Health Consultation

Focused Evaluation of Cancer Incidence Within One-Mile Radius Area of the Shpack Landfill Superfund Site and Response to Comments

SHPACK LANDFILL

NORTON and ATTLEBORO, BRISTOL COUNTY, MASSACHUSETTS

EPA FACILITY ID: MAD980503973

Prepared by the
Massachusetts Department of Public Health

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

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Environmental Toxicology Program
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Overview:	MDPH has reached several important conclusions about the Shpack Landfill Superfund Site in Norton and Attleboro.
Conclusion 1:	MDPH concluded that within the **one-mile radius area** around the Shpack Landfill, incidence rates for the **following types of cancer** (selected either because of potential associations with exposures to contaminants of concern at the Shpack Landfill or of particular concern to residents) were approximately as expected during the four time periods evaluated spanning 23 years (1982-2004): bladder, bone, brain and central nervous system, kidney, liver and intrahepatic bile duct, prostate, thyroid cancer, as well as leukemia, multiple myeloma, and non-Hodgkin lymphoma..
Basis for Decision:	To determine whether elevated numbers of cancer diagnoses occurred within the one-mile radius area surrounding the Shpack Landfill, the observed number of cancer diagnoses in the one-mile radius area was compared to the number that would be expected based on the statewide cancer rate. In general, incidence rates for the ten cancer types listed above occurred as expected based on statewide cancer rates. Age at diagnosis, histologies or subtypes, smoking status, and spatial and temporal patterns were evaluated for these diagnoses. No unusual patterns were observed in the diagnoses of these cancer types.
Conclusion 2:	MDPH concluded that, within the **one-mile radius area** around the Shpack Landfill, the incidence of **lung and bronchus cancer** was elevated in 2 of the 4 time periods evaluated; however, neither of these elevations was statistically significant.
Basis for Decision:	Between 1982 and 2004, 39 diagnoses were reported when approximately 29 would be expected. Smoking is, by far, the major risk factor for lung and bronchus cancer. Among the 32 individuals with a known smoking history, 29 (91%) were current or former smokers at the time of their diagnosis. Lung and bronchus cancer histologies (or subtypes) and spatial and temporal patterns of lung and bronchus cancer in the one-mile radius area were also evaluated. No unusual patterns emerged in any of these supplemental analyses.

MDPH also evaluated the geographic distribution of residence at diagnosis for those individuals with lung and bronchus cancer who did not have a history of smoking and again found no unusual spatial patterns. The spatial patterns of individual's residences at diagnosis closely followed the population density of the census blocks within the one-mile radius area.

In addition to a history of tobacco use, other possible factors that could have contributed to an increased risk of lung cancer include indoor residential exposure to radon (naturally occurring; not site-related) and exposure via inhalation to metals burned primarily at the adjacent Attleboro Landfill Incorporated (ALI) Landfill in Attleboro between the mid-40s and early 70s. Exposure to radon (a naturally occurring radioactive gas produced by the breakdown of uranium in soil and rocks) has been identified as the second leading cause of lung and bronchus cancer, and the leading cause among nonsmokers. Given the prevailing wind direction of north, Norton residents living downwind of the ALI Landfill may have been exposed historically to metals burned at the landfill. It is possible that these types of exposure (that is, radon and metals) combined with cigarette smoking may have increased the risk of developing lung cancer for some residents.

Conclusion 3: MDPH concluded that, within the **one-mile radius area** around the Shpack Landfill, the incidence of **breast cancer** in females was elevated in 3 of the 4 time periods evaluated; however, the elevations were not statistically significant.

Basis for Decision: Between 1982 and 2004, 48 diagnoses of breast cancer were reported when approximately 33 would be expected. Breast cancer was included in this evaluation for two reasons: community concern and some indication in the scientific/medical literature that exposure to vinyl chloride may be associated with increased breast cancer risk. As reported in the PHA, vinyl chloride was detected between 1988 and 1990 at a concentration exceeding a health-based comparison value in one private well located at the Attleboro Landfill. The PHA determined that exposure to vinyl chloride in the private well water was unlikely to cause any adverse health effects based on the amount and duration of the possible exposure.

Age at diagnosis, breast cancer histologies or subtypes, staging information, and spatial and temporal patterns were also evaluated. Based on the staging information reviewed, women residing within the one-mile radius area appear to have been screened for breast cancer earlier than women statewide. Although somewhat younger at diagnosis for two of the four time periods, overall, ages at diagnosis were similar to those seen statewide and in national statistics. Breast cancer subtypes of the 47 women diagnosed were consistent with what would be expected based on

the epidemiological literature. No concentrations of cases were observed when dates of diagnosis and the geographic distribution of residences were examined.

Next Steps: The MDPH will continue to monitor the incidence of lung and bronchus and breast cancer in the communities of Attleboro and Norton through city/town cancer incidence reports published by the Massachusetts Cancer Registry.

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

This health consultation provides a focused evaluation of cancer incidence within a one-mile radius area of the Shpack Landfill Superfund site. It was conducted under a cooperative agreement with the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) and in response to public comments received relative to the 2007 draft Health Consultation (HC) report titled *Evaluation of Cancer Incidence in Census Tracts of Attleboro and Norton, Bristol County, Massachusetts: 1982-2002,* hereinafter referred to as the 2007 public comment draft HC. The public comment draft HC was released at a public meeting in Norton on January 16, 2007 to provide an opportunity for public review and submittal of comments to the Massachusetts Department of Public Health/Bureau of Environmental Health (MDPH/BEH). During the community meeting and in subsequent written comments received on the report, some residents expressed concern that the public comment draft HC did not adequately evaluate the pattern of cancer among residents living in the most immediate vicinity of the Shpack Landfill. To address this concern, the BEH's Community Assessment Program (CAP) conducted two additional evaluations:

- The first was a public health assessment providing an evaluation of possible environmental exposures from landfill-related chemical and radioactive contaminants and potential adverse health effects for residents living near the landfill. This

evaluation is contained in a separate MDPH report being released concurrently with this report. It is titled *Public Health Assessment: Evaluation of Environmental Concerns Related to the Shpack Landfill Superfund Site, Norton and Attleboro, Bristol County, Massachusetts* (MDPH 2011). That report will be referred to hereinafter as the PHA.

- The second, presented in this HC, was an evaluation of cancer incidence for an area approximating a one-mile radius around the Shpack Landfill. This type of evaluation is not typically conducted because the data are not readily available. In order to conduct these supplemental analyses, MDPH constructed the population (with counts by age category) for the one-mile radius area based on 38 U.S. census blocks in Norton and Attleboro, as well as identifying, through the Massachusetts Cancer Registry, individuals who were diagnosed with any type of cancer while residing in one of the 38 census blocks. Cancer incidence rates were then calculated for the 23-year period 1982 through 2004 for the one-mile radius area for 12 types of cancer either potentially associated with exposure to contaminants of concern identified at the Shpack Landfill or of particular concern to residents. In this HC, the incidence of cancer is evaluated and then interpreted in the context of what was reported in the PHA about the chemical and radioactive contamination at the Shpack Landfill. The extent of contamination, the potential pathways for human exposure, and the potential for adverse health effects as presented in the PHA, is considered in this HC. In addition, to more fully address community concerns, a review was conducted of all other types of cancer diagnoses within the one-mile radius area over the 23-year period; this review is contained in Appendix A.

This HC also contains a response to the comments received on the 2007 public comment HC (see Appendix B).

III. BACKGROUND

The Shpack Landfill is located on the town line between Norton and Attleboro and covers a 9-acre area (Figure 1). It was reportedly active between the mid-1940s and the 1970s, receiving

domestic, industrial, and low-level radioactive waste. The site was first designated for remedial action under the United States Department of Energy's Formerly Utilized Sites Remedial Action Program (FUSRAP) in 1981. In 1986, the United States Environmental Protection Agency (USEPA) added the site to the National Priorities List (NPL) under the federal Superfund Program.

Since the late 1980s and early 1990s, extensive environmental investigations of 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 September 2004, the USEPA issued a Record of Decision (ROD) that presented the selected remedial actions to be undertaken at the site (USEPA 2004).

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

Several CAP reports evaluated cancer in these communities prior to the comprehensive evaluation released in 2007 as the public comment draft HC. Of particular note however was a 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). In this report, the 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).

In the 2007 public comment draft HC referenced earlier (MDPH 2007), the CAP evaluated the incidence of 13 different types of cancer within Attleboro and Norton and their respective census tracts for the 21-year period of 1982–2002. To evaluate patterns or trends over time, cancer incidence rates were calculated for four time periods: 1982–1987, 1988–1993, 1994–1999, and 2000–2002. Of the 13 cancer types evaluated in the city of Attleboro and the town of Norton, most occurred approximately at or near expected rates, based on the statewide rates of cancer and the populations of Attleboro and Norton. However, several exceptions were noted including statistically significant elevations in the incidence of lung and bronchus cancer among females in Attleboro during 1988–1993 and among males in Attleboro during 1994–1999; thyroid cancer among males in Attleboro during 1988–1993; liver cancer among males in Attleboro during 2000–2002; and, bladder cancer among females in Attleboro during 2000–2002. In addition, some census tracts demonstrated statistically significant elevations in the incidence of breast cancer, Hodgkin's disease, brain and central nervous system cancer, and lung and bronchus cancer. Although particular cancer types may have been elevated in one of the four time periods, these elevations were not persistent over time.

IV. OBJECTIVES

The specific objectives of this investigation follow:

- To examine the occurrence of cancer in neighborhoods of Norton and Attleboro within an approximate one-mile radius area of the Shpack Landfill;
- To evaluate the incidence of cancer within the one-mile radius area in light of the findings of the PHA, particularly with respect to the extent of contamination, the potential pathways of exposure, and the subsequent potential for adverse health effects to occur.

- To review available information from the MCR on risk factors for individuals diagnosed with cancer in Norton and Attleboro while residing within the one-mile radius area;

- To compare risk factor information for residents of the one-mile radius area to what would be expected, based on the medical literature for the particular types of cancer; and

V. METHODS

A. Determination of One-Mile Radius Area Surrounding Former Shpack Landfill Site

In the 2007 public comment draft HC, cancer incidence rates were calculated for the census tracts in closest proximity to the Shpack Landfill. According to the U.S. Census Bureau, a census tract is a smaller statistical subdivision of a county which generally has between 1,500 and 8,000 people. (Counties with fewer people have a single census tract.) When first delineated, census tracts are designed to be homogeneous with respect to population characteristics, economic status, and living conditions. The spatial size of census tracts varies widely depending on the density of settlement. The census tract surrounding the Shpack Landfill in Attleboro (CT 6317) is comprised of 71 smaller census blocks while the census tract surrounding the landfill in Norton (CT 6112) is comprised of 120 census blocks. To evaluate a smaller area, as requested by some concerned residents, 21 census blocks in Attleboro were combined with 17 census blocks in Norton to construct a population residing within roughly a one-mile radius around the landfill. As seen in Figure 2, the area defined by these 38 census blocks is irregular in shape; however, importantly, combining census blocks allowed for the delineation of an area for which more accurate population estimates (by age categories) were available. Hereinafter, in this report, the 38 census block area will be referred to as the one-mile radius area. Based on the 2000 U.S. Census, these 38 census blocks constitute a total area of approximately 4.1 square miles (the area of a rough circle with a radius of approximately one mile).

Using Geographic Information System (GIS) software, a one mile radius was drawn around the Shpack Landfill. Census blocks whose area fell more than 50% inside of the radius were included in the evaluation (see Figure 2). Census blocks are defined by the U.S. Census Bureau

as small areas bounded on all sides by visible features, such as streets, roads, streams, and railroad tracks, and by invisible boundaries, such as city, town, township, and county limits, property lines, and short, imaginary extensions of streets and roads. Census blocks are usually small areas such as a city block, however, in less populated areas census blocks may contain many square miles of territory.

