Appendix E

NYSDEC Air Monitoring Data at Fresh Kills Landfill (2004)

FINAL

An Assessment of Methane and Toxic Compounds over the Fresh Kills Landfill and Surrounding areas of New York City: A Pilot Study

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INTRODUCTION

Fresh Kills landfill, located on Staten Island, is the largest landfill in the world and has been in operation since 1948. At its height of operation, 7000-8000 tons of refuse were processed daily, six days a week. Fresh Kills was permanently closed to residential waste in the spring of 2001, but was later re-opened on a limited basis to provide a repository site and forensic analysis of the debris from the World Trade Center disaster.

Since 1970, the disposal of residential waste has occurred in four areas, covering 1100 acres of the landfill, (Sections 1/9, 2/8, 3/4 and 6/7). Landfill gas collection and processing began in Section 1/9 in 1982. In 1998, the New York City Department of Sanitation (NYSDOS) began burning landfill gases using high temperature flares. The goal of the flaring project was to significantly reduce emissions and odors at many locations in and around the landfill by burning off the landfill gas that was not being recovered and processed. The flare stations have been used intermittently since 1999, given that a gas collection system has been installed in all sections of the landfill. Final covers to minimize gas and leechate migration are complete for Sections 2/8 and 3/4 and there are plans to install final covers on Sections 1/9 and 6/7. New York State Department of Environmental Conservation (NYSDEC) representatives who work on-site have reported no odors or public odor complaints since the landfill closure (NYSDEC, 2004). In addition, the on-site methane hot-spot program has not recorded any surface methane excursions above the 500ppm (0.05%) regulatory limit anywhere on the former landfill indicating minimal methane break through from the covers in place.

Historically, there has been concern over the possible detrimental health effects from pollutants escaping from the landfill and odor complaints from the surrounding communities regarding the landfill. In response, several studies were conducted in an attempt to characterize the air quality in and around Fresh Kills (ATSDR, 1998; NYSDEC, 1995). Despite these actions, public concern still remained regarding the effect of the Fresh Kills landfill on local air quality. To alleviate some of these concerns, beginning in 1999, a pilot study was initiated to further examine the air quality in the proximity of the landfill (NYSDEC, 2000). The goals were to gain a better understanding of the contribution of the landfill to observed pollutant levels at monitoring sites in and around the landfill. To this end, measured methane was used as a surrogate or a tracer for emissions of various hydrocarbons from the landfill.

This report summarizes the analysis based upon measured methane concentrations over a network of monitors located in and around the landfill as well as selected hydrocarbons measured as part of the state toxic network. It is determined that there is a poor relationship between the methane and toxics. Also, an assessment of selected toxic compounds indicated a decreasing trend for some compounds, suggesting the lack of influence of the landfill on local air quality. However, in order to address any future concerns that may arise regarding possible health impacts associated with the emissions from the closed landfill, it is recommended that a network, comprising of monitors on and off the landfill, be continued to further track the changes in air quality.

DATA

The ambient monitoring program included hourly measurements of methane (CH_4), as well as total and non-methane hydrocarbons over the Fresh Kills landfill and in the surrounding communities. Given the logistics and problems associated with launching a monitoring network, the measurement periods varied across the network. Figure 1 displays the location of the monitoring sites and Table 1 lists the monitors and sampling periods. Additionally, Table 2 lists the distances between the monitoring sites.

In addition to hydrocarbon measurements, several toxic compounds were measured at some of the above sites (primarily Fresh Kills East and West). Additionally, two other monitors, Latourette golf course (LAT) and Fresh Kills Unloading Zone (FKU) measured toxics for a shorter time span. Table 3 lists the specific toxic compounds and their pollutant identification numbers. Toxic compounds were measured every sixth day and are 24-hour average samples.

A comprehensive landfill gas measurement program was conducted at the landfill under the oversight of the United States Environmental Protection Agency in the summer of 1995 (USEPA, 1995). The development of an overall landfill gas emission profile for numerous air toxics was established for the passive vents and gas break through areas on the landfill surface. This work provided a snapshot of air toxics emissions from the landfill during a period when sections of the landfill were still operational, but also were undergoing closure and installation of the gas collection system. Table 4 provides a list and the frequency of detection for the various air toxic compounds that were detected in the landfill gas passive vents. Currently the passive vent system is not in use since the gas collection system for the entire landfill was installed in 1999.

Meteorological data were also measured at the FKW and NYB sites. These data consisted of hourly wind speed and direction, spanning roughly, the same time period as the hydrocarbon measurements.

ANALYSIS

Meteorology:

Wind roses are shown in Figures 2a-2c for the Fresh Kills West monitor for 2000 to 2002 (the monitor is located directly on the landfill). Prevailing winds were generally from the Southwest to Northwest sector.

CH_4, NMHC and THC:

We examined the annual hourly average and annual average daily maximum methane concentrations for the available data. We focus on the time period of 2000 to 2002 and on the FKW, SWH and NYB monitors as these sites had the longest data records. The Fresh Kills West (FKW) average concentrations of hourly methane show little variation from 2000 to 2002.

Average concentrations are around 5 ppm. Average daily maximum values show a small decrease from 2000-2002 from 20.5 to 17.3 ppm. Hourly average concentrations of methane at Susan Wagner High School (SWH) show little variation from Jan 2000 through Dec 2002, with average concentrations around 2.2 ppm. Average daily maximum values show a small decrease from 2000-2002 from 4.1 to 3.5 ppm. NY Botanical Gardens (NYB) average concentrations of hourly methane show a very slight increase between 2000 and 2002 from 2.1 to 2.2 ppm. Average daily maximum values show little variation during the measurement period. Tables 5a-5b summarize these estimates. The FKW site has the highest concentrations of methane of the three. The large standard deviations listed for FKW suggests, that these concentrations are influenced by large excursions of methane in and over the landfill.

Annual average daily maximum and annual average hourly NMHC concentrations at FKW show no clear trend. Values for both increase from 2000 to 2001 then fall from 2001 to 2002. At SWH, there is a slight downward trend in both annual average daily maximum and annual average hourly NMHC concentrations. Hourly values drop from 0.21 ppm in 2000 to 0.12 ppm in 2002. Daily maximum concentrations fall from 0.44 ppm to 0.26 ppm over the same period. The NYB monitor shows a slight upward trend in annual average hourly NMHC concentrations from 0.21 ppm to 0.27 ppm. There is no clear trend in daily maximum values at this site. The FKW site has the highest NMHC values. Again, standard deviations are large for each one of the means indicating a large amount of scatter in the data. NMHC values are summarized in Tables 6a-6b.

Annual average hourly total hydrocarbon concentrations show little variation over the three-year measurement period at the three locations. Both FKW and SWH exhibit no clear trend. Values at both sites rise from 2000 to 2001 and then fall from 2001 to 2002. There is a slight increasing trend from 2.29 ppm to 2.53 ppm at the NYB monitor. The annual average daily maximum THC at both the FKW and SWH sites show decreasing trends over the three-year period. There is no clear trend at the NYB site and values decrease then increase over the three-year period. As expected, total hydrocarbons are highest at the FKW site. Again, standard deviations are quite large, particularly at the FKW site. Total hydrocarbon concentrations are summarized in Tables 7a-7b.

Wind Speed and direction associated with high methane levels:

Wind speed and direction data were used to characterize the prevailing wind flow patterns over the landfill and surrounding areas and to attempt to associate specific wind directions with high methane measurements. Meteorological data were measured at some of the monitoring sites in and around the Fresh Kills landfill. Meteorological data was used from the FKW monitor directly on the landfill and at the NYB and SWH monitors located off site. We focus our analysis on the year 2002, as this was the year with the most data.

The 95th percentile methane values were calculated at each monitoring location where wind data was available. The goal here was to examine if there is a causal relationship between the wind direction and corresponding high methane values. The FKW monitor had a 95th percentile value of 17.2 ppm, which was most frequently exceeded when winds were from the south and to a lesser extent from the east and southeast. These wind flows would bring air from over the landfill to the FKW monitor on high methane days. It should be noted that prevailing winds are from the southwest to northwest direction at FKW. The 95th percentile value at the SWH monitor was 3.6 ppm, which was most frequently exceeded when winds were from the south. This would seem to suggest sources other than the landfill are affecting the SWH monitor. The NYB monitor had a 95th percentile value of 3.1 ppm, which was most frequently exceeded when winds were from the northwest. The high concentrations at NYB are probably associated with sources located to the northwest of the monitor and require further investigation. Figures 3-5 display pollution roses for the FKW, SWH and NYB sites.

Correlations in methane data among Fresh Kills monitors:

We examined correlations associated with daily average and daily maximum methane among the monitors located on the landfill to determine if a relationship exists among them. The focus of this analysis was the data from 2002. Correlations among times series of daily average methane are generally quite poor. The strongest correlation is seen between FKU and FKW with an R^2 of 0.67. When the data are segregated by season, the above pair still exhibits the greatest correlation through all seasons, except summer, where FKE and FKW show the highest ($R^2 = 0.74$). Correlations among times series of daily maximum methane are also quite poor. Again the combination of FKU and FKW shows the strongest correlation at $R^2 = 0.57$. Furthermore, these two monitors exhibit the strongest correlations when examined on a seasonal basis. Finally, Correlations between data from the landfill monitors with the closest off-site monitor (SWH) were very low, (the highest value of R^2 was 0.48 for summer season daily maximum data between FKE and SWH). This would seem to suggest that there is little relationship between the closest off site monitor to any one monitor located on the landfill.

Correlations in methane data among Fresh Kills monitors for high values:

Daily average and daily maximum methane data for 2002 between the Fresh Kills monitors was examined to determine if a relationship exists. This would help us determine if high methane days are a landfill-wide event. Only data greater than the 95th percentile value at each monitor was considered. Correlations were very poor among measurements at the Fresh Kills monitors and the number of observations between pairs prevented meaningful conclusions. The greatest number of common data points was between SWH and FKU. Although there were more concurrent observations among the monitors when considering daily maximum data, the relationship was also found to be very poor. The strongest correlation was between FKW and FKU ($R^2 = 0.38$). Again, even when concentrations are highest, there is no strong relationship between the data from monitors located on or off the landfill.

