained access to the site through missing sections of fencing or holes in the fence discovered during site work in 1999 and subsequently repaired in 2003. This section of the public health assessment evaluates potential exposures to contaminated sediment for past, present, and future visitors to the Shpack

Landfill and for past, present, and future visitors to areas surrounding the Shpack Landfill (i.e., offsite).

Sediment samples were collected from wetland and swampy areas located in the interior of the landfill, as well as from areas such as Chartley Swamp and Chartley Pond located beyond the fence line of the landfill. Because there are no physical barriers to restrict access to some of these wetland areas, incidental ingestion and dermal contact with contaminants detected above comparison values in sediment were evaluated for children or adult recreational users who may have accessed the wetlands in the past, and those who may access them in the present or future.

The majority of the chemical contaminants detected in sediment (60 of 77 contaminants detected) were detected below residential soil comparison values; therefore, potential exposures to these chemical contaminants in wetland sediment would not be expected to result in health effects. The maximum concentrations of chemical contaminants in wetland sediment that were outside of the range of both comparison values and background soil concentrations include metals, PAHs, one VOC (trichloroethylene) and PCBs (Table 4). However, it is important to note that although some contaminants are above comparison values, these values are based on a residential exposure scenario, and it is unlikely that a visitor to the landfill would have had contact with wetland sediments for a comparable frequency and duration of time due to the nature of the area and its distance from residences.

Radioactive material concentrations analyzed in sediment samples were slightly elevated for gross alpha and gross beta activity in onsite sediment but at or near background levels at the edge of Chartley Swamp and in offsite streams.

For the Shpack Landfill, a typical exposure scenario assumes that an individual visits the site 1 day each week, for 52 weeks each year, for 10 years as a child or 30 years as an adult. This is based on community reports that area residents may have dropped off refuse at the landfill and these individuals and their children may have spent time collecting salvageable items. This scenario is conservative because it may overestimate the actual exposure of an individual because it is unlikely that visitors dropping off refuse

would be exposed to areas of soil covered in water (i.e., sediment). Also, it is unlikely that individuals would be visiting the landfill frequently during the colder months of the year. Risk calculations using these exposure assumptions were conducted for all contaminants detected in sediment that exceeded comparison values and typical background levels [i.e., trichloroethylene (TCE), three PAHs, eight metals, and Aroclor 1254]. It is worthwhile to note that present and future visitors of the Shpack Landfill would not likely come into contact with sediment containing the highest levels of most contaminants or radioactive contaminants because access is presently restricted by the security fence and clean-up of the site is currently underway as detailed in the USEPA's Record of Decision (USEPA 2004a).

Exposure calculations, using exposure assumptions as discussed earlier, were also conducted separately for past exposures to radioactive contaminants (predominantly ^{226}Ra, ^{235}U, and ^{238}U) detected in onsite sediment. The exposure doses were calculated using the same parameters as those for soil ingestion. Assuming a child or an adult recreational user could have inadvertently ingested onsite sediment containing the maximum detected concentrations, neither non-cancer health effects nor an unusual cancer risk would be expected. As stated earlier, present access to the Shpack Landfill is restricted by the security fence. Cleanup activities under the guidance of the U.S. Army Corps of Engineers were completed in 2011; therefore, future exposures would not be expected.

Trichloroethylene (TCE) was the only VOC detected above its comparison value at one sediment sampling location in the interior wetlands of the Shpack Landfill. TCE was not detected in Chartley Swamp or any areas outside of the fence line (i.e., offsite areas). Recreational users of the Shpack Landfill in the past may have come in contact with TCE during occasional visits to the landfill. Assuming a child accessing the Shpack Landfill in the past touched or inadvertently ingested wetland sediment containing the maximum

concentration of TCE detected (10.45 ppm) for 1 day each week for 52 weeks per year for 10 years, neither increased cancer nor non-cancer health effects would be expected.[6]

Exposure calculations were conducted for all contaminants detected in sediment that exceeded comparison values and typical soil background levels. Exposure calculations indicate that for a majority of the contaminants (TCE, all three PAHs, and six metals), ingestion of or dermal exposure to the maximum concentration measured in sediment at the Shpack Landfill would not be expected to result in either adverse non-cancer health effects or elevated cancer risk. However, further evaluation was conducted for copper, nickel, and Aroclor 1254.

Copper

Copper occurs naturally in sediment and is an essential nutrient for humans at low levels (ATSDR 2004). Further evaluation of copper in sediment at the Shpack Landfill showed that exposure is unlikely to result in adverse health effects. A typical exposure scenario assumes that a resident visited the Shpack Landfill wetlands 1 day each week, for 52 weeks each year, for 10 years as a child or 30 years as an adult and touched or inadvertently ingested 200 mg of wetland sediment with the average concentration of copper (2,087 ppm). Ingestion of sediment containing the average concentration of copper and using these exposure assumptions indicates that the exposure dose would be

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[6] $$\text{Cancer Effects Exposure Factor} = \frac{(1\ \text{days/week})\,(52\ \text{weeks/year})\,(10\ \text{years})}{(70\ \text{years})\,(365\ \text{days/year})} = 0.020$$

$$\text{Cancer Effects Exposure Dose(Child)} = \frac{(\text{max TCE concentration})\,(\text{ingestion rate})\,(\text{exposure factor})\,(\text{conversion factor})}{\text{body weight}}$$

$$= \frac{(13\ \text{mg/kg})\ (200\ \text{mg/day})\ (0.020)\ (1\text{kg}/10^{6}\ \text{mg})}{30\ \text{kg}} = 1.8x10^{-6}$$

$$\text{Cancer Risk} = (\text{Cancer Effects Dose})\,(\text{Cancer Slope Factor})$$

$$= (1.8 \times 10^{-6}\ \text{mg/kg/day})\ (0.046\ \text{mg/kg/day}^{-1})$$

$$= 8.3 \times 10^{-8}$$

below ATSDR's health guideline, the intermediate MRL[7] (the intermediate MRL was used in the absence of a chronic MRL or EPA RfD). Thus, it is unlikely that health effects would be expected based upon this exposure scenario.

Present and future visitors of the Shpack Landfill would not likely come into contact with sediment containing high level of metals, as access is currently restricted by the security fence and Chartley Swamp appears to act as a barrier to migration of contaminants outside the landfill (ERM 2004b).

Nickel

Nickel is classified as a possible human carcinogen by the National Toxicology Program (NTP) and the International Agency for Research on Cancer (IARC), and inhalation of nickel compounds has resulted in cancer of the lungs and nasal sinuses of workers in nickel refineries or nickel-processing plants (ATSDR 2005b). Much of the nickel found in air, soil, sediment, and rock is so strongly attached to dust and soil particles that it is not readily taken up by humans and, therefore, cannot easily affect health. If nickel is ingested, most of it leaves quickly in the feces and the small amount that gets into the bloodstream leaves in the urine. The most common adverse health effect of nickel exposure in humans is an allergic reaction, typically a skin rash at the site of contact.

Recreational users of and visitors to the Shpack Landfill may have come into contact with wetland areas located at the interior of the landfill. Incidental ingestion and dermal contact with nickel detected above comparison values in sediment could have been possible for children or adult recreational users who may have accessed the wetlands in the past, or those who may access them in the present and future. Inhalation of sediment

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$$\text{Non - Cancer Effects Exposure Factor} = \frac{(1\text{ days/week})\,(52\text{ weeks/year})\,(10\text{years})}{(10\text{ years})\,(365\text{ days/year})} = 0.142$$

$$\text{Non - Cancer Effects Exposure Dose(Child)} = \frac{(\text{average copper concentration})\,(\text{ingestion rate})\,(\text{exposure factor})\,(\text{conversion factor})}{\text{body weight}}$$

$$= \frac{(2{,}087\text{ mg/kg})\,(200\text{ mg/day})\,(0.142)\,(1\text{kg}/10^{6}\text{ mg})}{30\text{ kg}} = 0.0027$$

$$\text{ATSDR Heath Guideline (Intermediate MRL)} = 0.01$$

containing elevated levels of nickel would be unlikely because the wetland sediment is covered by water most of the year and would not be likely to generate frequent dust.

A typical exposure scenario assumes that a recreational user ingests 100 mg (adult) or 200 mg (child) of sediment containing the average concentration of nickel for 1 day each week for 30 years (adult) or 10 years (child). Based on this scenario, the estimated exposure doses for adults and children are 0.0039 mg/kg/day and 0.018 mg/kg/day, respectively. Both the exposure dose for the adult and child recreational user are below the EPA reference dose (RfD) of 0.02 mg/kg/day for lifetime exposures. Therefore, non-cancer health effects for a recreational user or visitor due to nickel exposure at the Shpack Landfill would not be expected.

Aroclor 1254

Aroclor 1254, a PCB, was detected above comparison values at the Shpack Landfill and required further evaluation. Because PCBs are classified as probable carcinogens by the NTP and USEPA, carcinogenic risk was evaluated for Aroclor 1254 (ATSDR 2000b). Additional exposure calculations show that exposure to the levels of Aroclor 1254 measured at the site is unlikely to result in adverse health effects. Assuming a child visiting the Shpack Landfill touched or inadvertently ingested sediment with the average concentration of Aroclor 1254 detected at the Shpack Landfill for 1 day every week for 52 weeks over 10 years, an increased cancer risk would be unlikely [8].

Non-carcinogenic risk was also evaluated for exposure to Aroclor 1254. A typical exposure scenario assumes that a recreational user ingests 100 mg (adult) or 200 mg

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[8] $$\text{Cancer Effects Exposure Factor} = \frac{(1\text{ days/week})\,(52\text{ weeks/year})\,(10\text{ years})}{(70\text{ years})\,(365\text{ days/year})} = 0.020$$

$$\text{Cancer Effects Exposure Dose(Child)} = \frac{(\text{avg Aroclor-1254 concentration})\,(\text{ingestion rate})\,(\text{exposure factor})\,(\text{conversion factor})}{\text{body weight}}$$

$$= \frac{(7\text{ mg/kg})\ (200\text{ mg/day})\ (0.020)\ (1\text{kg}/10^{6}\text{ mg})}{30\text{ kg}} = 9.5x10^{-7}$$

$$\text{Cancer Risk} = (\text{Cancer Effects Dose})\,(\text{Cancer Slope Factor})$$

$$= (9.5 \text{ x } 10^{-7}\text{ mg/kg/day})\,(2\text{ mg/kg/day}^{-1})$$

$$= 1.9 \text{ x } 10^{-6}$$

(child) of sediment containing the average concentration of Aroclor 1254 for 1 day each week for 30 years (adult) or 10 years (child). Based on this scenario, the estimated exposure doses for adults and children are 0.0000014 mg/kg/day and 0.0000066 mg/kg/day, respectively. Neither the estimated exposure dose for the adult or child recreational user is above the health guideline of 0.00002 mg/kg/day. Thus, it is unlikely that adverse effects would be observed at these exposure levels.

