Massachusetts
Department Of
Public Health

# Health Consultation:
# Evaluation of Potential Historical Exposure to Perchlorate-Contaminated Well Water at the Mount Greylock Regional School and Evaluation of Thyroid Cancer Incidence from 1982-2008 in Hancock, Lanesborough, New Ashford, and Williamstown, Berkshire County, Massachusetts

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Bureau of
Environmental Health,
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# I. SUMMARY

**Introduction:** This health consultation was conducted because some residents of communities served by the Mount Greylock Regional School – Hancock, Lanesborough, New Ashford, and Williamstown – expressed concerns about the occurrence of thyroid cancer in their communities. In addition, residents have expressed concern about a possible link between historical perchlorate contamination in Wells #1 and #2 formerly used for drinking water for the Mount Greylock Regional School and thyroid cancer and thyroid disease in the communities. Perchlorate was discovered in the wells in 2004 and, upon learning of the contamination, bottled water was used at the school for drinking and cooking.

**Overview:** The MDPH has reached two important conclusions about the incidence of thyroid cancer in Hancock, Lanesborough, New Ashford, and Williamstown and potential historical exposures to perchlorate-contaminated well water at the Mount Greylock Regional School.

**Conclusion 1:** The MDPH concluded that, based on available historical information, potential exposures by ingesting drinking water from Wells #1 and #2 by Mount Greylock Regional School staff and students would not be expected to have harmed people's health.

**Basis for Decision:** Historical sampling of Wells #1 and #2 on the Mount Greylock Regional School grounds in 2004 and 2005 showed the presence of perchlorate contamination. When the contamination was discovered, bottled water was used by the school for drinking and cooking. However, the wells had been previously used as the source of drinking water for the high school. It is not known how long the contamination was in the wells; the source was presumed to be fireworks launched on the school grounds between 1989-1992 and 1999-2003. Based on perchlorate sampling data from 2004 and 2005 for Wells #1 and #2 and conservative exposure assumptions, noncancer health effects would not be expected. The reason for this is that the levels estimated to get into an adult's or student's body would be below levels that would harm their health.

**Conclusion 2:** The MDPH concluded that the incidence of thyroid cancer in Hancock, Lanesborough, New Ashford, and Williamstown over the 27-year period of 1982 through 2008 does not appear unusual. The incidence of thyroid cancer in the four communities was approximately as expected based on the statewide thyroid cancer experience. It is important to note that, based on a consensus of medical and epidemiological experts, perchlorate is not thought to be a potential cancer-causing substance.

**Basis for Decision:** To determine whether the incidence of thyroid cancer in Hancock, Lanesborough, New Ashford, and Williamstown was elevated, the observed number of thyroid cancer diagnoses in each community was compared to the number that would be expected based on the statewide cancer rate. Overall, the numbers of observed diagnoses of thyroid cancer in the four communities were approximately as expected for each of the four communities. In addition, no unusual trends emerged when the overall age, gender and spatial patterns were examined in more detail.

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**Next Steps:**

- ❖ The MDPH recommends no further investigation into historical perchlorate contamination associated with two former wells located on the grounds of the Mount Greylock Regional School and no further investigation of thyroid cancer incidence in Hancock, Lanesborough, New Ashford, and Williamstown at this time.

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**For More Information:** If you have concerns about your health, you should contact your health care provider. You may also call the MDPH at 617-624-5757 and ask for information on the Mount Greylock Regional School investigation.

## II. INTRODUCTION

At the request of some concerned residents, the Community Assessment Program (CAP) of the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH), reviewed the incidence of thyroid cancer in the communities of Hancock, Lanesborough, New Ashford, and Williamstown[1]. Concerns focused on a perceived increase in the number of individuals with thyroid cancer in these communities as well as in staff and students affiliated with the Mount Greylock Regional School. In addition, residents expressed concern that perchlorate contamination of two bedrock wells serving the Mount Greylock Regional School might have adversely affected the health of the students and staff. The contamination was discovered in April 2004 and, upon discovery of the contamination, bottled water was used at the school for drinking and cooking.

This Health Consultation (HC) provides thyroid cancer incidence data for the four communities of Hancock, Lanesborough, New Ashford, and Williamstown. Mount Greylock Regional School serves students in grades 7 through 12 from these four communities. In addition, information is presented on what is known about the perchlorate contamination that was discovered in 2004 in the school well water, the toxicity of perchlorate, and the potential health risks associated with exposure to perchlorate at the levels detected in the school wells.

## III. BACKGROUND

In 2004, the Massachusetts Department of Environmental Protection (MassDEP) promulgated emergency regulations requiring public water supplies to test for the chemical perchlorate. Perchlorate is an inorganic chemical used as an oxidizer in solid propellants for rockets, missiles, fireworks, and explosives. It is a primary component of fireworks and explosives. In its draft report *The Occurrence and Sources of Perchlorate in Massachusetts* (MassDEP 2006a), MassDEP reported that, of the 591 water supplies in Massachusetts tested for perchlorate at that time, 12 sources in 9 water supply systems

[1] This report was supported in part by funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

had perchlorate above the MassDEP drinking water health advisory of 1 microgram per liter (μg/L) or 1 part per billion (ppb). (Since then, MassDEP has promulgated a perchlorate drinking water standard of 2 ppb.)

Two bedrock wells servicing the Mount Greylock Regional School in Williamstown were tested between April 2004 and February 2005 and found to contain concentrations of perchlorate above the MassDEP health advisory of 1 ppb. Eight samples from Well #1 had perchlorate levels ranging from 5.05 to 11 ppb. During this same time period, eight samples from Well #2 had perchlorate levels ranging from 0.46 to 2.8 ppb (MassDEP 2006b). Fireworks were launched from the school grounds between 1989 and 1992, and from 1999 to 2003 (MassDEP 2006a) and were presumed to be the source of the perchlorate.

