# Health Consultation

# Assessment of Drinking Water Quality And Cancer Incidence Scituate, MA 1987-1997

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## I. INTRODUCTION

At the request of a concerned resident and the Scituate Health Department, the Community Assessment Unit (CAU) of the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) conducted an evaluation of cancer incidence in the town of Scituate, Massachusetts. Specifically, the request initiating this investigation included concerns about cancer and the quality of the drinking water in the Third Cliff area of Scituate.

Community concern focused primarily on the incidence of leukemia and cancers of the abdomen, breast, colon, and testes in the Third Cliff area. In response to these concerns, the CAU conducted an evaluation of the incidence of cancers of the breast, kidney, liver, testes, and leukemia by smaller geographic areas in to town of Scituate with particular emphasis on the Third Cliff area. These cancer types were selected in order to address community concern regarding suspected elevations in the incidence of these cancer types and because the scientific literature suggests environmental factors (e.g., exposure to chemicals) may be associated with their development. Although concern was also expressed about the incidence of abdominal cancer and colon cancer, according to available scientific and medical literature, these cancer types are thought to be associated primarily with non-environmental factors such as family history and behavioral factors (e.g., diet). Additionally, current cancer surveillance data indicate that the rates of stomach and colon/rectal cancer in Scituate for the years 1982 to 1997 are approximately equal to what would be expected for both males and females. Therefore, these cancer types were not evaluated in this report. In addition, the CAU contacted the Massachusetts Department of Environmental Protection (MDEP) and the Town of Scituate Water Department in order to review and obtain available environmental sampling data for the Scituate municipal drinking water supply.

## II. BACKGROUND

The town of Scituate is located 23 miles southeast of Boston in Plymouth County and is bordered by the towns of Cohasset to the northwest, Hingham to the west, Norwell to the southwest, Marshfield to the south, and the Atlantic Ocean to the east and north (refer to Figure 1). Scituate is primarily a residential community and comprises an area of approximately 32 square miles with 977 residents per square mile (DHCD 2000). The 2000 U.S. Census reports a total of 17,863 residents in the town of Scituate (USDOC 2001).

The town of Scituate is divided into three smaller geographic areas or census tracts (CTs) (CTs 5051.01, 5051.02, and 5052). The Third Cliff area is located in CT 5052, in the southeastern portion of the town. The CT is the smallest geographic area for which cancer rates can be accurately calculated. Specifically, a CT is a smaller, population-based subdivision of a county. The focus of this evaluation was to analyze cancer incidence and environmental concerns in CTs 5051.01, 5051.02, and 5052 with particular emphasis on CT 5052, the location of the Third Cliff area. Census tract locations and boundaries in Scituate are also presented in Figure 1.

## III. EVALUATION OF ENVIRONMENTAL CONCERNS

In response to resident concerns, the MDEP, Division of Water Supply, and the town of Scituate Water Department were contacted to obtain and review information regarding the Scituate municipal drinking water supplies. Available information and environmental sampling data between the years 1980 to the present was evaluated.

All public water supplies in Massachusetts are sampled on a regular basis to monitor the quality and ensure the safety of drinking water. It is not unusual to detect some compounds in a drinking water supply. For this reason, the MDEP has created standards known as Massachusetts Maximum Contaminant Levels (MMCLs) for public drinking water supplies. These standards dictate the maximum concentration at which a chemical can safely exist in

drinking water. If a chemical is detected below the MMCL, that chemical is considered to be at a level that is safe for drinking water.

Available sampling data for the Scituate water supply was reviewed and a screening evaluation was conducted to identify substances that are not expected to result in adverse health effects and substances that need to be considered for further analysis to determine whether they may be of potential health concern. The screening analysis identifies maximum concentrations of contaminants detected in the water supply and compares these concentrations to MMCLs and health-based comparison values established by the ATSDR (ATSDR 1999). It should be noted that many public water supplies, including Scituate's municipal water supply, are sampled several times per year. MDEP averages results of these analyses over yearly periods and compares these averages to MMCLs to determine if chemicals present in the municipal water exist at levels safe for drinking water (MDEP 2001). Therefore, the annual average concentration of a chemical detected in a water supply is used to determine whether an exceedance of the MMCLs has occurred. For this analysis, however, the maximum concentration of a substance detected in the water supply was compared to the MMCL and appropriate health-based comparison value in order to conduct a conservative screening evaluation.

The ATSDR comparison values are specific concentrations of a chemical for various environmental media (e.g., air, soil, or water) that are used by health assessors to identify environmental contaminants that require further evaluation. These comparison values are developed based on health guidelines and assumed exposure situations that represent high estimates of human exposure (i.e., residential scenario). Chemical concentrations detected in environmental media that are less than a comparison value are unlikely to pose a health threat. However, chemical concentrations detected in environmental media above a comparison value do not necessarily represent a health threat. In order for a compound to impact one's health, it must not only be present in a certain environmental media but one must also come in contact with the compound via the contaminated media.

Therefore if a concentration of a chemical in an environmental medium (e.g., water) is greater than the appropriate comparison value, the potential for exposure to the chemical should be further evaluated to determine whether health effects may be possible. Further evaluation is necessary because the comparison values used in the screening analysis are derived based on high estimates of exposure that do not apply to all situations. They are therefore considered conservative in order to be health protective. Factors related to actual exposure that are unique to the specific situation under investigation need to be considered to determine if an adverse health effect from this chemical could occur.

## A. Municipal Water Supply

The Scituate municipal drinking water supply has been sampled on numerous occasions beginning in 1980. Currently, drinking water used by the town is sampled on a regular basis. The results of drinking water sampling are reported to the MDEP to ensure that the town's drinking water supply is in compliance with state drinking water standards. According to the MDEP, the municipal drinking water supply for Scituate is currently in compliance with state drinking water standards (Martin 2000).

The town of Scituate obtains its municipal water from several sources. The Humarock section of Scituate, located in CT 5052, receives its municipal water from the town of Marshfield. The rest of the town obtains its drinking water from six groundwater wells (wells 10, 11, 17, 18A/18B, 19, and 22) and one surface water body (Old Oaken Bucket Pond) (Martin 2000). Well 18A was removed from service in 1996 due to structural concerns, and was replaced with well 18B (Babbin 2000). Water obtained from the Old Oaken Bucket Pond is treated prior to distribution at the Old Oaken Bucket Pond surface water treatment plant. This water is treated with aluminum sulfate, carbon, and chlorine to ensure that the water is suitable for drinking and other personal uses. Water obtained from the six groundwater wells is also treated with potassium hydroxide, sodium fluoride, and other sodium compounds before it enters the water distribution system (Babbin 2000). Refer to Figure 2 for the location of these drinking water sources.

Municipal water obtained from the six groundwater wells and the surface water treatment plant is mixed within the distribution system. For example, water from groundwater well 19 flows through a short water main toward a large water main located on Route 3A. Here, water from well 19 is diluted with the flow of other water supply sources (e.g., other groundwater wells and water from Old Oaken Bucket Pond) which also enter the large water main at this junction. It is important to note that not all wells in Scituate are actively used at all times; the use and activation of the wells depends heavily upon the town's demand for water. According to the Scituate Water Division, the Third Cliff area is not located near any specific well or water supply (Babbin 2000). Therefore, water received by residents of the Third Cliff area cannot readily be differentiated from water received by residents residing in other areas of Scituate.

Both water supply sources (i.e., groundwater and surface water) have been tested for the presence of metals. Between the years 1980 to 1987, municipal water from the six groundwater wells (wells 10, 11, 17, 18A, 19, 22) and the Old Oaken Bucket Pond surface water treatment plant was sampled and analyzed for the presence of these inorganic compounds (CDM 1988). Metals, such as calcium, chloride, copper, iron, magnesium, manganese, nitrogen, potassium, sodium, and sulfate were detected in both water supplies. The maximum concentrations detected of all of the above metals were below the ATSDR health-based comparison values. The levels at which these metals were detected were also below MMCLs, with the exception of sodium (53 ppm) and iron (0.67 ppm), which were above their MMCLs of 20 ppm and 0.3 ppm, respectively.

Both the surface water supply and the groundwater supply have been sampled and tested for the presence of contamination on numerous occasions. A further discussion of the historic sampling activities for these sources and their results is presented below.

### *1. Surface Water Supply*

In 1986, water from the Old Oaken Bucket Pond surface water treatment plant was sampled by the MDEP. Two trihalomethanes (THMs), chloroform and bromodichloromethane, were

detected in water obtained from the surface water treatment plant. THMs are a family of chemicals that are formed when drinking water is chlorinated as a method of disinfection. Until recently, the MMCL for total THMs was 100 ppb (total THMs are chloroform, chlorodibromethane, bromodichloromethane, and dibromochloromethane). The federal MCL for total THMs was recently lowered to 80 ppb. Chloroform was detected in treated water from Old Oaken Bucket Pond at a maximum concentration of 130 ppb. Bromodichloromethane was detected at a maximum concentration of 11 ppb. Thus, these results indicate levels of total THMs above the previous and current MCL (100 and 80 ppb, respectively). However, as noted earlier, Scituate's drinking water is a mixed supply of surface and groundwater sources. Compliance with state drinking water standards for THMs is determined by running annual average sample results from four areas of the distribution system (e.g., tap samples). During these years, the annual average levels of THMs were below 100 ppb and therefore in compliance with state standards (CDM 1988).

### *2. Groundwater Well Water Supply*

Scituate's six groundwater supply wells were first sampled in July 1981. Wells 10, 11, 17, 18A, 19 and 22 were sampled by the MDEP and analyzed for the presence of volatile organic compounds (VOCs). No VOCs were detected in wells 11 and 17. Chloroform was detected in well 18A at a maximum concentration of 7.6 parts per billion (ppb). This concentration is below the MMCL of 100 ppb for total THMs (refer to Table 1). Trichloroethylene (TCE) was detected in well 19 during 1981 at a maximum concentration of 11.7 ppb, exceeding the MMCL of 5 ppb. Tetrachloroethylene (PCE) was detected in well 10 at a maximum concentration of 0.3 ppb, which is below the MMCL of 5 ppb. 1,1,1-Trichloroethane (TCA) was detected in both wells 19 and 22 (CDM 1988). The maximum detected concentration of TCA in 1981 (0.3 ppb) was below the MMCL of 200 ppb (refer to Table 1).

Three of these six groundwater wells were sampled again in the fall of 1984. Wells 17, 19, and 22 were re-sampled and analyzed for the presence of VOCs. Results of the analyses indicated that no VOCs were detected in wells 17 and 22. However, TCE was detected in

well 19 at a maximum concentration of 19 ppb (CDM 1988), which exceeded the MMCL of 5 ppb.

Further sampling of water from the six groundwater wells (wells 10, 11, 17, 18A, 19 and 22) was conducted in 1986 by the MDEP. These samples were analyzed for the presence of VOCs. No VOCs were detected in four of the six wells (wells 10, 11, 17, and 22). One VOC, chloroform, was detected in well 18A at a maximum concentration of 1.9 ppb (Refer to Table 1) which was below the MMCL of 100 ppb. TCE was again detected in well 19 at a maximum concentration of 12 ppb. This concentration is above the MMCL of 5 ppb. Sampling of well 19 conducted one year later, found both TCE (detected at 11 ppb) and TCA (detected at 2 ppb).