Off-site Exposures

Samples taken at offsite locations, including Chartley Swamp and Chartley Pond, do not indicate extensive migration of site-related contaminants to offsite locations. VOCs, SVOCs (including PAHs), and pesticides were not measured above comparison values beyond the fence line in offsite areas such as Chartley Swamp and nearby Chartley Pond. Metals detected at offsite areas were consistent with background concentrations or were not expected to result in adverse health effects even assuming highly conservative exposure scenarios. Therefore, it is not expected that nearby residents or recreational users in areas such as Chartley Pond or Chartley Swamp would experience increased cancer risk or non-cancer health effects from exposure to sediments in the present or future.

D. Exposure to Surface Water

Surface water samples were collected from wetland and swampy areas located in the interior of the landfill, as well as from Chartley Swamp and Chartley Pond located beyond the fence line of the landfill. Since there are no physical barriers to restrict access to some of these wetland areas, incidental ingestion and dermal contact with contaminants detected above comparison values in surface water could have been possible for children or adult recreational users who may have accessed the wetlands in the past, or those who may access them in the present and future. The maximum concentrations of chemical contaminants in surface water that were greater than comparison values include metals; three PAHs; one pesticide, alpha-BHC; one PCB, Aroclor-1254; and one VOC, vinyl chloride (Table 5). However, it is important to stress that although these chemical contaminants are above comparison values, the comparison

values represent a daily drinking water exposure. For example, a daily ingestion rate of 1 liter of water per day for a child and 2 liters of water per day for an adult is used to calculate the EMEG comparison value. It is unlikely that a resident would have had contact with surface water for a comparable frequency (i.e., daily ingestion or daily bathing) and in comparable amounts (i.e., 1–2 liters).

Exposure scenario calculations were conducted for all chemicals detected in surface water that exceeded comparison values. Exposure calculations assumed that a recreational user or visitor to the landfill ingests 0.05 liter (child resident) or 0.025 liters (adult resident) of surface water containing the average concentration of a contaminant for 1 day each week of the year for 30 years (adult) or 12 years (child). Calculations indicate that neither increased cancer risk nor adverse non cancer health effects would be expected from any of the constituents evaluated in surface water in and around the Shpack Landfill site, including at offsite locations in Chartley Swamp and Chartley Pond.

Exposure calculations were also conducted for past exposures to gross alpha and gross beta activity in onsite surface water. As mentioned earlier, most of the surface water samples analyzed for radioactive contaminants have been analyzed for gross alpha and gross beta activity; however, individual isotopic analysis was not done. Although the gross alpha concentrations occasionally exceeded the comparison value for drinking water, the comparison values represent a daily drinking water exposure of 2 liters per day everyday. It is highly unlikely that anyone would ingest 2 liters of onsite surface water during weekly visits to the landfill. Based on a typical exposure scenario for recreational users visiting the Shpack Landfill weekly and ingesting a small amount of surface water during each visit, no adverse health effects would be expected.

E. Exposure to Indoor/Ambient Air

Ambient Air

Limited outdoor air sampling results for airborne radioactive materials and airborne chemical contaminants were available from locations near the site (Betchtel 1984, ERM 1993a). Airborne radioactive material was sampled at two locations and airborne chemical contaminants were sampled at six locations. The air samples were analyzed for

Ra^{226}, U^{234}, U^{235}, and U^{238}. The chemical samples were analyzed for VOCs, SVOCs, and inorganic compounds (except mercury). For radioactive contaminants measured in air near the site, the annual exposures for a child and an adult were calculated using the maximum results detected during the air sampling[9]. The calculated exposure doses were less than 1 mrem/year (<0.01 mSv/yr) which is well below air release limits allowable by USEPA (10 mrem/year). Levels of chemical constituents measured in outdoor air were below health-based guidance levels. Based on the limited sampling data available for review, adverse health effects would not be expected at the level reported for chemical and radiological constituents.

There are indications that burning of various materials occurred at the Shpack Landfill prior to 1980, primarily prior to 1965 (USEPA 2004d, ERM 1991). Research also indicates that significant burning of refuse occurred at the adjacent ALI Landfill, that opened as a burning dump in 1946 and ceased burning by the early 1970s (James Mooney, City of Attleboro Health Department, personal communication, 2010). It was reported that a substantial amount of the metals disposed of in the ALI Landfill were salvaged by the landfill owner and burned at high temperatures on the property so that the owner could distinguish between metals and reclaim some of them for sale. The prevailing winds at the ALI Landfill were reportedly in the northerly direction, towards Norton, and downwind Norton residents complained of smoke coming from the ALI Landfill into their neighborhoods. Without historical ambient air monitoring data it is not possible to more fully evaluate health effects for this potential exposure pathway.

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[9] Exposure for each isotope is calculated and summed for each scenario. For a 10-year old child, the calculation for each isotope would be:

Isotopic concentration (Bq/m^3) x inhalation rate (5,475 m^3/year) x CF (Sv/Bq)

The total exposure from measured radium and uranium would be 0.004 mSv/year = 0.4 mrem/year

Note: Bq = Becquerel (1 Bq = 27 picocuries)

m^3 = cubic meters

Sv = sievert (1 Sv = 100 rem; 1 mSv = 100 mrem)

CF = conversion factor from activity inhaled to exposure dose (unique for each isotope)

However, detailed information on cancer incidence in Norton can be found in the MDPH report entitled *Health Consultation: Focused Evaluation of Cancer Incidence Within One-Mile Radius Area of the Shpack Landfill Superfund Site and Response to Comments* (MDPH 2011).

Indoor Air

Exposure to VOCs detected in groundwater or well water in the vicinity of the Shpack Landfill could occur through indoor air in homes if VOCs are present in offsite shallow groundwater at sufficient concentrations. This process may occur via volatilization of chemicals from groundwater up through the soil and into indoor air of the building located above or adjacent to the contaminated groundwater. To evaluate this potential exposure, MDPH used a screening method recommended by ATSDR for vapor intrusion into indoor air. The guidance provides concentrations for contaminants of concern (called USEPA target concentrations) in groundwater by which this potential exposure pathway should be evaluated (ITRC 2007; USEPA 2002). Table 6 shows the maximum concentrations for contaminants that exceed the USEPA target concentrations for constituents in groundwater.

Because two VOCs (bromoform and vinyl chloride) detected in residential well water in the vicinity of the landfill exceeded USEPA target groundwater concentrations, MDPH conducted modeling to evaluate whether those contaminants are likely to migrate via vapor intrusion into the indoor air of nearby homes.

MDPH modeled indoor air concentrations using the maximum VOC concentrations detected in residential well water in the vicinity of the landfill using USEPA's Screening Level Implementation of the Johnson and Ettinger Vapor Intrusion Model (Johnson and Ettinger Model) (USEPA 2004b, 2004c) (See Table 6). This model estimates indoor air concentrations based on site-specific information including contaminant concentration, depth to contaminated media, soil type, soil temperature, and building construction. MDPH selected conservative parameters for soil type and soil temperature and evaluated the maximum concentrations of VOCs detected in residential well water above USEPA

target concentrations. Modeling was conducted for screening purposes to represent worst-case conditions and to determine whether further evaluation may be necessary.

The theoretical indoor air concentration for bromoform (0.013 $\mu g/m^3$) was below the CREG value (0.91 $\mu g/m^3$), indicating that adverse health effects to residents in the vicinity of the Shpack Landfill would not be expected. The theoretical indoor air concentration for vinyl chloride (2.1 $\mu g/m^3$) was below the intermediate EMEG comparison value (77 $\mu g/m^3$), but above the CREG value (0.11 $\mu g/m^3$) and required further evaluation (See Table 6).

In order to further evaluate the risk of health effects due to exposure to vinyl chloride at homes in the immediate vicinity of the landfill, the theoretical indoor air concentration for vinyl chloride (again modeled using worst-case conditions) was used along with assumptions that a nearby resident would be exposed to this maximum concentration for 365 days per year for 30 years.[10] Calculations indicate that neither increased cancer risk nor non-cancer health effects would be expected from exposure to the bromoform or vinyl chloride concentrations measured in drinking water and modeled to indoor air. Based on the levels of contaminants measured in private drinking water wells located on the properties of nearby homes and the indoor air concentrations predicted by the Johnson-Ettinger model using very conservative assumptions, it appears unlikely that VOCs detected in groundwater would present an exposure concern for indoor air in nearby homes.

10

$$\text{Cancer Effects Exposure Dose(Adult)} = \frac{(\text{max Vinyl Chloride concentration})(\text{Exposure Time})(\text{Exposure Frequency})(\text{Exposure Duration})}{\text{Averaging Time}}$$

$$= \frac{(2.1\ \text{ug/m}^3)(24\ \text{hours/day})(365\ \text{days/year})(30\ \text{years})}{(70\ \text{year lifetime})(365\ \text{days/year})(24\ \text{hours/day})} = 0.9\text{ug/m}^3$$

$$\text{Cancer Risk} = (\text{Cancer Effects Dose})(\text{Cancer Unit Risk})$$

$$= (0.9\ \text{ug/m}^3)(8.8 \times 10^{-6}\ \text{ug/m}^3)$$

$$= 7.9x10^{-6}$$

VII. DISCUSSION

This evaluation was initiated due to the Shpack Landfill's designation as a NPL site and in response to community concerns about possible environmental exposures and potential adverse health effects for residents living near the landfill. This assessment focused on evaluating exposure opportunities for residents living in the vicinity of the landfill and for community members who, in the past, may have visited the site to drop off refuse at the landfill or to spend time collecting salvageable items from the landfill.

For residents living in the vicinity of the Shpack Landfill in the past and present, the evaluation of environmental data and the exposure pathway analysis indicate that drinking tap water from private wells located in the vicinity of the Shpack Landfill Superfund Site is not expected to harm people's health. The assessment also indicates that:

- Residents living in the vicinity of the Shpack Landfill in the past and present and exposed to site-related radioactive contaminants from consuming water from residential wells have not been exposed to site-related radioactive contaminants above health-based comparison values.

- Radon, a naturally-occurring radioactive gas, has been measured in the past in the well water of homes in the vicinity of the Shpack Landfill at levels that were above ATSDR's health-based comparison value. The primary public health risk for radon, which is classified as a carcinogen, is breathing radon in indoor air. Data on indoor radon air concentrations were not available to evaluate in order to determine if residents could be breathing elevated levels of radon in their homes. Without indoor air sampling results and the knowledge of where, when, and how these samples were collected, no health impact determination can be made.

- Arsenic has been measured in the past and present in the well water of homes near the Shpack Landfill. In some instances, levels measured in four homes (Maple, House 7 and N. Worcester, House 1 in Norton, and Peckham, House 3 and Peckham, House 4 in Attleboro) in the vicinity of the landfill were above

ATSDR's health-based comparison values and above USEPA's MCL for arsenic in drinking water (see Table 2c). A detailed evaluation on exposure to arsenic concluded that the average concentration of arsenic in each well was consistent with the USEPA drinking water standard of 10 ppb applicable to public drinking water supplies nationwide.

