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MACT Implementation at an Organic Chemical Manufacturing Facility: Human Health Risk Reduction

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MACT Implementation at an Organic Chemical Manufacturing Facility: Human Health Risk Reduction

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Abstract

Human health risk assessments are used by environmental regulatory agencies to determine risk from Hazardous Air Pollutants (HAPs). In this study, the Human Exposure Model (HEM-3) was used to compare the cancer and non-cancer inhalation health effects of a single organic chemical manufacturing facility in Geismar, Louisiana prior to and after Maximum Achievable Control Technologies (MACT) were implemented. The results indicate significant reductions in both cancer risk and non-cancer hazards. The analysis also indicated that the equivalent cancer risk reduction could have been achieved by addressing MACT in only one production process and one single pollutant (ethylene dichloride) within that process. This demonstrates the value that these risk assessments have at evaluating emissions at the facility level, and how they could be used in the control strategy decision making process.

KEYWORDS: Risk Assessment, Maximum Achievable Control Technology, MACT, NESHAP, Cancer Risk, Organic Chemical Manufacturing, Inhalation, Human Exposure Model, HEM-3

Introduction

Purpose of Research

The purpose of this research was to determine the inhalation health impacts of implementation of National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations at an organic chemical manufacturing facility in Geismar, Louisiana. The facility is regulated by the Environmental Protection Agency (EPA) and Louisiana Department of Environmental Quality (LDEQ) under the Clean Air Act (CAA). The Clean Air Act was originally established in 1963, giving the federal government responsibility for air pollution control. The most dramatic change in the CAA came in the form of the 1970 Clean Air Act Amendments. These amendments formed the Environmental Protection Agency (EPA) and several programs for air quality standards, most notably, the National Ambient Air Quality Standards (NAAQS), New Source Performance Standards (NSPS), and National Emission Standards for Hazardous Air Pollutants (NESHAP).

The original NESHAP regulations required setting pollutant specific, health based standards for each Hazardous Air Pollutant (HAP). HAPs are those pollutants that are hazardous to public health or the environment, but are not regulated under other portions of the Clean Air Act. The implementation of these standards proved to be cumbersome, and NESHAP standards were only established for nine pollutants. Title III of the 1990 Clean Air Act Amendments brought sweeping changes to this program. According to the CAA Amendments, HAPs “present, or may present, through inhalation or other routes of exposure, a threat of adverse human health effects (including, but not limited to, substances which are known to be, or may reasonably be anticipated to be, carcinogenic, mutagenic, teratogenic, neurotoxic, which cause reproductive dysfunction, or which are acutely or chronically toxic) or adverse environmental effects whether through ambient concentrations, bioaccumulation, deposition, …”. The Hazardous Air Pollutant list was then expanded to the current 188 listed chemicals. The 1990 CAA amendments required establishment of technology based standards for source categories of these listed HAPs. If a facility has a potential to emit of 10 tons per year of an individual HAP, or an aggregate total of 25 tones per year of all listed HAPs, the site is considered a major source of Hazardous Air Pollutants. These major sources must determine which source category applies to their operations, and therefore which NESHAP regulation it is subject to.

Within each NESHAP source category, the EPA has established Maximum Achievable Control Technology (MACT) standards for major sources of HAPs. These technology based standards are established by collecting information from regulated facilities, including the type of emissions, emission controls, and cost of these controls. The EPA performs a cost-health benefit analysis of these controls at the best performing facilities (top 12%), and establishes the MACT standards by promulgating rules applicable to these source categories.

Within 8-years after promulgation of a new MACT standard, the EPA is required to review the residual risk associated with the regulated HAPs. If after the implementation of the technology based standard, emissions still pose a significant health risk to the public, further emission reductions may be required. In 2008, the Geismar facility implemented the Miscellaneous Organic Chemical Manufacturing NESHAP, thus reducing HAP emissions from the location. The purpose of this study is to determine the inhalation health risk reduction that occurred from this single facility as a result of the applicable MACT requirements. This was accomplished by utilizing EPA approved human health risk models to determine the risk associated with Hazardous Air Pollutant Emissions prior to and after MACT implementation.

The Miscellaneous Organic Chemical NESHAP

The Miscellaneous Organic Chemical Manufacturing NESHAP (or MON as it is commonly termed) is codified in the US Code of Federal Regulations (CFR) under 40 CFR Part 63 Subpart FFFF. The federal regulation, which was promulgated as a final rule in the Federal Register on November 10, 2003, was intended to capture, as a source category, facilities that manufacture organic chemical products, which were not already subject to another specific federal Maximum Achievable Control Technology (MACT) regulation. Based on industry and public comments, revisions to the MON were proposed on December 8, 2005 and the amendments were published in the Federal Register on July 14, 2006. The revised rule extended the compliance deadline for existing affected sources from November 10, 2006 to May 10, 2008.

The MON rule establishes source specific standards, and it applies to both new and existing miscellaneous organic chemical manufacturing process units (MCPU) at major stationary sources. A Miscellaneous Organic Chemical Manufacturing process (MCPU or "process") is defined as all equipment, which collectively function to produce a product or isolated intermediate. The rule regulates emissions from storage tanks, process vents, transfer racks, fugitive equipment, wastewater streams, liquid streams in open systems, heat exchange systems and other equipment, and establishes control requirements and associated monitoring, recordkeeping and reporting requirements for each affected emission source. In addition, the rule requires compliance with work practice and operational standards for certain equipment and activities, as well as compliance with 40 CFR 63 Subpart A, including the development of a Startup, Shutdown and Malfunction Plan (SSMP) for the affected process equipment.

Implementation of the MON at Lion Copolymer Geismar

At the time the Miscellaneous Organic Chemical Manufacturing NESHAP was promulgated, some operations at the Geismar facility were subject to previously implemented NESHAP MACT standards. Specifically, the facility operates synthetic rubber manufacturing units (Polymer Units) which are subject to 40 CFR 63 Subpart U National Emission Standards for Hazardous Air Pollutant Emissions: Group I Polymers and Resins (Polymers MACT), which was implemented in 2001. In addition, the facility also operated a Maleic Hydrazide production unit, which was subject to Subpart F--

National Emission Standards for Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry (HON MACT). As stated previously, the purpose of the MON was to capture those sources which produce organic chemicals that were not previously regulated under another NESHAP. Therefore, the production units which were not previously covered, were required to be assessed for applicability under the MON. Any process that meet the following general applicability criteria are considered to be an MCPU subject to the MON (EPA 2005b):

(1) Produces an organic chemical or chemicals classified using the 1987 version of SIC code 282, 283, 284, 285, 286, 287, 289, or 386; an organic chemical or chemicals classified using the 1997 version of NAICS code 325; quaternary ammonium compounds and ammonium sulfate produced with caprolactam; hydrazine; or organic solvents classified in any of the above mentioned SIC or NAICS codes that are recovered using non-dedicated solvent recovery operations;

(2) Processes, uses, or produces an organic HAP; and

(3) Is not an affected source or part of an affected source under another 40 CFR part 63 subpart.

The table below lists the affected units at the Geismar facility and which NESHAP was ultimately applicable.

Table 1: NESHAP Affected Processes

Affected Process	Applicable NESHAP Regulation	Year of Implementation
Maleic Hydrazide Production Unit	Subpart F (HON)	1995
Polymer Units	Subpart U (Polymers MACT)	2001
Polymers Wastewater Treatment	Subpart U (Polymers MACT)	2001
BHT Production Unit	Subpart FFFF (MON)	2008
Celogen AZ Production Unit	Subpart FFFF (MON)	2008
Celogen OT Production Unit	Subpart FFFF (MON)	2008
Deepwell Unit	Subpart FFFF (MON)	2008
Flexzone Production Unit	Subpart FFFF (MON)	2008
Services & Lab areas	Subpart FFFF (MON)	2008
Sulfur Recovery Unit	Subpart FFFF (MON)	2008
Thiazoles Production Unit	Subpart FFFF (MON)	2008
UBOB Production Unit	Subpart FFFF (MON)	2008

Additionally, for those processes that met the applicability criteria of this rule, the MON contains provisions for designating processes as either existing or new based on the construction date of the unit. Under the MON, new processes may have control requirements that differ from existing sources, and new processes may also be subject to additional requirements. All processes at the Geismar site met the criteria to be considered existing sources. Therefore, the facility proceeded with the required studies to assess the emission points associated with MON applicable process to determine the control requirements, if necessary, for each.

The MON Regulation

Applicability

Under the Miscellaneous Organic Chemical Manufacturing NESHAP (MON), an affected source is comprised of all storage tanks, surge control vessels, bottoms receivers, continuous process vents, batch process vents, hydrogen halide/halogen HAP process vents, Particulate Matter (PM) HAP process vents, transfer racks, fugitive equipment, wastewater streams, liquid streams in open systems, and heat exchange systems that are associated with a MCPU located at a major source.

Control Requirements

The Maximum Achievable Control Technology (MACT) standards of the MON are divided into standards for:

(1) Process vents

(2) Storage tanks

(3) Transfer operations

(4) Wastewater

(5) Equipment leaks

(6) Heat exchange systems

In each case, there are requirements for calculating emissions from these sources to determine the emission rates, concentrations, and uncontrolled emissions if control devices are utilized. The rule provides equations to guide the facility on how to estimate organic HAP emissions from certain common chemical manufacturing operations. Based on the emission rates and/or concentrations, controls may be required to reduce HAP emissions. If an emission point also contains halogenated HAPs, and a combustion device is selected as the control device, then the additional halogen control requirements also apply.

Batch Process Vents

Batch process vents are vents from a process unit operation, through which a HAP-containing gas stream is, or has the potential to be, released to the atmosphere. This also includes vents from multiple unit operations within a process that are manifolded together into a common header. Examples of batch process vents include, but are not limited to, vents on condensers used for product recovery, reactors, filters, centrifuges, and process tanks. For the purpose of requiring controls, batch vents are divided into two groups.

Group 1 batch process vent means each of the batch process vents in a process for which the collective uncontrolled organic HAP emissions from all of the batch process vents are greater than or equal to 10,000 lb/yr at an existing source or greater than or equal to 3,000 lb/yr at a new source. Emission points that undiluted and uncontrolled either contain less than 50 ppm by volume HAP or that emit less than 200 pounds per year are exempted. The emission control requirements for Group 1 Batch process vents are 98% if using a Control Device or 95% efficient Recovery Device. Group 2 batch process vent are those batch process vents that do not meet the definition of Group 1 batch process vent. These emission sources do not require controls.

Continuous Process Vents

Continuous Process Vents are defined by the MON as the point of discharge to the atmosphere (or control device, if any) of a gas stream, if it has the following characteristics:

- Some, or all, of the gas stream originates as a continuous flow from an air oxidation reactor, distillation unit, or reactor.
- Does not pass through any other unit operation for a process purpose
- Contains greater than 0.005 weight percent organic HAP

- Is discharged in the gas phase

Continuous process vents are divided into two groups. The first, Group 1 continuous process vents, are continuous process vents for which the flow rate is greater than or equal to 0.005 standard cubic meter per minute, and the Total Resource Effectiveness (TRE) index value, that is less than 1.9 at an existing source and less than 5.0 at a new source. The TRE Index is a measure of the BTU content of the stream, that is, the capability of the stream to support combustion without an excessive quantity of supplemental fuel. TRE is calculated using the following equations:

Equation 1 Net Heating Value

$$HT = K_1(\sum C_j H_j)(1 - B_{WS})$$

H_T	Net heating value of the sample, megaJoule per standard cubic meter,
K_l	Constant, 1.74×10-7 (parts per million)-1 (gram-mole per standard cubic meter) (megaJoule per kilocalorie)
B_{ws}	Water vapor content of the vent stream, proportion by volume
C_j	Concentration on a dry basis of compound j in parts per million
H_j	Net heat of combustion of compound j, kilocalorie per gram-mole, based on combustion at 25°C and 760 millimeters mercury

Equation 2 Emission Rate of Total Organic Carbon (E_{TOC}) or Hazardous Air Pollutant (E_{HAP})

$$E = K_2 (\sum C_i M_i) Q_S$$

E	Emission rate of TOC (minus methane and ethane) or emission rate of total organic HAP in the sample, kilograms per hour
K_2	Constant, 2.494×10-6 (parts per million)-1 (gram-mole per standard cubic meter) (kilogram/gram) (minutes/hour)
C_j	Concentration on a dry basis of organic compound j in parts per million
M_j	Molecular weight or organic compound j, gram/gram-mole.
Q_s	Vent stream flow rate, dry standard cubic meter per minute, at a temperature of 20°C.

Equation 3 Emission Rate of Halogen Atoms

$$E = K_2 Q (\sum{}_j (\sum{}_i CjM_{j,i} L_{j,i}))$$

E	mass of halogen atoms, dry basis, kilogram per hour.
K_2	Constant, 2.494×10-6 (parts per million)-1 (kilogram-mole per standard cubic meter) (minute/hour), where standard temperature is 20°C.
C_j	Concentration of halogenated compound j in the gas stream, dry basis, parts per million by volume.
M_{ji}	Molecular weight of halogen atom i in compound j of the gas stream, kilogram per kilogram-mole.
L_{ji}	Number of atoms of halogen i in compound j of the gas stream.
Q	Flow rate of gas stream, dry standard cubic meters per minute, determined according to paragraph (d)(1) or (d)(2)(i) of this section.
j	Halogenated compound j in the gas stream.
i	Halogen atom i in compound j of the gas stream.
n	Number of halogenated compounds j in the gas stream.
m	Number of different halogens i in each compound j of the gas stream.

Equation 4 Total Resource Effectiveness (TRE)

$$TRE = \frac{a + b(Q_S) + c(H_T) + d(E_{TOC})}{E_{HAP}}$$

TRE	TRE index value.
E_{HAP}	Hourly emission rate of total organic HAP, kilograms per hour
Q_s	Vent stream flow rate, standard cubic meters per minute, at a standard temperature of 20°C
H_T	Vent stream net heating value, megaJoules per standard cubic meter
E_{TOC}	Emission rate of TOC (minus methane and ethane), kilograms per hour
a,b,c,d	Coefficients presented in table 1 of the regulation

For existing continuous process vents, the MON standard requires 98 percent control of HAPs from vents determined to have a Total Resource Effectiveness (TRE) Index of <1.9. As an alternative, a facility may reduce the exhaust concentration of total organic compounds (TOCs) to 20 ppmv or less. For new continuous process vents, the final standards require 98 percent control from vents with a TRE Index of <5.0. Group 2 continuous process vent are continuous process vent that do not meet the definition of a Group 1 continuous process vent. These emission sources do not require controls.