Correlations of CH4 and NMHC data between monitors during prevailing wind:

The general prevailing wind direction, as represented by the FKW monitor, was from the southwest to northwest direction. We correlated all hourly methane and NMHC data available during the 2000 to 2002 time period, among monitors in and around the landfill to determine if there was any relationship during this wind regime. There was not a strong relationship between any of the monitors. These results are presented in Table 8. For methane, the strongest correlation is between the FKE and FKU monitors at $R^2 = 0.35$. For NMHC, the same monitor pair (FKE/FKU) has the strongest correlation, however, the R^2 of 0.06 was not significant.

Correlations between monitors with longer data records:

In order to gain insight into a possible link between air quality near the landfill and surrounding communities, the relationship between the SWH and NYB monitors, both of which had longer data records, (i.e. 2000-2002) was examined. Considering daily average and daily maximum, there was no significant relationship with either metric for this monitor pair. R^2's were extremely poor, being less than 0.1.

Correlations between CH_4 and NMHC with various toxic compounds at the Fresh Kills Landfill:

We examined the correlation between CH_4 and NMHC with various toxic compounds measured on the landfill for all available data in the 2000 to 2002 time period. The toxic compounds are 24-hour averages measured every sixth day; hence, the 24-hour average values for methane and NMHC were calculated for the analysis. At FKW, NMHC showed strong correlations with some of the toxics compounds such as MTBE, MPXYL, BENZ, TOL, EBENZ, OXYL and 124 TMB. Values of R^2 were in the 0.80-0.85 range for these compounds. A similar relationship between toxics and methane was not seen at FKW. At the NYB site, correlations were weak between both methane and NMHC and the toxic compounds. The highest R^2 was 0.48 for both methane and NMHC with TCE. Results for all sites are summarized in Tables 9a and 9b.

Spatial correlations of toxic compounds between monitors in and around the landfill:

The relationship between toxic compounds measured at sites in and around the landfill was examined for available data in the 2000 to 2002 time frame. Tables 10a-10h show the correlation matrices for the various toxic compounds between sites. Correlations are generally highest between sites in close proximity to each other, i.e. FKW and FKU. The LAT monitor, located on the perimeter of the landfill, did have some reasonably strong correlations with FKE and FKU data for Benzene, Ethyl benzene, Toluene, O Xylene and M, P Xylene.

TRENDS IN AIR TOXICS

As noted previously, a number of toxic compounds were measured at the Fresh Kills East and West monitors. For many compounds, measurement began in the early to mid 1990's and continues today. Taking advantage of this longer time frame of available data, we examined the toxics measurements for any trends over the time period. Also provided are the estimates of potential public health impact based on the annual mean concentration.

Measurement methods and sites

Three different methods have been used for VOC monitoring in the New York state network. In the period 1990-1994 samples were collected in adsorbent-lined tubes according to traditional hi-volume particulate sampler procedures. The day after sampling, the sample tubes are capped and shipped to the laboratory along with information on flow rate and total volume. Each sampling event for the entire network was analyzed as a batch using a Gas Chromatograph/Mass Spectrometer. The reference number for this method is NYSDEC-17a. This reflects the updated and related EPA method code of TO-17.

At the end of 1994, method NYSDEC-17a was altered slightly by changing the trap adsorbents in the tubes to increase the chemical target list and reduce the background contamination. Since this was only a minor modification of method NYSDEC-17a, the reference number for this method was given as NYSDEC-17b.

In 1999 the method was changed again such that samplers push the air into pressurized canisters instead of through the tubes. This results in samples that are stable for longer periods of time. EPA method TO-15 is the basis for this method, so a reference number for this procedure is NYSDEC-15a. For all methods, detailed calibration and QA procedures were followed throughout the process. A more detailed description of the analysis is available at www.dec.state.ny.us/website/dar/reports/voc_rpt.

All VOC measurements, including benzene, were conducted by taking a 24-hour sample every sixth day. As previously mentioned, only two Fresh Kills monitoring sites had a sufficient number of observations to allow analysis of year-to-year changes.

Monitoring initially began at the Meteorological Tower site (7097-12) in 1994 but was later moved to the Fresh Kills West site in 1997. The new location was chosen for its upwind location, proximity to New Jersey, as well as having an open space for gathering weather data. Because the new location was moved only a few hundred yards, we combine the data from the two sites designated as Fresh Kills West.

The second site originally began monitoring at the District 2 Garage (7097-08) location in 1994 at the northeast corner of the landfill. This location was considered a perimeter site as the garage is situated at the landfill perimeter fence. However, in 2001, due to security reasons, the monitor was moved 300 yards to the north to the Fresh Kills East location. Again, because of the close proximity, the data was pooled and designated as Fresh Kills East.

Data analysis

While in each particular year only one measurement method was used, over the period 1990-1992, toxics were measured by three different methods. Differences in measuring methods can cause a bias in trend assessment (Henry et al., 2000). Thus, it is important to use calibration procedures to reduce data to a single reference method. Regression relationships between different methods were derived from collocated measurements by old and new methods:

- Collocated NYSDEC-17a to NYSDEC-17b measurements were run on the Fresh Kills site Port Richmond (Staten Island) during 1995.

- Methods NYSDEC-17b and NYSDEC-15a were simultaneously used at District 2 Garage at Fresh Kills landfill and Richmond Avenue (also Staten Island) during the period from December 1997 to May 1998.

Regression relationships derived from these data sets were used to express all measurements in terms of the current measurement method NYSDEC-15a.

From the regulatory point of view, the most useful measure of abundance of a certain toxics in the air is its mean annual concentration. However, toxics are often measured at concentrations, which are at or below the instrument limit of detection (LOD). When this happens, mean values from samples cannot be directly computed. Instead, we use the Helsel robust method (Gilliom and Helsel, 1986; Helsel, 1990). With this method, a distribution is fit to the data above the reporting limit but the fitted distribution is used only to extrapolate a collection of values below the reporting limit. The estimated values are treated as observed and pooled together with observations above the limit of detection then the mean and variance are estimated for all measurements.

The Helsel robust method is applied for analysis of toxics observations in our database only if at least 20% percent of data are above the limit of detection, and if these 20% consist of at least 5 observations - a commonsense, if arbitrary, constraint.

Prior to analysis, all observations in the pooled sample were adjusted for the difference in measurement methods and values below the detection limit are replaced with estimates by Helsel robust method. During analysis, all data units were converted to ug/m^3 so comparisons could be made with Annual Guideline Concentrations (AGCs). The Department uses AGCs to evaluate the potential public health impacts from the inhalation of air toxics. The potential public health impacts of air toxics are assessed by calculating the ratio of the observed mean concentration to the Annual Guidance Concentration (AGC).

Potential public health impacts or the risk characterization of air toxics exposure can be characterized as cancer risk estimates and non-cancer risk estimates. Cancer risk estimates are the statistical probability of developing cancer over a lifetime (70 years) and are developed for air toxics that have been identified as human or animal carcinogens. For example, the benzene AGC of 0.13 ug/m^3 is the ambient air concentration that corresponds to an increased cancer risk of one in one million. The Division of Air Resources accepts a cancer risk range of one-in-one hundred thousand (10^{-5}) to one-in-one-million (10^{-6}) as range of "generally acceptable risk" when making air pollution permitting decisions. The potential cancer risk is assessed by calculating the ratio of the observed mean concentration to Annual Guidance Concentration (AGC). Non-cancer risk estimates or potential hazards are based on other observable health effects in humans or animals. For example, the toluene AGC of 400 ug/m^3 is the ambient air concentration that is estimated to result in no deleterious health effects after a lifetime (70 year) of continuous inhalation exposure. The potential non-cancer risk or hazard quotient is assessed by calculating the ratio of the observed mean concentration to Annual Guidance Concentration (AGC). A hazard quotient less than or equal to one indicates that non-cancer health effects are not likely to occur from exposure to the air toxic.

RESULTS

It should be noted that 1994 had too few observations to be utilized; so all analyses start at 1995. We should note that the chemical target list was expanded over the years. Consequently, some of the chemicals do not have a sufficient observation history for meaningful analysis. In particular Methyl Tertiary Butyl Ether (MTBE) and 1, 3 Butadiene (13BD) were not measured before 2000 at FKW and before 2002 at FKE.

We also consider Chloroform (CLFM) to have insufficient history, although it was measured since 1995. The reason for this is that in the period 1995-1998 more than 90% of the observations were below limit of detection (LOD). On the other hand, in 2002, with a different method less than 5% of the observations were below LOD, indicating that *NYSDEC-17b was not good enough for measuring CLFM*. Thus, meaningful Chloroform observations start only since the year 2000.

Chemicals with sufficient measurement history can be divided into two groups. The first group consists of chemicals with mean concentrations, which present extremely low potential risk. Chemical in this group are:

- *Chloromethane* (CLMA) has a hazard quotient around 0.01.
- *1,1,1 Trichloroethane* (111TC) - a hazard quotient at or below 0.01
- *M, P Xylene* (MPXYL) has a hazard quotient at or below 0.03
- *Toluene* (TOL) has a hazard quotient at 0.05 or below
- *Ethylbenzene* (EBENZ) has a hazard quotient at 0.002 or below
- *O Xylene* (OXYL) has a hazard quotient at 0.02 or below
  1,2,4-Trimethylbenzene (124TMB) has a hazard quotient below 0.02
- *O Dichlorobenzene* (ODCBZ): Values of ODCBZ are not adjusted for difference in methods, as there are no established relationships between different methods. However, in all years almost 100% of the values are below LOD, which is about 0.2 ug/m^3 and the AGC is 360 ug/m3. The hazard quotient from ODCBZ is very small.
- *M Dichlorobenzene* (MDCBZ): Values of ODCBZ are not adjusted for differences in methods, as there are no established relationships between different methods. However, in all years daily maximum observed values do not exceed 1.6 ug/m^3 while AGC is 360 ug/m^3.