- Based on the levels of VOCs detected in the residential well water at homes in the vicinity of the landfill and conservative indoor air concentrations predicted by the Johnson-Ettinger model, it is unlikely that VOCs detected in the well water near the Shpack Landfill would present an indoor air exposure concern in nearby homes.

- For residences with sodium concentrations in drinking water above the Massachusetts guideline of 20 ppm, individuals who are on a sodium restricted diet or who wish to monitor their sodium intake should be aware of the concentration of sodium detected in their drinking water and review the attached "Sodium in Drinking Water Fact Sheet."

For community members who, in the past, may have visited the site, the assessment indicates that:

- Past adult and child visitors to the Shpack Landfill may have had occasional exposures to soil, surface water and sediment at the site. However, based on the chemical and radioactive contaminant levels detected and the frequency and duration of contact expected, it is unlikely that potential exposures would result in adverse health effects.

Based on evaluation of available environmental data for the Shpack Landfill and surrounding areas, opportunities for exposure to many of the detected constituents are not expected to result in adverse health impacts. However, MDPH also prepared a companion report, *Focused Evaluation of Cancer Incidence Within One-Mile Radius Area of the Shpack Landfill Superfund Site and Response to Comments,* that discusses the cancer incidence data in the context of the available environmental data and more

comprehensively addresses community concerns relative to cancer and environmental exposures (MDPH 2011).

VIII. LIMITATIONS

The environmental data available from the Shpack Landfill site had several important limitations. Historical levels of chemical contamination in groundwater, drinking water, soil, and other environmental media are unavailable for years between the beginning of the Shpack property's use as a waste disposal area (approximately 1946) and the early 1980's when the first chemical data were collected. Environmental data through 2004 were evaluated in this assessment. Also, even at homes where residential well water data are available for some time periods, the complete data necessary to calculate true averages over time are unavailable. Historical levels of radioactive contamination in the various environmental media are also unavailable for years prior to 1978. In addition, community members have indicated that burning of refuse may have occurred at the Shpack Landfill. However, there are no ambient air sampling data available to determine whether historical air emissions resulted in air concentrations of chemicals in the vicinity of the landfill at levels sufficient to result in exposure and/or health impacts to residents.

An analytical data gap also exists in relation to radon concentrations measured in the residential well water of homes in the vicinity of the landfill. In the mid-1980's, concentrations of radon in well water were detected above the current health-based comparison values in some homes. Although the radon is naturally-occurring and is not related to contamination at the Shpack Landfill, radon in water can become airborne and can enter the lungs when residents breathe air. Uncertainty exists because analytical data on indoor air concentrations of radon are not available. Without this information, no health impact determination can be made.

This public health assessment also included discussion of descriptive health outcome data for cancer. Cancer incidence data, as discussed in detail in the 2007 Health Consultation by MDPH, were reviewed to determine whether the pattern or occurrence of selected cancer types were unusual in the areas closest to the Shpack Landfill. As stated in the health consultation, inherent limitations in descriptive analyses and the available data

make it difficult at best to determine causal relationships or synergistic roles that may have played a part in the development of individual cancers in these communities. Cancers in general have a variety of risk factors known or suggested to be related to the cause of the diseases. Behavioral factors such as tobacco use, diet, and alcohol consumption are considered the most important risk factors for a number of cancers. Other factors associated with cancer are socioeconomic status, reproductive factors, exposure to infectious agents (i.e., viruses) and heredity/genetics. It is beyond the scope of this report to determine the causal relationship of these factors and the development of cancer or other health outcomes in Norton and Attleboro.

IX. CONCLUSIONS

Based on MDPH's evaluation of the available environmental data and the exposure pathway analysis, MDPH concludes that:

- **For Shpack Landfill Visitors**, accidentally eating small amounts of soil or sediment, or accidentally drinking small amounts of surface water while occasionally visiting the Shpack Landfill Superfund Site is not expected to harm people's health. Also, touching soil containing radioactive contaminants while occasionally visiting the Shpack Landfill is not expected to harm people's health. The reason for this is because, based on the available information, although some exposure may have occurred in the past as a result of site conditions, potential exposures were not at levels likely to result in health effects.

- **For Nearby Residents,** drinking tap water from private wells located in the vicinity of the Shpack Landfill Superfund Site is not expected to harm people's health. However, MDPH cannot conclude at this time whether breathing in radon, while not related to contamination at the Shpack Landfill, could harm people's health. The reason for this is because high levels of radon (naturally occurring; not site-related) have been measured in drinking water, but levels of radon in indoor air are unknown.

X. RECOMMENDATIONS

- MDPH recommends that residents living in the immediate vicinity of the Shpack Landfill and using residential well water for drinking or non-drinking water purposes (such as filling swimming pools, watering gardens, or washing cars) follow USEPA and MDEP guidance that recommends owners test their wells initially for all contaminants, then at a minimum of once every 10 years (yearly for bacteria and nitrite/nitrate) (MDEP 2004).

- Given the potential that contaminant concentrations in private wells could change in the future, prudent public health practice dictates that homes with contaminated private wells secure an alternate source of drinking water. Therefore, MDPH supports the USEPA's recommendation in the Record of Decision (USEPA 2004a) for the Shpack Landfill to connect the homes nearest the Shpack Landfill on Union Road to the municipal water supply.

- MDPH recommends that residents consuming residential well water containing levels of arsenic that were occasionally measured above the USEPA MCL (10 ppb) take steps to reduce exposure opportunities to arsenic. This includes residents at Maple, House 7 and N. Worcester, House 1 in Norton, and Peckham, House 3 and Peckham, House 4 in Attleboro (Note: Residents were notified of past residential well water sampling results by USEPA). Measures to reduce or eliminate exposure opportunities include connecting to the municipal water supply, drinking bottled water or treating well water using point-of-use or point-of-entry devices to remove arsenic from the tap water.

- In order to restrict the future use of groundwater at the homes adjacent to the Shpack Landfill, MDPH recommends that local health and/or municipal officials in Attleboro develop a testing and approval process for all new residential wells to ensure that contaminated groundwater is not consumed in the future. The Town of Norton has regulations in place to ensure that new private wells are tested for contaminants.

- Upon request, MDPH will be available to review new chemical and radioactive contamination data for groundwater, soil, sediment, surface water or air should site conditions change as a result of ongoing work by the USEPA and the U.S. Army Corp of Engineers to remove contamination from the Shpack Landfill.

- MDPH recommends that residents have their homes tested for radon. Data from a joint MDPH/USEPA study show that one out of four houses may have levels of radon above the 4 pCi/L action level. If you have further questions on radon, you may call MDPH's Radiation Control Program toll free at (800) 723-6695, and they will advise you on how to get your home tested and assist you in interpreting the results. (See attached Radon Fact Sheet)

- MDPH recommends that residents on sodium-restrictive diets who consume drinking water from a well where sodium was detected above 20 ppm consult with their physicians about their sodium intake and review the "Sodium in Drinking Water Fact Sheet" in Appendix B.

XI. PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan for the Shpack Landfill contains a description of actions to be taken by the ATSDR, the MDPH, and/or others subsequent to completion of this public health assessment. The purpose of the Public Health Action Plan is to ensure that this public health assessment not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of the ATSDR/MDPH to follow up on this plan to ensure that it is implemented. The public health actions to be implemented by ATSDR/MDPH are as follows:

- Upon request, the MDPH is available to assist the Norton and Attleboro Health Departments in developing and implementing a testing and approval process for new private well construction in the vicinity of the Shpack Landfill.

- Should new environmental data be generated for the Shpack Landfill site, particularly following remediation by the U.S. Army Corps of Engineers and USEPA, or if additional data or historical ambient air quality data become available, the MDPH will further characterize opportunities for exposure upon request of the Norton and Attleboro Health Departments.

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XIII. REPORT PREPARATION

This Public Health Assessment for the Shpack Landfill Site was prepared by the Bureau of Environmental Health of the Massachusetts Department of Public Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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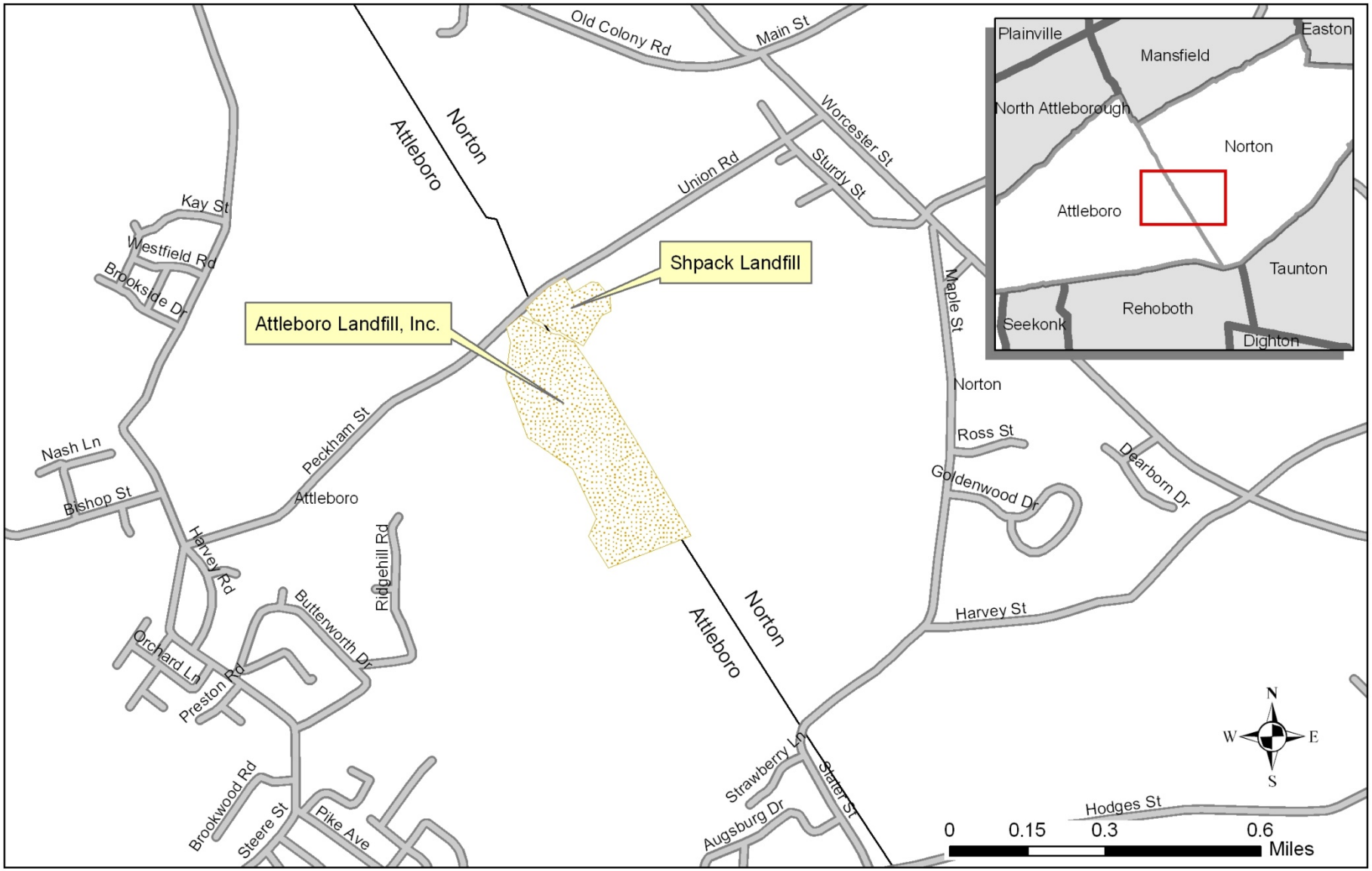
Figures

