The Merrimack Valley Pediatric Asthma Epidemiological Study

- Air Quality Dispersion Modeling/Exposure Assessment

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Executive Summary

Emissions from municipal waste combustors and other stationary sources of air pollution have heightened concern about the respiratory health of residents living in the Merrimack Valley region in Northeastern Massachusetts. In addition, the topographic configuration of this region (a broad valley oriented generally southwest to northeast) can result in the trapping of air pollutants that are emitted from stationary and mobile sources. To help address regional concerns about public health, the Massachusetts Department of Public Health (MADPH) retained KM Chng Environmental Inc. to support the exposure assessment portion of its epidemiological study of asthma in children in the Merrimack Valley. The study region includes the towns of Dracut, Andover, North Andover, and the cities of Lawrence, Methuen, and Haverhill (also referred to in this report as "the six-community study region," or the specifically-named town or city (by itself) as a geographic entity in the Merrimack Valley).

In order to determine the most appropriate meteorological data for the analysis, data were acquired and wind roses were developed and analyzed for two locations in the Merrimack Valley, and for Boston's Logan International Airport, a flat, exposed coastal location approximately 22 miles southeast of the study area. A Pasquill Stability Class frequency analysis was also performed to aid in the determination of the most appropriate meteorological data.

While most of the land area being modeled in the six-community study region where the stack plumes will be dispersing is in a rural environment, the urban areas of Lawrence and Haverhill are also in the modeling domain. Because the study area included several urban areas and a number of areas with mixed land use, a preliminary dispersion modeling sensitivity analysis was performed using permitted (allowable) particulate matter (PM10) stack emissions data that were initially available at the onset of this study. The purpose of this preliminary modeling, using the USEPA's ISCST3 model, was to select the appropriate dispersion model option for rural or urban mode.

The wind rose and Pasquill Stability Class frequency analyses confirmed the selection of the 1998-2001 Lawrence Municipal Airport hourly meteorological database for use in the final dispersion modeling since those data were shown to be the most representative of meteorological conditions expected in the study area. This model sensitivity analysis confirmed the selection of the rural mode option for use in the final dispersion modeling since most of the land area being modeled in the six-community study region where the stack plumes disperse is in a rural environment, and maximum cumulative source concentrations would not be underestimated using the rural mode option. It was also found from the preliminary dispersion modeling that the selection of meteorological databases and model options can have a significant impact on the locations and magnitudes of modeled maximum ground-level concentrations, given the terrain in the Merrimack Valley region.

Final refined air quality dispersion modeling with actual stack emissions data from 39 facilities located within, or in the vicinity of, the six-community study region was performed using the USEPA's ISCST3 model and a grid of approximately 6,300 receptors with 250 meter spacing covering nearly 150 square miles. An additional 82 discrete receptors, representing the locations

of specific schools in the study area provided by the MADPH, were also evaluated separately in this modeling study.

Seasonal and annual average dispersion modeling was performed for each of four years (1998-2001) using the Lawrence Municipal Airport meteorological database, and actual PM10 and VOC facility emissions. To help smooth out any year-to-year meteorological variability, composite four-year average seasonal and annual average concentration values were calculated at each modeled receptor for purposes of identifying long-term (chronic) impacts within the study area. The seasonal and annual concentrations at each receptor for each pollutant modeled therefore, represented four-year composite averages for the MADPH's use to spatially evaluate and correlate concentration predictions with pediatric asthma prevalence data. No short-term average modeling (less than or equal to 24 hours) to assess potential acute exposure impacts from air pollutant emissions was performed in this study.

Using base maps of the six-community study region, plots of cumulative source four-year composite average seasonal and annual PM10 and VOC concentrations were developed that depicted isopleth bands showing the locations of maximum predicted PM10 and VOC concentrations. Tables were also prepared that summarize the locations and magnitudes of the highest modeled composite four-year average seasonal and annual PM10 and VOC concentrations for each modeled facility and for all facilities combined (cumulative) on a seasonal and annual basis. The 82 school receptor locations were modeled on a cumulative source basis only, and composite 4-year average seasonal and annual PM10 and VOC concentrations were likewise calculated.

The detailed methodology and assumptions used for the dispersion modeling are discussed in this study. A discussion on modeling uncertainties has also been included to help address several areas of uncertainty associated with the dispersion modeling. A summary of the dispersion modeling results is given below.

Higher cumulative seasonal and annual PM10 concentrations were found to occur in portions of Haverhill. This concentration pattern reflects the larger facility emission rate and the lower stack plume height above ground that was associated with the principal contributing source described in this study. The highest modeled cumulative seasonal PM10 concentrations ranged from 6.73 $\mu g/m^3$ (spring season) to 17.05 $\mu g/m^3$ (summer season). The highest modeled cumulative annual PM10 concentration was 9.14 $\mu g/m^3$. The differences in highest cumulative seasonal and annual PM10 concentrations can be attributed to seasonal variations in the meteorological data used in the modeling. The majority of the modeled receptors (approximately 99 percent of the 6,313 total Cartesian grid receptors) also had cumulative seasonal and annual PM10 concentrations that did not exceed 2 $\mu g/m^3$.

Higher cumulative seasonal and annual VOC concentrations were found to occur in portions of Haverhill, Lawrence, Andover, and Dracut. This concentration pattern reflects the larger facility emission rates and the lower stack plume heights above ground that were associated with the principal contributing sources described in this study. The highest modeled cumulative seasonal VOC concentrations (and their corresponding locations) ranged from 20.77 $\mu g/m^3$ (winter season, in Lawrence) to 39.16 $\mu g/m^3$ (summer season, in Haverhill). The highest modeled cumulative

annual VOC concentration was 21.25 $\mu g/m^3$ (also in Haverhill). The temporal and spatial differences in highest cumulative seasonal and annual VOC concentrations can also be attributed to seasonal variations in that existed in the meteorological data used in the modeling. The majority of the modeled receptors (approximately 99 percent of the 6,313 total Cartesian grid receptors) also had cumulative seasonal and annual VOC concentrations that did not exceed 8 $\mu g/m^3$.

School 47 in Haverhill had the highest average modeled seasonal (fall) and annual PM10 concentrations of 3.82 $\mu g/m^3$ and 2.86 $\mu g/m^3$, respectively. School 53 in Haverhill is in the vicinity of School 47; hence, the modeled average seasonal and annual PM10 concentrations were quite similar. School 66 in Lawrence had the next highest average modeled seasonal (fall) and annual PM10 concentrations of 2.19 $\mu g/m^3$ and 1.77 $\mu g/m^3$, respectively. The majority of the other school receptor locations had modeled average seasonal and annual PM10 concentrations below 1 $\mu g/m^3$. These modeled average seasonal and annual PM10 concentrations are all well below USEPA's and MADEP's annual PM10 National Ambient Air Quality Standard of 50 $\mu g/m^3$.

School 47 in Haverhill had the highest average modeled seasonal (fall) and annual VOC concentrations of 10.58 $\mu g/m^3$ and 7.82 $\mu g/m^3$, respectively. School 53 in Haverhill is in the vicinity of School 47; hence, the modeled average seasonal and annual VOC concentrations were quite similar. School 66 in Lawrence had the next highest average modeled seasonal (fall) and annual VOC concentrations of 8.90 $\mu g/m^3$ and 6.79 $\mu g/m^3$, respectively. The majority of the other school receptor locations had modeled average seasonal and annual PM10 concentrations ranging between 1 and 3 $\mu g/m^3$.

This study also demonstrated the importance of relying upon local (site- or area-specific) meteorological data when performing cumulative source dispersion modeling exposure assessments when the results are to be coupled geographically with asthma prevalence or other health effects data.

1. Introduction

In 1999, the Massachusetts Department of Environmental Protection (MADEP) performed a regional air quality modeling and health effects study ("Aggregate Incinerator Impact Study" [1]) to address community concerns about the adequacy of retrofit air emissions controls on existing municipal solid waste combustors in the Merrimack Valley region in Northeastern Massachusetts. In 2000, the Massachusetts Department of Public Health (MADPH) asked for additional emission inventory studies and cumulative source dispersion modeling evaluations, involving the proposed Nickel Hill Power Plant, to help address regional air quality health concerns in the Merrimack Valley region [2]. Despite such studies, regional environmental and community health groups continued to express their perceived health concerns (which included addressing asthma in children) to municipal officials, regulatory and public health agencies, and the news media. In 2001, the MADPH initiated a pediatric asthma study for the Merrimack Valley region to help identify the "asthmagens" (asthma precursors) which may be causing or contributing to the observed asthma in children. As shown in Figure 1.1, MADPH's exposure assessment study region (the dispersion modeling domain) includes the towns and the cities of Dracut, Andover, North Andover, Lawrence, Methuen, and Haverhill.

The MADPH believed that assessment of local wind patterns was very important for the Merrimack Valley region, in order to determine if any meaningful correlations existed between pediatric asthma prevalence data and exposure to source emissions or other asthmagens. Moreover, it was the location of individual and cumulative source impacts that has been of particular concern to the MADPH. Therefore, in March 2002, the MADPH identified the need for a new regional air quality modeling study to support the exposure assessment component of its ongoing asthma epidemiological research program with the following two prerequisites: (a) use several years of *representative local meteorological data* for performing the exposure assessment dispersion modeling, and (b) from previous evaluations [2], use the same dispersion model, applicable modeling methods, and the available permitted facility (major stationary source) data to expedite performing this new regional study, and to provide a basis for comparison with the previous study results. (In fact, this new study also was a recommended follow-up activity included in a prior MADPH study of breast cancer and air pollution concerns in Andover, MA.) As discussed below, in addition to evaluating permitted major stationary sources, the MADPH also wanted the scope of this modeling study to include other regional manufacturing facilities whose VOC emissions were relatively large (e.g., greater than 25 tons per year) as compared to other existing facilities found in MADEP's emissions database [2].

The fact that permitted major stationary sources have been included in the air quality dispersion modeling should not suggest that such sources are primarily causing, or significantly contributing to asthma prevalence in the Merrimack Valley region. Non-permitted emission source categories, e.g., "area sources," mobile sources including heavy duty diesel vehicle emissions, or even non-anthropogenic factors, may ultimately be more important in contributing to observed asthma prevalence and/or exacerbation of the disease. It was beyond the scope of this study to perform air quality dispersion modeling for these other emission source categories.

1.1 Meteorological Issues

The maximum modeled concentrations for the proposed Nickel Hill Power Plant had been shown to be relatively small compared to applicable ambient air quality standards and MADEP's health guidelines [2]. Moreover, while the magnitudes of maximum annual average concentrations from the proposed Nickel Hill Power Plant were nearly identical when using long-term "regional" meteorological data from Boston's Logan International Airport (Logan Airport) and short-term "local" meteorological data from Haverhill, MA, the locations of these concentration maxima were very dissimilar (several thousand meters apart from one another and occurring in different directions relative to the proposed power plant location as depicted in the project EIR). Hence, the local prevailing wind patterns (expected to be generally aligned with the southwest-northeast axis of the Merrimack River valley) can have a pronounced effect on where the locations of maximum concentration impacts from stack emissions occur. However, the use of just one year of Haverhill, MA wind data (as used in the previous dispersion modeling studies [1,2]) while more representative for the Merrimack Valley region than Logan Airport data, may not adequately account for the possible year-to-year spatial variations in peak short-term (acute exposure) and long-term (chronic exposure) air quality impacts.

1.2 Additional Modeling Study Considerations

To help resolve the meteorological data issues discussed above, multi-year meteorological data were acquired, and wind roses were developed and analyzed for two locations in the Merrimack Valley, and for Boston's Logan International Airport. (Logan Airport is in a flat, exposed coastal location approximately 22 miles southeast of the study area.) A Pasquill Stability Class frequency analysis was also performed to aid in the determination of the most appropriate meteorological data. The wind roses and Pasquill Stability Class frequency analyses were used to ascertain the locations where source emissions are likely being transported, and to justify the selection of the meteorological data for the refined dispersion modeling.

Because the study area included several urban areas and a number of areas with mixed land use, a preliminary dispersion modeling sensitivity analysis was also performed using permitted (allowable) particulate matter (PM10) stack emissions data that were initially available at the onset of this study. The purpose of this preliminary modeling was to select the appropriate dispersion model options to be used in the final refined dispersion modeling, i.e., for rural or urban mode.

The proposed models, methodologies, databases, and other technical considerations used for the air quality dispersion modeling for the six-community study area are described below in Section 2. Section 3 presents the study results, while Section 4 discusses modeling uncertainties. Conclusions and references are presented in Sections 5 and 6, respectively.

2. Study Methodology

2.1 Model Selection and Application

To be consistent with the previous modeling studies for the Merrimack Valley Region [1,2], the USEPA's Industrial Source Complex Short Term (ISCST3) dispersion model [3,4] was used to perform the refined dispersion modeling in this study. The most recent version of the ISCST3 model, that was available from the USEPA "SCRAM" Electronic Bulletin Board (model version dated 02035, or 4 February 2002), was used. The ISCST3 dispersion model calculates concentrations at each modeled receptor for every hour of each year. The ISCST3 model was applied using USEPA's standard regulatory default options, as discussed in the "Guideline on Air Quality Models [5]." These options include: stack tip downwash, final plume rise, buoyancy induced dispersion, default vertical potential temperature gradient and wind profile exponents, and calm wind processing.

The ISCST3 model is designed to run in either a rural or urban mode depending upon the land use setting in the modeled region. The selection of rural or urban mode affects the model's selection of dispersion coefficients and wind profile exponents that are used. It is beyond the model's capability to change from urban to rural mode, or vice-versa, in the same model run if the land use happens to change at different locations between a source and receptor. While most of the land area being modeled in the six-community study region where the stack plumes will be dispersing is in a rural environment [6], the urban areas of Lawrence and Haverhill are also in the modeling domain. As discussed above, a preliminary dispersion modeling sensitivity analysis was performed in order to select the appropriate dispersion model option for rural or urban mode in the final dispersion modeling.

2.2 Facility Operation and Emission Data

Table 2.1 identifies the facility stack and emission rate parameters that were used in this dispersion modeling study, and Figure 2.1 shows the locations of these facilities. PM10 and volatile organic compound (VOC) emissions were selected as the potential pollutants of concern because the MADPH wanted to establish if these specific substances might be contributing to asthma prevalence in children. For purposes of performing the urban versus rural mode sensitivity analysis, permitted (allowable) particulate matter (PM10) stack emissions data initially available for Facilities 1 through 29 in Table 2.1 were used [2]. These permitted major stationary sources (including Facility 30 for which allowable PM10 stack emissions data were not initially available) mainly consist of solid waste incinerators, paperboard companies, microelectronic industries, cogeneration facilities, and industrial and institutional boilers. Facilities 31 through 39 in Table 2.1 were also included in this study since their actual VOC emissions were reported to exceed 25 tons per year [2] (the major modification threshold in Massachusetts for ozone nonattainment areas). For the final dispersion modeling, actual 1998 PM10 and VOC stack emissions data provided by the MADEP for all 39 facilities listed in Table 2.1, were modeled individually and cumulatively with ISCST3. It was beyond the scope of this study to speciate the total VOC emissions into individual toxic substances in the dispersion modeling. Additional assumptions made regarding use of these facility operations and emissions data are contained in Table 2.1

Although actual facility emissions data were available for 1998, actual emissions data for other years relevant to this study (i.e., 1999-2001) could not be provided in a timely manner. Hence, the same 1998 actual facility emissions data were used for the other years modeled in this study to account for possible annual variations that may occur in the meteorological database.

The MADEP identified the fact that some facilities in the study region had been permanently shut down within the past few years. Other existing facilities in the study region recently have voluntarily opted to reduce their actual and/or allowable stack emissions as reflected by operating permit restrictions imposed by the MADEP for such (former) major stationary sources. Other facilities (e.g., municipal solid waste combustors) have been retrofitted with additional pollution control equipment to reduce their emissions to comply with applicable USEPA and MADEP regulations. All facilities have been evaluated in the final dispersion modeling at their former (generally higher) actual emission levels that occurred during the late 1990s since MADPH's tabulated asthma prevalence data for its epidemiological study generally coincides with the source operation conditions that existed previously. Hence, this modeling approach provides for a more realistic appraisal of the exposure conditions that actually existed in the Merrimack Valley region during the period of greatest interest. Some facilities have undergone name changes since the late 1990s, but their former names were used in this study for continuity with the emissions databases being used.

Building downwash influences were considered in the dispersion modeling only for two facilities (Facility 1 – the Massachusetts Refusetech Incinerator, and Facility 27 – the BFI Medical Waste Incinerator). These facilities have stack heights less than the "Good Engineering Practice" (GEP) height as defined by the USEPA [7]. KM Chng's approach was consistent with the previous studies [1,2] which had simplified the cumulative source modeling effort by only accounting for building downwash effects for these two major stationary sources. Moreover, the detailed building dimensions data necessary to evaluate downwash were not readily available for the majority of the sources modeled.

2.3 Receptor Grid Data

A 250 meter-spaced Cartesian receptor grid with corresponding terrain heights determined at each receptor location was developed to cover the entire six-community study region. This grid spacing resulted in 6,313 receptors being modeled. This receptor grid spacing density was sufficient for the purpose of showing the areas of maximum PM10 and VOC concentration predictions for the longer-term concentration averaging times used in this study. Receptor elevations were calculated using 3 meter interval contour data available from the MassGIS website (www.state.ma.us/mgis/massgis.htm) that is maintained by the Commonwealth of Massachusetts Executive Office of Environmental Affairs. An additional 82 receptors, representing the locations of specific schools in the study area provided by the MADPH, were also evaluated separately in this modeling study.

2.4 Meteorological Data

To demonstrate the importance of identifying and using representative local meteorological data for this dispersion modeling study, hourly quality assured, meteorological data were acquired

and evaluated for the following three locations: (1) National Weather Service meteorological data for Logan Airport for the period 1991-1995 (these preprocessed data from the MADEP were used in the previous dispersion modeling studies [1,2]); (2) MADEP's Storrow Park High Street site in Lawrence, MA for the period 1991-1995; and (3) Lawrence Municipal Airport for the period 1998-2001.

Hourly National Weather Service data collected at Logan Airport is representative of a flat, exposed coastal location setting. Logan Airport is located approximately 22 miles southeast of the (inland) study area.

MADEP's Storrow Park site, which measures only wind direction and wind speed meteorological parameters, is located approximately one mile west-southwest of Lawrence Municipal Airport, and is located in the vicinity of the Merrimack River near Lawrence General Hospital. (Note: the MADEP had decommissioned the Storrow Park monitoring site during 2003.)

Lawrence Municipal Airport is a General Aviation airport, and does not operate 24 hours per day. Until mid-1997, when automated meteorological data collection commenced at Lawrence Municipal Airport, meteorological observations were missing every day for a large block of hours. Hence, available meteorological data for Lawrence Municipal Airport prior to the calendar year 1998 were deemed unsuitable for long-term dispersion modeling purposes. The 1998-2001 hourly surface meteorological data for Lawrence Municipal Airport, and corresponding upper air meteorological data for the Portland, ME region were obtained from the National Climatic Data Center in Asheville, NC. These "raw" data records were then preprocessed using the most recent version of USEPA's PCRAMMET meteorological preprocessor program (version dated 99169 available from the USEPA "SCRAM" Electronic Bulletin Board [8]) to develop the appropriate formatted hourly meteorological database for subsequent use in the ISCST3 model.

To perform dispersion modeling using MADEP's available 1991-1995 hourly meteorological database from Storrow Park (to properly account for local wind influences in the Merrimack Valley region) would have required the merging of hourly atmospheric stability and ambient air temperature data from Logan Airport with the corresponding Storrow Park hourly wind direction and wind speed data. Since the determination of hourly atmospheric stability class for use in the ISCST3 model is largely affected by wind speed, the higher anticipated wind speeds at Logan Airport could significantly bias the data, relative to the atmospheric stability conditions that had actually occurred in the Merrimack Valley region. The previous dispersion modeling study results [1,2] also demonstrated that MADEP's 1991-1995 preprocessed meteorological database (that also includes hourly atmospheric stability class data) from Logan Airport should not be used alone since the higher wind speeds (unrepresentative for the Merrimack Valley region) could affect the degree of stack plume rise and stack plume dilution (i.e., dispersion rates). This, in turn, could affect the locations and magnitudes of maximum modeled ground-level concentrations given the terrain in the study area. To assess these effects, and to confirm the selection of meteorological data for the dispersion modeling, annual wind roses were developed for each of the above meteorological monitoring locations, and a Pasquill Stability Class frequency analysis was also performed.

2.5 Concentration Averaging Times

To satisfy the MADPH's study goals and objectives, seasonal and annual average dispersion modeling for actual PM10 and VOC facility emissions was performed using the available, representative four year (1998-2001) meteorological database for Lawrence Municipal Airport. To help smooth out any year-to-year meteorological variability, composite four-year average seasonal and annual average concentration values were calculated at each modeled receptor for purposes of identifying long-term (chronic) impacts within the study area. The seasonal and annual concentrations at each receptor for each pollutant modeled therefore, represent a four-year composite average to facilitate the MADPH being able to spatially evaluate and correlate concentration predictions with asthma prevalence data. No short-term average modeling (less than or equal to 24 hours) to assess potential acute exposure impacts from air pollutant emissions was performed in this study.

2.6 Concentration Isopleth Maps and Tables

Using base maps of the six-community study region, plots of cumulative source four-year composite average seasonal and annual PM10 and VOC concentrations were developed that depicted isopleth bands showing the locations of maximum predicted PM10 and VOC concentrations. Tables were also prepared that summarize the locations and magnitudes of the highest modeled composite four-year average seasonal and annual PM10 and VOC concentrations for each modeled facility and for all facilities combined (cumulative) on a seasonal and annual basis. The specific school receptor locations provided by the MADPH were also modeled on a cumulative source basis only, and composite four-year average seasonal and annual PM10 and VOC concentrations were likewise calculated. Tables and graphics presenting these dispersion modeling results are discussed below.

3. Study Results

The meteorological data analyses and preliminary dispersion model sensitivity analysis results were originally reported by R. Rothstein, et al. [9] at the 2003 Annual Air and Waste Management Conference in San Diego, CA, and are provided below. The final dispersion modeling using actual facility emissions data was completed during early 2004 and the modeling results are also provided below.

3.1 Meteorological Data Analyses

3.1.1 Wind Rose Analysis

Figures 3.1 through 3.3 present annual wind rose plots that were prepared for Logan Airport (Boston, MA) for the period 1991-1995; MADEP's Storrow Park High Street site (Lawrence, MA) for the period 1991-1995; and Lawrence Municipal Airport for the period 1998-2001. The frequencies of specific wind directions and wind speeds can vary somewhat at a given site from year to year due to the frequency of weather patterns that can affect an area. There are, however, some important differences that can be readily observed in the wind roses for Logan Airport as compared to both of the Lawrence, MA sites.

Prevailing wind directions at Logan Airport were found to be generally from the west-northwest and northwest, with a secondary maximum from the southwest direction. Prevailing wind directions at both of the Lawrence, MA sites were found to be generally from the southwest, with secondary maxima from the west through northwest directions. These prevailing wind directions generally reflect the terrain influences of the Merrimack River valley, onshore sea breezes that mainly affect the eastern Massachusetts coastal region, and large-scale weather systems that affect both regions.

The average wind speed at Logan Airport for the period 1991-1995 was 5.6 meters/second (12.4 mph), and the frequency of calm winds averaged 0.25% during this time period. For the Lawrence, MA Storrow Park site, the average wind speed for the period 1991-1995 was 2.5 meters/second (5.6 mph), and the frequency of calm winds averaged 6.4% during this time period. For Lawrence Municipal Airport, the average wind speed for the period 1998-2001 was 1.9 meters/second (4.3 mph), and the frequency of calm winds averaged 12.6% during this same time period. The higher average wind speeds and smaller percentage of calm winds at Logan Airport generally reflect the influences of its coastal setting. The slightly lower average wind speeds and higher percentage of calm winds at Lawrence Municipal Airport, as compared to the Lawrence, MA Storrow Park site can be attributed to the different instrumentation and procedures used by the agencies to collect and record the data, the slightly lower base elevation at Lawrence Municipal Airport, and the fact that the periods of wind records between both locations do not coincide. The wind roses (and higher frequency of calms) for both Lawrence, MA sites also appear to be very similar to the annual (1989-1990) wind rose for the Haverhill, MA site (as used in the previous cumulative source dispersion modeling studies [1,2]).

The locations where source emissions are routinely being transported within the Merrimack Valley study region over the annual period will "mirror" the wind rose patterns. That is, for any given source, the highest annual concentrations will tend to occur toward the northeast and

southeast of any given source. Locations of regional terrain features will also affect the downwind distances and directions where such maximum concentrations are predicted to occur.

3.1.2 Stability Class Analysis

The determination of hourly atmospheric stability class for use in the ISCST3 model is largely affected by wind speed. Hence, the higher anticipated wind speeds expected at Logan Airport could significantly bias the data, relative to the atmospheric stability conditions that would have actually occurred in the Merrimack Valley region. Table 3.1 illustrates this point by comparing the calculated annual frequencies of occurrence of Pasquill Stability Class (A-F) for the Lawrence Municipal Airport and Logan Airport. As shown in Table 3.1, the year-to-year frequencies of occurrence of each stability class are fairly similar at each airport site. However, Logan Airport has a preponderance of Pasquill Stability Class D and E (averaging 72.32% and 12.89%, respectively), while the frequencies of occurrence for Lawrence are fairly uniform for each of the Pasquill Stability Classes B through E (ranging between 12% and 14%), with F stability averaging 30.81%.

These wind rose and Pasquill Stability Class frequency analyses confirmed the selection of the 1998-2001 Lawrence Municipal Airport meteorological data for use in the final ISCST3 modeling since those data were shown to be the most representative of meteorological conditions expected in the study area.

3.2 Urban Versus Rural Model Sensitivity Analysis

One year of hourly meteorological data for Lawrence Municipal Airport for 1998 was modeled with ISCST3 in both urban and rural modes using the permitted (allowable) PM10 stack emissions data for permitted facilities. The purpose of this modeling was to determine, on a cumulative source basis, how much the locations and magnitudes of annual average concentrations may vary between urban and rural mode.

Figures 3.4 and 3.5 show cumulative permitted (allowable) emission source annual average PM10 concentration isopleths for urban and rural modes, respectively. The following results were obtained from this urban versus rural model sensitivity analysis:

- "Worst Case" Modeling Mode – 5,083 of the 6,313 grid receptors (80.5 percent) have higher PM10 concentrations under rural mode than under urban mode. Conversely, 1,230 of the 6,313 receptors (19.5 percent) have higher PM10 concentrations under urban mode than under rural mode. There are no receptors for which the rural mode concentrations and the urban mode concentrations are identical.

- Location of Maximum Concentration – Maximum PM10 concentrations were found to occur at the same receptor located in the vicinity of Storrow Park in Lawrence, MA under both urban and rural modes. The maximum PM10 concentration of 16.4 $\mu g/m^3$ occurs under urban mode. The maximum PM10 concentration under rural mode (at the same receptor) is 11.8 $\mu g/m^3$. A paperboard facility located in Lawrence (Facility 28) had the largest PM10 contribution due to its geographic proximity to this receptor, the magnitude

of its modeled allowable PM10 emission rate, and the prevailing southwesterly winds aligning that source with the receptor.

