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Assessment of Cancer Incidence in Census Tracts, 4563.00 and 4564.01 in Stoughton, Massachusetts 1982-1994

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ASSESSMENT OF CANCER INCIDENCE IN CENSUS TRACTS 4563 AND 4564.01 IN STOUGHTON, MASSACHUSETTS

1982-1994

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I. INTRODUCTION

At the request of Representative Louis Kafka and the Stoughton Citizen's Association, the Community Assessment Unit (CAU) of the Massachusetts Department of Public Health, Bureau of Environmental Health Assessment (MDPH, BEHA) conducted an evaluation of cancer incidence in Stoughton, Massachusetts. Specifically, the requests initiating this investigation included concerns about cancer incidence in the neighborhoods surrounding the Ark-Les Switch Corporation and the Environmental Compliance Corporation (ECC) located on Canton Street in the northwest part of town. The town of Stoughton is located in Norfolk County approximately 20 miles south of Boston. According to the 1990 U.S. Census, Stoughton has a total population of approximately 26,777 and is divided into six smaller geographic areas or census tracts (CTs). The Ark-Les and ECC sites are located in CTs 4563 and 4564.01 that comprise the northwest portion of Stoughton. Refer to Figure 1 for census tract locations in Stoughton. Refer to Figure 2 for the locations of relevant environmental sites in Stoughton.

II. OBJECTIVES

This investigation is a descriptive evaluation of health outcome data for cancer. Although the primary focus of this report is to review cancer incidence in the two CTs surrounding the Ark-Les Corporation and ECC site (CTs 4563 and 4564.01), the report also provides a review of cancer incidence in the town of Stoughton overall as well as its other four CTs (4561.01, 4561.02, 4562 and 4564.02). The intent of this investigation was to evaluate the temporal and geographic pattern of cancer in Stoughton census tracts and the possible role that risk factors, including environmental factors, might have played in cancer incidence in this area.

Information from descriptive analyses can be useful in determining whether or not a common etiology (or cause) of cancers is possible and can serve to identify areas where further public health investigations or actions may be warranted. Such actions may

include follow-up environmental investigations or, when an excess of well-established risk factors associated with a disease in a certain geographic area has been identified, public health intervention activities (i.e., cancer screening, smoking cessation, etc.). The purpose of this evaluation is to report our findings for cancer incidence and discuss them in the context of the available information to determine whether recommendations for follow-up are warranted.

The specific objectives of this investigation were as follows:

- To evaluate the incidence of cancer in Stoughton by smaller geographic areas within the town (i.e., CTs 4563 and 4564.01) to determine if certain areas have higher or lower cancer rates;

- To evaluate the geographic distribution of cancer by mapping individual cases in CTs 4563 and 4564.01 in order to determine whether any indication of a pattern of cases exists in certain areas within either of these census tracts;

- To review available descriptive information for cancer cases in Stoughton related to risk factors for developing cancer as reported by the Massachusetts Cancer Registry (MCR);

- To review available environmental data for hazardous sites of concern (i.e., Ark-Les and ECC) to determine whether environmental exposures are possible; and

- To discuss the results of this evaluation in the context of the available scientific and medical literature on cancer to determine whether future investigation or public health action is warranted.

III. METHODS FOR ANALYZING CANCER INCIDENCE DATA

A. Case Identification

The observed number of cancer cases in this evaluation was derived from cases reported to the Massachusetts Cancer Registry (MCR) as primary site cancer cases diagnosed in Stoughton residents during 1982 through 1994. Cases were selected for inclusion based on the address reported to the hospital or reporting facility at the time of diagnosis.

The MCR began collecting information on Massachusetts residents diagnosed with cancer in the state in 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.111s.111B). The 13-year period 1982-1994 constitutes the period for which the most recent and complete cancer incidence data were 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. Primary site (location in the body where the disease originated) and histology (tissue or cell type) classify the different cancer types. Epidemiological studies have revealed that different types of cancer are individual diseases with separate causes, risk factors, characteristics and patterns of survival (Bang 1996).

Eleven cancer types were evaluated in this investigation. These include cancers of the bladder, brain, breast, kidney, liver, lung, pancreas and stomach, as well as Hodgkin's disease, non-Hodgkin's lymphoma (NHL) and leukemia. These cancer types were selected for evaluation based on citizen concerns or because the scientific literature suggests environmental factors may be associated with their development. Only primary site cancers were included in this evaluation. Cancers that occur as the result of the metastases or the spread of a primary site cancer to another location in the body are not considered as a separate cancer and were, therefore, not included.

It should be noted that, this report presents brain cancer data only for primary brain cancer. Primary brain tumors are those tumors that arise from the brain and its coverings. The MCR compiles and reports tumors originating in the central nervous system as one group. This group of tumors includes malignant brain tumors, spinal cord tumors, nerve sheath tumors and benign tumors of the brain and spinal cord. Because of differences in risk factors associated with primary brain cancer and cancers originating from other sites in the central nervous system (the majority of which develop due to congenital disorders), for purposes of this report, only primary brain tumors have been analyzed. Metastatic brain tumors, which result from other types of primary cancer spreading to the brain, were not included in this analysis (Black 1991a).

Occasionally, the MCR research file may contain duplicate cases. The data discussed in this report have been controlled for duplicate cases by excluding them from the analyses. However, reports of multiple primary site cancer cases were included. Duplicate cases are additional reports of the same primary site cancer case. A multiple primary cancer case is defined by the MCR as a new tumor of the same histology (cell type) as an earlier cancer, if diagnosed in the same primary site (original location in the body) more than two months after the initial diagnosis (MCR 1996). The determination that a case was a duplicate and should be excluded from the analyses was made by the MCR after consulting with the hospital or reporting facilities and obtaining additional information regarding the histology and/or pathology of the case.

B. Calculation of Standardized Incidence Ratios (SIRs)

To determine whether elevated numbers of cancer cases have occurred in Stoughton or its census tracts, cancer incidence data were analyzed by age and gender to compare the observed number of cancer cases in each census tract to the number that would be expected based on the statewide cancer experience. Standardized incidence ratios (SIRs) were calculated for the period 1982-1994 for each of the eleven cancer types for the six census tracts and the town as a whole. SIRs were also calculated for the two time periods 1982-1986 and 1987-1994, in order to evaluate temporal trends in cancer incidence.

The census tract (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. CTs usually contain between 2,500 and 8,000 persons and are designed to be homogenous with respect to population characteristics (US DOC 1990). The town of Stoughton is composed of six CTs. The location and boundaries of the six Stoughton CTs are illustrated in Figure 1.

An SIR is an estimate of the occurrence of cancer in a population relative to what might be expected if the population had the same cancer experience as some larger comparison population designated as "normal" or average. Usually, the state as a whole is selected to be the comparison population. Using the state of Massachusetts as a comparison population provides a stable population base for the calculation of incidence rates. As a result of the instability of incidence rates based on small numbers of cases, SIRs were not calculated when fewer than five cases were observed.

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 in the comparison or "normal" population. 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. Accordingly, an SIR of 150 is interpreted as 50% more cases than the expected number; an SIR of 90 indicates 10% fewer cases 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 cases and six observed cases indicates a 50% excess in cancer, but the excess is actually only two cases. Conversely, an SIR of 150 based on 400 expected cases and 600 observed cases represents the same 50% excess in cancer, but because the

SIR is based upon a greater number of cases, the estimate is more stable. It is very unlikely that 200 excess cases of cancer would occur by chance alone.

Further, in order to calculate incidence rates, it is necessary to obtain accurate population information. The population figures used in this analysis were interpolated based on 1980 and 1990 U.S. census data for each CT in Stoughton (U.S. DOC 1980, 1990). Midpoint population estimates were calculated for each time period evaluated. To estimate the population between census years, an assumption was made that the change in population occurred at a constant rate throughout the ten-year interval between each census.

C. Calculation of 95% Confidence Interval

In addition to calculating SIRs, the statistical significance of each SIR was also assessed. A 95% confidence interval (95% CI) was calculated for each SIR 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 (Rothman and Boice 1982). A 95% CI is a method of assessing the magnitude and stability of an SIR. 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 a 5% chance that the observed difference is the result of random fluctuation in the number of observed cancer cases.