Chemicals that are present in mean concentrations at or above the AGC are Benzene (BENZ), Tetrachloroethylene (PERC), Trichloroethylene (TCE) and para-Dichlorobenzene (PDCBZ). The AGC values for these compounds were developed to be protective against carcinogenic effects. The most recent annual averages for BENZ and PDCBZ are within the range of "generally acceptable risk" when making air pollution permitting decisions. The most recent annual averages for PERC and TCE are below the one in one million cancer risk level. This means the cancer risk from exposure to these two compounds can be considered trivial. They are presented in more detail in Tables 11 - 14. These tables have identical structure, with column definitions as follows:

Period	Year
Totcount:	Sample size
Lmdlcount:	Count of non-detects, concentrations less than or equal to LOD
Per25:	25th percentile of concentrations (first quartile)
Per50:	Median of concentrations
Per75:	75th percentile of concentrations (third quartile)
Per90:	90th percentile of concentrations
Maks:	Maximum observed concentration
Robustavg	Mean obtained by robust method
Agcratio:	Ratio of mean to Annual Guidance Concentration. Robustavg is used for mean if censoring does not exceed 80% with at least 5 observations above LOD. Otherwise, and only if AGC>LOD, Mdlhalfavg is used for mean.

As an example, at the Fresh Kills East site, in 1998 PERC (Table 12a) has 7 out of 47 observations below LOD. The median concentration is 0.74 ug/m^3, while maximum observed value for the year was 2.28 ug/m^3. Annual mean estimated by Helsel's method is (after adjustment for difference in methods) 0.475 ug/m^3, and the ratio of mean to AGC is also 0.475.

Benzene (BENZ) observations are presented in Tables 11a (FKE) and 11b (FKW).

- FKE annual means decrease from 1.79 ug/m^3 in 1995 to 1.34 ug/m^3 in 2002, implying 25% decrease.

- FKW behaves in a similar manner as FKE, except that there is noticeable spike in 2001, which has annual mean of 3.6 ug/m^3 as compared to 1.6 and 1.4 ug/m^3 in 2000 and 2002 respectively. We have checked original data and found that concentrations in April and May of 2001 were unusually high. For example, on the 19 May 2001 observed concentration was 41 ug/m^3, more than 20 times the average value. Just with this day removed, mean annual concentration for 2001 drops from 3.6 ug/m^3 to 2.90 ug/m^3. This observation is deemed to be real, as benzene on nearby sites shows increased values for the same day, so we did not dismiss the number. However, we note that this is a relic of one-time local episode, not representative of a long-term trend.

Tetrachloroethylene (PERC) observations are presented in Tables 12a (FKE) and 12b (FKW).

- Fresh Kills East observations in the period 1995-1998 do not show discernible trend. Annual mean concentration and potential cancer risk for 2002 are about half of what they used to be in the 1995-1998.
  Values of the 75th percentile fall with time - there is a reduction in higher concentrations.

- Fresh Kills West has similar behavior

Trichloroethylene (TCE) observations are presented in Tables 13a (FKE) and 13b (FKW).

- FKE: both 2002 and 1998 have adjusted annual mean concentrations, which are half of what they were in the period 1995-1997.

- FKW has no discernible pattern.

P Dichlorobenzene (PDCBZ) observations are presented in Tables 14a (FKE) and 14b (FKW).

- Same method had in other years implying possible problems with PDCBZ measurements at FKE in 1995. Mean annual concentrations for 1996-1998 were in the range 0.47-0.59 ug/m^3. Mean annual concentrations for 2002 is 0.31 ug/m^3, a 34% decrease from 1996.

- FKW does not have a clear pattern, but again there seems to be spike in 2001.

DISCUSSION

Annual average methane concentrations measured on the landfill (around 5.0 ppm) are elevated in comparison to annual measurements made in other areas of the New York City Metropolitan area (around 2.2 ppm) and global background methane concentrations (1.8 ppm). This finding is expected since the Fresh Kills landfill is a major source of methane emissions. However, it is difficult to draw any definitive conclusions on the behavior of methane concentrations in the communities bordering the Fresh Kills landfill. The methane concentrations are markedly lower at the Susan Wagner site, which is only 3.3 miles away from the Fresh Kills West monitor. Both daily maximum and daily average values are highest at the Fresh Kills West monitor located on the landfill compared to the Susan Wagner and NY Botanical Gardens sites. Annual daily maximum methane concentrations at both the Fresh Kills West and Susan Wagner monitors show a slight decrease over the three-year period.

The daily average and daily maximum methane values for 2002 at the various monitors are poorly correlated. The strongest relationship appears to be between the daily maximum and daily average values at the Fresh Kills West and Fresh Kills Unloading Zone monitors. This result is reasonable given the fact that the prevailing winds at the FKW monitor are generally from the west and southwest and that the Unloading zone site is three quarters of a mile due east of the FKW monitor. When correlations are examined by season, the poor correlations and small number of data points suggest no seasonal relationship exists among the monitors except for the aforementioned two. The closest two off-landfill monitors, Susan Wagner and NY Botanical Gardens both have three years of data, but no significant relationship was shown to exist.

Methane does not appear to be correlated between the landfill and off-landfill monitors during times when the winds were from the prevailing wind direction, or during episodes when monitors are measuring high concentrations. These findings are probably attributable to the installation of the landfill gas collection system and the active monitoring of the landfill surface to minimize gas breakthrough since 1999. Both methane and NMHC are not strongly correlated with the toxic compounds measured on the landfill, except for NMHC and a few toxics at the FKW site. The lack of a strong relationship could indicate that these toxic compounds have sources other than the landfill.

The spatial correlation of toxic compounds between monitors on and off the landfill revealed limited information. The various compounds appeared to show the strongest relationship among data from monitors in close proximity to each other. This points to a fairly localized behavior of some of these compounds and possibly limited transport as well.

Using wind data from the FKW site, we note that prevailing winds over the landfill are generally from the southwest to northwest. Monitors located within the landfill boundaries (East, West and Unloading Zone) have the highest daily average and daily maximum methane concentrations, while those downwind and off-site (Susan Wagner and Botanical Gardens) have much lower concentrations. The poor correlation between data from offsite and landfill locations, seem to suggest that the higher concentrations seen at the landfill monitors have little impact on downwind or off-site monitors.

There are many other sources of the air toxics monitored in Richmond County. These sources can be broadly categorized as; major stationary sources, area and other sources, on-road sources (vehicles) and non-road sources (i.e. construction and lawn equipment). Since air toxics are considered a localized problem we have evaluated the emissions totals from three surrounding counties (Union NJ, Middlesex NJ and Richmond NY) that have air masses that could impact the air quality of Richmond County. The general prevailing wind direction, as represented by the FKW monitor, was from the southwest to northwest direction. Table 15 provides percentages of selected air toxics emissions from each of the source categories discussed above for each county. These compounds were selected because of the strong correlations with NMHC in Table 9(a) that is representative of the general prevailing wind direction at the FKW west monitor. We have found a strong signal using MTBE as a tracer for incoming emissions. This compound was detected at a low frequency in studies that have characterized the emissions from the landfill in 1995 Table 4, which means that other sources are responsible for the emissions detected at the FKW site. Table 15 indicates that major stationary sources in the area are responsible for the strong MTBE signal detected at the FKW site. This signal can be specifically attributed to petroleum refining and bulk storage facilities in these counties. This source category has a distinct emission profile which can be characterized in descending order of air releases as follows: MTBE, toluene, mixed xylenes and benzene. Total MTBE emissions to the atmosphere from this source category in the three county area were reported to be 79.3 tons in 2001. (USEPA, 2004)

Some of the toxic compounds did exhibit slight trends over their measurement period. Of the sixteen compounds considered in this analysis, four were considered to have a reasonably long data record and mean concentrations above the AGC. Mean benzene levels decreased at both the FKW and FKE sites. Tetrachloroethylene showed no discernible trend at FKW. At the FKE site, mean values of TCE decreased from 1996 on, and the 75th percentile values decrease with time, indicating a reduction in higher concentrations over time. The relationship between methane and air toxics emissions from the landfill is not apparent for the years reviewed (i.e. 2000 - 2002). This may be due to the final installation of the gas collection system at the landfill, which was completed sometime in 1999. This gas collection system has significantly reduced the emissions of methane from the landfill.

Because Fresh Kills landfill is surrounded by highly urbanized and industrial areas, including petrochemical industries to the west, the Newark and New York City metropolitan areas to the north and northeast, and major shipping and port areas to the northwest it is difficult to delineate its contribution to local methane concentrations from that of the other sources. Since the landfill remains closed, and no correlation between methane and toxic compounds was found, future monitoring should focus on methane, NMHC and toxics on a limited network of sites for continued trend analysis.