- Average Concentration Differences for Receptors Modeled – For all of the 6,313 receptors modeled, rural mode concentrations averaged about 0.49 $\mu g/m^3$ higher than urban mode concentrations. That is, the average difference between rural and urban mode PM10 concentrations at each receptor is 0.49 $\mu g/m^3$. The average difference of the 5,083 receptors, having rural mode PM10 concentrations higher than urban mode PM10 concentrations, is 0.44 $\mu g/m^3$; and the average difference of the 1,230 receptors, having urban mode PM10 concentrations higher than rural mode PM10 concentrations, is 0.31 $\mu g/m^3$.

- Comparison of Concentration Isopleth Patterns – A comparison of the concentration isopleth patterns presented in Figures 3.4 and 3.5 shows that regional terrain influences on the locations where source concentration impacts occur are more pronounced for rural mode. The maximum concentration isopleth pattern is more widespread and occurs further from each source under rural mode. This is likely due to interactions between stack plumes (especially those with the greatest release height) and terrain (especially areas of high elevation). In rural mode, the ISCST3 model applies smaller values for the dispersion coefficients than in urban mode, which causes plumes to be modeled with less dispersion. Compared to urban mode, this inhibited spreading increases the distance from the source to the point of maximum concentration, and increases the modeled concentrations at elevated terrain that is close to the plume.

This model sensitivity analysis confirmed the selection of the rural mode option for use in the final ISCST3 dispersion modeling using actual facility emissions data. This is because most of the land area being modeled in the six-community study region where the stack plumes disperse is in a rural environment, and maximum cumulative source concentrations will not be underestimated using the rural mode option.

3.3 Regional PM10 Source Concentration Impacts

Figures 3.6 through 3.10 show isopleth plots of cumulative source four-year (1998-2001) composite average seasonal and annual PM10 concentrations for the six-community study region. The plots depict isopleth bands showing the areas of maximum PM10 concentration predictions over the composite seasonal and annual periods for all 39 facilities modeled. To facilitate the evaluation of each facility individually, tables were prepared which summarize the locations and magnitudes of the highest modeled composite four-year average seasonal and annual PM10 concentrations for all of the facilities modeled both individually and cumulatively. Tables 3.2 through 3.6 show the cumulative source contributions for the highest modeled composite four-year (1998-2001) average seasonal and annual PM10 concentrations for all facilities modeled. Tables 3.7 through 3.11 show the location and magnitude of the highest modeled composite four-year (1998-2001) average seasonal and annual PM10 concentrations for each facility modeled individually.

Cumulative Source PM10 Concentrations

The results of the regional cumulative source modeling analysis for PM10 are presented below. The facility identification numbers below refer to those identified in Table 2.1.

- Cumulative Source Maximum Winter Season PM10 Concentrations (Table 3.2) – The highest cumulative winter season PM10 concentration of 7.91 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 7.57 $\mu g/m^3$, or 96 percent to the highest cumulative concentration. Facility 5, located in Lawrence, contributed an additional 0.17 $\mu g/m^3$, or 2.2 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 96 percent of the 6,313 total Cartesian grid receptors modeled had cumulative winter season PM10 concentrations below 1 $\mu g/m^3$, and approximately 99 percent were below 2 $\mu g/m^3$.

- Cumulative Source Maximum Spring Season PM10 Concentrations (Table 3.3) – The highest cumulative spring season PM10 concentration of 6.73 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 6.51 $\mu g/m^3$, or 97 percent to the highest cumulative concentration. Facility 30, also located in Haverhill, contributed an additional 0.08 $\mu g/m^3$, or just over 1 percent to this value, and Facility 5, located in Lawrence, contributed an additional 0.07 $\mu g/m^3$, or 1 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 98 percent of the 6,313 total Cartesian grid receptors modeled had cumulative spring season PM10 concentrations below 1 $\mu g/m^3$, and approximately 99 percent were below 2 $\mu g/m^3$.

- Cumulative Source Maximum Summer Season PM10 Concentrations (Table 3.4) – The highest cumulative summer season PM10 concentration of 17.05 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 16.69 $\mu g/m^3$, or 98 percent to the highest cumulative concentration. Facility 5, located in Lawrence, contributed an additional 0.16 $\mu g/m^3$, or slightly less than 1 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 96 percent of the 6,313 total Cartesian grid receptors modeled had cumulative summer season PM10 concentrations below 1 $\mu g/m^3$, and approximately 99 percent were below 2 $\mu g/m^3$.

- Cumulative Source Maximum Fall Season PM10 Concentrations (Table 3.5) – The highest cumulative fall season PM10 concentration of 10.42 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 9.99 $\mu g/m^3$, or 96 percent to the highest cumulative concentration. Facility 5, located in Lawrence, contributed an additional 0.24 $\mu g/m^3$, or just over 2 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 94 percent of the 6,313 total Cartesian grid receptors modeled had cumulative fall season PM10 concentrations below 1 $\mu g/m^3$, and approximately 99 percent were below 2 $\mu g/m^3$.

- Cumulative Source Maximum Annual PM10 Concentrations (Table 3.6) – The highest cumulative annual PM10 concentration of 9.14 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 8.87 $\mu g/m^3$, or 97 percent to the highest cumulative concentration. Facility 5, located in Lawrence, contributed an additional 0.12 $\mu g/m^3$, or just over 1 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 96 percent of the 6,313 total Cartesian grid receptors modeled had cumulative annual PM10 concentrations below 1 $\mu g/m^3$, and approximately 99 percent were below 2 $\mu g/m^3$.

Individual Source PM10 Concentrations

The results of the individual source modeling analysis for PM10 are presented below. The facility identification numbers below refer to those identified in Table 2.1.

- Individual Source Maximum Winter Season PM10 Concentrations (Table 3.7) – Facility 35, located in Haverhill, produced the highest individual source winter season PM10 concentration of 7.57 $\mu g/m^3$ at a receptor located 372 meters to the east-northeast from this facility. Facility 5, located in Lawrence, produced the second highest individual source winter season PM10 concentration of 1.01 $\mu g/m^3$ at a receptor located 1,034 meters to the northeast of that facility. All other modeled facilities had individual maximum predicted winter season PM10 concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Spring Season PM10 Concentrations (Table 3.8) – Facility 35, located in Haverhill, produced the highest individual source spring season PM10 concentration of 6.51 $\mu g/m^3$ at a receptor located 151 meters to the northeast from this facility. Facility 5, located in Lawrence, produced the second highest individual source spring season PM10 concentration of 0.75 $\mu g/m^3$ at a receptor located 1,034 meters to the northeast of that facility. Facility 30, located in Haverhill, produced the third highest individual source spring season PM10 concentration of 0.57 $\mu g/m^3$ at a receptor located 3,029 meters to the northeast of that facility. All other modeled facilities had individual maximum predicted spring season PM10 concentrations ranging from two tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Summer Season PM10 Concentrations (Table 3.9) – Facility 35, located in Haverhill, produced the highest individual source summer season PM10 concentration of 16.69 $\mu g/m^3$ at a receptor located 151 meters to the northeast from this facility. Facility 5, located in Lawrence, produced the second highest individual source summer season PM10 concentration of 1.59 $\mu g/m^3$ at a receptor located 1,034 meters to the northeast of that facility. All other modeled facilities had individual maximum predicted summer season PM10 concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Fall Season PM10 Concentrations (Table 3.10) – Facility 35, located in Haverhill, produced the highest individual source fall season PM10 concentration of 9.99 $\mu g/m^3$ at a receptor located 504 meters to the northeast from this facility. Facility 5, located in Lawrence, produced the second highest individual source fall season PM10 concentration of 1.62 $\mu g/m^3$ at a receptor located 1,034 meters to the northeast of that facility. Facility 30, located in Haverhill, produced the third highest individual source fall season PM10 concentration of 1.19 $\mu g/m^3$ at a receptor located 3,029 meters to the northeast of that facility. All other modeled facilities had individual maximum predicted fall season PM10 concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Annual PM10 Concentrations (Table 3.11) – Facility 35, located in Haverhill, produced the highest individual source annual PM10 concentration of 8.87 $\mu g/m^3$ at a receptor located 151 meters to the northeast from this facility. Facility 5, located in Lawrence, produced the second highest individual source annual PM10 concentration of 1.24 $\mu g/m^3$ at a receptor located 1,034 meters to the northeast of that facility. All other modeled facilities had individual maximum predicted annual PM10 concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

As shown in Figures 3.6 through 3.10, higher cumulative seasonal and annual PM10 concentrations were found to occur in portions of Haverhill. This concentration pattern reflects the larger facility emission rate and the lower stack plume height above ground that was associated with the principal contributing source described above (Facility 35 in Haverhill). Highest modeled cumulative seasonal PM10 concentrations ranged from 6.73 $\mu g/m^3$ (spring season) to 17.05 $\mu g/m^3$ (summer season). The highest modeled cumulative annual PM10 concentration was 9.14 $\mu g/m^3$. The differences in highest cumulative seasonal and annual PM10 concentrations can be attributed to seasonal variations in the meteorological data used in the modeling. The majority of the modeled receptors (approximately 99 percent of the 6,313 total Cartesian grid receptors) also had cumulative seasonal and annual PM10 concentrations that did not exceed 2 $\mu g/m^3$.

3.4 Regional VOC Source Concentration Impacts

Figures 3.11 through 3.15 show isopleth plots of cumulative source four-year (1998-2001) composite average seasonal and annual VOC concentrations for the six-community study region. The plots depict isopleth bands showing the areas of maximum VOC concentration predictions over the composite seasonal and annual periods for all 39 facilities modeled. To facilitate the evaluation of each facility individually, tables were prepared which summarize the locations and magnitudes of the highest modeled composite four-year average seasonal and annual VOC concentrations for all of the facilities modeled both individually and cumulatively. Tables 3.12 through 3.16 show the cumulative source contributions for the highest modeled composite four-year (1998-2001) average seasonal and annual VOC concentrations for all facilities modeled. Tables 3.17 through 3.21 show the location and magnitude of the highest modeled composite four-year (1998-2001) average seasonal and annual VOC concentrations for each facility modeled individually.

Cumulative Source VOC Concentrations

The results of the regional cumulative source modeling analysis for VOC are presented below. The facility identification numbers below refer to those identified in Table 2.1.

- Cumulative Source Maximum Winter Season VOC Concentrations (Table 3.12) – The highest cumulative winter season VOC concentration of 20.77 $\mu g/m^3$ occurred in Lawrence in the vicinity of Facility 31, and that facility contributed 19.10 $\mu g/m^3$, or 92 percent to the highest cumulative concentration. Facilities 32 and 33 (in Lowell), and Facility 35 (in Haverhill) each contributed an additional 0.25 $\mu g/m^3$, or slightly over 1 percent (each) to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 96 percent of the 6,313 total Cartesian grid receptors modeled had cumulative winter season VOC concentrations below 5 $\mu g/m^3$, and approximately 99 percent were below 8 $\mu g/m^3$.

- Cumulative Source Maximum Spring Season VOC Concentrations (Table 3.13) – The highest cumulative spring season VOC concentration of 22.39 $\mu g/m^3$ occurred in Andover in the vicinity of Facility 38, and that facility contributed 21.58 $\mu g/m^3$, or 96 percent to the highest cumulative concentration. Facility 31, located in Lawrence, contributed an additional 0.31 $\mu g/m^3$, or just over 1 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 97 percent of the 6,313 total Cartesian grid receptors modeled had cumulative spring season VOC concentrations below 4 $\mu g/m^3$, and approximately 99 percent were below 6 $\mu g/m^3$.

- Cumulative Source Maximum Summer Season VOC Concentrations (Table 3.14) – The highest cumulative summer season VOC concentration of 39.16 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 37.43 $\mu g/m^3$, or 96 percent to the highest cumulative concentration. Facility 31, located in Lawrence, contributed an additional 1.08 $\mu g/m^3$, or almost 3 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 97 percent of the 6,313 total Cartesian grid receptors modeled had cumulative summer season VOC concentrations below 5 $\mu g/m^3$, and approximately 99 percent were below 7 $\mu g/m^3$.

- Cumulative Source Maximum Fall Season VOC Concentrations (Table 3.15) – The highest cumulative fall season VOC concentration of 24.37 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 22.42 $\mu g/m^3$, or 92 percent to the highest cumulative concentration. Facility 31, located in Lawrence, contributed an additional 1.15 $\mu g/m^3$, or almost 5 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 96 percent of the 6,313 total Cartesian grid receptors modeled had cumulative fall season VOC concentrations below 5 $\mu g/m^3$, and approximately 99 percent were below 8 $\mu g/m^3$.

- Cumulative Source Maximum Annual VOC Concentrations (Table 3.16) – The highest cumulative annual VOC concentration of 21.25 $\mu g/m^3$ occurred in Haverhill in the vicinity of Facility 35, and that facility contributed 19.89 $\mu g/m^3$, or 94 percent to the highest cumulative concentration. Facility 31, located in Lawrence, contributed an additional 0.80 $\mu g/m^3$, or almost 4 percent to this value. All other modeled facilities had much smaller contributions to this value. It was determined that approximately 94 percent of the 6,313 total Cartesian grid receptors modeled had cumulative annual VOC concentrations below 4 $\mu g/m^3$, and approximately 99 percent were below 7 $\mu g/m^3$.

Individual Source VOC Concentrations

The results of the individual source modeling analysis for VOC are presented below. The facility identification numbers below refer to those identified in Table 2.1.

- Individual Source Maximum Winter Season VOC Concentrations (Table 3.17) – Facility 31, located in Lawrence, produced the highest individual source winter season VOC concentration of 19.10 $\mu g/m^3$ at a receptor located 670 meters to the east-southeast from this facility. Facility 35, located in Haverhill, produced the second highest individual source winter season VOC concentration of 16.96 $\mu g/m^3$ at a receptor located 372 meters to the east-northeast of that facility. Facility 38, located in Andover, produced the third highest individual source winter season VOC concentration of 16.44 $\mu g/m^3$ at a receptor located 121 meters to the south-southeast of that facility. Facilities 32, 33, 36, 37 (in Lowell), and 39 (in Andover) had the next highest individual source winter season VOC concentrations which ranged from 9.98 $\mu g/m^3$ to 2.50 $\mu g/m^3$. All other modeled facilities had individual maximum predicted winter season VOC concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Spring Season VOC Concentrations (Table 3.18) – Facility 38, located in Andover, produced the highest individual source spring season VOC concentration of 21.58 $\mu g/m^3$ at a receptor located 121 meters to the south-southeast from this facility. Facility 35, located in Haverhill, produced the second highest individual source spring season VOC concentration of 14.60 $\mu g/m^3$ at a receptor located 151 meters to the northeast of that facility. Facility 31, located in Lawrence, produced the third highest individual source spring season VOC concentration of 12.40 $\mu g/m^3$ at a receptor located 670 meters to the east-southeast of that facility. Facilities 32, 33, 36, 37 (in Lowell), and 39 (in Andover) had the next highest individual source spring season VOC concentrations which ranged from 5.12 $\mu g/m^3$ to 1.64 $\mu g/m^3$. All other modeled facilities had individual maximum predicted spring season VOC concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Summer Season VOC Concentrations (Table 3.19) – Facility 35, located in Haverhill, produced the highest individual source summer season VOC concentration of 37.43 $\mu g/m^3$ at a receptor located 151 meters to the northeast from this

facility. Facility 38, located in Andover, produced the second highest individual source summer season VOC concentration of 26.52 $\mu g/m^3$ at a receptor located 477 meters to the northeast of that facility. Facilities 31 (in Lawrence), 32, 33, 36, 37 (in Lowell), and 39 (in Andover) had the next highest individual source summer season VOC concentrations which ranged from 12.01 $\mu g/m^3$ to 3.61 $\mu g/m^3$. All other modeled facilities had individual maximum predicted summer season VOC concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Fall Season VOC Concentrations (Table 3.20) – Facility 35, located in Haverhill, produced the highest individual source fall season VOC concentration of 22.41 $\mu g/m^3$ at a receptor located 504 meters to the northeast from this facility. Facility 38, located in Andover, produced the second highest individual source fall season VOC concentration of 22.13 $\mu g/m^3$ at a receptor located 477 meters to the northeast of that facility. Facilities 31 (in Lawrence), 32, 33, 36, 37 (in Lowell), and 39 (in Andover) had the next highest individual source fall season VOC concentrations which ranged from 13.71 $\mu g/m^3$ to 3.63 $\mu g/m^3$. All other modeled facilities had individual maximum predicted fall season VOC concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

- Individual Source Maximum Annual VOC Concentrations (Table 3.21) – Facility 35, located in Haverhill, produced the highest individual source annual VOC concentration of 19.89 $\mu g/m^3$ at a receptor located 151 meters to the northeast from this facility. Facility 38, located in Andover, produced the second highest individual source annual VOC concentration of 17.90 $\mu g/m^3$ at a receptor located 121 meters to the south-southeast of that facility. Facilities 31 (in Lawrence), 32, 33, 36, 37 (in Lowell), and 39 (in Andover) had the next highest individual source annual VOC concentrations which ranged from 13.63 $\mu g/m^3$ to 2.84 $\mu g/m^3$. All other modeled facilities had individual maximum predicted annual VOC concentrations ranging from a few tenths to a few one-thousandths of a $\mu g/m^3$, reflecting the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources.

As shown in Figures 3.11 through 3.15, higher cumulative seasonal and annual VOC concentrations were found to occur in portions of Haverhill, Lawrence, Andover, and Dracut. This concentration pattern reflects the larger facility emission rates and the lower stack plume heights above ground that were associated with the principal contributing sources described above (Facility 31 in Lawrence; Facilities 32, 33, 36, and 37 in Lowell; Facility 35 in Haverhill; and Facilities 38 and 39 in Andover). The highest modeled cumulative seasonal VOC concentrations (and their corresponding locations) ranged from 20.77 $\mu g/m^3$ (winter season, in Lawrence) to 39.16 $\mu g/m^3$ (summer season, in Haverhill). The highest modeled cumulative annual VOC concentration (and corresponding location) was 21.25 $\mu g/m^3$ (also in Haverhill). The temporal and spatial differences in highest cumulative seasonal and annual VOC concentrations can be attributed to seasonal variations in the meteorological data used in the modeling. The majority of the modeled

receptors (approximately 99 percent of the 6,313 total Cartesian grid receptors) also had cumulative seasonal and annual VOC concentrations that did not exceed 8 $\mu g/m^3$.

3.5 PM10 and VOC Source Concentration Impacts at School Locations

The 82 school receptor locations identified by the MADPH were modeled on a cumulative source basis only, and composite 4-year average seasonal and annual PM10 and VOC concentrations were calculated. Tables 3.22 and 3.23 show the cumulative source composite four-year (1998-2001) average seasonal and annual PM10 and VOC concentrations respectively for all facilities modeled.

As shown in Table 3.22, School 47 in Haverhill had the highest average modeled seasonal (fall) and annual PM10 concentrations of 3.82 $\mu g/m^3$ and 2.86 $\mu g/m^3$, respectively. School 53 in Haverhill is in the vicinity of School 47; hence, the modeled average seasonal and annual PM10 concentrations were quite similar. School 66 in Lawrence had the next highest average modeled seasonal (fall) and annual PM10 concentrations of 2.19 $\mu g/m^3$ and 1.77 $\mu g/m^3$, respectively. The majority of the other school receptor locations had modeled average seasonal and annual PM10 concentrations below 1 $\mu g/m^3$. These modeled average seasonal and annual PM10 concentrations are all well below USEPA's and MADEP's annual PM10 National Ambient Air Quality Standard of 50 $\mu g/m^3$.

As shown in Table 3.23, School 47 in Haverhill had the highest average modeled seasonal (fall) and annual VOC concentrations of 10.58 $\mu g/m^3$ and 7.82 $\mu g/m^3$, respectively. School 53 in Haverhill is in the vicinity of School 47; hence, the modeled average seasonal and annual VOC concentrations were quite similar. School 66 in Lawrence had the next highest average modeled seasonal (fall) and annual VOC concentrations of 8.90 $\mu g/m^3$ and 6.79 $\mu g/m^3$, respectively. The majority of the other school receptor locations had modeled average seasonal and annual PM10 concentrations ranging between 1 and 3 $\mu g/m^3$.

4. Modeling Uncertainties

There are several different areas of uncertainty associated with this dispersion modeling analysis. Principal areas of modeling uncertainty are associated with the ISCST3 dispersion model itself; and the facility emission rates, stack and building parameters, and meteorological data used in the model. These areas of modeling uncertainty are addressed below.

4.1 ISCST3 Dispersion Model Uncertainties

The basic ISCST3 model used in this study has been in existence since the late 1970s, and is still listed as a USEPA regulatory guideline air quality dispersion model. (As discussed previously, the most recent version of the ISCST3 model, that was available from the USEPA "SCRAM" Electronic Bulletin Board (model version dated 02035, or 4 February 2002), was used.) This model has been used for a variety of purposes including supporting air quality research studies, environmental impact assessments, and air permit applications for stationary point sources. The basis of the ISCST3 model is the straight-line steady-state Gaussian plume equation, which is used to address a variety of source features and emission characteristics. The ISCST3 model assumptions are reasonable for homogeneous terrain and steady-state hourly meteorological conditions. In this study, elevated point source stack emissions were simulated in the ISCST3 model using constant stack and emission rate parameters for each facility considered. The seasonal and annual average concentration predictions at each modeled receptor were based on averaging the individually-calculated 1-hour concentration values over the annual period. Hence, any uncertainties in stack and emission rate parameters, or meteorological data, will translate directly into model prediction uncertainties.

To help address Gaussian dispersion modeling accuracy and uncertainty issues for stationary point sources, the USEPA and other trade organizations have conducted numerous model validation studies over the past two decades that have included statistical model performance evaluations of observed versus predicted concentration values [5]. Corresponding measured meteorological data, and other source, site and regional-specific factors that could affect dispersion rates and model predictions (such as land surface characteristics and terrain features) are typically addressed in such model validation studies. These studies also incorporate well-quantified stack and emission rate parameters (e.g., use of tracer gas releases in the stack emissions), and extensive air quality sampling at ground-level and at the stack plume elevation.

Even with well-quantified stack and emission rate parameters, any potential variations in meteorological conditions that exist within the modeled region can significantly affect model results. Moreover, unknown or unresolved inherent uncertainties that are associated with all dispersion model formulations will contribute to differences between observed and predicted concentration values. Various Gaussian dispersion model validation studies (that have included the ISCST3 model) have shown that when using well-defined and properly modeled source, site, and meteorological data, differences in the highest estimated 1-hour average concentrations of $\pm$ 10 to 40 percent are typically observed [5]. Such differences are certainly well within the often quoted factor of two accuracy that has long been recognized for Gaussian dispersion model applications [5]. However, even when highest 1-hour concentration predictions have been similar to observed values, they do not necessarily occur at the same receptor locations at the

same time. This is because the exact locations of maximum concentration predictions are very sensitive to wind direction, and stack plume height and dilution are very sensitive to wind speed.

Although the ISCST3 rural mode option was assumed to be most representative for the study region, the urban areas of Lawrence and Haverhill were also in the modeling domain. However, as discussed before, the model sensitivity analysis in this study confirmed the selection of the rural mode option for use in the final ISCST3 dispersion modeling using actual facility emissions data.

4.2 Facility Emission Rates

Ideally, the most technically appropriate modeling approach would have been to acquire and use facility emissions that had actually occurred during each calendar year being modeled. However, project time and resource constraints precluded developing such detailed source emissions information. As discussed previously, although actual facility emissions data were available for 1998, actual emissions data for other years relevant to this study (i.e., 1999-2001) could not be provided in a timely manner. Hence, the same actual facility emissions data were used for the other years modeled in this study. However, the potential for variations in cumulative seasonal and annual source concentration patterns would be greater than modeled if actual facility emission rates were to vary significantly from year to year. This point is also illustrated when comparing the concentration isopleth patterns from Figure 3.5 (preliminary modeling), which was based on allowable PM10 stack emissions data with Figure 3.10 (final modeling), which was based on actual PM10 stack emissions data.

Moreover, constant emission rates for each hour of the day, season, and year were also assumed for each facility being modeled. Therefore, the potential for variations in cumulative seasonal source concentration patterns would also be greater than modeled if individual hourly facility emissions rates were to vary considerably from season to season.

4.3 Facility Stack and Building Parameters

Certain facilities were included in this dispersion modeling study even if insufficient information was available regarding the source release (stack) characteristics to model these facilities (Facilities 37 and 39 in Table 2.1). In such instances, a representative 30 foot stack height, with no plume rise, was assumed for these facilities. This assumption could lead to an over-prediction of calculated concentrations in the immediate vicinity of these facilities, especially if elevated terrain is also nearby. Since it was found in this study that maximum modeled concentrations tended to decrease quite rapidly within approximately the first 1,000 meters (about 0.6 mile) of facilities with short stacks, this assumption did not significantly affect the magnitudes of the cumulative source concentration results for the majority of modeled receptors within the entire study region.

Facilities 31 through 36, and Facility 38 in Table 2.1 were found to consist of numerous short stacks. Hence, for each facility, a simplifying assumption was used in which the total PM10 and VOC emissions were assumed to be emitted through a single representative stack. With this assumption, however, not accounting for physical separation of each of these facility stacks could lead to a small over-prediction of concentrations at the nearest receptors to each facility.

Building downwash influences were also considered in the dispersion modeling for just two of the major stationary sources being considered (Facility 1 and Facility 27). As discussed previously, the detailed building dimensions data necessary to evaluate downwash were not readily available for the other facilities modeled. For such facilities that have relatively short stack heights above ground, an under-prediction of the maximum concentration impacts may occur in the immediate vicinity of those specific sources where stack emissions may be subject to building downwash effects. However, the purpose of this modeling study was to estimate neighborhood-scale concentrations rather than "close-in" localized maximums. At the larger source-receptor distances that are characteristic of the neighborhood scale, the effects of building downwash on seasonal and annual average concentrations are not expected to be significant for the study purpose. The receptor grid spacing density used was sufficient for the purpose of showing the areas of maximum PM10 and VOC concentrations on a neighborhood-scale for the longer-term concentration averaging times assumed.

4.4 Meteorological Data

In this study, hourly meteorological data acquired for Lawrence Municipal Airport were assumed to be the most representative of the entire modeled region. Significant differences in wind conditions are not anticipated within the modeled region based on comparing the Haverhill [1,2] and Lawrence region wind rose data that were generated in this study. Moreover, other multi-year hourly meteorological databases that could have been selected were either based on measurements made in the vicinity of Lawrence Municipal Airport (MADEP's Storrow Park monitoring data), or were determined not to be representative of the meteorological conditions in the modeled study region (National Weather Service data from Logan Airport). In any event, the ISCST3 model is incapable of simulating wind field conditions from meteorological data acquired simultaneously from multiple monitoring sites.