Once the contamination was found in 2004, bottled water was supplied to the school for drinking and cooking. The school immediately removed Well #1 from service and switched to Well #2 for non-drinking and non-cooking purposes. Health notices were posted at water access points (bubblers, bathroom faucets, kitchen faucets, ice machines, and outside faucets). The ban on the use of Well #2 for drinking and cooking was lifted by the MassDEP in May 2005, based on monitoring data showing that the levels of perchlorate in water from Well #2 were below the health advisory of 1 ppb. Since August 2006, the school has relied exclusively on a replacement well, Well #3, for all uses. Well #3 is in a wooded area approximately 500 feet west of the school and is tested for perchlorate as required by MassDEP regulations (D. Cabral, MassDEP Western Region, Drinking Water/Municipal Services Section Chief, personal communication, June 2012).

Because of the historical contamination in the Mount Greylock Regional School's wells, residents have expressed concerns about possible impacts on the health of students attending the school and staff working at the school when the wells were contaminated with perchlorate. In particular, the concerns have focused mainly on thyroid cancer and other thyroid diseases. To address these concerns, this report summarizes 27 years of thyroid cancer incidence data for the four communities served by the school and evaluates the potential health risks associated with exposure to perchlorate based on

available perchlorate sampling data from 2004 and 2005. It is important to point out that the consensus of experts who evaluate the carcinogenic potential of chemicals is that, while perchlorate can impact thyroid hormonal levels, it is unlikely that perchlorate poses a risk of thyroid cancer in humans (National Research Council 2005). Perchlorate is of health concern because it interferes with iodide uptake in the thyroid gland and can therefore impact the normal function of the thyroid which produces important hormones. Thyroid hormones regulate metabolic processes throughout the body and are critical to developing fetuses and infants. In this evaluation, the potential health risks associated with the ingestion of school well water are evaluated based on what is known about perchlorate's toxicity to the thyroid gland.

## IV. EVALUATION OF HEALTH RISKS FROM INGESTION OF DRINKING WATER CONTAINING PERCHLORATE

To evaluate concerns about potential historical exposures to perchlorate from drinking water drawn from the wells at the Mount Greylock Regional School, the MDPH reviewed the sampling data contained in the MassDEP's report titled *The Occurrence and Sources of Perchlorate in Massachusetts* (MassDEP 2006a). The concentrations of perchlorate detected in Wells #1 and #2 at the high school in 2004 and 2005 are presented in Table 1.

For Well #1, concentrations of perchlorate detected from the eight samples collected and analyzed ranged from 5.05 µg/L to 11 µg/L. For Well #2, concentrations of perchlorate detected from eight samples ranged from 0.46 µg/L to 2.8 µg/L. The average and maximum concentrations of perchlorate in the two wells combined are 4.9 µg/L and 11 µg/L, respectively. As mentioned previously, after the initial test results, bottled water was supplied to the school to prevent future exposure opportunities to perchlorate in the water.

No federal drinking water standard currently exists for perchlorate. Standards or guidelines across the country for perchlorate in drinking water range from 2 µg/L (in Massachusetts) to 18 µg/L (in Nevada). Differences between individual state standards or guidelines include different exposure assumptions (for example, MassDEP assumes that drinking water is the source of 20 percent of a person's total perchlorate exposure) and

differences in scientific opinion about the level of perchlorate exposure unlikely to result in adverse health effects even for sensitive populations. It should be noted that standards or guidelines are intentionally set to be well below those levels where health effects might occur even in the most sensitive populations, as determined by human or animal studies (that is, typically, at least 10 to 100 times lower than an effects level).

The USEPA Integrated Risk Information System (IRIS) has classified perchlorate as not likely to be carcinogenic to humans (USEPA 2012). This is consistent with the conclusion of the National Research Council in its document entitled *Health Implications of Perchlorate Ingestion* in which a committee, established to study the health implications of perchlorate ingestion, concluded that it is unlikely that perchlorate poses a risk of thyroid cancer in humans (National Research Council 2005).

To evaluate the potential health risks associated with exposure to perchlorate in drinking water drawn from Wells #1 and #2 at the Mount Greylock Regional School, MDPH made conservative assumptions to estimate the doses that school employees and students could have received if they consumed the maximum and average detected concentrations of perchlorate in the well water. For example, we assumed both students and staff would drink one liter of water from the school every day of the school year (180 days for students; 250 days for school administrative staff who work year-round). We also assumed that exposures occurred for 6 years for students and 15 years for staff (which is the maximum number of years of potential exposure assuming that contamination began after fireworks were used in 1989). Assuming exposure to the average detected concentration of perchlorate (4.8 µg/L), noncancer health effects would not be expected. The estimated exposure doses for staff and students are below the reference dose of 0.07 µg/kg/day used in the development of the MassDEP drinking water standard for perchlorate. Although the estimated exposure doses associated with the maximum detected concentration of perchlorate (11 µg/L) slightly exceed the reference dose (0.11 µg/kg/day versus 0.07 µg/kg/day), noncancer health effects would not be expected even at the maximum concentration because of the uncertainty/safety factor of 100 applied to the reference dose. This factor was applied to provide a margin of safety to the reference dose. See Appendix A for the exposure dose calculations.

## V. ANALYSIS OF CANCER INCIDENCE

Thyroid cancer incidence rates were calculated for the communities of Hancock, Lanesborough, New Ashford, and Williamstown[2]. Rates for five time periods were calculated: 1982-1986, 1987-1991, 1992-1996, 1997-2001, and 2002-2008. The year 1982 represents the first year that data from the Massachusetts Cancer Registry (MCR) became available. The most current year for which complete data were available at the initiation of this analysis is 2008. Therefore, 27 years of cancer incidence data were reviewed in this analysis.