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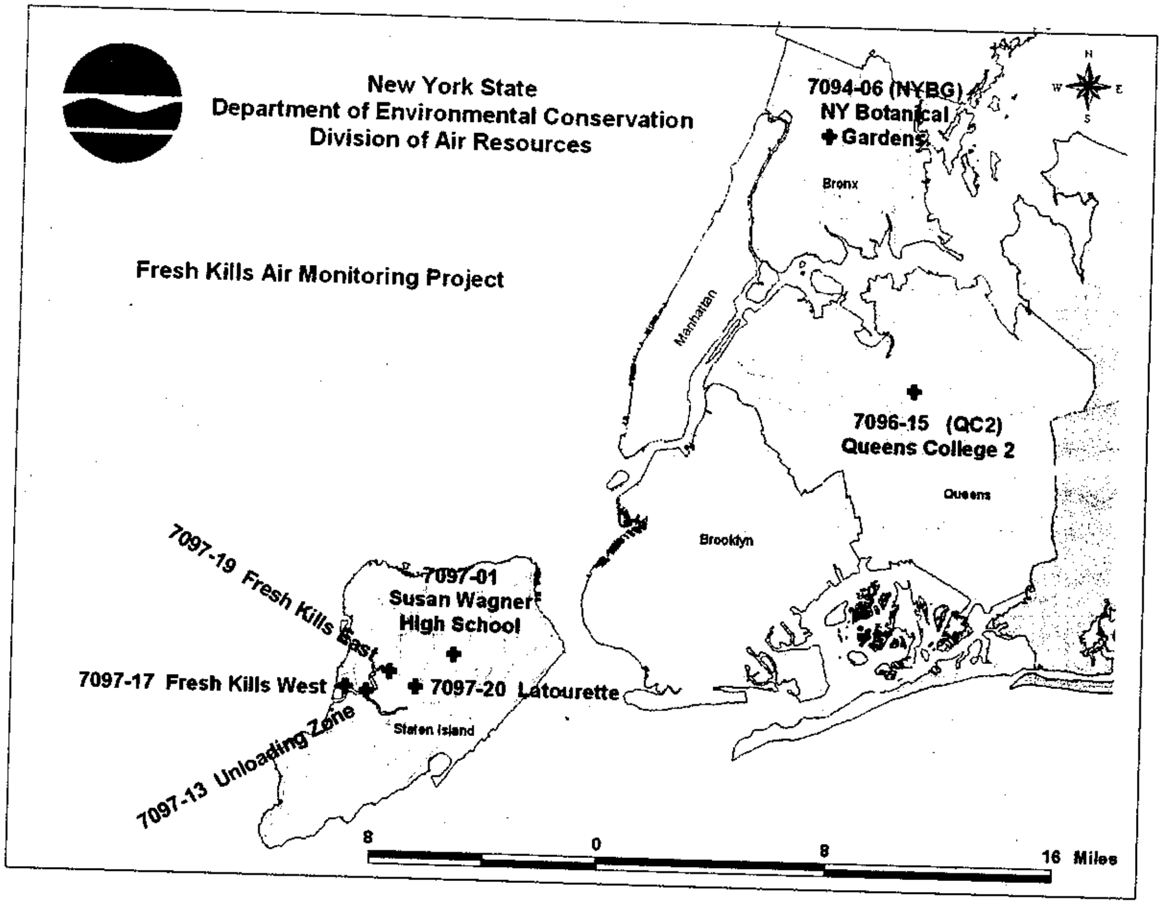
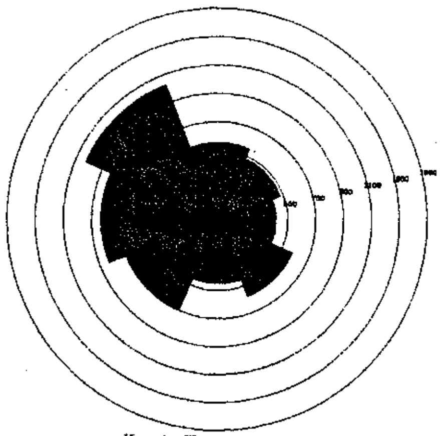
United States Environmental Protection Agency (EPA). 2004. Toxics Release Inventory – 2001. ONLINE: http://www.epa.gov/tri/

Figure 1. Location of air monitoring stations in and around Fresh Kills Landfill.



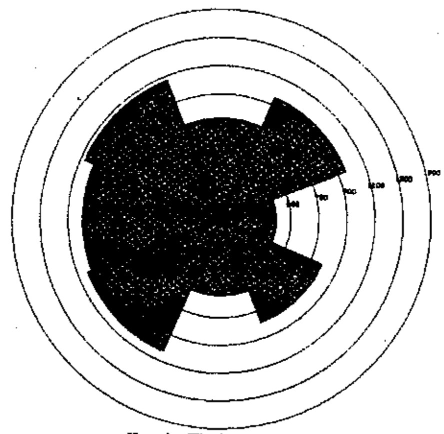
Figures 2a-2c. Wind roses for Fresh Kills West met site.

Fresh Kills West, NY



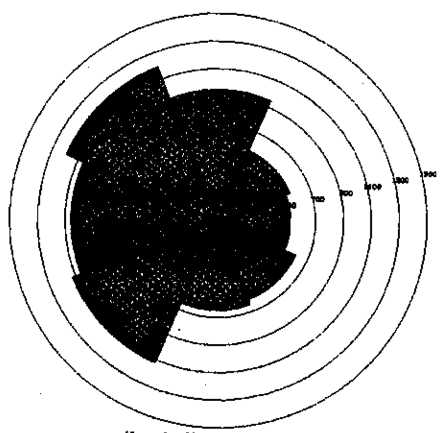
Hourly Wind Direction
2000

Fresh Kills West, NY



Hourly Wind Direction
2001

Fresh Kills West, NY



Hourly Wind Direction
2002

Table 1. Monitor names, ID's and sampling periods for Fresh Kills and surrounding sites. (* - Indicates toxic compound monitoring site)

Monitor ID	Monitor Name	Abbreviation	Sampling Period
709717	Fresh Kills West*	FKW	Oct 99 - Dec 02
709719	Fresh Kills East*	FKE	Sep 02 - Dec 02
709713	Fresh Kills Unloading Zone*	FKU	May 02 - Dec 02
709701	Susan Wagner High School	SWH	Jan 00 - Dec 02
709406	NY Botanical Gardens	NYB	Nov 99 - Dec 02
709720	LaTourette Golf Course*	LAT	-

Table 2. Approximate distance between monitors on the Fresh Kills landfill.

Monitor Pair	Miles	Kilometers
FKW - FKU	0.7	1.2
FKW - FKE	1.5	2.3
FKW - LAT	2.1	3.4
FKW - SWH	3.3	5.3
FKE - LAT	0.9	1.4
FKE - FKU	0.9	1.4
FKE - SWH	2.0	3.2
FKU - LAT	1.5	2.3
LAT - SWH	1.5	2.5

Table 3. Name and ID numbers for toxic compounds measured on Fresh Kills Landfill.

Identification Number	Name	Abbreviation
43218	1,3 Butadiene	13BD
43372	Methyl Tertiary Butyl Ether	MTBE
43814	1,1,1 Trichloroethane	111TC
43817	Tetrachloroethlene	PERC
43801	Chloromethane	CLMA
43803	Chloroform	CLFM
43824	Trichloroethylene	TCE
45109	M, P, Xylene	MPXYL
45201	Benzene	BENZ
45202	Toluene	TOL
45203	Ethylbenzene	EBENZ
45204	O Xylene	OXYL
45208	1,2,4 Trimethylbenzene	124TMB
45805	O Dichlorobenzene	ODCBZ
45806	M Dichlorobenzene	MDCBZ
45807	P Dichlorobenzene	PDCBZ

Table 4. Frequency of toxic compounds measured in the passive vents (n = 257) from the Fresh Kills Landfill in 1995.

Name	% Frequency of Detection
1,3 Butadiene	0
Methyl Tertiary Butyl Ether	8.6
1,1,1 Trichloroethane	72.9
Tetrachloroethlene	85.7
Chloromethane	77.1
Chloroform	0
Trichloroethylene	78.6
m,p- Xylene	100
Benzene	98.6
Toluene	100
Ethylbenzene	100
o-Xylene	100
1,2,4 Trimethylbenzene	100
o-Dichlorobenzene	97.1
m-Dichlorobenzene	97.1
p- Dichlorobenzene	100

Table 5a. Annual average hourly methane concentrations in ppm.

	Fresh Kills West (FKW)		Susan Wagner HS (SWH)		NY Botanical Gardens (NYB)	
Year	Average	SD	Average	SD	Average	SD
2000	5.12	8.54	2.22	0.99	2.09	0.31
2001	5.06	8.01	2.26	0.94	2.15	0.28
2002	4.81	8.2	2.18	0.84	2.24	0.66

Table 5b. Annual average daily maximum methane concentrations.

	Fresh Kills West (FKW)		Susan Wagner HS (SWH)		NY Botanical Gardens (NYB)	
Year	Average	SD	Average	SD	Average	SD
2000	20.27	19.87	4.09	2.29	2.62	1.13
2001	16.40	17.40	3.89	1.97	2.48	0.46
2002	17.26	19.04	3.54	2.23	2.58	0.85

Table 6a. Annual average hourly non-methane hydrocarbon concentrations.

	Fresh Kills West (FKW)		Susan Wagner HS (SWH)		NY Botanical Gardens (NYB)	
Year	Average	SD	Average	SD	Average	SD
2000	0.32	0.47	0.21	0.18	0.21	0.30
2001	0.69	1.47	0.20	0.15	0.23	0.33

2002	0.28	0.40	0.12	0.13	0.27	0.40

Table 6b. Annual average daily maximum non-methane hydrocarbon concentrations.

	Fresh Kills West (FKW)		Susan Wagner HS (SWH)		NY Botanical (NYB)	
Year	Average	SD	Average	SD	Average	SD
2000	1.08	1.12	0.44	0.33	0.57	0.78
2001	1.82	3.62	0.42	0.28	0.55	0.81
2002	0.78	1.27	0.26	0.40	0.72	0.96

Table 7a. Annual average hourly total hydrocarbon concentrations.

	Fresh Kills West (FKW)		Susan Wagner HS (SWH)		NY Botanical (NYB)	
Year	Average	SD	Average	SD	Average	SD
2000	5.48	8.68	2.43	1.07	2.29	0.52
2001	5.66	8.34	2.47	1.01	2.36	0.48
2002	5.06	8.21	2.40	0.89	2.53	0.95

Table 7b. Annual average daily maximum total hydrocarbon concentrations.