As mentioned before, use of Logan Airport meteorological data could significantly bias the determination of the atmospheric stability conditions that had actually occurred in the Merrimack Valley region. Considering that the dispersion rates used in the model are very sensitive to atmospheric stability class, the wind rose and Pasquill Stability Class frequency analyses in this study likewise confirmed the selection of Lawrence Municipal Airport meteorological data for the dispersion modeling.

4.5 Modeling Uncertainties - Conclusion

Since long-term average seasonal and annual modeling was performed in this study, the effect of the modeling uncertainties discussed above on the predicted concentrations will be less pronounced than would have been the case if short-term average modeling (less than or equal to 24 hours) had also been performed. However, the overall combined effect of the modeling uncertainties discussed above on predicted concentrations is unclear. Certain assumptions and model limitations may cause concentrations to either increase or decrease. Ultimately, for the objective of this study, the predicted concentration results appear to be reasonable and adequate for use by the MADPH in its exposure assessment.

5. Conclusions

In this study, wind roses were developed from meteorological data acquired for two locations in the Merrimack Valley region, and for Logan Airport in Boston, MA. The wind roses were used to help ascertain the locations where source emissions are likely being transported in the study region, to justify the selection of the meteorological database used in the refined dispersion modeling, and to help facilitate MADPH's interpretation of asthma prevalence data in the context of evaluating potential environmental contributors. A preliminary dispersion modeling sensitivity analysis was also performed to select the appropriate dispersion model options. It was found that the selection of meteorological databases and model options has a significant impact on the locations and magnitudes of maximum modeled ground-level concentrations, given the terrain in the Merrimack Valley region. Since the determination of hourly atmospheric stability class for use in the ISCST3 model is largely affected by wind speed, it was found that the higher anticipated wind speeds at Logan Airport could significantly bias the concurrent atmospheric stability conditions that had actually occurred in the Merrimack Valley region. The higher wind speeds measured at Logan Airport (unrepresentative for the Merrimack Valley region) also could affect the degree of stack plume rise and stack plume dilution; and hence, the locations and magnitudes of maximum modeled ground-level concentrations. This study has demonstrated the need for relying upon local (site- or area-specific) meteorological data when performing cumulative source dispersion modeling exposure assessments when the results are to be coupled geographically with asthma prevalence or other health effects data.

The fact that permitted major stationary sources have been included in the air quality dispersion modeling should not suggest that such sources are primarily causing, or significantly contributing to asthma prevalence in the Merrimack Valley region. In fact, the majority of the permitted major stationary sources considered in this study (e.g., Facilities 1 through 30 in Table 2.1) were found to contribute very little to the highest modeled cumulative seasonal and annual PM10 and VOC concentrations due to the smaller facility emission rates and/or the higher stack plume heights above ground that were associated with those sources. However, other sources considered in this study (e.g., Facilities 31 through 39 in Table 2.1) were the principal contributors to the highest modeled cumulative seasonal and annual PM10 and VOC concentrations due to the larger facility emission rates and the lower stack plume heights above ground associated with those sources.

6. References

1. *Aggregate Impact Study for Inhalation Exposures to Air Toxics Emitted from Incinerators in the Merrimack Valley: Post Retrofit Case – Final Draft Report.* Massachusetts Department of Environmental Protection, Office of Research and Standards, Boston, MA, 14 January 1999.

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3. *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume I – User Instructions.* U.S. Environmental Protection Agency. Research Triangle Park, NC. Report Number EPA-454/B-95-003a. September, 1995 (model source code – reissued 4 February 2002).

4. *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II - Description of Model Algorithms.* U.S. Environmental Protection Agency. Research Triangle Park, NC. Report Number EPA-454/B-95-003b. September, 1995 (model source code – reissued 4 February 2002).

5. 40 CFR Part 51 Appendix W 2003 Edition *Guideline on Air Quality Models.* USEPA TTN "SCRAM" Electronic Bulletin Board.

6. A.H. Auer, *Correlation of Land Use and Cover with Meteorological Anomalies.* Journal of Applied Meteorology. Vol. 17, pp. 636-643, 1978.

7. *Guideline for Determination of Good Engineering Practice Stack Height.* U.S. Environmental Protection Agency. Research Triangle Park, NC. Report Number EPA-450/4-80-023R. June, 1985.

8. *PCRAMMET Meteorological Preprocessor Program, Version Dated 99169.* USEPA TTN "SCRAM" Electronic Bulletin Board.

9. R. Rothstein, A. Goldman, D. Ernst, and R. Knorr, *The Merrimack Valley Pediatric Asthma Study – Key Meteorological and Dispersion Modeling Issues*. (Presented at the 96st Annual Meeting and Exhibition of the Air and Waste Management Association, San Diego, California, 2003).

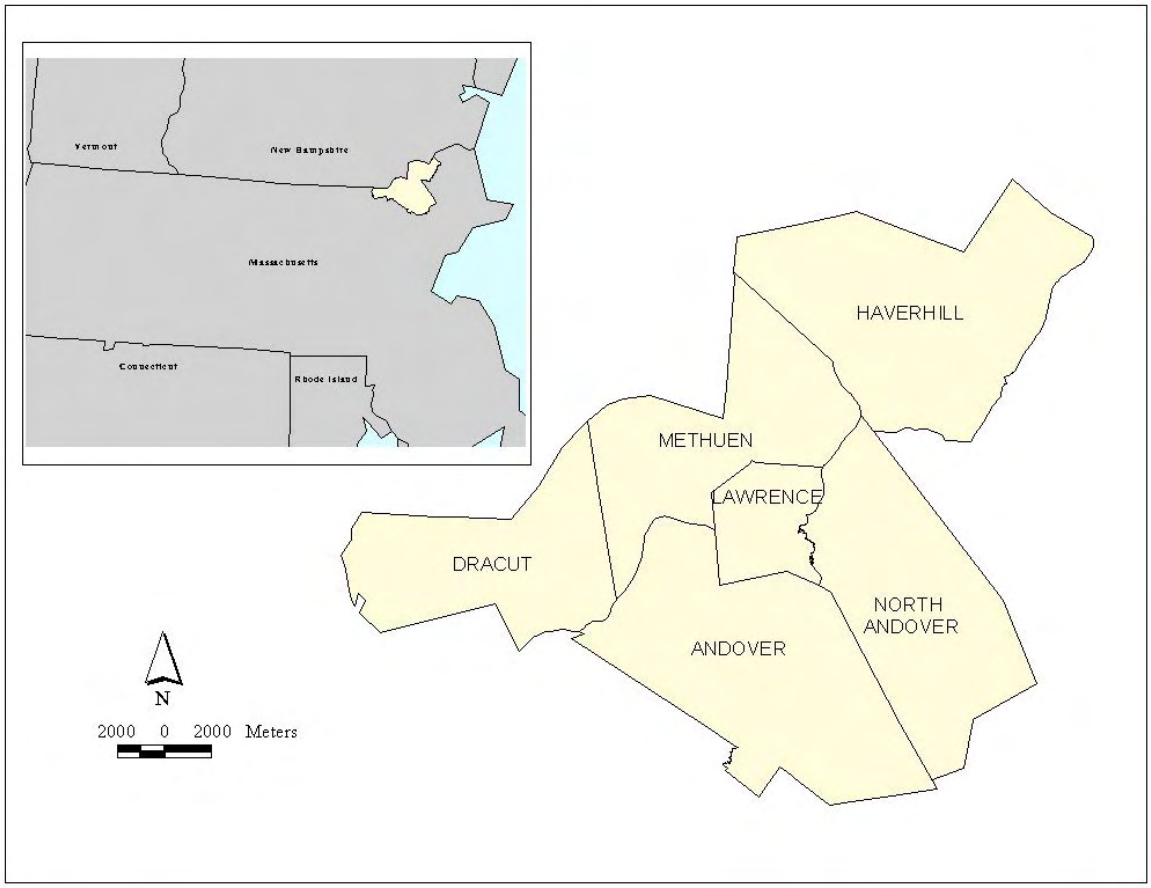


Figure 1.1: Merrimack Valley Region Modeling Domain

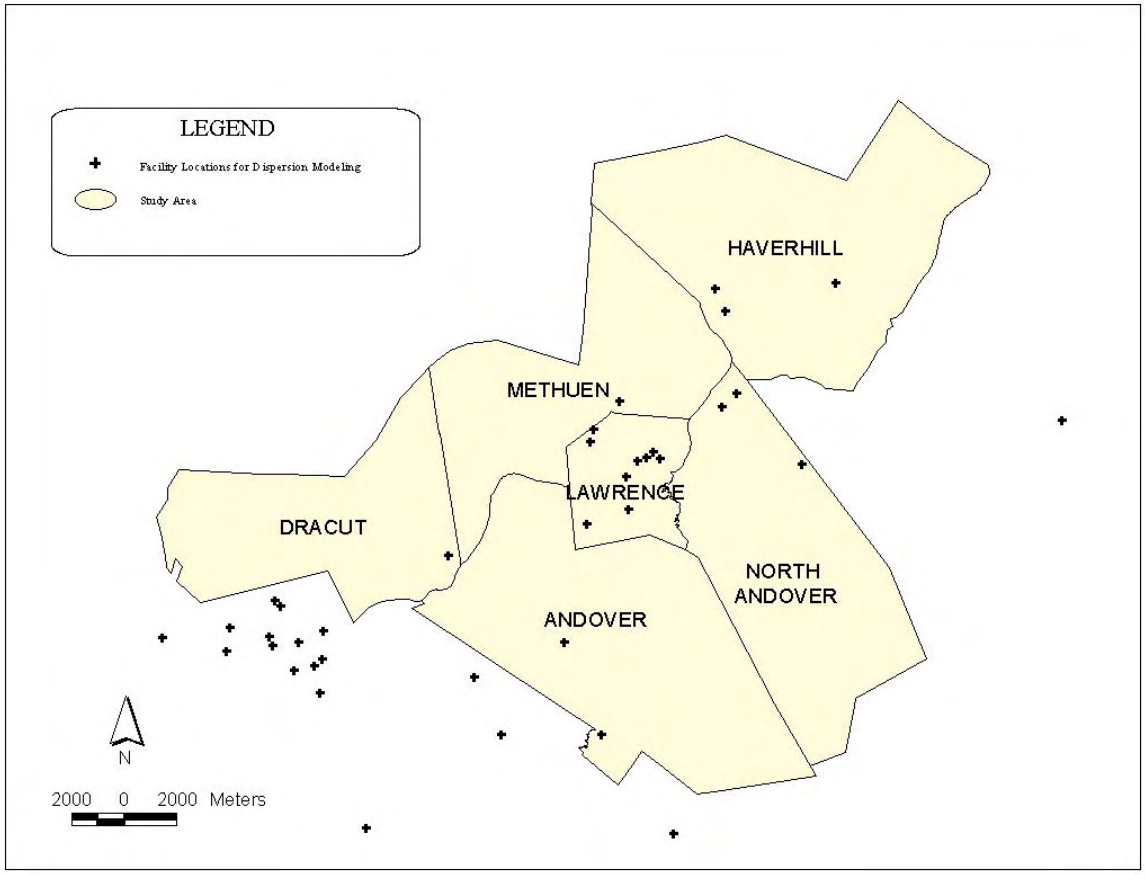


Figure 2.1: Facility Locations in the Merrimack Valley Study Region

Figure 3.1: Cumulative Wind Rose for Logan International Airport, Boston, MA 1991-1995

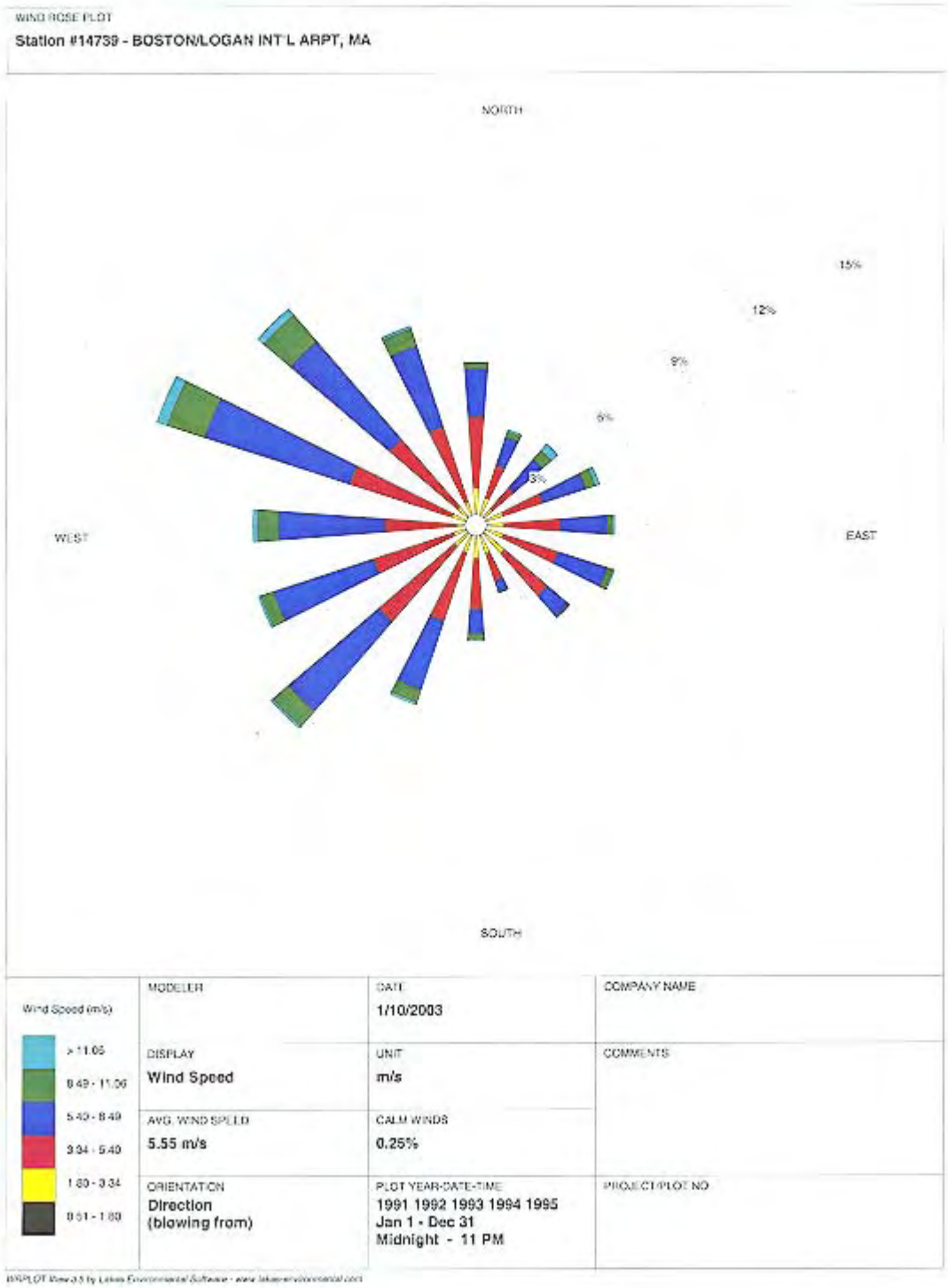


Figure 3.2: Cumulative Wind Rose for MADEP's Storrow Park Site, Lawrence, MA 1991-1995

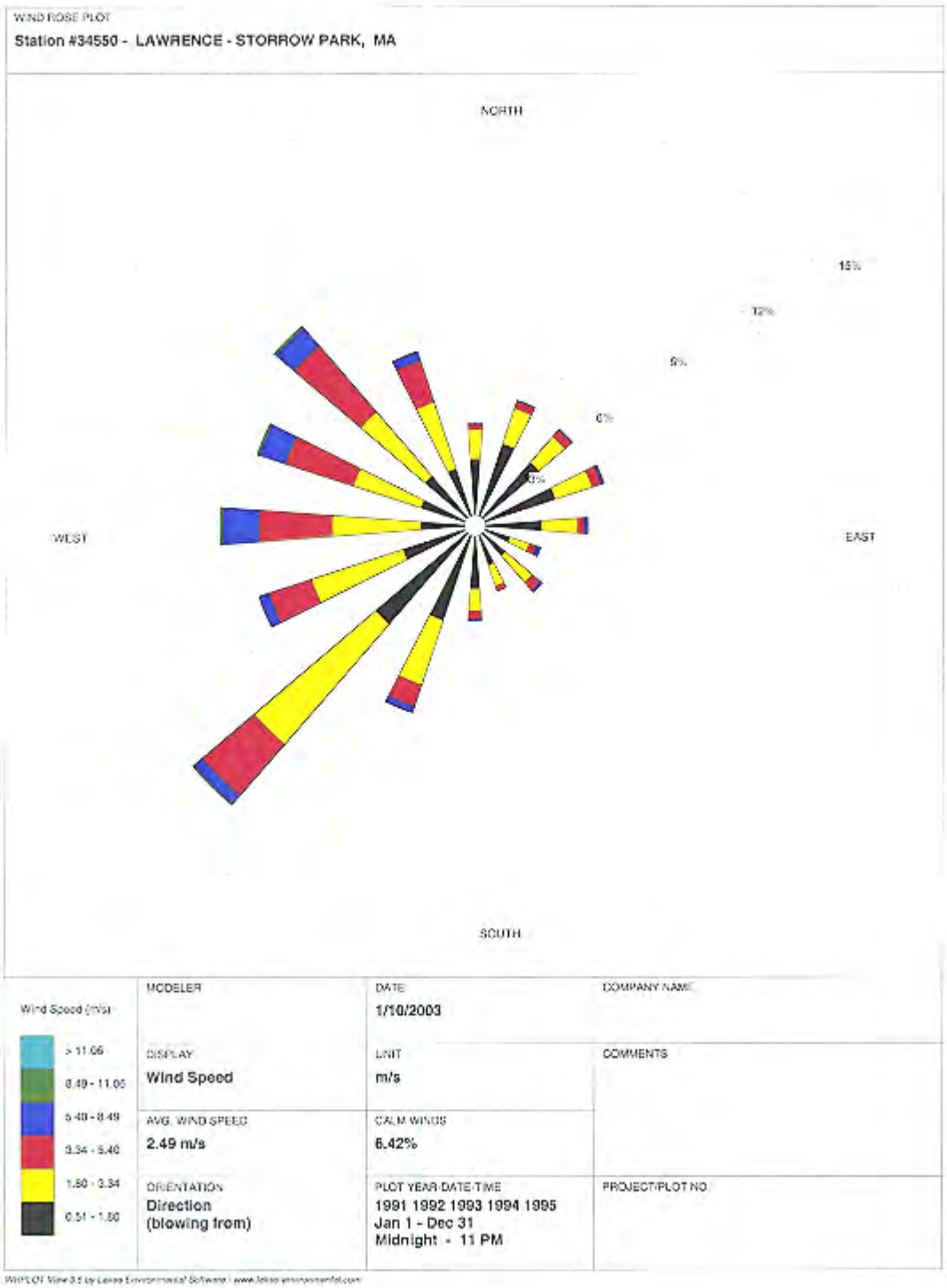
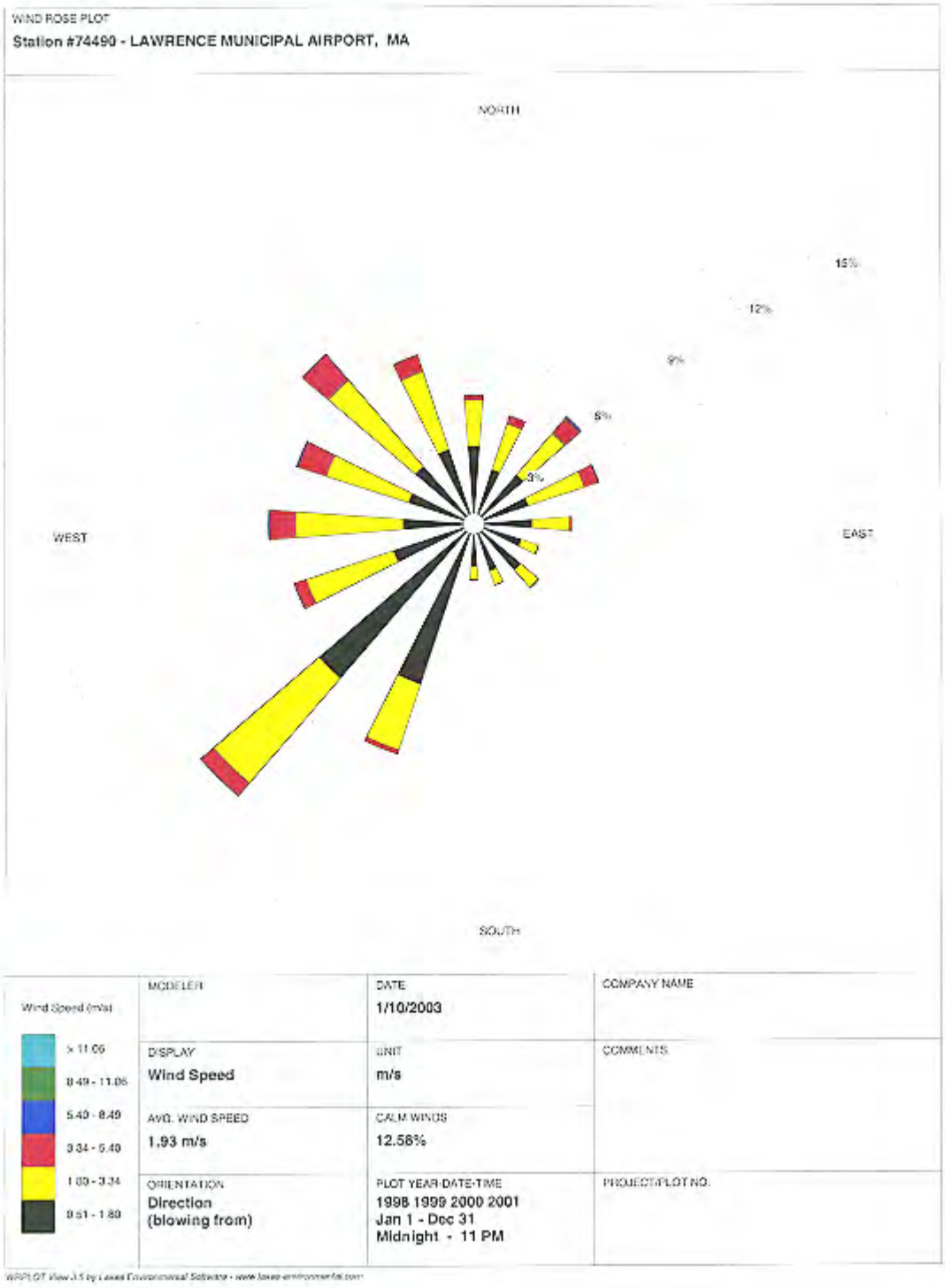


Figure 3.3: Cumulative Wind Rose for Lawrence Municipal Airport, MA 1998-2001



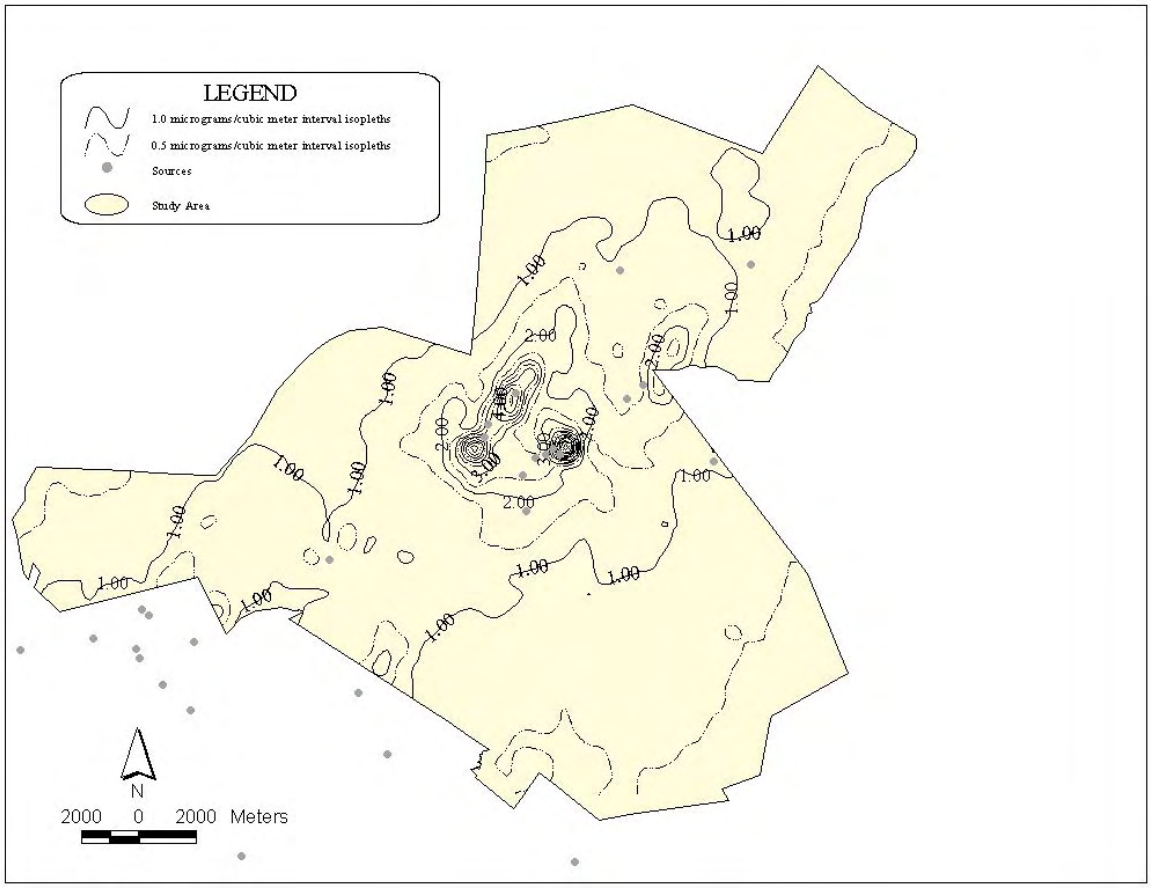


Figure 3.4: Preliminary Dispersion Modeling – 1998 Urban Mode Isopleths (ug/m^3)