Approximately 2,300 individuals reside in the newly-constructed one-mile radius area. This is based on the mid-year population for the years between 1982 and 2004, the 23-year period for which cancer incidence rates were calculated. This population falls within the size range of a typical U.S. census tract, which by definition contains between 1,500 and 8,000 individuals.

B. Case Identification/Definition

The MCR, a division within the MDPH Bureau of Health Information, Statistics, Research and Evaluation (BHISRE), is a population-based surveillance system that has been monitoring cancer incidence in the Commonwealth since 1982. All new diagnoses of cancer among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111. s 111b). This information is kept in a confidential database. To calculate cancer incidence rates within the area constituting approximately a one-mile radius around the Shpack Landfill, CAP staff then reviewed the MCR data files to identify all cancer diagnoses reported among residents of the area.

At the time of this analysis, the 23-year period from 1982-2004 constituted the time period for which the most recent and complete cancer incidence data were available from the MCR. The public comment HC evaluated cancer incidence data from 1982 through 2002. Since then, data became available for 2003 and 2004. For the purpose of this analysis, cancer diagnoses were evaluated within four time periods: 1982-1987, 1988-1993, 1994-1999, and 2000-2004.

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Epidemiologic studies have revealed that different types of cancer are individual diseases with separate causes, risk factors, characteristics, and patterns of survival (Berg 1996). Cancer types are classified by the location in the body where the disease originated (the primary

site) and the tissue or cell type of the cancer (histology). Therefore, each of the cancer types reviewed in this report was evaluated separately. Cancers that occur as the result of the metastasis or the spread of a primary site cancer to another location in the body are not considered as separate cancers and, therefore, were not included in this analysis.

Cancer incidence data (i.e., reports of new cancer diagnoses) for the years 1982-2004 were obtained from the MCR for the 38 census blocks in Attleboro and Norton included in this analysis. Cases were selected for inclusion based on the address reported to the hospital or reporting medical facility at the time of diagnosis. Cancer incidence rates were calculated for 12 cancer types: bladder cancer, bone, brain and central nervous system (CNS) cancer, breast cancer, kidney cancer, leukemia, liver and intrahepatic bile duct (IBD) cancer, lung and bronchus cancer, multiple myeloma, non-Hodgkin lymphoma (NHL), prostate cancer, and thyroid cancer. Coding for cancer types in this report follows the International Classification of Diseases for Oncology (ICD-O) system. These cancer types were selected for evaluation because of their potential associations with contaminants of concern identified at the Shpack Landfill and/or residents' concerns about suspected elevations in particular cancer types. For a full discussion of the contaminants of concern associated with the Shpack Landfill, please see the PHA (MDPH 2011). As mentioned previously, in addition to calculating cancer incidence rates for the 12 cancer types, a review of all types of cancer reported among residents of the one-mile radius area was undertaken (Appendix A).

It should be noted that the MCR research file might contain duplicate reports of individuals diagnosed with cancer. The data in this report have been controlled for duplicate cases by excluding them from the analyses. Duplicate cases are additional reports of the same primary site cancer case. In the Attleboro and Norton census blocks evaluated in this HC, no duplicate reports were identified during the years 1982-2004.

C. Calculation of Standardized Incidence Ratios (SIRs)

To determine whether elevated numbers of cancer diagnoses occurred in the one-mile radius area surrounding the former Shpack Landfill site, cancer incidence data were tabulated by gender and

age group[1] to compare the observed number of cancer diagnoses to the number that would be expected based on the statewide cancer rate. Standardized incidence ratios (SIRs) were calculated for the periods 1982-1987, 1988-1993, 1994-1999, and 2000-2004 for each of the 12 primary cancer types when they occurred in a frequency of 5 or more diagnoses per time period. The SIRs are presented in Tables 2 through 5. SIRs were not calculated for some cancer types in some time periods due to the small number of observed diagnoses (less than five). It is standard MDPH policy not to calculate rates with fewer than five observed diagnoses due to the instability of the rate. However, the expected number of diagnoses was calculated during each time period and for each of the 12 cancer types, and the observed and expected numbers of diagnoses were compared to determine whether excess numbers of diagnoses were occurring.

To calculate SIRs, it is necessary to obtain accurate population information. The population figures used in this analysis were interpolated based on 1980, 1990, and 2000 United States census data for each census block within the one-mile radius area (USDOC 1980, 1990, 2000). Midpoint population estimates were calculated for each time period evaluated (i.e., 1984, 1990, 1996, and 2001). To estimate the population between census years, an assumption was made that the change in population occurred at a constant rate throughout the 10-year interval between each census.[2]

D. Interpretation of a Standardized Incidence Ratio (SIR)

An SIR is an estimate of the occurrence of cancer in a population relative to what might be expected if the population had the same cancer experience as a larger comparison population designated as "normal" or average. Usually, the state as a whole is selected to be the comparison population. Using the state of Massachusetts as a comparison population provides a stable population base for the calculation of incidence rates.

[1] Eighteen 5-year age groups, available for the census years of 1990 and 2000, were used to calculate the SIRs. Because of limitations in 1980 census data, SIRs for 1982-1987 were calculated based on six age groups (0-19, 20-44, 45-64, 65-74, 75-84, and 85+).

[2] Using slightly different population estimates or statistical methodologies, such as grouping ages differently or rounding off numbers at different points during calculations, may produce results slightly different from those published in this report.

Specifically, an SIR is the ratio of the observed number of cancer diagnoses in an area to the expected number of diagnoses multiplied by 100. The statewide incidence rate is applied to the population structure of the area to calculate the number of expected cancer diagnoses. The SIR is a comparison of the number of cancer diagnoses in a specific area to the statewide rate. In this analysis, the number of cancer diagnoses in the area comprised of the 38 census blocks surrounding the Shpack Landfill site is compared to the statewide rate. Comparisons of SIRs between communities or census tracts/census blocks are not possible because each of these areas has different population characteristics.

An SIR of 100 indicates that the number of cancer diagnoses observed in the population being evaluated is equal to the number of cancer diagnoses expected in the comparison or "normal" population. An SIR greater than 100 indicates that more cancer diagnoses occurred than were expected, and an SIR less than 100 indicates that fewer cancer diagnoses occurred than were expected. Accordingly, an SIR of 150 is interpreted as 50% more cancer diagnoses than the expected number; an SIR of 90 indicates 10% fewer cancer diagnoses than expected.

Caution should be exercised, however, when interpreting an SIR. The interpretation of an SIR depends on both the size and the stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on four expected diagnoses and six observed diagnoses indicates a 50% excess in cancer, but the excess is actually only two diagnoses. Conversely, an SIR of 150 based on 400 expected diagnoses and 600 observed diagnoses represents the same 50% excess in cancer, but because the SIR is based upon a greater number of diagnoses, the estimate is more stable. It is very unlikely that 200 excess diagnoses of cancer would occur by chance alone. As a result of the instability of incidence rates based on small numbers of diagnoses, SIRs were not calculated when fewer than five diagnoses were observed for a particular cancer type.

E. Calculation of the 95% Confidence Interval

To help interpret or measure the stability of an SIR, the statistical significance of each SIR was assessed by calculating a 95% confidence interval (95% CI) to determine if the observed number

of diagnoses is “significantly different” from the expected number or if the difference may be due solely to chance (Rothman and Boice 1982). Specifically, a 95% CI is the range of estimated SIR values that have a 95% probability of including the true SIR for the population. If the 95% CI range does not include the value 100, then the study population is significantly different from the comparison or "normal" population. "Significantly different" means there is less than a 5% chance that the observed difference (either increase or decrease) is the result of random fluctuation in the number of observed cancer diagnoses.

For example, if a confidence interval does not include 100 and the interval is above 100 (i.e., 105-130), there is a statistically significant excess in the number of cancer diagnoses. Similarly, if the confidence interval does not include 100 and the interval is below 100 (i.e., 45-96), the number of cancer diagnoses is statistically significantly lower than expected. If the confidence interval range includes 100, the true SIR may be 100. In this case, it cannot be determined with certainty that the difference between the observed and expected number of diagnoses reflects a real cancer increase or decrease or is the result of chance. It is important to note that statistical significance does not necessarily imply public health significance. Determination of statistical significance is just one tool used to interpret SIRs.

In addition to the range of the estimates contained in the confidence interval, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103-115) allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval (e.g., 85-450) leaves considerable doubt about the true SIR, which could be much lower than or much higher than the calculated SIR. This would indicate an unstable statistic. Again, due to the instability of incidence rates based on small numbers of diagnoses, statistical significance was not assessed when fewer than five diagnoses were observed.

F. Evaluation of Risk Factor Information

Available information reported to the MCR related to risk factors for cancer development was reviewed and compared to known or established incidence patterns for the cancer types evaluated in this report. This information is collected for each individual at the time of cancer

diagnosis and includes the individual's age at diagnosis, the subtype or histology (i.e., tissue type) of the cancer, the stage of disease, and the individual's smoking history and occupation. One or even several factors acting over time can be related to the development of cancer. For example, tobacco use has been linked to bladder, kidney, and lung and bronchus cancers. Other cancer risk factors may include lack of crude fiber in the diet, high fat consumption, alcohol abuse, and reproductive history. Heredity, or family history, is an important factor for several cancers. In addition, some occupational exposures, such as jobs involving contact with asbestos, have been shown to be carcinogenic (cancer-causing). Exposure to environmental contaminants has also been associated with certain types of cancer. The available risk factor information from the MCR was evaluated for residents of the Attleboro and Norton census blocks included in this analysis. However, information about personal risk factors such as family history of cancer, hormonal events, diet, and other factors that may also influence the development of cancer is not collected by the MCR or any other readily accessible source; therefore, it was not possible to evaluate the possible contribution of those factors.

G. Determination of Geographic Distribution

Address at the time of diagnosis for each individual diagnosed with cancer was mapped using a computerized geographic information system (GIS) (ESRI 2006). This allowed for the assignment of census block location for each individual diagnosed with cancer as well as an evaluation of the spatial distribution of individual diagnoses at a smaller geographic level (e.g., neighborhoods). The geographic distribution was determined using a qualitative evaluation of the point pattern of cancer diagnoses in the one-mile radius area surrounding the former Shpack Landfill site. In instances where the address information from the MCR was incomplete (i.e., did not include specific streets or street numbers), efforts were made to research those cases using Registry of Motor Vehicle records and telephone books issued within 2 years of an individual's diagnosis. The residences of two individuals diagnosed with cancer could not be mapped due to insufficient address information. In accordance with Massachusetts laws aimed at protecting the confidentiality of patients (M.G.L. c.111. s 24A), maps of the locations of the residence of individuals with cancer cannot be provided in this report.

VI. RESULTS

In order to more readily consider cancer incidence patterns in relation to environmental exposure opportunities, the potential exposure pathways for the Shpack Landfill and the populations potentially exposed were identified using information presented in the PHA (MDPH 2011) (see Table 1). The PHA evaluated environmental data that have been collected and analyzed for contaminants in drinking water, soil, sediment, and surface water. These samples were collected by several consulting firms and contractors over many years, as part of the site investigation and remediation activities under the oversight of the U.S. Environmental Protection Agency.

In addition, burning of some materials occurred at the Shpack Landfill prior to 1980, primarily prior to 1965 (MDPH 2011). 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 the metals to be reclaimed for sale. The prevailing winds at the ALI Landfill were reportedly in the northerly direction, towards Norton, and downwind Norton residents reportedly complained of smoke coming from the ALI Landfill into their neighborhoods in Norton. Without historical ambient air monitoring data it was not possible to evaluate health effects for this potential exposure pathway in the PHA (MDPH 2011). However, the incidence of lung and bronchus cancer within the one-mile radius area was evaluated and is discussed later in this HC.