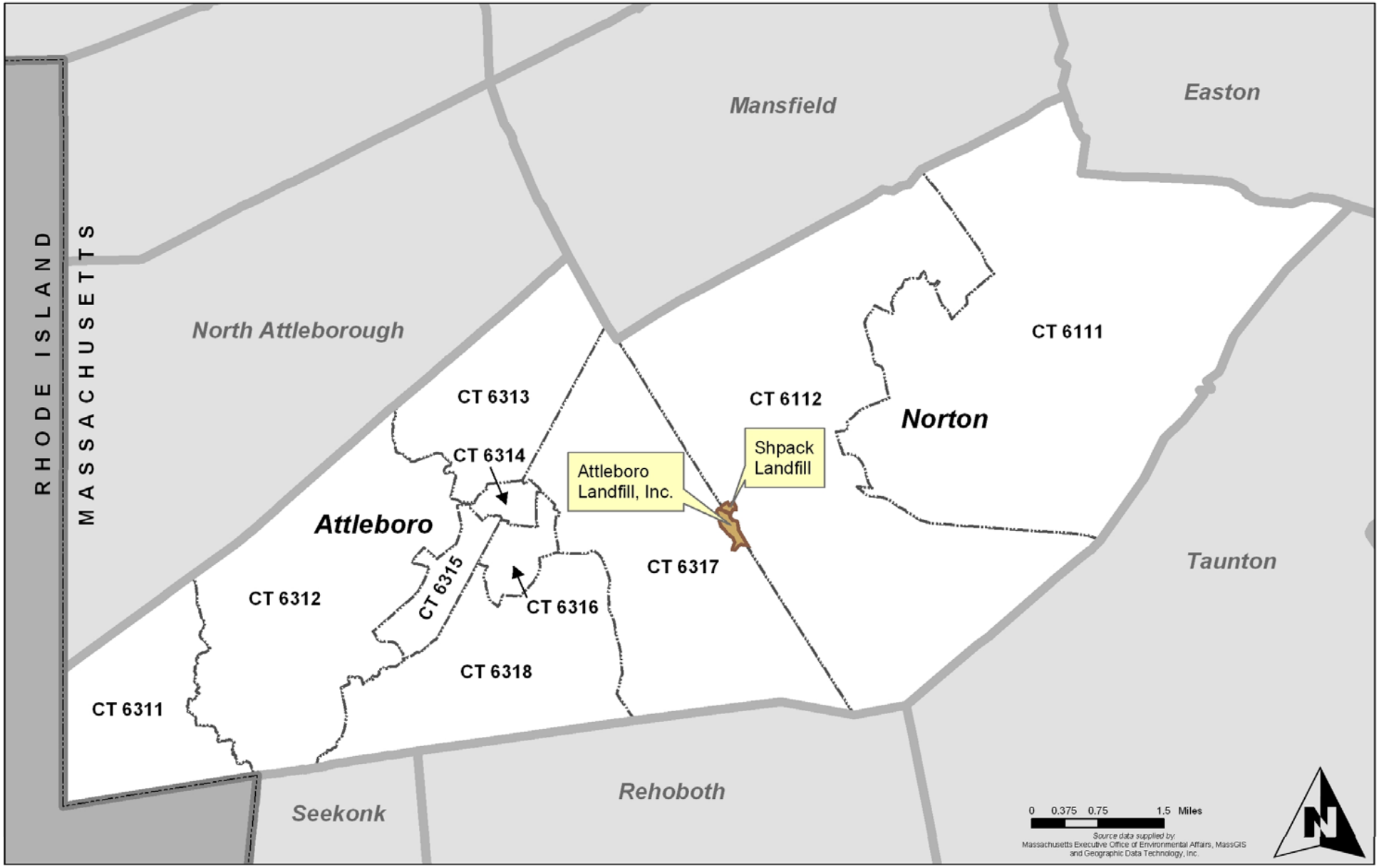
Figure 1
Location of Shpack Landfill
Norton and Attleboro, Massachusetts



Landfill
Town Boundary
Road

Geographic data supplied by: Massachusetts Executive Office of Environmental Affairs, MassGIS; Geographic Data Technology, Inc.

Figure 2
Location of Census Tracts (CT) in Norton and Attleboro
Norton and Attleboro, Massachusetts



Bureau of BEH Environmental Health

Geographic data supplied by: Massachusetts Executive Office of Environmental Affairs, MassGIS; Geographic Data Technology, Inc.

Landfill
Census Tract (CT) Boundary
Town Boundary
State Boundary

Figure 3
U.S. Army Corps Phased Excavation at Shpack Landfill Site
Norton and Attleboro, Massachusetts

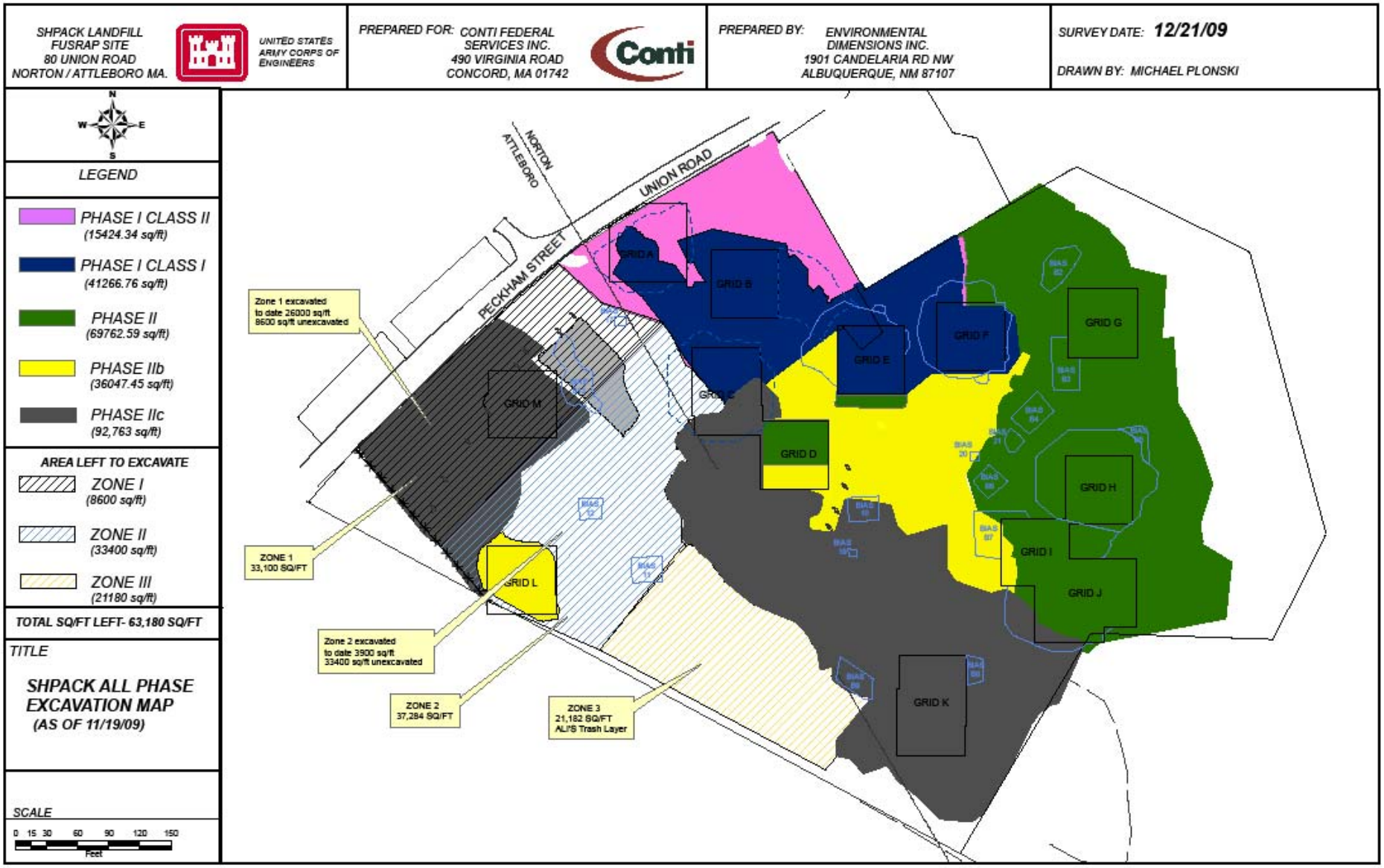
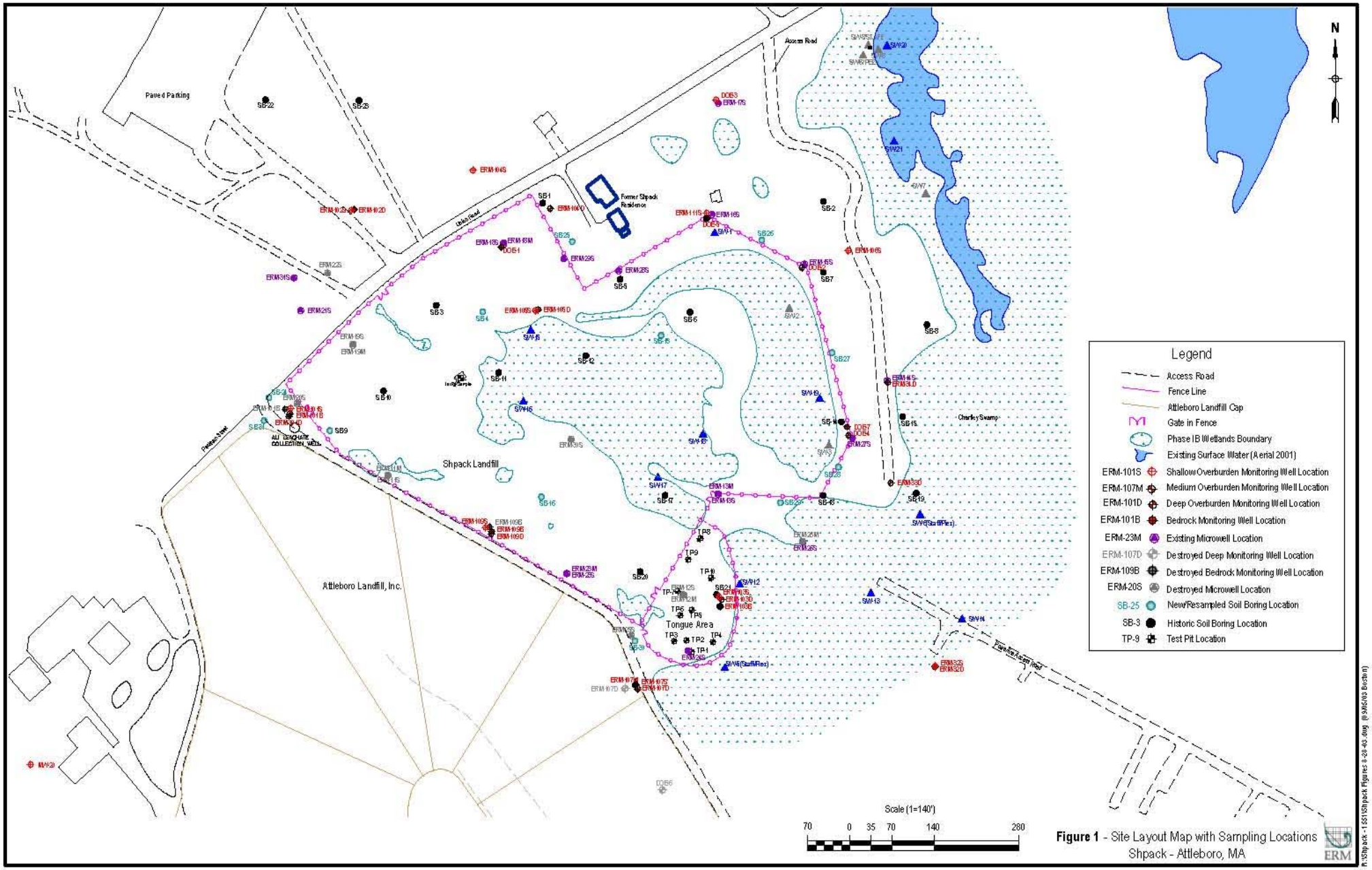