Scituate Town Hall is described by the Scituate Water Department as the very first location to receive finished water containing water from Well 19. A water sample was obtained from a utility sink in the Town Hall in 1986 and analyzed for the presence of VOCs. TCE was detected at a concentration of 6.9 ppb, exceeding the MMCL of 5 ppb (Refer to Table 1). Following these sampling results, the town of Scituate hired an environmental consulting firm, Camp, Dresser, and McKee, Inc. (CDM), to investigate the contamination at well 19.

Additional sampling activities were conducted by CDM in 1988 to further evaluate the nature and extent of TCE contamination in well 19. Eighteen groundwater-monitoring wells were installed in the vicinity of well 19. Specifically, 14 shallow monitoring wells were installed at depths ranging from 30 to 50.5 feet below ground surface and four deep monitoring wells were installed at depths ranging from 45 to 90 feet below ground. These wells were screened for the presence of VOCs. Based on the screening results, samples from 11 of the monitoring wells were sent to the laboratory for confirmatory VOC analysis. A second round of sampling was conducted for three monitoring wells to confirm results, and a third round of sampling included seven samples to evaluate temporal changes (i.e., changes over time) in VOC concentrations found in the monitoring wells (CDM 1988).

The results indicated that TCE was detected in the three deep monitoring wells installed around well 19 at concentrations ranging from 30 to 58 ppb, exceeding the MMCL of 5 ppb. PCE was also detected in these monitoring wells at concentrations ranging from 2.6 to 9.3 ppb. The maximum concentration of PCE (9.3 ppb) exceeded the MMCL for PCE (5 ppb). VOCs including toluene, PCE, and carbon tetrachloride also were detected in the shallow monitoring wells installed around well 19. The maximum concentration of toluene detected was 32 ppb, below the MMCL of 1,000 ppb. The maximum concentration of PCE detected (5 ppb) was equal to the MMCL (5 ppb). Carbon tetrachloride (11-12 ppb) was detected at a concentration exceeding its MMCL (5 ppb).

As part of the CDM investigation, water samples from well 19 and Scituate Town Hall were obtained and collected on a monthly basis. Six samples were collected from both of these locations between June and November 1988. Results of the analysis indicate that TCE was detected in well 19 during all six sampling rounds at concentrations ranging from 6.4 to 13.0 ppb. TCE was detected in water from the Town Hall during five sampling rounds at concentrations ranging from 2.5 to 9.6 ppb. The highest concentrations of TCE in water from Town Hall, 6.9 and 9.6 ppb, were detected in 1986 and 1988, respectively (refer to Table 1).

Between the years 1991 and 1998, quarterly sampling of well 19 was conducted. During this time period, the data reviewed indicated that the maximum detected concentration of TCE was 6.2 ppb. This maximum concentration is slightly higher than the MMCL for TCE of 5 ppb[1]. More recent sampling conducted in 1999 detected TCE in well 19 at a maximum concentration of 2 ppb, below the MMCL of 5 ppb. Thus, it appears that TCE in well 19 continues to be detected, although at slightly lower concentrations (e.g., < 7 ppb), in the testing conducted in the 1990s versus the concentrations detected in the 1980s (e.g., < 20 ppb).

[1] When a water supply is sampled and analyzed for chemicals several times per year, MDEP determines compliance with MMCLs by calculating a running annual average of all samples taken during a one-year period and comparing that value to the MMCL.

Based on the results of the CDM investigation, several possible sources of groundwater contamination were identified. Because of the proximity of the town municipal complex to well 19, and the known use of chlorinated solvents and degreasers discharged at the complex, CDM concluded that the source of well 19 contamination was most likely the municipal complex (CDM 1988). Several source areas were identified at the municipal complex, including an area of underground storage tanks, a vehicle maintenance area, a materials storage area, and sewage facilities. Of the monitoring wells installed in the vicinity of well 19, the highest concentrations of TCE were detected in the wells installed at the materials storage area behind the school bus parking lot and at the school bus parking lot and maintenance area. According to the CDM investigation, a contamination plume in the groundwater originates near the materials storage area and moves southwest toward well 19 (CDM 1988). However, the boundaries of the plume are not well defined due to the limited number of sampling locations.

### *3. Water Main Pipes*

In Scituate, some water mains, or large, subsurface pipes that distribute water throughout town, are lined with a vinyl plastic material. These pipes are called vinyl lined asbestos cement (VLAC) piping. In the late 1960s, VLAC piping was developed because conventional asbestos cement pipes were found to produce poor tasting water. In the late 1970s, it was discovered that VLAC pipe was capable of leaching tetrachloroethylene (PCE) into the water carried by the pipes (MDPH 1997b). This problem is more pronounced in pipes that are flushed infrequently (e.g., dead-end or low flow pipes). Although the manufacture of VLAC pipes ceased in 1980, by this time, approximately 660 miles of VLAC pipes had been installed in Massachusetts (Larsen et al 1983).

In 1980, the Massachusetts Department of Environmental Quality Engineering (now the MDEP) made recommendations to public water suppliers in Massachusetts about how to control PCE concentrations in VLAC pipes (DEQE 1980). The most effective, but most expensive, solution to the problem was to replace the VLAC pipes entirely. If replacement was not possible, a number of other measures could be implemented including installing

bleeders on dead-end pipes to increase water flow and looping dead-end water mains. In addition to these measures, the MDEP recommended, and then required, that all dead-end and low-flow areas served by VLAC pipes be tested for PCE to monitor the effectiveness of the remedial measures at keeping PCE concentrations below drinking water guidelines or standards (DEQE 1980, DEQE 1989)

VLAC water mains serve thirty areas in Scituate. Historically, these water mains were sampled at different times during some or all of the following years: 1980, 1983, 1985, and 1989. Review of available documents indicate that PCE was detected at concentrations exceeding the MMCL for PCE (5 ppb) in 15 out of the 30 locations sampled during this time period (SWD 1989). Table 2 shows the 15 locations where PCE was detected above the drinking water standard, as well as the years each location was sampled. PCE was not detected above the drinking water standard in water mains sampled in the Third Cliff area. In general, the highest concentrations of PCE were detected during the earlier years 1980 and 1985. In 1980, PCE was detected above the MCL in eight of the 15 locations sampled. The highest concentrations were detected on Turner Road (located in CT 5101.01) and Booth Hill Road (located in CT 5101.02) (Refer to Figure 3). PCE was detected in the water main located on Turner Road at a maximum concentration of 205 ppb, above the MCL of 5 ppb. PCE was also detected in the water main located on Booth Hill Road at a maximum concentration of 2,271 ppb (SWD 1989, 2000). Most of these 15 areas were serviced by dead-end water mains.

Concentrations of PCE tended to decrease with each year of sampling. In May 1980, the concentration of PCE in the water main located on Turner Road was 205 ppb. In December 1980, the concentration of PCE in this water main was 3.8 ppb. In August 1985, the concentration of PCE in this same main was 1.4 ppb. Similarly, the water main on Booth Hill Road contained 2,271 ppb of PCE in May 1980 with subsequent sampling of this water main in December 1980, November 1981, and August 1985 reveling PCE concentrations of 10, 11, and 10 ppb, respectively (SWD 1989).

During the later year of sampling (1989), three of the 12 locations sampled were found to contain PCE at concentrations above drinking water standards. These locations were the water main at Oceanside Drive, the Sanitary Landfill, and the Montessori School. The water main at Oceanside Drive, however, is not connected to any residences, businesses, or other establishments, therefore no one is exposed to this water. In addition, the water main at the Sanitary Landfill is used only to supply a lavatory and a fire hydrant; employees are supplied bottled water for drinking, thus limiting the potential for exposure to this water. The water main at the Montessori School is privately owned, and is not part of the municipal water system. According to the Scituate Water Division, the school was notified and advised of the PCE problem in this area (SWD 1989).

More recent sampling of nine of these locations was conducted in September 1999. PCE was detected at only two locations: Booth Hill Road and Conservation Way. The concentrations of PCE detected at these locations were below drinking water standards (SWD 2000).

### B. MDEP 21E Sites

Under Chapter 21E of the Massachusetts General Laws (also known as the State Superfund), the MDEP investigates potentially hazardous waste sites in the Commonwealth and conducts and oversees cleanup of these sites. The most recent information regarding sites located in Scituate was reviewed. According to the most current information (MDEP 2000b), there are 35 potentially hazardous sites in the town of Scituate. The name and location of these sites is listed on Table 3. Eight of these sites were releases reported to the MDEP prior to October 1, 1993, and 27 sites were reported after October 1, 1993. Approximately 89% (31) of these sites are petroleum releases and 11% (4) are associated with hazardous material. These 21E sites were mapped to determine their relative locations in Scituate. Refer to Figure 4 for the location of these sites.

## IV. EXPOSURE PATHWAY ANALYSIS

To determine whether residents of the Third Cliff area or the town of Scituate as a whole were, are, or could be exposed to levels of chemicals in the water supply that may potentially

produce adverse health effects, an exposure pathway analysis was conducted. The exposure pathway analysis is an evaluation of the environmental and human components that lead to exposure. The pathway analysis consists of five elements: a source of contamination, transport through an environmental medium (e.g., air, soil, water), a point of exposure, a route of human exposure, and an exposed population.

Exposure to a chemical must first occur before any potential adverse health effects can result. Five conditions must be present for exposure to occur. First, there must be a source of that chemical. Second, a medium (e.g., water, soil, sediment, air) must be contaminated by either the source or by chemicals transported away from the source. Third, there must be a location where a person can potentially contact the contaminated medium. Fourth, there must be a means by which the contaminated medium could enter a person's body (e.g., ingestion, inhalation and dermal absorption). Finally, the chemical must actually reach the target organ susceptible to the toxic effects caused by that particular substance at a sufficient dose and for a sufficient exposure time for an adverse health effect to occur (ATSDR 1993).

A completed exposure pathway indicates that exposure to humans occurred in the past, is occurring in the present, or will occur in the future. A completed exposure pathway exists when all of the above five elements are present. A potential exposure pathway exists when one or more of the five elements is missing or uncertain and indicates that exposure to a contaminant could have occurred in the past, could be occurring in the present, or could occur in the future. An exposure pathway can be eliminated if at least one of the five elements is missing and will not likely be present in the future. The discussion that follows incorporates only those exposure pathways that are important and relevant to this evaluation in Scituate.

## A. Completed Exposure Pathways

### *1. Municipal Water (Scituate Town Hall)*

Past exposures to TCE may have been possible for individuals exposed to municipal water at Scituate Town Hall. The primary way that people may have been exposed to this water is via ingestion or through dermal contact (i.e., drinking or washing hands). All of the water

samples obtained at the Town Hall were taken from a utility sink; this water is not used for consumption (Babbin 2000). Although it is unlikely that significant exposures occurred at Town Hall, no water samples were obtained from the bathroom faucets or other water outputs that may be more likely used for consumption purposes and hand washing.