Storage Tanks

The MON regulation defines a storage tank as a tank or other vessel used to store organic liquids that contain one or more HAP as raw material feed stocks. Storage tank also means a tank or other vessel in a tank farm that receives and accumulates used solvent from multiple batches of a process or processes for purposes of solvent recovery. Group 1 storage tanks are those storage tanks with a capacity greater than or equal to 10,000 gal storing material that has a maximum true vapor pressure of total HAP greater than or equal to 6.9 kilopascals at an existing source or greater than or equal to 0.69 kilopascals at a new source. Subject tanks must either operate a floating roof or control HAP emissions by at least 95 percent. A Group 2 storage tank is a storage tank that does not meet the definition of a Group 1 storage tank, which does not require controls.

Transfer Operations

The MON defines a transfer rack as the collection of loading arms and loading hoses, at a single loading rack, that are assigned to an MCPU, and are used to fill tank trucks or rail cars with organic liquids that contain one or more organic HAP. The transfer rack also includes all associated pumps, meters, shutoff valves, relief valves, and other piping and valves. Group 1 transfer racks are those that load more than 0.65 million liters/year of liquids that contain organic HAP with a rack-weighted average partial pressure greater than or equal to 1.5 pound per square inch absolute. Group 1 transfer operations must utilize a vapor balance line or a 98% efficient control device. Group 2 transfer rack means those that not meet the definition of a Group 1 transfer rack, which do not require controls.

Wastewater

Any wastewater streams meeting the Group 1 criteria listed in the MON regulations is classified as an “affected wastewater stream” and must utilize vapor suppression and closed conveyance system through final treatment or disposal. There are 3 allowable treatment standards under the MON regulation.

1. Reduce the maximum concentration to less than 50 ppm.
2. Treat the wastewater to reduce the concentration by the required percent reduction values listed in the MON regulation.
3. Install a “design steam stripper” that meets the MON design requirements.

All other wastewaters from an affected MCPU are considered Group 2 wastewater streams and do not require controls.

Equipment Leaks

Potential fugitive sources of HAPs, such as pumps, valves, connectors, and open-ended lines, are subject to the MON rule if it is in >5 percent HAP service for more than 300 hours per year. All affected components must be monitored on a regular prescribed schedule and leaks repaired within the required time frame. A leak is defined as 2,000 ppm of THC from pumps and 10,000 ppm from agitators.

Heat Exchange Systems

For heat exchange systems, a monitoring program must be implemented to detect and repair leaks into the cooling water.

MACT Implementation at the Geismar Facility

In early 2005, the Geismar Facility commenced intensive efforts to determine the impacts that the new MON rule would have on the facility. The obvious concern was the capital expenditures required to meet the Maximum Achievable Technology (MACT) requirements that would be required to be implemented for existing emission sources.

All equipment associated with the affected MON processes, which are BHT Production Unit, Celogen AZ Production Unit, Celogen OT Production Unit, Deepwell Unit, Flexzone Production Unit, Services & Lab areas, Sulfur Recovery Unit, Thiazoles Production Unit, UBOB Production Unit, and certain MH batch process vents, were reviewed during the affected equipment identification step of the MON evaluation. The type of equipment reviewed included continuous process vents, batch process vents, hydrogen halide/halogen HAP process vents, storage tanks, surge control vessels, bottoms receivers, transfer racks, sampling connection systems, process and maintenance wastewater, liquid streams in open systems, and heat exchange systems. Overall, the facility took the steps detailed below to determine MON applicability.

1. Determine the Group status for each process vent, batch vent, storage tank and transfer rack
    - Vents where sufficient information was not available were designated as Group 1
    - If calculations did not meet the requirements of the MON rule, new calculations were developed based on the equations described in the rule
2. Evaluated Group 1 emissions vented to air pollution control device (APCD)
    - Performance test, design evaluation, or calculate controlled emissions
    - Establish operating limits for parameter monitoring
3. Wastewater treatment units
    - Performance test or design evaluation
    - Collected data on wastewater to determine the Group status
4. Initial inspections
    - Floating roofs, closed-vent systems

The Geismar facility completed a preliminary review of the MON affected processes in 2006, determining that significant emission control upgrades would be required primarily in the Flexzone Production Unit, UBOB Production Unit, Thiazoles Unit, and Celogen OT Production Unit. Capital cost estimates were made based on various options to meet the MACT requirements. Initial capital expenditure estimations indicated that the upgrades would total 9 to 10 million dollars for all affected processes. At the time, many of these production units were antiquated and profitability for the products was below expectations. Ultimately, the decision was made to cease operations in certain production units and sell the facility to a new owner.

Over the next few years, the Geismar facility ceased process operations in the Celogen AZ, B9, BHT, Maleic Hydrazide, Flexzone, Thiazoles, and UBOB Units. Under the new owner, the Celogen OT, Celogen AZ, and Deepwell Units continued operations and MACT controls implemented where applicable.

The Celogen OT Unit was affected most significantly, requiring emissions controls for a few sources in the process, as well as implementation of a Leak Detection and Repair program to monitor and repair fugitive emission leaks, in compliance with MON requirements. The HAPs associated with this production unit include ethylene dichloride, hydrazine (as hydrazine hydrate), and hydrogen chloride. The centrifuge vent for this process was determined to be a continuous batch process vent requiring MACT controls for the hazardous air pollutant ethylene dichloride. Under the MON rule, the facility had the option to implement controls that would render the emission source exempt from the requirement by limiting the HAP concentration to 50 ppmv or 200 lbs per year of HAPs. Otherwise, the facility would be required to implement a 99 percent efficient control device or 95 percent efficient recovery device. The facility opted to control the emissions to below 50 ppmv by use of a control scheme involving a steam eductor, condenser, and absorption system. The schematic of the system is shown in the figure below.

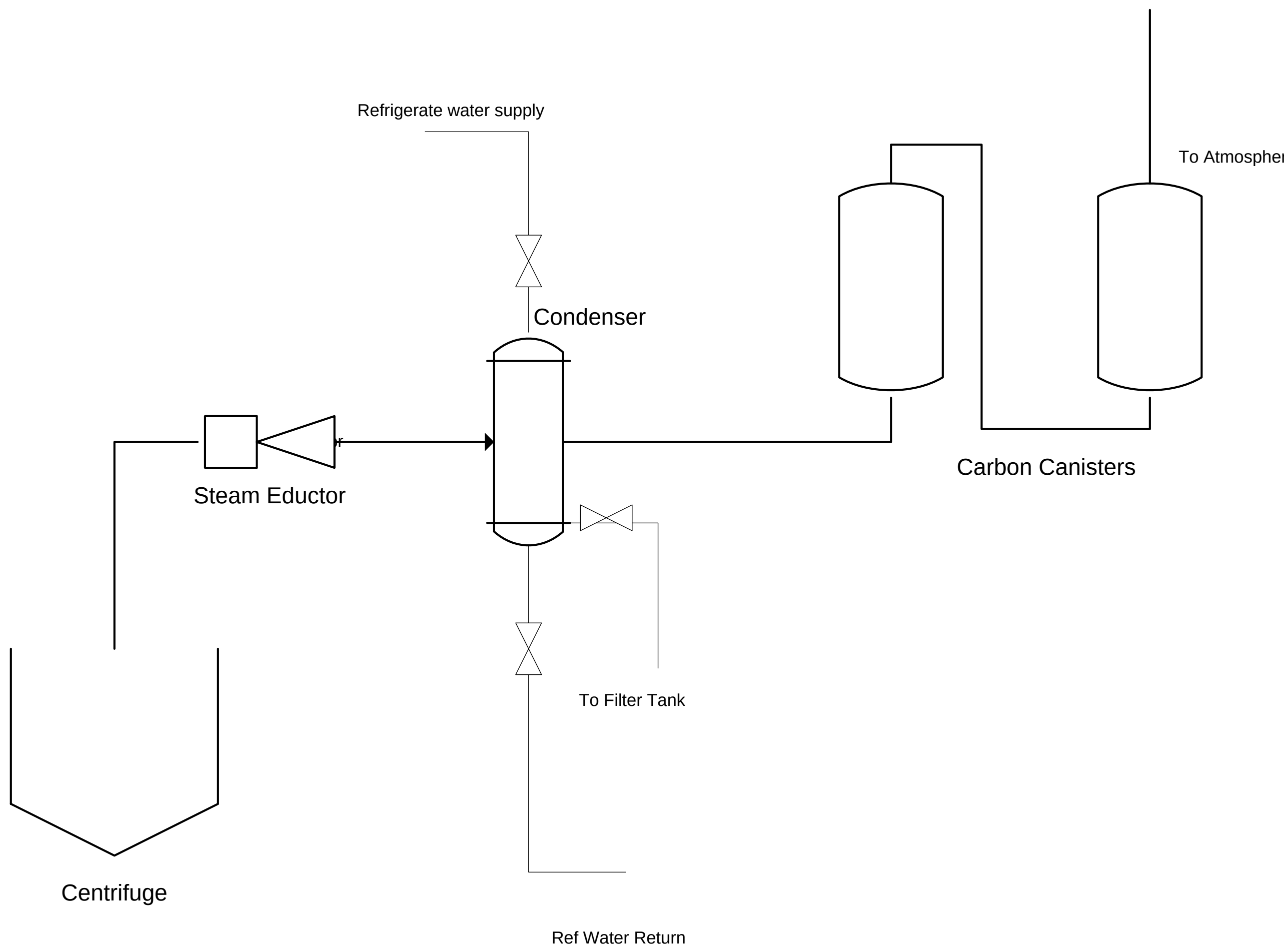


Figure 1 - Centrifuge Vent MON Emission Control

The purpose of the steam eductor is to pull a vacuum on the centrifuge vent, aiding in the volatilization of the organic HAP contained in the product being centrifuged. After passing through the steam eductor, pressure is increased, and the stream vents through a heat exchanger, which condenses water vapor and organic HAPs. Condensers are typical devices used to control volatile organic compounds (VOCs) in chemical manufacturing facilities. Condensers are best applied for control of VOCs and HAPs when concentration or above 5000 ppmv (Schnelle 2002). At these concentrations, typical efficiencies can run between 50 to 90 percent. The emission stream from the centrifuge vent contained lower concentrations of ethylene dichloride and studies indicated that the condenser alone would not meet the control requirements under the MON.

To meet the 50 ppmv exiting concentration requirement, the organic HAP laden stream was routed to two activated carbon absorption canisters arranged in series. Carbon absorption involves to the use of granular or pelletized activated carbon which is brought into contact with the gaseous hydrocarbon vent stream. The activated carbon is manufactured by carbonization of an organic material, typically coconut shell, wood, or coal, then “activated” by oxidation using hot air or steam. The principle behind carbon absorption is that attractive forces between the atoms, molecules, and ions in the activated carbon are unsatisfied at the surface and therefore attract the hydrocarbon molecules in the vent gas. As stated previously, there were two canisters, which were installed in series. This orientation reduces the potential for break-through of ethylene dichloride. The system is monitored using a Flame Ionization Detector (FID) weekly to measure the concentration of VOCs prior to, between, and after the carbon canisters. By performing these tests, the canisters can be replaced before break-though of the second canister occurs. The activated carbon is then sent off-site for regeneration. The figure below is a photograph of the activated carbon canisters in use.

Figure 2 – Dual Canister Carbon Absorber System

Risk Assessment Methodology

Purpose of Risk Assessments

Humans are exposed every day to various concentrations of natural and artificial chemical substances. Although many of these substances can be toxic at high concentrations, typical public exposures are below the concentrations where acute deleterious effects are obvious. However, the potential for long-term cumulative effects, and the identification of these adverse effects has driven environmental regulatory agencies to perform health risk assessments of hazardous air pollutants.

For the purposes of this study, risk assessment is defined as the qualitative or quantitative evaluation of the inhalation health risk resulting from exposure to hazardous air pollutants. Risk assessments are used by environmental regulatory agencies to estimate the probability that exposure to these pollutants will produce an adverse health effect on the surrounding population. These assessments can be use to drive the development of regulations, for which the purpose is to protect the public, or evaluate the effectiveness of current policies. Risk assessment typically includes one or more of the following components:

- **Chemical Hazard Identification**
  The hazards of each chemical to be assessed must be identified as the first step in the risk assessment. This process may include identifying and describing carcinogen and non-carcinogen health effects.

- **Dose Response Assessment**
  Dose response assessment is a central component of the quantitative risk assessment procedure. This process comprises estimating the environmental concentration of a contaminant, and accounting for human characteristics such

as body weight and behavior (e.g., the amount of time spent in a specific location, which affects exposure duration) (Rajkumar, 2000).

- **Exposure Assessment**
  In this process, the ground level concentrations of each hazardous pollutant must be estimated to determine the exposure to the affected local area. There are over 70 tools that can be used to gather the information and to perform risk assessments (Barzyk 2009). These include online databases, web-based geographic information systems (GIS), and human exposure computer models.

- **Risk Characterization**
  In this step, the relevant information developed as part of the previous steps is integrated and the risks are quantified.

For criteria pollutants, available ambient monitoring data from a central outdoor monitoring station has been historically used in air pollution epidemiology studies. For example, the LDEQ operates four ambient air quality monitoring stations in the Geismar area. These stations measure ozone, volatile organic compounds (VOCs), nitrogen oxides (NOx), and particulate matter, but do not measure HAPs. Although monitoring is generally recognized as providing a more reliable estimate of exposure, it carries its own limitations, such as cost for implementing on a large population scale over long periods of time to estimate long-term exposures (Payne-Sturgis, 2004). This is exceeding true for the monitoring of individual hazardous air pollutants, therefore most regulating agencies only have limited monitoring data on HAP compounds. In most cases, air modeling is utilized to predict ground level concentration of these chemical to use in the risk assessment methodology.

There is a degree of uncertainty, specifically when utilizing modeling data or the purposes of risk assessment. The U.S. Environmental Protection Agency (EPA 1992) has classified uncertainty in exposure assessment into three broad categories:

(1) Uncertainty regarding missing or incomplete information needed to fully define exposure and dose (*scenario uncertainty*);
(2) Uncertainty regarding some factor influencing the exposure (*parameter uncertainty*); and
(3) Uncertainty regarding gaps in scientific theory required in making predictions on the basis of causal inferences (*model uncertainty*).