### A. Methods for Analyzing Cancer Incidence

The MCR is a population-based surveillance system that began collecting information in 1982 on Massachusetts residents diagnosed with cancer. Massachusetts law requires all new cancer diagnoses among residents 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. Data are collected on a daily basis and are reviewed for accuracy and completeness. This process corrects misclassification of data (for example, incorrect city/town assignment). Once these steps are finished, the data for that year are considered "complete". Due to the volume of information received by the MCR, the large number of reporting facilities, and the six-month period between diagnosis and required reporting, the most current registry data that are complete will inherently be a minimum of two years prior to the current date. The year 2008 constitutes the most recent and complete cancer incidence data available at the time of this analysis.

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Cancers 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). Epidemiologic studies have revealed that different types of cancer are individual diseases with separate causes, risk factors, characteristics and patterns of survival (Berg 1996). Therefore, it is appropriate to evaluate each type of cancer separately. Cancers that occur

[2] The ICD-O-3 code used to identify thyroid cancer diagnoses in this report is: C73.9 (primary site) and all histology codes except 9590 – 9989 (International Classification of Diseases for Oncology, 3rd edition).

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.

It should be noted that any duplicate records included in the MCR data were eliminated from analyses in this report. Duplicate cases are additional reports of the same primary site cancer diagnosed in an individual by another health-care provider. The decision that a case was a duplicate and should be excluded from the analyses was made by the MCR after consulting with the reporting hospital/diagnostic facility and obtaining additional information regarding the histology and/or pathology of the case. However, reports of individuals with multiple primary site cancers were included as separate cases in this report. In general, a diagnosis of a multiple primary cancer is defined by the MCR as a new cancer in a different location in the body or a new cancer of the same histology (cell type) as an earlier cancer, if diagnosed in the same primary site (original location in the body) more than 2 months after the initial diagnosis (MCR 2003).

To assess whether the incidence of thyroid cancer is unusual, a statistic called the standardized incidence ratio (SIR) was calculated using data from the MCR. The SIR is a comparison of the number of diagnoses in the community to the number of expected diagnoses based on the statewide rate. 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. Age-specific statewide incidence rates were applied to the population distribution of the community to calculate the number of expected cancer diagnoses.[3]

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. An SIR greater than 100 indicates that more cancer diagnoses occurred than expected and an SIR less than 100 indicates that fewer cancer diagnoses occurred than expected. Accordingly, an SIR of 150 is interpreted as 50% more diagnoses than the expected number; an SIR of 90 indicates 10% fewer diagnoses than expected. To help interpret an SIR, the statistical

[3] Using 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.

significance of an SIR can be assessed by calculating a 95% confidence interval (CI) to determine if the observed number of diagnoses is "statistically significantly different" from the expected number or if the difference may be due solely to chance (Rothman and Boice 1982). When an SIR is statistically significant, there is less than a 5% percent chance that the observed difference (either increase or decrease) in the rate is the result of random fluctuation in the number of observed cancer diagnoses. It should be noted that SIRs and 95% CIs are not calculated when the observed number of diagnoses is fewer than five. Appendix B provides a more detailed explanation of SIRs and 95% CIs.

In addition to calculating SIRs, residence at diagnosis was mapped for individuals diagnosed with thyroid cancer in the four communities over the 27-year period. This was done to evaluate the spatial pattern of diagnoses in the communities.

### B. Results of Cancer Incidence Analysis

Tables 2 through 6 summarize the incidence of thyroid cancer for the communities of Hancock, Lanesborough, New Ashford, and Williamstown for the five time periods evaluated. In the results summarized below, thyroid cancer incidence is first reported by individual community and then for the four communities combined.

For the two communities of Hancock and New Ashford, no diagnoses of thyroid cancer were observed during the 27-year time period. For Hancock, approximately 1.7 diagnoses would be expected based on the statewide experience for thyroid cancer and the population of Hancock. For New Ashford, approximately 0.6 diagnoses would have been expected.

For the community of Lanesborough, five diagnoses were observed over the 27-year period when approximately 6.7 diagnoses would be expected. In four of the five time periods, the incidence of thyroid cancer in Lanesborough was approximately as expected or less than expected. In the earliest time period, 1982-1986, one diagnosis was observed in males when approximately 0.2 diagnoses would be expected.

For the community of Williamstown, 14 diagnoses were observed over the 27-year period when approximately 16.6 would be expected. For the three most recent time

periods, covering 1992 through 2008, for both males and females, the number of observed diagnoses was consistently less than the number expected. For 1982-1986, no males were diagnosed with thyroid cancer while two females were diagnosed when approximately 0.9 diagnoses would be expected. For 1987-1991, one male was diagnosed with thyroid cancer when approximately 0.5 diagnoses were expected. For females during this same time period, two diagnoses were observed when approximately one diagnosis would have been expected.

When examined by time period, the incidence of thyroid cancer in the four communities combined was approximately as expected for the three most current time periods: 1992-1996, 1997-2001, and 2002-2008. In the earliest time period, 1982-1986, no diagnoses were reported in Hancock or New Ashford while, in Lanesborough and Willamstown, one additional diagnosis occurred over what would be expected. In Lanesborough, one male was diagnosed with thyroid cancer when approximately 0.2 diagnoses would be expected; no diagnoses were observed in females. In Williamstown, two diagnoses were observed in females when 0.9 diagnoses would be expected; no diagnoses were observed in males. In the following time period, 1987-1991, no diagnoses were reported in Hancock, Lanesborough, or New Ashford. In Williamstown, one diagnosis occurred in males when approximately 0.5 diagnoses would be expected. In Willamstown females during this time period, two diagnoses were observed when approximately 1.1 diagnoses would be expected.