Figure 4
Layout and Sampling Locations at Shpack Landfill
Norton and Attleboro, Massachusetts



Tables

Table 1
Summary of Important Exposure Pathways for the Shpack Landfill
Norton and Attleboro, Massachusetts

Environmental Medium	Exposure Pathway	Potential Contaminant(s)	Point of Exposure	Route of Exposure	Receptor Population	Time Frame	Type of Pathway	Notes
Groundwater	Tap Water from private wells	VOCs, SVOCs, PAHs, Metals, PCBs, Radioactive Contaminants	Off-site wells	Ingestion, Dermal contact, Inhalation while showering	Nearby Resident Resident of Former Shpack Residence	Past, Present, Future (Nearby Resident Only)	Completed	ROD Cleanup Plan calls for nearby homes to be connected to public water supply and that restrictions be put in place to eliminate future use of private wells in the immediate vicinity of the Shpack Landfill
	GW Contamination volatilizing to indoor air	VOCs, SVOCs, PAHs, Metals, PCBs, Radioactive Contaminants	Off-site residences	Inhalation	Nearby Resident Resident of Former Shpack Residence	Past, Present, Future (Nearby Resident Only)	Potential	Indoor air measurements not available; Johnson & Ettinger Model used to model potential indoor air concentrations from groundwater

Table 1 (Continued)
Summary of Important Exposure Pathways for the Shpack Landfill
Norton and Attleboro, Massachusetts

Environmental Medium	Exposure Pathway	Potential Contaminant(s)	Point of Exposure	Route of Exposure	Receptor Population	Time Frame	Type of Pathway	Notes
Soil	Off-site surface soil located near former Shpack Residence	VOCs, SVOCs, PAHs, Metals, PCBs, Radioactive Contaminants	Wetlands; Swamp Areas; Yard	Incidental Ingestion, Dermal Contact	Resident of Former Shpack Residence	Past, Present	Potential	
	On-site and nearby off-site surface soil	VOCs, SVOCs, PAHs, Metals, PCBs, Radioactive Contaminants	Wetlands; Swamp Areas	Incidental Ingestion, Dermal Contact	Recreational User	Past, Present	Potential	
Sediment	On-site and nearby off-site surface sediment	VOCs, SVOCs, PAHs, Metals, PCBs, Radioactive Contaminants	Wetlands; Swamp Areas	Incidental Ingestion, Dermal Contact		Past, Present	Potential	
Surface Water	On-site and nearby off-site surface water	VOCs, SVOCs, PAHs, Metals, PCBs, Radioactive Contaminants	Wetlands; Swamp Areas	Incidental Ingestion, Dermal Contact		Past, Present	Potential	

Table 2a
Maximum concentrations of contaminants detected in residential well water samples at homes near the Shpack Landfill that exceeded comparison values
(Samples taken from 1979-2004)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppb unless otherwise noted)*	Drinking water comparison value *(ppb unless otherwise noted)*
Methylene chloride*	Sep-86	Maple, House 8	11	Chronic EMEG (child) = 600 Chronic EMEG (adult) = 2,100 CREG = 18
Vinyl Chloride	Apr-88	179 Peckham Street	4.9	Chronic EMEG (child); RMEG (child) = 30 Chronic EMEG (Adult), RMEG (adult) = 110 CREG = 0.025 U.S. EPA MCL = 2
Arsenic	Sep-86 Feb-88	Maple, House 7	19	Chronic EMEG (child); RMEG (child) = 3 Chronic EMEG (child); RMEG (adult) = 11 CREG = 0.023 U.S. EPA MCL & MDEP MMCL = 10
Cadmium	Apr-03	Maple Street, House 5	204	Chronic EMEG (child) = 1 Chronic EMEG (adult) = 3.5 Intermediate EMEG (child); RMEG (child) = 5 Intermediate EMEG (adult); RMEG (adult) 18 U.S. EPA MCL = 5
Copper	Aug-03	Maple Street, House 2	1,410	Intermediate EMEG (child) = 100 Intermediate EMEG (adult) = 350 U.S. EPA MCL & MDEP MMCL*** = 1,300
Lead	Sep-86	Union, House 1	120 **	U.S. EPA MCL & MDEP MMCL*** = 15 MCLG = 0
Manganese	Apr-88	179 Peckham St	6,890	RMEG (child) = 500 RMEG (adult) = 1,800 LTHA = 300
Sodium	Jul-02	Peckham, House 4	42,500	MassDEP Recommended Concentration Limit = 20,000

Table 2a (Continued)
Maximum concentrations of contaminants detected in residential well water samples at homes near the Shpack Landfill that exceeded comparison values
(Samples taken from 1979-2004)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppb unless otherwise noted)*	Drinking water comparison value *(ppb unless otherwise noted)*
Radon	Mar-87	Maple, House 5	7,580 pCi/L	Proposed U.S. EPA MCL = 300 pCi/L

Data sources:
ERM - New England, Inc. 1991. Remedial Investigation and Feasibility Study, Shpack Landfill Superfund Site, Norton, Massachusetts. January 28, 1991 (Doc ID: 200474)
Environmental Resources Management, Inc. (ERM). 1993. Initial Site Characterization Report, Shpack Landfill Superfund Site, Norton/Attleboro, MA. March 17, 1993. (Doc ID: 200425)
ERM - New England, Inc. 2004. Draft Final Phase 1B Remedial Investigation Report, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. June 17, 2004. (Doc ID: 210484, 210485)
Massachusetts Department of Environmental Protection (MDEP). 2001. Transmittal of Summary of Pre-1990 Residential Well Sampling. February 15, 2001. (Doc ID: 209663)

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR, ATSDR 2008)

Chronic EMEG (adult/child) = Environmental Media Evaluation Guide (i.e., for adult or childhood exposures greater than 1 year) (ATSDR 2008)

Intermediate EMEG (adult) = Environmental Media Evaluation Guide for adults (I.e., for exposures between 14 days and 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (child) = Environmental Media Evaluation Guide for children (I.e., for exposures between 14 days and 1 year and considers vulnerabilities of children when it comes to environmental exposures). (ATSDR, ATSDR 2008)

RMEG (adult/child) = Reference Dose Media Evaluation Guides (an estimate of a daily exposure to the general public, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a specified duration of exposure). (ATSDR 2008)

EPA/ORNL RSL = USEPA and Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA/ORNL, ORNL 2008)

MCL = Maximum Contaminant Level for drinking water (U.S. EPA, ATSDR 2008)

MCLG = Maximum Contaminant Level Goal for drinking water (U.S. EPA, ATSDR 2008)

MDEP MMCL = Massachusetts Maxiumum Contaminant Level for drinking water (MDEP, MDEP 2008)

LTHA = Lifetime Health Advisory (U.S. EPA, ATSDR 2008

* Methylene chloride is also known as dichloromethane.
** Possible laboratory or sampling error. Duplicate results indicate that lead was detected below the U.S. EPA drinking water action level. See Section V for discussion.
*** This is an action level for copper and lead. Action must be taken if more than 10% of drinking water samples exceed this value.

Table 2b
Maximum concentrations of contaminants detected in residential well water samples at Former Shpack Residence (68 Union Road) that exceeded comparison values (well samples taken from 1978-2004)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration (ppb)	Drinking water comparison value (ppb)
Aldrin	May-84	68 Union Road	0.01	CREG = 0.0021 Chronic EMEG (child) = 0.3 Chronic EMEG (adult) = 1.1
Lead	Aug-82	68 Union Road	194*	U.S. EPA MCL & MDEP MMCL** = 15 MCLG = 0
Manganese	Sep-86	68 Union Road	2,110	RMEG (child) = 500 RMEG (adult) = 1,800
Nickel	May-00	68 Union Road	2,400	RMEG (child) = 200 RMEG (adult) = 700

Data sources:
ERM - New England, Inc. 1991. Remedial Investigation and Feasibility Study, Shpack Landfill Superfund Site, Norton, Massachusetts. January 28, 1991 (Doc ID: 200474)
ERM - New England, Inc. 2004. Draft Final Phase 1B Remedial Investigation Report, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. June 17, 2004. (Doc ID: 210484, 210485)
NUS Corporation (NUS). 1985. Final Site Response Assessment Report (SRA), Shpack/Attleboro Landfill Incorporated, Norton/Attleboro, Massachusetts. November 21, 1985. (Doc ID: 209594)

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR, ATSDR 2008)

Chronic EMEG (adult/child) = Environmental Media Evaluation Guide (i.e., for adult or childhood exposures greater than 1 year) (ATSDR 2008)

Intermediate EMEG (adult) = Environmental Media Evaluation Guide for adults (I.e., for exposures between 14 days and 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (child) = Environmental Media Evaluation Guide for children (I.e., for exposures between 14 days and 1 year and considers vulnerabilities of children when it comes to environmental exposures). (ATSDR, ATSDR 2008)

RMEG (adult/child) = Reference Dose Media Evaluation Guides (an estimate of a daily exposure to the general public, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a specified duration of exposure). (ATSDR 2008)

EPA/ORNL RSL = USEPA and Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA/ORNL, ORNL 2008)

MCL = Maximum Contaminant Level for drinking water (U.S. EPA, ATSDR 2008)

MCLG = Maximum Contaminant Level Goal for drinking water (U.S. EPA, ATSDR 2008)
MDEP MMCL = Massachusetts Maxiumum Contaminant Level for drinking water (MDEP, MDEP 2008)
LTHA = Lifetime Health Advisory (U.S. EPA, ATSDR 2008)

* Possible laboratory or sampling error. All subsequent drinking water samples taken from 1984 through 2003 indicate that lead was detected below the U.S. EPA drinking water action level.
** This is an action level for lead. Action must be taken if more than 10% of drinking water samples exceed this value.