A. Standardized Incidence Ratios

The following pages provide a summary of cancer incidence rates by time period, for the 12 cancer types identified earlier, for the one-mile area around the former Shpack Landfill.

1982-1987

Between 1982 and 1987, 30 individuals within the one-mile radius area were diagnosed with one of the 12 cancer types. Table 2 contains observed and expected numbers of diagnoses, SIRs, and 95% confidence intervals for this time period.

For five types of cancer – brain & CNS, leukemia, liver/IBD, multiple myeloma, and thyroid – no diagnoses were reported among residents living within the one-mile radius area during this time period. For bladder and prostate cancer and breast cancer in females, the number of observed diagnoses was approximately the same as the number of expected diagnoses.

For bone and kidney cancer, breast cancer in males, and NHL, slight elevations in the number of observed diagnoses were noted. (As discussed earlier, consistent with DPH policy, statistical significance is not calculated when fewer than five diagnoses have been reported, due to the instability of the rate.) One male was diagnosed with bone cancer when approximately 0.1 diagnoses would have been expected. Two females were diagnosed with kidney cancer when approximately 0.4 diagnoses would have been expected. One male within the one-mile radius area was diagnosed with breast cancer when approximately 0.1 diagnoses would have been expected. Three diagnoses of NHL were reported when approximately two would be expected.

Ten individuals within the one-mile radius area were diagnosed with lung and bronchus cancer between 1982 and 1987. During this time period, approximately seven diagnoses would have been expected (SIR = 147, 95% CI: 70 – 269). Among males, six individuals were diagnosed when four diagnoses would be expected (SIR = 137, 95% CI: 50 – 298). Four females in the one-mile radius area were diagnosed with lung and bronchus cancer in this time period while approximately two diagnoses were expected. The differences between the numbers of observed and expected diagnoses during this time period were not statistically significant.

1988-1993

During the six-year time period of 1988-1993, 29 individuals within the one-mile radius area were diagnosed with one of the 12 cancer types evaluated. Table 3 contains observed and expected numbers of diagnoses, SIRs and 95% confidence intervals for this time period.

For five types of cancer – bladder, bone, liver/IBD, multiple myeloma, and thyroid – no diagnoses were reported among residents living within the one-mile radius area during this time period. For brain & CNS cancer, leukemia, lung and bronchus cancer in males, NHL, prostate cancer, and kidney cancer, the number of observed diagnoses was approximately the same as the number of expected diagnoses. The number of observed diagnoses of lung and bronchus cancer in females was slightly higher than expected during this time period, with four diagnoses observed when approximately three would have been expected.

Twelve women within the one-mile radius area were diagnosed with breast cancer between 1988 and 1993, when approximately eight diagnoses would have been expected (SIR = 150, 95% CI: 78 – 262). This elevation was not statistically significant. No diagnoses of breast cancer were reported among males during this time period.

1994-1999

During the six-year time period of 1994-1999, 41 individuals within the one-mile radius area were diagnosed with one of the 12 types of cancer. Table 4 contains observed and expected numbers of diagnoses, SIRs and 95% confidence intervals for this time period.

For five types of cancer – bladder, brain & CNS, kidney, leukemia, and multiple myeloma – no diagnoses were reported among residents living within the one-mile radius area during this time period. For bone, liver/IBD, lung and bronchus, NHL, and thyroid cancer, the number of observed diagnoses was approximately the same as the number of expected diagnoses.

Between 1994 and 1999, 15 women in the one-mile radius area were diagnosed with breast cancer while approximately nine diagnoses would have been expected (SIR = 163, 95% CI: 91 – 269). This elevation was not statistically significant. No males within the one-mile radius were diagnosed with breast cancer during this time period.

Twelve men were diagnosed with prostate cancer in the one-mile radius area between 1994 and 1999 when about nine diagnoses would have been expected (SIR = 137, 95% CI: 71 – 239). This elevation was not statistically significant.

2000-2004

During the five-year time period of 2000-2004, 51 individuals within the one-mile radius area were diagnosed with one of the 12 cancer types. Table 5 contains observed and expected numbers of diagnoses, SIRs and 95% confidence intervals for this time period.

For three types of cancer – bone, liver & IBD, and multiple myeloma – no diagnoses were reported among residents living within the one-mile radius area during this time period. For brain and CNS cancer, NHL and bladder, kidney, and thyroid cancers, the numbers of observed diagnoses were approximately the same as the numbers of expected diagnoses. A slight elevation in the number of diagnoses of leukemia was observed with three diagnoses reported when approximately one diagnosis was expected.

Thirteen women within the one-mile radius area were diagnosed with breast cancer during 2000-2004 when approximately eight diagnoses would have been expected (SIR = 158, 95% CI: 84 – 271). This elevation was not statistically significant. No diagnoses of breast cancer were observed in males during this time period.

Lung and bronchus cancer was diagnosed in 13 residents of the one-mile radius area during this time period when approximately seven diagnoses would have been expected (SIR = 175, 95% CI: 33 – 300). In males, eight diagnoses were reported when four diagnoses were expected (SIR = 200, 95% CI: 86 – 393). In females, five diagnoses were observed when approximately three

diagnoses would have been expected (SIR = 147, 95% CI: 47 – 343). None of these elevations was statistically significant.

Twelve males within the one-mile radius area were diagnosed with prostate cancer when approximately nine diagnoses were expected for this time period (SIR = 133, 95% CI: 69 – 233). This elevation was not statistically significant.

B. Risk Factor Analyses

Information available from the MCR related to age and gender as well as other factors related to the development of cancer such as smoking and occupation was reviewed for individuals diagnosed with cancer within the one-mile radius area, particularly for breast, lung and bronchus, and prostate cancer (those cancer types discussed above for which elevations occurred). Information for the cancer types evaluated in this report was compared to known or established epidemiological patterns to assess whether any unexpected patterns existed among individuals within the one-mile radius area.

Breast Cancer

Over the 23-year period of 1982 - 2004, 48 individuals within the one-mile radius area of the Shpack Landfill site were diagnosed with breast cancer. Forty-seven of these individuals were females and one was a male.

According to the American Cancer Society (ACS), breast cancer is the most frequently diagnosed cancer among women in the United States. Women are 100 times more likely than men to develop breast cancer. The chance of developing invasive breast cancer at some time in a woman's life is about 1 in 8 (12%). From the epidemiological literature, it is known that a woman's risk of developing breast cancer increases with age. The ACS reports that about 2 out of 3 (67%) women with invasive breast cancer are age 55 or older when they are diagnosed while about 1 out of 8 invasive breast cancer diagnoses are among women younger than age 45 (ACS 2009). In Massachusetts, the average age at diagnosis of breast cancer during the 1982-2004 time period was 63 years of age and the median age at diagnosis was 64.

Within the one-mile radius area, the average age at diagnosis of the 47 females with breast cancer was approximately 60 years of age, which is slightly younger than for Massachusetts females statewide. Ages at diagnosis ranged from 35 to 89, with a median of 59 years of age (compared to a median of 64 years for Massachusetts as a whole). Of the 47 females diagnosed with breast cancer during this time period, approximately 66% were age 55 or older at diagnosis, compared to 66% nationwide. Fifteen percent of the females were younger than 45 at diagnosis compared to 13% nationwide.

For each of the four time periods evaluated, age at diagnosis information was reviewed separately for females diagnosed with breast cancer during the specific time period, so as to compare their risk factor information to what would be expected based upon the statewide experience during the same time period. For two time periods, 1982-1987 and 1994-1999, the average age at diagnosis was essentially the same within the one-mile radius area as across the state. In the remaining two time periods, women within the one-mile radius area were diagnosed, on average, 5 to 8 years earlier than women across the state.

Although somewhat younger at diagnosis during two of the four time periods, overall, ages at diagnosis within the one-mile radius area approximate those seen based on nationwide statistics, as described by the American Cancer Society, as well as statewide statistics. Some differences would be expected, given the relatively small number of diagnoses within the one-mile radius area compared to the number statewide.

According to the American Cancer Society, invasive ductal carcinoma is the most common type of breast cancer in women and makes up approximately 75-80% of all breast cancer diagnoses. Among the 47 diagnoses of breast cancer within the one-mile radius area, eight different histologies (or cell types) were reported to the MCR. Of these, invasive ductal carcinoma was the most frequently diagnosed type of breast cancer, representing a minimum of 73% of all breast cancer diagnoses within the one-mile radius area. The percentage of invasive ductal carcinomas could be as high as 82% if histologies of mixed tissue type that include the breast ducts (as well as other breast tissue) are included. Although there was somewhat more variability in the distribution of subtypes when examined by individual time period (as would be

expected), overall the subtypes of breast cancer seen within the one-mile radius area appear to be consistent with what would be expected, based on national and statewide statistics.

Cancer staging information was reviewed for women diagnosed with breast cancer within the one-mile radius area. Staging describes the extent of spread of an individual's cancer; from a public health perspective, earlier breast cancer staging reflects to some extent whether women are being screened early and regularly for breast cancer. Since the inception of the MCR in 1982, breast cancer staging has changed over time. Prior to 1995, the MCR did not require the use of a standardized staging system; this meant that hospital registrars used different staging systems when reporting diagnoses to the MCR. In 1995 the MCR adopted one staging system and required all hospital registrars to report staging information using this system. Due to the variability in the staging data for diagnoses prior to 1995, staging data were analyzed for the 1995-2004 time period only.

From 1995-2004, approximately 84% of breast cancer diagnoses among females within the one-mile radius area were made at the local stage of disease, approximately 16% were diagnosed at the regional stage, and none were diagnosed at either the distant stage or with an unknown stage. Statewide, during this time period, 79% of breast cancer diagnoses were diagnosed at the local stage, 16% regional, 3% distant, and 2% unknown. A localized breast cancer is contained within the tissue of origin, or primary site, whereas a regional cancer has spread to the lymphatic system, and tumor cells can be detected in one or more lymph nodes. There was a higher percentage of localized breast cancers within the one-mile radius area compared to the statewide experience, which may reflect better screening among women within the one-mile radius area; however, this difference was not statistically significant.

When examined by year of diagnosis, there were no unusual patterns in the incidence of breast cancer in any particular year over the 23-year period 1982-2004. With the exception of one year, when no diagnoses occurred, the number of new diagnoses of breast cancer within the one-mile radius area ranged from one to four each year.

The ACS also reports that women, who as children or young adults, had radiation therapy to the chest as treatment for another cancer (such as Hodgkin lymphoma or NHL) are at significantly higher risk for breast cancer. Review of MCR data showed that five of the 48 (10%) individuals diagnosed with breast cancer during 1982-2004 had been previously diagnosed with a different cancer type. While it is unknown whether radiation was used for treatment of their previous cancers, it is possible that such treatment may have contributed to some breast cancer diagnoses.

Known risk factors that increase a woman's risk of developing breast cancer include the following: a family history of breast cancer; certain genetic mutations; pre-existing medical conditions such as benign breast conditions, radiation therapy to the chest for a previous cancer, and a history of ovarian cancer; reproductive factors including early age at menstruation, late age at menopause, late age at first full-term pregnancy, and hormone replacement therapy; and lifestyle factors such as lack of physical activity, regular alcohol consumption, and obesity. Cumulative exposure of the breast tissue to estrogen and progesterone hormones may be one of the greatest contributors to an increased risk of breast cancer. To date, no specific environmental factors have been conclusively linked to an increased risk of breast cancer. However, studies are still being conducted to study possible associations between exposure to environmental chemicals, particularly those with estrogen-like properties, and an increased risk of breast cancer.