For each time period and community, the geographic distribution of the place of residence at the time of diagnosis was generally consistent with the population density in each community.

## VI. DISCUSSION

At the request of some concerned residents, the MDPH conducted an evaluation of the incidence of thyroid cancer in the four communities of Hancock, Lanesborough, New Ashford, and Williamstown. This request was prompted by concerns about health conditions/disease, particularly thyroid cancer and thyroid disease(s), being potentially related to historical exposure to perchlorate-contaminated drinking water at the Mount

Greylock Regional School. Perchlorate contamination was discovered in 2004 in two wells that previously supplied drinking water to staff and students at the Mount Greylock Regional School. Bottled water was used at the school for drinking and cooking once the perchlorate contamination was discovered. It is not known how long the perchlorate may have been in the well water, however, fireworks were launched from the school grounds between 1989 and 1992 and from 1999 to 2003 and were presumed to be the source of the perchlorate (MassDEP 2006a). Therefore, assuming that the fireworks were the source of the perchlorate in the well water, it is possible that the wells became contaminated with perchlorate sometime between 1989 and 2004.

The thyroid gland is the target organ of perchlorate toxicity. Perchlorate interferes with iodide uptake by the thyroid gland and can disrupt the synthesis of thyroid hormones critical to normal growth, development, and other physiological functions (Zewdie et al. 2010). As discussed earlier, although perchlorate can adversely affect the thyroid gland in sufficient doses, it is not thought to be likely to cause thyroid cancer (NRC 2005; USEPA 2012). MDPH's review of thyroid cancer incidence data was intended to address the concerns of some residents of a perceived increase in the incidence of this type of cancer in their communities; however, based on the medical/epidemiological literature and an expert panel established by the National Research Council, the incidence of thyroid cancer in these communities would not be expected to be associated with the historical presence of perchlorate in the Mount Greylock Regional School wells.

Appendix C contains a summary of risk factors associated with thyroid cancer. For reasons that are unclear, benign thyroid nodules and thyroid cancers occur almost three times more often in females than in males. This was true for the four communities evaluated in this report as well; over the 27-year period, 14 females were diagnosed with thyroid cancer compared to five males. The American Cancer Society reports that thyroid cancer is commonly diagnosed at a younger age than most other adult cancers. Eighty percent of newly diagnosed thyroid cancer patients are under 65 years of age (ACS 2012). Thyroid cancer is one of the most common cancers for individuals below 40 years of age. The National Cancer Institute, in its report titled *Cancer Epidemiology in Older Adolescents and Young Adults 15 to 29 Years of Age*, reported that, although uncommon,

thyroid cancer is not an unusual finding in the adolescent and young adult population (Bleyer A et al. 2006). Between 1975 and 2000, it represented approximately 7.8% of all cancers diagnosed in the 15- to 19-year age group, 11.5% in patients 20 to 24 years old, and 10.1% in individuals from ages 25 to 29. The NCI also reported that thyroid cancer is very rare in children younger than 15 years of age. In the four communities over the 27-year period, the age range at diagnosis was from 20 to over 60 years of age with 70% diagnosed at the ages of 35 and over.

Established risk factors for thyroid cancer include family history, particularly for the medullary subtype of thyroid cancer, and certain inherited conditions such as Gardner syndrome, familial polyposis, or a family history of goiters with multiple thyroid nodules. Ionizing radiation is also an established risk factor for thyroid cancer. This does not include routine diagnostic x-rays that use very low doses of radiation. Exposure to high levels of ionizing radiation from nuclear fallout (such as at Chernobyl, Nagasaki, and Hiroshima) has been linked with increased incidence of thyroid cancer. In addition, high dose radiation associated with treatments for certain types of cancer may put an individual at increased risk of thyroid cancer. A diet low in iodine may increase the risk of the subtype called follicular carcinoma of the thyroid; because most table salt in the US is fortified with iodine, however, this is not thought to be a risk factor of thyroid cancer in this country.

To assess the potential for noncancer health impacts in the staff and students at the Mount Greylock Regional School who may have consumed water contaminated with perchlorate, MDPH estimated the dose that an adult and an adolescent may have received if they were exposed to the maximum and the average of the detected concentrations of perchlorate from sampling in 2004 and 2005. The estimated doses were based on conservative or health-protective assumptions such as a daily drinking water ingestion rate of one liter per day from the wells for 6 years, in the case of student, and for 15 years, in the case of an adult staff person.

A review of 27 years of thyroid cancer incidence data for the communities of Hancock, Lanesborough, New Ashford, and Williamstown showed that the incidence of thyroid cancer in these communities for the most part was approximately as expected during the

1982-2008 time period. In addition, based on conservative exposure assumptions and assuming that the available data on historical perchlorate concentrations in the Mount Greylock Regional School wells are representative of exposures that may have occurred in the past, adverse health effects would not be expected.

## VII. CHILD HEALTH CONSIDERATIONS

The MDPH recognizes that the unique vulnerabilities of children demand special emphasis in communities faced with contamination in their environment. Children are at a greater risk than adults for certain kinds of exposure to hazardous substances in the environment. Children are smaller, resulting in higher doses of contaminant exposure per body weight than adults. The developing body systems of children can sustain permanent damage if certain toxic exposures occur during critical growth stages.

The incidence and patterns of thyroid cancer among residents (of all ages) of Hancock, Lanesborough, New Ashford, and Williamstown are discussed in Section V ("Analysis of Cancer Incidence") of this report. As mentioned previously, the incidence of thyroid cancer in these communities for the 27-year period of 1982-2008 does not appear unusual.

In addition, past exposure of adolescents attending the Mount Greylock Regional School between 1989 and 2004 may have been possible. However, based on the exposure assessment conducted for this report, adverse health effects would not be expected.