Table 2c
Exceedances of Maximum Contaminant Levels (or applicable comparison values) in Residential Well Water by Sampling Period

Year	1981 - 1983	1984 - 1985	1986	1987 - 1988	1989 - 1990	1991 -1992	2000 - 2002	2003 - 2004
Former Shpack Residence (68 Union Rd)	Lead 194 ppb ‡	Aldrin 0.01 ppb	Manganese 2,110 ppb				Nickel 2,400 ppb	Nickel 1,800 ppb
Union, House 1			Lead 120 ppb * Lead 17 ppb					
Maple, House 1								
Maple, House 2								Copper 1,410 ppb
Maple, House 3								
Maple, House 4								
Maple, House 5								Cadmium 204 ppb
Maple, House 6								
Maple, House 7			Arsenic 19 ppb	Arsenic 19 ppb				
Maple, House 8			Methylene Chloride 11 ppb					
Maple, House 9			Methylene Chloride 5.4 ppb					
Maple, House 10			Lead 70 ppb					
N. Worcester, House 1						Arsenic 10.1 ppb		Arsenic 11 - 16.4 ppb (4 samples)
Peckham, House 1								
Peckham, House 2							Manganese 754 ppb	Manganese 520 - 607 ppb (3 samples) Lead 32 ppb*
Peckham, House 3							Arsenic 10.2 ppb	Arsenic 11 - 14.9 ppb Manganese 5,050 ppb
Peckham, House 4				Arsenic 12 ppb			Sodium 42,500 ppb	
179 Peckham Street (Attleboro Landfill)	Manganese 820 - 1,300 ppb (4 samples)	Manganese 3,560 ppb	Manganese 5,020 ppb Manganese 5,590 ppb	Manganese 5,520 - 6,890 ppb (3 samples) Vinyl Chloride 3.1 ppb Vinyl Chloride 4.9 ppb	Manganese 5,080 ppb Vinyl Chloride 2.2 ppb Vinyl Chloride 3 ppb	Manganese 3,360 ppb Manganese 3,200 ppb		

‡ Possible laboratory or sampling error. All subsequent drinking water samples taken from 1984 through 2003 indicate that lead was detected below the U.S. EPA drinking water action level.
* Possible laboratory or sampling error. Duplicate results indicate that lead was detected below the U.S. EPA drinking water action level. See Section V for discussion.
** Measured at 32 ppb before filter in this home and 4 ppb and 3.6 ppb after filtration in the home.

Table 3a
Maximum concentrations of contaminants detected in soil samples in the vicinity of the Shpack Landfill that exceeded comparison values (Recreational User)
(Samples taken from 1989-2004)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppm unless otherwise noted)*	Soil Background *(ppm unless otherwise noted)*	Soil comparison value *(ppm unless otherwise noted)*
Trichloroethylene (TCE)	Jun-02	Landfill Interior (SB-04)	3.3	---	EPA/ORNL RSL = 0.91
Carbazole	Oct-92	Landfill Interior (SB-04)	34	---	---
Benzo(a)anthracene	Oct-92	Landfill Interior (SB-04)	68	0.005 - 0.02 (rural soil) 0.169 - 59 (urban soil)	EPA/ORNL RSL = 0.15
Benzo(a)pyrene	Oct-92	Landfill Interior (SB-04)	54	0.002 - 1.3 (rural soil) 0.165 - 0.22 (urban soil)	CREG = 0.096 EPA/ORNL RSL = 0.015
Benzo(k)fluoranthene	Oct-92	Landfill Interior (SB-04)	34		EPA/ORNL RSL = 1.5
Chrysene	Oct-92	Landfill Interior (SB-04)	67	0.0383 (rural soil) 0.251-0.64 (urban soil)	EPA/ORNL RSL = 15
Dibenz(ah)anthracene	Oct-92	Landfill Interior (SB-04)	3.9	---	EPA/ORNL RSL = 0.015
Indeno(1,2,3-cd)pyrene	Jun-02	Landfill Interior, Near Attleboro Landfill Fence Line (SB-09)	32	---	EPA/ORNL RSL = 0.15
Dioxin TEQ	Jun-02	Landfill Interior (ERM-105)	0.0005	---	Chronic EMEG (child) = 0.00005 Chronic EMEG (adult) = 0.0007
Antimony	Oct-92	Landfill Interior (SB-20)	75.4	0.76 (range: <1 - 8.8)	RMEG (child) = 20 RMEG (adult) = 280 EPA/ORNL RSL = 31
Arsenic	Oct-92	Landfill Interior (SB-16)	29.3	7.4 (range: <0.1 - 73)	Chronic EMEG (child) = 15 Chronic EMEG (adult) = 210 CREG = 0.5
Beryllium	Oct-92	Tongue Area (SB-21)	361	0.85 (range: <1 - 7)	Chronic EMEG; RMEG (child) = 100 Chronic EMEG; RMEG (adult) = 1,400

Table 3a (Continued)
Maximum concentrations of contaminants detected in soil samples in the vicinity of the Shpack Landfill that exceeded comparison values (Recreational User)
(Samples taken from 1989-2004)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppm unless otherwise noted)*	Soil Background *(ppm unless otherwise noted)*	Soil comparison value *(ppm unless otherwise noted)*
Cadmium	Jul-02	Tongue Area (TP-06)	104	0.01 - 1 *	Chronic EMEG (child) = 5 Chronic EMEG (adult) = 70 RMEG (child) = 25 RMEG (adult) = 350
Chromium (total)	Jul-02	Tongue Area (TP-06)	2,990	52 (range: 1 - 1,000)	Chronic EMEG (child) (Cr VI) = 45 Chronic EMEG (adult) (Cr VI) = 630 RMEG (child) (Cr VI) = 150 RMEG (adult) (Cr VI) = 2,100
Cobalt	Jul-02	Tongue Area (TP-06)	933	---	Intermediate EMEG (child) = 500 Intermediate EMEG (adult) = 7000
Copper	Sep-89	SS006	30,600	22 (range: <1 - 700)	Intermediate EMEG (child) = 500 Intermediate EMEG (adult) = 7000 EPA/ORNL RSL = 3100
Lead	Jun-02	Landfill Interior (SB-13)	13,200	17 (range: <10 - 300)	EPA/ORNL RSL = 400
Manganese	Jun-02	Landfill Interior (SB-13)	12,700	---	RMEG (child) = 2,500 RMEG (adult) = 35,000
Mercury	Oct-92	Landfill Interior (SB-17)	30.7	0.12 (range: 0.01 - 3.4)	EPA/ORNL RSL (methyl mercury) = 7.8 EPA/ORNL RSL (mercury) = 10
Nickel	Jul-02	Tongue Area (TP-06)	80,200	18 (range: <5 - 700)	RMEG (child) = 1,000 RMEG (adult) = 14,000 EPA/ORNL RSL = 1,500
Zinc	Jun-02	Landfill Interior (SB-13)	38,000	52 (range: <5 - 2,900)	Chronic EMEG; RMEG (child) = 15,000 Chronic EMEG; RMEG (adult) = 210,000
Aroclor 1248	Oct-92	Landfill Interior (SB-13)	2	---	EPA/ORNL RSL = 0.22
Aroclor 1260	Jun-02	Landfill Interior (SB-16)	0.42	---	EPA/ORNL RSL = 0.22

Table 3a (Continued)
Maximum concentrations of contaminants detected in soil samples in the vicinity of the Shpack Landfill that exceeded comparison values (Recreational User)
(Samples taken from 1989-2004)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppm unless otherwise noted)*	Soil Background *(ppm unless otherwise noted)*	Soil comparison value *(ppm unless otherwise noted)*
Radium-226	2002	Landfill Interior - Center (Sample 1281)	1,600 pCi/g	---	EPA/ORNL SSR = 4.4 pCi/g
Uranium 234	2002	Landfill Interior - Southeast (Sample 1274)	5,340 pCi/g	---	EPA/ORNL SSR = 20 pCi/g
Uranium 235	2002	Landfill Interior - Southeast (Sample 1274)	730 pCi/g	---	EPA/ORNL SSR = 20 pCi/g
Uranium 238	2002	Landfill Interior - Southeast (Sample 1274)	14,200 pCi/g	---	EPA/ORNL SSR = 22 pCi/g

Data sources:
Environmental Resources Management, Inc. (ERM). 1993. Initial Site Characterization Report, Shpack Landfill Superfund Site, Norton/Attleboro, MA. March 17, 1993. (Doc ID: 200425)
ERM - New England, Inc. 2004. Draft Final Phase 1B Remedial Investigation Report, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. June 17, 2004. (Doc ID: 210484, 210485)
Roy F. Weston. 1989. Data Validation for Shpack Landfill Data TDD# 01-8909-L1, PCS#0711. November 16, 1989. (Doc ID: 209602)

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR, ATSDR 2008)

Chronic EMEG (adult/child) = Environmental Media Evaluation Guide (i.e., for adult or childhood exposures greater than 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (adult) = Environmental Media Evaluation Guide for adults (i.e., for exposures between 14 days and 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (child) = Environmental Media Evaluation Guide for children (i.e., for exposures between 14 days and 1 year and considers vulnerabilities of children when it comes to environmental exposures) (ATSDR, ATSDR 2008)

RMEG (adult/child) = Reference Dose Media Evaluation Guides (an estimate of a daily exposure to the general public, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a specified duration of exposure) (ATSDR, ATSDR 2008)

EPA/ORNL RSL = USEPA and Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA/ORNL, ORNL 2008)

EPA/ORNL SSR = USEPA and Oak Ridge National Laboratory Soil Screening Guidance for Radionuclides (USEPA/ORNL, USEPA 2000)

Source of background values:
Estimated arithmetic mean for the Eastern United States (east of 96th meridian). Cited in ATSDR 1993. ATSDR Public Health Assessment Guidance Manual. Atlanta: U.S. Department of Health and Human Services
* Source of background value ATSDR 1999 Toxicological Profile for Cadmium. Section 5.4.3

Table 3b
Maximum concentrations of contaminants detected in soil samples taken off-site at the former Shpack residence that exceeded comparison values
(1989-2004)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration (ppm)	Soil Background (ppm)	Soil comparison value (ppm)
Arsenic	Oct-92	Off Site, Near Former Shpack Resdence (SB-25)	4.9	7.4 (range: <0.1 - 73)	Chronic EMEG (child) = 15 Chronic EMEG (adult) = 210 CREG = 0.47

Data sources:

ERM - New England, Inc. 2004. Draft Final Phase 1B Remedial Investigation Report, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. June 17, 2004. (Doc ID: 210484, 210485)