	Fresh Kills West (FKW)		Susan Wagner HS (SWH)		NY Botanical (NYB)	
Year	Average	SD	Average	SD	Average	SD
2000	20.73	19.73	4.47	2.61	3.14	1.57
2001	17.34	17.83	4.24	2.38	2.95	0.96
2002	17.66	19.16	3.80	2.03	3.24	1.42

Table 8. Coefficient of determination (R^2) for methane (above diagonal) and NMHC (below diagonal) when winds were from the SW to NW direction. (2000-2002 data)

	FKW	FKE	FKU	SWH	NYB
FKW	-	0.028	0.234	0.031	0.029
FKE	0.017	-	0.345	0.205	0.007
FKU	0.028	0.060	-	0.118	0.029
SWH	0.021	0.022	0.001	-	0.047
NYB	0.029	0.018	0.042	0.000	-

Table 9a. Correlations between CH_4 and NMHC with various toxic compounds at FKW

	CH_4		NMHC	
	N	R^2	N	R^2
13BD	151	0.105	151	0.131
MTBE	147	0.002	147	0.853
CLMA	168	0.001	168	0.099
DCMA	168	0.000	168	0.313
CLFM	168	0.017	168	0.308
111TCA	168	0.000	168	0.255
PERC	168	0.068	168	0.025
TCE	168	0.017	168	0.046
MPXYL	168	0.002	168	0.842
BENZ	168	0.012	168	0.845
TOL	168	0.003	168	0.827
EBENZ	168	0.003	168	0.857
OXYL	168	0.004	168	0.861
124TMB	168	0.003	168	0.832
ODCBZ	168	0.006	168	0.000
MDCBZ	168	0.000	168	0.000
PDCBZ	168	0.031	168	0.019

Table 9b. Correlations between CH_4 and NMHC with various toxic compounds at NYB

	CH_4		NMHC	
	N	R^2	N	R^2
13BD	100	0.065	99	0.082
MTBE	94	0.020	93	0.010
CLMA	106	0.010	105	0.017
DCMA	106	0.015	105	0.005
CLFM	106	0.058	105	0.040
111TCA	106	0.005	105	0.001
PERC	106	0.233	105	0.211
TCE	106	0.479	105	0.480
MPXYL	106	0.185	105	0.147
BENZ	106	0.083	105	0.095
TOL	106	0.071	105	0.073
EBENZ	106	0.157	105	0.122
OXYL	106	0.163	105	0.164
124TMB	106	0.395	105	0.379
ODCBZ	106	0.000	105	0.000
MDCBZ	106	0.000	105	0.000

Table 10a. (1,3 BD) Above diagonal & (MTBE) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.33	0.89	0.33	0.03
FKE	0.18	-	0.72	0.21	0.39
FKU	0.99	0.50	-	0.38	0.57
NYB	0.20	0.08	0.22	-	0.53
LAT	0.25	0.83	0.72	0.11	-

Table 10b. (1,1,1 TCE) Above diagonal & (PERC) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.00	0.99	0.00	0.00
FKE	0.63	-	0.20	0.03	0.04
FKU	0.98	0.77	-	0.00	0.05
NYB	0.00	0.00	0.00	-	0.03
LAT	0.81	0.55	0.87	0.16	-

Table 10c. (CLMA) Above diagonal & (CLFM) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.13	0.91	0.77	0.24
FKE	0.31	-	0.21	0.06	0.12
FKU	0.96	0.68	-	0.80	0.31
NYB	0.04	0.01	0.03	-	0.41
LAT	0.35	0.61	0.49	0.01	-

Table 10d. (TCE) Above diagonal & (MPXYL) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.54	0.94	0.02	0.19
FKE	0.37	-	0.76	0.08	0.36
FKU	0.99	0.81	-	0.03	0.31
NYB	0.27	0.27	0.33	-	0.18
LAT	0.38	0.77	0.90	0.39	-

Table 10e. (BENZ) Above diagonal & (TOL) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.20	0.99	0.15	0.28
FKE	0.25	-	0.76	0.53	0.80
FKU	0.99	0.75	-	0.21	0.86
NYB	0.16	0.45	0.23	-	0.67
LAT	0.27	0.81	0.89	0.59	-

Table 10f. (EBENZ) Above diagonal & (OXYL) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.38	0.99	0.31	0.39
FKE	0.39	-	0.80	0.34	0.77
FKU	0.99	0.81	-	0.37	0.87
NYB	0.17	0.30	0.25	-	0.38
LAT	0.38	0.76	0.89	0.42	-

Table 10g. (1,2,4 TMB) Above diagonal & (ODCBZ) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.42	0.99	0.03	0.34
FKE	0.35	-	0.82	0.23	0.66
FKU	0.98	0.40	-	0.05	0.71
NYB	0.22	0.40	0.22	-	0.23
LAT	0.33	0.14	0.18	0.11	-

Table 10h. (MDCBZ) Above diagonal & (PDCBZ) below diagonal.

	FKW	FKE	FKU	NYB	LAT
FKW	-	0.35	0.98	0.15	0.34
FKE	0.40	-	0.38	0.37	0.14
FKU	0.96	0.39	-	0.12	0.15
NYB	0.34	0.06	0.33	-	0.07
LAT	0.61	0.29	0.60	0.09	-

Table 11a. Benzene at Fresh Kills East (AGC=0.13 ug/m^3)

Year	Totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	robustavg	agcratio
1995	51	7	0.7902	1.5947	2.3360	3.5970	6.4042	1.7905	13.7572
1996	48	8	0.7838	1.8636	3.1185	4.7505	10.4610	2.3115	17.7609
1997	51	12	0.2313	1.2572	2.2317	3.3138	7.6758	1.6189	12.4393
1998	47	5	0.5388	0.9966	1.6301	2.3389	3.9400	1.1950	9.1814
2002	61	0	0.8597	1.1372	1.6062	2.1842	3.6366	1.3357	10.2612

Table 11b. Benzene at Fresh Kills West (AGC=0.13 ug/m^3)

Year	Totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	robustavg	agcratio
1995	50	8	0.7525	1.4719	2.4975	3.3355	5.3369	1.6671	12.8088
1996	46	10	0.3586	1.5634	2.6624	5.0258	9.6185	2.1035	16.1620
1997	48	9	0.6211	1.5886	2.4892	3.0972	7.8468	1.7197	13.2142
1999	17	0	1.3079	1.6317	1.9619	2.1628	2.9348	1.6374	12.5807
2000	54	0	0.9474	1.3302	1.9953	2.2126	8.0229	1.5781	12.1246
2001	54	0	1.4483	1.9044	2.7562	5.3413	40.9947	3.6047	27.6961
2002	52	0	0.9251	1.1963	1.7194	2.4225	3.5888	1.4058	10.8018

Table 12a. Tetrachloroethylene at Fresh Kills East (AGC=1.0 ug/m^3)

Year	totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	robustavg	agcratio
1995	51	10	0.5676	0.8148	1.3736	1.6989	4.1806	1.0002	0.9999
1996	48	9	0.6070	1.0687	1.8068	3.2422	16.9845	1.9467	1.9461
1997	51	15	0.3762	0.6994	1.2337	1.8856	4.5962	0.8881	0.8878
1998	47	7	0.6091	0.7455	1.0572	1.4748	2.2753	0.8535	0.8531
2002	61	19	0.2241	0.3395	0.5962	1.0891	1.9963	0.4746	0.4748

Table 12b. Tetrachloroethylene at Fresh Kills West (AGC=1.0 ug/m^3)

Year	totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	robustavg	agcratio
1995	52	20	0.3762	0.6138	0.8773	1.1346	3.0399	0.6104	0.6106
1996	50	18	0.3762	0.5873	0.8773	1.9786	6.2706	0.8766	0.8765
1997	49	25	0.3762	0.3762	0.7455	1.0436	2.7364	0.5004	0.5004
1999	17	2	0.4244	0.6620	0.8657	1.2507	2.2407	0.7394	0.7390
2000	54	21	0.2173	0.3395	0.5093	1.1326	6.2740	0.5208	0.5210
2001	54	10	0.3327	0.5500	1.0117	1.4191	3.1030	0.7028	0.7026
2002	52	18	0.2377	0.3667	0.5228	0.7944	1.4259	0.3857	0.3856

Table 13a. Trichloroethylene at Fresh Kills East (AGC=0.45 ug/m^3)

Year	totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	robustavg	agcratio
1995	52	22	0.0156	0.1267	0.3485	0.7051	2.2565	0.2766	0.6146
1996	50	20	0.0156	0.1820	0.4946	0.9521	1.9235	0.3469	0.7708
1997	50	21	0.0156	0.1751	0.6122	1.3892	4.6988	0.5869	1.3047
1998	47	25	0.0156	0.0156	0.2465	0.4285	0.5569	0.1498	0.3330
2002	61	10	0.1235	0.1584	0.2148	0.3152	0.6390	0.1783	0.3963

Table 13b. Trichloroethylene at Fresh Kills West (AGC=0.45 ug/m³)

Year	totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	robustavg	agcratio
1995	51	29	0.0156	0.0156	0.1751	0.3276	0.9108	0.1181	0.2620
1996	50	35	0.0156	0.0156	0.1095	0.2583	0.5778	0.0671	0.1489
1997	48	33	0.0156	0.0156	0.2169	0.6331	2.6104	0.2229	0.4955
1999	17	5	0.1074	0.2417	0.3625	0.8248	1.0203	0.3184	0.7076
2000	54	35	0.0537	0.0698	0.1477	0.3179	1.1277	0.1010	0.2240
2001	54	16	0.0940	0.1933	0.4591	0.6788	1.8580	0.3077	0.6835
2002	52	24	0.0806	0.1235	0.1826	0.2502	0.4457	0.1224	0.2719

Table 14a. P Dichlorobenzene at Fresh Kills East (AGC=0.09 ug/m³)

Year	totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	Robustavg	agcratio
1995	52	48	0.3630	0.3630	0.3630	0.3630	1.7471		
1996	51	30	0.3630	0.3630	0.7849	1.3492	2.7640	0.4724	5.2422
1997	49	21	0.3630	0.5145	0.8943	1.4490	2.2039	0.5956	6.6056
1998	47	21	0.3312	0.5181	0.7494	1.1137	1.6185	0.5121	5.6820
2002	61	20	0.1791	0.2945	0.4327	0.5649	0.7813	0.3095	3.4325

Table 14b. P Dichlorobenzene at Fresh Kills West (AGC=0.09 ug/m³)

Year	totcount	lmdlcount	Per25	Per50	Per75	Per90	maks	Robustavg	agcratio
1995	52	51	0.3630	0.3630	0.3630	0.3630	0.7236		
1996	49	43	0.3630	0.3630	0.3630	0.5102	0.7879		
1997	49	38	0.3630	0.3630	0.3630	0.6731	0.9874	0.2801	3.1090
1999	17	6	0.1803	0.3065	0.5860	0.7152	0.8414	0.3690	4.0929
2000	54	43	0.0811	0.1202	0.2043	0.3798	1.0698	0.1076	1.1938
2001	54	23	0.0631	0.2945	0.5259	0.8126	2.4461	0.3732	4.1390
2002	52	32	0.1382	0.2284	0.3245	0.4820	0.7513	0.1947	2.1590

Table 15. Percent of total state emissions of selected toxic compounds by county and source category (USEPA 1996).