As stated earlier, air modeling is utilized to determine ambient concentrations of hazardous air pollutants, because it would simply be impractical to perform wide scale sampling of personnel exposure for affected communities. Plume dispersion models are designed to capture local pollutant concentration gradients (e.g., within a few kilometers from the source) and can provide detailed resolution of the spatial variations in hourly average concentrations. These models have their limitations, using many assumptions to derive data. In some studies, direct exposure monitoring studies were performed and compared with modeling results obtained using EPA approved methods. Payne-Sturgis et al demonstrated that the EPA's ASPEN model sufficiently estimated exposures for certain VOCs in an urban community, but substantially underestimated exposures or other chemicals (Payne-Sturgis, 2004). When combining risks associated with multiple contaminants, this uncertainty could result in an overall underestimation of the health risks posed to the public.

The Human Exposure Model (HEM-3)

Human Exposure Model-3 is a Windows based software program distributed by the EPA to perform streamlined, but rigorous, health risk assessments for air pollution emissions. It was originally developed in 1986 and was updated in 2002 to the current version in use. The model is generally used for a complex industrial facility or a localized cluster of facilities. The three main functions of HEM-3, which will be discussed further, are:

- Dispersion Modeling
- Estimation of Population Exposure
- Estimation of Human Health Risks

Dispersion Modeling

HEM-3 has the ability to utilize two common dispersion modeling software, AERMOD and the Industrial Source Complex – Short Term (ISCST3), to determine the fate and transport of modeled pollutants. The user is given the option to select either of these dispersion models during the input phase of the program. ISCST utilizes a steady state Gaussian plume dispersion, which assumes a normal distribution in the vertical and horizontal directions. AERMOD utilizes advanced algorithms for calculation of dispersion, plume rise, buoyancy , and the effects of complex terrain. In 2005, the EPA deemed AERMOD as the replacement to the ISC model. Typical inputs for these models include:

- Location of sources
- Source Type
- Dimensions of Source (Area and Volume sources)
- Stack Characteristics (diameter, velocity, temperature)
- Release height
- Receptor locations
- Meteorological parameters
- Topography

In a study performed by Silverman et al, the two models were compared in respect to human health risk assessments. They determined in that study that ISC3 tended to predict higher air concentrations nearer the modeled site than AERMOD (Silverman, 2007). In addition, the maximum ground level concentration was higher using the ISC model. The magnitude of differences differed depending on the types of sources and site specific conditions.

Estimation of Population Exposure

Upon completing the appropriate modeling, the HEM-3 program identifies the Census block locations within the selected modeling area. The most current Census data (2000) is used to estimate the population affected by the model.

Estimation of Human Health Risks

The final step in the model is the calculation of human health risk. The HEM-3 software estimates the cancer and non-cancer health effects due to inhalation exposure to hazardous air pollutants. Risk assessors commonly refer to potential harm from exposure to carcinogens as “risk” and non-carcinogens as “hazards” (Silverman, 2007).

Cancer risks are estimated using the EPA established unit risk estimate (URE) for that particular HAP. URE is an upper-bound estimate of the probability of contracting cancer over a 70-year period for continuous exposure to an agent at a concentration of 1 µg/m^3 in air, neglecting other factors. The interpretation of inhalation unit risk would be as follows: if unit risk = 2 × 10^{-6} per µg/m^3, 2 excess cancer cases (upper bound estimate) are expected to develop per 1,000,000 people if exposed daily for a lifetime to 1 µg of the chemical per m^3 of air (EPA 2010). The following equations are used by HEM-3 to calculate the cancer risk for receptors.

Equation 5 - Total Cancer Risk

$$CR_T = \sum_{i,j} CR_{i,j}$$

Equation 6 - Cancer Risk for Source & Pollutant

$$CR_{i,j} = DF_{i,j} \times CF \times \sum_k \left[E_{i,k} \times URE_k\right]$$

CR_T	total cancer risk at a given receptor (probability for one person)
$\Sigma_{i, j}$	the sum over all sources i and pollutant types j (particulate or gas)
$CR_{i, j}$	cancer risk at the given receptor for source i and pollutant type j
$DF_{i, j}$	dilution factor [(µg/m) / (g/sec)] at the given receptor for source i and pollutant type j
CF	conversion factor, 0.02877 [(g/sec) / (ton/year)]
Σ_k	sum over all pollutants k within pollutant group j (particulate or gas)
$E_{i, k}$	emissions of pollutant k from source i
URE_k	cancer unit risk factor for pollutant k

The estimates provided reflect the risk of developing cancer for an individual breathing the ambient air at a given receptor site 24-hours per day for 70-years. The standard factors used in determining a URE are a 70 kilogram male with an air intake of 20 cubic meters per day. The probability of developing cancer of one chance in 10,000 is written as 1×10^{-4}. EPA cites an acceptable risk range of 1×10^{-4} to 1×10^{-6} for potential cancer risk (NRC, 1994).

Non-cancer health effects are quantified in HEM-3 using hazard quotients and hazard indices for the various human target organs. The hazard quotient for a given chemical and receptor site is the ratio of the ambient concentration of the chemical to the level at which no adverse effects are expected. The hazard index for a given organ is the sum of hazard quotients for the substances that affect that organ. Reference Concentrations (RfC) are the basis for these calculations shown below. The RfC is defined as an estimate of daily or continuous exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (U.S. EPA 1999a). The value of the RfC is derived by determining a point of departure divided by uncertainty factors (UFs), which are used to account for uncertainties in the available studies, such as limitations in the database, variability within humans, and differences in species response (i.e., animal-to-human extrapolation) (Castorina, 2003). Therefore the uncertainty may increase the RfC by an order of magnitude.

Equation 7 - Total Organ Specific Hazard Index

$$HI_T = \sum_{i,j} HI_{i,j}$$

Equation 8 - Organ Specific Hazard Index for Source & Pollutant

$$HI_{i,j} = DF_{i,j} \times CF \times \sum_k \left[\frac{E_{i,k}}{RfC_k} \right]$$

HI_T	total organ-specific hazard index at a given receptor and for a given organ
$\Sigma_{i,j}$	the sum over all sources i and pollutant types j (particulate or gas)
$DF_{i,j}$	dilution factor [(μg/m) / (g/sec)] at the given receptor for source i and pollutant type j
CF	conversion factor, 0.02877 [(g/sec) / (ton/year)]
Σ_k	sum over all pollutants k within pollutant group j (particulate or gas)
$E_{i,k}$	emissions of pollutant k from source i
$HI_{i,j}$	organ-specific hazard index at the given receptor for source i and pollutant type j
RfC_k	noncancer health effect reference concentration for pollutant k

Hazardous Air Pollutants

Carcinogen HAPs

Cancer describes a group of related diseases that affect a variety of organs and tissues in the human body. Cancer results from a combination of genetic damage and non-genetic factors that favor the growth of damaged cells. The U.S. EPA's 2005 Guidelines for Carcinogen Risk Assessment (U.S. EPA, 2005a) provides guidance on hazard identification for carcinogens. The approach recognizes three broad categories of data: (1) human data (primarily epidemiological); (2) results of long-term experimental animal bioassays; and (3) supporting data, including a variety of short-term tests for genotoxicity and other relevant properties. In hazard identification of carcinogens under the 2005 guidelines, the human data, animal data, and "other" evidence are combined to characterize the weight of evidence regarding the agent’s potential as a human carcinogen into one of several hierarchic categories (U.S. EPA, 2005a):

Group A (human carcinogen): These are HAPs compounds for which human data are sufficient to demonstrate a cause and effect relationship between exposure and cancer incidence (rate of occurrence) in humans.

Group B (probable human carcinogen):

- **Group B1:** These are HAPs compounds for which limited human data suggest a cause and effect relationship between exposure and cancer incidence (rate of occurrence) in humans.
- **Group B2:** These are HAPs compounds for which animal data are sufficient to demonstrate a cause-and-effect relationship between exposure and cancer incidence (rate of occurrence) in animals, and human data are inadequate or absent.

Group C (possible human carcinogen): These are HAPs compounds for which animal data are suggestive to demonstrate a cause-and-effect relationship between exposure and cancer incidence (rate of occurrence) in animals.

Group D (not classifiable as to human carcinogenicity): These are HAPs compounds for which human and animal data are inadequate to either suggest or refute a cause-and effect relationship for human carcinogenicity.

Group E (evidence of non-carcinogenicity): These are HAPs compounds for which animal data are sufficient to demonstrate the absence of a cause-and-effect relationship between exposure and cancer incidence (rate of occurrence) in animals.

Table 2 - Key Geismar Facility Carcinogens

Pollutant	CAS No.	Carcinogen Classification	URE	RFC (mg/m^3)
1,3-Butadiene	106-99-0	B2	0.00003	0.002
Acetaldehyde	75-07-0	B2	2.2E-06	0.009
Aniline	62-53-3	B2	1.6E-06	0.001
Benzene	71-43-2	A	7.8E-06	0.03
Ethylene dichloride	107-06-2	B2	0.000026	2.4
Formaldehyde	50-00-0	B1	5.5E-09	0.0098
Naphthalene	91-20-3	C	0.000034	0.003

Ethylene Dichloride

Ethylene Dichloride, also known commonly as 1,2-dichlorothane, is a chlorinated hydrocarbon liquid used in industry as an industrial solvent in cleaning and extraction processes. At the Geismar facility is used as a solvent in the Celogen OT production process. Emissions occur from the volatilization of the chemical in process vessels, storage tank, equipment and fugitive leaks. This is the primary HAP that was addressed as part of the MON rule emission control improvements. Exposure to ethylene dichloride may result in irritation to the eyes, throat and nose. The symptoms of exposure include central nervous system depression and gastrointestinal upset. Chronic exposures may result in damage to the kidney, liver, and adrenals. This chemical is listed as a probable human carcinogen.

Aniline

Aniline is a liquid that was utilized in the facility's Thiazoles process. It is toxic by ingestion, inhalation, or by skin contact. Aniline damages hemoglobin in the blood, which in turn reduces the body's ability to transport oxygen in the blood stream (ATSDR, 2010).

Benzene

Benzene is a contaminant of Toluene, which was used in several production units at the facility. It is an aromatic hydrocarbon, which is a liquid at room temperature. Benzene is rapidly absorbed through the lungs; approximately 50% of the benzene in air is absorbed (ATSDR, 2010). At low exposure levels, benzene is rapidly metabolized and excreted predominantly as conjugated urinary metabolites.

Napthalene

Naphthalene is a white hydrocarbon solid that evaporates easily. Fuels such as petroleum and coal contain naphthalene. Exposure to large amounts of naphthalene may damage or destroy red blood cells (ATSDR, 2010)

Acetaldehyde

Acetaldehyde is an aldehyde compound, which was a byproduct in production processes at the Geismar Facility. It has been listed as a probable human carcinogen due to inhalation carcinogenicity in animal studies.

1,3-Butadiene

1,3-Butadiene is a highly volatile hydrocarbon used at the facility. Effects on the nervous system and irritations of the eyes, nose, and throat have been seen in people who breathed contaminated air. Breathing lower levels may cause irritation of the eyes, nose, and throat (ATSDR, 2010).

Formaldehyde

Formaldehyde is a common contaminant in many products and raw materials. At room temperature, formaldehyde is a colorless, hydrocarbon gas with a distinct pungent odor. Low levels of formaldehyde can cause irritation of the eyes, nose, throat, and skin. It is possible that people with asthma may be more sensitive to the effects of inhaled formaldehyde (ATSDR, 2010)

Non-Carcinogenic HAPs

Cancer is commonly used in risk assessment modeling and allows comparisons of risk estimates among compounds, however non-cancer risks also are used in modeling and include reproductive, neurotoxic, cardio, respiratory, and numerous other deleterious effects. The calculation for non-cancer hazards is driven primarily by the reference concentration (RfC). The table blow lists the major non-cancer HAPs at the Geismar facility and their respective RfCs.

Table 3 - Key Non-Cancer HAPs

Pollutant	CAS Number	RFC (mg/m^3)	Target Organs
1,3-Butadiene*	106-99-0	0.002	Reproductive
Acetaldehyde*	75-07-0	0.009	Respiratory
Aniline*	62-53-3	0.001	Spleen
Benzene*	71-43-2	0.03	Immunological
Ethyl Chloride	75-00-3	10	Developmental
Ethylene dichloride*	107-06-2	2.4	Kidney
Formaldehyde*	50-00-0	0.0098	Respiratory
Hydrochloric acid	7647-01-0	0.02	Respiratory
Methanol	67-56-1	4.0	Developmental
Methyl Chloride	74-87-3	0.09	Neurological
Methyl Isobutyl Ketone	108-10-1	3.0	Developmental
Naphthalene*	91-20-3	0.003	Respiratory
n-Hexane	110-54-3	0.7	Neurological, Respiratory
Toluene	108-88-3	5.0	Respiratory, Neurological

** indicates pollutants with carcinogenic effects as well*

n-Hexane

n-Hexane is an aliphatic hydrocarbon that is a liquid at room temperature. The Geismar facility uses large amounts of hexane isomer as a solvent, which n-hexane is a component.

Toluene

Toluene is an aromatic hydrocarbon used as a solvent in many processes at the Geismar facility. Toluene will typically affect the nervous system if over-exposed. Low to moderate exposure levels can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, loss of appetite, and hearing, and color vision loss (ATSDR, 2010).

Methanol

Methanol is a colorless alcohol that was used in the UBOB and Thiazoles processes. Exposures can cause respiratory irritation and developmental disorders. Higher exposure can cause blindness in some cases.

Methyl Chloride

Methyl Chloride, also known a chloromethane, is a clear colorless gas that occurs as a byproduct. Low exposure levels can also cause staggering, blurred or double vision, dizziness, fatigue, personality changes, confusion, tremors, nausea, or vomiting. These symptoms can last for several months or years (ASTDR, 2020). Exposure to chloromethane may also cause liver and kidney damage.

Methyl Isobutyl Ketone

Methyl Isobutyl Ketone is also known as MIBK or 2-hexanone. It was used as a solvent in the facility's Flexzone process. Breathing 2-hexanone can harm your nervous system. Workers who were exposed to 2-hexanone in the air for almost a year felt weakness, numbness, and tingling in the skin of the hands and feet (ASTDR, 2010).

Ethyl Chloride

Ethyl Chloride, also known as chloroethane is a byproduct at the facility. It occurs as a colorless gas. Exposure to this chemical can also cause staggering, blurred or double vision, dizziness, fatigue, confusion, tremors, nausea, or vomiting.