Therefore, to provide a conservative evaluation of potential exposure to TCE in Town Hall water, it was assumed that individuals consumed 2 liters of water per day containing the highest concentration of TCE detected in the utility sink (9.6 ppb) at Scituate Town Hall. The calculated exposure dose (Appendix C) was lower than the lowest dose known to cause health effects in animals. This suggests that individuals exposed to TCE in Town Hall water via the ingestion route likely would not have experienced adverse health outcomes.

### *2. Municipal Water Supply (Town-Wide)*

Past exposure to TCE in the municipal water supply was possible for residents throughout Scituate. TCE has been detected at levels above the MCL in the past in water obtained from well 19, monitoring wells installed around well 19, and from Scituate Town Hall. MDPH is not aware of any past sampling and/or TCE analyses of tap water in Scituate residences or buildings using municipal water. Therefore, the potential presence of TCE in municipal water supplied to residences in Scituate in the past cannot be confirmed. However, based on the water distribution system for the town, it appears likely that the amount of TCE detected at the Town Hall was probably higher than what would have been potentially found at residences and other, more distant locations farther down the distribution system. Therefore, if TCE were present in the municipal water, it probably existed at lower concentrations than what was detected at the Town Hall, which is the first output to receive water from well 19. If it is assumed that the maximum detected concentration of TCE at Town Hall (9.6 ppb) may have reached some residences, the estimated exposures to adults or children who consumed two liters of water per day do not suggest that any adverse health effects would occur (Appendix D).

### *3. Municipal Water Mains*

In the past, individuals receiving water from VLAC pipes in Scituate may have been exposed to PCE at concentrations above state drinking water standards. This is particularly true for those residents receiving water from water mains located on Turner Road and Booth Hill Road. The primary way exposure may have occurred is through ingestion, inhalation, and dermal contact with municipal water. Because these water mains were sampled sporadically, and because remedial measures may have been implemented before and/or after samples were collected from the pipes, the concentrations of PCE to which people were typically exposed may have varied and is uncertain.

Current and future exposures to PCE in drinking water from VLAC water mains are not likely because sampling conducted since 1980 has not detected PCE in most of these mains at concentrations above the MMCL. According to the Scituate Water Department, these water mains are flushed on an annual basis, using hydrants or bleeders (devices that allow water to be released from mains). This process releases stagnant water, in order to prevent elevated concentrations of PCE (Babbin 2000). In 1996, the Town of Scituate replaced four water mains (located on Kathy's Path, Dreamwold Road, Gridley Bryant Road, and the Sanitary Landfill) containing VLAC piping material with polyvinyl chloride (PVC) piping, which does not leach PCE (Babbin 2000).

## B. Potential Exposure Pathways

### *1. Municipal Water (Scituate Town Hall)*

Recently, water samples from well 19 continue to contain TCE, although at levels below drinking water standards. The nature and extent of TCE contamination in the well 19 area is not fully understood. Therefore, future exposures to TCE via this pathway are possible. Although employees working at the Town Hall are currently supplied with bottled water for consumption, this arrangement was negotiated through a union contract, whose duration is unknown. Because it is difficult to predict if the levels of TCE may increase in the groundwater beneath well 19 in the future, the potential exists for individuals to be exposed

to elevated concentrations of this contaminant via ingestion, inhalation, or dermal exposure in the future.

### *2. Municipal Water Supply (Town-wide)*

Current and future exposures to TCE in the municipal water supply are possible for residents throughout Scituate. TCE has been detected in the past in water obtained from well 19, monitoring wells installed around well 19, and from Scituate Town Hall. Well 19 continues to be operational and continues to supply residents with drinking water. Although the municipal water supply currently complies with state drinking water standards, results of environmental sampling from well 19 indicate the continuing presence of TCE. Because the nature and extent of contamination is not fully understood, it is possible that in the future TCE may become present in the municipal water supply at concentrations above standards. However, based on the water distribution system for the town, it appears likely that any amount of TCE detected at the Town Hall is probably higher than what would be found at residences and other, more distant locations farther down the distribution system. Therefore, if TCE were to become present in the municipal water, it would probably exist at lower concentrations than what would be detected at the Town Hall, which is the first output to receive water from well 19. Further, as described previously, if it is assumed that the maximum detected concentration of TCE at Town Hall (9.6 ppb) may have reached some residences, the estimated exposures from consumption of this water to either adults or children do not indicate any adverse health effects would occur (Appendix D).

## C. Eliminated Exposure Pathways

### *1. Municipal Water (Scituate Town Hall)*

Current exposure to TCE in the municipal water supply at Scituate Town Hall is not occurring. Therefore, this represents an eliminated exposure pathway. According to the MDEP, the municipal drinking water supply for Scituate currently complies with state drinking water standards (Martin 2000). Recent water sampling data for well 19, which is the primary source of drinking water for Scituate Town Hall, indicates that although TCE is still present, levels are below drinking water standards. In addition, employees working at

the Town Hall have been supplied with bottled water for consumption purposes for several years (Sullivan 2001).

## V. EVALUATION OF CANCER INCIDENCE IN SCITUATE

### A. Methods for Analyzing Cancer Incidence Data

Cancer incidence data were obtained from the Massachusetts Cancer Registry (MCR), of the MDPH, Bureau of Health Statistics, Research, and Evaluation, which has been monitoring cancer incidence in the state of Massachusetts since 1982. All newly diagnosed cancer cases are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c. 11B). The 16-year period 1982-1997 constitutes the period for which the most recent and complete cancer incidence data were available at the time of this analysis. Cancer in general has a lengthy latency or development period that can range from 10 to 30 years and in some cases may be more than 40 or 50 years (Bang 1996, Frumpkin 1995). The latency period is the period between exposure to a disease causing agent and the appearance of manifestations of the disease (Last 1995). For the majority of tumors, the period between first exposure and the appearance of the tumor is 12 to 25 years. Therefore, this report summarizes cancer incidence data for the 11-year time period 1987-1997.

The MCR data are continually quality controlled so that corrections may be made in subsequent reports. Occasionally, the MCR research file may contain duplicate cases. For this analysis, each case of cancer was individually reviewed resulting in further refinement of the data that are included in the MCR City and Town Supplement Reports. In this evaluation, the MCR research file contained four duplicate cases of cancer.

To determine whether elevated numbers of cancer cases have occurred in the town of Scituate and each of its three CTs, cancer incidence data were analyzed by age and gender to compare the observed number of cancer cases to the number that would be expected based on the statewide cancer experience. Standardized incidence ratios (SIRs) were calculated for the

time period 1987-1997 for the five cancer types evaluated (i.e., breast, kidney, leukemia, liver, testes).

Specifically, an SIR is the ratio of the observed number of cancer cases to the expected number of cases multiplied by 100. An SIR of 100 indicates that the number of cancer cases observed in the population evaluated is equal to the number of cancer cases expected. An SIR greater than 100 indicates that more cancer cases occurred than expected and an SIR less than 100 indicates that fewer cancer cases occurred than expected. For example, an SIR of 150 is interpreted as the occurrence of 50% more cases than expected. Likewise, an SIR of 90 indicates the occurrence of 10% fewer cases than expected.

To determine if the observed number of cases is significantly different from the expected number, or if the difference may be due solely to chance, a 95% confidence interval (95% CI) was calculated for each SIR (Rothman and Boice 1982). A 95% CI assesses the magnitude and stability of an SIR. 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 5% chance that the observed difference is the result of random fluctuation in the number of observed cancer cases. When an SIR is statistically significant, as indicated by an * symbol, there is a less than 5% chance that the observed number of cases is due to chance alone. SIRs and 95% CIs are not calculated when the observed number of cases is less than five. A more detailed explanation of the SIR and 95% CI is provided in Appendix A.

The geographic distribution of cancer cases in Scituate was determined using available address information from the MCR indicating residence at diagnosis. This information was mapped for each individual using a computerized geographic information system (GIS) (ArcView 1996). This allowed for the assignment of CT location for each case as well as an evaluation of the spatial distribution of cases at a smaller geographic level (i.e., neighborhoods). The geographic distribution was assessed using a qualitative evaluation of the point pattern of cases within the town. In instances where the address information was

incomplete (i.e., did not include specific streets or street numbers), efforts were made to research those cases using town residential lists issued within two years of an individual's diagnosis and site visits to the area.

The MCR routinely collects data related to risk factors for individual cancer cases (e.g., age, occupation). The available risk factor information from the MCR was evaluated for breast cancer, testicular cancer, leukemia, kidney cancer, and liver cancer. However, information about personal risk factors (e.g., family history, hormonal events, and diet) which may also influence the development of cancer, is not collected by the MCR and, therefore, could not be evaluated in this investigation.

## B. Results of Cancer Incidence Analysis

Tables 4 through 7 summarize cancer incidence data town-wide in Scituate and for each census tract for the time period 1987 to 1997. Figure 1 illustrates the location and boundaries of the three census tracts in Scituate. The following sections present results for Scituate as a whole and for each census tract.

### *1. Cancer Incidence in Scituate as a Whole (Table 4)*

During the time period 1987-1997, breast cancer among females occurred above the expected rate (164 cases observed versus approximately 124 cases expected; SIR = 132). This elevation was statistically significant (95% CI = 112-154). No breast cancer cases were observed among males in Scituate. Kidney cancer also occurred more often than expected, although not significantly, overall and among both males and females when evaluated separately. Testicular cancer among males occurred slightly more often than expected town-wide. Five cases were observed among males and approximately four cases were expected (SIR=117). Liver cancer occurred less often than expected in Scituate during the years evaluated (two cases observed versus approximately four cases expected).

Overall, leukemia occurred more often than expected. Among both males and females combined, 17 cases were observed and approximately 14 cases were expected (SIR=122).

This elevation, based on an increase of approximately three cases, was not statistically significant. Among males, leukemia occurred less often than expected (five cases were observed and approximately eight cases were expected). Among females leukemia occurred more often than expected. Twelve cases were observed among females when approximately six cases were expected (SIR=196). This elevation was borderline statistically significant (95% CI=101-342). These data are summarized in Table 4.

### *2. Cancer Incidence in Census Tract 5051.01 (Table 5)*

Census Tract 5051.01 is located in the northeast part of Scituate. During the time period 1987-1997, cancer incidence in CT 5051.01 among both males and females combined occurred more often than the expected rates for two of the five cancer types evaluated. No cases of liver or testicular cancer occurred in this census tract during 1987-1997. Among females, breast cancer occurred more often than expected (54 cases observed versus approximately 40 cases expected; SIR=135). This elevation was borderline statistically significant (95% CI = 101-176). No cases of breast cancer occurred among males.

Kidney cancer also occurred more often than expected in CT 5051.01. Overall, 11 cases were observed when approximately six were expected (SIR=184). Leukemia occurred about as often as expected among both males and females combined. Overall, five cases were observed and approximately five cases were expected (SIR=109). Among males, leukemia occurred less often than expected. One case was observed among males and approximately three cases were expected. However, among females, leukemia occurred slightly more often than expected. Four cases were observed among females when approximately two cases were expected.