For example, if a confidence interval does not include 100 and the interval is above 100 (e.g., 105-130), then this means statistically there is a significant excess in the number of cancer cases. Similarly, if the confidence interval does not include 100 and the interval is below 100 (e.g., 45-96), then statistically the number of cancer cases is significantly lower than expected. If the confidence interval range includes 100, then the true SIR may be 100, and it cannot be concluded with sufficient confidence that the observed number of cases is not the result of chance and reflects a real cancer increase or decrease. Again, as a result of the instability of incidence rates based on small numbers

of cases, statistical significance was not assessed when fewer than five cases were occurred.

In addition to the range of the SIR estimates contained in the confidence interval, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103-115) allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval (e.g., 85-450) leaves considerable doubt about the true SIR, which could be much lower than or much higher than the calculated SIR. This would indicate an unstable statistic.

D. Determination of Geographic Distribution

The geographic distribution of cancer cases in Stoughton 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) (MapInfo 1994). 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 and within each census tract. 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 telephone books and town residential lists issued within two years of an individual's diagnosis. Address locations were also confirmed by site visits to the area.

E. Evaluation of Cancer Risk Factors

The MCR routinely collects data related to possible risk factors for individual cancer cases (e.g., age, smoking status, and occupation). The available risk factor information from the MCR was evaluated for cancers that were elevated in Stoughton. However, information about personal risk factors (e.g., family history, hormonal events, diet) that may also influence the development of cancer are not collected by the MCR and, therefore, could not be evaluated in this investigation. In addition, many cancers

have a lengthy latency period. The latency period is the period between exposure to a disease-causing agent and the appearance of manifestations of the disease (Last 1995). For that reason, residential histories were constructed for individuals diagnosed with certain cancer types described in this report if preliminary analyses suggested a possible geographic pattern. Information for residential histories was obtained from annual resident lists and voter registration lists for the town of Stoughton (Town of Stoughton 1962-1994).

IV. CANCER INCIDENCE ANALYSIS

In addition to analyzing cancer incidence data for CTs 4563 and 4564.01, cancer incidence data were also examined town-wide and in Stoughton's four other CTs. Tables 1 through 3 summarize cancer incidence for Stoughton and the two census tracts of concern (CTs 4563 and 4564.01), respectively for three different time periods: 1982-1994 and for two smaller time periods 1982-1986 and 1987-1994. Tables summarizing cancer incidence data for the four remaining CTs in Stoughton are located in Appendix A. Figure 1 depicts the location and boundaries of the Stoughton CTs evaluated in this report.

A. Cancer Incidence in Stoughton

During the period 1982-1994, the majority of cancer types occurred less than or about equal to what was expected in Stoughton overall. Cancers of the kidney, bladder, and brain, as well as leukemia and Hodgkin's disease, occurred less often than expected town-wide for the entire 1982-1994 time period (refer to Table 1A). The incidence of leukemia occurred statistically significantly less often than expected. Eighteen cases occurred where approximately 29 cases were expected (SIR=62; 95% CI= 37-98). The lower rate of leukemia in the town was primarily due to a less than expected rate in this cancer type among males. Seven cases of leukemia occurred among males during the 13-year period where approximately 17 cases were expected (SIR=42; 95%CI=17-87). The rate of leukemia in females was approximately the rate expected.

Cancer of the pancreas, stomach, breast and NHL occurred slightly more often than expected. However, none of the elevations was statistically significant. In Stoughton overall, a statistically significant elevation occurred in lung cancer (254 cases observed vs. approximately 217 cases expected). This elevation was primarily the result of a statistically significant elevation that occurred among females in the town and accounted for the majority (i.e., 62%) of the excess cases. Females in Stoughton experienced a 28% increase in lung cancer above the statewide incidence (106 cases observed vs. approximately 83 cases expected; SIR=128). These data are summarized in Table 1A. Although the elevation in lung cancer was primarily due to an increase among females, males in Stoughton also experienced an elevated rate of lung cancer during 1982-1994 (148 cases observed vs. approximately 134 cases expected). The increase among males however was not statistically significant.

Review of cancer incidence in the town during two smaller time periods (1982-1986 and 1987-1994) showed that, with the exception of cancers of the lung and pancreas, no consistent pattern of elevated cancer was observed for any of the 11 cancer types examined. These data are summarized in Table 1B. During both time periods, lung and pancreatic cancer were elevated among females in the town, while lung cancer was slightly elevated among males. Although these two cancer types were consistently elevated among females during each of the smaller time periods examined, a statistically significant elevation was observed for lung cancer during the earlier time period 1982-1986. Pancreatic cancer was 41% (SIR=141) higher among females in Stoughton than females in Massachusetts during 1982-1986 and 56% higher (SIR=156) in Stoughton during 1987-1994. However, these elevations were based on increases of approximately three and six cases, respectively.

Some elevations were also observed town-wide in other cancer types during the two smaller time periods examined. However, these elevations were specific to only one of the time periods evaluated and were not statistically significantly elevated. For example, brain cancer incidence was elevated during the earlier time period as a result of an increase observed among females. During 1982-1986, six cases occurred among females in Stoughton where slightly less than four cases were expected (SIR=172). Also,

stomach cancer incidence was elevated among males during the earlier time period 1982-1986. Ten cases were observed where approximately eight cases were expected to occur (SIR=126). The incidence of NHL was elevated among females during the later time period 1987-1994. Twenty-four cases occurred where approximately 17 cases were expected based on statewide incidence (SIR=142). Again, none of these elevations was statistically significant.

B. Cancer Incidence in Stoughton Census Tracts

As previously mentioned, although cancer incidence was reviewed in the town of Stoughton overall, the main focus of this evaluation was to address concerns over suspected elevations in cancer in certain areas of the town (i.e., CTs 4563 and 4564.01). Therefore, a review of cancer incidence in these two CTs is discussed in detail in the following sections followed by an overview of results of the cancer incidence analysis in Stoughton's four other CTs. A summary of cancer incidence data for CTs 4563 and 4564.01 is located in Tables 2 and 3.

1. Census Tract 4563

During the 13-year period 1982-1994, cancer incidence in CT 4563 was generally about equal to or below expected rates. Among males and females combined, elevations occurred in cancers of the lung (77 cases observed vs. approximately 67 cases expected), kidney (15 cases observed vs. approximately 11 cases expected), and pancreas (14 cases observed vs. approximately 10 cases expected). None of these elevations were statistically significant (see Table 2A). In addition, the incidence of these three cancer types, when reviewed separately for males and females, was not statistically significantly elevated.

The incidence of bladder cancer and NHL was less than expected overall and among males in this CT; however, females experienced slight elevations in these two cancer types that were not statistically significant. Cancer of the breast, Hodgkin's

disease and leukemia occurred less often among both males and females during the entire 13-year time period.

When evaluated for smaller time periods, cancer incidence in CT 4563 generally occurred about equal to or lower than expected rates for all 11 cancer types during the earlier time period 1982-1986 (see Table 2B). Lung cancer was elevated overall and among females during the later time period 1987-1994. Among females in this census tract, 23 cases of lung cancer were observed where approximately 18 cases were expected (SIR=127). Kidney cancer was elevated among both males and females during the later time period 1987-1994, with an excess of approximately three and two cases, respectively. With the exception of cancers of the lung and kidney, the incidence of cancer types in this census tract also occurred equal to or lower than expected rates during the later portion of the time period. Again, no statistically significant elevations occurred and most increases were based on a small number of cases (i.e., less than three).

2. Census Tract 4564.01

During the 13-year period 1982-1994, cancer incidence in CT 4564.01, located south of CT 4563, generally occurred about equal to or below expected rates. However, statistically significant elevations occurred in the incidence of Hodgkin's disease and non-Hodgkin's lymphoma (NHL). Refer to Table 3A for a summary of these data. Among males and females combined, five cases of Hodgkin's disease occurred in this area of town where less than two cases were expected based on the statewide incidence of this cancer (SIR=337). Although the incidence of this cancer displayed a statistically significant increase overall, the width of the 95% CI indicates that the SIR is unstable (95% CI=109-786). This is a result of the small number of cases that contributed to the increase (i.e., slightly more than three). Among males in this area, Hodgkin's disease occurred approximately equal to the expected number of cases. However, among females the incidence of this cancer was elevated. Four cases occurred among females during 1982-1994 where approximately one case was expected.