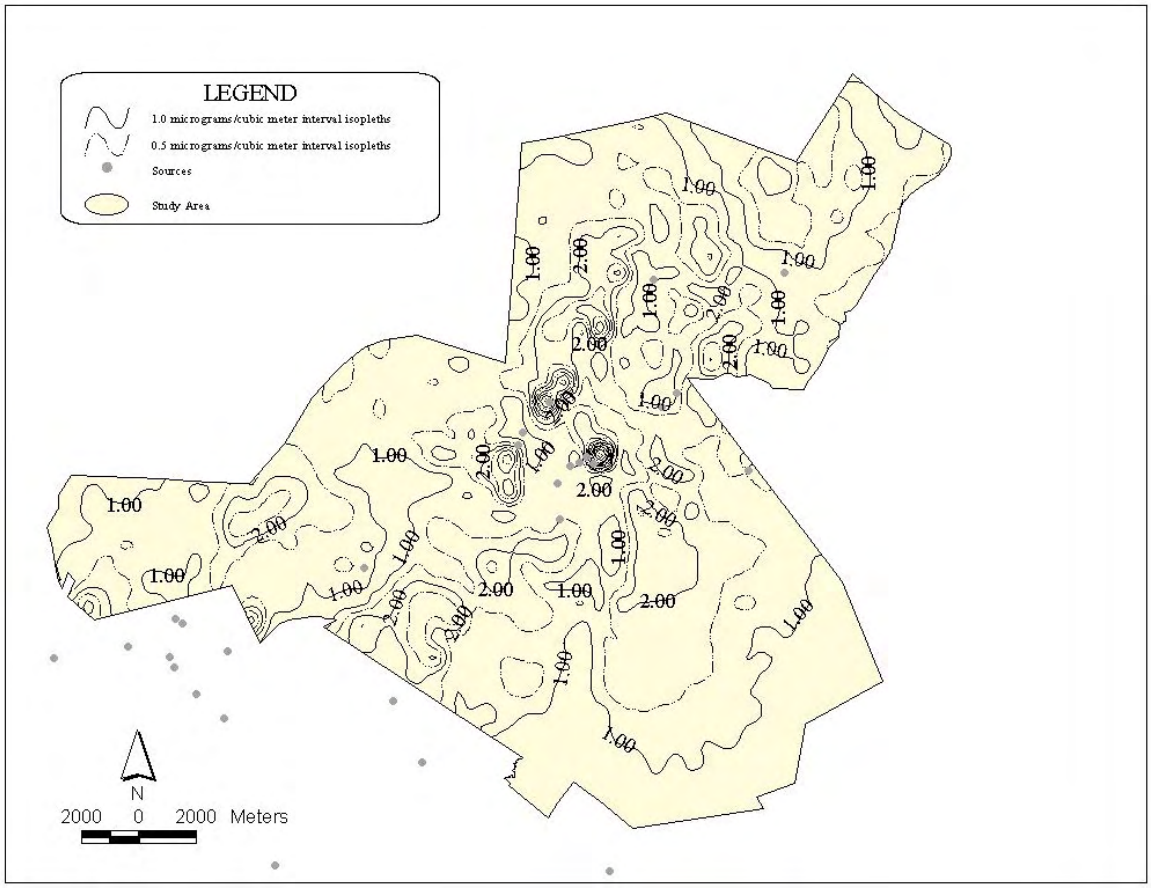


Figure 3.5: Preliminary Dispersion Modeling – 1998 Rural Mode Isopleths (ug/m^3)

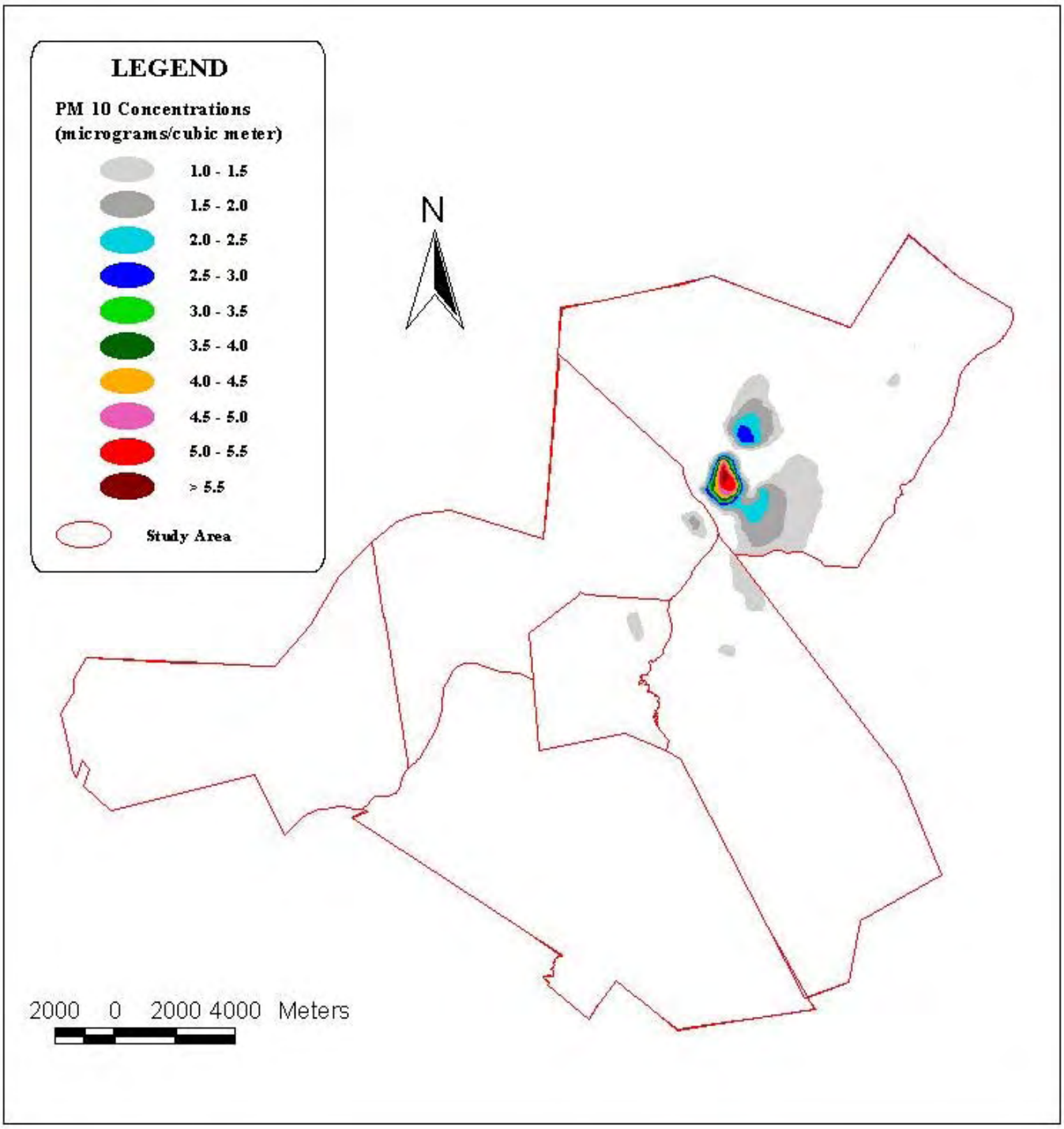


Figure 3.6: 1998-2001 Cumulative Source PM10 Concentration Isopleths for Winter Season (December, January, February)

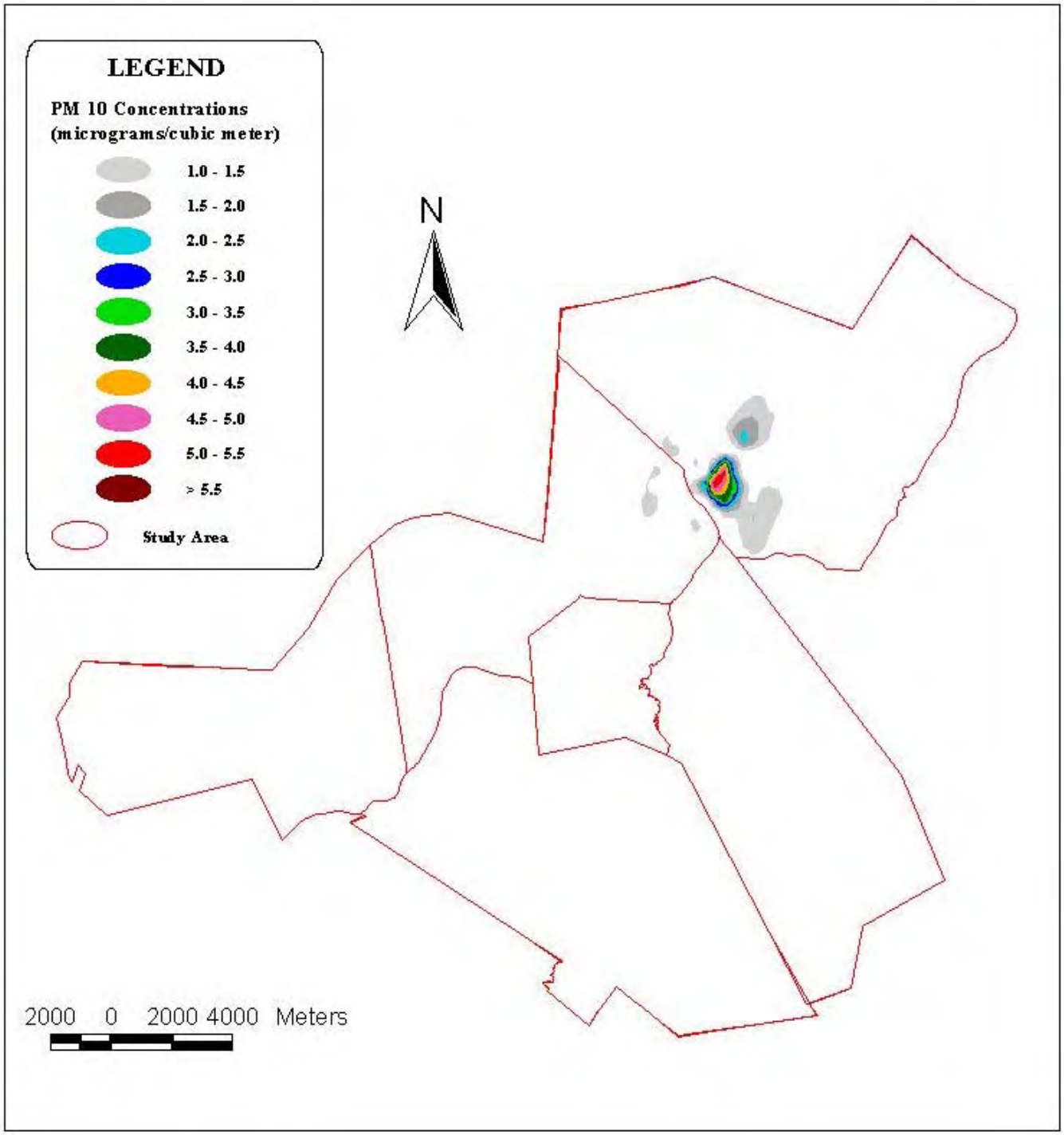


Figure 3.7: 1998-2001 Cumulative Source PM10 Concentration Isopleths for Spring Season (March, April, May)

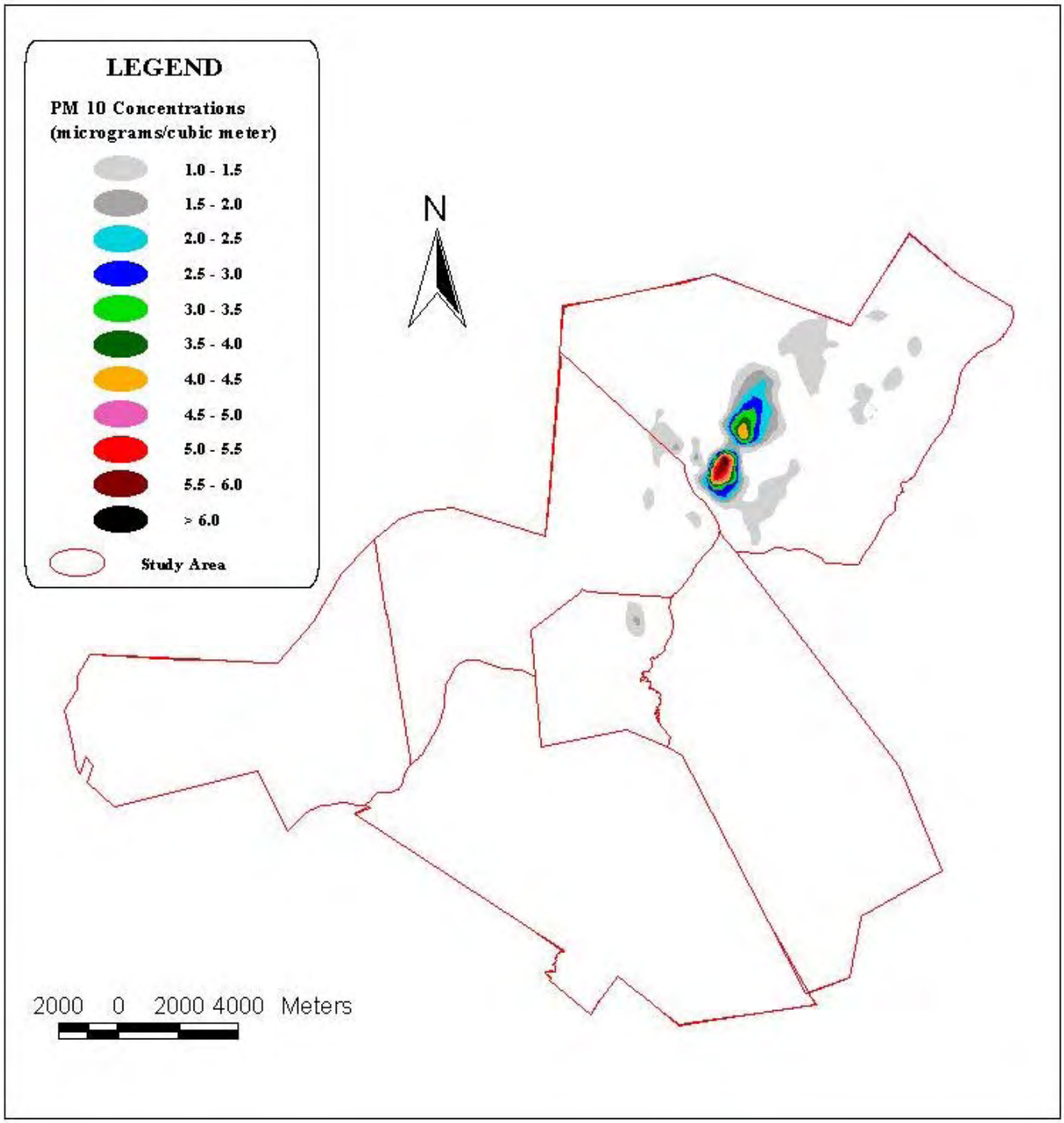


Figure 3.8: 1998-2001 Cumulative Source PM10 Concentration Isopleths for Summer Season (June, July, August)

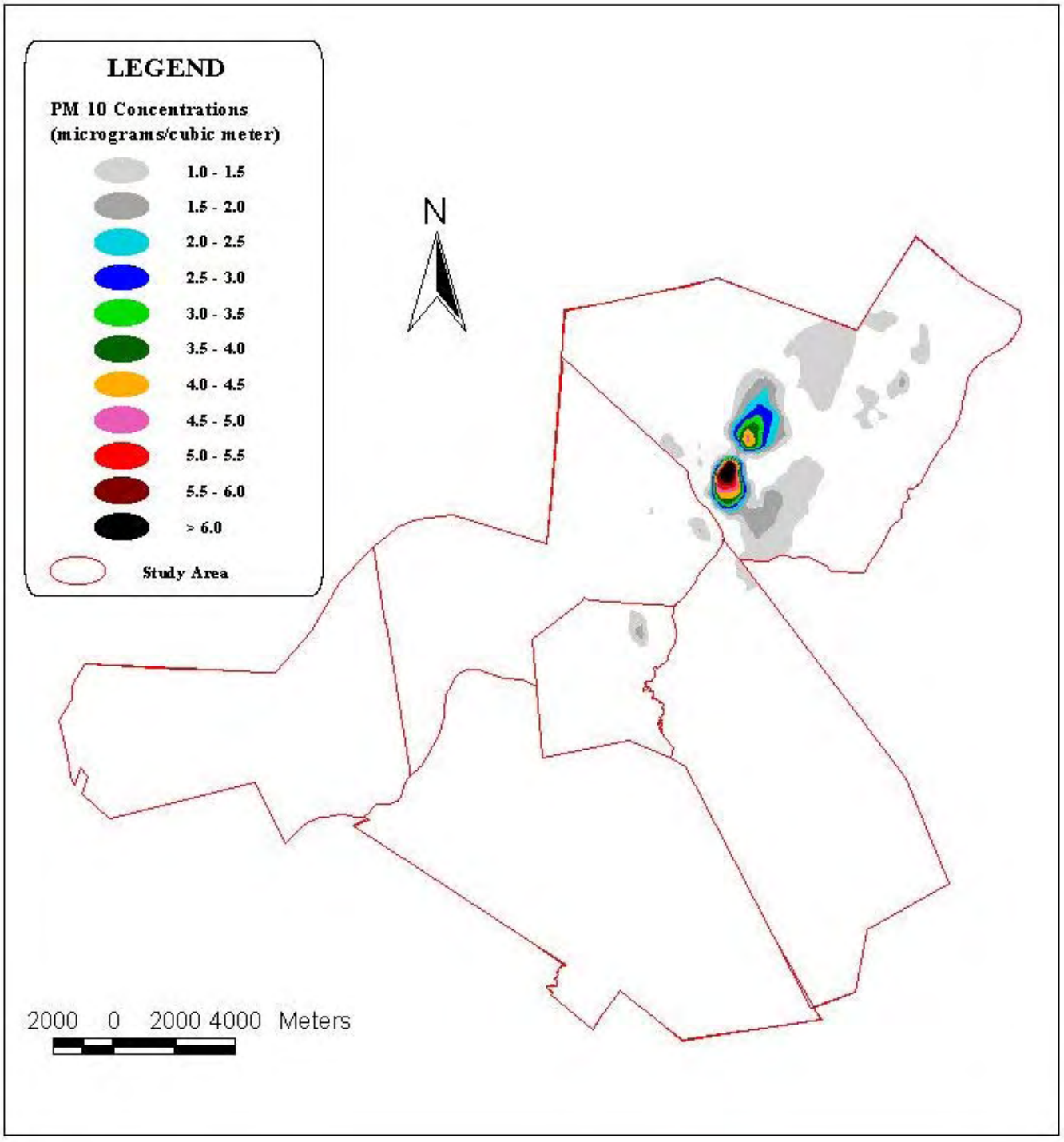


Figure 3.9: 1998-2001 Cumulative Source PM10 Concentration Isopleths for Fall Season (September, October, November)

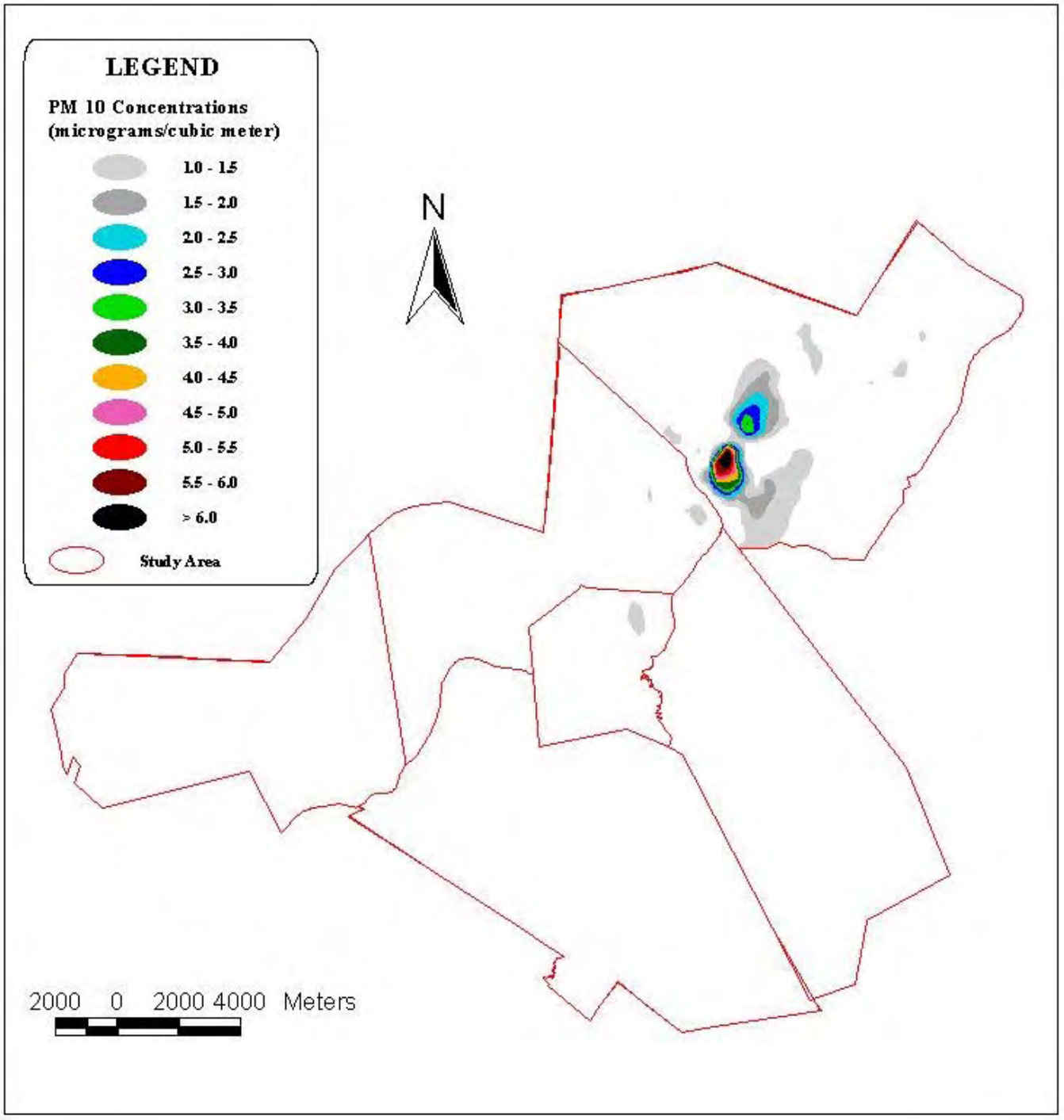


Figure 3.10: 1998-2001 Cumulative Source PM10 Concentration Isopleths for Annual Period

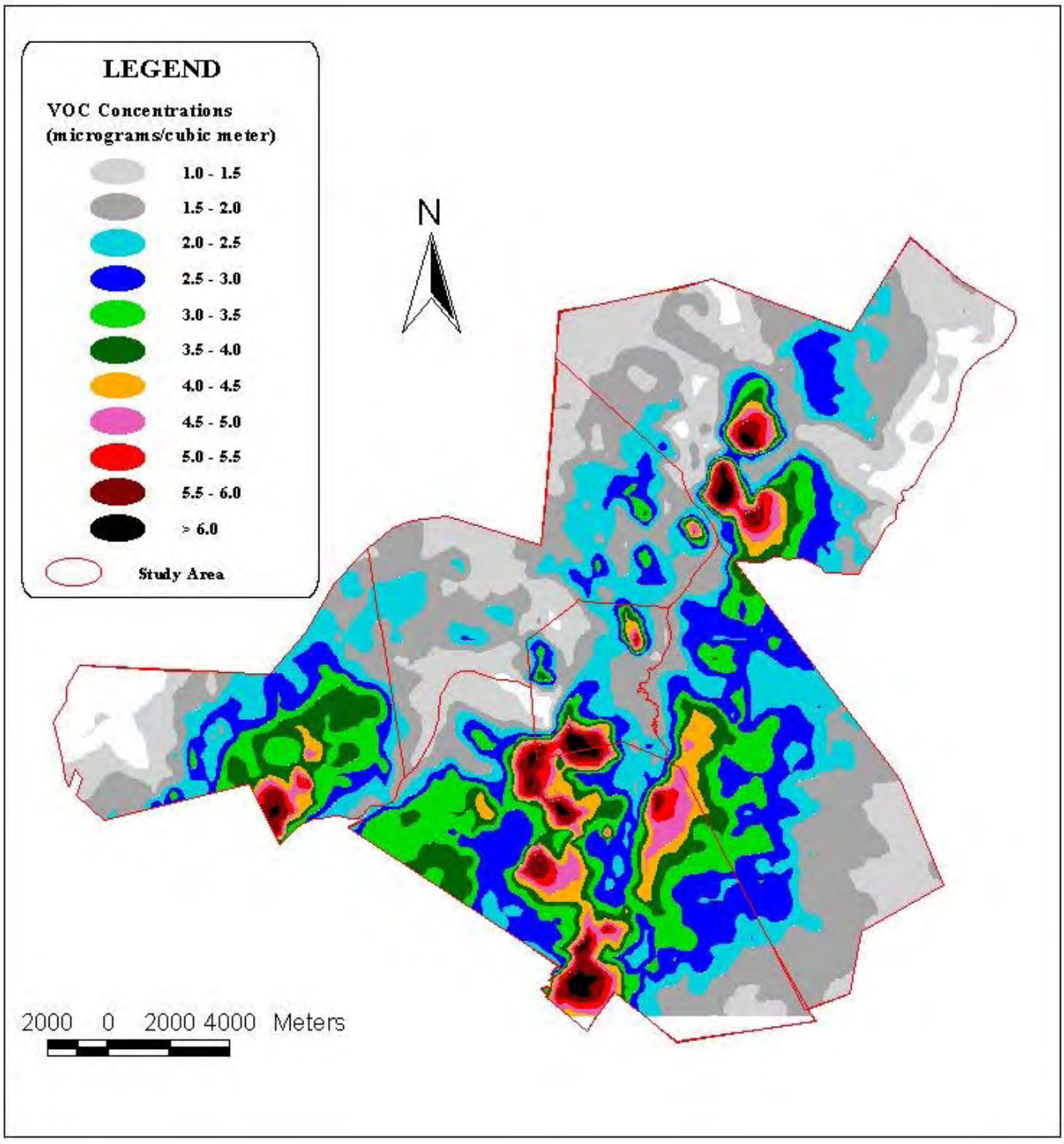


Figure 3.11: 1998-2001 Cumulative Source VOC Concentration Isopleths for Winter Season (December, January, February)