## VIII. LIMITATIONS

As part of this HC, thyroid cancer incidence data were analyzed to determine whether the pattern or occurrence of thyroid cancer in the communities of Hancock, Lanesborough, New Ashford, and Williamstown is unusual. The pattern of diagnoses of thyroid cancer was evaluated in a geographical context to determine whether further investigation seems warranted. Information from descriptive analyses, which may suggest a common etiology (or cause) is possible, can serve to identify areas where further analyses may be needed. Inherent limitations in the available data and this type of analysis make it

impossible to determine the precise causal relationships or synergistic roles that may have contributed to the development of individual cancers in a community. Cancers in general have a variety of risk factors known or suggested to be related to the etiology of the disease that could not be evaluated in this investigation. It is beyond the scope of this investigation to determine the causal relationship of these factors and the development of thyroid cancer in the four communities. Also, this type of analysis cannot determine what may have caused cancer in any one particular individual.

It is not known when Wells #1 and #2 first became contaminated with perchlorate, however assuming that the source of the perchlorate was fireworks used on the school property, then the period of exposure to perchlorate-contaminated drinking water for an adult employed at the school could have ranged from between one to 15 years. For a student, it was assumed that the period of exposure was the 6 years of attendance at the school. Another uncertainty is the actual amount of water consumed by an individual while at the school. To be conservative, it was assumed that a liter of water was ingested every day at the school. Finally, the exposure assessment in this report is based on an assumption that the perchlorate concentrations measured in 2004 and 2005 were representative of the entire period when a person may have been exposed. No other sampling data are available other than the 2004 and 2005 sampling data used in this assessment; however, given that fireworks were launched as late as 2003, measurements in 2004 provide some reasonable measure of potential exposure. Based on this analysis, it is also not possible to predict the health risk that a particular individual may face who may have exposed to perchlorate; rather, this evaluation can be used to estimate theoretical health risks.

## IX. CONCLUSIONS

Based on the MDPH's evaluation of the available well water sampling data, the exposure assessment, and thyroid cancer incidence data, MDPH concludes that:

- Based on available perchlorate sampling data from 2004 and 2005 for Wells #1 and #2, which were previously used for drinking water at the Mount Greylock Regional School until 2004, and conservative exposure assumptions, noncancer

health effects would not be expected. The reason for this is because, based on available information and conservative assumptions about the frequency and duration of potential exposures, levels of perchlorate that could get into an adult's or a student's body were estimated to be below levels that would harm their health.

- Within the communities of Hancock, Lanesborough, New Ashford, and Williamstown, the incidence of thyroid cancer over the 27-year period of 1982 through 2008 does not appear unusual. The incidence of thyroid cancer in these communities was approximately as expected based on the statewide thyroid cancer experience.

## X. RECOMMENDATIONS

The MDPH recommends no further investigation into historical perchlorate contamination associated with two former wells located on the grounds of the Mount Greylock Regional School and no further investigation of thyroid cancer incidence in Hancock, Lanesborough, New Ashford, and Williamstown at this time.

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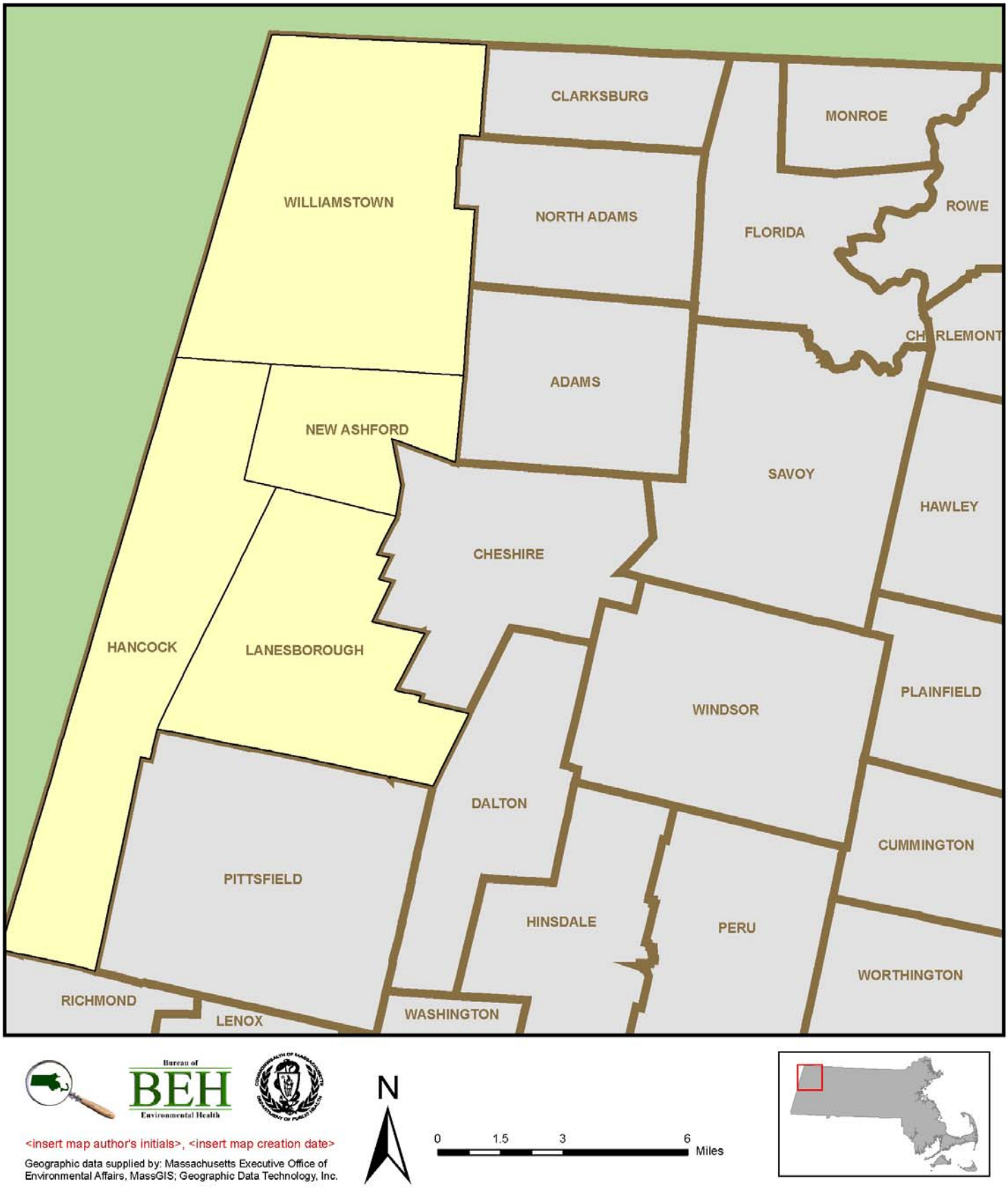
# FIGURES