Lung and Bronchus Cancer

In the 23-year time period of 1982-2004, 39 diagnoses of lung and bronchus cancer were observed among individuals within the one-mile radius area. Twenty-two of these diagnoses occurred in males, and seventeen in females.

According to the American Cancer Society, lung and bronchus cancer is the second most common cancer in both men (after prostate cancer) and women (after breast cancer). The risk of developing lung cancer is higher for males than females. Lung and bronchus cancers mainly occur in older individuals, with roughly two-thirds of those diagnosed older than 65 years of age. Fewer than 3% of diagnoses occur in individuals under the age of 45. Nationally, the average

age at diagnosis is 71 years. In Massachusetts, the average age at diagnosis of lung and bronchus cancer during the 1982-2004 period was 68 years of age and the median age at diagnosis was 69.

The average age at diagnosis of lung and bronchus cancer within the one-mile radius surrounding the former Shpack landfill site from 1982-2004 was approximately 61 years of age. Ages at diagnosis ranged from 39 to 83 years of age, with a median of 59. Of the 39 individuals diagnosed with lung and bronchus cancer within the one-mile radius, four were below the age of 50 at diagnosis. According to the American Cancer Society, lung cancer is most prevalent among the population age 65 and older. Forty-one percent (n=16) of those diagnosed within the one-mile radius were age 65 or over when diagnosed, compared to approximately 66% nationwide.

For each of the four time periods evaluated, age at diagnosis information was reviewed separately for individuals diagnosed with lung and bronchus cancer during the specific time period, to best compare their risk factor information to what would be expected based upon the statewide experience during the same time period. The difference in average age at diagnosis between those individuals who resided within the one-mile radius area and the statewide average age at diagnosis ranged from 5 to 8 years earlier for residents within the one-mile radius area, depending on the time period. Overall, individuals within the one-mile radius area were diagnosed with lung and bronchus cancer at a younger age than would have been expected based on national and statewide statistics.

Lung cancer is divided into two main types: small cell lung cancer and non-small cell lung cancer. About 85% to 90% of lung and bronchus cancers are non-small cell lung cancers, which are further sub-divided into three types: adenocarcinoma, squamous cell carcinoma, and large-cell undifferentiated carcinoma. The different types of lung cancer occur with different frequencies in the population. The American Cancer Society estimates that approximately 40% of all lung and bronchus cancers are adenocarcinomas, 25-30% are squamous cell carcinomas, 10-15% are small cell cancers, and 10-15% are large cell carcinomas (ACS 2008). Within the one-mile radius area, the most frequently diagnosed lung and bronchus cancer subtype was adenocarcinoma (40%), followed by squamous cell carcinoma (17.5%). Within each of the four

time periods evaluated, adenocarcinomas and squamous cell carcinomas also constituted the largest percentages of lung and bronchus cancer subtypes. Therefore, the distribution of lung and bronchus cancer subtypes within the one-mile radius area appears to closely follow national and statewide trends.

The greatest risk factor for lung and bronchus cancer is smoking. About 87% of all lung cancers are thought to be caused directly by smoking cigarettes or by exposure to second hand smoke, or environmental tobacco smoke (ACS 2008). A nonsmoker who lives with a smoker has about a 20% to 30% greater risk of developing lung cancer. The risk of developing lung cancer depends on the intensity of one's smoking habits (e.g., duration of habit, amount smoked, tar yield of cigarette, and filter type). Smoking cessation decreases the elevated risk by about 50%; however, former smokers still carry a greater risk of developing lung cancer than those who have never smoked. Of the 39 individuals diagnosed with lung and bronchus cancer within the one-mile radius area over the 23-year time period, smoking history was known for 82% (n=32). Approximately 91% (n=29) of those with known smoking status were current or former smokers at the time of their diagnosis. When tobacco use history was examined for each of the four time periods, among those individuals for whom smoking status was known, the number of non-smokers diagnosed with lung and bronchus period in any given time period ranged from none to one. Tobacco use history was unknown for seven individuals.

Long-term exposure to elevated levels of radon (a naturally occurring radioactive gas produced by the breakdown of uranium in soil and rocks) in indoor air has been identified as the second leading cause of lung and bronchus cancer, and the leading cause among nonsmokers. The level of radon that occurs outdoors is not dangerous. Radon gas found in rocks and soil can, however, move to indoor air and drinking water. Houses that are built on soil with natural uranium deposits can have high levels of indoor radon, particularly in basements. In addition, radon in drinking water can become airborne during typical indoor household activities such as bathing and cooking. Other major pathways for radon entry into the home include cracks in floors or walls, construction joints, and gaps around service pipes (USEPA 2007). Radon can then enter the body when it is breathed in or swallowed. Some of the radon that is ingested or breathed in may be exhaled. Other portions of the ingested or inhaled radon may rapidly move to the lungs

where it can remain and undergo radioactive decay. Scientists believe that long-term exposure to elevated levels of radon in indoor air increases the risk of developing lung and bronchus cancer. Smoking cigarettes can multiply the risk of developing lung cancer.

The MDPH Public Health Assessment, being issued concurrently with this report, discusses what is known about radon in the area around the Shpack Landfill (MDPH 2011). Based on the findings reported in the PHA, particularly with respect to the specific types of radioactive contamination detected at the landfill, it was determined that radon was not related to contamination found at the landfill. However, radon (naturally occurring ; not site-related) was detected in the 1980s at elevated levels in the drinking water of several properties in the vicinity of the landfill. According to the PHA, it is not known if any indoor radon air concentrations have been measured in the homes on these properties. Without indoor air sampling results and the knowledge of where, when and how these samples were collected, the PHA reported that it was not possible to make a health impact determination. Although it is possible that elevated indoor radon levels could have contributed to the incidence of lung cancer within the one-mile radius area, if they existed, it is not possible to draw any firm conclusions about this. It is worthwhile noting however that a study previously undertaken by MDPH/BEH, in which radon was measured in the homes of Attleboro females diagnosed with lung cancer and compared to radon measurements in a group of randomly selected homes in Attleboro, showed that although the median radon levels in both sets of homes were below the USEPA recommended remediation level of 4 picocuries per liter, the median radon concentration in the homes of those with lung cancer was higher than the median concentration in the randomly selected control homes.

As discussed earlier, research indicates that significant burning of refuse occurred at the ALI Landfill which opened as a burning dump in 1946 and ceased burning by the early 1970s (James Mooney, City of Attleboro Health Department, personal communication, 2010). Although some burning also occurred at the Shpack Landfill prior to 1980, primarily prior to 1965, the amount and frequency of burning was reportedly significantly greater at the ALI Landfill (MDPH 2011). 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 the metals to be reclaimed 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 in Norton. Although no historical environmental data exist to confirm this, it is possible that Norton residents living downwind of the ALI Landfill could have been exposed via inhalation to chemicals burned at the landfill and transported downwind via the wind. Inhalation exposure to some heavy metals, such as hexavalent chromium, has the potential to increase an individual's risk of lung cancer.

Several occupational exposures have been identified as playing a role in the development of lung and bronchus cancer. For example, workplace exposure to asbestos is an established risk factor for this disease. In addition to asbestos and radon, exposure to chemical compounds including arsenic, beryllium, cadmium, silica, vinyl chloride, nickel compounds, chromium compounds, coal products, mustard gas, chloromethyl ethers, diesel exhaust, and radioactive ores such as uranium are also occupational risk factors for lung and bronchus cancer. Occupational exposure to these compounds in conjunction with cigarette smoking can dramatically increase the risk of developing lung cancer. Of the 19 individuals diagnosed with lung and bronchus cancer within the one-mile radius for which usual occupation was reported to the MCR, six had occupations with potential exposures to chemicals associated with an increased risk of lung or bronchus cancer; however, information regarding specific job duties that could help to further define exposure potential for these individuals was not available. Occupational information was not reported to the MCR for 21 of the 39 individuals.

As reported in the PHA (MDPH 2011), arsenic was measured at levels above the current drinking water standard of 10 parts per billion (ppb) in some residential well water 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. 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 2007). Although there were occasional exceedances of the drinking water standard of 10 ppb in some properties in the vicinity of the landfill, the PHA concluded,

upon careful evaluation of the sampling data, that residents are unlikely to have an unusually increased risk of developing cancer as a result of their exposure. This conclusion took into account exposure doses that residents could have received over a lifetime in comparison to health-based guidelines.

When assessed by year of diagnosis, no unusual patterns in incidence were observed for lung and bronchus cancer within the one-mile radius area. The number of individuals diagnosed in any given year with lung and bronchus cancer ranged from zero to four. For five of the 23 years, there were no diagnoses. For 16 of the 23 years, the number of diagnoses in a given year ranged from one to three. For two years (1987 and 2000), there were four diagnoses each year.

Prostate Cancer

Between 1982 and 2004, 33 diagnoses of prostate cancer were reported among residents of the one-mile radius area surrounding the former Shpack Landfill site.

According to the American Cancer Society, prostate cancer is the most common cancer in American men (other than benign skin cancers). About 1 in 6 men will be diagnosed with prostate cancer during his lifetime. Prostate cancer is rare before the age of 40, but the chance of developing prostate cancer rapidly rises after age 50. Almost 2 out of 3 prostate cancers are found in men over the age of 65. Prostate cancer seems to run in families, which suggests that there may be an inherited or genetic factor. Diet has been shown as a possible risk factor for prostate cancer, with a diet high in red meat and high-fat dairy products increasing the risk and a diet high in vegetables, fruits, and legumes decreasing the risk. Exposure to certain agricultural pesticides may be associated with an increased risk of prostate cancer among pesticide applicators and possibly farmers. However, additional research is necessary. Certain medical conditions may be linked to an increased risk of prostate cancer; these include inflammation of the prostate gland and high levels of testosterone and prostate cells called high-grade prostatic intraepithelial neoplasia (PIN) (ACS 2008a).

The average age at diagnosis of prostate cancer within the one-mile radius area was approximately 69 years of age, which is consistent with the average age statewide. Age at

diagnosis ranged from 51 to 88 years of age, with a median of 68 (compared to a median age statewide of 70). Sixty-four percent (n=21) of those diagnosed within the one-mile radius area were age 65 or over at diagnosis, compared to approximately 66% nationwide.

When age at diagnosis information was examined separately for each time period, the average age at diagnosis for men diagnosed with prostate cancer while residing within the one-mile radius area within one of the first two time periods was older than men statewide, ranging from 3 to 9 years older. For the subsequent two time periods, the average age at diagnosis for men diagnosed with prostate cancer while residing within the one-mile radius area was slightly younger than men statewide by about 3 years.

From 1995-2004, approximately 83% of prostate cancer diagnoses among males within the one-mile radius area were made at the local stage of disease, approximately 17% were diagnosed at the regional stage, and none were diagnosed at either the distant stage or with an unknown stage. Statewide, during this time period, 80% of prostate cancer diagnoses were diagnosed at the local stage, 9% regional, 4% distant, and 7% unknown. In other words, men diagnosed with prostate cancer who lived within the one-mile radius area were diagnosed at earlier stages compared to the statewide experience. In addition, while 4% of statewide prostate cancer diagnoses were distant stage diagnoses, no diagnoses within the one-mile radius were distant stage diagnoses. These differences in staging between the one-mile radius area and the state may reflect better screening among men within the one-mile radius area; however, the differences were not statistically significant.

When assessed by year of diagnosis, the diagnoses of prostate cancer have become slightly more frequent in recent years (beginning in the mid- to late-1990s) within the one-mile radius. The average number of diagnoses per year, over the 23-year period, was 1.5 diagnoses.

C. Other Cancer Types

Over the 23-year time period, the observed number of diagnoses of bladder, bone, brain & CNS, kidney, liver & IBD, and thyroid cancer as well as leukemia, multiple myeloma and NHL were

about as expected based on the statewide experience. These diagnoses were assessed for any geographic or temporal patterns and no unusual patterns were observed.