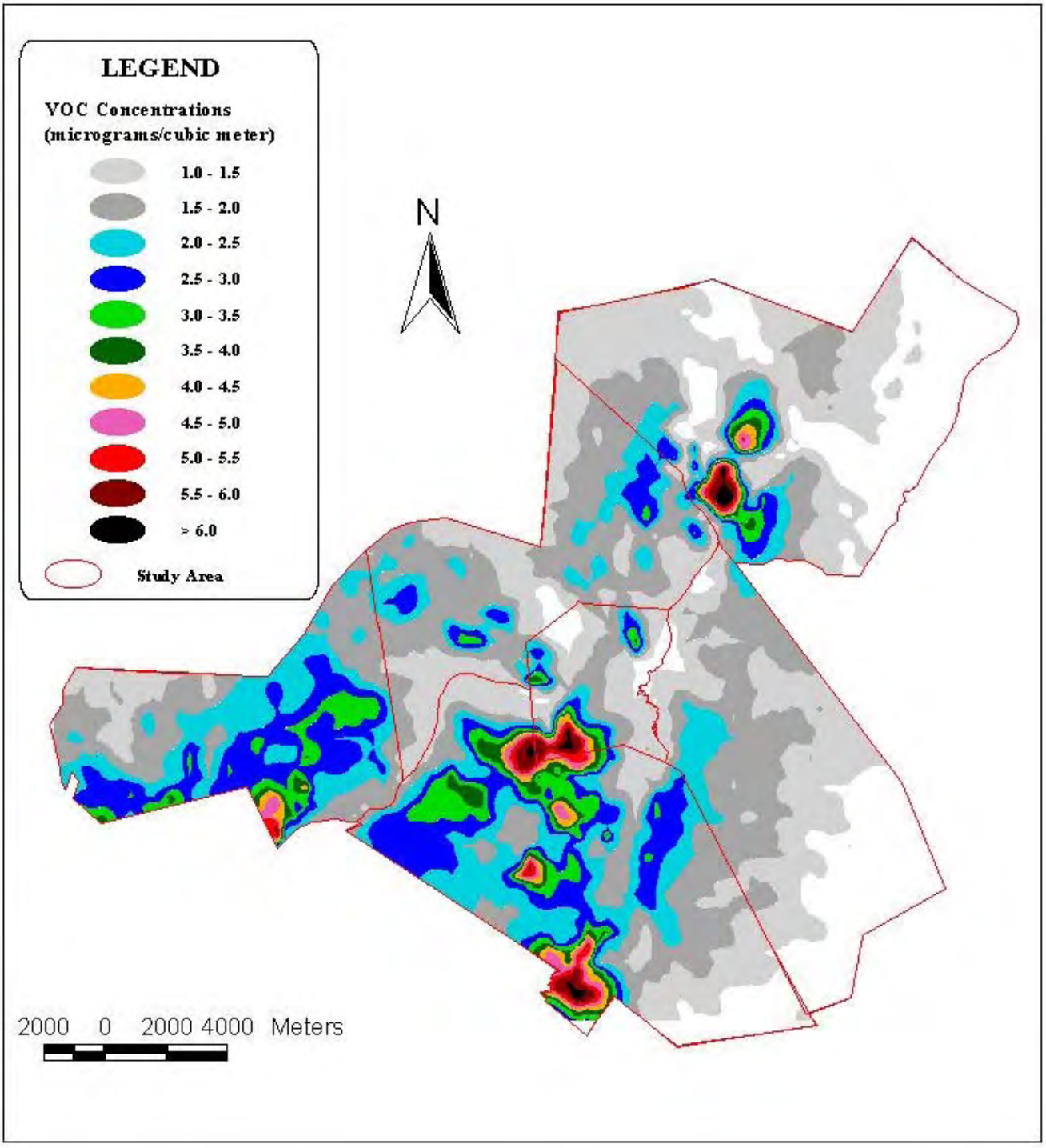


Figure 3.12: 1998-2001 Cumulative Source VOC Concentration Isopleths for Spring Season (March, April, May)

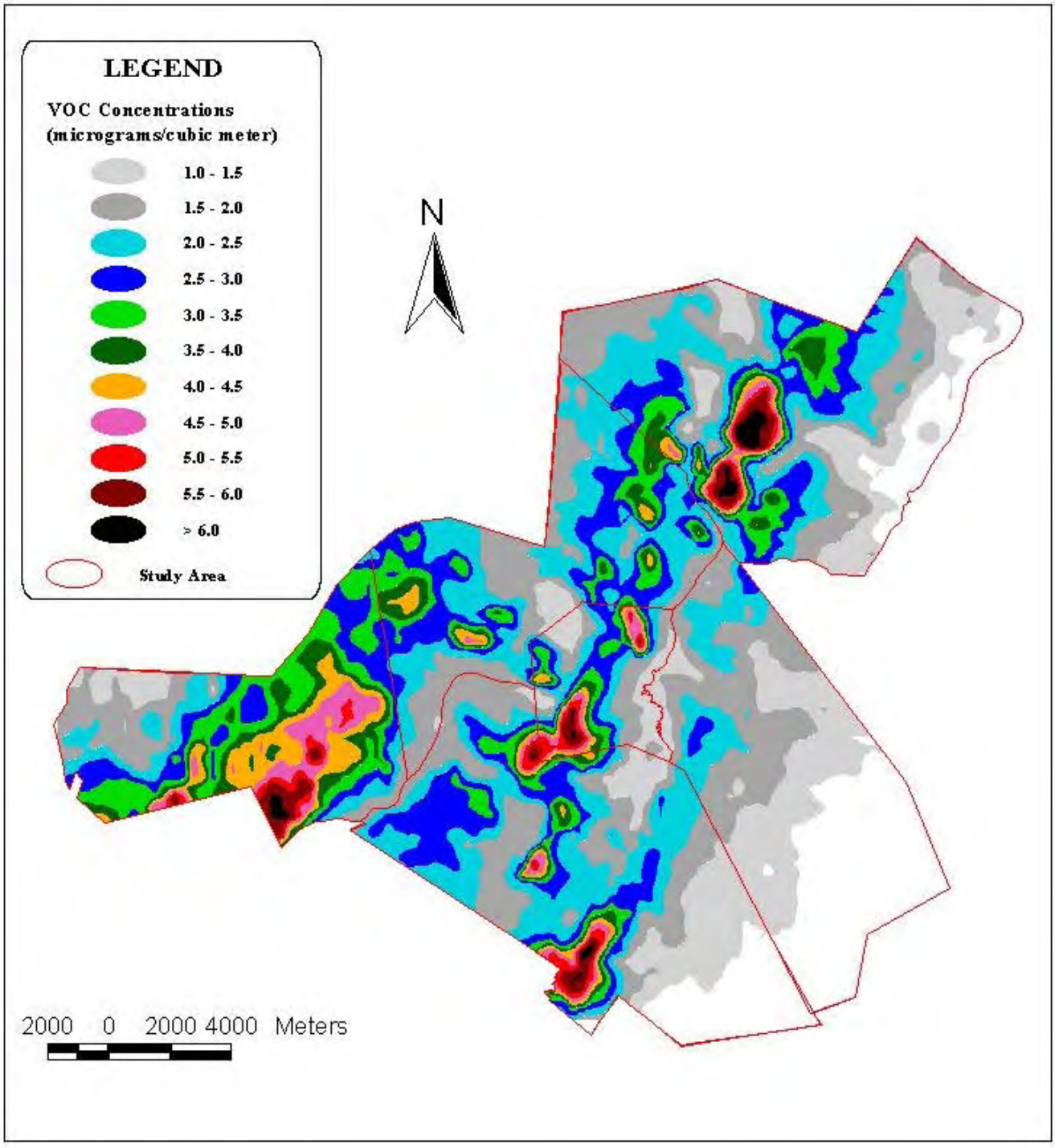


Figure 3.13: 1998-2001 Cumulative Source VOC Concentration Isopleths for Summer Season (June, July, August)

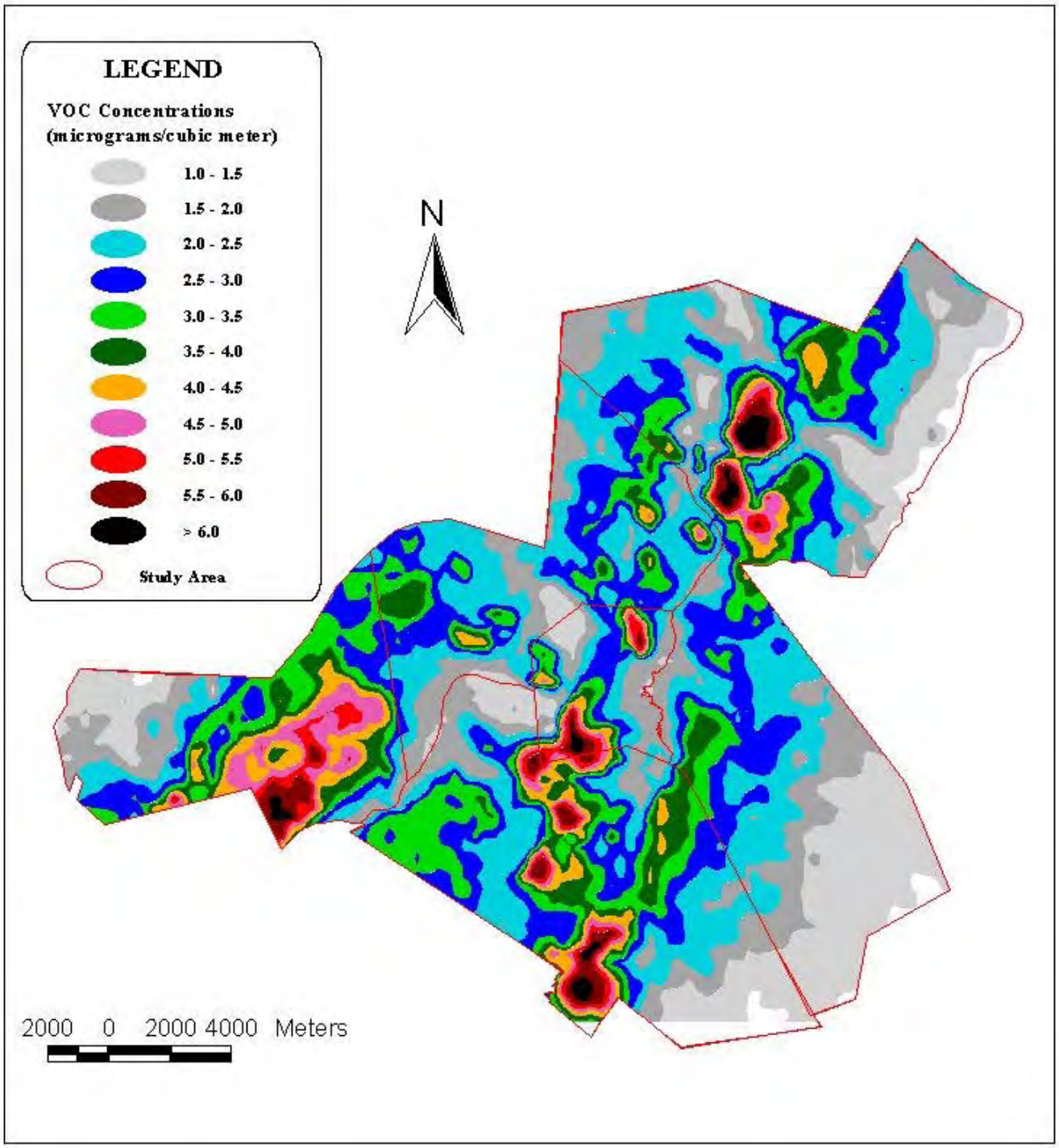


Figure 3.14: 1998-2001 Cumulative Source VOC Concentration Isopleths for Fall Season (September, October, November)

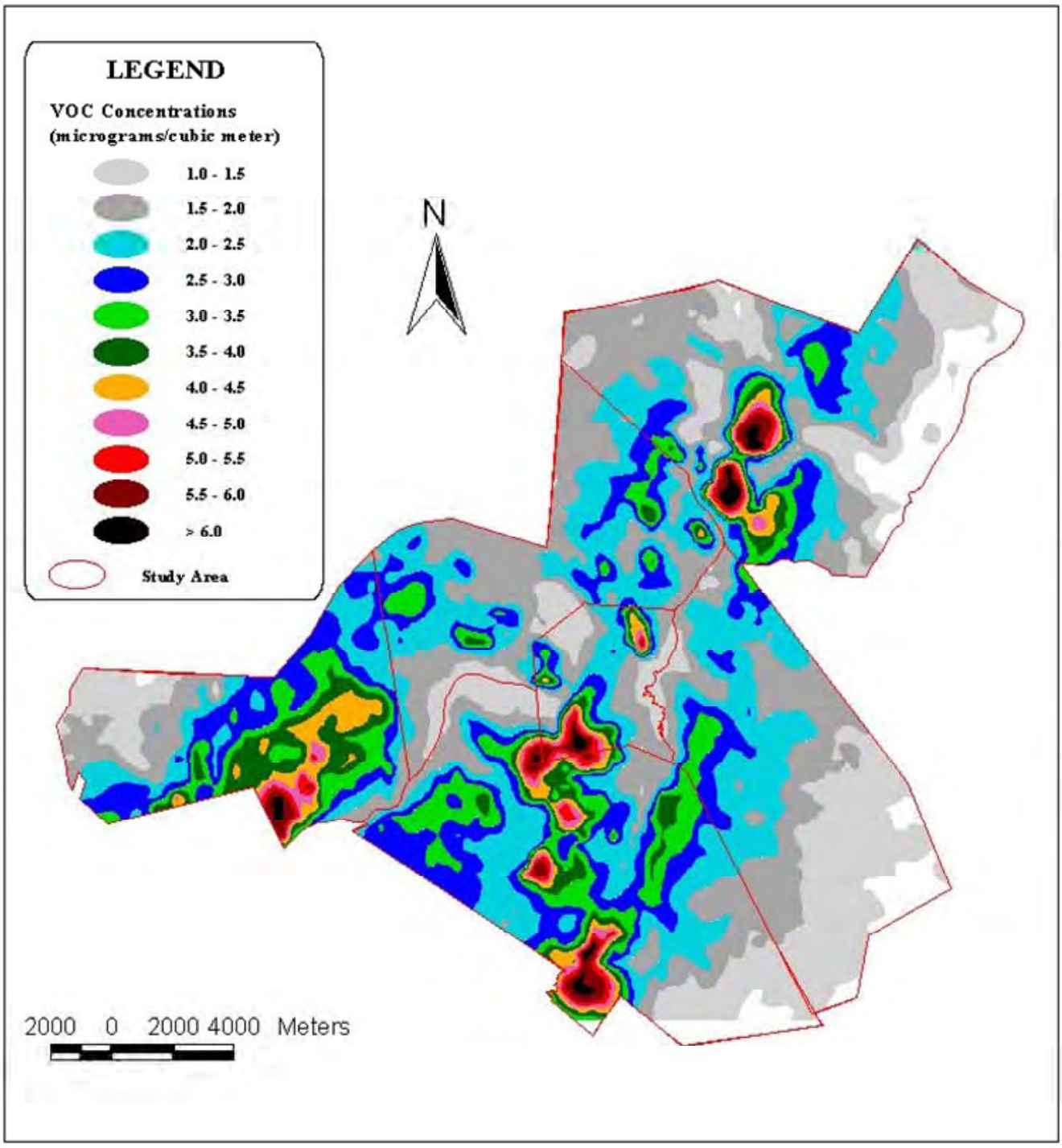


Figure 3.15: 1998-2001 Cumulative Source VOC Concentration Isopleths for Annual Period

Table 3.2

1998-2001 Cumulative Source Maximum PM10 Concentration and Source Contributions to the Maximum Concentration for Winter Season (December, January, February)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327000	4736250	39.00	0.00065	0.01%	3959	11
2	Ogden Havehill	326210	4736640	18.59	327000	4736250	39.00	0.00018	0.00%	881	116
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	327000	4736250	39.00	0.00621	0.08%	7459	47
4	Ogden Lawrence Boiler	321528	4731181	19.81	327000	4736250	39.00	0.00287	0.04%	7459	47
5	Newark Atlantic Paperboard	323323	4730469	11.89	327000	4736250	39.00	0.17433	2.20%	6851	32
6	Lucent Technologies	327051	4733016	14.94	327000	4736250	39.00	0.00331	0.04%	3234	359
7	Lowell Cogen	309543	4723480	29.87	327000	4736250	39.00	0.00023	0.00%	21629	54
8	Baker Commodities	317152	4722286	39.01	327000	4736250	39.00	0.00685	0.09%	17087	35
9	Lowell Hospital	307926	4724169	39.01	327000	4736250	39.00	0.00033	0.00%	22578	58
10	U Mass Lowell South	309838	4724981	35.97	327000	4736250	39.00	0.00053	0.01%	20531	57
11	Tewksbury Hospital	318170	4720140	45.11	327000	4736250	39.00	0.00104	0.01%	18371	29
12	Malden Mills	321665	4731645	17.98	327000	4736250	39.00	0.00584	0.07%	7048	49
13	U Mass Lowell North	309589	4725168	32.92	327000	4736250	39.00	0.00268	0.03%	20639	58
14	Holy Family Hospital	322616	4732698	57.00	327000	4736250	39.00	0.00161	0.02%	5642	51
15	Merrimack Paper	322886	4729848	14.94	327000	4736250	39.00	0.02598	0.33%	7610	33
16	L'Energia	310321	4722546	35.97	327000	4736250	39.00	0.01258	0.16%	21587	51
17	BNZ Materials	313057	4716585	35.97	327000	4736250	39.00	0.00072	0.01%	24106	35
18	Lawrence Hospital	323907	4730800	17.98	327000	4736250	39.00	0.00607	0.08%	6267	30
19	Merrimack Valley Industrial	309392	4723823	39.01	327000	4736250	39.00	0.00064	0.01%	21552	55
20	Winstanley Enterprises Inc.	305369	4723771	27.87	327000	4736250	39.00	0.00104	0.01%	24972	60
21	Heffron Asphalt	324681	4716389	28.04	327000	4736250	39.00	0.00043	0.01%	19996	7
22	Brox Industries	316147	4726909	29.87	327000	4736250	39.00	0.02135	0.27%	14319	49
23	Everett Mills	323655	4730579	14.94	327000	4736250	39.00	0.00342	0.04%	6584	31
24	Brooks School	329525	4730329	50.90	327000	4736250	39.00	0.00020	0.00%	6437	337
25	Saints Medical Center	311421	4724039	29.87	327000	4736250	39.00	0.00138	0.02%	19794	52
26	Andrea Management Corp.	323323	4730469	14.94	327000	4736250	39.00	0.00249	0.03%	6851	32
27	BFI Med. Waste Incinerator	323455	4728477	16.76	327000	4736250	39.00	0.00293	0.04%	8543	25
28	Pacific Mills	324149	4730566	11.89	327000	4736250	39.00	0.00358	0.05%	6359	27
29	Americraft Carton	311299	4721685	32.92	327000	4736250	39.00	0.00475	0.06%	21416	47
30	Haverhill Paperboard	330795	4737186	12.00	327000	4736250	39.00	0.04713	0.60%	3909	256
31	Crown Cork & Seal	321413	4728074	29.87	327000	4736250	39.00	0.00000	0.00%	9903	34
32	Ideal Tape Company	307778	4723277	29.87	327000	4736250	39.00	0.00000	0.00%	23190	56
33	Bradford Industries	311385	4722984	29.87	327000	4736250	39.00	0.00000	0.00%	20489	50
34	Hood Coatings	339337	4732004	39.01	327000	4736250	39.00	0.00000	0.00%	13047	289
35	Vernon Plastics Inc.	326643	4736144	17.98	327000	4736250	39.00	7.56503	95.68%	372	73
36	Majilite Manufacturing	311092	4722725	27.13	327000	4736250	39.00	0.00000	0.00%	20880	50
37	Oak Finishers	310510	4723631	27.13	327000	4736250	39.00	0.00000	0.00%	20764	53
38	The Gillette Company	321967	4720116	24.08	327000	4736250	39.00	0.00000	0.00%	16901	17
39	Raytheon Systems Co.	320556	4723602	45.11	327000	4736250	39.00	0.00000	0.00%	14195	27
	Cummulative Total	na	na	na	327000	4736250	39.00	7.90629		na	na

Table 3.3

1998-2001 Cumulative Source Maximum PM10 Concentration and Source Contributions to the Maximum Concentration for Spring Season (March, April, May)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	326750	4736250	24.00	0.00108	0.02%	3920	7
2	Ogden Havehill	326210	4736640	18.59	326750	4736250	24.00	0.00105	0.02%	666	126
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	326750	4736250	24.00	0.00589	0.09%	7278	46
4	Ogden Lawrence Boiler	321528	4731181	19.81	326750	4736250	24.00	0.00084	0.01%	7278	46
5	Newark Atlantic Paperboard	323323	4730469	11.89	326750	4736250	24.00	0.06751	1.00%	6720	31
6	Lucent Technologies	327051	4733016	14.94	326750	4736250	24.00	0.00278	0.04%	3248	355
7	Lowell Cogen	309543	4723480	29.87	326750	4736250	24.00	0.00009	0.00%	21428	53
8	Baker Commodities	317152	4722286	39.01	326750	4736250	24.00	0.00410	0.06%	16944	35
9	Lowell Hospital	307926	4724169	39.01	326750	4736250	24.00	0.00015	0.00%	22367	57
10	U Mass Lowell South	309838	4724981	35.97	326750	4736250	24.00	0.00023	0.00%	20323	56
11	Tewksbury Hospital	318170	4720140	45.11	326750	4736250	24.00	0.00070	0.01%	18252	28
12	Malden Mills	321665	4731645	17.98	326750	4736250	24.00	0.00304	0.05%	6860	48
13	U Mass Lowell North	309589	4725168	32.92	326750	4736250	24.00	0.00110	0.02%	20428	57
14	Holy Family Hospital	322616	4732698	57.00	326750	4736250	24.00	0.00090	0.01%	5450	49
15	Merrimack Paper	322886	4729848	14.94	326750	4736250	24.00	0.01411	0.21%	7478	31
16	L'Energia	310321	4722546	35.97	326750	4736250	24.00	0.00837	0.12%	21394	50
17	BNZ Materials	313057	4716585	35.97	326750	4736250	24.00	0.00046	0.01%	23963	35
18	Lawrence Hospital	323907	4730800	17.98	326750	4736250	24.00	0.00315	0.05%	6147	28
19	Merrimack Valley Industrial	309392	4723823	39.01	326750	4736250	24.00	0.00024	0.00%	21348	54
20	Winstanley Enterprises Inc.	305369	4723771	27.87	326750	4736250	24.00	0.00021	0.00%	24756	60
21	Heffron Asphalt	324681	4716389	28.04	326750	4736250	24.00	0.00022	0.00%	19968	6
22	Brox Industries	316147	4726909	29.87	326750	4736250	24.00	0.00850	0.13%	14131	49
23	Everett Mills	323655	4730579	14.94	326750	4736250	24.00	0.00193	0.03%	6461	29
24	Brooks School	329525	4730329	50.90	326750	4736250	24.00	0.00027	0.00%	6539	335
25	Saints Medical Center	311421	4724039	29.87	326750	4736250	24.00	0.00052	0.01%	19598	51
26	Andrea Management Corp.	323323	4730469	14.94	326750	4736250	24.00	0.00140	0.02%	6720	31
27	BFI Med. Waste Incinerator	323455	4728477	16.76	326750	4736250	24.00	0.00086	0.01%	8443	23
28	Pacific Mills	324149	4730566	11.89	326750	4736250	24.00	0.00150	0.02%	6251	25
29	Americraft Carton	311299	4721685	32.92	326750	4736250	24.00	0.00202	0.03%	21234	47
30	Haverhill Paperboard	330795	4737186	12.00	326750	4736250	24.00	0.08306	1.23%	4152	257
31	Crown Cork & Seal	321413	4728074	29.87	326750	4736250	24.00	0.00000	0.00%	9764	33
32	Ideal Tape Company	307778	4723277	29.87	326750	4736250	24.00	0.00000	0.00%	22983	56
33	Bradford Industries	311385	4722984	29.87	326750	4736250	24.00	0.00000	0.00%	20300	49
34	Hood Coatings	339337	4732004	39.01	326750	4736250	24.00	0.00000	0.00%	13284	289
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	6.51241	96.79%	151	45
36	Majilite Manufacturing	311092	4722725	27.13	326750	4736250	24.00	0.00000	0.00%	20691	49
37	Oak Finishers	310510	4723631	27.13	326750	4736250	24.00	0.00000	0.00%	20566	52
38	The Gillette Company	321967	4720116	24.08	326750	4736250	24.00	0.00000	0.00%	16828	17
39	Raytheon Systems Co.	320556	4723602	45.11	326750	4736250	24.00	0.00000	0.00%	14083	26
	Cummulative Total	na	na	na	326750	4736250	24.00	6.72859		na	na

Table 3.4

1998-2001 Cumulative Source Maximum PM10 Concentration and Source Contributions to the Maximum Concentration for Summer Season (June, July, August)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	326750	4736250	24.00	0.00192	0.01%	3920	7
2	Ogden Havehill	326210	4736640	18.59	326750	4736250	24.00	0.00294	0.02%	666	126
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	326750	4736250	24.00	0.01306	0.08%	7278	46
4	Ogden Lawrence Boiler	321528	4731181	19.81	326750	4736250	24.00	0.00166	0.01%	7278	46
5	Newark Atlantic Paperboard	323323	4730469	11.89	326750	4736250	24.00	0.16268	0.95%	6720	31
6	Lucent Technologies	327051	4733016	14.94	326750	4736250	24.00	0.00310	0.02%	3248	355
7	Lowell Cogen	309543	4723480	29.87	326750	4736250	24.00	0.00021	0.00%	21428	53
8	Baker Commodities	317152	4722286	39.01	326750	4736250	24.00	0.00896	0.05%	16944	35
9	Lowell Hospital	307926	4724169	39.01	326750	4736250	24.00	0.00027	0.00%	22367	57
10	U Mass Lowell South	309838	4724981	35.97	326750	4736250	24.00	0.00042	0.00%	20323	56
11	Tewksbury Hospital	318170	4720140	45.11	326750	4736250	24.00	0.00152	0.01%	18252	28
12	Malden Mills	321665	4731645	17.98	326750	4736250	24.00	0.00605	0.04%	6860	48
13	U Mass Lowell North	309589	4725168	32.92	326750	4736250	24.00	0.00200	0.01%	20428	57
14	Holy Family Hospital	322616	4732698	57.00	326750	4736250	24.00	0.00177	0.01%	5450	49
15	Merrimack Paper	322886	4729848	14.94	326750	4736250	24.00	0.03298	0.19%	7478	31
16	L'Energia	310321	4722546	35.97	326750	4736250	24.00	0.01731	0.10%	21394	50
17	BNZ Materials	313057	4716585	35.97	326750	4736250	24.00	0.00099	0.01%	23963	35
18	Lawrence Hospital	323907	4730800	17.98	326750	4736250	24.00	0.00711	0.04%	6147	28
19	Merrimack Valley Industrial	309392	4723823	39.01	326750	4736250	24.00	0.00049	0.00%	21348	54
20	Winstanley Enterprises Inc.	305369	4723771	27.87	326750	4736250	24.00	0.00041	0.00%	24756	60
21	Heffron Asphalt	324681	4716389	28.04	326750	4736250	24.00	0.00017	0.00%	19968	6
22	Brox Industries	316147	4726909	29.87	326750	4736250	24.00	0.01869	0.11%	14131	49
23	Everett Mills	323655	4730579	14.94	326750	4736250	24.00	0.00437	0.03%	6461	29
24	Brooks School	329525	4730329	50.90	326750	4736250	24.00	0.00028	0.00%	6539	335
25	Saints Medical Center	311421	4724039	29.87	326750	4736250	24.00	0.00130	0.01%	19598	51
26	Andrea Management Corp.	323323	4730469	14.94	326750	4736250	24.00	0.00328	0.02%	6720	31
27	BFI Med. Waste Incinerator	323455	4728477	16.76	326750	4736250	24.00	0.00180	0.01%	8443	23
28	Pacific Mills	324149	4730566	11.89	326750	4736250	24.00	0.00299	0.02%	6251	25
29	Americraft Carton	311299	4721685	32.92	326750	4736250	24.00	0.00412	0.02%	21234	47
30	Haverhill Paperboard	330795	4737186	12.00	326750	4736250	24.00	0.05682	0.33%	4152	257
31	Crown Cork & Seal	321413	4728074	29.87	326750	4736250	24.00	0.00000	0.00%	9764	33
32	Ideal Tape Company	307778	4723277	29.87	326750	4736250	24.00	0.00000	0.00%	22983	56
33	Bradford Industries	311385	4722984	29.87	326750	4736250	24.00	0.00000	0.00%	20300	49
34	Hood Coatings	339337	4732004	39.01	326750	4736250	24.00	0.00000	0.00%	13284	289
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	16.69340	97.89%	151	45
36	Majilite Manufacturing	311092	4722725	27.13	326750	4736250	24.00	0.00000	0.00%	20691	49
37	Oak Finishers	310510	4723631	27.13	326750	4736250	24.00	0.00000	0.00%	20566	52
38	The Gillette Company	321967	4720116	24.08	326750	4736250	24.00	0.00000	0.00%	16828	17
39	Raytheon Systems Co.	320556	4723602	45.11	326750	4736250	24.00	0.00000	0.00%	14083	26
	Cummulative Total	na	na	na	326750	4736250	24.00	17.05268		na	na