**Figure 1. Map of Hancock, Lanesborough, New Ashford, and Williamstown.**



# TABLES

**Table 1. Historical Perchlorate Concentrations in Wells 1 and 2 at Mount Greylock Regional High School**

| Sample Collection Date | Concentration (µg/L) | |
|---|---|---|
| | Well #1 | Well #2 |
| 4/15/2004 | 5.05 | 1.03 |
| 5/6/2004 | 9.6 | 2.5 |
| 5/7/2004 | 9.1 | 2.3 |
| 5/7/2004 | 5.23 | 1.14 |
| 9/29/2004 | 11 | 1.2 |
| 10/5/2004 | 7.12 | 1.71 |
| 10/5/2004 | 10 | 2.8 |
| 2/22/2005 | 6.01 | 0.46 |

Source: MassDEP Draft Report *The Occurrence and Sources of Perchlorate in Massachusetts*, April 2006

**Table 2**
**Thyroid Cancer Incidence**
**Selected Communities in Massachusetts**
**1982-1986**

| Census Tract | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Hancock | 0 | 0.1 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC | 0 | 0.1 | NC | NC -- NC |
| Lanesborough | 1 | 0.5 | NC | NC -- NC | 1 | 0.2 | NC | NC -- NC | 0 | 0.3 | NC | NC -- NC |
| New Ashford | 0 | 0.0 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC |
| Williamstown | 2 | 1.4 | NC | NC -- NC | 0 | 0.5 | NC | NC -- NC | 2 | 0.9 | NC | NC -- NC |

† Cases for which census tract designation was not possible are included in the town total.

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 3**
**Thyroid Cancer Incidence**
**Selected Communities in Massachusetts**
**1987-1991**

| Census Tract | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Hancock | 0 | 0.1 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC | 0 | 0.1 | NC | NC -- NC |
| Lanesborough | 0 | 0.6 | NC | NC -- NC | 0 | 0.2 | NC | NC -- NC | 0 | 0.4 | NC | NC -- NC |
| New Ashford | 0 | 0.0 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC |
| Williamstown | 3 | 1.6 | NC | NC -- NC | 1 | 0.5 | NC | NC -- NC | 2 | 1.1 | NC | NC -- NC |

† Cases for which census tract designation was not possible are included in the town total.

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**
**Thyroid Cancer Incidence**
**Selected Communities in Massachusetts**
**1992-1996**

| Census Tract | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Hancock | 0 | 0.2 | NC | NC -- NC | 0 | 0.1 | NC | NC -- NC | 0 | 0.1 | NC | NC -- NC |
| Lanesborough | 0 | 0.8 | NC | NC -- NC | 0 | 0.2 | NC | NC -- NC | 0 | 0.6 | NC | NC -- NC |
| New Ashford | 0 | 0.1 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC |
| Williamstown | 1 | 2.1 | NC | NC -- NC | 0 | 0.5 | NC | NC -- NC | 1 | 1.5 | NC | NC -- NC |

† Cases for which census tract designation was not possible are included in the town total.

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**
**Thyroid Cancer Incidence**
**Selected Communities in Massachusetts**
**1997-2001**

| Census Tract | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Hancock | 0 | 0.3 | NC | NC -- NC | 0 | 0.1 | NC | NC -- NC | 0 | 0.2 | NC | NC -- NC |
| Lanesborough | 1 | 1.2 | NC | NC -- NC | 0 | 0.3 | NC | NC -- NC | 1 | 0.9 | NC | NC -- NC |
| New Ashford | 0 | 0.1 | NC | NC -- NC | 0 | 0.0 | NC | NC -- NC | 0 | 0.1 | NC | NC -- NC |
| Williamstown | 2 | 3.0 | NC | NC -- NC | 0 | 0.7 | NC | NC -- NC | 2 | 2.3 | NC | NC -- NC |

† Cases for which census tract designation was not possible are included in the town total.

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 6**
**Thyroid Cancer Incidence**
**Selected Communities in Massachusetts**
**2002-2008**

| Census Tract | Total | | | | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI | Obs | Exp | SIR | 95% CI |
| Hancock | 0 | 1.0 | NC | NC -- NC | 0 | 0.3 | NC | NC -- NC | 0 | 0.8 | NC | NC -- NC |
| Lanesborough | 3 | 3.6 | NC | NC -- NC | 1 | 0.9 | NC | NC -- NC | 2 | 2.7 | NC | NC -- NC |
| New Ashford | 0 | 0.4 | NC | NC -- NC | 0 | 0.1 | NC | NC -- NC | 0 | 0.3 | NC | NC -- NC |
| Williamstown | 6 | 8.5 | 70 | 26 -- 153 | 2 | 2.1 | NC | NC -- NC | 4 | 6.5 | NC | NC -- NC |

† Cases for which census tract designation was not possible are included in the town total.