### *3. Cancer Incidence in Census Tract 5051.02 (Table 6)*

Census tract 5051.02 comprises the central and western part of the town of Scituate adjacent to Cohasset and Norwell. Between the years 1987-1997, cancer incidence among males and females combined in this census tract, with the exception of breast cancer, generally occurred at expected rates for the five cancer types evaluated. Breast cancer among females occurred more often than expected. Forty-nine cases were observed when approximately 32 cases

were expected (SIR=153). This elevation was statistically significant (95% CI=113-202). No cases of breast cancer were observed among males in this census tract. Testicular cancer among males occurred at the expected rate (one case was observed and approximately one case was expected).

Kidney cancer occurred less often than expected. Among both males and females combined, three cases of kidney cancer were observed when approximately five were expected. Leukemia also occurred less often than expected among both males and females combined (three cases were observed when approximately four cases were expected). No cases of leukemia were observed among males. Among females, leukemia occurred slightly more often than expected (three cases were observed and approximately two cases were expected).

### *4. Cancer Incidence in Census Tract 5052 (Table 7)*

Census Tract 5052 is located in the southeast portion of Scituate and contains the Third Cliff area. During the time period 1987-1997, breast cancer among females in CT 5052 occurred slightly more often than expected. Sixty cases were observed where approximately 52 were expected (SIR=116). This elevation, however, was not statistically significant. No cases of breast cancer were observed among males. Testicular cancer among males occurred slightly more often than expected. Four cases were observed and approximately two cases were expected.

Kidney cancer occurred about as often as expected. Overall, seven cases were observed while slightly more than seven cases were expected. Leukemia occurred slightly above the expected rate among males and females combined. Overall, eight cases were observed and approximately six cases were expected (SIR=139). This increase was due to one additional case that occurred among males and females in this census tract. Among males, leukemia occurred slightly more often than expected (four cases observed versus approximately three cases expected). Among females, leukemia occurred slightly more often than expected (four cases observed versus approximately three cases expected). None of these elevations in leukemia incidence were statistically significant.

### *5. Geographic Distribution*

Place of residence at the time of diagnosis was mapped for all five cancer types evaluated. In addition to determining the census-tract-specific incidence ratios for each cancer type, a qualitative evaluation was conducted to determine whether any specific cancer type appeared to be concentrated in any area(s) of the CTs in Scituate, particularly CT 5052, the location of the Third Cliff area. The geographic distribution of cancer cases on Booth Hill Road and Turner Road was also evaluated as part of this investigation.

Evaluation of these data showed that there were no apparent spatial patterns of any particular cancer type at a smaller geographic level (i.e., neighborhoods) within the three CTs in Scituate. Although leukemia among females and males and females combined, testicular cancer among males, and breast cancer among females occurred more often than expected in CT 5052 (the location of Third Cliff), no geographic patterns were observed among these cancer types.

Because the primary area of resident concern is the Third Cliff area of Scituate, located in CT 5052, and because high levels of PCE were detected in VLAC municipal water mains on Booth Hill Road and Turner Road, the CAU reviewed and analyzed data obtained from the MCR on all persons residing in these areas who were diagnosed with cancer between the years 1987-1997. These data were reviewed and analyzed for all cancer types reported to the MCR (e.g., cancers of the bladder, brain, breast, cervix, colon, esophagus, Hodgkin's Disease, kidney, larynx, leukemia, liver, lung, non-Hodgkin's lymphoma, oral cavity, ovary, pancreas, prostate, stomach, testis, and uterus). Place of residence at time of diagnosis was mapped for each individual. A qualitative evaluation was conducted to determine if any cancer types appeared concentrated in the Third Cliff area or on Booth Hill Road and/or Turner Road. Review of the geographic distribution of these individuals displayed an even and random distribution. The cancer types that did occur in the Third Cliff neighborhood and on Booth Hill Road and Turner Road were of various types and displayed no unusual pattern with respect to age, year of diagnosis or gender when compared to established incidence trends for cancer.

## *6. Evaluation of Cancer Risk Factors*

Cancer is not just one disease but is a term that describes a wide variety of diseases. As such, epidemiological studies have shown that different cancer types have separate causes, patterns of incidence, risk factors, latency periods (i.e., period between exposure and development of disease), characteristics and trends in survival. Five types of cancer were evaluated in this investigation. Therefore, available risk factor information from the MCR was evaluated for these five cancer types (breast, kidney, testis, liver, and leukemia). For leukemia cases, information pertaining to the histology (or cell type) of individual leukemia cases was reviewed. Information for cases reported with these cancer types in Scituate was compared to known or established incidence trends to assess whether an unexpected or atypical pattern exists among the individuals diagnosed.

### a. Breast Cancer

The risk of developing breast cancer can be influenced by a number of factors. Epidemiological studies have determined some well-established risk factors for this cancer type. The most well established risk factors for breast cancer are related to genetics and specific reproductive events in a woman's life, such as age at first pregnancy, number of births, and age at menopause (Kessler 1992). Other factors such as a woman's age and demographic characteristics (e.g., socioeconomic status) are known to increase breast cancer risk. More recent research on breast cancer has included evaluation of the possible contributions of occupation or environmental factors in breast cancer development.

#### *1) Gender Distribution*

Breast cancer is the most common cancer diagnosed among women in the United States, accounting for almost 30% of all newly diagnosed cancers among females (Henderson et al. 1996). All individuals diagnosed with breast cancer between 1987 and 1997 in Scituate were women.

*2) Age Distribution*

Breast cancer has the highest incidence rate of all cancers among women ages 35 and above, with higher incidence rates in the older age groups (Devesa et al. 1995). Breast cancer incidence and age have been shown to be related where the incidence increases from age 35 to 45, increasing at a slower rate from age 45 to 50, and at a steeper rate in post-menopausal women after age 50 (Kessler 1992). This pattern was observed among the women diagnosed with breast cancer in Scituate where, female breast cancer incidence in Scituate increased with increasing age. Approximately 76% of women diagnosed with breast cancer during the time period evaluated were over age 50. According to the American Cancer Society (ACS), approximately 77% of new cases of breast cancer occur in women over age 50 (ACS 1999).

It should also be noted that the population of women in Scituate age 45 and over rose by nearly 20% during the 10-year time period, 1990-2000 (USDOC 1990, USDOC 2000). The number of breast cancer cases diagnosed in women age 45 and over in Scituate also increases over the duration of this time period. Because breast cancer is typically diagnosed in women over age 45, the increase in the population of this particular age group of women in Scituate may play a role in the increase in breast cancer diagnoses from 1990 to 2000.

*3) Socioeconomic Status*

Research indicates that women of higher socioeconomic status have an increased incidence of breast cancer when compared with women of lower socioeconomic status (Henderson et al 1996). It is unlikely, however, that socioeconomic status, in itself, is a risk factor for breast cancer. Rather, socioeconomic status is likely an indicator of the presence of other risk factors for breast cancer, like differences in breast cancer screening rates, patterns of reproductive behavior, occupational backgrounds, and lifestyle factors (i.e., diet, cultural practices). Scituate, when ranked by 1990 U.S. Census median family income data (an indicator of socioeconomic status), falls within the top 17% of all Massachusetts cities and towns. In addition, individuals residing in Scituate generally have higher per capita incomes and education levels than the "average" person living in Massachusetts (MDPH 2001).

*4) Staging of Disease at Time of Diagnosis*

Staging categorizes the extent of disease and its spread at the time of diagnosis. Breast cancer survival correlates strongly with an early stage diagnosis of cancer, especially with cancer limited to the breast (local or Stage I). Screening improves the odds of breast cancer diagnosis at an early stage. Hence, an evaluation of staging information can help to determine whether a greater percentage of breast cancer patients in a given area are being diagnosed at an early or late stage disease. This information can then be used to identify cancer patterns within communities where further public health intervention may be warranted. Such information may serve to indicate whether individuals residing in Scituate are receiving adequate breast cancer screening. An increased use of screening results in early detection of the cancer, therefore increasing the town-wide incidence of the cancer.

Review of staging information for the women diagnosed with breast cancer in Scituate between 1987 and 1997 indicates that the majority of individuals (i.e., approximately 63%) were diagnosed at an early stage of the disease. This pattern was true for the town as a whole and for all three CTs. The percentage of women in Massachusetts diagnosed with early stage breast cancer in the 1987 to 1997 time period is also about 63%. Staging information was unknown for approximately 4% of the women. Breast cancer was generally detected during an early stage of the disease in most women diagnosed with this cancer in Scituate during the time period evaluated. This increase observed in the incidence of breast cancer in Scituate may, therefore, be related to individuals in Scituate generally receiving adequate or increased breast cancer screening.

**b. Kidney Cancer**

*1) Age Distribution*

Epidemiological studies have shown that incidence rates of kidney cancer rise with increasing age before reaching a plateau at approximately age 70 (McLaughlin 1996). This pattern was observed among the individuals diagnosed with kidney cancer in Scituate. The

incidence of kidney cancer generally increased in the town with increasing age, with 57% of the cases diagnosed over the age of 60 years.

*2) Smoking Status*

Smoking is a major risk factor for the development of kidney cancer. Smoking status at time of diagnosis was reviewed for those individuals diagnosed with kidney cancer in Scituate to determine whether smoking may have played a role in the development of this cancer. Unfortunately, smoking status information was unknown for nearly half (43%) of the individuals diagnosed with kidney cancer during the time period evaluated in. Seven individuals reported being either a current or former smoker at time of diagnosis and five reported having never smoked. Due to the limited data, the role that smoking may have played in the incidence of kidney cancer in Scituate is unclear. Smoking, however, may have been a contributing factor in the diagnosis of some individuals with kidney cancer in Scituate.

*3) Occupation*

The CAU also reviewed occupation as reported to the MCR for males and females diagnosed with kidney cancer and residing in Scituate during the 1987-1997 time period. This information was reviewed to determine whether occupational factors may have contributed to the development of kidney cancer in some individuals in the town.

Some occupational exposures to particular chemicals are thought to increase the risk of developing kidney cancer. Exposure to cadmium is associated with an increased incidence of kidney cancer (Linehan WM et al, 1997). In addition, some studies have shown an increased incidence of this cancer type among leather tanners, shoe workers, and workers exposed to asbestos. For the majority of individuals (57%), the occupational data were incomplete (i.e., listed as unknown or retired) to define exposure potential. However, for those individuals for which an occupation was listed, none have been suggested to be associated with the development of kidney cancer. It should be noted, however, that the occupational

information reported to the MCR is generally limited to job title and often does not include specific job duty information that could further define exposure potential for individual cases.

### c. Leukemia

Leukemia is the most common type of cancer diagnosed among children. However, leukemia also occurs among adults, usually of older ages. There are four main types of leukemia with notable differences in the age distribution by type (NCI 1996). Acute lymphocytic leukemia (ALL) is most common among children. Chronic lymphocyte leukemia (CLL) rarely occurs before age 30, after which the incidence increases rapidly with increasing age. The majority of CLL cases (i.e., 90%) occur in people over 50 years old. Acute myeloid leukemia (AML) displays the highest incidence among young and middle aged adults. Chronic myelocytic leukemia (CML) can occur at any age, but is most often observed in individuals from age 30-50 years old.