D. Geographic Distribution of Cancer Diagnoses within the One-Mile Radius

The spatial distribution of place of residence at diagnosis was reviewed for individuals within the one-mile radius area who were diagnosed with the 12 cancer types discussed above. The geographic distribution of the reported residences of these individuals diagnosed during the 23-year time period did not appear unusual. This was also true when the geographic distribution of residence at diagnosis was examined separately for each of the four time periods. MDPH also evaluated the geographic distribution of residence at diagnosis for those individuals with lung and bronchus cancer who did not have a history of smoking and again found no unusual spatial patterns. The spatial patterns of residences at diagnosis closely followed the population density of the census blocks within the one-mile radius area.

VII. DISCUSSION

According to the American Cancer Society (ACS), one out of three people develop cancer in their lifetime, and this disease will affect three out of every four families. Because of its prevalence, cancer diagnoses often appear to occur in "clusters," and it is understandable that individuals may perceive that there are an unusually high number of cancer cases in their surrounding neighborhoods or community. Upon close examination, many of these "clusters" are not unusual increases as first thought, but are related to such factors as local population density, variations in reporting, or natural fluctuations in occurrence. The review of information in this report is helpful in identifying whether an atypical pattern of cancer is occurring in the area surrounding the Shpack Landfill to determine if further investigation is warranted.

Cancer has a long latency period or period of development (i.e., the interval between first exposure to a disease-causing agent and the appearance of symptoms of the disease). Latency periods vary by cancer type as well as by individual factors such as genetics and susceptibility. In particular, solid tumors such as bladder, kidney, and liver cancer generally have a long latency period that ranges from at least 10 to 30 years and may be as long as 50 years (Levy and

Wegman 1995). Because the Shpack Landfill operated from approximately 1946 until 1968, and the first year for which MCR data are available is 1982, the community has expressed concern over the fact that cancers diagnosed before 1982 are not included in this evaluation. Although earlier data are not available, it is still useful to analyze cancer incidence data from 1982 to 2004 due to the long latency periods of some of the cancer types evaluated. If exposure to contaminants at the landfill resulted in an increased risk of cancer, one would expect to observe higher cancer incidence rates in the years from approximately 1966 to 2008.

The numbers of reported diagnoses of breast cancer in females within the one-mile area were greater than the numbers expected, based on statewide breast cancer rates; however, the differences were not statistically significant within any given time period. Nonetheless, particularly during the latter three time periods, the incidence of breast cancer within the one-mile radius area was higher than expected. Available risk factor information was reviewed to assess whether risk factor patterns among women residing within the one-mile radius area appeared different from what would be expected based on the epidemiological literature. Age at diagnosis, breast cancer histologies or subtypes, staging information, and spatial and temporal patterns were evaluated. Although slightly younger at diagnosis, particularly during two of the four time periods, overall, ages at diagnosis within the one-mile radius area approximate those seen based on nationwide statistics, as described by the American Cancer Society, as well as statewide statistics. Some differences would be expected, given the relatively small number of diagnoses within the one-mile radius area compared to the number statewide. The breast cancer subtypes within the one-mile radius area appear to be consistent with what would be expected. The staging information reviewed suggests that women residing within the one-mile radius area have been screened for breast cancer earlier than women statewide. It is also possible that a small number of women, for whom breast cancer was their second cancer diagnosis, had received radiation therapy to the chest for their previous cancer treatment; previous radiation therapy to the chest is a risk factor for breast cancer.

During two of the four time periods, the numbers of observed diagnoses of lung and bronchus cancer in both males and females were greater than the numbers expected. These differences were not statistically significant during any one time period. To better understand these

differences, a closer examination of available risk factor information was undertaken. Statistics related to age at diagnosis showed that the average age at diagnosis of individuals diagnosed with lung and bronchus within the one-mile radius area was somewhat younger than would be expected based on national and statewide statistics; however, it is important to point out that the statistics for the one-mile radius area are based on relatively small numbers; because of this, one or two diagnoses within younger individuals can affect the statistics greatly. For the four individuals, from the total of 39 individuals with lung and bronchus cancer, who were diagnosed at ages less than 50 years, each reported being a current or former smoker. Smoking history was reported to the MCR for 32 of the 39 individuals. Of the 32 individuals, 29 (91%) reported being current or former smokers at the time of their diagnosis. Place of residence at diagnosis was examined for the three non-smokers; none lived in close proximity to one another within the one-mile radius area. The subtypes of lung and bronchus cancers diagnosed in individuals residing within the one-mile radius area were consistent with what would be expected, with the majority of diagnoses being adenocarcinomas followed by squamous cell carcinomas. Occupational exposures may have played a role in a small number of diagnoses. Although no historical environmental data exist to confirm this, it is possible that Norton residents living downwind of the ALI Landfill could have been exposed via inhalation to chemicals burned at the landfill and transported downwind via the wind. Inhalation exposure to some heavy metals, such as hexavalent chromium, has the potential to increase an individual's risk of lung cancer. No unusual temporal trends were noted over the 23-year time period, with the number of diagnoses in a given year fairly consistent over the entire time period.

No statistically significant elevations in prostate cancer were seen during any of the four time periods evaluated. The differences that were noted between the numbers of observed and expected diagnoses in the latter two time periods, with slightly more diagnoses occurring in the mid- to late-1990s compared to the earlier years, closely mirror what was seen statewide. In two MCR special reports on prostate cancer (MCR 2000; MCR 2006), rising incidence rates seen statewide in the 1990s were attributed to the use of early detection tests (the prostate specific antigen test and digital rectal exams) that became relatively common beginning around 1990.

Four cancer types – bone, multiple myeloma, leukemia, and non-Hodgkin lymphoma (NHL) – have been reported in the epidemiological literature as being associated with exposure to high-dose ionizing radiation such as that released during atomic bomb blasts or nuclear power plant accidents or high-dose ionizing radiation received as part of intense medical therapies (not routine dental or medical x-rays). As mentioned earlier, although radioactive contamination was found at the Shpack Landfill, it is important to note that the levels of radioactive contaminants detected were many times lower than those associated with industrial accidents or high-dose medical therapies. The PHA concluded that, although some exposure to radioactive contamination at the landfill may have occurred in the past, due to site conditions, potential exposures were not at levels likely to harm people's health (MDPH 2011).

Over the 23-year time period, two diagnoses of bone cancer, four diagnoses of leukemia, and nine diagnoses of NHL were reported within the one-mile radius area. There were no observed diagnoses of multiple myeloma. Closer examination of the incidence of NHL showed that during two of the four time periods evaluated in this report, the number of observed diagnoses of NHL was slightly above the number expected: three diagnoses observed compared to approximately two expected. For the other two time periods, the numbers of observed diagnoses of NHL were approximately as expected or less than expected. A closer examination of the incidence of leukemia within the one-mile radius showed that it was about as expected throughout the entire 23-year time period. For each of these four cancer types, available risk factor information was reviewed to assess whether any unusual risk factor, spatial, or temporal patterns emerged. No unusual patterns emerged when age at diagnosis, subtype/histology, or spatial, or temporal distribution were examined.

The PHA contains a full discussion of the potential health risks from exposure to chemical and radioactive contaminants detected at the former Shpack Landfill. MDPH concluded in the PHA that the levels of chemical and radioactive contaminants found in soil, sediment, surface water, and drinking water do not present an elevated cancer risk. Although high levels of radon (naturally occurring; not site-related) were measured in well water in some homes in the vicinity of the landfill, the major public health risk is breathing in radon in indoor air. When water containing radon is used for showering, cooking, and other household uses, the radon can be

released from the water to the air. There can be other contributors to the level of radon in indoor air, and there can be mitigating conditions that can reduce the concentrations. It is not known if any indoor radon air concentrations have been measured in the homes with naturally-occurring radon in their well water.

In an earlier report issued by the MDPH in 2001, *Evaluation of Female Lung Cancer Incidence and Radon Exposure in Attleboro, MA 1982-1994* (MDPH 2001), the 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 air of homes (or former homes) of females diagnosed with lung cancer was compared to the concentrations measured in a group of randomly selected homes in the city. Although the median radon air concentration in both the case and control homes was below the USEPA's recommended remediation level of 4 pCi/L, the median radon concentration in the air of case homes (2.4 pCi/L) was higher than the median concentration measured in the air of randomly selected control homes (1.9 pCi/L) (MDPH 2001).

VIII. LIMITATIONS

This health consultation is an investigation that analyzes descriptive health outcome data for cancer to determine whether the pattern or occurrence of selected cancers is unusual. Information from descriptive analyses, which may suggest that a common etiology (or cause) is possible, can serve to identify areas where further analyses are needed. Inherent limitations in this type of analysis 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 etiology (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), heredity/genetics, and occupational and

environmental exposures. It is beyond the scope of this report to determine the causal relationship of these factors in the development of cancer or other health outcomes within the communities of Norton and Attleboro.

This health consultation focused on a one-mile radius area around the Shpack Landfill site. Information on the occurrence of cancer among residents of the one-mile radius area was obtained from the Massachusetts Cancer Registry, a statewide surveillance system that began collecting data in 1982 on all new cancer diagnoses among Massachusetts residents. It is important to point out that the potential for a resident of the one-mile radius area to be exposed to site-related contaminants depended heavily on variables such as whether they visited the site, what kind of activities they engaged in while on the site, whether historical burning at the site resulted in breathing in contaminants downwind of the site, and whether a resident used a private well downgradient of the site for drinking water or other uses. The Public Health Assessment contains a detailed discussion of the potential ways in which residents of the one-mile radius area could have been exposed to site-related contamination. Nonetheless, this descriptive review of cancer incidence data allowed for a screening-level evaluation of the pattern of cancer in the area most likely to be impacted if, indeed, exposure to site-related contamination could be assumed to affect cancer rates in the population.

IX. CONCLUSIONS

- Within the one-mile radius area, the incidence of the following types of cancer was approximately as expected, based on the statewide cancer experience, for the period between 1982 and 2004: bladder, bone, brain and central nervous system, kidney, leukemia, liver and intrahepatic bile duct, multiple myeloma, non-Hodgkin's lymphoma, and thyroid cancer. The incidence of prostate cancer was slightly elevated in the latter two of the four time periods evaluated; however, the elevations were not statistically significant and could be due to natural variation in the observed number of diagnoses as

well as improved diagnostic tests for prostate cancer introduced during the 1990s, the same timeframe as the slight elevations.

- Within the one-mile radius area, the incidence of breast cancer was elevated in 3 of the 4 time periods evaluated. Although not statistically significantly elevated in any one time period, the elevations persisted over time. Based on the detailed evaluation in the PHA of contamination at the landfill and potential pathways of human exposure, in addition to the geographic distribution of residences at diagnosis, exposure to landfill-related contaminants was not likely to have played a primary role in the development of breast cancer among residents in this area.

- Within the one-mile radius area, the incidence of lung and bronchus cancer was elevated during two of the four time periods evaluated; however, none of the elevations was statistically significant however. Exposure to radon (a naturally occurring radioactive gas produced by the breakdown of uranium in soil and rocks) has been identified as the second leading cause of lung and bronchus cancer, and the leading cause among nonsmokers. Although not related to the former Shpack Landfill, based on the detection of radon in the drinking water of several homes in the vicinity of the landfill, it is possible that indoor air radon levels may have contributed to the incidence of lung and bronchus cancer in these communities. Smoking may also have played some role in the incidence of lung and bronchus cancer. Although no historical environmental data exist to confirm this, it is possible that Norton residents living downwind of the ALI Landfill could have been exposed via inhalation to chemicals burned at the landfill and transported downwind via the wind. Inhalation exposure to some heavy metals, such as hexavalent chromium, has the potential to increase an individual's risk of lung cancer.