Hydrochloric acid

Hydrochloric acid is a low pH liquid, also known as HCl, found in aqueous form. It is a by-product for thee Celogen OT process at the Geismar facility. It can cause severe respiratory irritant if inhaled.

Human Exposure Model (HEM-3) Assessments

Study Methodology

As stated in early, the purpose of this research was to determine the inhalation health impacts of implementation of MON NESHAP regulations at an organic chemical manufacturing facility in Geismar, Louisiana. This was accomplished by:

- Identifying the applicable regulatory requirements of the MON rule and the steps taken to implant the control requirements at the facility.
- Compiling the hazardous air pollutant (HAP) emissions data a representative year prior to MON implementation and the year following completion of the MON implementation.
- Assess the human health exposure risks for both years utilizing the Human Exposure Model (HEM-3) software provided by the EPA.
- Evaluate the change in risk and hazard between the two years to determine the residual risk and subsequent reduction.

As with any assessment it is critical to define the steps and milestones that must be achieved to meet the overall purpose of the study. Each of the steps followed in this study are described in the following paragraphs.

1. **Define Scope and Objectives:** The critical first step in a health risk assessment should be defining the scope and objective required to meet the goal of the study. The purpose is to narrowly define the scope so that it is not overly broad and each objective is attainable. The following figure demonstrates the organization and objectives of the study.

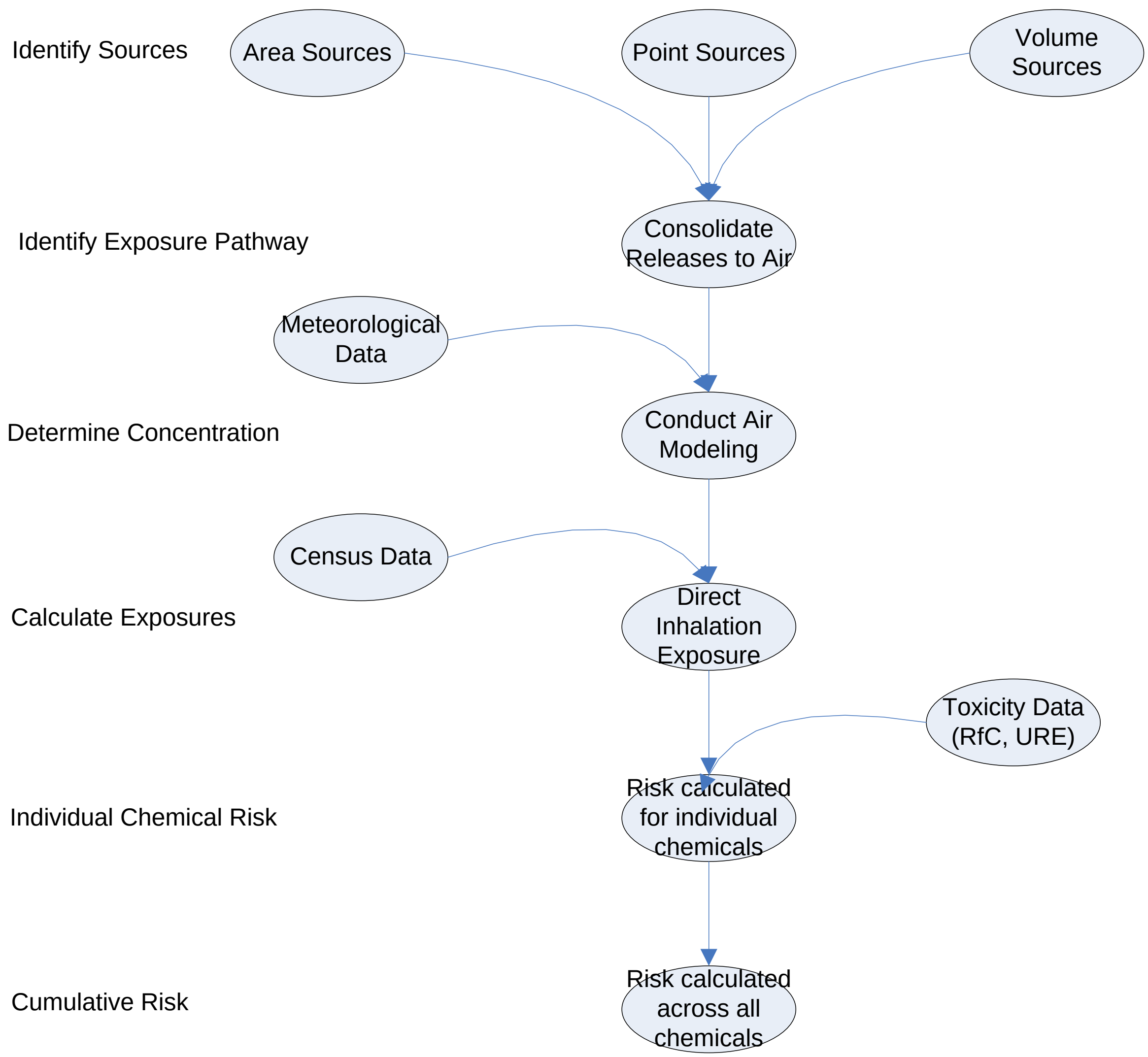


Figure 3 - Project Scope & Objectives Flow Chart

2. **Select Assessment Facility/Sources**: The purpose of this study is to determine the impacts of the MON rule on the inhalation risk associated with emissions from the Geismar Facility. Therefore, the scope of this project was limited to the individual facility, and does not include other site in the vicinity. As the Geismar facility is in an industrial complex in an industrial area, expanding the coverage to other facilities would also expand the study beyond the original scope. The sources that are involved in this study are limited to those emitting hazardous air pollutants. All 188 regulated HAPs may be affected by the MON regulation, therefore the decision was made to include all HAP emission sources from the

facility. In addition, by including all HAPS, the study can gain perspective on the total cumulative residual risk associated with the facility.

3. **Define Assessment Area:** The area within a 50 kilometer (approximately 31 mile) radius surrounding the Geismar facility was the area selected for the study.

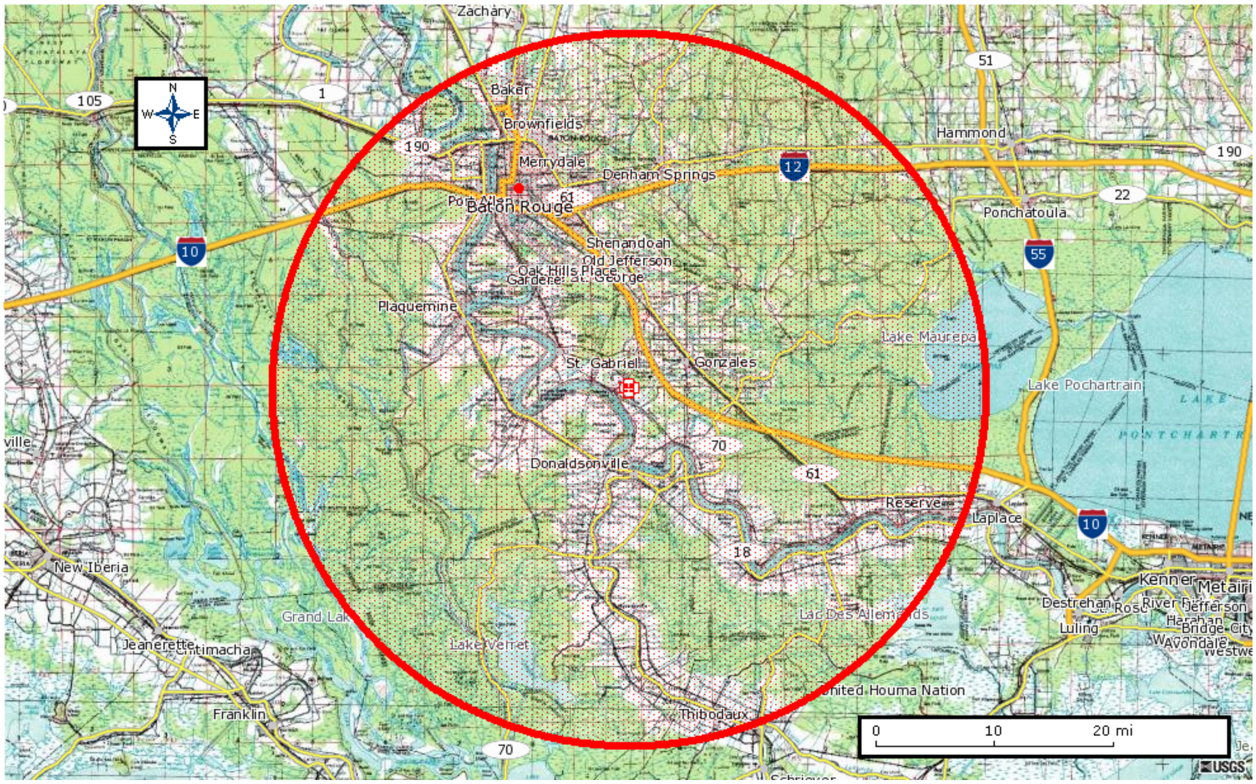


Figure 4 - Area of Study

4. **Emission/Source Characterization**: Collecting the emission source data for each source is one of the most important and intensive steps in the risk assessment process. The characteristics of each source must be input and verified to ensure accuracy in the plume dispersion model. In this study, existing information on the facility emission sources was manipulated into an Excel file to match the format required by the HEM-3 software. All of the information was verified and additional information collected and input into the file.

5. **Compiling Emission Data:** Emissions data must be compiled in a spreadsheet to input into HEM-3. Annually, major sources of criteria pollutants and hazardous air pollutant are required by the LDEQ to submit emissions estimates for the previous calendar year. This information is compiled in a database, which can be used to perform modeling associated with air quality permitting. The submitted information was used to populate the spreadsheet for use in the model. As with the source information, much of the data required manipulation to meet the required criteria for the model, such as metric unit, formats, etc. To determine the overall change in risk from Pre-MON conditions to Post-MON conditions, the pre-MON year was established as 2006 and the post-MON year was established as 2009.

6. **Verify & Correct Source Locations**: Although much care is taken to establish the location of each emission source, inevitably there are errors in data entry. The latitude and longitudes are input into the HEM-3 software within the emission source data file. Within the software, the user can preview the source locations on a map to determine if there are source location errors in the file. After review of the maps, numerous latitude/longitude entries required correction.

7. **Execute HEM-3 Model:** After all of the input files have been verified, the HEM-3 model can be run. The user selects the options based on the type of assessment desired. The parameters selected for each model run are described in the table below.

Table 4 - HEM-3 Inputs

Parameter	Input	Reasoning
Dispersion Model	AERMOD	AERMOD is considered "state of the art" and is the current EPA accepted model
Dispersion Environment	Rural	The facility is located in a rural area and did not meet the criteria for "urban".
Acute Calculations	No	The facility does not have measured lb/hr emission rates, only calculated maximum, which may not be representative of actual operations.
PM Deposition	No	There were no particulate matter (PM) HAP assessed during this study
Plume Depletion	No	There was insufficient information available to determine this parameter.
Max Radius	50 KM	This distance proved sufficient to capture adverse health affects within the population.
MET Data	Baton Rouge, LA - surface Slidell, LA – upper air	This meteorological data represented the closest stations to the facility (38 mi, 113, mi respectively)
Census Data	2000 Census	The 2000 Census represents the most current data

8. Evaluate Outputs: After the model is run, HEM-3 delivers output files and screens quantifying the results of the risk assessment. Much of this data is presented in the tables and figures in the following sections. The output data from the individual years was evaluated for cumulative and individual chemical risks and hazards. The cumulative data was compared between the two representative years to determine the residual risk associated with the facility HAP emissions and the subsequent risk reduction.

Pre-MON Emissions 2006

The calendar year 2006 was selected to represent the Pre-MON rule emissions at the Geismar facility because none of the MON control improvements, nor any major production unit shut-downs, had occurred. The following table details the major hazardous air pollutant emissions from the facility during this year. "Others" includes numerous additional HAPs whose annual emissions were below .5 tons per year.

Table 5 - 2006 Annual HAP Emissions

Pollutant	Emissions (tons/year)
n-Hexane	217.55
Toluene	59.80
Methanol	21.37
Ethylene Dichloride	13.81
Methyl Chloride	8.31
Methyl Isobutyl Ketone	7.65
Aniline	5.68
Ethyl Chloride	3.26
Hydrochloric acid	2.59
Others	7.94

As illustrated in the chart below, the majority of HAPs, approximately 62.5 percent are comprised of n-hexane. Although these emissions were not associated with Mon applicable production units, the emissions were included in this study to ensure that the non-cancer hazard assessment was representative of the total HAP emissions from the facility.