#### *1) Gender Distribution*

According to the epidemiologic literature, rates for all types of leukemia are higher among males than among females. This trend was not observed among individuals diagnosed with leukemia in Scituate. Leukemia occurred more often among women than among men for CTs 5051.01 and 5051.02 and for the town as a whole for the time period 1987-1997. Leukemia occurred equally among men and among women in CT 5052.

#### *2) Age Distribution*

In Scituate, the average age of females diagnosed with leukemia was approximately 68 years. The majority of the cases (92%) were greater than 50 years old at the time of diagnosis. All individuals over age 45 who were diagnosed with leukemia were diagnosed with either AML, CLL, or CML. No cases of childhood leukemia were reported in Scituate during the time period 1987-1997.

*3) Histology (Cell Type)*

In Scituate, review of the histologies of each leukemia case indicated a distribution expected for adult leukemia. Approximately 59% of the individuals diagnosed with leukemia between the years 1987-1997 were diagnosed with CLL and AML. Leukemia occurred significantly more often than expected among women for the town as a whole during the time period 1987-1997. Women diagnosed with leukemia in Scituate during this time period, however, were diagnosed with several different types of leukemia. No particular histology of leukemia appeared prevalent in women diagnosed with this cancer in Scituate during the time period evaluated.

*4) Occupation*

The CAU reviewed occupation as reported to the MCR for individuals diagnosed with leukemia to determine whether occupational factors may have contributed to the development of leukemia in some individuals in the town.

Some occupational exposures to particular chemicals are thought to increase the risk of developing certain kinds of leukemia. Exposure to ionizing radiation, chronic, high-dose exposure to pesticides, and other chemicals such as benzene, are all thought to increase the risk of developing certain types of this disease (Linet and Cartwright 1996, LSA 1999, NCI 1996). Two individuals residing in CTs 5051.01 and 5052 reported occupations in which exposure to some of the chemicals listed above may have been possible. For many individuals, the occupational data were insufficient to define exposure potential, and therefore, it could not be determined what role occupation may have played in the development of leukemia in these individuals.

### d. Testicular Cancer

Testicular cancer among males in Scituate occurred slightly more often than expected for the town as a whole. For CT 5051.01 and CT 5051.02, testicular cancer occurred approximately equal to expected rates. In CT 5052, the CT where the Third Cliff neighborhood is located, testicular cancer occurred more often than expected (four cases were observed when approximately two were expected).

#### *1) Age Distribution*

The majority of individuals diagnosed with testicular cancer in Scituate were between the ages of 20 and 44; testicular cancer is one of the most frequently diagnosed cancers among men of this age group (Schottenfeld 1996).

#### *2) Occupation*

Certain occupations, like PVC manufacturing, mining, food and beverage processing, employment in the utilities industry, and employment in the leather industry, are associated with an increased risk of developing testicular cancer (Knight et al. 1996). Some research has also suggested that occupational exposure to extremely low and extremely high temperatures may increase the risk of developing testicular cancer (Zhang et al. 1995). Occupation as reported to the MCR was reviewed for each case of testicular cancer in Scituate. This information was reviewed to determine whether occupational factors might have contributed to the development of this disease. Review of this information did not reveal any occupations that have been suggested as associated with testicular cancer.

### e. Liver Cancer

In the town of Scituate as a whole, liver cancer occurred less often than expected for the time period 1987-1997 (two cases observed versus about four cases expected). Both cases of liver

cancer occurred in CT 5051.02, located in the southwestern portion of the town. Approximately one case of liver cancer was expected to occur during the time period evaluated in CT 5051.02. No cases of liver cancer occurred in CT 5052, the location of the Third Cliff Area.

*1) Gender Distribution*

Liver cancer is most commonly diagnosed among males in the United States (El-Serag et al 1999). Both individuals who were diagnosed with liver cancer between 1987 and 1997 in Scituate were male.

*2) Age Distribution*

The risk for developing liver cancer increases with age with most cases of this cancer being diagnosed in individuals over age 55 (London and McGlynn 1996). Both individuals diagnosed with liver cancer in Scituate during the time period evaluated were over age 55 at the time of diagnosis.

*3) Occupation*

Vinyl chloride is a known human carcinogen and occupational exposure to this chemical (e.g., via PVC manufacturing) has been associated with the development of liver cancer (London and McGlynn 1996). Unfortunately, occupational information available through the MCR for the individuals diagnosed with liver cancer in Scituate was not complete. Therefore, the role that occupation may have played in the development of liver cancer in these individuals in unclear.

## VI. DISCUSSION

As previously mentioned, it is not unusual to detect different types of compounds in a public drinking water supply. In the past, several different compounds have been detected in Scituate's municipal drinking water supply. THMs, a group of chemicals formed during routine drinking water disinfection processes, have been found in several wells and in the

surface water supply. These compounds are typically found in any drinking water supply that uses chlorination as a disinfection method. TCE, a chemical degreasing agent, has been detected in Scituate municipal drinking water well 19. On some occasions the concentration of TCE in well 19 exceeded the MMCL. Sampling of municipal water at Scituate Town Hall in the past also has shown levels of TCE above the MMCL. However, exposure dose calculations indicate that persons exposed to the highest concentration of TCE detected in Scituate's drinking water would not experience adverse health effects as a result. Because Scituate Town Hall is the first location to receive water from well 19, the highest concentrations of TCE have probably been detected there, as opposed to other more distant locations. Currently, Scituate's drinking water supply is in compliance with state and federal drinking water standards. However, because monitoring wells installed near well 19 continue to show the presence of TCE at concentrations above the MMCL and because well 19 remains operational, the potential exists for residents to be exposed to TCE at concentrations above the MMCL in the future. The town of Scituate is currently working with the MDEP to address this issue. The MDPH supports this collaboration.

Currently, there is no conclusive evidence that TCE in drinking water causes leukemia or other types of cancer in humans. One scientific study indicated that pregnant women exposed to drinking water contaminated with high levels of TCE (e.g., 267 ppb) had a higher risk of bearing a child who would develop leukemia (MDPH 1997c). This cancer risk was not associated directly with the women who consumed the TCE contaminated water, but with the offspring of the women who consumed the TCE contaminated water. The findings of this study and other studies concerning the carcinogenic potential of PCE, however, are not conclusive. Although leukemia was elevated in Scituate, no children were diagnosed with leukemia in the time period evaluated. The increase of leukemia was primarily among females in the town as a whole, but when reviewed by smaller geographic areas at the census tract level, no pattern was observed that would indicate a cluster or increase in any one particular area of the town, including the Third Cliff Area.

Although some studies have shown an association between drinking water contaminated with TCE and leukemia, others have found no definitive evidence for an excess of cancer

in people exposed. A recent groundwater monitoring study, found that the average levels of TCE present in groundwater are approximately 7 ppb, exceeding both the comparison value and current drinking water standards. Occupational studies of workers exposed to unmeasured levels of TCE in air have been unable to provide definitive evidence for an increased cancer risk and are often limited by multiple chemical exposures and small numbers of study participants (ATSDR 1997b). When laboratory rats and mice ingested high doses of TCE (e.g., 500 mg/kg/day) every day for their entire life, they developed tumors in the lungs, liver, and testes (ATSDR 1997b).

Some VLAC water main pipes in Scituate were found to contain elevated levels of PCE (above the MMCL) in the past. The highest concentrations were found in dead-end mains on Booth Hill Road and Turner Road. Because historical sampling data is not available for many of the areas known to receive water from VLAC pipes, it is not possible to accurately determine what concentration of PCE residents may have been exposed to in the past.

In 1997, MDPH/BEHA conducted a health consultation in a Massachusetts community that also contained VLAC municipal water mains and, subsequently, PCE within the water contained in these mains. As part of this previous analysis, the maximum daily PCE exposure dose was calculated considering that PCE existed in the VLAC water mains at a maximum concentration of 3,500 ppb. It was concluded that the highest possible PCE dose for adults or children would have always been at least ten times lower than the dose at which non-cancer health effects of PCE have been observed in animals (about 5,000 ppb/kg/day) (MDPH 1997b). Therefore, because the maximum concentration of PCE in VLAC water mains in Scituate (2,271 ppb) was less than 3,500 ppb, maximum daily doses of PCE to individuals drinking water from these mains would also be well below the dose at which non-cancer health effects have been observed in animals. Thus, exposure to these levels of PCE found in water mains in Scituate and particularly on Booth Hill Road and Turner Road are not expected to result in adverse, non-cancer health effects in individuals consuming this water.

Some scientific animal studies have associated exposure to PCE with the development of cancer (ATSDR 1997a). The highest concentrations of PCE detected in the water contained in VLAC mains on Booth Hill Road and Turner Road were 2,271 and 205 ppb, respectively. If these concentrations remained consistent for 30 years throughout all areas where the VLAC pipes are located, individuals residing on these roads and consuming water from these mains could be at a higher risk of developing cancer than individuals not consuming water containing this level of PCE (MDPH 1997b). Chemical analysis of water from these mains, however, did not reveal a consistent PCE concentration. In fact, other than the sampling events on Booth Hill Road and Turner Road in 1980, all levels of PCE were at consistently lower levels (i.e. 11 ppb or less). Therefore, because the levels of PCE in the water mains on Booth Hill Road and Turner Road do not appear to be consistently high, it is not likely that exposure to PCE in these mains would contribute to an increased risk of cancer development in individuals consuming this water. In addition, no atypical pattern of cancer incidence was observed on the roads services with VLAC pipes.

Review of cancer incidence data for the town of Scituate during the years 1987-1997 does not suggest any unusual or unexpected patterns for any of the five cancer types evaluated. Breast cancer, however, occurred significantly more often than expected in the town as a whole and Scituate CT 5051.02. Review of breast cancer risk factors (e.g., gender, age, socioeconomic status) and distribution patterns (e.g., geographic distribution, staging) available through the MCR or other data sources did not reveal any unusual patterns or trends that were inconsistent with established incidence patterns for breast cancer. It should be noted that information regarding several, highly important risk factors for breast cancer (e.g., family history, age at menarche, age at first birth, age a menopause) were not available through the MCR and, thus, could not be evaluated. Also, scientific literature does not suggest any associations between environmental exposures, including exposure to TCE or PCE in drinking water, and the development of breast cancer.

Leukemia among females in the town as a whole also occurred significantly more often than expected for the time period evaluated. In contrast with the typical epidemiology of the disease, leukemia occurred more often among females than males in Scituate. However,

further evaluation of these cases did not reveal any specific trends or common patterns among these individuals.

When evaluated by CT, both leukemia (among both males and females) and testicular cancer were slightly elevated in CT 5052, the census tract containing the Third Cliff area. Both elevations were due to an increase of less than three cases above the expected number of cases. Breast cancer also occurred more often than expected in CT 5052, although the increase was not statistically elevated from expected. When evaluated by gender, both breast cancer and leukemia occurred more often among females for all three CTs evaluated. Among males, leukemia and breast cancer generally occurred less often than expected, and testicular cancer occurred more often than expected overall and in CT 5052. Kidney cancer among males occurred slightly more often than expected, although not significantly, in CT 5051.01. Due to the small number of cases, in many instances SIRs and 95% CIs could not be calculated. Therefore, the elevation in the rates of occurrence of these cancer types is difficult to interpret statistically and are somewhat unstable.