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR, ATSDR 2008)

Chronic EMEG (adult/child) = Environmental Media Evaluation Guide (i.e., for adult or childhood exposures greater than 1 year) (ATSDR, ATSDR 2008)

Source of background value:

Estimated arithmetic mean for the Eastern United States (east of 96th meridian). Cited in ATSDR 1993. ATSDR Public Health Assessment Guidance Manual. Atlanta: U.S. Department of Health and Human Services

Table 4
Maximum concentrations of contaminants detected in sediment samples in the vicinity of Shpack Landfill that exceeded comparison values (Recreational User)
(samples taken from 1980-2003)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppm unless otherwise noted)*	Soil Background *(ppm unless otherwise noted)*	Soil comparison value *(ppm unless otherwise noted)*
Trichloroethylene (TCE)	Apr-03	SW-18 (Landfill Interior)	10.45	---	EPA/ORNL Regional Screening Levels (residential soil) = 0.9
Benzo(a)anthracene	Apr-03	SW-18 (Landfill Interior)	16	0.005 - 0.02 (rural soil)† 0.169 - 59 (urban soil)†	EPA/ORNL Regional Screening Levels (residential soil) = 0.15
Benzo(b)fluoranthene	Apr-03	SW-18 (Landfill Interior)	19	0.02 - 0.03 (rural soil)† 15 - 62 (urban soil)†	EPA/ORNL Regional Screening Levels (residential soil) = 0.15
Benzo(a)pyrene	Apr-03	SW-18 (Landfill Interior)	15	0.002 - 1.3 (rural soil)† 0.165 - 0.22 (urban soil)†	CREG = 0.96 EPA/ORNL Regional Screening Levels (residential soil) = 0.015
Benzo(k)fluoranthene	Apr-03	SW-18 (Landfill Interior)	8.85	0.01-0.11 (rural soil)† 0.3-26(urban soil)†	EPA/ORNL Regional Screening Levels (residential soil) = 1.5
Chrysene	Apr-03	SW-18 (Landfill Interior)	16	0.0383 (rural soil)† 0.251-0.64 (urban soil)†	EPA/ORNL Regional Screening Levels (residential soil) = 15
Dibenz(ah)anthracene	Apr-03	SW-18 (Landfill Interior)	2.55	0.5 (natural soil)^	EPA/ORNL Regional Screening Levels (residential soil) = 0.015
Antimony	Apr-03	SW-18 (Landfill Interior)	377.5	0.76 (range: <1 - 8.8)*	RMEG (child) = 20 RMEG (adult) = 280 EPA/ORNL Regional Screening Levels (residential soil) = 31
Arsenic	Oct-92	SW-07 (Chartley Swamp)	38	7.4 (range: <0.1 - 73)*	Chronic EMEG (child) = 15 Chronic EMEG (adult) = 210 CREG = 0.47
Cadmium	Jul-02	SW-12 (Fenceline bordering Chartley Swamp)	82.1	0.01 - 1 ‡	Chronic EMEG (child) = 5 Chronic EMEG (adult) = 70 RMEG (child) = 25 RMEG (adult) = 350
Chromium (total)	Mar-80	Unspecified On-Site Location	3,060	52 (range: 1 - 1,000)*	Chronic EMEG (child) (Cr VI) = 45 Chronic EMEG (adult) (Cr VI) = 630 RMEG (child) (Cr VI) = 150 RMEG (adult) (Cr VI) = 2,100

Table 4 (Continued)
Maximum concentrations of contaminants detected in sediment samples in the vicinity of Shpack Landfill that exceeded comparison values
(Recreational User)
(samples taken from 1980-2003)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppm unless otherwise noted)*	Soil Background *(ppm unless otherwise noted)*	Soil comparison value *(ppm unless otherwise noted)*
Copper	Mar-80	Unspecified On-Site Location	36,170	22 (range: <1 - 700)*	Intermediate EMEG (child) = 500 Intermediate EMEG (adult) = 7000 EPA/ORNL Regional Screening Levels (residential soil) = 3100
Lead	Mar-80	Unspecified On-Site Location	3,055	17 (range: <10 - 300)*	EPA/ORNL Regional Screening Levels (residential soil) = 400
Nickel	Mar-80	Unspecified On-Site Location	301,318	18 (range: <5 - 700)*	RMEG (child) = 1,000 RMEG (adult) = 14,000 EPA/ORNL Regional Screening Levels (residential soil) = 1,500
Silver	Apr-03	SW-18 (Landfill Interior)	326	0.6 (natural soil)^	RMEG (child) = 250 RMEG (adult) = 3,500
Zinc	Mar-80	Unspecified On-Site Location	56,497	52 (range: <5 - 2,900)*	Chronic EMEG; RMEG (child) = 15,000 Chronic EMEG; RMEG (adult) = 210,000
Aroclor 1254	Apr-03	SW-18 (Landfill Interior)	84	---	Chronic EMEG; RMEG (child) = 1 Chronic EMEG; RMEG (adult) = 14 Intermediate EMEG (child) = 1.5 Intermediate EMEG (adult) = 21

Data sources:
Environmental Resources Management, Inc. (ERM). 1993. Initial Site Characterization Report, Shpack Landfill Superfund Site, Norton/Attleboro, MA. March 17, 1993. (Doc ID: 200425)
ERM - New England, Inc. 2004. Draft Final Phase 1B Remedial Investigation Report, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. June 17, 2004. (Doc ID: 210484, 210485)
Massachusetts Department of Environmental Quality Engineering (MDEQE). 1980. Waste Water Analysis and Radioactivity Results. Various documents dated 1978 through 1980. (Doc ID: 209621)

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR, ATSDR 2008)

Chronic EMEG (adult/child) = Environmental Media Evaluation Guide (i.e., for adult or childhood exposures greater than 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (adult) = Environmental Media Evaluation Guide for adults (i.e., for exposures between 14 days and 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (child) = Environmental Media Evaluation Guide for children (i.e., for exposures between 14 days and 1 year and considers vulnerabilities of children when it comes to environmental exposures).

RMEG (adult/child) = Reference Dose Media Evaluation Guides (an estimate of a daily exposure to the general public, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a specified duration of exposure). (ATSDR, ATSDR 2008)

EPA/ORNL RSL = USEPA and Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA/ORNL, ORNL 2008)

Sources of background values:
† Range of background Soil Concentrations. ATSDR Toxicological Profiles 2005 (on CD-ROM), Table 5-3. ATSDR 2005b.
*Esimated arithmetic mean (observed range) for the Eastern United States (east of 96th meridian). USGS. Shacklette HT, Boerngen JG. 1984. Element Concentrations in Soils and Other Surficial Materials of the conterminous United States. U.S. Geological Survey Professional Paper 1270. Washington: United States Government Printing Office, 1984.
‡ ATSDR 1999. Toxicological Profile for Cadmium. Atlanta: U.S. Department of Health and Human Services.
^ Massachusetts Department of Environmental Protection. 2002. Technical Update: Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil. May 2002.

Table 5
Maximum concentrations of contaminants detected in surface water samples at the Shpack Landfill that exceeded comparison values (Recreational User)
(Samples taken from 1984 - 2003)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppb unless otherwise noted)*	Drinking water comparison value *(ppb unless otherwise noted)*
Vinyl Chloride	Apr-03	SW-19	1.3	Chronic EMEG (child) = 30 Chronic EMEG (adult) = 110 CREG = 0.025
Benzo(b)fluoranthene	Oct-92	SW-01	0.3	EPA/ORNL RSL = 0.029
Benzo(a)pyrene	Oct-92	SW-01	0.4	CREG = 0.0048 U.S. EPA MCL = 0.2
Benzo(k)fluoranthene	Oct-92	SW-01	0.4	EPA/ORNL RSL = 0.29
alpha-BHC	Apr-03	SW-16	0.015	Chronic EMEG (child) = 80 Chronic EMEG (adult) = 280 CREG = 0.0056
Aroclor 1254	Oct-92	SW-01	0.43	Chronic EMEG (child) = 0.2 Chronic EMEG (adult) = 0.7
Aluminum	Jul-02	SW-05	33,300	Chronic EMEG (child) = 10,000 Chronic EMEG (adult) = 35,000
Antimony	Oct-92	SW-02	36	RMEG (child) = 4 RMEG (adult) = 14 U.S. EPA MCL = 6

Table 5 (Continued)
Maximum concentrations of contaminants detected in surface water samples at the Shpack Landfill that exceeded comparison values
(Recreational User)
(Samples taken from 1984 - 2003)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppb unless otherwise noted)*	Drinking water comparison value *(ppb unless otherwise noted)*
Arsenic	Jul-02	SW-04	31.4	CREG = 0.023 Chronic EMEG (child); RMEG (child) = 3 Chronic EMEG (Adult), RMEG (adult) = 11 U.S. EPA MCL = 10
Barium	Oct-92	SW-01	7,500	Chronic EMEG (child); RMEG (child) = 2,000 Chronic EMEG (adult); RMEG (adult) = 7,000
Beryllium	Jul-02	SW-05	1,480	Chronic EMEG (child); RMEG (child) = 20 Chronic EMEG (adult); RMEG (adult) = 70
Cadmium	Jul-02	SW-05	121	Chronic EMEG (child) = 1 Chronic EMEG (adult) = 3.5
Calcium	Jul-02	SW-05	335,000	MassDEP Recommended Upper limit = 150,000
Chromium (total)	Jul-02	SW-05	13,300	Hexavalent Chromium: Chronic EMEG (child) = 9 Hexavalent Chromium: Chronic EMEG (adult) = 32 U.S. EPA MCL = 100
Cobalt	Jul-02	SW-05	1,960	Intermediate EMEG (child) = 100 Intermediate EMEG (adult) = 350
Copper	Jul-02	SW-05	4,220	Intermediate EMEG (child) = 100 Intermediate EMEG (adult) = 350
Iron	Jul-02	SW-05	270,000	EPA/ORNL RSL = 11,000
Lead	Jul-02	SW-05	868	U.S. EPA MCL** = 15 MCLG = 0
Manganese	Jul-02	SW-06	5,490	RMEG (child) = 500 RMEG (adult) = 1,800 EPA LTHA = 300

Table 5 (Continued)
Maximum concentrations of contaminants detected in surface water samples at the Shpack Landfill that exceeded comparison values
(Recreational User)
(Samples taken from 1984 - 2003)

Contaminant	Date of sample	Descriptive location of sample	Maximum concentration *(ppb unless otherwise noted)*	Drinking water comparison value *(ppb unless otherwise noted)*
Mercury	Jul-02	SW-05	41.1	EPA/ORNL RSL = 0.63 MDEP MMCL = 2
Nickel	Jul-02	SW-05	235,000	RMEG (child) = 200 RMEG (adult) = 700 EPA LTHA = 100
Sodium	Oct-92	SW-01	125,000	MassDEP Recommended Concentration Limit = 20,000
Vanadium	Oct-92	SW-05	618	Intermediate EMEG (child) = 100 Intermediate EMEG (adult) = 350
Zinc	Jul-02	SW-05	49,900	Chronic/Intermediate EMEG (child); RMEG = 3,000 Chronic/Intermediate EMEG (adult); RMEG = 11,000 EPA LTHA = 2,000
Gross Alpha	Jul-02	SW-05	44.1+/- 8.9pCi/L	U.S. EPA MCL & MDEP MMCL = 15 pCi/L
Gross Beta	1984	SW-03	160 +/- 20 pCi/L	U.S. EPA MCL & MDEP MMCL = 50 pCi/L