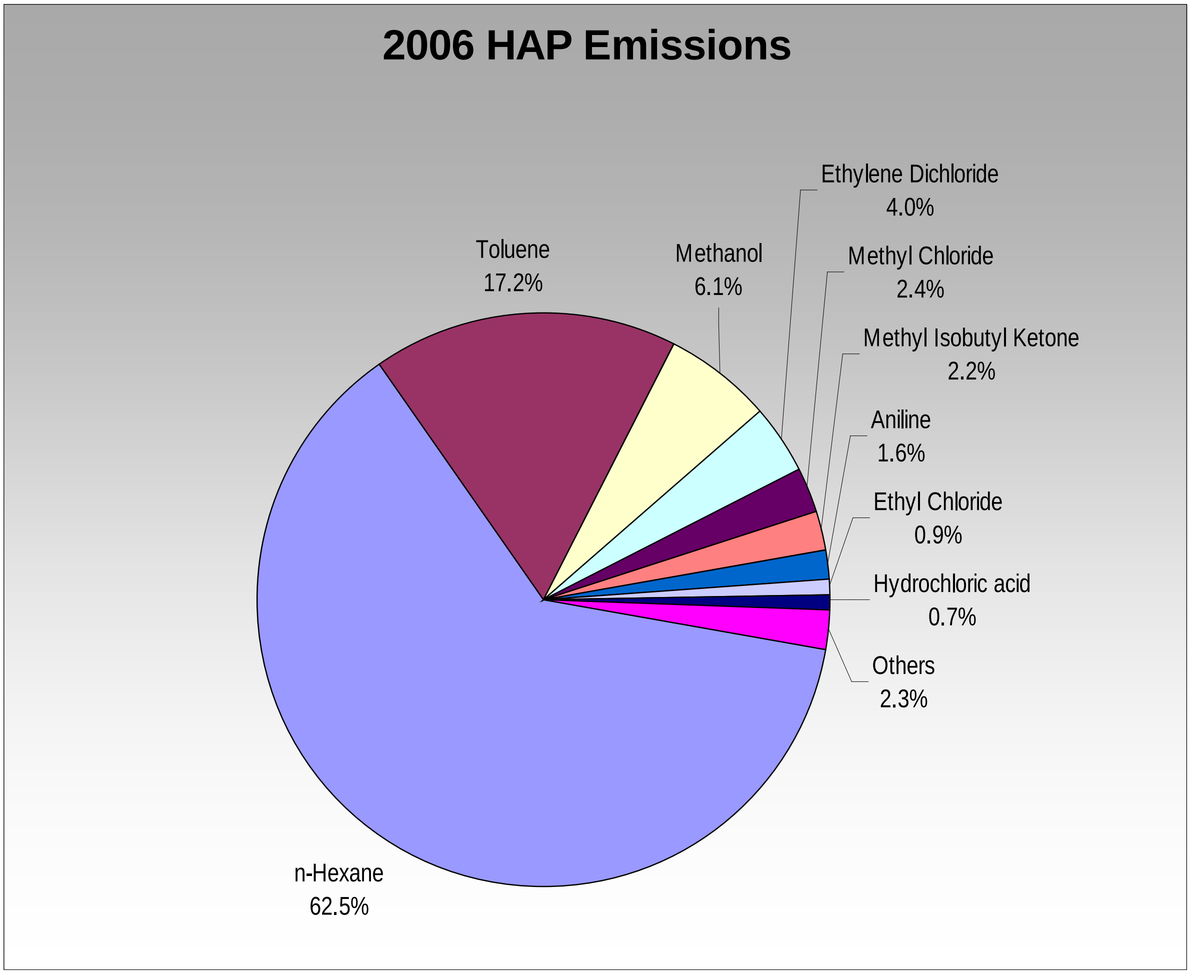


Figure 5 - 2006 HAP Emissions by Percentage

The outputs of the HEM-3 software were evaluated for cancer and non-cancer risks. The following table details the cancer risk associated with carcinogen HAP emissions in the area of the study. The model indicates that a total 72, 651 people in the area have some degree of cancer risk. Because there are numerous sources in the area that may contribute to these effects, the actual risk may be significantly higher than indicated.

Table 6 - 2006 Cancer Risk by Population

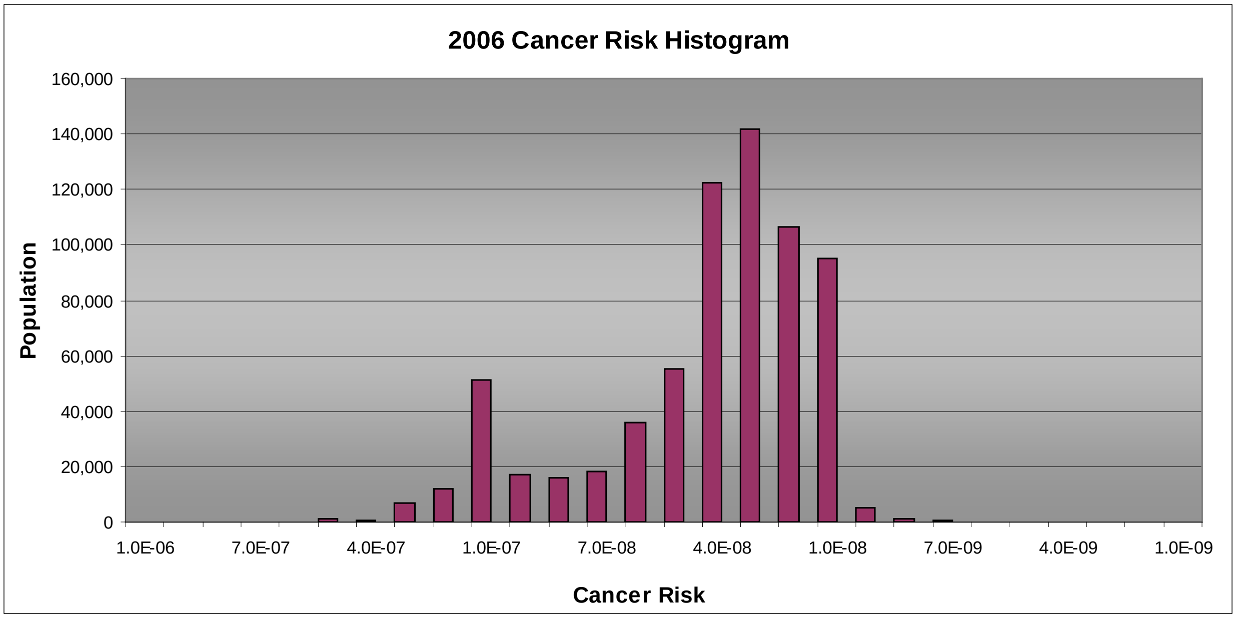
Cancer Risk (2006)	Population
Greater than or equal to 1 in 1,000	-
Greater than or equal to 1 in 10,000	-
Greater than or equal to 1 in 20,000	-
Greater than or equal to 1 in 100,000	-
Greater than or equal to 1 in 1,000,000	228
Greater than or equal to 1 in 10,000,000	72,423

To determine which hazardous air pollutants were contributing to the cancer risk, the following table was extracted from the HEM-3 outputs. As can be seen, Ethylene Dichloride is the major contributor, over 98 percent, of the total cancer risk. Coincidentally, this is the HAP that was most affected by the MON and required installation of additional emission controls to meet the MACT standards.

Table 7 - Potential Cancer Impact (per Year) by Pollutant (2006)

Pollutant	Number of Cases Per Year
All modeled pollutants	*5.40E-04*
Ethylene Dichloride	5.30E-04
Aniline	1.30E-05
Benzene	3.80E-06
Naphthalene	9.60E-10
Acetaldehyde	5.60E-10
1,3-Butadiene	3.70E-10
Formaldehyde	2.10E-12

Additionally, a cancer histogram was generated to demonstrate the population affected and their respective cancer risk. As can be seen in the following figure, the bulk of the population falls into the 4.0×10^{-8} to 1.0×10^{-8} range.



Post-MON Emissions 2009

The 2009 calendar year was selected to represent post-MON conditions at the Geismar facility. As required in the MON rule, all MACT controls were in place and operation in May 2008. Because only approximately half of the year were MON affected controls in place, 2009 was most representative. In addition, the numerous production unit shut-downs had been completed at that time. The table below details the annual emissions from the facility during this year.

Table 8 - 2009 Annual HAP Emissions

Pollutant	Emissions(tons/year)
n-Hexane	263.50
Ethylene Dichloride	3.82
Ethyl Chloride	3.18
Toluene	0.44
Others	0.06

As can be seen in the following figure, n-hexane again represents the majority of the HAPs emitted. Compared with the chart from the 2006 emissions, it is obvious that with the numerous process unit shut-downs, many of the HAPs previously listed are no longer shown on the emissions inventory. The emissions from n-hexane, which previously accounted for 62.5 percent of the total HAP emissions, now account for over 97 percent. While ethylene dichloride emissions now account for 14 percent, versus 4 percent, of HAP emissions, the facility actually effected a 72% total annual emission reduction of this pollutant from 2006 to 2009. This is largely due to MON MACT controls implemented in 2008.

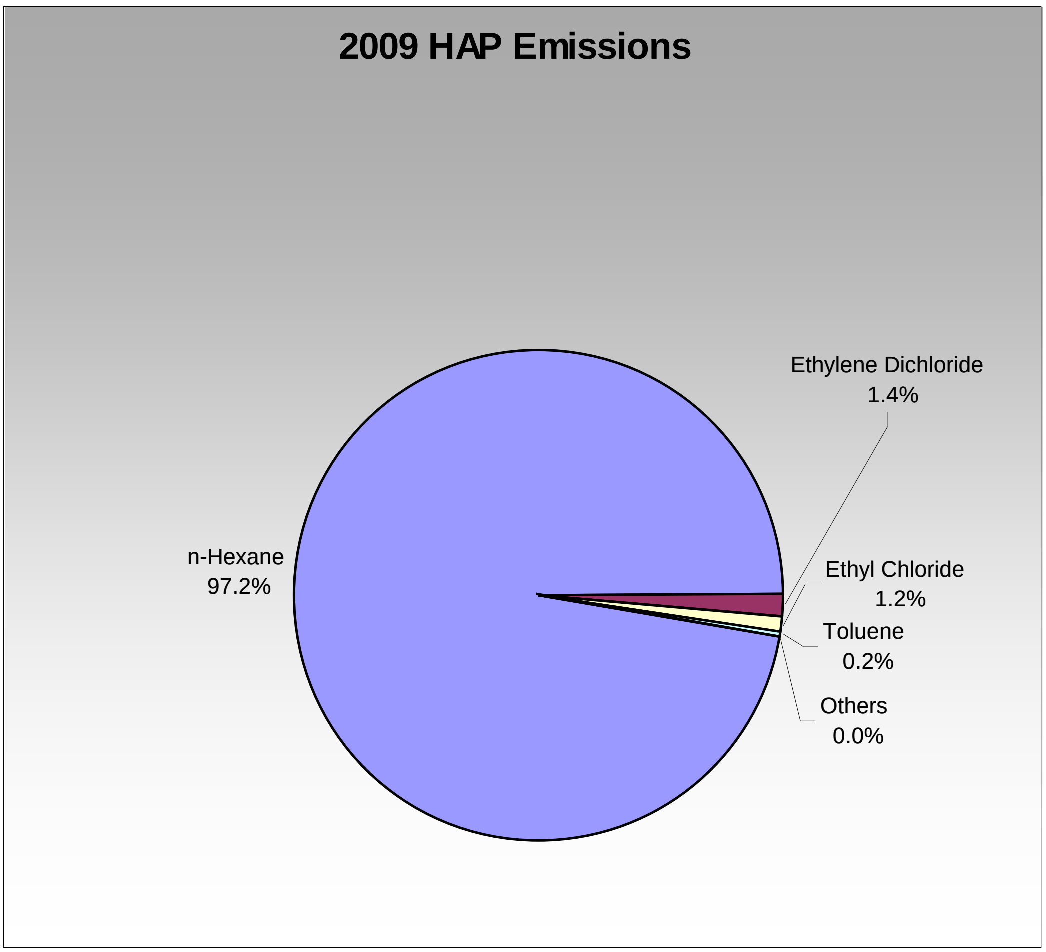


Figure 6 - 2009 HAP Emissions by Percentage

Again, for the 2009 calendar year, the outputs of the HEM-3 software were evaluated for cancer and non-cancer risks. The following table details the cancer risk associated with carcinogen HAP emissions in the area of the study. The model indicates that a total 3,897 people in the area have some degree of cancer risk.

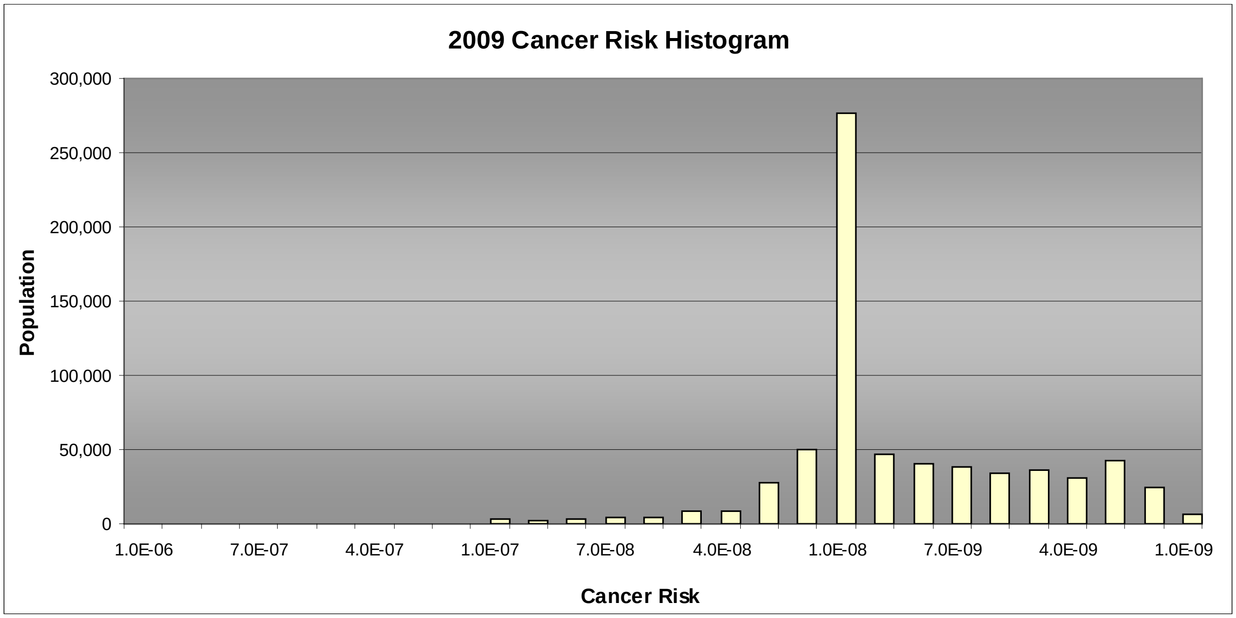
Cancer Risk (2009)	Population
Greater than or equal to 1 in 1,000	-
Greater than or equal to 1 in 10,000	-
Greater than or equal to 1 in 20,000	-
Greater than or equal to 1 in 100,000	-
Greater than or equal to 1 in 1,000,000	-
Greater than or equal to 1 in 10,000,000	3,897

To determine which hazardous air pollutants were contributing to the cancer risk, the following table was extracted from the HEM-3 outputs. As can be seen, Ethylene Dichloride again is the major contributor, over 99.7 percent, of the total cancer risk. Therefore the cancer risk is driven almost entirely from ethylene dichloride emissions.

Table 9 - Potential Cancer Impact (per Year) by Pollutant (2009)

Pollutant	**Number of Cases Per Year**
All modeled pollutants	1.40E-04
Ethylene Dichloride	1.40E-04
p-Dichlorobenzene	4.60E-09
Benzene	4.70E-07
Naphthalene	9.20E-10
Acetaldehyde	5.30E-10
1,3-Butadiene	3.70E-10
Formaldehyde	2.10E-12

The cancer histogram was generated again for 2009 to demonstrate the population affected and their respective cancer risk. As can be seen in the following figure, the bulk of the population falls primarily in the 1.0 x 10^{-8} range.