The incidence of NHL was also statistically significantly elevated in this CT with 16 cases observed overall versus approximately six cases expected based on Massachusetts incidence (SIR=285). When evaluated separately by gender, elevations in NHL were observed for both males and females during 1982-1994. However, the elevation observed among males was statistically significant where the elevation observed among females in this CT was not. Among males, 10 cases occurred where approximately three cases were expected (SIR=326). Among females, six cases occurred where less than three were expected (SIR=236).

An elevation was also observed during 1982-1994 in stomach cancer incidence. The elevation was based on an increase of approximately four cases overall and was not statistically significant. When the incidence of stomach cancer was reviewed for males and females separately, small increases were observed that consisted of less than two cases.

When evaluated by smaller time periods, cancer incidence in CT 4564.01 among males and females combined was generally equal to or lower than expected incidence rates. Elevations were observed for lung cancer and NHL (refer to Table 3B). Lung cancer was slightly elevated overall and among both males and females when evaluated separately. None of the elevations observed were statistically significant. During the later time period, lung cancer occurred at less than expected rates for both males and females.

As noted earlier, Hodgkin's disease was statistically significantly elevated for the period 1982-1994 due primarily to an excess among females (4 cases observed versus approximately one case expected). When evaluated by smaller time periods, two cases among females occurred in each of the time periods, and less than one case was expected for each period. The number of cases was too small to evaluate statistical significance.

The incidence of NHL was elevated during both smaller time periods. The elevations in this cancer type were observed among both males and females. However, the earlier time period displayed slight increases where three cases were observed among

males versus approximately one expected case and among females, two cases were observed versus one expected case. During the later time period 1987-1994, elevations were also observed in the incidence of NHL and a statistically significant elevation was observed for this cancer type overall. This elevation was due primarily to a statistically significant elevation among males (SIR=333; 95% CI=133-686). Seven cases occurred among males in this census tract where approximately two cases were expected. Among females, four cases occurred where approximately two cases were expected.

The temporal distribution of these cases was further reviewed to determine whether any pattern existed over time or if there was any pattern of increased cases for any one year during the 13-year period 1982-1994. Review of NHL incidence by year of diagnosis demonstrated a consistent annual incidence of NHL during the later portion of the time period 1987-1994. However, the number of cases that occurred annually were generally too few to determine any specific temporal pattern in the incidence of this cancer type.

3. Cancer Incidence in CTs 4561.01, 4561.02, 4562 and 4564.02

During the 13-year period 1982-1994, cancer incidence in the four remaining Stoughton census tracts was about equal to or less than expected based on statewide incidence for the majority of the 11 cancer types evaluated. These data are summarized in Tables 4 through 7 located in Appendix A. Lung cancer incidence was elevated in three of the four census tracts and occurred equal to the expected rate in CT 4564.02, located in the southwest portion of town. With the exception of CT 4561.01, located in the southeast portion of town, none of the elevations were statistically significant.

Statistically significant elevations were observed in specific cancer types such as lung, breast and pancreatic cancer in individual census tracts. Although the pattern of elevated cancer was not consistent across census tracts and generally was specific to certain time periods, all of the significant elevations were observed among females. In CT 4561.01, a statistically significant elevation in lung cancer incidence occurred overall primarily due to a statistically significant elevation among females in this area of

Stoughton (see Table 4A). Among females, 23 cases of lung cancer were observed versus approximately 10 cases expected (SIR=235). Review of lung cancer incidence by smaller time periods within the 13 years examined revealed statistically significant elevations among the female population in this census tract during both smaller time periods 1982-1986 and 1987-1994. Refer to Tables 4A and 4B located in Appendix A for a summary of these data.

Statistically significant elevations were also observed among females for breast and pancreatic cancer in specific census tracts. Pancreatic cancer was statistically significantly elevated among females in CT 4561.02 (see Table 5A). Overall, nine cases were observed among females in this census tract versus approximately four cases expected (SIR=252). As indicated by the width of the 95% CI (115-478), the stability of this SIR is uncertain. Review of the incidence of this cancer over time also demonstrated elevations during the two smaller time periods (see Table 5B). Results of the analyses by smaller time period however, are difficult to interpret as the increases were based on a relatively small number of cases that occurred in each time period (i.e., less than three).

In CT 4564.02, a statistically significant elevation was observed in breast cancer incidence for the entire 1982-1994 time period. These data are summarized in Tables 7A. There were 56 cases of female breast cancer observed in this census tract, where approximately 36 cases were expected (SIR=154; 95% CI=116-200). This elevation was essentially the result of a statistically significant elevation during the later portion of the 13-year period (1987-1994). Breast cancer incidence was also elevated in CT 4564.02 during the earlier portion of the 13 years examined (i.e., 1982-1986), however, the elevation was not statistically significant (refer to Table 7B).

C. Geographic Distribution

Place of residence at the time of diagnosis was mapped for all cancer types to assess any possible geographic pattern of cases. In addition to determining 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 some area(s)

within any of the census tracts in Stoughton, particularly CTs 4563 and 4564.01, the location of Ark-Les Switch Corporation and ECC.

Review of these data showed that there were no apparent spatial patterns of any specific cancer type at smaller geographic levels (i.e., neighborhoods) within the six census tracts in Stoughton. In addition, there was no specific pattern of cases observed in the vicinity of the Ark-Les Switch Corporation or ECC site. Some areas where cancer cases appeared more concentrated within CT 4563 were the result of the presence of a multi-unit-housing complex.

Although the incidence of Hodgkin's disease and NHL were significantly elevated in CT 4564.01, no geographic patterns were observed with respect to proximity to the Ark-Les Switch Corporation or ECC sites. Information about the geographic distribution of cancer cases and the potential relationship to hazardous sites identified in this area is further discussed in a later section of this report (see Section V. Community Environmental Concerns).

D. Evaluation of Risk Factor Information

As previously mentioned, cancer is a term that describes a variety of diseases. As such, epidemiological studies have generally 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. Available information related to age and gender patterns as well as other factors related to the development of cancer (e.g., smoking, occupation and latency period) was reviewed for the cancer types that were elevated in CTs 4563 and 4564.01 in Stoughton. These cancer types included lung, kidney, pancreas, Hodgkin's disease and NHL. In addition, available risk factor information related to cancer types that were significantly elevated in other Stoughton census tracts (i.e., lung, breast and pancreatic cancer) was also reviewed. Information for these cancer types in Stoughton was compared to known or established incidence trends to assess whether an unexpected pattern exists among cases diagnosed in this area of Stoughton.

1. Gender/Race

Many cancer types reveal different incidence patterns, especially with respect to race and gender. Some epidemiologic investigations have indicated that certain gender and ethnic groups experience increases or decreases in the incidence of a particular cancer type. Review of trends in cancer incidence among racial or gender groups allows for the determination of patterns that may be indicative of risk factors for increased cancer (i.e., differences in personal habits, dietary practices, education and environmental exposures).

Epidemiologic studies have shown that Hodgkin's disease is more common among men than women and more common among whites than blacks (Mueller 1996). The pattern of Hodgkin's disease in Stoughton overall displayed an equal distribution of cases among males and females. In CT 4563, one case of Hodgkin's disease occurred during 1982-1994. In CT 4564.01, a statistically significant elevation was observed overall in the incidence of Hodgkin's disease. Although the number of cases was small, the pattern of incidence was not consistent with known gender patterns of this disease as the majority of cases (four of five cases) were diagnosed among females. However, this result should be interpreted with caution, as the total number of cases was relatively small.

Since 1970, incidence rates for kidney cancer have risen approximately 2% per year among the four major race and gender groups (white males, white females, black males, and black females) (McLaughlin et. al. 1996). Recent shifts in the incidence of this cancer type have resulted from rapid increases among blacks as compared to whites (McLaughlin et. al. 1996). However, for all racial groups the incidence of kidney cancer among men is more than twice the rate among women. The majority of kidney cancer cases that occurred in Stoughton were diagnosed among men. In CTs 4563 and 4564.01, nearly all of the cases were diagnosed among Caucasians during the 1982-1994 time period. In addition, the majority of cases in these two census tracts were diagnosed in men (i.e., approximately 60%).