The Public Health Assessment (PHA) for the Shpack Landfill provides a detailed evaluation of available environmental data for the Shpack Landfill site (MDPH 2011). Based on MDPH's evaluation of the available environmental data in the PHA, the exposure pathway analysis in the PHA, and information related to the cancer types evaluated in this analysis, MDPH concludes that:

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

- **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 IN FOLLOW-UP TO PHA AND MDPH CANCER INCIDENCE ANALYSIS

Based on the findings of the PHA and this HC, MDPH makes the following recommendations:

- The 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. USEPA/MDEP recommend 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).

- The 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.

- The MDPH recommends that residents consuming residential well water containing levels of arsenic above the USEPA MCL (10 ppb) take steps to reduce exposure

opportunities to arsenic. This includes advising residents who live at Maple, House 7 and N. Worcester, House 1 in Norton, and Peckham, House 3 and Peckham, House 4 in Attleboro not to consume private well water. 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, the MDPH recommends that local health and/or municipal officials of Norton and Attleboro develop a testing and approval process for all new residential wells to ensure that contaminated groundwater is not consumed in the future as drinking water by residents.

- Upon request, the 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 U.S Environmental Protection Agency and the U.S. Army Corp of Engineers to remove contamination from the Shpack Landfill.

GENERAL RECOMMENDATIONS

- The 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 the MDPH/BEH Radiation Control Program toll free at (800) 723-6695. They can advise individuals on how to get their homes tested and assist them in interpreting the results. (See attached Radon Fact Sheet)

- The 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.

- MDPH recommends that the local Boards of Health in Attleboro and Norton work with the MDPH Tobacco Control Program to provide community-based smoking cessation interventions.

XI. PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan for the Shpack Landfill contains a description of actions to be taken by ATSDR and/or the MDPH at and in the vicinity of the Shpack Landfill subsequent to completion of this Health Consultation. The purpose of the Public Health Action Plan is to ensure that this health consultation not only identifies potential 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:

- The MDPH will continue to monitor the incidence of lung and bronchus and breast cancer in the city of Attleboro and the town of Norton through city/town cancer incidence reports published by the Massachusetts Cancer Registry.

- The MDPH/BEH will forward a copy of this health consultation to the Attleboro and Norton Boards of Health for consideration in the planning of community prevention and intervention strategies to reduce cancer risk among residents (e.g., home radon testing and tobacco cessation programs). In addition, if requested, the MDPH Environmental Health Education Program will work with the Boards of Health for any follow-up educational and outreach activities that may be planned locally.

XII. REFERENCES

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PREPARER

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

CERTIFICATION

The Health Consultation, Focused Evaluation of Cancer Incidence Within One-Mile Radius Area of the Shpack Landfill Superfund Site *MAD 980503973*, was prepared by the Massachusetts Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the Health Consultation was initiated. Editorial review was completed by the cooperative agreement partner.

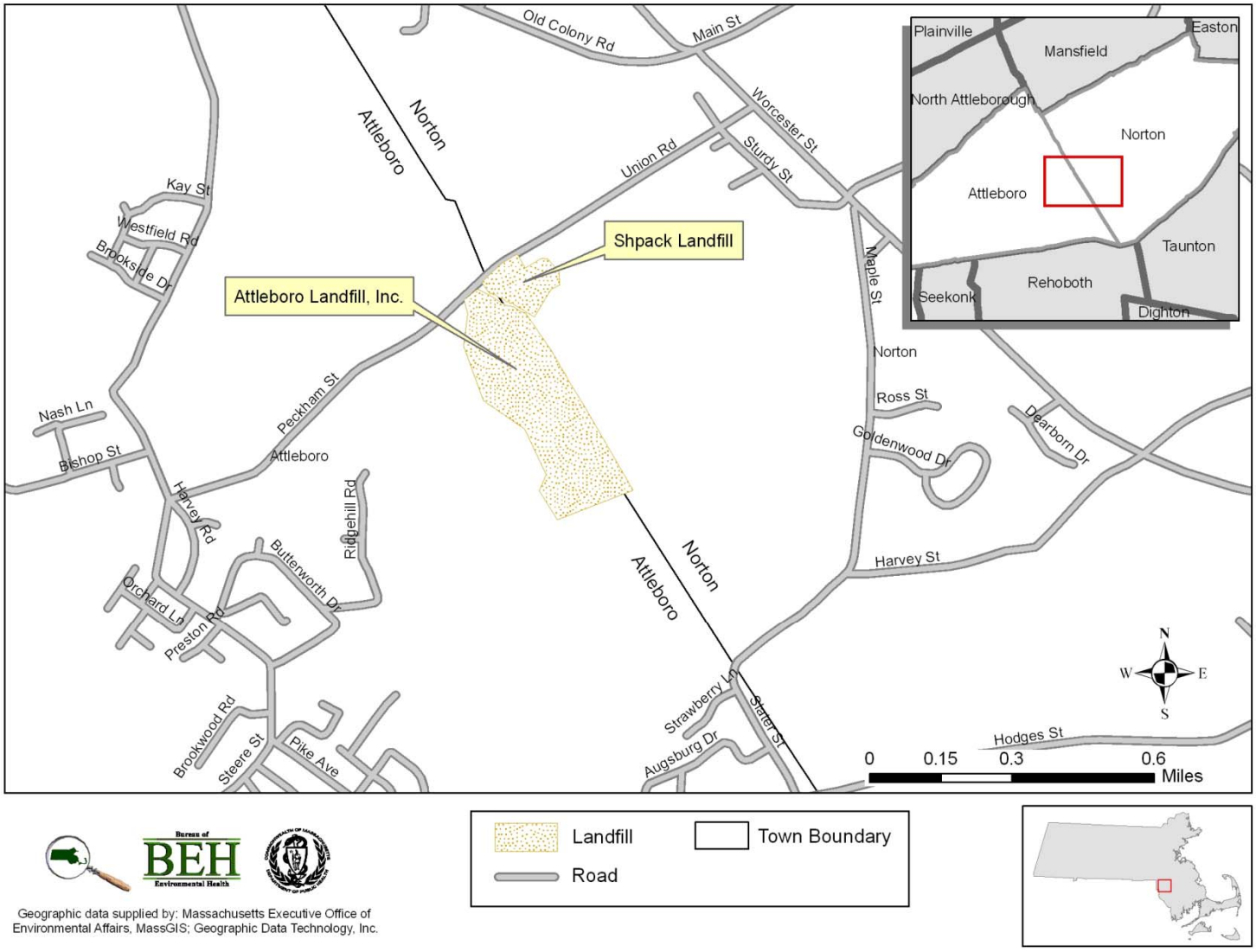
Technical Project Officer, CAT, SPAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this Health Consultation and concurs with its findings.

Team Lead, CAT, SPAB, DHAC

FIGURES & TABLES

Figure 1
Location of Shpack Landfill
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
Town Boundary
Road

Figure 2: One-Mile Radius Area Surrounding Former Shpack Landfill Site

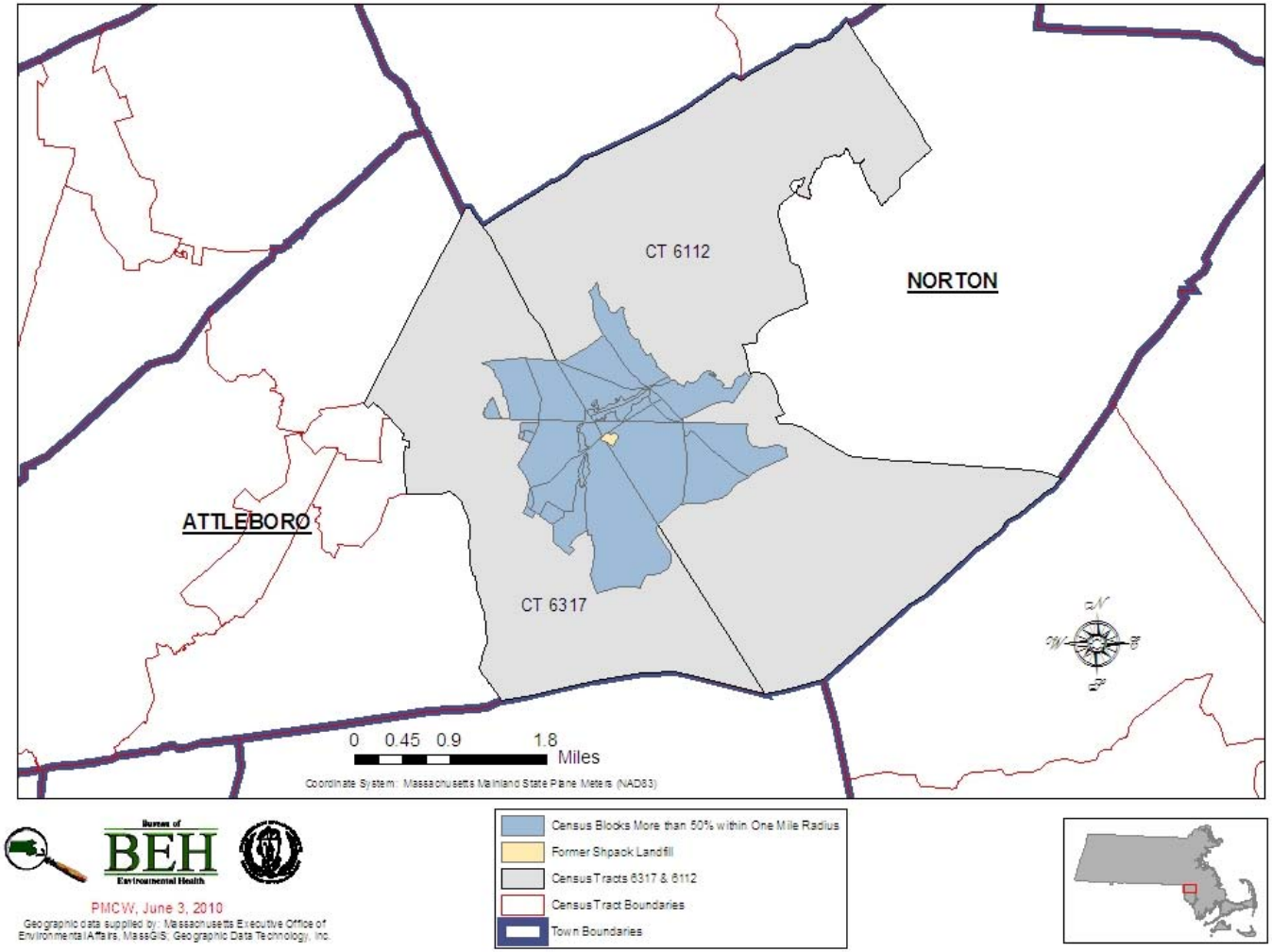


Table 1
Summary of Important Exposure Pathways for the Shpack Landfill
Norton and Attleboro, Massachusetts

Environmental Medium	Exposure Pathway	Potential Contaminant(s)	Point of Exposure	Route of Exposure	Receptor Population	Time Frame	Type of Pathway
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
	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
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 2
Cancer Incidence
One-Mile Radius Surrounding Former Shpack Landfill Site, Attleboro/Norton, Massachusetts
1982-1987

Cancer Type	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
Bladder	2	2.1	NC	NC	NC	1	1.5	NC	NC	NC	1	0.6	NC	NC	NC
Bone	1	0.1	NC	NC	NC	1	0.1	NC	NC	NC	0	0.1	NC	NC	NC
Brain & CNS	0	1.0	NC	NC	NC	0	0.5	NC	NC	NC	0	0.5	NC	NC	NC
Breast	8	7.5	107	46	210	1	0.1	NC	NC	NC	7	7.5	94	38	194
Kidney	2	0.9	NC	NC	NC	0	0.6	NC	NC	NC	2	0.4	NC	NC	NC
Leukemia	0	1.0	NC	NC	NC	0	0.6	NC	NC	NC	0	0.4	NC	NC	NC
Liver / IBD	0	0.2	NC	NC	NC	0	0.2	NC	NC	NC	0	0.1	NC	NC	NC
Lung & Bronchus	10	6.8	147	70	269	6	4.4	137	50	298	4	2.4	NC	NC	NC
Multiple Myeloma	0	0.4	NC	NC	NC	0	0.2	NC	NC	NC	0	0.2	NC	NC	NC
Non-Hodgkins Lymphoma	3	1.5	NC	NC	NC	1	0.8	NC	NC	NC	2	0.7	NC	NC	NC
Prostate	4	3.9	NC	NC	NC	4	3.9	NC	NC	NC	0	0.0	NC	NC	NC
Thyroid	0	0.4	NC	NC	NC	0	0.1	NC	NC	NC	0	0.3	NC	NC	NC

Note: SIRs are calculated based on the exact number of expected diagnoses.
Expected number of diagnoses presented are rounded to the nearest tenth.
SIRs and 95% CIs are not calculated when the observed number is < 5.