Comparison of Results

As stated in previous sections, the purpose of this study was to evaluate the change in risk and hazard between the two years to determine the residual risk and subsequent reduction. The two key elements that were compared are the cancer risk for cancer effects and the hazard indices for non-cancer effects.

As indicated in the following table, when comparing the total population with cancer risk, the models indicate a 94.6 percent reduction in at-risk population. This can be attributed to the significant reduction in ethylene dichloride, which was the main driver for cancer risk in the models.

Table 10 - Cancer Risk Comparison

Cancer Risk	Population		Percent Reduction
	2006 Pre-MON	2009 Post-MON	
Greater than or equal to 1 in 1,000	-	-	0%
Greater than or equal to 1 in 10,000	-	-	0%
Greater than or equal to 1 in 20,000	-	-	0%
Greater than or equal to 1 in 100,000	-	-	0%
Greater than or equal to 1 in 1,000,000	228	-	100%
Greater than or equal to 1 in 10,000,000	72,423	3,897	94.6%
Total	**72,651**	**3,897**	**94.6%**

The histograms for each year were combined in the following figure to illustrate the shift in cancer risk to a lower probability. As indicated, the mean shifts from the 4.0 x 10^{-8} to 1.0 x 10^{-8} range down to most of the population at or below 1.0 x 10^{-8} in 2009.

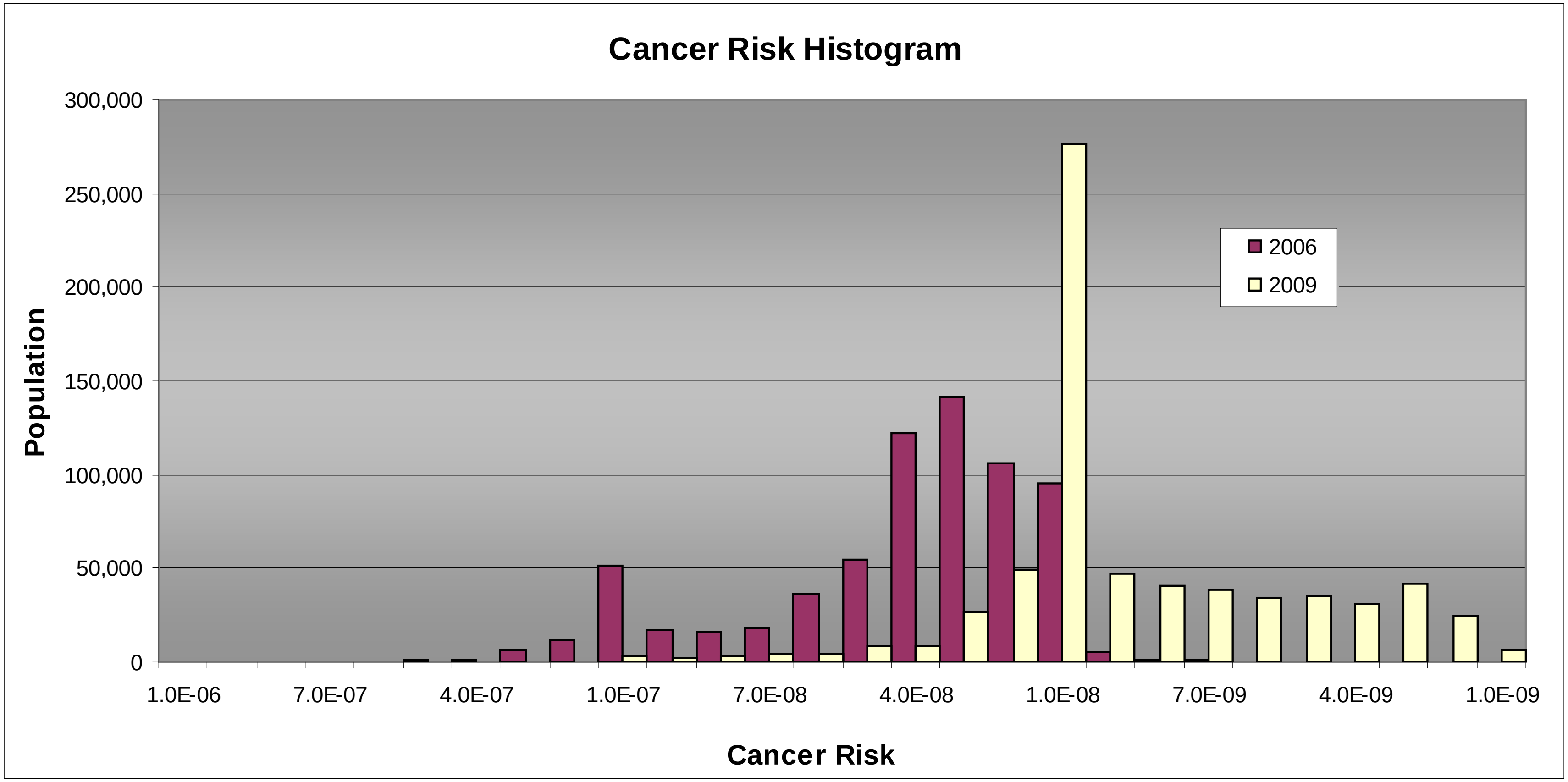


Figure 7 - Cancer Histogram

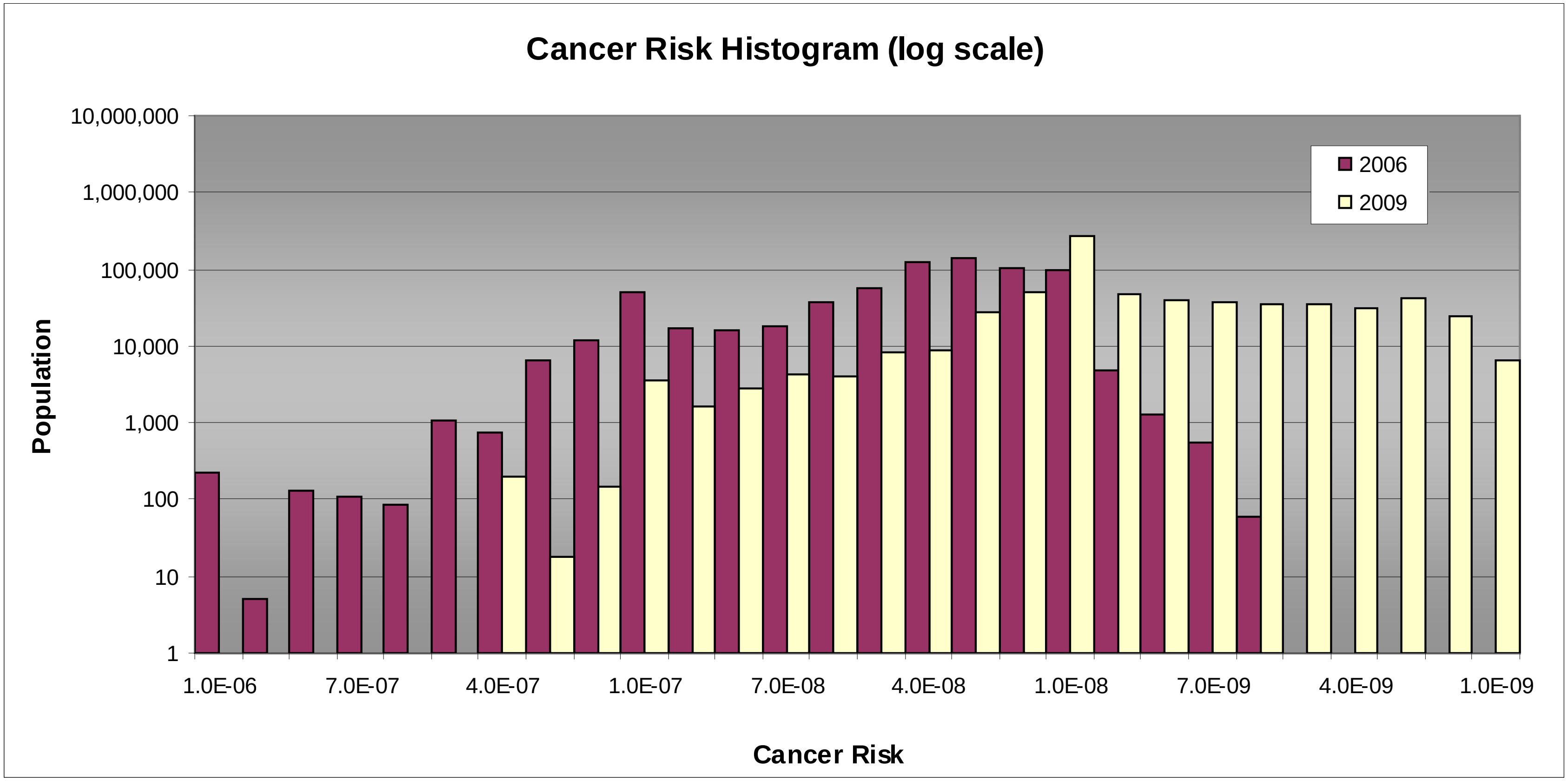


Figure 8 - Cancer Histogram (log scale)

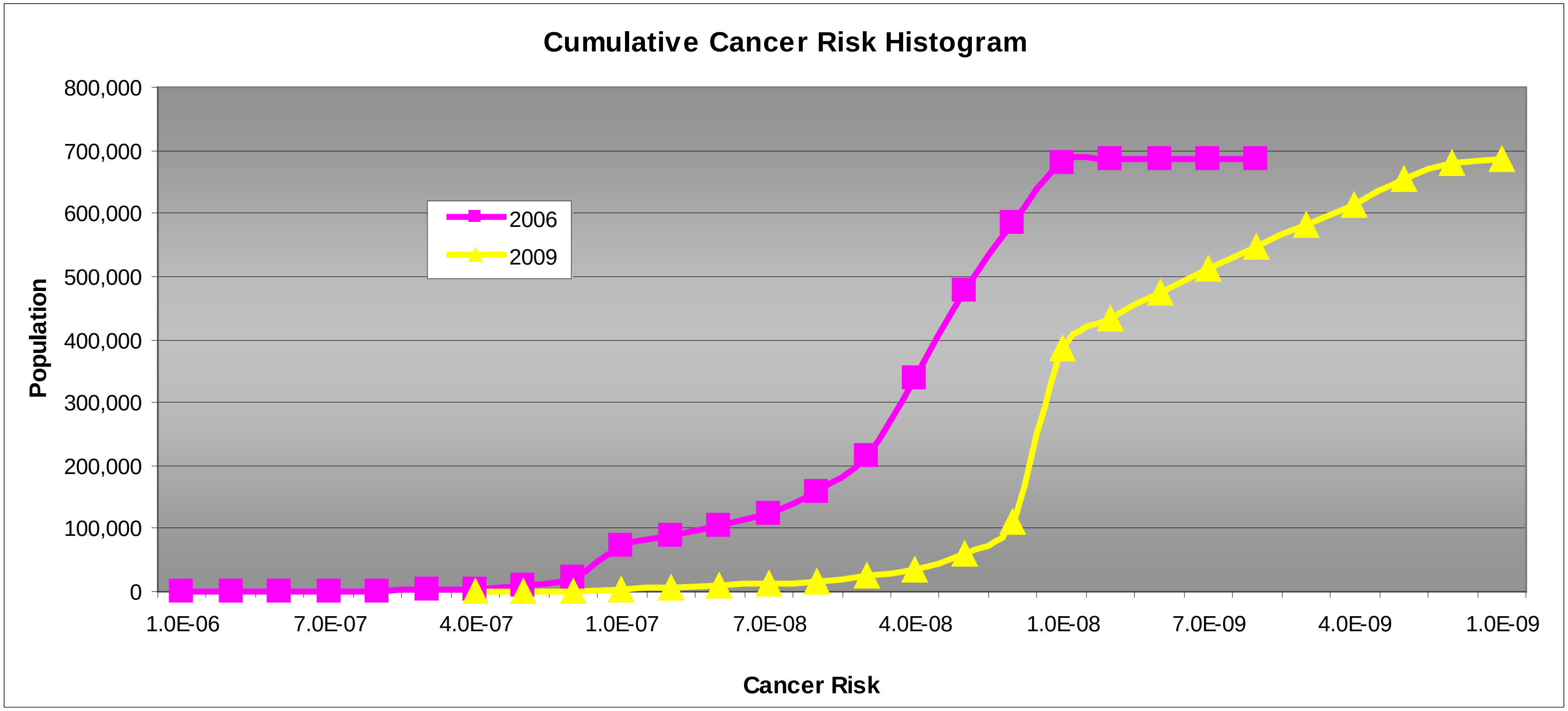


Figure 9 - Cumulative Population Cancer Histogram

Non-cancer risks were evaluated using the Hazard Index. Hazard indexes are collated in HEM-3 for various toxicological effects, such as respiratory, liver, neurological, developmental, reproductive, kidney, immunological, and spleen. As indicated in the table below, the emission reductions resulted in significant reduction in the maxim hazard indices that the model calculated.

Table 11 - Maximum Offsite Hazard Indices

Parameter	2006 Hazard Index	2009 Hazard Index	Percent Reduction
Total hazard index - chronic	68	0.39	99%
Respiratory HI	63	0.39	99%
Liver HI	0.032	0.0042	87%
Neurological HI	0.4	0.39	3%
Developmental HI	0.064	0.0049	92%
Reproductive HI	0.0021	0.000082	96%
Kidney HI	0.0021	0.000081	96%
Immunological HI	0.11	0.09	18%
Spleen HI	27	0	100%
Whole body HI	0.043	0	100%

The table above lists the maximum calculated Hazard Indices by toxicological effect. The cumulative total index for each is listed in the table below. As can be seen, the emissions were not significant enough to place any value on these risks.