Review of the distribution of cancer cases according to various risk factors (e.g., age, smoking, and occupation) did not reveal any pattern or trend that was unexpected or inconsistent with established incidence patterns for the five cancer types evaluated. Based on this review of cancer incidence data, no unusual patterns or unexpected trends of cancer incidence were observed in the town of Scituate as a whole, or in any of its three census tracts. In addition, no spatial pattern of any particular cancer type was noted in relation to the Third Cliff area, or Booth Hill Road and Turner Road.

It should be noted that this evaluation reviewed available data for risk factors related to cancer types in this report. The cancer types evaluated in this report have a number of other risk factors that were not evaluated as part of this analysis. Additional information regarding known or suspected risk factors for the five cancer types evaluated in this report is attached in Appendix B.

## VII. CONCLUSIONS

- Cancer incidence in the Third Cliff Area of Scituate between 1987 and 1997 was no greater than expected. Although some individuals residing in this area were diagnosed with cancer during the time period evaluated, the cancers were of various types and were not geographically distributed in an atypical pattern. In addition, the pattern of cancer incidence in this area did not suggest a relationship to drinking water quality or any other common environmental factor.

- In the past, Scituate residents connected to the municipal water supply may have been exposed to levels of TCE, PCE, and THMs above the MMCLs for drinking water. However, based on the data reviewed, it does not appear likely that local residents were exposed to significant concentrations of TCE and THMs, which would result in adverse health outcomes.

- Insufficient sampling data exists to determine if individuals obtaining water from VLAC pipes in Scituate, particularly those on Booth Hill Road and/or Turner Road, may have been exposed to elevated levels of PCE in the past. However, review of cancer incidence data for all cancer types through the MCR do not indicate any unusual patterns of incidence or unexpected trends in either of these areas.

- During the time period 1987-1997, breast cancer occurred more often than expected in Scituate as a whole, and in each of its CTs. These elevations were statistically significant in the town as a whole and in CT and 5051.02. However, review of the breast cancer incidence data available through the MCR did not indicate any unusual patterns of incidence or unexpected trends. Therefore, the elevations observed in breast cancer incidence do not appear to be related to any particular common factor (environmental or non-environmental).

- During the time period 1987-1997, leukemia among females occurred statistically significantly more often than expected in the town as a whole. Review of leukemia

incidence data available through the MCR, however, did not indicate any unusual patterns of incidence or unexpected trends. Therefore, these elevations observed in leukemia incidence do not appear to be related to a common environmental or non-environmental factor.

- There were no unusual geographic patterns for any one of the five cancer types reviewed in Scituate or its three CTs. Further, no geographic pattern of cancer cases was observed in relation to Booth Hill Road and Turner Road, areas with elevated levels of PCE due to the presence of dead-end VLAC water mains, potentially hazardous waste sites as identified by MDEP, or in the Third Cliff area.

- ATSDR requires that one of five conclusion categories be used to summarize findings of a health consultation. These categories are as follows: (1) Urgent Public Health Hazard; (2) Public Health Hazard; (3) Indeterminate Public Health Hazard; (4) No Apparent Public Health Hazard; (5) No Public Health Hazard. A category is selected from site-specific conditions such as the degree of public health hazard based on the presence and duration of human exposure, contaminant concentration, the nature of toxic effects associated with site-related contaminants, presence of physical hazards, and community health concerns. Based on ATSDRs criteria, ATSDR would classify the Scituate municipal water supply, in the past and the future, as posing an Indeterminate Public Health Hazard, due to absence of complete environmental sampling data for VLAC water mains and municipal well 19. Currently, the Scituate municipal water supply would be categorized as posing No Apparent Public Health Hazard, based on review of available environmental sampling data and community specific cancer incidence data.

## VIII. RECOMMENDATIONS

- The MDPH recommends no further investigation of cancer incidence in Scituate at this time but will continue to monitor cancer incidence in the town through the Massachusetts Cancer Registry.

- The MDPH recommends continued quarterly monitoring of groundwater from well 19 to ensure the municipal drinking water supply continues to comply with state drinking water standards and to prevent potential future exposures.

- The MDPH will review any additional environmental sampling data for well 19 or for VLAC water mains, as it becomes available, at the request of local officials and Scituate residents.

- The MDPH supports further work by MDEP and the town of Scituate to characterize the nature and extent of contamination at public well 19.

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Figure 1
Location of Census Tracts
Scituate, Massachusetts