Obs = Observed number of diagnoses
Exp = Expected number of diagnoses
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Bureau of Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

*Based on the structure of 1980 Census data, age standardization was calculated using different categories than subsequent time periods. Six age categories of 0-19, 20-44, 45-64, 65-74, 75-84, and 85+ were used for this analysis, rather than 18 5-year age groups.

TABLE 3
Cancer Incidence
One-Mile Radius Surrounding Former Shpack Landfill Site, Attleboro/Norton, Massachusetts
1988-1993

Cancer Type	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
Bladder	0	1.7	NC	NC	NC	0	1.2	NC	NC	NC	0	0.4	NC	NC	NC
Bone	0	0.1	NC	NC	NC	0	0.1	NC	NC	NC	0	0.1	NC	NC	NC
Brain & CNS	1	1.0	NC	NC	NC	0	0.5	NC	NC	NC	1	0.5	NC	NC	NC
Breast	12	8.0	149	77	260	0	0.1	NC	NC	NC	12	8.0	150	78	262
Kidney	1	1.2	NC	NC	NC	1	0.7	NC	NC	NC	0	0.4	NC	NC	NC
Leukemia	1	0.9	NC	NC	NC	1	0.5	NC	NC	NC	0	0.4	NC	NC	NC
Liver / IBD	0	0.3	NC	NC	NC	0	0.2	NC	NC	NC	0	0.1	NC	NC	NC
Lung & Bronchus	8	6.7	119	51	234	4	4.0	NC	NC	NC	4	2.7	NC	NC	NC
Multiple Myeloma	0	0.4	NC	NC	NC	0	0.2	NC	NC	NC	0	0.2	NC	NC	NC
Non-Hodgkins Lymphoma	1	1.8	NC	NC	NC	1	1.0	NC	NC	NC	0	0.8	NC	NC	NC
Prostate	5	5.6	89	29	208	5	5.6	89	29	208	0	0.0	NC	NC	NC
Thyroid	0	0.5	NC	NC	NC	0	0.1	NC	NC	NC	0	0.4	NC	NC	NC

Note: SIRs are calculated based on the exact number of expected diagnoses.
Expected number of diagnoses presented are rounded to the nearest tenth.
SIRs and 95% CIs are not calculated when the observed number is < 5.

Obs = Observed number of diagnoses
Exp = Expected number of diagnoses
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Bureau of Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 4
Cancer Incidence
One-Mile Radius Surrounding Former Shpack Landfill Site, Attleboro/Norton, Massachusetts
1994-1999

Cancer Type	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
Bladder	0	1.8	NC	NC	NC	0	1.3	NC	NC	NC	0	0.4	NC	NC	NC
Bone	1	0.1	NC	NC	NC	1	0.1	NC	NC	NC	0	0.1	NC	NC	NC
Brain & CNS	0	0.9	NC	NC	NC	0	0.5	NC	NC	NC	0	0.4	NC	NC	NC
Breast	15	9.3	162	91	267	0	0.1	NC	NC	NC	15	9.2	163	91	269
Kidney	0	1.4	NC	NC	NC	0	0.9	NC	NC	NC	0	0.5	NC	NC	NC
Leukemia	0	1.3	NC	NC	NC	0	0.7	NC	NC	NC	0	0.5	NC	NC	NC
Liver / IBD	1	0.5	NC	NC	NC	1	0.3	NC	NC	NC	0	0.1	NC	NC	NC
Lung & Bronchus	8	7.9	101	44	199	4	4.5	NC	NC	NC	4	3.4	NC	NC	NC
Multiple Myeloma	0	0.5	NC	NC	NC	0	0.3	NC	NC	NC	0	0.2	NC	NC	NC
Non-Hodgkins Lymphoma	3	2.2	NC	NC	NC	2	1.2	NC	NC	NC	1	1.0	NC	NC	NC
Prostate	12	8.8	137	71	239	12	8.8	137	71	239	0	0.0	NC	NC	NC
Thyroid	1	0.8	NC	NC	NC	1	0.2	NC	NC	NC	0	0.6	NC	NC	NC

Note: SIRs are calculated based on the exact number of expected diagnoses.
Expected number of diagnoses presented are rounded to the nearest tenth.
SIRs and 95% CIs are not calculated when the observed number is < 5.

Obs = Observed number of diagnoses
Exp = Expected number of diagnoses
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Bureau of Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 5
Cancer Incidence
One-Mile Radius Surrounding Former Shpack Landfill Site, Attleboro/Norton, Massachusetts
2000 - 2004

Cancer Type	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
Bladder	2	1.3	NC	NC	NC	2	1.0	NC	NC	NC	0	0.3	NC	NC	NC
Bone	0	0.1	NC	NC	NC	0	0.1	NC	NC	NC	0	0.0	NC	NC	NC
Brain & CNS	1	0.8	NC	NC	NC	1	0.5	NC	NC	NC	0	0.4	NC	NC	NC
Breast	13	8.3	157	84	269	0	0.1	NC	NC	NC	13	8.2	158	84	271
Kidney	3	1.5	NC	NC	NC	2	1.0	NC	NC	NC	1	0.6	NC	NC	NC
Leukemia	3	1.2	NC	NC	NC	2	0.7	NC	NC	NC	1	0.5	NC	NC	NC
Liver / IBD	0	0.6	NC	NC	NC	0	0.5	NC	NC	NC	0	0.1	NC	NC	NC
Lung & Bronchus	13	7.4	175	33	300	8	4.0	200	86	393	5	3.4	147	47	343
Multiple Myeloma	0	0.6	NC	NC	NC	0	0.3	NC	NC	NC	0	0.2	NC	NC	NC
Non-Hodgkins Lymphoma	2	2.1	NC	NC	NC	1	1.2	NC	NC	NC	1	0.9	NC	NC	NC
Prostate	12	9.0	133	69	233	12	9.0	133	69	233	0	0.0	NC	NC	NC
Thyroid	2	1.3	NC	NC	NC	0	0.3	NC	NC	NC	2	1.0	NC	NC	NC

Note: SIRs are calculated based on the exact number of expected diagnoses.
Expected number of diagnoses presented are rounded to the nearest tenth.
SIRs and 95% CIs are not calculated when the observed number is < 5.

Obs = Observed number of diagnoses
Exp = Expected number of diagnoses
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Bureau of Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

APPENDICES

Appendix A

Qualitative Analysis of Other Cancer Types

Appendix A
Qualitative Analysis of Other Cancer Types

To further address the concerns of residents living in close proximity to the former Shpack Landfill, an analysis was conducted of all other types of cancer (that is, those types not already discussed in this report) that were diagnosed between 1982 and 2004 within the one-mile radius area.

Over the 23-year time period evaluated, an additional 24 different types of cancer were reported to the MCR among individuals residing within the one-mile radius area at time of diagnosis, representing the occurrence of many different diseases with different risk factors.

The other types of cancer observed within the one-mile radius area included types not associated with contaminants of concern at the former Shpack Landfill. These included cancers of the cervix, colon/rectum, uterus, esophagus, Hodgkin lymphoma, melanoma, oral cavity and pharynx, ovary, pancreas, stomach, testes, adrenal gland, anus, gallbladder, larynx, penis, soft tissue sarcoma, thymus, vagina, ureter, and other unknown primary site cancers. With the exception of cancers of the colon/rectum, melanoma, uterus, ovary, stomach, and oral cavity & pharynx, the maximum number of diagnoses of any of these cancer types over the 23-year time period was four.

The majority of these cancer types are mainly associated with non-environmental risk factors such as family history, genetics, smoking, diet, alcohol consumption, and other lifestyle behaviors. A summary of the risk factors associated with those cancer types where more than four diagnoses were reported over the 23-year time period follows:

- Colo-rectal cancer, of which there were 33 diagnoses over the 23-year time period, is one of the most commonly diagnosed cancers in the U.S. and Massachusetts, following breast, lung and bronchus, and prostate cancer. Risk factors associated with colo-rectal cancer include family history, genetic susceptibility, pre-existing medical conditions such as inflammatory bowel

disease, obesity, diet, lack of physical exercise, and possibly alcohol consumption and smoking.

- Stomach cancer, of which there 6 diagnoses over the 23-year time period, is associated with family history, certain genetic mutations and hereditary conditions, certain medical conditions (such as pernicious anemia), previous infection with *H. Pylori* bacteria, smoking, and possibly excessive alcohol consumption, diet, and occupational exposures in the coal, metal, and rubber industries.
- Melanoma, the malignant form of skin cancer, was diagnosed among 13 individuals within the one-mile area over the 23-year time period. Risk factors associated with melanoma include exposure to ultraviolet radiation, family history, and genetic susceptibility.
- Nine individuals were diagnosed with oral cancer or pharyngeal cancer within the one-mile radius area. The major risk factors associated with oral and pharyngeal cancer are tobacco use and heavy drinking.
- Ovarian cancer, of which there were 6 diagnoses over the 23-year time period, is associated with age, obesity, the use of fertility drugs, a family history of ovarian, breast, or colo-rectal cancer, and a personal history of breast cancer.
- Uterine cancer, of which there were 8 diagnoses over the 23-year time period, is associated with a history of pelvic radiation therapy for another cancer and race, with African American women having a two-fold increased risk over white or Asian women.

Because smoking and tobacco use are important risk factors for cancers of the oral cavity, pharynx, stomach, pancreas, esophagus as well as colo-rectal cancer, smoking history was reviewed for those 56 individuals diagnosed with one of these cancer types. Of the 45 individuals for whom tobacco use history was reported to the MCR, 20 (44%) were reported to be current or former smokers at the time of their diagnosis.

Summary

To address community concerns, a review was conducted of all types of cancer within the one-mile radius area, in addition to those 12 types of cancer discussed in the report. With the exception of six types of cancer (colo-rectal, melanoma, stomach, ovarian, uterine, and oral cavity & pharynx), the maximum number of diagnoses of any of these cancer types over the 23-year time period was four. The majority of these cancer types are mainly associated with non-environmental risk factors such as family history, genetics, smoking, diet, alcohol consumption, and other lifestyle behaviors. Environmental factors would not be expected to play a role in the incidence of these types of cancer.