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
## Exposure Dose Calculations for Ingestion of Drinking Water by Students and School Staff

**Exposure Dose Calculation Formulas:**

Noncancer Health Effects Exposure Factor:

$$NC\_EF = \frac{F \times ED}{ED \times 365\ days}$$

Noncancer Health Effects Exposure Dose:

$$NC\_D = \frac{[C]_{drinking\ water} \times IR \times NC\_EF}{BW}$$

***Where:***

| | |
|---|---|
| NC_EF | = Noncancer Exposure Factor (unitless) |
| F | = Frequency of Exposure (days/year) |
| ED | = Years of Exposure (years) |
| NC_D | = Noncancer Exposure Dose (ug/kg/day) |
| $[C]_{drinking\ water}$ | = Concentration in Drinking Water (ug/L) |
| IR | = Drinking Water Ingestion Rate (L/day) |
| BW | = Body Weight (kg) |

***Assumptions:***

1. The receptors evaluated were adolescents (ages 12 to 18) and adults.
2. The average and maximum contaminant concentration detected in the Mount Greylock Regional School wells were assumed as the drinking water concentration.
3. The amount of drinking water ingested was assumed to be 1 liter per day.
4. The exposure factor was determined assuming students consumed drinking water from the wells for the entire school year for 6 years (180 days per year). For school staff, it was assumed that they consumed the drinking water for 250 days per year for 15 years; this assumes 5 days/week for 50 weeks/year and the maximum number of years for which exposure to contaminated water was assumed to have been possible.
5. The average body weight was assumed to be as follows: adult = 70 kilograms; adolescent = 50 kilograms.

## Appendix A
## Exposure Dose Calculations for Ingestion of Drinking Water by Students and School Staff

**Exposure Dose Calculations for Ingestion of Drinking Water Containing Perchlorate:**

**1. Adult**

$$\text{Noncancer Health Effects Exposure Factor} = \frac{250\ \text{days/year} \times 15\ \text{years}}{15\ \text{years} \times 365\ \text{days}} = 0.68$$

Assuming *maximum* detected perchlorate concentration:

$$\text{Noncancer Health Effects Exposure Dose} = \frac{11\ \text{ug/L} \times 1\ \text{L/day} \times 0.68}{70\ \text{kg}} = 0.11\ \text{ug/kg/day}$$

Assuming *average* detected perchlorate concentration:

$$\text{Noncancer Health Effects Exposure Dose} = \frac{4.8\ \text{ug/L} \times 1\ \text{L/day} \times 0.68}{70\ \text{kg}} = 0.047\ \text{ug/kg/day}$$

**2. Adolescent (ages 12 to 18)**

$$\text{Noncancer Health Effects Exposure Factor} = \frac{180\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.49$$

Assuming *maximum* detected perchlorate concentration:

$$\text{Noncancer Health Effects Exposure Dose} = \frac{11\ \text{ug/L} \times 1\ \text{L/day} \times 0.49}{50\ \text{kg}} = 0.11\ \text{ug/kg/day}$$

Assuming *average* detected perchlorate concentration:

$$\text{Noncancer Health Effects Exposure Dose} = \frac{4.8\ \text{ug/L} \times 1\ \text{L/day} \times 0.49}{50\ \text{kg}} = 0.047\ \text{ug/kg/day}$$

## Appendix B
## Explanation of a Standardized Incidence Ratio (SIR)
## And 95% Confidence Interval

To determine whether an elevation is occurring among individuals diagnosed with cancer in a community or census tract (CT), cancer incidence data are tabulated by gender according to eighteen age groups to compare the observed number of cancer diagnoses to the number that would be expected based on the statewide cancer rate. 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. Age-specific statewide incidence rates are applied to the population distribution of a community to calculate the number of expected cancer diagnoses. The SIR is a comparison of the number of diagnoses in the specific area (i.e., community or census tract) to the number of expected diagnoses based on the statewide rate. Comparison of SIRs between communities or census tracts is not possible because each of these areas has different population characteristics.

To calculate an SIR, it is necessary to obtain accurate population information. Population is interpolated based on U.S. census data for the community of interest. Midpoint population estimates are calculated for each time period evaluated. To estimate the population between census years, an assumption is made that the change in population occurs at a constant rate throughout the ten-year interval between each census.

A CT is a geographic subdivision of a city or town designated by the United States Census Bureau. Because age group and gender-specific population information is necessary to calculate incidence rates, the CT is the smallest geographic area for which cancer rates can be accurately calculated. Specifically, a CT is a smaller statistical subdivision of a county as defined by the U.S. Census Bureau. CTs usually contain between 1,500 and 8,000 persons and are designed to be homogenous with respect to population characteristics (U.S. DOC 2000).

An SIR of 100 indicates that the number of cancer diagnoses observed in the population 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 expected and an SIR less than 100 indicates that fewer cancer diagnoses occurred than expected. Accordingly, an SIR of 150 is interpreted as 50% more diagnoses than the expected number; an SIR of 90 indicates 10% fewer 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 are not calculated when fewer than five diagnoses are observed for a particular cancer type.

## Appendix B
## Explanation of a Standardized Incidence Ratio (SIR)
## And 95% Confidence Interval

To help interpret or measure the stability of an SIR, the statistical significance of an SIR can be assessed by calculating a 95% confidence interval (95% CI) to determine if the observed number of diagnoses is "statistically 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 has 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% percent chance that the observed difference (either increase or decrease) in the rate 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 (e.g., 105-130), then 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 (e.g., 45-96), then the number of cancer diagnoses is statistically significantly lower than expected. If the confidence interval range includes 100, then 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 alone does not necessarily imply public health significance. Determination of statistical significance is just one tool used to interpret cancer patterns in a community.