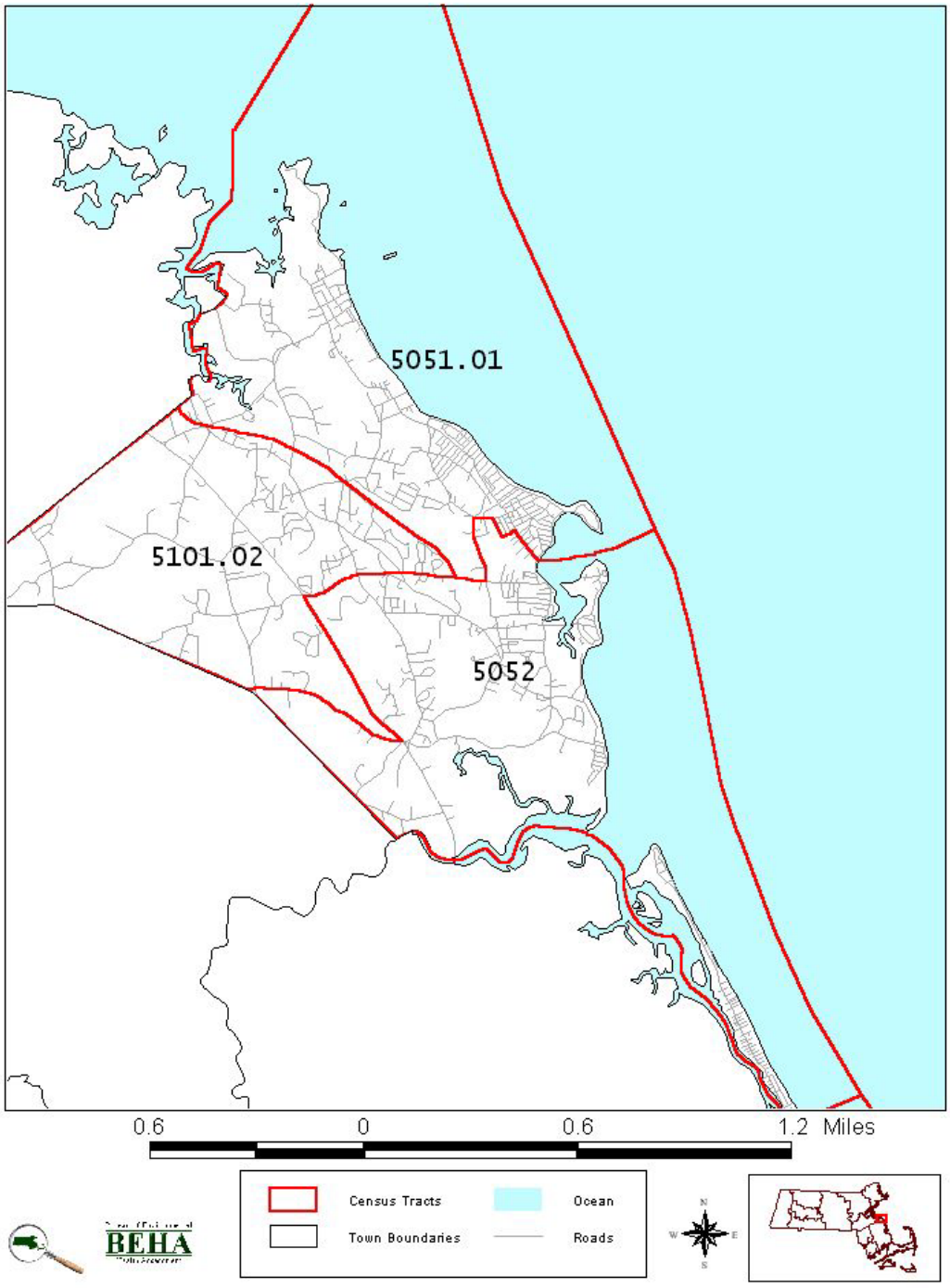

Figure 2
Location of Municipal Water Supplies
Scituate, Massachusetts

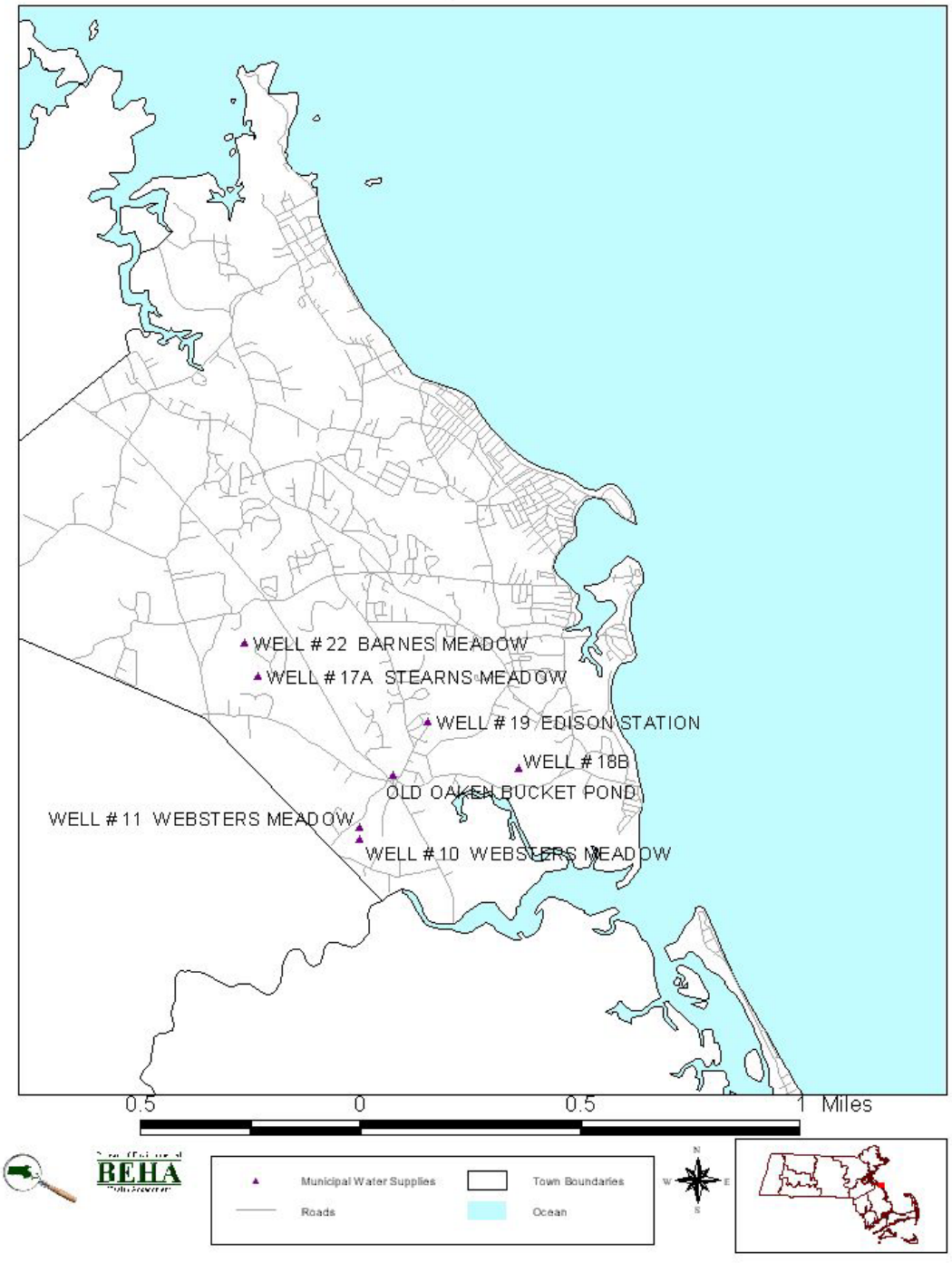

Figure 3
Locations of Booth Hill Road and Turner Road
Scituate, Massachusetts

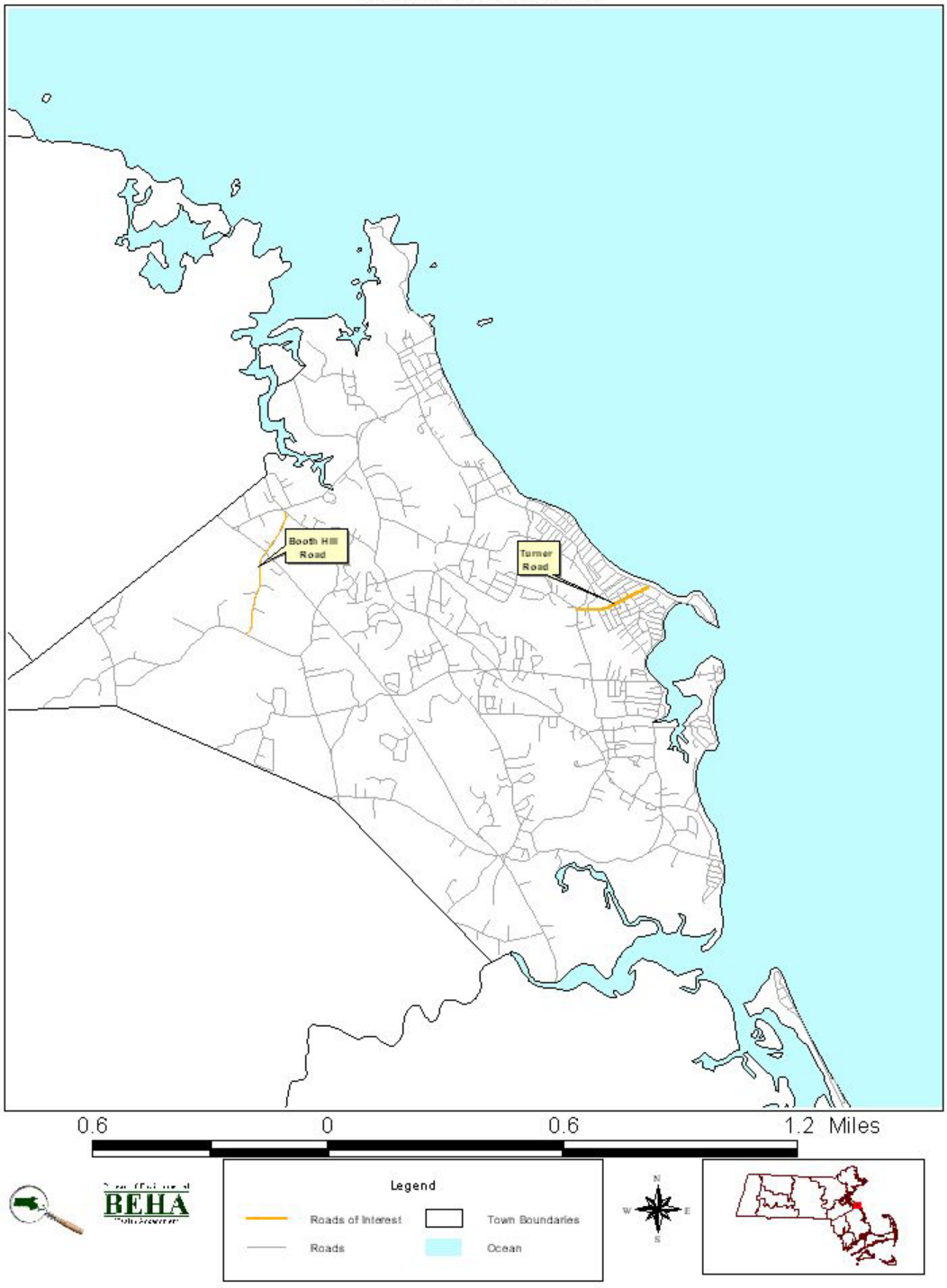

Figure 4
Location of MDEP 21E Sites
Scituate, Massachusetts

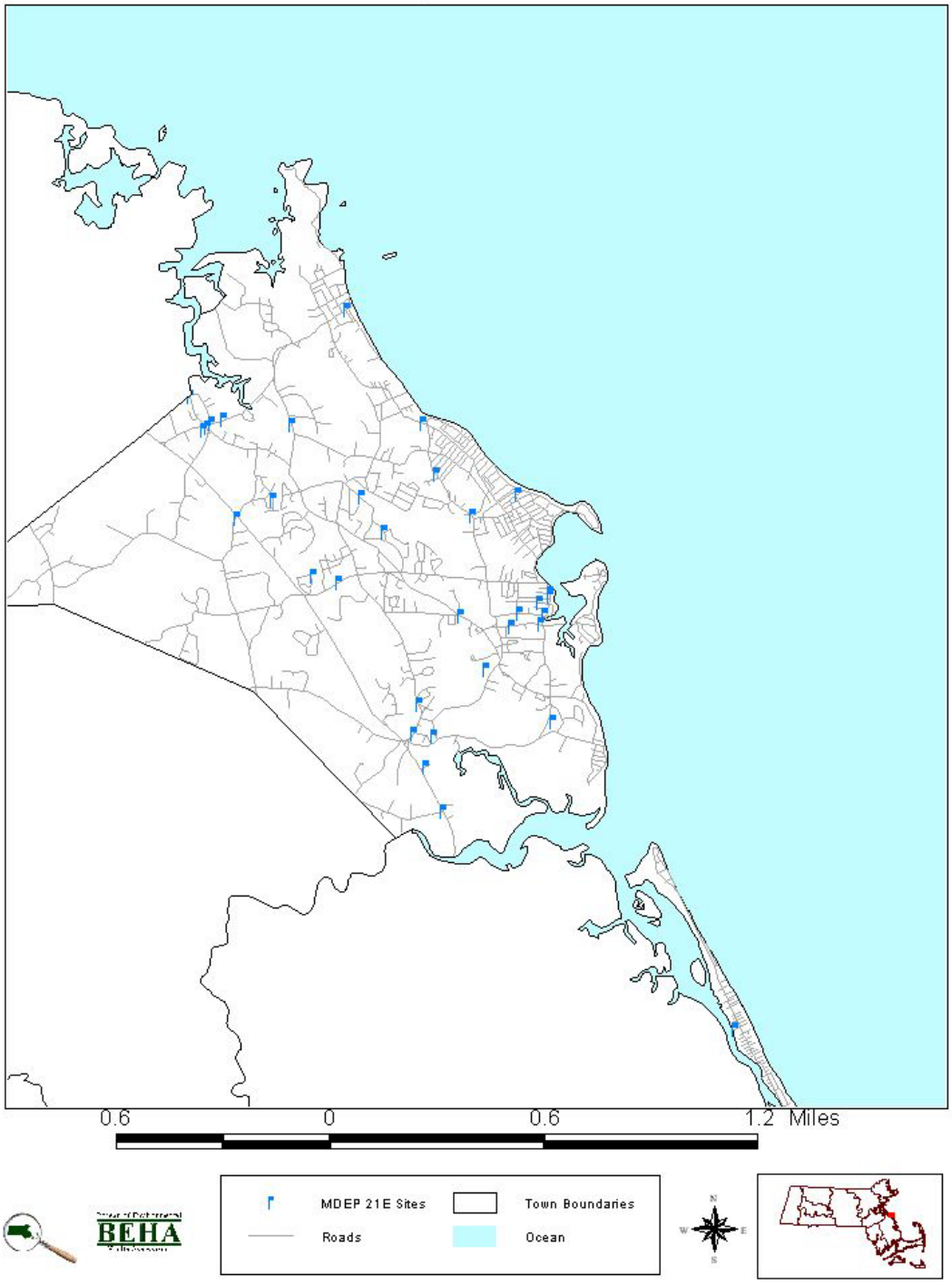

TABLE 1
SUMMARY OF COMPOUNDS OF CONCERN
MUNICIPAL WATER SUPPLY
1981-1993
SCITUATE, MASSACHUSETTS

| COMPOUND | SAMPLING LOCATION | SAMPLING DATE | MAXIMUM DETECTED CONCENTRATION (ppb) | DRINKING WATER COMPARISON VALUE (ppb) | EPA MAXIMUM CONTAMINANT LEVEL (ppb) |
|---|---|---|---|---|---|
| Bromodichloromethane | Old Oaken Bucket Pond | 1986 | 130 | Chronic EMEG (adult) = 700<br>Chronic EMEG (child) = 200 | 100* |
| Chloroform | Well 18A | 1981 | 7.6 | Chronic EMEG (adult) = 400<br>Chronic EMEG (child) = 100 | 100* |
| | | 1986 | 1.9 | | |
| | Old Oaken Bucket Pond | 1986 | 11 | | |
| Tetrachloroethylene | Well 10 | 1981 | 0.3 | CREG = 0.7 | 5 |
| 1,1,1-Trichloroethane | Well 19 | 1981 | 0.3 | NA | 200 |
| | | 1987 | 2.0 | | |
| Trichloroethylene | Well 19 | 1981 | 11.7 | CREG = 3 | 5 |
| | | 1984 | 19.0 | | |
| | | 1986 | 12.0 | | |
| | | 1987 | 11.0 | | |
| | | 1988 | 13.0 | | |
| | Town Hall | 1986 | 6.9 | | |
| | | 1988 | 9.6 | | |

**Data Source:**

Report on Contamination at Municipal Well No. 19, Town of Scituate, Massachusetts. Camp Dresser & McKee, Inc., Boston, MA, 1988.

Annual Quarterly Sampling Data for the Town of Scituate, 1980-present.