Appendix B
Response to Comments on Health Consultation
Public Comment Release
Evaluation of Cancer Incidence in Census Tracts of Attleboro and Norton, Bristol County, Massachusetts: 1982-2002

Appendix B
Response to Comments on Health Consultation
Public Comment Release
Evaluation of Cancer Incidence in Census Tracts of Attleboro and Norton, Bristol County, Massachusetts: 1982-2002

The Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health's (BEH) Community Assessment Program (CAP) received comments from two individuals on the *Public Comment Release* version of the *Health Consultation, Evaluation of Cancer Incidence in Census Tracts of Attleboro and Norton, Bristol County, Massachusetts: 1982-2002* for the Shpack Landfill. These individuals are coordinators for the Citizens Advisory Shpack Team (CAST). The report was released on January 16, 2007 at a public meeting in Norton. Below are MDPH's responses to these comments. The comments have been summarized and, where possible, they have been listed together and a single response has been provided.

Comment: *The population used for the Health Consultation was not the population affected by the Shpack Landfill from 1946 to 1968. There were very few people who lived on Union Road and Sturdy Street during the period 1946 to 1968 who still lived there during the period 1982 to 2002. Also, the population of Norton changed considerably between the 1940s and 1982 and 2002. Use of the 1982 to 2002 period was problematic. The MDPH should have used Norton census and school records to establish a base population affected by the Shpack Landfill from 1946 to 1968.*

Persons who were diagnosed before 1982 or after 2002, or who lived outside of the two census tracts used, also don't register in the MPDH [sic] study, and therefore are of no concern.

Response: Evaluation of cancer incidence in Norton and Attleboro began in 1982 because this is the first year for which cancer incidence data are available through the Massachusetts Cancer Registry (MCR). Data available prior to 1982 are limited to

cancer mortality data gained through a search of the cause of death as recorded on a death certificate. An evaluation of mortality data for years prior to 1982 is of limited value because mortality data underestimate actual cancer incidence as the number of people diagnosed with cancer will likely exceed the number who die from cancer. Depending on the type of cancer, death certificates can be an inadequate source of information for identifying individuals who had cancer, as an underlying condition, or died from cancer. A more accurate assessment of cancer in a community can be obtained by evaluating cancer incidence rather than cancer mortality.

Unfortunately, the MCR is not a follow-up registry. For that reason, there are no readily available data to address this information gap.

Data through the year 2002 were the most accurate and complete data available to the Community Assessment Program (CAP) when the Health Consultation was begun. Due to the high volume of data collected and the 6-month period between diagnosis and required reporting, the most current registry data that are complete will inherently be a minimum of 2 years prior to the current date. Two additional years of data became available for this follow-up Health Consultation report and, as requested, the one-mile radius cancer incidence analysis in the 2011 Health Consultation has been updated to include these additional diagnoses.

Comment: *The MDPH did not focus on the Shpack Landfill neighborhood. The geographic area used for the Health Consultation was not the geographic area affected by the Shpack Landfill from 1946 to 1968. The census tracts used encompass a far larger area than the area affected by conditions at the Shpack Landfill from 1946 to 1968. The census tracts increased the base population making each cancer incident less significant than it would be in a more precise or smaller base.*

Response: While the Health Consultation did contain an extensive evaluation of cancer incidence in the two census tracts containing the landfill in Norton and Attleboro in Section V, Section VII contained a discussion of cancer incidence within one-mile of the

Shpack Landfill. A review of cancer patterns within a one-mile radius of the landfill for all data available at the time of the Public Comment Health Consultation showed a total of 35 different types of cancer. This indicates the presence of many different diseases, each with their own set of risk factors. This review did not display an unusual number of rare cancer types. Also, age patterns did not appear unusual in the one-mile radius around the landfill. Furthermore, no atypical spatial patterns or atypical patterns with respect to time of diagnosis were observed. However, to fully address this review comment, the Final Health Consultation will be updated to provide a more extensive discussion and evaluation of cancer incidence within the one-mile radius for 1982 forward.

Comment: *The analytical content of the report, for the most part, is not relevant. Also, there are statistical glitches in MDPH's findings. Almost none of the statistics for Norton's two census tracts could be considered significant due to the number of cases (whether observed or expected). The conclusions are rendered meaningless due to the sampling numbers.*

Response: To determine whether an elevation is occurring among individuals diagnosed with cancer in a Norton and Attleboro and the individual census tracts (CT) of each community, cancer incidence data were tabulated by gender and age group to compare the observed number of cancer diagnoses to the number that would be expected based on the statewide cancer rate. To aid in making this comparison, a statistic called an SIR or standardized incidence ratio is calculated. A complete explanation of the SIR statistic is available in Section V of this report.

Cancer incidence evaluations in smaller geographic areas, such as census tracts, often involve small numbers of diagnoses. SIRs that are calculated based on small numbers of diagnoses are inherently less stable than SIRs calculated based on greater numbers of diagnoses. As a result of the instability of incidence rates based on small numbers of diagnoses, SIRs are not calculated when fewer than five diagnoses are observed for a particular cancer type. This approach is standard practice within MDPH's Bureau of

Environmental Health and its Bureau of Health Information, Statistics, Research, and Evaluation. It should be noted, however, that even though an SIR is not calculated when there are fewer than five diagnoses, an expected number of diagnoses is calculated and compared to the observed number of diagnoses. Therefore, all diagnoses are evaluated in the Health Consultation, using appropriate methods, based on the relative number of diagnoses.

The conclusions of this report are based on many factors, not solely the statistical significance or lack of statistical significance of the SIR. SIRs as well as comparisons between the numbers of observed and expected diagnoses are used in conjunction with an evaluation of the geographic and temporal distributions of diagnoses, cancer histologies and subtypes, and risk factor information to provide a meaningful and complete picture of cancer incidence in a community.

Comment: *Based on MDPH logic (including SIR and CI) almost none of the statistics of cancer incidence in the two census tracts could be considered significant, because the number of cases (whether observed or expected) was too low for any degree of confidence.*

Response: The issue of small numbers is common in most small-area evaluations. For that reason, MDPH/BEH developed a peer-reviewed protocol for conducting small-area investigations that maximizes the use of readily-available health data. We believe that our approach best addresses community concerns and can be (and has been) the basis of recommending additional research when unusual patterns are observed. MDPH/BEH is one of the few health departments in the country that uses health outcome data to address community concerns. As discussed in the previous comment, statistics are just one tool that BEH uses to conduct health consultations.

Comment: *How many others are/or will be out there, but because they've moved away (or died) will never know of the connection with the Shpack Dump?*

Response: While the lack of access to information about in- and out-migration (or mobility) can be an important data limitation, it is important to note that the Massachusetts Cancer Registry (MCR) is a high quality cancer registry that captures more than 95% of all diagnosed cancers among Massachusetts residents and records their address at the time of diagnosis. The MCR is rated by the North American Association of Central Cancer Registries as having achieved gold standard status, the highest rating for state cancer registries. Although clearly some individuals who may have lived much of their lives in Norton or Attleboro moved away before their diagnoses, it is also true that some individuals lived elsewhere and then moved to Norton or Attleboro, where they were diagnosed with cancer.

Comment: *There is almost no mention of the carcinogenic compounds found there [Shpack Landfill] or attention given to individuals who may have been exposed to those toxins between 1946 and 1982.*

Response: The Public Health Assessment, issued concurrently with this HC, contains an evaluation of available environmental data for the site. This assessment estimates potential exposure opportunities using worst-case assumptions (e.g. maximum concentration detected in environmental media) and helps to provide a more comprehensive picture of public health hazards in the past, present, and future.

Comment: *The designation of the Shpack Site as "An Indeterminate Public Health Hazard"…"in the Past, Present and Future" is absurd. Consider the involvement of numerous government agencies and others since the discovery of contamination at Shpack in 1978, and their cost in terms of time, energy and dollars…Why would these agencies of the federal government consent to such an extensive, grueling effort and extraordinary expense to cleanup a site that did not pose a "Public Health Hazard?"*

Response: The designation "Indeterminate Public Health Hazard" is used for sites when a professional judgment on the level of health hazard cannot be made because information critical to such a decision is lacking. It is in no way meant to suggest that no

hazard existed or exists in the past, present, or future. The Health Consultation assigned this designation to the Shpack Landfill site because information on the presence and duration of human exposure, levels of contaminant concentrations, nature of toxic effects associated with each contaminant, and presence of physical hazards had yet to be evaluated by MDPH. The assignment of the Shpack Landfill site to one of the ATSDR five Hazard Categories (Urgent Public Health Hazard, Public Health Hazard, Indeterminate Public Health Hazard, No Apparent Public Health Hazard or No Public Health Hazard) is made independently of other federal agencies decisions' for remediation (or clean-up) at the site. As discussed in the Health Consultation, the designation of the Shpack Landfill site as an "Indeterminate Public Health Hazard" was assigned pending further analysis of the available environmental data in the Public Health Assessment (PHA). Additional ATSDR Hazard Categories will be assigned in the PHA based on an evaluation of available environmental data and an analysis of available health outcome data.

Comment: *Conclusions reached by MDPH: "Review of specific diagnosis (i.e. primary cancer type, histology) and geographic distribution for each child (i.e. ages 0-19) diagnosed with cancer did not suggest that an atypical pattern of cancer occurred among children in Attleboro and Norton" ignores the fact of a considerable latency period for most cancers.*

Response: The latency period is defined as the time between exposure to a cancer-causing agent and the development of the disease. As stated in the comment, we know from the medical literature that some cancer types have a long latency period, as long as several decades. Unfortunately, very little is known about the etiology of childhood cancer and latency period for cancer in children (i.e. ages 0-19). It is generally assumed that most childhood cancers have a significantly shorter latency period than adult cancers. Any child diagnosed in 1982 or later, while residing within a one-mile radius of the site, would be reported to the Massachusetts Cancer Registry and included in the one-mile radius analysis presented in the final Health Consultation.

Individuals, particularly adults, exposed to potential cancer-causing agents in the 1940s through the 1980s, could develop cancer many decades later, well into the 2000s. Because of the uncertainties about the roles of latency periods, the MDPH/BEH has monitored and will continue to monitor the incidence of all cancer types in the communities of Norton and Attleboro through city/town cancer incidence reports published by the Massachusetts Cancer Registry.

Comment: *Finally, I'm at a loss to understand the purpose of this "Health Consultation." A note of explanation at the front of the report tells me that an ATSDR health consultation is a response to a specific request for information about health risks related to a site in order to prevent or mitigate exposures which may lead to actions such as: restricting use of or replacing water supplies, intensifying environmental sampling, restricting site access, or removing contaminated material…All of the above mentioned actions are already taken care of or ongoing thanks to the site's designation under Superfund and FUSRAP.*

Response: The Massachusetts Department of Public Health/Bureau of Environmental Health (MDPH/BEH) is tasked with responding to environmental health concerns and providing communities with epidemiologic and toxicological health assessments. A cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR) allows BEH staff to work with staff from ATSDR to fulfill this mission. Work completed by BEH staff and work completed under the ATSDR cooperative agreement, such as this Health Consultation, follows a similar investigative process. A HC may often result in further restrictions relative to site access or other remedial steps well beyond those previously employed by environmental regulatory agencies charged with Superfund or FUSRAP cleanup.

A Health Consultation is also a way for ATSDR and MDPH to respond to a need for health information in a community. ATSDR Health Consultations take many forms and may provide information about concentrations of hazardous substances, exposure pathways, toxicity, health outcome data, or physical hazards. The Health Consultation

for the Shpack Landfill site contained an evaluation of cancer incidence at both the community and census tract level as well as a discussion of cancer incidence in the one-mile radius surrounding the Shpack Landfill site. In general, recommendations from this type of Health Consultation can be used as the basis for further investigation, if necessary. As stated previously, MDPH has also prepared a Public Health Assessment for the Shpack Landfill site to evaluate environmental sampling data, exposure pathways, and toxicity (MDPH 2011).

Appendix C
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 U.S. 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 followup 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 (t½)
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)

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