Data sources:

Cabrera Services, Inc. 2003. Final Letter Report: Focused Site Inspection: Characterization Surveys for Radiological Contaminants of Concern, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. April 2003. (Doc ID: 205015, 205016)

Environmental Resources Management, Inc. (ERM). 1993. Initial Site Characterization Report, Shpack Landfill Superfund Site, Norton/Attleboro, MA. March 17, 1993. (Doc ID: 200425)

ERM - New England, Inc. 2004. Draft Final Phase 1B Remedial Investigation Report, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. June 17, 2004. (Doc ID: 210484, 210485)

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR, ATSDR 2008)

Chronic EMEG (adult/child) = Environmental Media Evaluation Guide (i.e., for adult or childhood exposures greater than 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (adult) = Environmental Media Evaluation Guide for adults (I.e., for exposures between 14 days and 1 year) (ATSDR, ATSDR 2008)

Intermediate EMEG (child) = Environmental Media Evaluation Guide for children (I.e., for exposures between 14 days and 1 year and considers vulnerabilities of children when it comes to environmental exposures). (ATSDR, ATSDR 2008)

RMEG (adult/child) = Reference Dose Media Evaluation Guides (an estimate of a daily exposure to the general public, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a specified duration of exposure). (ATSDR 2008)

EPA/ORNL RSL = USEPA and Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites (USEPA/ORNL, ORNL 2008)

MCL = Maximum Contaminant Level for drinking water (U.S. EPA, ATSDR 2008)

MCLG = Maximum Contaminant Level Goal for drinking water (U.S. EPA, ATSDR 2008)

MDEP MMCL = Massachusetts Maxiumum Contaminant Level for drinking water (MDEP, MDEP 2008)

LTHA = Lifetime Health Advisory (U.S. EPA, ATSDR 2008)

** This is an action level for lead. Action must be taken if more than 10% of tap water samples exceed this value.

Table 6
Modeled concentrations of contaminants in indoor air that exceeded USEPA target groundwater concentrations in the vicinity of the Shpack Landfill

Contaminant	Maximum concentration measured in groundwater (ug/L)	Descriptive location of sample	USEPA Target Groundwater Concentration (ug/L)	Modeled Indoor Air concentration (ug/m^3)	Air comparison value (ug/m^3)		
Bromoform	2.7	Union, House 1	0.0083	0.013	CREG	=	0.91
Vinyl Chloride	4.9	179 Peckham Street	2	2.1	Intermediate EMEG CREG	= =	77 0.11

Data sources:

ERM - New England, Inc. 2004. Draft Final Phase 1B Remedial Investigation Report, Shpack Landfill Superfund Site, Norton/Attleboro, Massachusetts. June 17, 2004. (Doc ID: 210484, 210485)

U.S. Environmental Protection Agency (USEPA). 2004. Johnson and Ettinger (1991) Model for Vapor Intrusion into Buildings. Version 3.1. February.

U.S. Environmental Protection Agency (USEPA). 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion Pathway from Gnovember 2002.

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR, ATSDR 2006)

Intermediate EMEG = Environmental Media Evaluation Guide (i.e., for exposures between 14 days and 1 year) (ATSDR, ATSDR 2008)

Appendix A

ATSDR Glossary of Environmental Health Terms

ATSDR Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the UNITED STATES Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health. This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

General Terms

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, ambient air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP [see Community Assistance Panel.]

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to

confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance [see Public health surveillance].

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry
A system of ongoing follow-up of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life ($t_{1/2}$)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm2
Milligram per square centimeter (of a surface).

mg/m3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

National Toxicology Program (NTP)
Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public health surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see public health surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health

effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

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

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)

National Center for Environmental Health (CDC)
(http://www.cdc.gov/nceh/dls/report/glossary.htm)

National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

For more information on the work of ATSDR, please contact:
Office of Policy and External Affairs
Agency for Toxic Substances and Disease Registry
1600 Clifton Road, N.E. (MS E-60)
Atlanta, GA 30333
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Appendix B

MDPH Sodium Fact Sheet and MDPH Radon Fact Sheet

Sodium in Drinking Water Fact Sheet

Is sodium found in drinking water?

Yes, sodium is a naturally occurring element found in water and soil. Drinking water contributes only a small fraction (less than 10%) to the overall daily sodium intake which ranges from 115 to 750 milligrams per day (mg/d) for infants, 325 to 2700mg/d for children and 1100 to 3300 mg/d for adults.

The Massachusetts Department of Environmental Protection (MDEP) currently requires all water suppliers to notify the Massachusetts Department of Public Health/Bureau of Environmental Health (MDPH/BEH), MDEP, and local Boards of Health of the detected concentrations of sodium in drinking water. Notification is required so that individuals who are on a sodium restricted diet or wish to monitor their sodium intake for other reasons will have this information.

What is sodium's purpose?

Sodium is an essential mineral which is necessary for the normal functioning of the body and maintenance of body fluids. Nerve function and muscle contraction are also affected by sodium intake.

Where do we get sodium?

Sodium cannot be stored or manufactured in the body and must be consumed in some drinking water and in foods such as animal foods, low-fat dairy products, some canned foods, pickles, and olives.

What is the current guideline for sodium in drinking water and who should be concerned about this guideline?

The MDEP guideline of 20 milligrams of sodium per liter of water represents a level of sodium in water that physicians and sodium-sensitive individuals should be aware of in cases where sodium exposures are carefully controlled. People who have difficulty regulating fluid volume as a result of several diseases such as hypertension and kidney failure are particularly affected by elevated levels of sodium.

Hypertension is the medical name for high blood pressure and is a common chronic medical problem in the United States. It is responsible for a major portion of cardiovascular disease and stroke deaths.

Kidney failure occurs when an excess of sodium in the body causes fluid concentrations to change and the kidney fails to remove fluid. The result is a kidney shut-down and the build-up of fluid in the body which can lead to edema and hypertension.

Edema is the collection of water in and around the body tissues. Mild cases of edema affect women prior to the start of their menstrual periods, and many pregnant women suffer with this condition.

How is sodium measured in my body?

Your doctor or health professional measures sodium by taking your blood or checking a urine sample (or both). If your sodium levels are elevated, your physician may prescribe a diet low in sodium.

Reducing sodium intake not only prevents high blood pressure, but may also prevent heart disease, according to clinical trial data from the National Heart, Lung, and Blood Institute of the National Institutes of Health.

Where do I go for more information?

If you have any questions about sodium and your health, call your physician or health professional.

If you have any questions regarding sodium in drinking water, call the Massachusetts Department of Environmental Protection's Drinking Water Program at (617) 292-5770.

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This fact sheet was prepared by the Environmental Health Education and Outreach Program in the Bureau of Environmental Health, Massachusetts Department of Public Health.

Public Health Fact Sheet on Radon

What is radon?
Radon is a naturally occurring radioactive gas. It is produced in the ground through the normal decay of uranium and radium. As it decays, radon produces new radioactive elements called radon daughters or decay products. Radon and radon daughters cannot be detected by human senses because they are colorless, odorless, and tasteless.

Where does radon come from?
Radon originates in the ground and can be found in soil and rocks. As with any gas, radon diffuses as it flows along the path of least resistance to the surface of the ground before entering the atmosphere. Once it enters the atmosphere, radon becomes diluted in the outdoor air and concentrations are so low that it is of minor concern.

Since it is a gas, radon can also move into any air space, such as basements, crawl spaces, or caves. Once inside an enclosed space, such as a home, radon can accumulate. For this reason, indoor concentrations are usually higher than those found outdoors. Houses with little air exchange because of improvements to prevent heat loss will generally have higher indoor radon levels than draftier houses.

How does radon get into homes?
Radon moves through small spaces in the soil and rock on which a house is built and can seep into a home through dirt floors, floor drains, sump pits, joints, or tiny cracks and pores in hollow-blockwalls. As a result, radon concentrations tend to be greater in the lower levels of a home, such as the basement.

Radon can also dissolve in well water and contribute to airborne radon in homes when released through running water. Studies indicate that very few public groundwater supplies contain enough radon to be a significant source of radon in homes. There is very little radon in surface water supplies because the water is exposed to outdoor air, thus diluting the radon concentrations.

Is exposure to indoor radon harmful?
When radon undergoes radioactive breakdown, it decays into other radioactive elements called radon daughters. Radon daughters are solids, not gases, and stick to surfaces such as dust particles i n the air. If contaminated dust is inhaled, these particles can adhere to the airways of the lung. As these radioactive dust particles break down further, they release small bursts of energy which can damage lung tissue and therefore increase the risk of developing lung cancer. In general, the risk increases as the level of radon and the length of exposure increases.

Radon itself, on the other hand, is almost chemically inactive and an inhaled radon atom is very likely to be exhaled before it decays. Thus, the main health risk from radon is exposure to its decay products.

What can be done to reduce exposure to indoor radon?
The federal government has studied the effectiveness of various ways to reduce high concentrations of radon in homes. The most obvious remedy is to increase ventilation of the home which allows the radon to escape. Another approach is to prevent radon from getting into the home, but determining how the gas enters a building poses a major difficulty. A booklet describing several methods to reduce high concentrations of radon can be obtained from the Massachusetts Department of Public Health's Radiation Control Program.

High levels of radon are reduced through a mitigation system installed into the home. The most common type of system is called sub-slab depressurization. The EPA does not advocate the sealing of cracks in the basement floor as a single approach to solving a radon problem.

Although there are no Massachusetts state or federal regulations for naturally occurring radon or radon daughters, the Environmental Protection Agency(EPA) has recommended guidelines for taking action. Concentrations of radon gas are measured as "picocuries per liter" (pCi/l). The EPA suggests that if an initial screening measurement results in a reading greater than 4 pCi/l, further measurements should be taken to determine the annual average exposure to radon and that action be taken within a reasonable period of time. The Massachusetts Department of Public Health's Radiation Control Program will assist you in obtaining further measurements.

How can I find out if my home has radon?
The Massachusetts Department of Public Health, Radiation Control Program in conjunction with the EPA did a study in 1988, and with the data obtained it is possible to estimate the potential of radon problems by county. The data shows that one out of four houses may have levels above the 4pCi/L action level however, the only way to know if your home has a radon problem is to do a radon test.

If you have further questions on radon, you may call the Radiation Control Program and they will advise you on how to get your home tested and assist you in interpreting the results.

Where can I get further information?

- Massachusetts Department of Public Health (www.mass.gov/dph)
- Radiation Control Program (www.mass.gov/dph/rcp)

This fact sheet is provided by the Radiation Control Program within the Department of Public Health.