Chemical Abbreviation	County	% Major	% Area	% On-Road	% Non-Road
EBENZ	Richmond	3.5	1.5	1.2	0.5
	Union	21.6	2.0	1.4	0.8
	Middlesex	23.1	2.6	2.8	1.5
BENZ	Richmond	3.2	0.5	1.0	0.7
	Union	19.9	1.4	1.8	1.1
	Middlesex	14.5	1.3	2.6	2.0
O,M,P XYL	Richmond	1.1	1.2	1.2	0.5
	Union	11.1	1.9	1.4	0.7
	Middlesex	11.5	2.6	2.7	1.4
TOL	Richmond	4.4	1.2	1.2	0.5
	Union	4.6	2.1	1.4	0.8
	Middlesex	7.7	2.4	2.7	1.5
MTBE	Richmond	0	1.1	1.6	0.5
	Union	39.1	3.4	2.8	0.7
	Middlesex	15.4	3.7	4.0	1.2

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Fresh Kills East [Site #7097-19] Annual VOC Data (2002-2003)

FE [Site #7097-19] 2002 data

AIRS Code	Compound	MDL PPBv	Min Value	Max Value	Median	Average	AGC PPBv
43823	dichlorodifluoromethane	0.02	0.474	1.051	0.611	0.633	2427
43801	chloromethane	0.02	0.297	0.87	0.584	0.575	373
43208	dichlorotetrafluoroethane	0.04	0	0.091	0.023	0.027	2432
43860	vinylchloride	0.05	0	0.072	0	NC	0.04
43218	13-Butadiene	0.04	0	0.279	0.068	0.077	0.01
43819	bromomethane	0.03	0	0.11	0.013	0.021	1.29
43812	chloroethane	0.06	0	0	0	NC	3790
43811	trichloromonofluoromethane	0.03	0.259	0.49	0.327	0.335	3560
43826	1,1-dichloroethene	0.02	0	0.031	0	NC	0.005
43802	dichloromethane	0.02	0.034	0.515	0.127	0.165	0.61
43207	trichlorotrifluoroethane	0.02	0.06	0.136	0.083	0.085	23488
43813	1,1-dichloroethane	0.02	0	0.031	0	NC	5
43372	MTBE	0.03	0.267	5.093	1.141	1.396	834
43835	2-chloroprene	0.08	0	0	0	NC	23.9
43839	cis 1,2-dichloroethene	0.03	0	0.03	0	NC	479
43803	chloroform	0.02	0.019	0.095	0.035	0.037	0.009
43815	1,2-dichloroethane	0.03	0	0.035	0.01	0.015	0.01
43814	1,1,1-trichloroethane	0.02	0.034	0.103	0.049	0.051	183
45201	benzene	0.03	0.087	1.14	0.357	0.419	0.04
43804	carbon tetrachloride	0.03	0.09	0.17	0.123	0.126	0.01
43829	1,2-dichloropropane	0.03	0	0.027	0	NC	0.87
43828	Bromodichloromethane	0.02	0	0.03	0	NC	0.003
43824	trichloroethene	0.02	0.012	0.119	0.03	0.035	0.08
43831	cis 1,3-dichloropropene	0.03	0	0.028	0	NC	0.04
43830	trans 1,3-dichloropropene	0.04	0	0.029	0	NC	0.04
43820	1,1,2-trichloroethane	0.03	0	0.026	0	NC	0.01

45202	toluene	0.04	0.277	2.768	0.797	0.950	106
43843	1,2-dibromoethane	0.03	0	0.028	0	NC	0.0007
43817	tetrachloroethene	0.02	0.019	0.294	0.051	0.079	0.15
45801	chlorobenzene	0.03	0	0.035	0.011	0.014	23.9
45203	ethylbenzene	0.06	0.049	0.468	0.148	0.175	230
45109	m/p-xylene	0.06	0.126	1.298	0.392	0.459	161
43806	Tribromomethane	0.03					
45220	styrene	0.10	0.02	0.449	0.101	0.133	235
43818	1,1,2,2-tetrachloroethane	0.03	0	0.02	0	NC	0.02
45204	o-xylene	0.04	0.046	0.43	0.139	0.162	161
45207	1,3,5-trimethylbenzene	0.05	0.012	0.14	0.048	0.055	59
45208	1,2,4-trimethylbenzene	0.05	0.027	0.428	0.136	0.155	59
45809	a-chlorotoluene	0.04	0	0.028	0	NC	0.004
45806	1,3-dichlorobenzene	0.03	0	0.032	0.006	0.012	60
45807	1,4-dichlorobenzene	0.04	0	0.13	0.05	0.055	0.015
45805	1,2-dichlorobenzene	0.03	0	0.034	0.007	0.012	60
45810	1,2,4-trichlorobenzene	0.03	0	0.036	0.006	0.010	NA
43844	hexachlorobutadiene	0.02	0	0.04	0.004	0.010	0.005

2002 Data Completeness: 100%, with the following exception(s):
Bromodichloromethane - 79%

FE [Site #7097-19] 2003 data

AIRS Code	Compound	MDL PPBv	Min Value	Max Value	Median	Average	AGC PPBv
43823	dichlorodifluoromethane	0.04	0.472	0.877	0.652	0.656	2427
43801	chloromethane	0.07	0.417	0.915	0.639	0.634	373
43208	dichlorotetrafluoroethane	0.03	0.016	0.056	0.028	0.030	2432
43860	vinylchloride	0.07	0	0.068	0		0.04
43218	13-Butadiene	0.03	0	0.283	0.084	0.096	0.01
43819	bromomethane	0.04	0	0.072	0.012	0.018	1.29
43812	chloroethane	0.05	0	0.066	0		3790
43811	trichloromonofluoromethane	0.04	0.273	0.456	0.317	0.340	3560
43826	1,1-dichloroethene	0.04	0	0.034	0		0.005
43802	dichloromethane	0.02	0.051	1.367	0.146	0.233	0.61
43207	trichlorotrifluoroethane	0.05	0.053	0.113	0.081	0.083	23488
43813	1,1-dichloroethane	0.04	0	0.029	0		5
43372	MTBE	0.05	0.085	9.142	0.939	1.473	834
43835	2-chloroprene	0.03	0	0	0		23.9
43839	cis 1,2-dichloroethene	0.04	0	0.025	0		479
43803	chloroform	0.04	0.016	0.145	0.043	0.058	0.009
43815	1,2-dichloroethane	0.03	0	0.042	0.014	0.016	0.01
43814	1,1,1-trichloroethane	0.04	0.029	0.153	0.041	0.046	183
45201	benzene	0.05	0.143	5.983	0.399	0.546	0.04
43804	carbon tetrachloride	0.05	0.025	0.148	0.109	0.110	0.01
43829	1,2-dichloropropane	0.05	0	0.032	0		0.87
43828	Bromodichloromethane	0.05	0	0.032	0		0.003
43824	trichloroethene	0.05	0.009	0.105	0.028	0.032	0.08
43831	cis 1,3-dichloropropene	0.05	0	0.027	0		0.04
43830	trans 1,3-dichloropropene	0.04	0	0.026	0		0.04
43820	1,1,2-trichloroethane	0.05	0	0.025	0.003	0.017	0.01
45202	toluene	0.05	0.122	3.178	0.783	0.999	106
43843	1,2-dibromoethane	0.04	0	0.031	0.006	0.014	0.0007
43817	tetrachloroethene	0.04	0.017	0.347	0.059	0.082	0.15

45801	chlorobenzene	0.04	0.003	0.047	0.015	0.015	23.9
45203	ethylbenzene	0.07	0.019	0.325	0.128	0.137	230
45109	m/p-xylene	0.12	0.037	1.369	0.356	0.413	161
45220	styrene	0.10	0.005	0.358	0.045	0.073	235
43818	1,1,2,2-tetrachloroethane	0.04	0	0.035	0.004	0.014	0.02
45204	o-xylene	0.05	0.014	0.382	0.131	0.136	161
45207	1,3,5-trimethylbenzene	0.06	0.004	0.136	0.05	0.055	59
45208	1,2,4-trimethylbenzene	0.05	0.01	0.448	0.141	0.161	59
45809	a-chlorotoluene	0.06	0	0.025	0.002	0.005	0.004
45806	1,3-dichlorobenzene	0.05	0.004	0.035	0.009	0.010	60
45807	1,4-dichlorobenzene	0.05	0.003	0.111	0.044	0.047	0.015
45805	1,2-dichlorobenzene	0.05	0.004	0.038	0.011	0.013	60
45810	1,2,4-trichlorobenzene	0.04	0	0.023	0.006	0.009	NA
43844	hexachlorobutadiene	0.06	0.003	0.036	0.007	0.009	0.005

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Fresh Kills West - Upwind Site [Site #7097-17] Annual Voc Data (1999-2003)