Throughout the world, the incidence of lung cancer among men exceeds, usually by two-fold or more, that among women. Among women, annual age-adjusted rates for this cancer are generally below 40 per 100,000 population (Blot and Fraumeni 1996). The gender difference is primarily due historically to a lower prevalence of smoking by females than males. However, this trend is decreasing as gender differences in cigarette consumption have become less pronounced among men and women (Blot and Fraumeni 1996). In the town of Stoughton, although lung cancer incidence was significantly elevated among females, the majority of the cases were still diagnosed among males (58%). A similar gender distribution was observed in CTs 4563 and 4564.01 where 56% and 68% of the cases, respectively, were males.

Among all NHL types combined, there is a greater male-to-female ratio and white-to-black ratio (Scherr and Mueller 1996). In Stoughton, the majority of cases were Caucasian and the distribution of cases according to gender revealed that a greater percentage of cases were male (63%). In CT 4564.01, where a statistically significant elevation was observed in NHL incidence, the majority of cases were also male (i.e., 63%).

Pancreatic cancer is about 50% more common in men than in women, varying somewhat by race, geographic location, and histologic type (Anderson et al 1996). In CT 4563 in Stoughton, eight of the 14 observed cases were male (57%) while six cases (43%) were diagnosed among females during the 13-year period examined. In CT 4564.01, two of the cases were male and two cases were female. In CT 4561.02 however, there was a statistically significant elevation of pancreatic cancer and the number of cases was three times greater in females than males (i.e., nine cases diagnosed among females, three cases diagnosed among males).

2. Age Distribution

Although Hodgkin's disease is relatively rare among children, two peaks in the age distribution for this cancer type have been identified (Mueller 1996). The first peak occurs in young adults usually between the ages of 15 to 39 and the second peak occurs

in older adults 55 years and above. In the town of Stoughton overall, the age distribution of Hodgkin's disease displayed a similar bimodal pattern (i.e., two peaks) and the majority of individuals were diagnosed before age 40 (i.e., 85%). In CT 4564.01, the majority of individuals were diagnosed between ages 15 to 39.

Incidence rates of kidney cancer rise with increasing age before reaching a plateau at approximately age 70 (McLaughlin et. al. 1996). The mean age of kidney cancer cases in Stoughton at the time of diagnosis was approximately 68 years. The incidence of kidney cancer generally increased with increasing age in CT 4563. In CT 4564.01, the number of kidney cancer cases was too few to determine any specific pattern; however all of the cases in this census tract were diagnosed after age 60.

Rates of lung cancer rise progressively with age until the age 80 in men and age 70 in women. The plateau and fall after age 80 in men and age 70 in women is mostly attributable to a lower prevalence of smoking in earlier-born cohorts (Blot and Fraumeni 1996). This information is consistent with the pattern of lung cancer in both CTs 4563 and 4564.01. In CT 4564.01, a similar age pattern of cases was also observed where the incidence of lung cancer decreased after age 74.

NHL occurs at all ages, however the incidence of this cancer generally increases with age (Scherr and Mueller 1996). In the town of Stoughton overall, the incidence of NHL also displayed an increasing pattern with increasing age. A similar pattern was also observed in CT 4564.01.

The most reliable and important known predictor of pancreatic cancer is age. In the first three decades of life, this cancer is extremely uncommon. The median age at diagnosis in the United States is 71 years, and the majority of cases occur between age 65 and 79 (Anderson et al 1996). Individuals over age 80 experience an increased risk of developing pancreatic cancer approximately 40 times greater than those individuals at age 40. In both CTs 4563 and 4564.01 combined, the median age of pancreatic cancer cases was 63 years of age and displayed a pattern similar to established incidence trends

for this cancer. The majority of pancreatic cancer cases in these two census tracts (70%) were diagnosed greater than age 60.

3. Smoking

During the 13-year period 1982-1994, the incidence of some cancer types was statistically elevated in the town or in certain census tracts within the town. Smoking is a known or suspected risk factor for the development of kidney and pancreatic cancer, and the principal risk factor for the development of lung cancer. Tobacco smoke, however, has not been an identified risk factor for the development of Hodgkin's disease or NHL. Therefore, smoking status information was not reviewed for these cancer types in Stoughton.

The distribution of current and former smokers among kidney cancer cases in Stoughton census tracts was less than that observed among kidney cancer cases in the state. In Massachusetts, 46% of kidney cancer cases reported a smoking status as current or former smoker (see Figure 3B) Evaluation of available information regarding smoking status for kidney cancer cases in CT 4563 revealed that five individuals (33%) reported a smoking status as current or former smoker. Seven individuals (47%) reported having never smoked, and smoking status was unknown for three individuals (20%) (See Figure 3C). With regard to the three cases observed in CT 4564.01 during the entire 1982-1994 time period, only one individual reported being a current or former smoker.

Review of smoking status for lung cancer cases in the town of Stoughton showed that overall the majority of cases were current or former smokers at the time of their diagnosis (79% among males and 68% among females) (see Figure 4A). The distribution of current or former smokers among lung cancer cases in Stoughton was similar to that for lung cancer cases in Massachusetts where 81% of male lung cancer cases and 78% of female lung cancer cases were current or former smokers (see Figure 4B).

A similar distribution was also observed in Stoughton's census tracts where the majority of lung cancer cases were current or former smokers. Evaluation of available

information regarding smoking status for lung cancer cases in CT 4563 revealed that 74% (n=57) reported a smoking status as current or former smoker. In CT 4564.01, 72% (n=18) of the cases reported a smoking status as current or former smoker. The distribution of smokers among lung cancer cases in Stoughton census tracts was consistent with that observed in the state. Refer to Figure 4 for the distribution of smoking status in Stoughton census tracts. In addition, in CT 4561.01 where a statistically significant elevation occurred in lung cancer among females, the majority of cases (70%) were current or former smokers at the time of diagnosis.

The percentage of pancreatic cancer cases that were current and former smokers was greater in Stoughton CTs 4563 and 4564.01 than in Massachusetts. Forty-three percent of pancreatic cancer cases in Massachusetts reported smoking status as current or former smoker (see Figure 5). Evaluation of available information regarding smoking status for pancreatic cancer cases in CT 4563 revealed that seven individuals (50%) reported a smoking status as current or former smoker, six individuals (43%) reported having never smoked, and smoking status was unknown for one individual (7%) (see Figure 5).

With regard to the four cases of pancreatic cancer observed in CT 4564.01 during the entire 1982-1994 time period, only one individual reported a smoking status as current or former smoker at the time of diagnosis. However, smoking status was unknown for two of the cases. In CT 4561.02 where a statistically significant elevation in pancreatic cancer was observed among females, 33% of these individuals reported never having smoked at the time of diagnosis. However, smoking status was unknown for approximately 56% of the female cases.

4. Occupation

Occupational information as reported to the MCR was reviewed for cancer types that have been associated with exposures in specific occupations. This information was reviewed to determine whether occupational factors might have contributed to the development of some cancers in Stoughton. 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.

Occupation is thought to contribute little to the etiology of kidney cancer, although some studies have found deaths from kidney cancer to be elevated among workers in certain occupations. Workers exposed to asbestos and coke-oven workers in steel plants exposed to high levels of polycyclic aromatic hydrocarbons (PAHs) have been reported to be at increased risk for kidney cancer (McLaughlin et. al. 1996, NCI 1996). It has also been suggested that kidney cancer occurs at an increased rate among workers in oil and petroleum refineries. However, recent studies of these workers have found little or no evidence of an excess incidence of kidney cancer (McLaughlin et. al. 1996). Occupational information reported to the MCR was incomplete or unknown for approximately 30% of kidney cancer cases in Stoughton. Two individuals diagnosed with kidney cancer in CTs 4563 and 4564.01 reported occupations in which exposure to solvents may have been possible.

Although the primary risk factor for the development of lung cancer is smoking, several occupational exposures have also been shown to increase the risk of developing lung cancer. These include miners, millers, textile, insulation, shipyard and cement workers (NCI 1996). In CTs 4563 and 4564.01, occupation was reported as retired or unknown for 38% (n=39) of the cases. However, seven individuals diagnosed with lung cancer reported occupations that have been associated with an increased risk of lung cancer.