**Notes:**

Chronic EMEG (child) = Environmental Media Evaluation Guide for children exposed chronically. (ATSDR)

Chronic EMEG (adult) = Environmental Media Evaluation Guide for adults exposed chronically. (ATSDR)

CREG = Cancer Risk Evaluation Guide for children and adults exposed for a lifetime. (ATSDR)

* = compliance with the EPA Maximum Contaminant Level for trihalomethanes, such as bromodichloromethane and chloroform, is determined using annual average sampling results from four areas of the water distribution system rather than from one sampling point.

TABLE 2
LOCATION AND DETECTED CONCENTRATIONS OF PCE IN
VINYL-LINED ASBESTOS CEMENT (VLAC) PIPES
1980-1989
SCITUATE, MASSACHUSETTS

| SAMPLING LOCATION | SAMPLING DATE | DETECTED CONCENTRATION OF PCE (ppb) |
|---|---|---|
| Turner Road | May-June 1980 | 205 |
| | December 1980 | 3.8 |
| | August 1985 | 1.4 |
| Oceanside Drive | November 1981 | 6.1 |
| | August 1985 | 5.8 |
| | August 1989 | 6 |
| Kathy's Path | May-June 1980 | ND |
| | August 1985 | 7.8 |
| Booth Hill Road | May-June 1980 | 2 |
| | December 1980 | 2,271 |
| | November 1981 | 10 |
| | August 1985 | 11 |
| Thomas Clapp Road | May-June 1980 | 10 |
| | August 1985 | 2 |
| Grove Street | May-June 1980 | 15 |
| | August 1985 | ND |
| Sanitary Landfill | August 1985 | 89 |
| | August 1989 | 24 |
| Three Ring Road | May-June 1980 | 25 |
| | April 1983 | 2 |
| | August 1985 | 5.5 |
| | August 1989 | 2 |
| Jason's Lane | August 1985 | 5.6 |
| | August 1989 | 2 |
| Hearthside Court | August 1985 | 6.7 |
| | August 1989 | 1 |
| Montessori School | December 1980 | 17.5 |
| | April 1983 | 3.9 |
| | August 1985 | 18 |
| | August 1989 | 12 |
| Dreamwold Road | December 1980 | 37.6 |
| | April 1983 | 6.1 |
| | August 1985 | 14 |
| | August 1989 | 4 |
| Gridley Bryant Road | May-June 1980 | 62 |
| | December 1980 | 31.3 |
| | November 1981 | 28 |
| | April 1983 | 3.3 |
| | August 1985 | 23 |
| | August 1989 | 5 |
| Riverview Place | May-June 1980 | ND |
| | August 1985 | 8.2 |
| | August 1989 | ND |
| Conservation Way | August 1985 | 9.6 |
| | August 1989 | 1 |

**Data Source:**

Letter to Larry Dayian, MDEP, from Richard Kenney, Scituate Water Division regarding PCE levels in VLAC pipes in Scituate, October 1989.

**Note:**

ND = Not detected.

TABLE 3
NAME AND LOCATION OF MDEP 21E SITES
SCITUATE, MASSACHUSETTS

| RELEASE TRACKING NUMBER (RTN) | ADDRESS | LOCATION AID |
|---|---|---|
| 4-0000154 | NEW KENT ST. | NEW KENT STREET SITE |
| 4-0000155 | 46 COUNTRY WAY | COUNTRY WAY |
| 4-0000239 | FIRST PARISH RD. | NEW ENGLAND TELEPHONE |
| 4-0000252 | COUNTRY WAY & BAILEY RD | MOBIL STATION #01-QLX/FMR |
| 4-0000278 | 108 STOCKBRIDGE RD. | PROPERTY |
| 4-0000510 | 157 FIRST PARISH RD | EXXON STATION R/S #3-7796/FMR |
| 4-0000798 | 141 FRONT ST. | SHELL SERVICE STATION |
| 4-0001091 | 150 FRONT ST | MILL WHARF MARINA |
| 4-0010119 | 816 COUNTRY WAY | RESIDNECE |
| 4-0010469 | 28 NEW DRIFTWAY | HERRING BROOK PLACE |
| 4-0010940 | 20 COUNTRY WAY | NO LOCATION AID |
| 4-0011019 | BAILEYS ISLAND | OFF WOOD ISLAND RD |
| 4-0011121 | 72 KENNETH RD | NO LOCATION AID |
| 4-0011246 | 7 MARSHFIELD AVE | SO RIVER YACHT YARD |
| 4-0011551 | 340 GANNETT RD | BUCKLEY/SCOTT |
| 4-0011670 | 5 CUSHING LANDING | NO LOCATION AID |
| 4-0011769 | 376 GANNET RD | POST OFFICE SUBSTATION |
| 4-0011953 | BROOKS RD & HAZEL AVE | POLE 2 |
| 4-0012183 | 781 CHIEF JUSTICE CUSHING HWY | RTE 3A, SUNOCO STN |
| 4-0012255 | 266 TILDEN RD | WAMPATUCK SHORE |
| 4-0012397 | 762 REAR COUNTRY WAY | NO LOCATION AID |
| 4-0012463 | 316 HATHERLY RD | SIMEONE PROPERTY |
| 4-0013186 | TILDEN RD | WAMPATUCK SCHOOL |
| 4-0013220 | CUSHING HWY | SCITUATE HIGH SCHOOL |
| 4-0013274 | 32 OTIS PL | HOUSE |
| 4-0013485 | GANNETT RD | NO LOCATION AID |
| 4-0014045 | 781 CHIEF JUSTICE CUSHING HWY | CJ 3A SUNOCO |
| 4-0014344 | OFF CHIEF JUSTICE CUSHING WAY | NEAR PARISH RD |
| 4-0014507 | 61 FIRST PARISH RD | 61 FIRST PARISH ROAD |
| 4-0014651 | 68 PRATT RD | RESIDENCE |
| 4-0014736 | 97 HOLLETT ST | RESIDENCE |
| 4-0014839 | 399 FIRST PARISH RD | NO LOCATION AID |
| 4-0014843 | 71 FRONT ST | SCITUATE MARKETPLACE |
| 4-0014888 | 79 LAWSON RD | RESIDENCE |
| 4-0015478 | 150 LAWSON RD | RESIDENCE |

**Data Source:**

MDEP Bureau of Waste Site Clean-up (BWSC) listing of 21E sites. Available: http://www.state.ma.us/dep/bwsc

**TABLE 4**

**Cancer Incidence in Scituate, Massachusetts**
**1987-1997**

| 1987-1997 | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| **Breast** | 164 | 124 | 132* | 112 - 154 | 0 | 1.0 | NC | NC | 164 | 123 | 133* | 113 - 155 |
| **Kidney** | 21 | 18.2 | 116 | 72 - 177 | 13 | 11.2 | 116 | 62 - 199 | 8 | 7.0 | 114 | 49 - 225 |
| **Leukemia** | 17 | 13.9 | 122 | 71 - 196 | 5 | 7.8 | 64 | 21 - 150 | 12 | 6.1 | 196* | 101 - 342 |
| **Liver** | 2 | 4 | NC | NC | 2 | 2.9 | NC | NC | 0 | 1.1 | NC | NC |
| **Testis** | 5 | 4.3 | 117 | 38 - 272 | 5 | 4.3 | 117 | 38 - 272 | 0 | 0 | NC | NC |

**NOTES:**
SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented here are rounded to the nearest tenth.
OBS = Observed number of cases.
EXP = Expected number of cases.
SIR = Standardized Incidence Ratio.
NC = Not calculated when OBS<5.
95% CI = 95% Confidence Interval.
* = Statistical Significance.

Data source: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Mass. Dept. of Public Health

**TABLE 5**

**Cancer Incidence in Census Tract 5051.01, Scituate, Massachusetts**
**1987-1997**

| 1987-1997 | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| **Breast** | 54 | 40.5 | 133 | 100 - 174 | 0 | 0.3 | NC | NC | 54 | 40.1 | 135* | 101 - 176 |
| **Kidney** | 11 | 6.0 | 184 | 92 - 329 | 6 | 3.8 | 159 | 58 - 347 | 5 | 2.2 | 225 | 73 - 526 |
| **Leukemia** | 5 | 4.6 | 109 | 35 - 254 | 1 | 2.7 | NC | NC | 4 | 2.0 | NC | NC |
| **Liver** | 0 | 1.3 | NC | NC | 0 | 1.0 | NC | NC | 0 | 0.3 | NC | NC |
| **Testis** | 0 | 1.7 | NC | NC | 0 | 1.7 | NC | NC | 0 | 0 | NC | NC |

**NOTES:**
SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented here are rounded to the nearest tenth.
OBS = Observed number of cases.
EXP = Expected number of cases.
SIR = Standardized Incidence Ratio.
NC = Not calculated when OBS<5.
95% CI = 95% Confidence Interval.
* = Statistical Significance.

Data source: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Mass. Dept. of Public Health

**TABLE 6**

**Cancer Incidence in Census Tract 5051.02, Scituate, Massachusetts**
**1987-1997**

| 1987-1997 | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| **Breast** | 49 | 32.4 | 151* | 112 - 200 | 0 | 0.3 | NC | NC | 49 | 32.1 | 153* | 113 - 202 |
| **Kidney** | 3 | 4.7 | NC | NC | 2 | 3.0 | NC | NC | 1 | 1.8 | NC | NC |
| **Leukemia** | 3 | 3.5 | NC | NC | 0 | 2.0 | NC | NC | 3 | 1.5 | NC | NC |
| **Liver** | 2 | 1.0 | NC | NC | 2 | 0.8 | NC | NC | 0 | 0.3 | NC | NC |
| **Testis** | 1 | 1.1 | NC | NC | 1 | 1.1 | NC | NC | 0 | 0 | NC | NC |

**NOTES:**
SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented here are rounded to the nearest tenth.
OBS = Observed number of cases.
EXP = Expected number of cases.
SIR = Standardized Incidence Ratio.
NC = Not calculated when OBS<5.
95% CI = 95% Confidence Interval.
* = Statistical Significance.

Data source: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Mass. Dept. of Public Health

**TABLE 7**

**Cancer Incidence in Census Tract 5052, Scituate, Massachusetts**
**1987-1997**

| 1987-1997 | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| **Breast** | 60 | 51.6 | 116 | 89 - 150 | 0 | 0.4 | NC | NC | 60 | 51.1 | 117 | 90 - 151 |
| **Kidney** | 7 | 7.4 | 94 | 38 - 194 | 5 | 4.4 | 113 | 36 - 263 | 2 | 3.0 | NC | NC |
| **Leukemia** | 8 | 5.8 | 139 | 60 - 273 | 4 | 3.1 | NC | NC | 4 | 2.7 | NC | NC |
| **Liver** | 0 | 1.7 | NC | NC | 0 | 1.2 | NC | NC | 0 | 0.5 | NC | NC |
| **Testis** | 4 | 1.5 | NC | NC | 4 | 1.5 | NC | NC | 0 | 0 | NC | NC |

**NOTES:**
SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented here are rounded to the nearest tenth.
OBS = Observed number of cases.
EXP = Expected number of cases.
SIR = Standardized Incidence Ratio.
NC = Not calculated when OBS<5.
95% CI = 95% Confidence Interval.
* = Statistical Significance.

Data source: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Mass. Dept. of Public Health