Table 3.5

1998-2001 Cumulative Source Maximum PM10 Concentration and Source Contributions to the Maximum Concentration for Fall Season (September, October, November)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327000	4736500	33.00	0.00123	0.01%	4205	10
2	Ogden Havehill	326210	4736640	18.59	327000	4736500	33.00	0.00033	0.00%	802	100
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	327000	4736500	33.00	0.00985	0.09%	7631	46
4	Ogden Lawrence Boiler	321528	4731181	19.81	327000	4736500	33.00	0.00226	0.02%	7631	46
5	Newark Atlantic Paperboard	323323	4730469	11.89	327000	4736500	33.00	0.23850	2.29%	7064	31
6	Lucent Technologies	327051	4733016	14.94	327000	4736500	33.00	0.00343	0.03%	3484	359
7	Lowell Cogen	309543	4723480	29.87	327000	4736500	33.00	0.00023	0.00%	21778	53
8	Baker Commodities	317152	4722286	39.01	327000	4736500	33.00	0.00983	0.09%	17292	35
9	Lowell Hospital	307926	4724169	39.01	327000	4736500	33.00	0.00035	0.00%	22713	57
10	U Mass Lowell South	309838	4724981	35.97	327000	4736500	33.00	0.00057	0.01%	20669	56
11	Tewksbury Hospital	318170	4720140	45.11	327000	4736500	33.00	0.00154	0.01%	18591	28
12	Malden Mills	321665	4731645	17.98	327000	4736500	33.00	0.00683	0.07%	7213	48
13	U Mass Lowell North	309589	4725168	32.92	327000	4736500	33.00	0.00290	0.03%	20774	57
14	Holy Family Hospital	322616	4732698	57.00	327000	4736500	33.00	0.00185	0.02%	5803	49
15	Merrimack Paper	322886	4729848	14.94	327000	4736500	33.00	0.03241	0.31%	7821	32
16	L'Energia	310321	4722546	35.97	327000	4736500	33.00	0.01590	0.15%	21746	50
17	BNZ Materials	313057	4716585	35.97	327000	4736500	33.00	0.00112	0.01%	24311	35
18	Lawrence Hospital	323907	4730800	17.98	327000	4736500	33.00	0.00800	0.08%	6485	28
19	Merrimack Valley Industrial	309392	4723823	39.01	327000	4736500	33.00	0.00064	0.01%	21697	54
20	Winstanley Enterprises Inc.	305369	4723771	27.87	327000	4736500	33.00	0.00059	0.01%	25098	60
21	Heffron Asphalt	324681	4716389	28.04	327000	4736500	33.00	0.00030	0.00%	20244	7
22	Brox Industries	316147	4726909	29.87	327000	4736500	33.00	0.02458	0.24%	14484	49
23	Everett Mills	323655	4730579	14.94	327000	4736500	33.00	0.00448	0.04%	6801	29
24	Brooks School	329525	4730329	50.90	327000	4736500	33.00	0.00031	0.00%	6668	338
25	Saints Medical Center	311421	4724039	29.87	327000	4736500	33.00	0.00147	0.01%	19949	51
26	Andrea Management Corp.	323323	4730469	14.94	327000	4736500	33.00	0.00315	0.03%	7064	31
27	BFI Med. Waste Incinerator	323455	4728477	16.76	327000	4736500	33.00	0.00232	0.02%	8771	24
28	Pacific Mills	324149	4730566	11.89	327000	4736500	33.00	0.00394	0.04%	6583	26
29	Americraft Carton	311299	4721685	32.92	327000	4736500	33.00	0.00583	0.06%	21587	47
30	Haverhill Paperboard	330795	4737186	12.00	327000	4736500	33.00	0.03743	0.36%	3857	260
31	Crown Cork & Seal	321413	4728074	29.87	327000	4736500	33.00	0.00000	0.00%	10110	34
32	Ideal Tape Company	307778	4723277	29.87	327000	4736500	33.00	0.00000	0.00%	23331	55
33	Bradford Industries	311385	4722984	29.87	327000	4736500	33.00	0.00000	0.00%	20652	49
34	Hood Coatings	339337	4732004	39.01	327000	4736500	33.00	0.00000	0.00%	13131	290
35	Vernon Plastics Inc.	326643	4736144	17.98	327000	4736500	33.00	9.99800	95.95%	504	45
36	Majilite Manufacturing	311092	4722725	27.13	327000	4736500	33.00	0.00000	0.00%	21043	49
37	Oak Finishers	310510	4723631	27.13	327000	4736500	33.00	0.00000	0.00%	20917	52
38	The Gillette Company	321967	4720116	24.08	327000	4736500	33.00	0.00000	0.00%	17140	17
39	Raytheon Systems Co.	320556	4723602	45.11	327000	4736500	33.00	0.00000	0.00%	14418	27
	Cummulative Total	na	na	na	327000	4736500	33.00	10.42001		na	na

Table 3.6

1998-2001 Cumulative Source Maximum PM10 Concentration and Source Contributions to the Maximum Concentration for Annual Period

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	326750	4736250	24.00	0.00104	0.01%	3920	7
2	Ogden Havehill	326210	4736640	18.59	326750	4736250	24.00	0.00101	0.01%	666	126
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	326750	4736250	24.00	0.00846	0.09%	7278	46
4	Ogden Lawrence Boiler	321528	4731181	19.81	326750	4736250	24.00	0.00145	0.02%	7278	46
5	Newark Atlantic Paperboard	323323	4730469	11.89	326750	4736250	24.00	0.11553	1.26%	6720	31
6	Lucent Technologies	327051	4733016	14.94	326750	4736250	24.00	0.00239	0.03%	3248	355
7	Lowell Cogen	309543	4723480	29.87	326750	4736250	24.00	0.00018	0.00%	21428	53
8	Baker Commodities	317152	4722286	39.01	326750	4736250	24.00	0.00682	0.07%	16944	35
9	Lowell Hospital	307926	4724169	39.01	326750	4736250	24.00	0.00026	0.00%	22367	57
10	U Mass Lowell South	309838	4724981	35.97	326750	4736250	24.00	0.00040	0.00%	20323	56
11	Tewksbury Hospital	318170	4720140	45.11	326750	4736250	24.00	0.00108	0.01%	18252	28
12	Malden Mills	321665	4731645	17.98	326750	4736250	24.00	0.00476	0.05%	6860	48
13	U Mass Lowell North	309589	4725168	32.92	326750	4736250	24.00	0.00200	0.02%	20428	57
14	Holy Family Hospital	322616	4732698	57.00	326750	4736250	24.00	0.00141	0.02%	5450	49
15	Merrimack Paper	322886	4729848	14.94	326750	4736250	24.00	0.02365	0.26%	7478	31
16	L'Energia	310321	4722546	35.97	326750	4736250	24.00	0.01248	0.14%	21394	50
17	BNZ Materials	313057	4716585	35.97	326750	4736250	24.00	0.00078	0.01%	23963	35
18	Lawrence Hospital	323907	4730800	17.98	326750	4736250	24.00	0.00507	0.06%	6147	28
19	Merrimack Valley Industrial	309392	4723823	39.01	326750	4736250	24.00	0.00047	0.01%	21348	54
20	Winstanley Enterprises Inc.	305369	4723771	27.87	326750	4736250	24.00	0.00044	0.00%	24756	60
21	Heffron Asphalt	324681	4716389	28.04	326750	4736250	24.00	0.00021	0.00%	19968	6
22	Brox Industries	316147	4726909	29.87	326750	4736250	24.00	0.01651	0.18%	14131	49
23	Everett Mills	323655	4730579	14.94	326750	4736250	24.00	0.00312	0.03%	6461	29
24	Brooks School	329525	4730329	50.90	326750	4736250	24.00	0.00023	0.00%	6539	335
25	Saints Medical Center	311421	4724039	29.87	326750	4736250	24.00	0.00108	0.01%	19598	51
26	Andrea Management Corp.	323323	4730469	14.94	326750	4736250	24.00	0.00235	0.03%	6720	31
27	BFI Med. Waste Incinerator	323455	4728477	16.76	326750	4736250	24.00	0.00144	0.02%	8443	23
28	Pacific Mills	324149	4730566	11.89	326750	4736250	24.00	0.00244	0.03%	6251	25
29	Americraft Carton	311299	4721685	32.92	326750	4736250	24.00	0.00398	0.04%	21234	47
30	Haverhill Paperboard	330795	4737186	12.00	326750	4736250	24.00	0.05042	0.55%	4152	257
31	Crown Cork & Seal	321413	4728074	29.87	326750	4736250	24.00	0.00000	0.00%	9764	33
32	Ideal Tape Company	307778	4723277	29.87	326750	4736250	24.00	0.00000	0.00%	22983	56
33	Bradford Industries	311385	4722984	29.87	326750	4736250	24.00	0.00000	0.00%	20300	49
34	Hood Coatings	339337	4732004	39.01	326750	4736250	24.00	0.00000	0.00%	13284	289
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	8.86952	97.04%	151	45
36	Majilite Manufacturing	311092	4722725	27.13	326750	4736250	24.00	0.00000	0.00%	20691	49
37	Oak Finishers	310510	4723631	27.13	326750	4736250	24.00	0.00000	0.00%	20566	52
38	The Gillette Company	321967	4720116	24.08	326750	4736250	24.00	0.00000	0.00%	16828	17
39	Raytheon Systems Co.	320556	4723602	45.11	326750	4736250	24.00	0.00000	0.00%	14083	26
	Cummulative Total	na	na	na	326750	4736250	24.00	9.14042		na	na

Table 3.7

1998-2001 Individual Source Maximum PM10 Concentrations and Receptor Locations for Winter Season (December, January, February)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327250	4730500	102.00	0.03090	2112	152
2	Ogden Havehill	326210	4736640	18.59	327250	4726500	114.00	0.02228	10193	174
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	327250	4726500	114.00	0.03368	7393	129
4	Ogden Lawrence Boiler	321528	4731181	19.81	321000	4730750	75.00	0.01579	682	231
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	1.01080	1034	41
6	Lucent Technologies	327051	4733016	14.94	327750	4732750	78.00	0.24472	748	111
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00399	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.14326	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728250	81.00	0.00617	5425	41
10	U Mass Lowell South	309838	4724981	35.97	312250	4725000	84.00	0.01401	2412	90
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00547	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.03325	4436	36
13	U Mass Lowell North	309589	4725168	32.92	312250	4725250	78.00	0.07526	2662	88
14	Holy Family Hospital	322616	4732698	57.00	324250	4735250	78.00	0.00994	3030	33
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.19592	1791	38
16	L'Energia	310321	4722546	35.97	315500	4733750	111.00	0.09026	12343	25
17	BNZ Materials	313057	4716585	35.97	318250	4723500	57.00	0.00516	8648	37
18	Lawrence Hospital	323907	4730800	17.98	327250	4730500	102.00	0.02893	3356	95
19	Merrimack Valley Industrial	309392	4723823	39.01	312000	4726250	57.00	0.01294	3563	47
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.05242	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.00703	3331	38
22	Brox Industries	316147	4726909	29.87	318000	4726000	81.00	0.41753	2064	116
23	Everett Mills	323655	4730579	14.94	324000	4731250	54.00	0.02169	754	27
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.12284	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.11879	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.03438	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01470	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.13332	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4725000	54.00	0.06378	3526	20
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.77886	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	NA[1]	NA	NA	NA	NA	NA
32	Ideal Tape Company	307778	4723277	29.87	NA	NA	NA	NA	NA	NA
33	Bradford Industries	311385	4722984	29.87	NA	NA	NA	NA	NA	NA
34	Hood Coatings	339337	4732004	39.01	NA	NA	NA	NA	NA	NA
35	Vernon Plastics Inc.	326643	4736144	17.98	327000	4736250	39.00	7.56503	372	73
36	Majilite Manufacturing	311092	4722725	27.13	NA	NA	NA	NA	NA	NA
37	Oak Finishers	310510	4723631	27.13	NA	NA	NA	NA	NA	NA
38	The Gillette Company	321967	4720116	24.08	NA	NA	NA	NA	NA	NA
39	Raytheon Systems Co.	320556	4723602	45.11	NA	NA	NA	NA	NA	NA

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.8

1998-2001 Individual Source Maximum PM10 Concentrations and Receptor Locations for Spring Season (March, April, May)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327250	4730500	102.00	0.02934	2112	152
2	Ogden Havehill	326210	4736640	18.59	322750	4735250	99.00	0.02339	3729	248
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	327250	4726500	114.00	0.02072	7393	129
4	Ogden Lawrence Boiler	321528	4731181	19.81	321000	4730750	75.00	0.02314	682	231
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	0.75080	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4732000	81.00	0.14078	1390	137
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00233	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.09388	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728750	81.00	0.00424	5810	38
10	U Mass Lowell South	309838	4724981	35.97	312000	4728250	81.00	0.00800	3919	33
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00366	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.02513	4436	36
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.05175	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.01261	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.14571	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.08430	3121	38
17	BNZ Materials	313057	4716585	35.97	317000	4724000	69.00	0.00351	8398	28
18	Lawrence Hospital	323907	4730800	17.98	321250	4729750	66.00	0.01637	2857	248
19	Merrimack Valley Industrial	309392	4723823	39.01	312000	4727500	54.00	0.00797	4508	35
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.03413	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.00528	3331	38
22	Brox Industries	316147	4726909	29.87	317000	4725500	63.00	0.21851	1647	149
23	Everett Mills	323655	4730579	14.94	324000	4731000	48.00	0.02346	544	39
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.08413	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.08052	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.02510	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01842	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.11595	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4725000	54.00	0.04256	3526	20
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.56989	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	NA[1]	NA	NA	NA	NA	NA
32	Ideal Tape Company	307778	4723277	29.87	NA	NA	NA	NA	NA	NA
33	Bradford Industries	311385	4722984	29.87	NA	NA	NA	NA	NA	NA
34	Hood Coatings	339337	4732004	39.01	NA	NA	NA	NA	NA	NA
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	6.51241	151	45
36	Majilite Manufacturing	311092	4722725	27.13	NA	NA	NA	NA	NA	NA
37	Oak Finishers	310510	4723631	27.13	NA	NA	NA	NA	NA	NA
38	The Gillette Company	321967	4720116	24.08	NA	NA	NA	NA	NA	NA
39	Raytheon Systems Co.	320556	4723602	45.11	NA	NA	NA	NA	NA	NA

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.9

1998-2001 Individual Source Maximum PM10 Concentrations and Receptor Locations for Summer Season (June, July, August)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	328500	4735000	75.00	0.02736	3465	40
2	Ogden Havehill	326210	4736640	18.59	332000	4743000	87.00	0.03331	8601	42
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	325000	4737500	87.00	0.03567	7210	29
4	Ogden Lawrence Boiler	321528	4731181	19.81	322500	4733000	63.00	0.01893	2062	28
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	1.59957	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4734000	75.00	0.23114	1367	44
7	Lowell Cogen	309543	4723480	29.87	312000	4728250	81.00	0.00477	5366	27
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.18633	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728750	81.00	0.00824	5810	38
10	U Mass Lowell South	309838	4724981	35.97	311500	4728250	81.00	0.01721	3667	27
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00730	13776	41
12	Malden Mills	321665	4731645	17.98	322750	4733750	69.00	0.05302	2368	27
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.10879	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.02935	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.28916	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.17032	3121	38
17	BNZ Materials	313057	4716585	35.97	317000	4724000	69.00	0.00778	8398	28
18	Lawrence Hospital	323907	4730800	17.98	327250	4736000	78.00	0.02637	6182	33
19	Merrimack Valley Industrial	309392	4723823	39.01	311500	4727750	57.00	0.01754	4457	28
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.07359	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.01064	3331	38
22	Brox Industries	316147	4726909	29.87	318500	4731000	63.00	0.24658	4719	30
23	Everett Mills	323655	4730579	14.94	324000	4731000	48.00	0.05245	544	39
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.07412	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.16871	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.05196	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323750	4728750	15.00	0.01567	402	47
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.27573	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4724750	48.00	0.09042	3292	21
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	1.13413	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	NA[1]	NA	NA	NA	NA	NA
32	Ideal Tape Company	307778	4723277	29.87	NA	NA	NA	NA	NA	NA
33	Bradford Industries	311385	4722984	29.87	NA	NA	NA	NA	NA	NA
34	Hood Coatings	339337	4732004	39.01	NA	NA	NA	NA	NA	NA
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	16.69340	151	45
36	Majilite Manufacturing	311092	4722725	27.13	NA	NA	NA	NA	NA	NA
37	Oak Finishers	310510	4723631	27.13	NA	NA	NA	NA	NA	NA
38	The Gillette Company	321967	4720116	24.08	NA	NA	NA	NA	NA	NA
39	Raytheon Systems Co.	320556	4723602	45.11	NA	NA	NA	NA	NA	NA

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.10

1998-2001 Individual Source Maximum PM10 Concentrations and Receptor Locations for Fall Season (September, October, November)

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	330750	4740500	93.00	0.02544	9297	29
2	Ogden Havehill	326210	4736640	18.59	332000	4743000	87.00	0.03075	8601	42
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	324750	4737500	90.00	0.03013	7093	27
4	Ogden Lawrence Boiler	321528	4731181	19.81	322500	4733000	63.00	0.01868	2062	28
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	1.61731	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4734000	75.00	0.23876	1367	44
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00523	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.20726	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728250	81.00	0.00911	5425	41
10	U Mass Lowell South	309838	4724981	35.97	312000	4728250	81.00	0.01716	3919	33
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00817	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.05307	4436	36
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.11284	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.01888	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.30234	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.14304	3121	38
17	BNZ Materials	313057	4716585	35.97	318250	4723500	57.00	0.00784	8648	37
18	Lawrence Hospital	323907	4730800	17.98	327250	4736000	78.00	0.02673	6182	33
19	Merrimack Valley Industrial	309392	4723823	39.01	312000	4727500	54.00	0.01769	4508	35
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.07864	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.01129	3331	38
22	Brox Industries	316147	4726909	29.87	318000	4726000	81.00	0.27012	2064	116
23	Everett Mills	323655	4730579	14.94	324000	4731250	54.00	0.03628	754	27
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.08765	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.17866	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.05301	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01717	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.22930	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4724750	48.00	0.08925	3292	21
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	1.19343	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	NA[1]	NA	NA	NA	NA	NA
32	Ideal Tape Company	307778	4723277	29.87	NA	NA	NA	NA	NA	NA
33	Bradford Industries	311385	4722984	29.87	NA	NA	NA	NA	NA	NA
34	Hood Coatings	339337	4732004	39.01	NA	NA	NA	NA	NA	NA
35	Vernon Plastics Inc.	326643	4736144	17.98	327000	4736500	33.00	9.99800	504	45
36	Majilite Manufacturing	311092	4722725	27.13	NA	NA	NA	NA	NA	NA
37	Oak Finishers	310510	4723631	27.13	NA	NA	NA	NA	NA	NA
38	The Gillette Company	321967	4720116	24.08	NA	NA	NA	NA	NA	NA
39	Raytheon Systems Co.	320556	4723602	45.11	NA	NA	NA	NA	NA	NA

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.11

1998-2001 Individual Source Maximum PM10 Concentrations and Receptor Locations for Annual Period

Facility PM10 Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327250	4730500	102.00	0.02485	2112	152
2	Ogden Havehill	326210	4736640	18.59	332000	4743000	87.00	0.02521	8601	42
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	325000	4737500	87.00	0.02447	7210	29
4	Ogden Lawrence Boiler	321528	4731181	19.81	321000	4730750	75.00	0.01725	682	231
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	1.24329	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4734000	75.00	0.18598	1367	44
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00400	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.15753	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728750	81.00	0.00689	5810	38
10	U Mass Lowell South	309838	4724981	35.97	312000	4728250	81.00	0.01334	3919	33
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00614	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.04063	4436	36
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.08665	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.01757	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.23296	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.11849	3121	38
17	BNZ Materials	313057	4716585	35.97	317000	4724000	69.00	0.00600	8398	28
18	Lawrence Hospital	323907	4730800	17.98	327250	4736000	78.00	0.02073	6182	33
19	Merrimack Valley Industrial	309392	4723823	39.01	311750	4727750	63.00	0.01355	4581	31
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.05961	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.00855	3331	38
22	Brox Industries	316147	4726909	29.87	318000	4726000	81.00	0.26040	2064	116
23	Everett Mills	323655	4730579	14.94	324000	4731000	48.00	0.03232	544	39
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.09162	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.13650	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.04106	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01425	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.18828	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4724750	48.00	0.07119	3292	21
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.91811	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	NA[1]	NA	NA	NA	NA	NA
32	Ideal Tape Company	307778	4723277	29.87	NA	NA	NA	NA	NA	NA
33	Bradford Industries	311385	4722984	29.87	NA	NA	NA	NA	NA	NA
34	Hood Coatings	339337	4732004	39.01	NA	NA	NA	NA	NA	NA
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	8.86952	151	45
36	Majilite Manufacturing	311092	4722725	27.13	NA	NA	NA	NA	NA	NA
37	Oak Finishers	310510	4723631	27.13	NA	NA	NA	NA	NA	NA
38	The Gillette Company	321967	4720116	24.08	NA	NA	NA	NA	NA	NA
39	Raytheon Systems Co.	320556	4723602	45.11	NA	NA	NA	NA	NA	NA

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.12

1998-2001 Cumulative Source Maximum VOC Concentration and Source Contributions to the Maximum Concentration for Winter Season (December, January, February)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	322000	4727750	54.00	0.00578	0.03%	6274	223
2	Ogden Havehill	326210	4736640	18.59	322000	4727750	54.00	0.00062	0.00%	9836	205
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	322000	4727750	54.00	0.00170	0.01%	3463	172
4	Ogden Lawrence Boiler	321528	4731181	19.81	322000	4727750	54.00	0.09133	0.44%	3463	172
5	Newark Atlantic Paperboard	323323	4730469	11.89	322000	4727750	54.00	0.01649	0.08%	3024	206
6	Lucent Technologies	327051	4733016	14.94	322000	4727750	54.00	0.01447	0.07%	7297	224
7	Lowell Cogen	309543	4723480	29.87	322000	4727750	54.00	0.00070	0.00%	13169	71
8	Baker Commodities	317152	4722286	39.01	322000	4727750	54.00	0.00232	0.01%	7305	42
9	Lowell Hospital	307926	4724169	39.01	322000	4727750	54.00	0.00031	0.00%	14522	76
10	U Mass Lowell South	309838	4724981	35.97	322000	4727750	54.00	0.00059	0.00%	12473	77
11	Tewksbury Hospital	318170	4720140	45.11	322000	4727750	54.00	0.00034	0.00%	8519	27
12	Malden Mills	321665	4731645	17.98	322000	4727750	54.00	0.01067	0.05%	3909	175
13	U Mass Lowell North	309589	4725168	32.92	322000	4727750	54.00	0.00153	0.01%	12677	78
14	Holy Family Hospital	322616	4732698	57.00	322000	4727750	54.00	0.00106	0.01%	4986	187
15	Merrimack Paper	322886	4729848	14.94	322000	4727750	54.00	0.03133	0.15%	2277	203
16	L'Energia	310321	4722546	35.97	322000	4727750	54.00	0.00564	0.03%	12786	66
17	BNZ Materials	313057	4716585	35.97	322000	4727750	54.00	0.00000	0.00%	14305	39
18	Lawrence Hospital	323907	4730800	17.98	322000	4727750	54.00	0.00147	0.01%	3597	212
19	Merrimack Valley Industrial	309392	4723823	39.01	322000	4727750	54.00	0.00000	0.00%	13205	73
20	Winstanley Enterprises Inc.	305369	4723771	27.87	322000	4727750	54.00	0.01078	0.05%	17100	77
21	Heffron Asphalt	324681	4716389	28.04	322000	4727750	54.00	0.00051	0.00%	11673	347
22	Brox Industries	316147	4726909	29.87	322000	4727750	54.00	0.03797	0.18%	5913	82
23	Everett Mills	323655	4730579	14.94	322000	4727750	54.00	0.00327	0.02%	3278	210
24	Brooks School	329525	4730329	50.90	322000	4727750	54.00	0.00050	0.00%	7955	251
25	Saints Medical Center	311421	4724039	29.87	322000	4727750	54.00	0.00073	0.00%	11211	71
26	Andrea Management Corp.	323323	4730469	14.94	322000	4727750	54.00	0.00617	0.03%	3024	206
27	BFI Med. Waste Incinerator	323455	4728477	16.76	322000	4727750	54.00	0.00620	0.03%	1627	243
28	Pacific Mills	324149	4730566	11.89	322000	4727750	54.00	0.00536	0.03%	3542	217
29	Americraft Carton	311299	4721685	32.92	322000	4727750	54.00	0.06929	0.33%	12300	60
30	Haverhill Paperboard	330795	4737186	12.00	322000	4727750	54.00	0.00209	0.01%	12899	223
31	Crown Cork & Seal	321413	4728074	29.87	322000	4727750	54.00	19.10172	91.95%	670	119
32	Ideal Tape Company	307778	4723277	29.87	322000	4727750	54.00	0.25142	1.21%	14909	73
33	Bradford Industries	311385	4722984	29.87	322000	4727750	54.00	0.25265	1.22%	11636	66
34	Hood Coatings	339337	4732004	39.01	322000	4727750	54.00	0.05531	0.27%	17851	256
35	Vernon Plastics Inc.	326643	4736144	17.98	322000	4727750	54.00	0.25239	1.21%	9593	209
36	Majilite Manufacturing	311092	4722725	27.13	322000	4727750	54.00	0.16790	0.81%	12010	65
37	Oak Finishers	310510	4723631	27.13	322000	4727750	54.00	0.15078	0.73%	12206	70
38	The Gillette Company	321967	4720116	24.08	322000	4727750	54.00	0.08034	0.39%	7634	0
39	Raytheon Systems Co.	320556	4723602	45.11	322000	4727750	54.00	0.13312	0.64%	4392	19
	Cummulative Total	na	na	na	322000	4727750	54.00	20.77466		na	na