Exposure to certain herbicides has been associated with an increased risk of NHL in studies of farmers, pesticide applicators, and manufacturing workers. Occupations other than agriculture that have been associated with NHL include rubber workers, petroleum refining workers, vinyl chloride workers, chemists, dry cleaners and aircraft maintenance workers. The etiologic (or causative) agents responsible for these excesses have not been identified definitively, but the occupations have in common exposure to organic solvents (NCI 1996). Occupation as reported to the MCR at the time of

diagnosis was reviewed for each NHL case in Stoughton. Review of this information did not reveal any occupations that have been suggested as associated with NHL.

Excess pancreatic cancer deaths have been observed in some occupations where exposure to chemicals or petroleum has occurred. These include manufacturers of photographic film, chemists, leather tanners and automobile mechanics (Anderson et. al. 1996). Although some studies have demonstrated an increased number of deaths due to pancreatic cancer among these occupations, further analytical studies have not confirmed these associations (NCI 1996). In CTs 4563 and 4564.01, review of occupational information did not reveal any occupations that have been suggested as associated with pancreatic cancer. However, a number of occupations were reported as unknown or incomplete (i.e., approximately 25%). In CT 4561.02, where a statistically significant elevation of pancreatic cancer was observed among females, the majority of cases reported occupation as unknown or retired (56%).

5. Residential History

Cancer in general has a long period of development or latency period that can range from 10 to 30 years and in some cases may be more than 40 or 50 years (Bang 1996, Frumkin 1995). The latency period is the interval between first exposure to a disease-causing agent(s) and the appearance of symptoms of the disease (Last 1995). Cancer does not usually develop within months after exposure. For most cancers, the latency period is an interval usually between 12 to 25 years (Bang 1996, Frumkin 1995). A residential history allows for determining the length of residence for individual cases in a certain area. This information can be useful in determining whether residence in a specific area could be related to the development of cancer given the latency period for that cancer.

Residential histories were constructed for individuals diagnosed with Hodgkin's disease and NHL in CTs 4563 and 4564.01. Among the six individuals diagnosed with Hodgkin's disease in these two CTs during the period 1982-1994, one individual was a long-term resident of the area prior to diagnosis (i.e., greater than 15 years). Two

individuals lived in this area for less than ten years before diagnosis and residential histories could not be determined three of the cases. Although additional research resulted in no further address information for these individuals, it is possible that these individuals lived in this area of Stoughton for a shorter period prior to their diagnosis with Hodgkin's disease and were, therefore, not listed in resident lists or other town sources. Considering the importance of latency, the occurrence of disease among these individuals is not likely to be associated with the environment in this area.

Among the 16 individuals diagnosed with NHL in CT 4563, approximately 44% (n=7) lived in the area for a period between 12 to 25 years. Eight of the cases resided in this census tract for less than 12 years, with the majority of these individuals residing in the area for seven years or less. Residential history could not be determined for one individual. In CT 4564.01, the majority of NHL cases (69%, n=11) were long-term residents of the census tract. That is, residential histories for these individuals indicated a period of residence in the range of 12 to 25 years. Two of the cases resided in this census tract for only five years or less and residential histories could not be determined for three individuals. As previously mentioned, although no further address information was available for these individuals, it is possible that these individuals lived in this area of Stoughton for a short period prior to their diagnosis with NHL. Therefore, it is less likely that the environment played a role in disease occurrence.

6. Stage at Diagnosis

The stage of cancer as reported to the MCR at the time of diagnosis was reviewed for breast cancer cases in Stoughton and each of its census tracts. Staging categorizes the extent of disease and its spread at the time of diagnosis. Breast cancer survival correlates strongly with a diagnosis of early stage cancer, especially with cancer limited to the breast (local or stage I) (Osteen et. al. 1996). An evaluation of staging information can help to determine whether cancer patients in a given area are being diagnosed at an early or late stage of the disease. This information can then be used to identify cancer patterns within communities where further public health intervention may be warranted.

This analysis defines stage in four categories: localized, regional, distant, or unknown. Localized breast cancer represents a diagnosis that the tumor is invasive but the cancer is confined to the breast. Regional indicates that the tumor has spread beyond the organ of origin (breast). This may include spread to adjacent tissues or organs, lymph nodes, or both. Distant indicates that the cancer has metastasized or spread to organs other than those adjacent to the organ of origin, or to distant lymph nodes or both (MCR 1996). Some of the cases reported to the MCR are reported with an unknown stage. This indicates that at the time of reporting the tumor had not been staged.

The distribution of the stage at diagnosis for female breast cancer cases in Stoughton during 1982-1994 was similar to the distribution observed in Massachusetts as a whole (see Figure 6). In both Stoughton and Massachusetts, a greater percentage of breast cancer cases were diagnosed at an early (i.e., local) stage than later stages of the disease (i.e., regional and distant). As shown in Figure 6, 67% of the female breast cancer cases in Stoughton were diagnosed at an early or local stage, while 25% of cases were detected at later stages (21% regional and 4% distant). The stage at diagnosis was unknown for 8% of the breast cancer cases in Stoughton.

Although in both Stoughton and Massachusetts the majority of female breast cancer diagnoses were at the local stage (67% in Stoughton vs. 59% in Massachusetts), Stoughton showed 8% more local breast cancer diagnoses than the state during 1982-1994. In contrast, a greater percentage of breast cancer cases were diagnosed in Massachusetts at the regional and distant stages.

When stage at diagnosis was reviewed annually in Stoughton, the greatest percentage of early stage breast cancer occurred during the years 1982 and 1986 and from the period 1990 to 1994 (greater than 67% annually). During 1982, all the breast cancer cases were diagnosed among Stoughton residents were early stage cancers. Refer to Figure 7 for the annual distribution of stage at diagnosis. For breast cancer cases in the one Stoughton census tract, 4564.02, where a statistically significant elevation of breast cancer was observed, the percentage of local stage cancers was approximately 5% greater than the town of Stoughton and 13% greater than the state.

V. COMMUNITY ENVIRONMENTAL CONCERNS

Several facilities in the northwestern portion of Stoughton are suspected of having released chemicals into the environment. Chemicals, particularly chlorinated solvents, have been detected in nearby streams, some private wells, and the indoor air of several homes. Residents of homes with contaminated wells or indoor air would have the greatest opportunities for exposure to these chemicals. However, other activities in the area (e.g., recreational activities, working) could also result in opportunities for exposures to these chemicals as well.

This report summarizes cancer incidence data for the period 1982-1994. Past opportunities for exposures to chemicals (e.g., during the 1950s, 1960s or 1970s) are more relevant to cancer data from this period than are current exposures. This is because as previously mentioned, the majority of cancer types evaluated have latency or development periods that can range from 12 to 25 years and possibly as long as 50 years (Bang 1996, Frumkin 1995). However, very little is known about the nature and extent of environmental contamination in the past in this area of Stoughton. In order to evaluate the potential for past exposure, the operational history and chemicals used at the main facilities currently under investigation by the Massachusetts Department of Environmental Protection (MDEP) are summarized in the following paragraphs. These facilities are located in either CT 4563 or 4564.01. The location of these facilities is displayed in Figure 2.

A. Ark-Les Switch Corporation

The Ark-Les Switch Corporation manufactures electric switches and terminals. This company has occupied the site at 1490 Central Street since 1960. Between 1955 and 1959, there was a machine shop on the site. The site was an undeveloped wood lot before 1955 (HMM 1994b).

Currently, metals, oils, and chlorinated solvents (primarily 1,1,1-trichloroethane or 1,1,1-TCA) are used in the industrial processes at the Ark-Les facility on Central Street (MCA 1989). Groundwater contamination by chlorinated solvents (primarily 1,1,1-TCA) has been detected beneath the Ark-Les property and properties downgradient of Ark-Les to the south side of Canton Street (HMM 1994b, Earth Tech 1995).

Ark-Les operates another facility at 53 Evans Drive in Stoughton. During the removal of three underground storage tanks at this site in 1987, releases of petroleum products were discovered. The petroleum-contaminated soil was excavated and removed (HMM 1994a).

B. Environmental Compliance Corporation (ECC)

The property at 441R Canton Road was originally farmland. The Walent Coal Company purchased the parcel in 1927 and used it to store coal and home heating oil between 1940 and 1972. There are also reports that tannery waste was dumped on the site during this period. Since 1972, hazardous materials storage and a processing facility has operated on the property. From 1972 to 1994, the business was owned by Jet-Line Services, Incorporated. Environmental Compliance Corporation (ECC) has operated the business since 1994 (MDEP 1998b, Cabral 1998).