Table 12 - 2006 Non-cancer Risk Exposure (Hazard Index)

level	Greater than or equal to 100	Greater than or equal to 50	Greater than or equal to 10	Greater than or equal to 1.0	Greater than or equal to 0.5	Greater than or equal to 0.2
Chronic HI	0	0	0	0	0	0
Respiratory HI	0	0	0	0	0	0
Liver HI	0	0	0	0	0	0
Neurotoxicity HI	0	0	0	0	0	0
Developmental HI	0	0	0	0	0	0
Reproductive HI	0	0	0	0	0	0
Kidney HI	0	0	0	0	0	0
Ocular HI	0	0	0	0	0	0
Endocrine HI	0	0	0	0	0	0
Hematological HI	0	0	0	0	0	0
Immunological HI	0	0	0	0	0	0
Skeletal HI	0	0	0	0	0	0
Spleen HI	0	0	0	0	0	0
Thyroid HI	0	0	0	0	0	0
Whole Body HI	0	0	0	0	0	0

Table 13 - 2009 Non-cancer Risk Exposure (Hazard Index)

level	Greater than or equal to 100	Greater than or equal to 50	Greater than or equal to 10	Greater than or equal to 1.0	Greater than or equal to 0.5	Greater than or equal to 0.2
Chronic HI	0	0	0	0	0	0
Respiratory HI	0	0	0	0	0	0
Liver HI	0	0	0	0	0	0
Neurotoxicity HI	0	0	0	0	0	0
Developmental HI	0	0	0	0	0	0
Reproductive HI	0	0	0	0	0	0
Kidney HI	0	0	0	0	0	0
Ocular HI	0	0	0	0	0	0
Endocrine HI	0	0	0	0	0	0
Hematological HI	0	0	0	0	0	0
Immunological HI	0	0	0	0	0	0
Skeletal HI	0	0	0	0	0	0
Spleen HI	0	0	0	0	0	0
Thyroid HI	0	0	0	0	0	0
Whole Body HI	0	0	0	0	0	0

Conclusion

The National Emission Standards for Hazardous Air Pollutants (NESHAP) is the guiding regulation by which the EPA reduces public health risks associated with hazardous air pollutants (HAPs). This is accomplished by regulating various different industries, thus requiring the installation of Maximum Achievable Control Technologies (MACT). As can be seen by the review of the MON rule, these NESHAP are often very rigorous and prescriptive. In the case of the MON, applicability is over numerous industry sectors, and the requirements cover nearly all of the 188 HAPs listed in the Clean Air Act.

In the case of the Geismar facility, the MON rule was one of several contributing factors in the ultimate decision to cease operations in affected production units. In the Celogen OT unit, the implemented controls resulted in a 72 % decrease in ethylene dichloride emissions. This in turn correlated to a 73.5 % decrease in cancer risk (by population affected). As shown in the HEM-3 outputs, ethylene dichloride also accounted for over 98% of the cancer risk in both comparison years. Therefore, it can be surmised that if MON controls had been implemented in the other units that eased operations, it would have had negligible effects on the facility's cancer risk.

For non-cancer hazards, the cumulative chronic hazard indices were negligible in both comparison years, therefore it is difficult to determine the overall non-cancer hazard reduction that may have resulted from the emission changes. However, thee maximum offsite impacts indicate several probability reductions near or above 90%, so it can be postulated that there is likely a significant reduction in toxicity hazards overall.

Unfortunately, there is still a great deal of uncertainty associated with the process. This includes uncertainty in the exposure / dose relationship, air modeling, data validity, and the myriad of assumptions that are made throughout the process. However, the these assessments have demonstrated their worth in aiding in the planning of environmental regulations and policies. Through this study, the following recommendation can be made:

- The authority having jurisdiction (EPA or LDEQ, should continue its efforts to model inhalation exposure to hazardous air pollutant for heavily industrialized areas.
- The results of this modeling can determine the risks that can be accepted and those that must be reduced. For example, a modeled area may be high in cancer risk and respiratory Hazard Index. Therefore, the agency would address the chemical associated with these toxicological effects in that local area.
- Facilities can then be classed as major or minor sources based on their contribution to these effects. Facility level studies could be performed to determine the need to implement MACT controls for specific HAPs.
- Work must continue on comparison analysis of modeling versus ambient air quality monitoring. Efforts should continue to ensure that the dispersion modeling programs are as accurate as possible.

Overall, the Human Health Risk Assessment is a valuable tool that can continue to be developed and utilized by policy makers to ensure that the appropriate health concerns are addressed and funds are allocated to value-added emission reduction projects.

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Appendix A

MON Applicability Threshold Criteria

and Control Requirements

Affected Source Type	Applicability Thresholds/Requirements	Control Requirements
Group 1 Storage Tank and Surge Control Vessel/Bottoms Receiver meeting Group 1 Storage Tank definition	The maximum true vapor pressure of total HAP at the storage temperature is ≥76.6 kilopascals (11.1 psi) and the capacity of the vessel is ≥ 10,000 gallons.	Reduce total HAP emissions by ≥95 percent by weight or to ≤ 20 ppmv of TOC or organic HAP and ≤ 20 ppmv of hydrogen halide and halogen HAP by venting emissions through a closed vent system to any combination of control devices (excluding a flare); or
		Reduce total organic HAP emissions by venting emissions through a closed vent system to a flare; or
		Reduce total HAP emissions by venting to a fuel gas system or process in accordance with 40 CFR 63.982(d).
Group 1 Storage Tank and Surge Control Vessel/Bottoms Receiver meeting Group 1 Storage Tank definition (cont.)	The maximum true vapor pressure of total HAP at storage temperature is <76.6 kilopascals (11.11 psi) and the capacity of the vessel is ≥ 10,000 gallons.	Comply with the requirements of 40 CFR 63, Subpart WW, except as specified in 40 CFR 63.2470; or
		Reduce total HAP emissions by ≥ 95 percent by weight or to ≤20 ppmv of TOC or organic HAP and ≤20 ppmv of hydrogen halide and halogen HAP by venting emissions through a closed vent system to any combination of control devices (excluding a flare); or
		Reduce total organic HAP emissions by venting emissions through a closed vent system to a flare; or
		Reduce total HAP emissions by venting emissions to a fuel gas system or process in accordance with 40 CFR 63.982(d).
Group 1Continuous Process Vent	NA	Reduce emissions of organic HAP by ≥ 98 weight-percent or to an outlet process concentration ≤ 20 ppmv as organic HAP or TOC by venting emissions through a closed-vent system to any combination of control devices (except a flare); or

Affected Source Type	Applicability Thresholds/Requirements	Control Requirements
		Reduce emissions of total organic HAP by venting emissions through a closed vent system to a flare; or
		Use a recovery device to maintain the TRE above 1.9 for an existing source.
Halogenated Group 1 Continuous Process Vent Stream	Using a combustion control device to control organic HAP emissions.	Use a halogen reduction device after the combustion device to reduce emissions of hydrogen halide and halogen HAP by ≥99 percent by weight, or to ≤0.45 kg/hr, or to ≤20 ppmv; or
		Use a halogen reduction device before the combustion device to reduce the halogen atom mass emission rate to ≤0.45 kg/hr or to a concentration ≤20 ppmv.
Group 2 Continuous Process Vent at an existing source	Using a recovery device to maintain the TRE level >1.9 but ≤5.0.	Comply with the requirements in 40 CFR 63.993 and the requirements referenced therein.
Group 1 Batch Process Vents	NA	Reduce collective uncontrolled organic HAP emissions from the sum of all batch process vents within the process by ≥98 percent by weight by venting emissions from a sufficient number of the vents through a closed-vent system to any combination of control devices (except a flare); or
		Reduce collective uncontrolled organic HAP emissions from the sum of all batch process vents within the process by ≥95 percent by weight by venting emissions from a sufficient number of the vents through a closed-vent system to any combination of recovery devices or a biofilter, except you may elect to comply with the requirements of Part 63 Subpart WW for any process tank; or
	For all other batch process vents within the process (not reduced to ≤ 20 ppmv), reduce collective organic	Reduce uncontrolled organic HAP emissions from one or more batch process vents

Affected Source Type	Applicability Thresholds/Requirements	Control Requirements
	HAP emissions by ≥ 98 percent by weight using a control device or by ≥ 95 percent by weight using a recovery device.	within the process by venting through a closed-vent system to a flare or by venting through a closed-vent system to any combination of control devices (excluding a flare) that reduce organic HAP to an outlet concentration ≤ 20 ppmv as TOC or total organic HAP.
Halogenated Group 1 Batch Process Vent	Using a halogen reduction device after the combustion control device; or	Reduce overall emissions of hydrogen halide and halogen HAP by ≥99 percent; or
		Reduce overall emissions of hydrogen halide and halogen HAP to ≤0.45 kg/hr; or
		Reduce overall emissions of hydrogen halide and halogen HAP to a concentration ≤20 ppmv.
	Using a halogen reduction device before the combustion control device.	Reduce the halogen atom mass emission rate to ≤0.45 kg/hr or to a concentration ≤20 ppmv.
Hydrogen Halide and Halogen Halide Process Vents – uncontrolled emissions ≥1,000 lb/yr.	NA	Reduce collective hydrogen halide and halogen HAP emissions by ≥99 percent by weight or to an outlet concentration ≤20 ppmv by venting through a closed-vent system to any combination of control devices; or.
		Reduce the halogen atom mass emission rate emission rate from the sum of all batch process vents and each individual continuous process vent to ≤ 0.45 kg/hr by venting through one or more closed-vent system to a halogen reduction device.
Group 1 Transfer Rack	NA	Reduce emissions of total organic HAP by ≥98 percent by weight or to an outlet concentration ≤20 ppmv as organic HAP or TOC by venting emissions through a closed-vent system to any combination of control devices (except a flare); or
		Reduce emissions of total organic HAP by venting emissions through a closed-vent system to a flare; or

Affected Source Type	Applicability Thresholds/Requirements	Control Requirements
		Reduce emissions of total organic HAP by venting emissions to a fuel gas system or process in accordance with 40 CFR 63.982(d); or
		Use a vapor balancing system designed and operated to collect organic HAP vapors displaced from tank trucks and railcars during loading and route the collected HAP vapors to the storage tank from which the liquid being loaded originated or to another storage tank connected by a common header.
Equipment in organic HAP service	NA	Comply with the requirements of 40 CFR Subpart UU; or
		Comply with the requirements of 40 CFR Subpart H; or
		Comply with the requirements of 40 CFR 65 Subpart F.
Process Wastewater Stream	NA	Comply with the requirements in 40 CFR 63.132 through 63.148 and the requirements referenced therein, except as specified in 40 CFR 63.2485.
Maintenance Wastewater Stream	NA	Comply with the requirements in 40 CFR 63.105 and the requirements referenced therein, except as specified in 40 CFR 63.2485.
Liquid Streams in an Open System within an MCPU.	NA	Comply with the requirements in 40 CFR 63.149 and the requirements referenced therein, except as specified in 40 CFR 63.2485.
Heat Exchange Systems	NA	Comply with the requirements of 40 CFR 63.104 and the requirements reference therein, except as specified in 40 CFR 63.2490.

Appendix B

2006 Emissions Data

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0003	A	2053 Inventory Tank		
			Ethyl Chloride	0.179003
			n-Hexane	0.0468745
R0004	A	2054 Equalization Tank		
			n-Hexane	0.0468745
			Ethyl Chloride	0.179003
R0006	A	2056 Flocculation Tank		
			n-Hexane	0.00091
			Ethyl Chloride	0.0037925
R0007	A	2057 Dissolved Air Floatation Unit		
			n-Hexane	5.8520255
			Ethyl Chloride	2.540929
R0012	A	2063 Sludge Holding Tank		
			Ethyl Chloride	0.0098605
R0014	A	2066 Effluent Lift Station Sump		
			Ethyl Chloride	0.001517
R0015	A	2067 Influent Lift Station Sump		
			n-Hexane	0.0018205
			Ethyl Chloride	0.006068
R0069	P	"B" Dryer Baghouse Collector Vent		
			Hydrochloric acid	0.003415
R0070	P	"A" Dryer Baghouse Collector Vent		
			Hydrochloric acid	0.003415
R0075	P	Hydrogen Chloride Scrubber		
			Hydrochloric acid	0.0012545
			Hydrochloric acid	0.0001395

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0077	P	Solid Recovery Tank		
			Hydrochloric acid	0.001365
R0087	P	400 -EDC Storage Tank		
			Ethylene Dichloride	0.22946
R0090	P	408 -Celogen OT/BHT Cooling Tower		
			Cresols (mixed)	0.0179915
			Toluene	0.007881
			Methyl isobutyl ketone	0.110339
			Acetonitrile	0.066726
			Ethylene Dichloride	0.0192385
R0091	P	7003 -CSA Storage Tank		
			Hydrochloric acid	0.0025445
R0092	P	25-Maleic Anhydride Storage Tank		
			Maleic anhydride	0.02344
R0110	P	2905-Cummins Diesel Fire Pump		
			Acrolein	0.0000095
			Benzene	0.0000955
			Xylenes (mixed)	0.000029
			Toluene	0.000042
			1,3-Butadiene	0.000004
			Naphthalene	0.0000085
			Formaldehyde	0.000121
			Acetaldehyde	0.0000785
R0111	P	2906-Detroit Diesel Fire Pump		
			Xylenes (mixed)	0.0000045
			Benzene	0.000015
			Acetaldehyde	0.000012

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Toluene	0.0000065
			Naphthalene	0.0000015
			1,3-Butadiene	0.0000005
			Formaldehyde	0.000019
			Acrolein	0.0000015
R0125	P	2933-Flexzone Emergency Generator		
			Acrolein	0.0000085
			Acetaldehyde	0.0000715
			Benzene	0.000087
			Naphthalene	0.000008
			1,3-Butadiene	0.0000035
			Formaldehyde	0.00011
			Toluene	0.000038
			Xylenes (mixed)	0.0000265
R0144	A	2071 Settling Tank		
			n-Hexane	0.0027305
			Ethyl Chloride	0.0113775
R0164	A	294 - Thiazoles Lift Station		
			Aniline	0.4101975
			Toluene	0.324682
R0165	A	297 - Cone Bottom Tank		
			Cresols (mixed)	0.019606
			Ethylene Dichloride	0.0000595
			Toluene	0.008899
			Hydrochloric acid	0.0002105
			Methanol	0.0024055
			Methyl isobutyl ketone	0.034137
			Aniline	0.0563155

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Acetonitrile	0.0040325
R0166	A	298 - Emergency Surge Tank		
			Methanol	0.020023
			Toluene	0.0643105
			Ethylene Dichloride	0.0004
			Aniline	0.9038255
			Acetonitrile	0.0269755
			Hydrochloric acid	0.0053185
			Cresols (mixed)	0.350163
			Methyl isobutyl ketone	0.260719
R0167	A	299 - Hold Tank		
			Hydrochloric acid	0.0029895
			Acetonitrile	0.056663
			Methyl isobutyl ketone	0.5005805
			Methanol	0.033928
			Ethylene Dichloride	0.000862
			Cresols (mixed)	0.2792125
			Aniline	0.8064905
			Toluene	0.1303595
R0168	A	300 - Hold Tank		
			Methyl isobutyl ketone	0.5005805
			Hydrochloric acid	0.0029895
			Toluene	0.1303595
			Acetonitrile	0.056663
			Cresols (mixed)	0.2792125
			Ethylene Dichloride	0.000862
			Methanol	0.033928