FW [Site #7097-17] 1999 data

AIRS Code	Compound	MDL PPBv	Min Value	Max Value	Median	Average	AGC PPBv
43823	dichlorodifluoromethane	0.10	0.50	0.83	0.66	0.66	2432
43801	chloromethane	0.10	0.40	0.72	0.52	0.52	373.6
43208	dichlorotetrafluoroethane	0.10	0.05	0.07	0.05	0.05	2353
43860	vinylchloride	0.08	0.04	0.06	0.04	0.04	0.005
43819	bromomethane	0.03	0.02	0.08	0.04	0.04	1.29
43812	chloroethane	0.10	0.05	0.08	0.05	0.05	3797
43811	trichloromonofluoromethane	0.10	0.22	0.41	0.32	0.31	3567
43826	1,1-dichloroethene	0.10	0.05	0.11	0.05	0.06	0.005
43802	dichloromethane	0.25	0.12	0.78	0.33	0.32	0.61
43207	trichlorotrifluoroethane	0.10	0.07	0.15	0.11	0.10	22801
43813	1,1-dichloroethane	0.10	0.05	0.05	0.05	0.05	5
43839	cis 1,2-dichloroethene	0.10	0.05	0.05	0.05	0.05	0.026
43803	chloroform	0.02	0.01	0.09	0.05	0.05	0.009
43815	1,2-dichloroethane	0.01	0.00	0.04	0.02	0.02	0.009
43814	1,1,1-trichloroethane	0.03	0.05	0.29	0.13	0.14	185.6
45201	benzene	0.04	0.17	0.92	0.50	0.50	0.04
43804	carbon tetrachloride	0.02	0.14	0.20	0.16	0.16	0.01
43829	1,2-dichloropropane	0.10	0.05	0.05	0.05	0.05	0.87
43824	trichloroethene	0.02	0.01	0.19	0.04	0.06	0.08
43831	cis 1,3-dichloropropene	0.10	0.05	0.05	0.05	0.05	0.055
43830	trans 1,3-dichloropropene	0.10	0.05	0.15	0.05	0.06	0.055
43820	1,1,2-trichloroethane	0.03	0.02	0.11	0.03	0.04	0.01
45202	toluene	0.04	0.24	2.22	1.17	1.15	106.4
43843	1,2-dibromoethane	0.10	0.05	0.05	0.05	0.05	0.0006
43817	tetrachloroethene	0.04	0.02	0.33	0.10	0.11	0.148
45801	chlorobenzene	0.02	0.01	0.04	0.03	0.02	23.9

45203	ethylbenzene	0.02	0.01	0.39	0.22	0.21	230.8
45109	m/p-xylene	0.04	0.15	1.19	0.75	0.69	161.5
45220	styrene	0.49	0.24	0.51	0.24	0.26	235
43818	1,1,2,2-tetrachloroethane	0.20	0.10	0.10	0.10	0.10	0.002
45204	o-xylene	0.03	0.06	0.53	0.30	0.29	161.5
45207	1,3,5-trimethylbenzene	0.26	0.13	0.59	0.13	0.18	59.1
45208	1,2,4-trimethylbenzene	0.03	0.05	1.43	0.25	0.35	59.1
45809	a-chlorotoluene	0.10	0.05	1.34	0.09	0.24	0.004
45806	1,3-dichlorobenzene	0.03	0.02	0.13	0.03	0.04	0.015
45807	1,4-dichlorobenzene	0.04	0.02	0.14	0.05	0.07	0.015
45805	1,2-dichlorobenzene	0.03	0.02	0.04	0.03	0.02	60
45810	1,2,4-trichlorobenzene	0.16	0.08	0.08	0.08	0.08	1.21
43844	hexachlorobutadiene	0.10	0.05	0.05	0.05	0.05	0.004

1999 Data Completeness: 59%

FW [Site #7097-17] 2000 data

AIRS Code	Compound	MDL PPBv	Min Value	Max Value	Median	Average	AGC PPBv
43814	1,1,1-trichloroethane	0.02	0.019	0.123	0.059	0.063	185.6
80246	1,1,2,2-tetrachloroethane	0.20	0.001	0.1	0.011	0.035	0.02
43820	1,1,2-trichloroethane	0.03	0.003	0.077	0.015	0.017	0.01
43813	1,1-dichloroethane	0.10	0.001	0.05	0.0075	0.020	5
43826	1,1-dichloroethene	0.10	0.002	0.05	0.05	0.031	0.005
45830	1,2,4-trichlorobenzene	0.16	0.001	0.154	0.08	0.067	NA
45208	1,2,4-trimethylbenzene	0.03	0.006	1.041	0.1615	0.192	59.1
43837	1,2-dibromoethane	0.10	0.001	0.058	0.027	0.030	0.0007
45805	1,2-dichlorobenzene	0.03	0.001	0.059	0.0065	0.010	60
43815	1,2-dichloroethane	0.01	0.001	0.05	0.005	0.013	0.01
43829	1,2-dichloropropane	0.10	0.002	0.057	0.05	0.034	0.87
45207	1,3,5-trimethylbenzene	0.26	0.02	0.404	0.076	0.101	59.1
80184	1,3-dichlorobenzene	0.03	0.003	0.1	0.015	0.021	60
45806	1,4-dichlorobenzene	0.04	0.001	0.178	0.02	0.031	0.015
45807	13Butadiene	0.05	0.003	0.624	0.05	0.062	0.01
43835	2-chloroprene	0.10	0.025	0.05	0.05	0.049	23.9
97100	Achlorotoluene	0.10	0.001	0.064	0.049	0.032	0.004
45201	benzene	0.04	0.11	2.515	0.4235	0.495	0.04
43828	Bromodichloromethane	0.10	0.004	0.05	0.05	0.046	0.003
80200	bromomethane	0.03	0.001	0.1	0.012	0.014	1.29
43804	carbontetrachloride	0.02	0.044	0.44	0.0985	0.104	0.01
45801	chlorobenzene	0.02	0.001	0.078	0.01	0.014	23.9
43812	chloroethane	0.10	0.023	0.092	0.05	0.050	3797
43803	chloroform	0.02	0.005	0.118	0.0235	0.029	0.009
97020	chloromethane	0.10	0.05	1.934	0.4475	0.470	373.6
97070	cis 1,2-dichloroethene	0.10	0.003	0.07	0.005	0.009	479
97080	cis 1,3-dichloropropene	0.10	0.001	0.05	0.05	0.031	0.04
97010	dichlorodifluoromethane	0.10	0.05	2.175	0.5645	0.623	2427
43802	dichloromethane	0.25	0.0125	1.627	0.129	0.234	0.61
97030	dichlorotetrafluoroethane	0.10	0.001	0.05	0.0095	0.013	2432

45203	ethylbenzene	0.02	0.038	0.938	0.155	0.180	230.8
80184	hexachlorobutadiene	0.10	0.002	0.13	0.032	0.033	0.005
45109	m/p-xylene	0.04	0.127	3.08	0.4615	0.523	161.5
43372	MTBE	0.10	0.001	9.06	0.84	1.575	834
45204	o-xylene	0.03	0.015	1.493	0.1855	0.224	161.5
45220	styrene	0.49	0.001	0.467	0.0395	0.083	235
43817	tetrachloroethene	0.04	0.008	0.924	0.0505	0.087	0.15
45202	toluene	0.04	0.237	7.753	0.961	1.223	106.4
97090	trans 1,3-dichloropropene	0.10	0.001	0.05	0.05	0.031	0.04
43806	Tribromomethane	0.05	0.002	0.05	0.011	0.023	0.09
43824	trichloroethene	0.02	0.002	0.21	0.014	0.026	0.08
97060	trichloromonofluoromethane	0.10	0.122	0.518	0.282	0.279	3567
97040	trichlorotrifluoroethane	0.10	0.025	0.227	0.0785	0.079	23488
43860	vinylchloride	0.08	0.002	0.04	0.040	0.034	0.005

2000 Data Completeness: 89%, with the following exception(s):

2-chloroprene - 84%

Chlorobenzene - 87%

FW [Site #7097-17] 2001 data

AIRS Code	Compound	MDL PPBv	Min Value	Max Value	Median	Average	AGC PPBv
43823	dichlorodifluoromethane	0.02	0.5	1.939	0.6665	0.807	2427
43801	chloromethane	0.02	0.053	1.649	0.5585	0.678	373
43208	dichlorotetrafluoroethane	0.04	0.000	0.09	0.0235	0.032	2432
43860	vinylchloride	0.05	0.000	0.101	0.000		0.04
43218	13-Butadiene	0.04	0.000	0.819	0.09	0.121	0.01
43819	bromomethane	0.03	0.000	0.13	0.017	0.028	1.29
43812	chloroethane	0.06	0.000	0.000	0.000		3790
43811	trichloromonofluoromethane	0.03	0.269	1.061	0.3415	0.421	3560
43826	1,1-dichloroethene	0.02	0.000	0.16	0.000		0.005
43802	dichloromethane	0.02	0.000	44.826	0.8555	3.376	0.61
43207	trichlorotrifluoroethane	0.02	0.063	3.569	0.1225	0.208	23488
43813	1,1-dichloroethane	0.02	0.000	0.151	0.008	0.023	5
43372	MTBE	0.03	0.355	213.2	4.104	10.873	834
43835	2-chloroprene	0.08	0.000	0.000	0.000		23.9
43839	cis 1,2-dichloroethene	0.03	0.000	0.118	0.000		479
43803	chloroform	0.02	0.000	0.32	0.047	0.066	0.009
43815	1,2-dichloroethane	0.03	0.000	1.065	0.0085	0.046	0.01
43814	1,1,1-trichloroethane	0.02	0.017	21.349	0.161	1.027	183
45201	benzene	0.03	0.225	12.851	0.6035	1.130	0.04
43804	carbon tetrachloride	0.03	0.065	0.387	0.121	0.151	0.01
43829	1,2-dichloropropane	0.03	0.000	0.164	0.000		0.87
43828	Bromodichloromethane	0.02	0.000	0.645	0.000		0.003
43824	trichloroethene	0.02	0.000	0.346	0.04	0.061	0.08
43831	cis 1,3-dichloropropene	0.03	0.000	0.172	0.000		0.04
43830	trans 1,3-dichloropropene	0.04	0.000	0.193	0.000		0.04
43820	1,1,2-trichloroethane	0.03	0.000	0.145	0.000		0.01
45202	toluene	0.04	0.533	88.566	1.7485	5.325	106
43843	1,2-dibromoethane	0.03	0.000	0.211	0.000		0.0007