ECC, like Jet-Line Services previously, mainly accepts waste oils and oily wastewater (MDEP 1998a). Releases of gasoline and other petroleum products onsite have been documented (Phoenix 1998).

C. Brookfield Engineering Laboratory, Inc.

Brookfield Engineering Laboratory, Inc. built the structure at 240 Cushing Street on an undeveloped parcel in 1952. The company manufactures electronics instruments, which involves milling and cleaning metal parts using oils and chlorinated solvents, respectively. Until 1997, the company also performed metal plating on the site (Fuss & O'Neil 1998). From approximately 1960 to 1992, the primary chlorinated solvent used

on the site was 1,1,1-TCA and then trichloroethylene (TCE) from 1992 to present (MDEP 1998a). In addition, chlorinated solvents (primarily 1,1,1-TCA) have been detected in the groundwater on the site (Fuss & O'Neil 1998).

D. F.C. Phillips, Inc.

F.C. Phillips Inc. purchased the formerly residential property at 473 Washington Street in 1915. Since that time, metal machine parts have been manufactured on this site. This process involves the use of chlorinated solvents and petroleum products. During the period 1915 and 1976, F.C Phillips, Inc. also performed metal plating at the facility. In 1987, chlorinated solvents were detected in the groundwater near the former wastewater discharge from the facility (H&A 1986, 1987). Since 1994, a pump-and-treat system has been operating with the aim of containing the groundwater contamination on the site (Rizzo 1998). The extent of the groundwater contamination from this site is uncertain but may reach as far as the intersection of Simpson and Central streets.

E. Other Facilities

In addition to these four facilities, there are several other properties in the area under investigation by the MDEP for suspected releases of hazardous substances. Zechello Rug Cleaning and Diaz Automotive (Getty Station) are both located near Canton Street between Simpson Street and Southworth Court. The Gill Machine Shop is located at the southern end of Southworth Court. The former Gill Machine Shop at 45 Brook Street is also under investigation. In addition, the U.S. Environmental Protection Agency recently collected soil and drum samples from the property of Donahue's Trucking at the intersection of Lambert and Rockland Streets (MDEP 1998c).

F. Evaluation of Environmental Information Relative to Cancer Incidence Data

Review of currently available environmental information revealed that the approximate area that appears to be most affected by environmental contamination from these sites is the area bound by Canton, Central, and Washington Streets. Canton Street

forms the boundary between CTs 4563 and 4564.01, and, therefore, most of this area lies within CT 4563 (see Figure 2). Areas along the outside edge of the area bounded by Canton, Central and Washington Street may also be affected. However, given that the environmental investigations of these sites are not complete, the full extent, nature and history of environmental contamination in central Stoughton is uncertain.

The geographic distribution of cancer cases was qualitatively evaluated in relation to the area identified as most likely to be affected by environmental contamination. No geographic patterns were observed with respect to this area. In addition, for the two cancer types that were statistically significantly elevated in CT 4564.01 (i.e., Hodgkin's disease and NHL), no cases were located in this area during the period 1982-1994.

Recently, several Canton Street homes showed indoor air detections of chlorinated solvents thought to be related to groundwater contamination in the area near the Ark-Les, ECC and other nearby facilities. Health concerns related to these recent detections are currently being evaluated in a separate MDPH consultation (MDPH 1999).

VI. DISCUSSION

Although elevations were noted among certain cancers in the two census tracts that were the focus of this assessment, with the exception of Hodgkin's disease and NHL in CT 4564.01, none of the elevations observed were statistically significant. Most cancer types occurred at a rate that was about equal to or below expected rates based on statewide incidence. Small elevations were observed in CT 4563 for cancers of the kidney, lung and pancreas. Again, none of these elevations represented a statistically significant difference between the observed and expected number of cases. In addition, the width of the 95% confidence interval for these SIRs indicated that, as a result of the relatively small number of cases, the elevations in these cancer types are somewhat unstable. Further, there was no apparent pattern with respect to elevations across time periods or gender for any of these cancer types.

Review of the distribution of cancer cases according to age and gender, as well as risk factor information related to smoking and occupation, did not reveal any pattern or trend that was unexpected or inconsistent with established incidence patterns for these cancer types. However, it should be noted that occupational information available from the MCR was fairly limited in that occupation was unknown for approximately 40% of the cancer cases in the two census tracts. With respect to smoking, the majority of individuals diagnosed with cancers of the kidney, lung and pancreas were current or former smokers at the time of diagnosis (i.e., generally 70% or greater). Therefore, it is possible that smoking played a role in the incidence of some of these cancers. The geographic location of cases also revealed no apparent spatial pattern of cancer cases in either CT 4563 or 4564.01, nor did it reveal any spatial pattern in relation to the area where the Ark-Les and ECC facilities are located.

However in CT 4564.01, a statistically significant elevation occurred in NHL particularly among males. Although the incidence of NHL was elevated in this census tract during both smaller time periods, when evaluated further, a statistically significant elevation was only observed among males during the later time period 1987-1994. The apparent increase in NHL in later years is consistent with similar increases observed in the incidence of this cancer in the state of Massachusetts and nationally. In Massachusetts, the incidence of NHL among males increased by approximately 52% from 1982 to 1994 (MDPH 1997). However, the increase observed among males in CT 4564.01 was significantly higher than the rate observed in Massachusetts.

With the exception of Hodgkin's disease and NHL, during the years 1982-1994 no pattern of increased cancer incidence was observed in CTs 4563 and 4564.01, located in the northwest portion of the town of Stoughton. The two cancer types that were significantly elevated displayed no consistent or specific pattern with respect to the age, year of diagnosis or geographic location of cases. In addition, none of the Hodgkin's disease and NHL cases occurred in the area thought to be most affected by environmental contamination from the Ark-Les, ECC, and other nearby sites.

Review of residential histories for Hodgkin's disease and NHL cases showed that the length of residence for the majority of cases in CT 4563 was not consistent with the latency period for cancer (i.e., 12 to 25 years). This suggests that residence in this census tract was not likely a primary factor related to the development of these cancers. However, in CT 4564.01, the length of residence for NHL cases did show that the majority of cases (69%) were long-term residents of the area prior to diagnosis. Therefore, the length of residence for some of the NHL cases in this census tract was consistent with the latency period for the development of this cancer. Although factors related to residence in this area cannot be ruled out as possible factor in the development of NHL, based on other information reviewed for these cases related to cancer development, it does not appear likely that local environmental exposures were the primary factor related to the increased incidence of NHL in this area.

Hodgkin's Disease and non-Hodgkin's Lymphoma (NHL)

Epidemiologic studies have established that the primary factors that are related to developing both Hodgkin's disease and NHL are infectious in nature. Although some studies have suggested that environmental (i.e., chemical) exposures may be related to the development of NHL, no definitive association has been established, and no such association has been established with the development of Hodgkin's disease. This report provides a descriptive evaluation of cancer rates in the town of Stoughton and smaller geographic areas within the town. As such, this evaluation cannot determine the causal relationship of individual cancers in this area with risk factors, environmental or non-environmental, discussed in this report. A discussion of risk factors related to the development of both Hodgkin's disease and NHL is provided in the following paragraphs. Additional risk factor information for other cancer types that were elevated in this analysis (i.e., breast, lung and pancreas) are discussed in Appendix B.

Hodgkin's disease is a form of cancer that involves the lymphatic system and can be classified in four histologic (or cellular) types. These four types of Hodgkin's disease occur with different frequencies according to age at diagnosis and the aggressiveness of the histologic type (Mueller 1996). However, due to substantial improvement in

effective therapy for this disease, mortality rates have decreased approximately 55% over the last ten decades. This decrease in mortality is also due to a better early stage diagnosis (Mueller 1996).

Epidemiologic studies have shown that Hodgkin's disease is more common among men than women and more common among whites than blacks. Although the disease is relatively rare among children, two peaks in the age distribution have been observed for this cancer type. The first peak occurs in young adults usually between the ages of 15 to 39 and the second peak occurs in older adults 55 years and above.