Table 3.13

1998-2001 Cumulative Source Maximum VOC Concentration and Source Contributions to the Maximum Concentration for Spring Season (March, April, May)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	322000	4720000	24.00	0.00170	0.01%	13073	199
2	Ogden Havehill	326210	4736640	18.59	322000	4720000	24.00	0.00024	0.00%	17164	194
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	322000	4720000	24.00	0.00125	0.01%	11191	178
4	Ogden Lawrence Boiler	321528	4731181	19.81	322000	4720000	24.00	0.00991	0.04%	11191	178
5	Newark Atlantic Paperboard	323323	4730469	11.89	322000	4720000	24.00	0.00139	0.01%	10552	187
6	Lucent Technologies	327051	4733016	14.94	322000	4720000	24.00	0.00374	0.02%	13962	201
7	Lowell Cogen	309543	4723480	29.87	322000	4720000	24.00	0.00027	0.00%	12934	106
8	Baker Commodities	317152	4722286	39.01	322000	4720000	24.00	0.00062	0.00%	5360	115
9	Lowell Hospital	307926	4724169	39.01	322000	4720000	24.00	0.00013	0.00%	14678	107
10	U Mass Lowell South	309838	4724981	35.97	322000	4720000	24.00	0.00020	0.00%	13142	112
11	Tewksbury Hospital	318170	4720140	45.11	322000	4720000	24.00	0.00023	0.00%	3833	92
12	Malden Mills	321665	4731645	17.98	322000	4720000	24.00	0.00263	0.01%	11650	178
13	U Mass Lowell North	309589	4725168	32.92	322000	4720000	24.00	0.00049	0.00%	13444	113
14	Holy Family Hospital	322616	4732698	57.00	322000	4720000	24.00	0.00015	0.00%	12713	183
15	Merrimack Paper	322886	4729848	14.94	322000	4720000	24.00	0.00179	0.01%	9888	185
16	L'Energia	310321	4722546	35.97	322000	4720000	24.00	0.00333	0.01%	11953	102
17	BNZ Materials	313057	4716585	35.97	322000	4720000	24.00	0.00000	0.00%	9573	69
18	Lawrence Hospital	323907	4730800	17.98	322000	4720000	24.00	0.00018	0.00%	10967	190
19	Merrimack Valley Industrial	309392	4723823	39.01	322000	4720000	24.00	0.00000	0.00%	13175	107
20	Winstanley Enterprises Inc.	305369	4723771	27.87	322000	4720000	24.00	0.00429	0.02%	17053	103
21	Heffron Asphalt	324681	4716389	28.04	322000	4720000	24.00	0.00071	0.00%	4497	323
22	Brox Industries	316147	4726909	29.87	322000	4720000	24.00	0.00900	0.04%	9055	140
23	Everett Mills	323655	4730579	14.94	322000	4720000	24.00	0.00027	0.00%	10708	189
24	Brooks School	329525	4730329	50.90	322000	4720000	24.00	0.00031	0.00%	12779	216
25	Saints Medical Center	311421	4724039	29.87	322000	4720000	24.00	0.00028	0.00%	11324	111
26	Andrea Management Corp.	323323	4730469	14.94	322000	4720000	24.00	0.00035	0.00%	10552	187
27	BFI Med. Waste Incinerator	323455	4728477	16.76	322000	4720000	24.00	0.00053	0.00%	8601	190
28	Pacific Mills	324149	4730566	11.89	322000	4720000	24.00	0.00039	0.00%	10782	191
29	Americraft Carton	311299	4721685	32.92	322000	4720000	24.00	0.01727	0.08%	10833	99
30	Haverhill Paperboard	330795	4737186	12.00	322000	4720000	24.00	0.00084	0.00%	19306	207
31	Crown Cork & Seal	321413	4728074	29.87	322000	4720000	24.00	0.30892	1.38%	8095	176
32	Ideal Tape Company	307778	4723277	29.87	322000	4720000	24.00	0.06679	0.30%	14595	103
33	Bradford Industries	311385	4722984	29.87	322000	4720000	24.00	0.06638	0.30%	11026	106
34	Hood Coatings	339337	4732004	39.01	322000	4720000	24.00	0.03893	0.17%	21087	235
35	Vernon Plastics Inc.	326643	4736144	17.98	322000	4720000	24.00	0.04978	0.22%	16798	196
36	Majilite Manufacturing	311092	4722725	27.13	322000	4720000	24.00	0.04593	0.21%	11243	104
37	Oak Finishers	310510	4723631	27.13	322000	4720000	24.00	0.09348	0.42%	12050	108
38	The Gillette Company	321967	4720116	24.08	322000	4720000	24.00	21.57505	96.38%	121	164
39	Raytheon Systems Co.	320556	4723602	45.11	322000	4720000	24.00	0.07893	0.35%	3881	158
	Cummulative Total	na	na	na	322000	4720000	24.00	22.38639		na	na

Table 3.14

1998-2001 Cumulative Source Maximum VOC Concentration and Source Contributions to the Maximum Concentration for Summer Season (June, July, August)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	326750	4736250	24.00	0.00428	0.01%	3920	7
2	Ogden Havehill	326210	4736640	18.59	326750	4736250	24.00	0.00039	0.00%	666	126
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	326750	4736250	24.00	0.00679	0.02%	7278	46
4	Ogden Lawrence Boiler	321528	4731181	19.81	326750	4736250	24.00	0.03876	0.10%	7278	46
5	Newark Atlantic Paperboard	323323	4730469	11.89	326750	4736250	24.00	0.01261	0.03%	6720	31
6	Lucent Technologies	327051	4733016	14.94	326750	4736250	24.00	0.00466	0.01%	3248	355
7	Lowell Cogen	309543	4723480	29.87	326750	4736250	24.00	0.00036	0.00%	21428	53
8	Baker Commodities	317152	4722286	39.01	326750	4736250	24.00	0.00093	0.00%	16944	35
9	Lowell Hospital	307926	4724169	39.01	326750	4736250	24.00	0.00015	0.00%	22367	57
10	U Mass Lowell South	309838	4724981	35.97	326750	4736250	24.00	0.00023	0.00%	20323	56
11	Tewksbury Hospital	318170	4720140	45.11	326750	4736250	24.00	0.00028	0.00%	18252	28
12	Malden Mills	321665	4731645	17.98	326750	4736250	24.00	0.01007	0.03%	6860	48
13	U Mass Lowell North	309589	4725168	32.92	326750	4736250	24.00	0.00051	0.00%	20428	57
14	Holy Family Hospital	322616	4732698	57.00	326750	4736250	24.00	0.00098	0.00%	5450	49
15	Merrimack Paper	322886	4729848	14.94	326750	4736250	24.00	0.01233	0.03%	7478	31
16	L'Energia	310321	4722546	35.97	326750	4736250	24.00	0.00555	0.01%	21394	50
17	BNZ Materials	313057	4716585	35.97	326750	4736250	24.00	0.00000	0.00%	23963	35
18	Lawrence Hospital	323907	4730800	17.98	326750	4736250	24.00	0.00132	0.00%	6147	28
19	Merrimack Valley Industrial	309392	4723823	39.01	326750	4736250	24.00	0.00000	0.00%	21348	54
20	Winstanley Enterprises Inc.	305369	4723771	27.87	326750	4736250	24.00	0.00440	0.01%	24756	60
21	Heffron Asphalt	324681	4716389	28.04	326750	4736250	24.00	0.00017	0.00%	19968	6
22	Brox Industries	316147	4726909	29.87	326750	4736250	24.00	0.00868	0.02%	14131	49
23	Everett Mills	323655	4730579	14.94	326750	4736250	24.00	0.00241	0.01%	6461	29
24	Brooks School	329525	4730329	50.90	326750	4736250	24.00	0.00028	0.00%	6539	335
25	Saints Medical Center	311421	4724039	29.87	326750	4736250	24.00	0.00036	0.00%	19598	51
26	Andrea Management Corp.	323323	4730469	14.94	326750	4736250	24.00	0.00328	0.01%	6720	31
27	BFI Med. Waste Incinerator	323455	4728477	16.76	326750	4736250	24.00	0.00180	0.00%	8443	23
28	Pacific Mills	324149	4730566	11.89	326750	4736250	24.00	0.00299	0.01%	6251	25
29	Americraft Carton	311299	4721685	32.92	326750	4736250	24.00	0.02347	0.06%	21234	47
30	Haverhill Paperboard	330795	4737186	12.00	326750	4736250	24.00	0.00327	0.01%	4152	257
31	Crown Cork & Seal	321413	4728074	29.87	326750	4736250	24.00	1.08205	2.76%	9764	33
32	Ideal Tape Company	307778	4723277	29.87	326750	4736250	24.00	0.08335	0.21%	22983	56
33	Bradford Industries	311385	4722984	29.87	326750	4736250	24.00	0.07606	0.19%	20300	49
34	Hood Coatings	339337	4732004	39.01	326750	4736250	24.00	0.05410	0.14%	13284	289
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	37.43004	95.58%	151	45
36	Majilite Manufacturing	311092	4722725	27.13	326750	4736250	24.00	0.05425	0.14%	20691	49
37	Oak Finishers	310510	4723631	27.13	326750	4736250	24.00	0.09139	0.23%	20566	52
38	The Gillette Company	321967	4720116	24.08	326750	4736250	24.00	0.09353	0.24%	16828	17
39	Raytheon Systems Co.	320556	4723602	45.11	326750	4736250	24.00	0.04516	0.12%	14083	26
	Cummulative Total	na	na	na	326750	4736250	24.00	39.16028		na	na

Table 3.15

1998-2001 Cumulative Source Maximum VOC Concentration and Source Contributions to the Maximum Concentration for Fall Season (September, October, November)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327000	4736500	33.00	0.00275	0.01%	4205	10
2	Ogden Havehill	326210	4736640	18.59	327000	4736500	33.00	0.00004	0.00%	802	100
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	327000	4736500	33.00	0.00513	0.02%	7631	46
4	Ogden Lawrence Boiler	321528	4731181	19.81	327000	4736500	33.00	0.05286	0.22%	7631	46
5	Newark Atlantic Paperboard	323323	4730469	11.89	327000	4736500	33.00	0.01849	0.08%	7064	31
6	Lucent Technologies	327051	4733016	14.94	327000	4736500	33.00	0.00515	0.02%	3484	359
7	Lowell Cogen	309543	4723480	29.87	327000	4736500	33.00	0.00041	0.00%	21778	53
8	Baker Commodities	317152	4722286	39.01	327000	4736500	33.00	0.00103	0.00%	17292	35
9	Lowell Hospital	307926	4724169	39.01	327000	4736500	33.00	0.00019	0.00%	22713	57
10	U Mass Lowell South	309838	4724981	35.97	327000	4736500	33.00	0.00032	0.00%	20669	56
11	Tewksbury Hospital	318170	4720140	45.11	327000	4736500	33.00	0.00029	0.00%	18591	28
12	Malden Mills	321665	4731645	17.98	327000	4736500	33.00	0.01137	0.05%	7213	48
13	U Mass Lowell North	309589	4725168	32.92	327000	4736500	33.00	0.00073	0.00%	20774	57
14	Holy Family Hospital	322616	4732698	57.00	327000	4736500	33.00	0.00102	0.00%	5803	49
15	Merrimack Paper	322886	4729848	14.94	327000	4736500	33.00	0.01212	0.05%	7821	32
16	L'Energia	310321	4722546	35.97	327000	4736500	33.00	0.00510	0.02%	21746	50
17	BNZ Materials	313057	4716585	35.97	327000	4736500	33.00	0.00000	0.00%	24311	35
18	Lawrence Hospital	323907	4730800	17.98	327000	4736500	33.00	0.00149	0.01%	6485	28
19	Merrimack Valley Industrial	309392	4723823	39.01	327000	4736500	33.00	0.00000	0.00%	21697	54
20	Winstanley Enterprises Inc.	305369	4723771	27.87	327000	4736500	33.00	0.00638	0.03%	25098	60
21	Heffron Asphalt	324681	4716389	28.04	327000	4736500	33.00	0.00030	0.00%	20244	7
22	Brox Industries	316147	4726909	29.87	327000	4736500	33.00	0.01139	0.05%	14484	49
23	Everett Mills	323655	4730579	14.94	327000	4736500	33.00	0.00247	0.01%	6801	29
24	Brooks School	329525	4730329	50.90	327000	4736500	33.00	0.00031	0.00%	6668	338
25	Saints Medical Center	311421	4724039	29.87	327000	4736500	33.00	0.00041	0.00%	19949	51
26	Andrea Management Corp.	323323	4730469	14.94	327000	4736500	33.00	0.00315	0.01%	7064	31
27	BFI Med. Waste Incinerator	323455	4728477	16.76	327000	4736500	33.00	0.00232	0.01%	8771	24
28	Pacific Mills	324149	4730566	11.89	327000	4736500	33.00	0.00394	0.02%	6583	26
29	Americraft Carton	311299	4721685	32.92	327000	4736500	33.00	0.03319	0.14%	21587	47
30	Haverhill Paperboard	330795	4737186	12.00	327000	4736500	33.00	0.00215	0.01%	3857	260
31	Crown Cork & Seal	321413	4728074	29.87	327000	4736500	33.00	1.14547	4.70%	10110	34
32	Ideal Tape Company	307778	4723277	29.87	327000	4736500	33.00	0.12084	0.50%	23331	55
33	Bradford Industries	311385	4722984	29.87	327000	4736500	33.00	0.10367	0.43%	20652	49
34	Hood Coatings	339337	4732004	39.01	327000	4736500	33.00	0.02020	0.08%	13131	290
35	Vernon Plastics Inc.	326643	4736144	17.98	327000	4736500	33.00	22.41757	91.98%	504	45
36	Majilite Manufacturing	311092	4722725	27.13	327000	4736500	33.00	0.07390	0.30%	21043	49
37	Oak Finishers	310510	4723631	27.13	327000	4736500	33.00	0.10356	0.42%	20917	52
38	The Gillette Company	321967	4720116	24.08	327000	4736500	33.00	0.15323	0.63%	17140	17
39	Raytheon Systems Co.	320556	4723602	45.11	327000	4736500	33.00	0.04936	0.20%	14418	27
	Cummulative Total	na	na	na	327000	4736500	33.00	24.37186		na	na

Table 3.16

1998-2001 Cumulative Source Maximum VOC Concentration and Source Contributions to the Maximum Concentration for Annual Period

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results						
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Percent Contribution (%)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	326750	4736250	24.00	0.00232	0.01%	3920	7
2	Ogden Havehill	326210	4736640	18.59	326750	4736250	24.00	0.00013	0.00%	666	126
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	326750	4736250	24.00	0.00440	0.02%	7278	46
4	Ogden Lawrence Boiler	321528	4731181	19.81	326750	4736250	24.00	0.03395	0.16%	7278	46
5	Newark Atlantic Paperboard	323323	4730469	11.89	326750	4736250	24.00	0.00896	0.04%	6720	31
6	Lucent Technologies	327051	4733016	14.94	326750	4736250	24.00	0.00359	0.02%	3248	355
7	Lowell Cogen	309543	4723480	29.87	326750	4736250	24.00	0.00031	0.00%	21428	53
8	Baker Commodities	317152	4722286	39.01	326750	4736250	24.00	0.00071	0.00%	16944	35
9	Lowell Hospital	307926	4724169	39.01	326750	4736250	24.00	0.00014	0.00%	22367	57
10	U Mass Lowell South	309838	4724981	35.97	326750	4736250	24.00	0.00022	0.00%	20323	56
11	Tewksbury Hospital	318170	4720140	45.11	326750	4736250	24.00	0.00020	0.00%	18252	28
12	Malden Mills	321665	4731645	17.98	326750	4736250	24.00	0.00792	0.04%	6860	48
13	U Mass Lowell North	309589	4725168	32.92	326750	4736250	24.00	0.00050	0.00%	20428	57
14	Holy Family Hospital	322616	4732698	57.00	326750	4736250	24.00	0.00078	0.00%	5450	49
15	Merrimack Paper	322886	4729848	14.94	326750	4736250	24.00	0.00884	0.04%	7478	31
16	L'Energia	310321	4722546	35.97	326750	4736250	24.00	0.00399	0.02%	21394	50
17	BNZ Materials	313057	4716585	35.97	326750	4736250	24.00	0.00000	0.00%	23963	35
18	Lawrence Hospital	323907	4730800	17.98	326750	4736250	24.00	0.00094	0.00%	6147	28
19	Merrimack Valley Industrial	309392	4723823	39.01	326750	4736250	24.00	0.00000	0.00%	21348	54
20	Winstanley Enterprises Inc.	305369	4723771	27.87	326750	4736250	24.00	0.00474	0.02%	24756	60
21	Heffron Asphalt	324681	4716389	28.04	326750	4736250	24.00	0.00021	0.00%	19968	6
22	Brox Industries	316147	4726909	29.87	326750	4736250	24.00	0.00766	0.04%	14131	49
23	Everett Mills	323655	4730579	14.94	326750	4736250	24.00	0.00172	0.01%	6461	29
24	Brooks School	329525	4730329	50.90	326750	4736250	24.00	0.00023	0.00%	6539	335
25	Saints Medical Center	311421	4724039	29.87	326750	4736250	24.00	0.00030	0.00%	19598	51
26	Andrea Management Corp.	323323	4730469	14.94	326750	4736250	24.00	0.00235	0.01%	6720	31
27	BFI Med. Waste Incinerator	323455	4728477	16.76	326750	4736250	24.00	0.00144	0.01%	8443	23
28	Pacific Mills	324149	4730566	11.89	326750	4736250	24.00	0.00244	0.01%	6251	25
29	Americraft Carton	311299	4721685	32.92	326750	4736250	24.00	0.02268	0.11%	21234	47
30	Haverhill Paperboard	330795	4737186	12.00	326750	4736250	24.00	0.00290	0.01%	4152	257
31	Crown Cork & Seal	321413	4728074	29.87	326750	4736250	24.00	0.80476	3.79%	9764	33
32	Ideal Tape Company	307778	4723277	29.87	326750	4736250	24.00	0.08636	0.41%	22983	56
33	Bradford Industries	311385	4722984	29.87	326750	4736250	24.00	0.07203	0.34%	20300	49
34	Hood Coatings	339337	4732004	39.01	326750	4736250	24.00	0.03408	0.16%	13284	289
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	19.88729	93.58%	151	45
36	Majilite Manufacturing	311092	4722725	27.13	326750	4736250	24.00	0.05215	0.25%	20691	49
37	Oak Finishers	310510	4723631	27.13	326750	4736250	24.00	0.08074	0.38%	20566	52
38	The Gillette Company	321967	4720116	24.08	326750	4736250	24.00	0.07406	0.35%	16828	17
39	Raytheon Systems Co.	320556	4723602	45.11	326750	4736250	24.00	0.03615	0.17%	14083	26
	Cummulative Total	na	na	na	326750	4736250	24.00	21.25065		na	na

Table 3.17

1998-2001 Individual Source Maximum VOC Concentrations and Receptor Locations for Winter Season (December, January, February)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327250	4730500	102.00	0.06899	2112	152
2	Ogden Havehill	326210	4736640	18.59	327250	4726500	114.00	0.00292	10193	174
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	327250	4726500	114.00	0.01752	7393	129
4	Ogden Lawrence Boiler	321528	4731181	19.81	321000	4730750	75.00	0.36909	682	231
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	0.07838	1034	41
6	Lucent Technologies	327051	4733016	14.94	327750	4732750	78.00	0.36743	748	111
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00697	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.01492	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728250	81.00	0.00340	5425	41
10	U Mass Lowell South	309838	4724981	35.97	312250	4725000	84.00	0.00773	2412	90
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00102	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.05534	4436	36
13	U Mass Lowell North	309589	4725168	32.92	312250	4725250	78.00	0.01898	2662	88
14	Holy Family Hospital	322616	4732698	57.00	324250	4735250	78.00	0.00549	3030	33
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.07326	1791	38
16	L'Energia	310321	4722546	35.97	315500	4733750	111.00	0.02891	12343	25
17	BNZ Materials	313057	4716585	35.97	NA[1]	NA	NA	NA	NA	NA
18	Lawrence Hospital	323907	4730800	17.98	327250	4730500	102.00	0.00538	3356	95
19	Merrimack Valley Industrial	309392	4723823	39.01	NA	NA	NA	NA	NA	NA
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.56679	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.00703	3331	38
22	Brox Industries	316147	4726909	29.87	318000	4726000	81.00	0.19367	2064	116
23	Everett Mills	323655	4730579	14.94	324000	4731250	54.00	0.01197	754	27
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.12284	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.03277	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.03438	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01470	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.13332	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4725000	54.00	0.36340	3526	20
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.04481	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	322000	4727750	54.00	19.10172	670	119
32	Ideal Tape Company	307778	4723277	29.87	309000	4726000	42.00	2.62048	2985	24
33	Bradford Industries	311385	4722984	29.87	312500	4724750	48.00	3.21398	2089	32
34	Hood Coatings	339337	4732004	39.01	334000	4723500	51.00	0.20024	10040	212
35	Vernon Plastics Inc.	326643	4736144	17.98	327000	4736250	39.00	16.96236	372	73
36	Majilite Manufacturing	311092	4722725	27.13	312500	4725000	54.00	2.49419	2675	32
37	Oak Finishers	310510	4723631	27.13	312000	4725500	48.00	2.80887	2390	39
38	The Gillette Company	321967	4720116	24.08	322000	4720000	24.00	16.43668	121	164
39	Raytheon Systems Co.	320556	4723602	45.11	320750	4723750	48.00	9.97623	244	53

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.18

1998-2001 Individual Source Maximum VOC Concentrations and Receptor Locations for Spring Season (March, April, May)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327250	4730500	102.00	0.06550	2112	152
2	Ogden Havehill	326210	4736640	18.59	322750	4735250	99.00	0.00307	3729	248
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	327250	4726500	114.00	0.01078	7393	129
4	Ogden Lawrence Boiler	321528	4731181	19.81	321000	4730750	75.00	0.54099	682	231
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	0.05822	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4732000	81.00	0.21138	1390	137
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00407	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.00978	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728750	81.00	0.00234	5810	38
10	U Mass Lowell South	309838	4724981	35.97	312000	4728250	81.00	0.00441	3919	33
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00068	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.04184	4436	36
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.01305	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.00696	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.05449	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.02700	3121	38
17	BNZ Materials	313057	4716585	35.97	NA[1]	NA	NA	NA	NA	NA
18	Lawrence Hospital	323907	4730800	17.98	321250	4729750	66.00	0.00305	2857	248
19	Merrimack Valley Industrial	309392	4723823	39.01	NA	NA	NA	NA	NA	NA
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.36898	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.00528	3331	38
22	Brox Industries	316147	4726909	29.87	317000	4725500	63.00	0.10170	1647	149
23	Everett Mills	323655	4730579	14.94	324000	4731000	48.00	0.01294	544	39
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.08413	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.02221	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.02510	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01842	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.11595	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4725000	54.00	0.24250	3526	20
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.03279	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	322000	4727750	54.00	12.40376	670	119
32	Ideal Tape Company	307778	4723277	29.87	306750	4725250	54.00	1.85324	2225	332
33	Bradford Industries	311385	4722984	29.87	312500	4725000	54.00	2.31520	2304	29
34	Hood Coatings	339337	4732004	39.01	331750	4728750	78.00	0.26009	8255	247
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	14.60217	151	45
36	Majilite Manufacturing	311092	4722725	27.13	312500	4725000	54.00	1.64365	2675	32
37	Oak Finishers	310510	4723631	27.13	312000	4725500	48.00	1.82385	2390	39
38	The Gillette Company	321967	4720116	24.08	322000	4720000	24.00	21.57505	121	164
39	Raytheon Systems Co.	320556	4723602	45.11	320750	4723750	48.00	5.11734	244	53

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.19

1998-2001 Individual Source Maximum VOC Concentrations and Receptor Locations for Summer Season (June, July, August)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	328500	4735000	75.00	0.06109	3465	40
2	Ogden Havehill	326210	4736640	18.59	332000	4743000	87.00	0.00437	8601	42
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	325000	4737500	87.00	0.01855	7210	29
4	Ogden Lawrence Boiler	321528	4731181	19.81	322500	4733000	63.00	0.44245	2062	28
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	0.12403	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4734000	75.00	0.34705	1367	44
7	Lowell Cogen	309543	4723480	29.87	312000	4728250	81.00	0.00836	5366	27
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.01941	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728750	81.00	0.00455	5810	38
10	U Mass Lowell South	309838	4724981	35.97	311500	4728250	81.00	0.00950	3667	27
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00136	13776	41
12	Malden Mills	321665	4731645	17.98	322750	4733750	69.00	0.08826	2368	27
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.02744	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.01619	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.10812	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.05455	3121	38
17	BNZ Materials	313057	4716585	35.97	NA[1]	NA	NA	NA	NA	NA
18	Lawrence Hospital	323907	4730800	17.98	327250	4736000	78.00	0.00491	6182	33
19	Merrimack Valley Industrial	309392	4723823	39.01	NA	NA	NA	NA	NA	NA
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.79571	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.01064	3331	38
22	Brox Industries	316147	4726909	29.87	318500	4731000	63.00	0.11492	4719	30
23	Everett Mills	323655	4730579	14.94	324000	4731000	48.00	0.02894	544	39
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.07412	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.04654	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.05196	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323750	4728750	15.00	0.01567	402	47
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.27573	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4724750	48.00	0.51517	3292	21
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.06525	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	321750	4728250	30.00	12.00772	380	62
32	Ideal Tape Company	307778	4723277	29.87	309750	4726750	51.00	4.06832	3994	30
33	Bradford Industries	311385	4722984	29.87	312500	4724750	48.00	5.24552	2089	32
34	Hood Coatings	339337	4732004	39.01	333750	4737750	60.00	0.31843	8014	316
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	37.43004	151	45
36	Majilite Manufacturing	311092	4722725	27.13	312500	4725000	54.00	3.61151	2675	32
37	Oak Finishers	310510	4723631	27.13	312000	4725500	48.00	3.66046	2390	39
38	The Gillette Company	321967	4720116	24.08	322250	4720500	24.00	26.52164	477	36
39	Raytheon Systems Co.	320556	4723602	45.11	320750	4723750	48.00	11.18172	244	53

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.20

1998-2001 Individual Source Maximum VOC Concentrations and Receptor Locations for Fall Season (September, October, November)