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, such as 103-115, allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval, for instance 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 is not assessed when fewer than five diagnoses are observed.

### References

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## Appendix C
## Risk Factor Summary for Thyroid Cancer

### How to Use this Factsheet

This risk factor summary was developed to serve as a general fact sheet. It is an overview and should not be considered exhaustive. For more information on other possible risk factors and health effects, please see the References section.

A risk factor is anything that increases a person's chance of developing cancer. Some risk factors can be controlled while others cannot. Risk factors can include *hereditary conditions*, *medical conditions or treatments*, *infections*, *lifestyle factors*, or *environmental exposures*. Although risk factors can influence the development of cancer, most do not directly cause cancer. An individual's risk for developing cancer may change over time due to many factors and it is likely that multiple risk factors influence the development of most cancers. Knowing the risk factors that apply to specific concerns and discussing them with your health care provider can help to make more informed lifestyle and health-care decisions.

For those cancer types with environmentally-related risk factors, an important factor in evaluating cancer risk is the route of exposure. This is particularly relevant when considering exposures to chemicals in the environment. For example, a particular chemical may have the potential to cause cancer if an individual inhales the chemical but that same chemical may not increase the risk of cancer if an individual has skin contact with the chemical. In addition, the dose and duration of time one might be exposed to an environmental agent is important in considering whether an adverse health effect might be expected.

Gene-environment interactions are another important area of cancer research. An individual's risk of developing cancer may depend on a complex interaction between their genetic make-up and exposure to an environmental agent (for example, a virus or a chemical contaminant). This may explain why some individuals have a fairly low risk of developing cancer as a result of an environmental factor or exposure, while others may be more vulnerable.

### Key Statistics

The thyroid gland is an organ at the base of the throat that makes hormones that help control heart rate, blood pressure, body temperature, and weight. The American Cancer Society estimates 56,460 individuals will be diagnosed with thyroid cancer in the U.S. in 2012: 43,210 in women, and 13,250 in men. In Massachusetts, thyroid cancer accounts for approximately 3% of all diagnosed cancers between 2004 and 2008. Women are three times more likely to develop thyroid cancer than men. The risk of thyroid cancer is highest among individuals between the ages of 20 and 55. Thyroid cancer rates have been increasing in Massachusetts since 1984, with significant increases since 1997. Between 1999 and 2003, incidence rates within Massachusetts increased by 81% for females and by 66% for males. These changes mirror national increases in thyroid cancer incidence and are attributed to better tumor detection using fine needle aspiration biopsy, ultrasound, and an increase in neck palpation as part of routine medical exams.

## Appendix C
## Risk Factor Summary for Thyroid Cancer

### Types of Thyroid Cancer

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Cancers 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).

There are several different subtypes of thyroid cancer. In Massachusetts, seventy percent of thyroid cancers are of the papillary carcinoma subtype. The second most common subtype is follicular carcinoma of the thyroid (15% of thyroid cancers). Other subtypes of thyroid cancer include medullary thyroid carcinoma (5-8%) and anaplastic carcinoma (0.5-1.5%). While thyroid cancer is one of the most common cancers for individuals below 40 years of age, each subtype of thyroid cancer has a different age-specific incidence pattern. Papillary carcinoma has a peak in incidence between 30 and 50 years of age, while follicular carcinoma has a peak in incidence among individuals between the ages of 40 and 60. Anaplastic carcinomas are usually diagnosed after age 60.

### Established Risk Factors

Each subtype of thyroid cancer may have different risk factors associated with its development.

*Hereditary Conditions*

Individuals with a family history of medullary thyroid cancer are more likely to develop this subtype. About 20% of medullary thyroid cancers result from inheriting an abnormal gene. Individuals with certain inherited medical conditions are also at higher risk of thyroid cancer. Higher rates of thyroid cancer occur among people with conditions such as Gardner syndrome, a family history of having multiple growths on the inside of the colon or rectum (familial polyposis), or a family history of having goiters (swollen thyroids) with multiple thyroid nodules.

*Environmental Exposures*

Ionizing radiation is an established risk factor for thyroid cancer. Numerous epidemiological investigations have found an elevated incidence of thyroid cancer among several groups of individuals treated with radiation in the early 20$^{th}$ century including children with ringworm of the scalp, infants with enlarged thymus glands, and adolescents with enlarged tonsils. Exposure to nuclear fallout has been linked to increased thyroid cancer in both nuclear power plant accidents such as at Chernobyl and among atomic bomb survivors in Japan. Individuals receiving treatment for certain cancers may receive ionizing radiation and be at an increased risk of thyroid cancer. Routine diagnostic x-rays, such as dental or chest x-rays, use very low doses of radiation, with their benefits usually outweighing their risks.

### Possible Risk Factors

*Lifestyle Factors*

A diet low in iodine may increase the risk of follicular carcinomas. However, this is not generally considered a cause of thyroid cancer in the United States as most table salt is fortified with iodine.

### Other Risk Factors That Have Been Investigated

Few other risk factors for thyroid cancer are known. No consistent findings have been found among studies exploring the association of thyroid cancer with oral contraceptive use, age at menarche, parity (number of pregnancies), and diet.

### Thyroid Cancer in Children

From 1975 to 1995, national incidence rates of thyroid carcinoma were practically negligible in very young children but substantially higher among 15-19 year olds, particularly for females. Exposure to ionizing radiation in childhood appears to be more strongly linked with the development of thyroid cancer than exposure in adulthood.

## XI. For More Information / References

*Much of the information contained in this summary has been taken directly from the following sources. This material is provided for informational purposes only and should not be considered as medical advice. Persons with questions regarding a specific medical problem or condition should consult their physician.*

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