The bimodal age distribution (i.e., two peaks) of this disease suggests that two distinct etiologies (or causes) for Hodgkin's disease may be involved for each group. Specifically, researchers have proposed that among young adults, Hodgkin's disease is caused by a biological agent of low infectivity and that among individuals of older ages, the cause is probably similar to those of other lymphomas (Mueller 1996). Furthermore, the clinical and cellular features of Hodgkin's disease suggest a chronic infectious process is related to the disease. The two viruses that have been linked most specifically to this disease are the Epstein-Barr virus (EBV) and the more recently discovered human herpesvirus-6 (HHV-6) (NCI 1996, Mueller 1996). EBV is a common herpesvirus. Several reports of Hodgkin's disease have been documented in individuals with primary EBV infection. In addition, several studies have also shown that young adults who have developed infectious mononucleosis have a significantly higher risk of developing Hodgkin's disease (NCI 1996, Mueller 1996).

Hodgkin's disease trends reveal that the disease has become increasingly associated with populations both of middle to higher socioeconomic status and small family size. Several epidemiological studies have also suggested that occupational exposure to workers in the chemical industry and woodworkers may be associated with the development of Hodgkin's disease. However, specific chemical exposures related to the development of this disease have not been identified (NCI 1996).

Lymphomas are cancers involving the cells of the lymphatic system. The majority of lymphomas involve the lymph nodes and spleen but the disease may also affect other areas within the body (Skarin et. al. 1996). Non-Hodgkin's lymphoma (NHL) is a classification of all lymphomas with the exclusion of Hodgkin's disease. Thus, NHL is a mixed group of diseases that is characterized by the malignant increase in specific cells of the immune system (B or T lymphocytes). The various types of NHL are thought to represent different diseases with different causes (Scherr and Mueller 1996). NHL can occur at all ages. However, the incidence of this disease generally increases with age. Among all NHL types there is a greater male to female ratio and white to black ratio (NCI 1996). In Massachusetts, the incidence of NHL among males increased by 53% from 11.6 cases per 100,000 in 1982 to 17.6 cases per 100,000 in 1994. Among Massachusetts women, the incidence of NHL increased from 9.5 cases per 100,000 in 1982 to 11.5 cases per 100,000 in 1994 (MCR 1997). This was an increase of 22% over the 13-year period 1982-1994.

Nationally the increase in NHL incidence has been attributed to changes in case classification, better diagnostic techniques, greater exposure to causative agents, and the increasing incidence of AIDS-related lymphomas (Devesa et al 1992, Scherr and Mueller 1996). Although the primary factors related to the development of NHL include conditions that suppress the immune system, viral infections and certain occupational exposures, these factors are thought to account for only a portion of the increase observed in this cancer type (Scherr and Mueller 1996).

NHL is more common among people who have abnormal or compromised immune systems, such as those with inherited diseases that suppress the immune system, organ transplant recipients, and individuals with autoimmune disorders (Scherr and Mueller 1996). NHL has also been reported to occur more frequently among individuals with conditions that require medical treatment resulting in suppression of the immune system, such as cancer chemotherapy. Current evidence suggests that the development of NHL is related to suppression of the individual's immune system as a result of treatment rather than the treatment itself (Scherr and Mueller 1996).

Several viruses have been shown to play a role in the development of NHL. Among organ transplant recipients, suppression of the immune system required for acceptance of the transplant leads to a loss of control or the reactivation of viruses that have been dormant in the body (e.g., Epstein-Barr Virus (EBV) and herpesvirus infections). In addition, cancer-causing viruses are known to cause lymphoma in various animals. Therefore, it has been proposed that these types of viruses may also be associated with the development of NHL among humans without compromised immune systems (Scherr and Mueller 1996). The infection with the human HTLV-I virus is known to cause T-cell lymphoma among adults. However, although this type of virus is known to cause lymphoma, it is a relatively rare infection and most likely contributes only a small amount to the total incidence of NHL (Scherr and Mueller 1996). Since EBV infection is common among the general population and has been shown to play a role in the development of most cases of transplant and AIDS related NHL, several studies have been conducted to determine the role of EBV infection in the development of NHL in general. These studies have shown that although viruses are causal factors for some subtypes of NHL, their role in the development of NHL as a whole may not be large (Scherr and Mueller 1996).

Some occupations have been associated with an increased risk of developing NHL, specifically occupations related to chemicals or agriculture. Farmers, herbicide and pesticide applicators, and grain workers appear to have the most increased risk (Zahm 1990, 1993; Tatham et. al. 1997). Studies conducted among agricultural workers have demonstrated increases in NHL among those using herbicides for more than 20 days per year and individuals who mix or apply herbicides. A greater incidence of NHL appears to be related specifically to exposure to the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) and a class of insecticides called organophosphates (Wigle et. al. 1990; Zahm et. al. 1990, Zahm et. al. 1993). Further studies of exposure to these chemicals and NHL incidence have shown that the increased risk is attributed to a specific impurity, 2,3,7,8-tetrachlorodibenzo-p-dioxin or 2,3,7,8-TCDD, present in these herbicides. However, reports of accidental industrial exposures to TCDD have not demonstrated an increased risk of NHL (Scherr and Mueller 1996). An elevated risk for NHL development has also been noted among fence workers, orchard workers, and meat workers.

In addition, epidemiological studies of long-term users of permanent hair coloring products have found an increased incidence of NHL (Zahm et al 1992; Scherr and Mueller 1996). However, a recent population based study found no association between the use of hair-color products and an increased risk of developing this type of cancer. The researchers further stated that results from this study and previous studies, including experimental animal studies, provide little convincing evidence linking NHL with normal use of hair-color products (Holly et. al. 1998).

Some studies have also found a positive association with the incidence of NHL and smoking. A study that evaluated the history of tobacco use and deaths from NHL determined that people who had ever smoked had a two-fold increase of dying from NHL as compared to those who never smoked. Further a four-fold increase was found among the heaviest smokers (Linet et. al. 1992). In addition, a more recent study that primarily examined occupation and NHL risk found a significant association with high levels of cigarette smoking and all NHL types (Tatham et. al. 1997).

VII. SUMMARY/CONCLUSIONS

Primary Conclusions

- During the period 1982-1994, the majority of the eleven cancer types evaluated in Stoughton occurred about equal to or less often than expected based on the statewide incidence of these cancers.

- Cancer incidence in CTs 4563 and 4564.01, the location of the Ark-Les and ECC sites, was less than or equal to expected rates for nine of the eleven cancer types evaluated in this assessment. No statistically significant elevations occurred in any cancer types in CT 4563.

- The incidence of Hodgkin's disease and non-Hodgkin's lymphoma (NHL) were statistically elevated in CT 4564.01. No consistent pattern of increase was observed

in these cancer types over time and none of the cases occurred in the area thought to be most affected by environmental contamination from the Ark-Les, ECC, and other nearby sites. In addition, length of residence for a number of individuals diagnosed with these cancers suggests that the environment is not likely to be a primary factor in the development of disease in this area.

Secondary Conclusions

- The incidence of leukemia occurred statistically significantly less often than expected in the town, particularly among Stoughton males.

- Lung cancer was statistically elevated among females in Stoughton, particularly during the earlier portion of the 13 years evaluated (i.e., 1982-1986). The town-wide elevation was largely the result of consistent and significant elevations that occurred among females in CT 4561.01, located in the southeast portion of Stoughton. The number of lung cancer cases among females was more than twice the number expected for this area based on statewide lung cancer rates. Available data suggest that smoking has likely played a role in the development of disease for these individuals.

- No specific spatial or geographic pattern of any of the eleven cancer types was observed in the town of Stoughton or within any of the six census tracts that subdivide the town. Further, no geographic pattern of cancer cases was observed in either CT 4563 or CT 4564.01 in relation to hazardous waste sites currently under investigation by the MDEP in this area.

VIII. RECOMMENDATIONS

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

- The MDPH recommends that the Stoughton Health Department coordinate with the MDPH, Office of Tobacco Control to determine appropriate smoking intervention strategies, particularly for females in the town.

- The MDPH will continue to provide technical assistance in reviewing environmental data for sites currently under investigation in the Canton Street area of Stoughton.

IX. REFERENCES

Anderson, K., et. al. 1996 Pancreatic Cancer. Chapter 35 Cancer Epidemiology and Prevention. 2nd ed. Schottenfeld, D. and Fraumeni, J.F. eds. Oxford University Press. New York, NY.