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	330750	4740500	93.00	0.05679	9297	29
2	Ogden Havehill	326210	4736640	18.59	332000	4743000	87.00	0.00403	8601	42
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	324750	4737500	90.00	0.01567	7093	27
4	Ogden Lawrence Boiler	321528	4731181	19.81	322500	4733000	63.00	0.43653	2062	28
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	0.12541	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4734000	75.00	0.35849	1367	44
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00915	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.02159	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728250	81.00	0.00503	5425	41
10	U Mass Lowell South	309838	4724981	35.97	312000	4728250	81.00	0.00947	3919	33
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00152	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.08835	4436	36
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.02845	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.01042	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.11305	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.04582	3121	38
17	BNZ Materials	313057	4716585	35.97	NA[1]	NA	NA	NA	NA	NA
18	Lawrence Hospital	323907	4730800	17.98	327250	4736000	78.00	0.00497	6182	33
19	Merrimack Valley Industrial	309392	4723823	39.01	NA	NA	NA	NA	NA	NA
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.85027	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.01129	3331	38
22	Brox Industries	316147	4726909	29.87	318000	4726000	81.00	0.12549	2064	116
23	Everett Mills	323655	4730579	14.94	324000	4731250	54.00	0.02002	754	27
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.08765	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.04929	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.05301	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01717	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.22930	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4724750	48.00	0.50852	3292	21
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.06866	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	322000	4727750	54.00	13.71606	670	119
32	Ideal Tape Company	307778	4723277	29.87	309750	4726750	51.00	3.96091	3994	30
33	Bradford Industries	311385	4722984	29.87	312500	4724750	48.00	5.02197	2089	32
34	Hood Coatings	339337	4732004	39.01	333750	4737750	60.00	0.22772	8014	316
35	Vernon Plastics Inc.	326643	4736144	17.98	327000	4736500	33.00	22.41757	504	45
36	Majilite Manufacturing	311092	4722725	27.13	312500	4725000	54.00	3.63200	2675	32
37	Oak Finishers	310510	4723631	27.13	312000	4725500	48.00	4.15459	2390	39
38	The Gillette Company	321967	4720116	24.08	322250	4720500	24.00	22.12540	477	36
39	Raytheon Systems Co.	320556	4723602	45.11	320750	4723750	48.00	11.55399	244	53

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.21

1998-2001 Individual Source Maximum VOC Concentrations and Receptor Locations for Annual Period

Facility VOC Source Data Information					Maximum Receptor Concentration Data Results					
Id Number	Facility Name	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	UTM Coordinates East (meters)	UTM Coordinates North (meters)	Base Elevation (meters)	Maximum Concentration (micro.g/m^3)	Receptor Distance (meters)	Bearing From North (degrees)
1	Mass Refusetech	326254	4732362	18.59	327250	4730500	102.00	0.05548	2112	152
2	Ogden Havehill	326210	4736640	18.59	332000	4743000	87.00	0.00331	8601	42
3	Ogd-Lawrence Incinerator	321528	4731181	19.81	325000	4737500	87.00	0.01273	7210	29
4	Ogden Lawrence Boiler	321528	4731181	19.81	321000	4730750	75.00	0.40314	682	231
5	Newark Atlantic Paperboard	323323	4730469	11.89	324000	4731250	54.00	0.09640	1034	41
6	Lucent Technologies	327051	4733016	14.94	328000	4734000	75.00	0.27924	1367	44
7	Lowell Cogen	309543	4723480	29.87	312250	4726000	72.00	0.00699	3698	47
8	Baker Commodities	317152	4722286	39.01	318500	4723750	75.00	0.01641	1990	43
9	Lowell Hospital	307926	4724169	39.01	311500	4728750	81.00	0.00380	5810	38
10	U Mass Lowell South	309838	4724981	35.97	312000	4728250	81.00	0.00736	3919	33
11	Tewksbury Hospital	318170	4720140	45.11	327250	4730500	102.00	0.00114	13776	41
12	Malden Mills	321665	4731645	17.98	324250	4735250	78.00	0.06764	4436	36
13	U Mass Lowell North	309589	4725168	32.92	311500	4728000	72.00	0.02185	3416	34
14	Holy Family Hospital	322616	4732698	57.00	323000	4733250	51.00	0.00969	672	35
15	Merrimack Paper	322886	4729848	14.94	324000	4731250	54.00	0.08711	1791	38
16	L'Energia	310321	4722546	35.97	312250	4725000	84.00	0.03795	3121	38
17	BNZ Materials	313057	4716585	35.97	NA[1]	NA	NA	NA	NA	NA
18	Lawrence Hospital	323907	4730800	17.98	327250	4736000	78.00	0.00386	6182	33
19	Merrimack Valley Industrial	309392	4723823	39.01	NA	NA	NA	NA	NA	NA
20	Winstanley Enterprises Inc.	305369	4723771	27.87	306500	4725500	45.00	0.64458	2066	33
21	Heffron Asphalt	324681	4716389	28.04	326750	4719000	39.00	0.00855	3331	38
22	Brox Industries	316147	4726909	29.87	318000	4726000	81.00	0.12093	2064	116
23	Everett Mills	323655	4730579	14.94	324000	4731000	48.00	0.01783	544	39
24	Brooks School	329525	4730329	50.90	329750	4730250	90.00	0.09162	238	109
25	Saints Medical Center	311421	4724039	29.87	312250	4725000	84.00	0.03766	1269	41
26	Andrea Management Corp.	323323	4730469	14.94	324000	4731250	54.00	0.04106	1034	41
27	BFI Med. Waste Incinerator	323455	4728477	16.76	323500	4728500	27.00	0.01425	51	63
28	Pacific Mills	324149	4730566	11.89	324250	4730750	51.00	0.18828	210	29
29	Americraft Carton	311299	4721685	32.92	312500	4724750	48.00	0.40563	3292	21
30	Haverhill Paperboard	330795	4737186	12.00	332750	4739500	75.00	0.05282	3029	40
31	Crown Cork & Seal	321413	4728074	29.87	322000	4727750	54.00	13.63183	670	119
32	Ideal Tape Company	307778	4723277	29.87	309750	4726750	51.00	3.08146	3994	30
33	Bradford Industries	311385	4722984	29.87	312500	4724750	48.00	3.93782	2089	32
34	Hood Coatings	339337	4732004	39.01	333750	4737750	60.00	0.21575	8014	316
35	Vernon Plastics Inc.	326643	4736144	17.98	326750	4736250	24.00	19.88729	151	45
36	Majilite Manufacturing	311092	4722725	27.13	312500	4725000	54.00	2.83921	2675	32
37	Oak Finishers	310510	4723631	27.13	312000	4725500	48.00	3.10892	2390	39
38	The Gillette Company	321967	4720116	24.08	322000	4720000	24.00	17.89952	121	164
39	Raytheon Systems Co.	320556	4723602	45.11	320750	4723750	48.00	9.43136	244	53

1 NA means "not applicable". The facility has a zero source emission rate resulting in no concentrations.

Table 3.22

1998-2001 Cumulative Source Seasonal and Annual PM10 Concentrations - School Receptor Locations

ID	School Name	Address	Town	Concentration (micrograms/ m^3)				
				Annual	Spring	Summer	Fall	Winter
1	Andover Montessori School	400 South Main	Andover	0.2549	0.2280	0.1564	0.2771	0.3587
2	The Pike School Inc.	Sunset Rock Road	Andover	0.3345	0.3008	0.2052	0.3627	0.4704
3	Shawsheen School	Ann's Lane	Andover	0.3458	0.3233	0.2597	0.3597	0.4409
4	Henry C. Sanborn Elementary	Lovejoy Road	Andover	0.3248	0.2667	0.2188	0.3337	0.4827
5	South Elementary School	Woburn Street	Andover	0.2097	0.1869	0.1375	0.2210	0.2935
6	West Elementary School	Beacon Street	Andover	0.3455	0.2918	0.2450	0.3532	0.4929
7	Doherty Middle School	Bartlett Street	Andover	0.3585	0.3248	0.2214	0.3915	0.4969
8	Bancroft Elementary School	Bancroft Street	Andover	0.3795	0.3310	0.2446	0.4084	0.5360
9	Andover West Middle School	20 Shawsheen Road	Andover	0.2858	0.2573	0.2008	0.2984	0.3869
10	Holy Trinity Elementary School	31 Trinity Street	Lawrence	0.2577	0.2627	0.2833	0.2492	0.2343
11	St. Patrick Elementary School	100 Parker Avenue	Lawrence	0.2512	0.2669	0.2442	0.2332	0.2584
12	St. Mary Imm Con. Elementary	301 Haverhill Street	Lawrence	0.4141	0.3378	0.4730	0.4487	0.3964
13	Joseph A. Campbell Elementary	1021 Metheun Street	Dracut	0.2432	0.2984	0.2544	0.2229	0.1927
14	Fellowship Christian Academy	1 Fellowship Way	Methuen	0.2756	0.3065	0.3338	0.2639	0.1953
15	Bradford Elementary School	118 Montvale Street	Haverhill	0.6395	0.4821	0.5583	0.7419	0.7814
16	John K. Tarbox	59 Alder Street	Lawrence	0.2440	0.2710	0.2979	0.2178	0.1871
17	North Central Elementary School	301 Haverhill Street	Lawrence	0.4141	0.3378	0.4731	0.4488	0.3964
18	Sacred Hearts Elementary School	31 South Chestnut	Haverhill	0.3430	0.2419	0.3781	0.4004	0.3539
19	St. Joseph Elementary School	56 Oak Terrace	Haverhill	0.6582	0.3964	0.8134	0.8461	0.5789
20	Solomon Schechter Day School	514 Main	Haverhill	1.1032	0.6546	1.2981	1.4856	0.9780
21	Sacred Heart Elementary School	23 Hawley Street	Lawrence	0.2345	0.2328	0.1906	0.2352	0.2779
22	St. Augusine Elementary School	526 Lowell Street	Lawrence	0.6355	0.7441	0.6305	0.5584	0.5974
23	Our Lady of Mount Carmel	82 Union	Methuen	0.4284	0.4752	0.4959	0.4377	0.3008
24	St. Ann's Home Hilltop	100A Haverhill Street	Methuen	0.3677	0.4267	0.4024	0.3134	0.3226
25	St. Monica Elementary School	212 Lawrence Street	Methuen	0.2718	0.3145	0.3083	0.2692	0.1920
26	Atkinson	111 Phillips Brooks Rd.	N. Andover	0.5977	0.5004	0.3582	0.6282	0.9124
27	St. Michael Elementary School	80 Maple Avenue	N. Andover	0.5265	0.4494	0.3739	0.5541	0.7347
28	Parker Avenue	77 Parker Avenue	Dracut	0.1388	0.1844	0.1422	0.1151	0.1101
29	Greenmont Avenue	37 Greenmont Avenue	Dracut	0.2548	0.2856	0.2739	0.2419	0.2136
30	Dracut Middle School	1560 Lakeview Avenue	Dracut	0.1317	0.1714	0.1376	0.1173	0.0972
31	George H. Englesby Junior High	1580 Lakeview Avenue	Dracut	0.1431	0.1824	0.1474	0.1303	0.1090
32	Prof. Center for Hand. Children	32 Osgood Street	Andover	0.2564	0.2172	0.1666	0.2652	0.3777
33	Saint Augustine	26 Central Street	Andover	0.3338	0.3031	0.2154	0.3653	0.4512
34	Early Childhood Center	137 Monument Street	Haverhill	1.1580	0.7350	1.4954	1.4205	0.9879
35	Bartlett	551 Washington Street	Haverhill	1.9639	1.1147	2.1637	2.5307	2.0658
36	Burnham Elementary School	45 Fountain Street	Haverhill	0.8962	0.5009	1.0117	1.1887	0.8894
37	Cogswell	351 South Main Street	Haverhill	0.8568	0.6610	0.8456	1.0066	0.9182
38	Crowell	26 Belmont Avenue	Haverhill	0.3701	0.3125	0.3800	0.4021	0.3897
39	Fox	75 Elm Street	Haverhill	0.8846	0.5020	0.9863	1.1843	0.8694
40	Golden Hill	140 Boardman Street	Haverhill	0.7639	0.5106	0.9991	0.8305	0.7235
41	Greenleaf	58 Chadwick Street	Haverhill	0.4123	0.2962	0.4603	0.4544	0.4415
42	Caleb Dustion Hunking	98 Winchester Street	Haverhill	1.1836	0.9340	1.0622	1.3464	1.3977
43	Knipe	97 Oxford Avenue	Haverhill	1.0909	1.1033	0.8656	1.1074	1.2941
44	Moody	59 Margin Street	Haverhill	0.5145	0.4059	0.5521	0.5784	0.5248
45	Dr. Paul Nettle	150 Boardman Street	Haverhill	0.7580	0.5318	0.9570	0.8397	0.7086
46	Pentucket Lake Elementary	252 Concord Street	Haverhill	0.9032	0.5395	1.0575	1.1730	0.8475
47	Silver Hill	675 Washington Street	Haverhill	2.8615	1.7132	3.1068	3.8224	2.8148
48	Smiley Elementary School	969 Main Street	Haverhill	0.7147	0.4385	0.9270	0.9021	0.5983
49	Tilton	70 Grove Street	Haverhill	1.6344	0.9926	1.7728	2.1573	1.6227
50	Walnut Square	645 Main Street	Haverhill	1.1693	0.7144	1.4192	1.5555	0.9943
51	John G. Whittier	256 Concord Street	Haverhill	0.8972	0.5390	1.0554	1.1606	0.8396
52	R. L. Wood	25 S. Spring Street	Haverhill	0.7506	0.6043	0.7563	0.8976	0.7456
53	Consentino	685 Washington Street	Haverhill	2.6580	1.6392	2.9132	3.5335	2.5530
54	Lawlor ECC	41 Lexington Street	Lawrence	0.2389	0.2623	0.2606	0.2296	0.2004
55	Lawrence Company ECC	114 Osgood Street	Lawrence	0.2991	0.3175	0.2419	0.2959	0.3406
56	General Donovan	50 Cross Street	Lawrence	0.2570	0.2834	0.2942	0.2346	0.2137
57	Saunders School	243 South Broadway	Lawrence	0.2471	0.2487	0.2190	0.2398	0.2792
58	Arlington Street School	150 Arlington Street	Lawrence	0.2414	0.2679	0.3119	0.2064	0.1774
59	Alexander B. Bruce	135 Butler Street	Lawrence	0.4591	0.5392	0.4739	0.3964	0.4187
60	Robert Frost	33 Hamlet Street	Lawrence	0.3578	0.3195	0.2726	0.3605	0.4774
61	Haverhill Street School	400 Haverhill Street	Lawrence	0.2422	0.2838	0.2759	0.2042	0.2017
62	James F. Hennessey	122 Hancock Street	Lawrence	0.2692	0.3458	0.2741	0.2193	0.2325
63	Francis M. Leahy	100 Erving Avenue	Lawrence	0.2290	0.2375	0.2536	0.2185	0.2051
64	James F. Leonard	60 Allen Street	Lawrence	0.3430	0.3041	0.4892	0.3153	0.2629
65	Henry K. Oliver	183 Haverhill Street	Lawrence	0.2192	0.2194	0.2488	0.2023	0.2056
66	John R. Rollins	451 Howard Street	Lawrence	1.7683	1.1853	2.0861	2.1864	1.6201
67	South Lawrence East School	165 Crawford Street	Lawrence	0.2871	0.3018	0.2278	0.2828	0.3359
68	Charles S. Storrow	50 Pleasant Street	Lawrence	0.8370	0.6339	0.8776	0.9364	0.9016
69	Emily G. Wetherbee	75 Newton Street	Lawrence	0.2718	0.2773	0.2580	0.2452	0.3035
70	Transitional Learning Center	67 North Parish Road	Lawrence	0.2796	0.2910	0.2094	0.2731	0.3447
71	Community Day Center	73 Prospect Street	Lawrence	0.5715	0.5182	0.6007	0.5786	0.5890
72	Lawrence Family Dev. Center	34 West Street	Lawrence	0.2299	0.2766	0.2568	0.1961	0.1869
73	Marsh	309 Pelham Street	Methuen	0.3182	0.3325	0.3702	0.3157	0.2509
74	Methuen Comp. Grammar School	100 Howe Street	Methuen	0.5035	0.5487	0.5509	0.4995	0.4094
75	Tenney Grammar School	75 Pleasant Street	Methuen	0.5435	0.5990	0.6004	0.5713	0.3983
76	Donald P. Timony Grammar	45 Pleasant View St.	Methuen	0.5441	0.6006	0.6119	0.5646	0.3938
77	Bradstreet	70 Main Street	N. Andover	0.3216	0.2914	0.2598	0.3279	0.4082
78	Thomson	266 Waverly Road	N. Andover	0.3346	0.3042	0.2389	0.3303	0.4680
79	North Andover Middle School	495 Main Street	N. Andover	0.6073	0.4973	0.3855	0.6470	0.9087
80	Kittredge	601 Main Street	N. Andover	0.5881	0.4799	0.3709	0.6266	0.8845
81	Franklin	Cypress Street	N. Andover	0.5860	0.5127	0.3578	0.6319	0.8458
82	Annie L. Sargent School	300 Abbott Street	N. Andover	0.4772	0.4152	0.2825	0.5139	0.7011

Table 3.23

1998-2001 Cumulative Source Seasonal and Annual VOC Concentrations - School Receptor Locations

ID	School Name	Address	Town	Concentration (micrograms/ m^3)				
				Annual	Spring	Summer	Fall	Winter
1	Andover Montessori School	400 South Main	Andover	2.1877	1.9521	1.4468	2.3242	3.0418
2	The Pike School Inc.	Sunset Rock Road	Andover	2.5522	2.1915	1.7398	2.8337	3.4639
3	Shawsheen School	Ann's Lane	Andover	2.7720	2.2828	1.9750	3.1084	3.7705
4	Henry C. Sanborn Elementary	Lovejoy Road	Andover	3.8549	3.1684	2.9048	4.1933	5.1829
5	South Elementary School	Woburn Street	Andover	3.3402	2.2169	2.5180	4.2709	4.3764
6	West Elementary School	Beacon Street	Andover	4.1166	3.7060	2.9675	4.7945	4.9848
7	Doherty Middle School	Bartlett Street	Andover	3.4796	2.7788	2.3217	4.0317	4.8221
8	Bancroft Elementary School	Bancroft Street	Andover	1.9182	1.5821	1.3323	2.1471	2.6314
9	Andover West Middle School	20 Shawsheen Road	Andover	2.6112	2.3583	1.8968	2.7792	3.4279
10	Holy Trinity Elementary School	31 Trinity Street	Lawrence	2.3854	1.5996	2.9911	2.8236	2.1455
11	St. Patrick Elementary School	100 Parker Avenue	Lawrence	2.1380	1.4887	2.4220	2.5172	2.1329
12	St. Mary Imm Con. Elementary	301 Haverhill Street	Lawrence	1.9143	1.2681	2.1032	2.3995	1.8976
13	Joseph A. Campbell Elementary	1021 Metheun Street	Dracut	2.6352	1.9479	2.7276	3.1034	2.7620
14	Fellowship Christian Academy	1 Fellowship Way	Methuen	1.7747	1.4610	2.1376	2.1429	1.3605
15	Bradford Elementary School	118 Montvale Street	Haverhill	1.8497	1.1912	1.6992	2.2895	2.2335
16	John K. Tarbox	59 Alder Street	Lawrence	1.2614	0.9370	1.4903	1.4006	1.2211
17	North Central Elementary School	301 Haverhill Street	Lawrence	1.9143	1.2681	2.1033	2.3994	1.8976
18	Sacred Hearts Elementary School	31 South Chestnut	Haverhill	1.3586	0.8357	1.4443	1.7315	1.4338
19	St. Joseph Elementary School	56 Oak Terrace	Haverhill	2.0732	1.1908	2.4383	2.7461	1.9250
20	Solomon Schechter Day School	514 Main	Haverhill	3.0855	1.7946	3.5814	4.1615	2.8161
21	Sacred Heart Elementary School	23 Hawley Street	Lawrence	2.0955	1.6697	2.1040	2.3962	2.2240
22	St. Augusine Elementary School	526 Lowell Street	Lawrence	3.4905	2.8859	3.6511	3.9624	3.4437
23	Our Lady of Mount Carmel	82 Union	Methuen	1.6528	1.2854	1.7702	1.9955	1.5523
24	St. Ann's Home Hilltop	100A Haverhill Street	Methuen	1.8974	1.8098	2.1613	2.2081	1.4130
25	St. Monica Elementary School	212 Lawrence Street	Methuen	1.1370	0.9296	1.1795	1.3343	1.1003
26	Atkinson	111 Phillips Brooks Rd.	N. Andover	3.1805	2.3280	2.5225	3.7413	4.1566
27	St. Michael Elementary School	80 Maple Avenue	N. Andover	2.0763	1.4774	1.6596	2.3919	2.8004
28	Parker Avenue	77 Parker Avenue	Dracut	2.7811	2.5706	3.4012	3.1419	2.0188
29	Greenmont Avenue	37 Greenmont Avenue	Dracut	3.9927	2.9688	4.3834	4.8881	3.7209
30	Dracut Middle School	1560 Lakeview Avenue	Dracut	1.4351	1.5571	1.8233	1.4755	0.8762
31	George H. Englesby Junior High	1580 Lakeview Avenue	Dracut	1.7041	1.8496	1.9584	1.9042	1.0934
32	Prof. Center for Hand. Children	32 Osgood Street	Andover	2.8208	2.5329	2.1320	3.0717	3.5554
33	Saint Augustine	26 Central Street	Andover	2.6969	2.1983	1.9763	3.1349	3.5071
34	Early Childhood Center	137 Monument Street	Haverhill	3.4259	2.0641	4.3426	4.3008	3.0187
35	Bartlett	551 Washington Street	Haverhill	5.0933	2.7721	5.5617	6.7301	5.3607
36	Burnham Elementary School	45 Fountain Street	Haverhill	2.6874	1.4883	2.9656	3.6229	2.6914
37	Cogswell	351 South Main Street	Haverhill	2.4957	1.6055	2.4203	3.1978	2.7813
38	Crowell	26 Belmont Avenue	Haverhill	1.1056	0.6834	1.1095	1.3791	1.2614
39	Fox	75 Elm Street	Haverhill	2.6524	1.4917	2.9110	3.5955	2.6252
40	Golden Hill	140 Boardman Street	Haverhill	1.7674	1.0394	1.7670	2.2063	2.0755
41	Greenleaf	58 Chadwick Street	Haverhill	1.5071	0.9194	1.5921	1.8835	1.6474
42	Caleb Dustion Hunking	98 Winchester Street	Haverhill	3.1485	2.0855	2.8815	3.8788	3.7775
43	Knipe	97 Oxford Avenue	Haverhill	3.1915	2.7484	2.7722	3.6007	3.6720
44	Moody	59 Margin Street	Haverhill	1.7137	1.1111	1.8322	2.1372	1.7918
45	Dr. Paul Nettle	150 Boardman Street	Haverhill	1.7488	1.0365	1.7365	2.2073	2.0306
46	Pentucket Lake Elementary	252 Concord Street	Haverhill	3.1198	1.8444	3.6371	4.1149	2.8992
47	Silver Hill	675 Washington Street	Haverhill	7.8166	4.5006	8.5920	10.5801	7.6296
48	Smiley Elementary School	969 Main Street	Haverhill	2.2483	1.3349	2.8699	2.8652	1.9430
49	Tilton	70 Grove Street	Haverhill	4.9894	2.8990	5.3903	6.7387	4.9536
50	Walnut Square	645 Main Street	Haverhill	3.2738	1.9224	3.9313	4.3937	2.8634
51	John G. Whittier	256 Concord Street	Haverhill	3.0924	1.8273	3.6179	4.0713	2.8701
52	R. L. Wood	25 S. Spring Street	Haverhill	2.2728	1.4832	2.2997	2.9705	2.3543
53	Consentino	685 Washington Street	Haverhill	7.3698	4.3205	8.1695	9.9565	7.0591
54	Lawlor ECC	41 Lexington Street	Lawrence	1.6433	1.1364	1.9650	1.9008	1.5766
55	Lawrence Company ECC	114 Osgood Street	Lawrence	1.5223	1.0991	1.4859	1.7316	1.7879
56	General Donovan	50 Cross Street	Lawrence	1.7886	1.2895	2.1639	1.9796	1.7246
57	Saunders School	243 South Broadway	Lawrence	2.1665	1.6183	2.3333	2.4950	2.2346
58	Arlington Street School	150 Arlington Street	Lawrence	1.1737	0.9792	1.3369	1.2747	1.1035
59	Alexander B. Bruce	135 Butler Street	Lawrence	1.9749	1.6380	2.0906	2.1315	2.0428
60	Robert Frost	33 Hamlet Street	Lawrence	4.2874	3.7805	3.9426	4.9104	4.5351
61	Haverhill Street School	400 Haverhill Street	Lawrence	1.5237	1.1178	1.8367	1.6708	1.4749
62	James F. Hennessey	122 Hancock Street	Lawrence	1.5172	1.2070	1.9108	1.6199	1.3439
63	Francis M. Leahy	100 Erving Avenue	Lawrence	1.9439	1.3323	2.3968	2.2889	1.7710
64	James F. Leonard	60 Allen Street	Lawrence	1.9914	1.3342	2.2658	2.4689	1.9092
65	Henry K. Oliver	183 Haverhill Street	Lawrence	2.4639	1.6596	3.1859	2.8702	2.1583
66	John R. Rollins	451 Howard Street	Lawrence	6.7907	4.2432	7.5859	8.9037	6.4625
67	South Lawrence East School	165 Crawford Street	Lawrence	1.4928	1.0955	1.4148	1.6709	1.8058
68	Charles S. Storrow	50 Pleasant Street	Lawrence	3.7805	2.3996	3.9283	4.8399	3.9702
69	Emily G. Wetherbee	75 Newton Street	Lawrence	3.1141	2.1300	3.8014	3.7221	2.8161
70	Transitional Learning Center	67 North Parish Road	Lawrence	1.6836	1.3029	1.5396	1.9091	1.9932
71	Community Day Center	73 Prospect Street	Lawrence	2.6962	1.6976	2.8265	3.3586	2.9132
72	Lawrence Family Dev. Center	34 West Street	Lawrence	1.2461	0.9603	1.4252	1.3802	1.2222
73	Marsh	309 Pelham Street	Methuen	3.1016	2.4808	3.8897	3.8072	2.2424
74	Methuen Comp. Grammar School	100 Howe Street	Methuen	2.2491	1.8583	2.3331	2.7033	2.0899
75	Tenney Grammar School	75 Pleasant Street	Methuen	2.2752	1.8547	2.3145	2.7800	2.1406
76	Donald P. Timony Grammar	45 Pleasant View St.	Methuen	1.9400	1.5839	1.9651	2.3840	1.8189
77	Bradstreet	70 Main Street	N. Andover	1.4756	0.9753	1.4462	1.7234	1.7709
78	Thomson	266 Waverly Road	N. Andover	1.5771	1.1186	1.4395	1.7981	1.9656
79	North Andover Middle School	495 Main Street	N. Andover	3.0117	2.2193	2.3352	3.5100	4.0142
80	Kittredge	601 Main Street	N. Andover	2.9798	2.1739	2.3056	3.5195	3.9512
81	Franklin	Cypress Street	N. Andover	2.7537	2.0237	2.1069	3.0873	3.8468
82	Annie L. Sargent School	300 Abbott Street	N. Andover	2.1845	1.6703	1.5889	2.4974	3.0145