43817	tetrachloroethene	0.02	0.011	0.457	0.0825	0.108	0.15
45801	chlorobenzene	0.03	0.000	0.255	0.013	0.031	23.9
45203	ethylbenzene	0.06	0.025	15.165	0.2915	0.802	230
45109	m/p-xylene	0.06	0.172	52.054	0.78	2.736	161
43806	Tribromomethane	0.03	0.000	2.186	0.000		
45220	styrene	0.10	0.000	0.711	0.091	0.124	235
43818	1,1,2,2-tetrachloroethane	0.03	0.000	0.777	0.004	0.037	0.02
45204	o-xylene	0.04	0.075	17.237	0.2805	0.903	161
45207	1,3,5-trimethylbenzene	0.05	0.009	5.533	0.087	0.288	59
45208	1,2,4-trimethylbenzene	0.05	0.042	15.086	0.225	0.818	59
45809	a-chlorotoluene	0.04	0.000	0.131	0.0015		0.004
45806	1,3-dichlorobenzene	0.03	0.000	0.312	0.000		60
45807	1,4-dichlorobenzene	0.04	0.000	0.407	0.05	0.069	0.015
45805	1,2-dichlorobenzene	0.03	0.000	0.322	0.003	0.035	60
45810	1,2,4-trichlorobenzene	0.03	0.000	0.457	0.000		NA
43844	hexachlorobutadiene	0.02	0.000	0.173	0.000		0.005

2001 Data Completeness: 89%, with the following exception(s):

MTBE - 82%

Tribromomethane - 88%

FW [Site #7097-17] 2002 data

AIRS Code	Compound	MDL PPBv	Min Value	Max Value	Median	Average	AGC PPBv
43823	dichlorodifluoromethane	0.02	0.490	0.926	0.565	0.581	2427
43801	chloromethane	0.02	0.292	0.798	0.589	0.569	373
43208	dichlorotetrafluoroethane	0.04	0.000	0.048	0.020	0.022	2432
43860	vinylchloride	0.05	0.000	0.035	0.000	NC	0.04
43218	13-Butadiene	0.04	0.000	0.304	0.052	0.069	0.01
43819	bromomethane	0.03	0.000	0.133	0.018	0.025	1.29
43812	chloroethane	0.06	0.000	0.000	0.000	NC	3790
43811	trichloromonofluoromethane	0.03	0.260	0.389	0.302	0.305	3560
43826	1,1-dichloroethene	0.02	0.000	0.028	0.000	NC	0.005
43802	dichloromethane	0.02	0.052	4.301	0.172	0.399	0.61
43207	trichlorotrifluoroethane	0.02	0.057	0.141	0.085	0.092	23488
43813	1,1-dichloroethane	0.02	0.000	0.037	0.006	0.013	5
43372	MTBE	0.03	0.000	13.274	1.857	2.402	834
43835	2-chloroprene	0.08	0.000	0.000	0.000	NC	23.9
43839	cis 1,2-dichloroethene	0.03	0.000	0.034	0.000	NC	479
43803	chloroform	0.02	0.010	0.103	0.032	0.037	0.009
43815	1,2-dichloroethane	0.03	0.000	0.043	0.000	NC	0.01
43814	1,1,1-trichloroethane	0.02	0.042	1.443	0.070	0.137	183
45201	benzene	0.03	0.118	1.125	0.376	0.441	0.04
43804	carbon tetrachloride	0.03	0.089	0.157	0.119	0.123	0.01
43829	1,2-dichloropropane	0.03	0.000	0.034	0.000	NC	0.87
43828	Bromodichloromethane	0.02	0.000	0.097	0.005	0.018	0.003
43824	trichloroethene	0.02	0.000	0.083	0.024	0.027	0.08
43831	cis 1,3-dichloropropene	0.03	0.000	0.034	0.003	0.015	0.04
43830	trans 1,3-dichloropropene	0.04	0.000	0.033	0.005	0.017	0.04
43820	1,1,2-trichloroethane	0.03	0.000	0.033	0.000	NC	0.01
45202	toluene	0.04	0.174	4.511	0.849	1.112	106
43843	1,2-dibromoethane	0.03	0.000	0.036	0.007	0.015	0.0007

43817	tetrachloroethene	0.02	0.017	0.210	0.056	0.066	0.15
45801	chlorobenzene	0.03	0.000	0.047	0.011	0.015	23.9
45203	ethylbenzene	0.06	0.042	0.483	0.148	0.166	230
45109	m/p-xylene	0.06	0.128	1.400	0.410	0.475	161
43806	Tribromomethane	0.03					
45220	styrene	0.10	0.000	0.254	0.044	0.056	235
43818	1,1,2,2-tetrachloroethane	0.03	0.000	0.031	0.000	NC	0.02
45204	o-xylene	0.04	0.046	0.502	0.146	0.166	161
45207	1,3,5-trimethylbenzene	0.05	0.015	0.178	0.050	0.056	59
45208	1,2,4-trimethylbenzene	0.05	0.039	0.444	0.134	0.154	59
45809	a-chlorotoluene	0.04	0.000	0.030	0.007	0.016	0.004
45806	1,3-dichlorobenzene	0.03	0.000	0.036	0.010	0.014	60
45807	1,4-dichlorobenzene	0.04	0.010	0.125	0.038	0.042	0.015
45805	1,2-dichlorobenzene	0.03	0.000	0.040	0.011	0.015	60
45810	1,2,4-trichlorobenzene	0.03	0.000	0.037	0.010	0.014	NA
43844	hexachlorobutadiene	0.02	0.000	0.044	0.009	0.014	0.005

2002 Data Completeness: 85%, with the following exception(s):

Bromodichloromethane - 67%

FW [Site #7097-17] 2003 data

AIRS Code	Compound	MDL PPBv	Min Value	Max Value	Median	Average	AGC PPBv
43823	dichlorodifluoromethane	0.04	0.445	0.834	0.625	0.635	2427
43801	chloromethane	0.07	0.355	0.872	0.659	0.639	373
43208	dichlorotetrafluoroethane	0.03	0.000	0.056	0.021	0.022	2432
43860	vinylchloride	0.07	0.000	0.035	0.000		0.04
43218	13-Butadiene	0.03	0.018	0.232	0.076	0.084	0.01
43819	bromomethane	0.04	0.000	0.061	0.013	0.019	1.29
43812	chloroethane	0.05	0	0	0		3790
43811	trichloromonofluoromethane	0.04	0.256	0.473	0.327	0.336	3560
43826	1,1-dichloroethene	0.04	0	0.043	0		0.005
43802	dichloromethane	0.02	0.088	7.640	0.236	0.771	0.61
43207	trichlorotrifluoroethane	0.05	0.059	0.137	0.084	0.086	23488
43813	1,1-dichloroethane	0.04	0.000	0.044	0.000		5
43372	MTBE	0.05	0.108	8.727	1.175	2.064	834
43835	2-chloroprene	0.03	0.000	0.000	0.000		23.9
43839	cis 1,2-dichloroethene	0.04	0	0.042	0		479
43803	chloroform	0.04	0.013	0.085	0.033	0.035	0.009
43815	1,2-dichloroethane	0.03	0.000	0.050	0.015	0.016	0.01
43814	1,1,1-trichloroethane	0.04	0.042	3.318	0.062	0.282	183
45201	benzene	0.05	0.170	0.965	0.390	0.449	0.04
43804	carbon tetrachloride	0.05	0.063	0.167	0.112	0.114	0.01
43829	1,2-dichloropropane	0.05	0.000	0.043	0.000		0.87
43828	Bromodichloromethane	0.05	0.000	0.059	0.000		0.003
43824	trichloroethene	0.05	0.008	0.079	0.022	0.027	0.08
43831	cis 1,3-dichloropropene	0.05	0.000	0.037	0.000		0.04
43830	trans 1,3-dichloropropene	0.04	0.000	0.041	0.003		0.04
43820	1,1,2-trichloroethane	0.05	0.000	0.038	0.000		0.01
45202	toluene	0.05	0.142	3.077	0.790	1.051	106
43843	1,2-dibromoethane	0.04	0.000	0.048	0.006	0.011	0.0007
43817	tetrachloroethene	0.04	0.017	0.291	0.058	0.070	0.15

45801	chlorobenzene	0.04	0.004	0.046	0.009	0.011	23.9
45203	ethylbenzene	0.07	0.020	0.313	0.110	0.122	230
45109	m/p-xylene	0.12	0.045	1.006	0.338	0.387	161
45220	styrene	0.10	0.010	0.107	0.034	0.041	235
43818	1,1,2,2-tetrachloroethane	0.04	0.000	0.038	0.004	0.013	0.02
45204	o-xylene	0.05	0.018	0.340	0.122	0.128	161
45207	1,3,5-trimethylbenzene	0.06	0.007	0.132	0.045	0.049	59
45208	1,2,4-trimethylbenzene	0.05	0.016	0.355	0.129	0.138	59
45809	a-chlorotoluene	0.06	0.000	0.027	0.000		0.004
45806	1,3-dichlorobenzene	0.05	0.004	0.041	0.008	0.010	60
45807	1,4-dichlorobenzene	0.05	0.007	0.085	0.032	0.034	0.015
45805	1,2-dichlorobenzene	0.05	0.000	0.044	0.010	0.012	60
45810	1,2,4-trichlorobenzene	0.04	0.000	0.026	0.007	0.009	NA
43844	hexachlorobutadiene	0.06	0.002	0.043	0.007	0.008	0.005

2003 Data Completeness: 74%