Bang, K.M. 1996. *Epidemiology of occupational cancer*. Occupational Medicine:state of the art reviews. 11(3): 467-485.

Black, P.M. 1991a. *Brain Tumors (first of two parts)*. New England Journal of Medicine. 324(21): 1471-76.

Blot, W., Fraumeni, J. 1996. Cancers of the Lung and Pleura. Chapter 31 in Cancer Epidemiology and Prevention. 2nd ed. Schottenfeld, D. and Fraumeni, J.F. eds. Oxford University Press. New York, NY.

Brown, LM, et al. 1992. *Smoking and Risk of Non-Hodgkin's Lymphoma and Multiple Myeloma.* Cancer Causes Control 3:49-55.

Cabral, D. 1998. Personal communication with Denise Cabral, Environmental Affairs Officer, Town of Stoughton, Massachusetts. November 1998.

Devesa et al. 1992. *Non-Hodgkin's Lymphoma Time Trends: United States and International Data.* Cancer Res (Suppl.) 52:5492s-549s. 1992.

Earth Tech. 1995. *Limited Groundwater and Surface Water Quality Study, Ark-Les Corporation, 1490 Central Street, Stoughton, Massachusetts*, Earth Tech, Concord, MA, July 1995.

Frumkin, H. 1995. Carcinogens. Chapter 14 in Occupational Health 3rd ed. Levy, B.S. and Wegman, D.H. eds. Little, Brown and Company. Boston, MA.

Fuss & O'Neil. 1998. *IRA Status Report, Brookfield Engineering Laboratory, Inc., 240 Cushing Street, Stoughton, Massachusetts*, Fuss & O'Neil, Inc., Manchester, CT, November 1998.

H&A. 1986. *Report on Site Assessment, 473 Washington Street, Stoughton, Massachusetts*, Haley & Aldrich, Inc., Cambridge, MA, December 1986.

H&A. 1987. *Report on Phase II Site Assessment for F.C. Phillips, Inc., Stoughton, Massachusetts*, Haley & Aldrich, Inc., Cambridge, MA, July 1987.

HMM. 1994a. *LSP Evaluation Opinion Transmittal Form and RAO Statement, Ark-Les Corporation, 53 Evans Drive, Stoughton, Massachusetts*, HMM Associates, Inc., Concord, MA, April 1994.

HMM. 1994b. *Transition Site Classification Review, Ark-Les Corporation, 1490 Central Street, Stoughton, Massachusetts*, HMM Associates, Inc., Concord, MA, May 1994.

Holly, Elizabeth A., et al. *Hair-Color Products and Risk for Non-Hodgkin's Lymphoma: A Population-Based Study in the San Francisco Bay Area.* American Journal of Public Health. December 1998, Vol. 88, No.12.

Last, John M. A Dictionary of Epidemiology. International Epidemiological Association, Inc.. Oxford University Press. New York: 1995.

Linet MS, et al. 1992. *Is cigarette smoking a risk factor for non-Hodgkin's lymphoma or multiple myeloma? results from the Lutheran Brotherhood Cohort Study.* Leuk Res 16:621-624.

MapInfo, ver. 3.0 1994. Copyright MapInfo Corporation, 1985-1994. Troy, New York.

Massachusetts General Laws, Chapter 111, Section 111B.

McLaughlin, J., et. al. 1996. Renal Cancer. Chapter 53 in . Cancer Epidemiology and Prevention. 2nd ed. Schottenfeld, D. and Fraumeni, J.F. eds. Oxford University Press, New York, NY.

MCA. 1989. *Preliminary Site Investigation, Ark-Les Corporation, Central Street, Stoughton, Massachusetts*, Mabbett, Capaccio & Associates, Inc., Bedford, MA, December 1989.

MCR. 1996. *Massachusetts Cancer Registry Abstracting and Coding Manual for Hospitals.* 2nd Ed. March 1996. Massachusetts Department of Public Health, Bureau of Health Statistics, Research and Evaluation, Massachusetts Cancer Registry. Boston, MA.

MDEP. 1998a. *Fact Sheet, Environmental Compliance Corporation, Draft Hazardous Waste Facility License*, Business Compliance Division, Bureau of Waste Prevention, Massachusetts Department of Environmental Protection, Boston, MA, February 1998.

MDEP. 1998b. Personal communication from James Kenny, Environmental Analyst, Bureau of Waste Site Cleanup, Massachusetts Department of Environmental Protection, Southeast Regional Office, Lakeville, MA, December 1st, 1998.

MDEP. 1998c. Personal communication from Gerard Martin, Chief, Site Management & Permits Section, Bureau of Waste Site Cleanup, Massachusetts Department of Environmental Protection, Southeast Regional Office, Lakeville, MA November 20th, 1998.

MDPH. 1997b. *Cancer Incidence in Massachusetts 1987-1994: City and Town Supplement.* Massachusetts Department of Public Health, Bureau of Health Statistics, Research, and Evaluation, Massachusetts Cancer Registry. November, 1997.

Mueller, N.E. 1996. Hodgkin's Disease. Chapter 41 in Cancer Epidemiology and Prevention, 2nd ed. Shottenfeld, D. and Fraumeni, J.F. eds. Oxford University Press, New York, NY.

NCI. 1996. Cancer Rates and Risks. 4th ed. National Cancer Institute, National Institutes of Health, Publication No. 96-691, 1996.

Osteen. et. al 1996. Cancer of the Breast. Cancer Manual 9th ed. American Cancer Society, Massachusetts Division, Boston, MA.

Phoenix. 1998. Assessment and Monitoring Summary Report, Environmental Compliance Corporation, 441 Canton Street, Stoughton, Massachusetts, Phoenix Environmental Services, Inc., Bedford, MA, June 1998.

Rizzo. 1998. *Release Abatement Measure Status Report, 471 Washington Street, Stoughton, Massachusetts*, Rizzo Associates, Inc., Natick, MA, June 1998.

Rothman, K. and J. Boice. 1982. Epidemiologic Analysis with a Programmable Calculator. Epidemiology Resources, Inc. Boston, MA.

Scherr, P.A., and Mueller, N.E. 1996. Non-Hodgkin's Lymphomas. Chapter 42 in Cancer Epidemiology and Prevention. 2nd ed. Schottenfeld, D. and Fraumeni, J.F. Oxford University Press. New York, NY.

Skarin, AT. et. al. 1996. Lymphoma. Cancer Manual 9th ed. American Cancer Society, Massachusetts Division. Boston, MA.

Town of Stoughton. 1962-1994. List of Residents and Voter Registration Lists.

Tatham, Lilith, et al. 1997. *Occupational Risk Factors for Subgroups of Non-Hodgkin's Lymphoma.* Epidemiology. 8 (5), September, 1997.

U.S. Department of Commerce (DOC). 1980. Census of Population: General Population Characteristics, Massachusetts. U.S. Department of Commerce, Washington, DC: US Gov't Printing Office.

U.S. DOC. 1990. Census of Population: General Population Characteristics, Massachusetts. U.S. Department of Commerce, Washington, DC: US Gov't Printing Office.

Wigle, Donald T., et al. 1990. *MortalityStudy of Canadian Male Farm Operators: Non-Hodgkin's Lymphoma Mortality and Agricultural Practices in Saskatchewan.* Journal of the National Cancer Institue. 82 (7), April 4, 1990.

Zahm, Shiela H., et al. 1990. *A Case-Control Study of Non-Hodgkin's Lymphoma and the Herbicide 2,4-Dichlorophenoxyacetic Acid (2,4-D) in Eastern Nebraska.* Epidemiology. 1(5), September 1990.

Zahm, Shiela H., et al. 1992. *Use of Hair Coloring Products and the Risk of Lymphoma, Multiple Myeloma, and Chronic Lymphocytic Leukemia*. American Journal of Public Health. 82, pp. 990-97, 1992.

Zahm, Shiela H., et al. 1993. *The Role of Agricultural Pesticide Use in the Development of Non-Hodgkin's Lymphoma in Women*. Archives of Environmental Health. 48 (5) September 1993.

Figures

Tables

Appendix A

Cancer Incidence in Remaining Census Tracts, Stoughton, MA

Tables 4 through 7: Census Tracts 4561.01, 4561.02, 4562, 4564.01 and 4564.02

Appendix B

Risk Factor Information for Cancers of the Breast, Lung and Pancreas