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Aniline	0.8064905
R0169	A	301 - Decanter		
			Acetonitrile	0.0044495
			Cresols (mixed)	0.028731
			Toluene	0.010116
			Methanol	0.0028645
			Hydrochloric acid	0.000335
			Ethylene Dichloride	0.000066
			Methyl isobutyl ketone	0.0396295
			Aniline	0.0803015
R0170	A	305 - Clear Water Tank		
			Ethylene Dichloride	0.000086
			Hydrochloric acid	0.0003755
			Aniline	0.0949015
			Toluene	0.0131055
			Cresols (mixed)	0.033518
			Methyl isobutyl ketone	0.0507535
			Methanol	0.00365
			Acetonitrile	0.00584
R0171	A	306 - Lift Station		
			Aniline	0.1765935
			Methyl isobutyl ketone	0.994208
			Methanol	0.012167
			Toluene	1.2479745
			Acetonitrile	0.0306955
			Ethylene Dichloride	0.0023745
			Hydrochloric acid	0.0005005

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Cresols (mixed)	0.053743
R0181	P	05 - Aniline Storage Tank Vent		
			Aniline	0.006421
R0183	P	103 - Thiazoles Flare		
			Carbon disulfide	0.000122
			Hydrogen sulfide	0.001025
			Carbon disulfide	0.0078705
			Aniline	0.0001005
			Methanol	0.0005165
R0184	P	164 - Hydrocarbon Scrubber		
			Toluene	0.2822
R0191	P	9002 - Cooling Tower		
			Hydrogen sulfide	0.26
			Carbon disulfide	0.04
			Toluene	0.044
R0192	P	9004 - Filter Vacuum Pump		
			Toluene	0.390468
R0193	A	9005 - Hypochlorite Tanks		
			Chlorine	0.1322185
			Hydrochloric acid	0.002282
R0196	P	9009 - Sodium Hypochlorite Weigh Tank		
			Hydrochloric acid	0.001141
R0197	P	9010 - Sodium Hypochlorite Weigh Tank		
			Hydrochloric acid	0.001141
R0198	P	9011 - NaMBT Storage Tank		
			Toluene	0.1849525

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0199	P	9012 - Crude NaMBT Storage Tank	Toluene	0.218926
R0200	P	9014 - NaMBT Storage Tank	Toluene	0.2355715
R0201	P	9015 - NaMBT Storage Tank	Toluene	0.1743055
R0202	P	9016 - MOM Slurry Tank	Toluene	0.489412
R0203	P	9017 - NaMBT Intermediate Storage Tank	Toluene	0.0922995
R0204	P	9018 - NaMBT Storage Tank	Toluene	0.0850465
R0205	P	9019 - NaMBT Storage Tank	Toluene	0.0850465
R0206	P	9020 - MOM Reactors	Toluene	0.290527
R0207	P	9021 - NaMBT Storage Tank	Toluene	0.111616
R0208	P	9023 - NaMBT Treatment Mixer	Toluene	0.014813
R0210	P	9025 - MOM Effluent Filter Tank	Toluene	0.0279725
R0215	P	9030 - 25% NaMBT Storage	Toluene	0.0415745
R0216	P	9031 - NaMBT Storage		

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Toluene	0.07293
R0223	P	21 - Paracresol Storage Tank		
			Cresols (mixed)	0.010313
R0225	P	23 - Acetonitrile Storage Tank		
			Acetonitrile	0.0550455
R0226	P	72 - Recovered Organics Receiver		
			Cresols (mixed)	0.001778
R0231	P	127A - Absorption Column		
			Acetonitrile	0.154715
R0232	P	216 - Organic Still Vacuum Vent		
			Cresols (mixed)	0.00277
R0235	A	219 - Sump		
			Acetonitrile	0.004
R0237	P	3001 - UDMH Storage Condenser/Scrubber		
			1,1-Dimethylhydrazine	0.003273
R0239	P	9032-Vent Scrubber/condenser		
			Toluene	0.091761
			Hydrogen sulfide	0.001357
			Toluene	0.2787755
			Hydrogen sulfide	0.002855
			Toluene	0.091761
			Toluene	0.091761
			Toluene	0.091761
			Hydrogen sulfide	0.002855
			Hydrogen sulfide	0.005445
			Hydrogen sulfide	0.002855
			Hydrogen sulfide	0.002855

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0241	P	46 - Poly II Sample Collection Vent Stack		
			n-Hexane	15.889066
R0242	A	48 - Poly I Wash Tank Sump 1		
			Ethyl Chloride	0.048543
			n-Hexane	0.005006
R0243	P	50 -Poly I Sample Collection Vent Stack		
			n-Hexane	14.4658995
R0244	A	52 - Poly II Wash Tank Sump 1		
			n-Hexane	0.0068265
			Ethyl Chloride	0.0629545
R0245	P	53 - Finishing II Dewatering Screen/Press Combined Vent		
			n-Hexane	3.924306
R0246	A	54 - Finishing I Recycle Water Sump		
			n-Hexane	0.00084
R0247	P	55 - Finishing II Dryer A Zone 1 Vent		
			n-Hexane	4.0183635
R0248	P	58 - Finishing II Dewatering Screen/Press Combined Vent		
			n-Hexane	3.924306
R0249	A	59 - Finishing II Recycle Water Drum		
			n-Hexane	0.00072
R0250	P	60 - Finishing II Dryer B Zone 1 Vent		
			n-Hexane	4.0183635
R0251	P	61 - Finishing II Dryer B Zone 2 Vent		
			n-Hexane	0.9326935
R0252	P	65 - Additive Storage Tank		

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			n-Hexane	0.40733
R0253	P	66 - Additive Storage Tank	n-Hexane	0.203665
R0254	P	67 - Dry Hexane Storage Tank Condenser	n-Hexane	0.209545
R0255	A	68 - Poly I Gel Floc Dewatering Screen Sump 2	n-Hexane	0.023935
R0256	A	69 - Poly II Filter Box Screen for PV-114	n-Hexane	0.088185
R0257	P	102 - Royalene Flare	n-Hexane	1.715
R0258	P	157 - Finishing I Dryer C Zone 2 Vent	n-Hexane	0.925307
R0259	P	159 - Finishing I A Dewatering Screen/Press Combined Vent	n-Hexane	4.209925
R0260	P	160 - Finishing I Dryer C Zone 1 Vent	n-Hexane	3.9799525
R0261	P	169 - Finishing I Dewatering Screen/Press Combined Vent	n-Hexane	4.209925
R0262	P	170 - Finishing I Dryer D Zone 2 Vent	n-Hexane	0.925307
R0263	P	172 - Finishing I Dryer D Zone 1 Vent	n-Hexane	3.9799525
R0264	P	211 - Dry Hexane Storage Tank	n-Hexane	0.522385

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0265	P	212 - Dry Hexane Storage Tank	n-Hexane	0.50643
R0266	P	245 - Finishing III A Dewatering Screen Vent	n-Hexane	0.1713715
R0267	P	246 - Finishing III B Dewatering Screen Vent	n-Hexane	0.1713715
R0268	P	247 - Finishing III Dryer A Feed Conveyor and Cyclone Vent	n-Hexane	12.6322375
R0269	P	248 - Finishing III Dryer B Feed Conveyor and Cyclone Vent	n-Hexane	12.6322375
R0270	P	249 - Finishing III Dryer A Zone 1 Vent	n-Hexane	3.173325
R0271	P	250 - Finishing III Dryer A Zone 3 Vent	n-Hexane	1.1385365
R0272	P	251 - Finishing III Dryer B Zone 1 Vent	n-Hexane	3.173325
R0273	P	252 - Finishing III Dryer B Zone 3 Vent	n-Hexane	1.1385365
R0274	P	254 - Poly III Sample Collection Vent Stack	n-Hexane	14.4658995
R0275	A	257 - Finishing III Water Drum	n-Hexane	0.00073
R0278	P	277 - Diene-Free Hexane Storage Tank	n-Hexane	0.409425

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0279	P	278 - Poly II Hexane Recovery Pot A		
			n-Hexane	0.529105
R0280	P	279 - Poly II Hexane Recovery Pot B		
			n-Hexane	0.529105
R0281	P	280 - Poly I Hexane Recovery Pot		
			n-Hexane	0.33174
R0282	P	285 - Poly III Cooling Tower		
			n-Hexane	2.649
R0283	P	290 - Poly III Hexane Recovery Pots		
			n-Hexane	0.529105
R0284	P	291 - Finishing 1 C Dryer Penthouse Vent		
			n-Hexane	14.3700815
R0285	P	292 - Finishing 1 D Dryer Penthouse Vent		
			n-Hexane	14.3700815
R0286	P	293 - Dry Hexane Storage Tank		
			n-Hexane	0.50979
R0287	A	302 - Royalene Lift Station		
			n-Hexane	0.00588
			Ethyl Chloride	0.0119
R0288	P	307 - Recovery Cooling Tower		
			n-Hexane	0.2316
R0289	A	2002 - Trilene I Wash Tank Sampling/Disposal		
			n-Hexane	0.008423
R0290	P	2003 - Trilene I Lab Hoods		
			n-Hexane	0.076083

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0291	P	2004 - Trilene I Copolymer Storage Vent	n-Hexane	0.14181
R0292	P	2007 - Trilene I A Off Spec Charge Tank	n-Hexane	0.0008285
R0293	P	2008 - Trilene I B Off Spec Charge Tank	n-Hexane	0.0008285
R0294	P	2009 - Trilene I A Copolymer Blend Storage Vent	n-Hexane	0.0752545
R0295	P	2010 - Trilene I B Copolymer Blend Storage Vent	n-Hexane	0.0752545
R0296	P	2011 - Trilene I C Copolymer Blend Storage Vent	n-Hexane	0.0752545
R0299	A	2014 - Trilene I Product Truck Loading	n-Hexane	0.0057995
R0300	A	2015 - Product Packing/Drum Loading	n-Hexane	0.289972
R0302	A	2017 - Trilene I Surface Water Sump 1	n-Hexane	0.0005525
R0303	A	2018 - Trilene I Process Sump 2	n-Hexane	0.0005525
R0304	A	2019 - Trilene I Surface Water Sump 3	Ethyl Chloride	0.00023
			n-Hexane	0.000276
R0306	P	2021 - Trilene I Drum Storage Area	n-Hexane	0.0044185

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0311	A	2108 - Trilene Semi-Works Product Packaging	n-Hexane	0.126
R0314	A	2201 - Poly I Monomer Compressor Oil Reservoir	n-Hexane	0.0018205
R0315	A	2202 - Poly I Filter Box for Slurry Tank PV-14	n-Hexane	0.087345
R0318	A	2205 - Poly I Floc Water Hydrosieve Vent	n-Hexane	0.10078
R0320	P	2207 - Poly I Recycle Water Drum Vent	n-Hexane	0.00042
R0321	A	2208 - Poly I Gel Floc Dewatering Screen Vent	n-Hexane	0.04997
R0323	P	2210 - Poly I Lab Hood Vent	n-Hexane	0.000455
R0324	P	2215 - Poly I/II Lab Vent	n-Hexane	0.0096
R0340	P	2301 - Finishing I Rework Tank	n-Hexane	0.00049
R0341	A	2302 - Finishing I Conveyors, delumpers, balers, wrappers	n-Hexane	0.307779
R0342	P	2401 - Poly II Monomer Compressor Oil Reservoir	n-Hexane	0.0018205
R0345	P	2406 - Poly II Hydrosieve Vent	n-Hexane	0.06551
R0346	P	2407 - Poly II Hydrosieve Vent		

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			n-Hexane	0.06551
R0347	P	2408 - Poly II Floc Tank Water Drum Vents	n-Hexane	0.027715
R0348	P	2410 - Poly II Recycle Water Drum Vent	n-Hexane	0.00042
R0351	A	2416 - Poly II Filter Box for PV-214	n-Hexane	0.088185
R0352	A	2501 - Finishing II Sump	n-Hexane	0.073905
R0353	P	2502 - Finishing II Dryer A Cyclone Vent	n-Hexane	14.503042
R0354	P	2503 - Finishing II Dryer B Cyclone Vent	n-Hexane	14.503042
R0355	P	2504 - Finishing II Dryer A Zone 2 Vent	n-Hexane	0.9326935
R0356	P	2505 - Finishing II Rework Tank	n-Hexane	0.000505
R0357	A	2506 - Finishing II Conveyors, delumpers, balers, wrappers	n-Hexane	0.3107335
R0358	A	2507 - Finishing II Crumb Separator	n-Hexane	0.015115
R0359	P	2603 - Poly III Monomer Compressor	n-Hexane	0.0018205
R0361	P	2607 - Poly III Skimmer Tank Vent	n-Hexane	0.130595

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0362	P	2608 - Poly III Recycle Water Tank	n-Hexane	0.028135
R0363	A	2610 - Poly III Gel Floc Dewatering Screen	n-Hexane	0.021835
R0364	A	2611 - Poly III Gel Floc Tank Dewatering Screen Sump 1	Ethyl Chloride	0.054611
R0366	P	2613 - Poly III Lab Hood	n-Hexane	0.00042
R0369	A	2618 - Poly III Gel Floc Sump	n-Hexane	0.0105
R0370	P	2619 - Poly III Lab Mill Vent	n-Hexane	0.00336
R0371	P	2704 - Finishing III Line A Dewatering Press Vent	n-Hexane	3.2476845
R0372	P	2705 - Finishing III Line B Dewatering Press Vent	n-Hexane	3.2476845
R0373	P	2714 - Finishing III Rework Tank	n-Hexane	0.00051
R0374	A	2715 - Finishing III Conveyors, delumpers, balers, wrappers	n-Hexane	0.2698605
R0375	A	2716 - Finishing III Sump I	n-Hexane	0.023935
R0376	A	2802T - Recovery Trench	n-Hexane	0.000044
R0378	A	2804T - Recovery Scrubber Trench		

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			n-Hexane	0.00876
R0379	A	2804 - Recovery "Cat K" Scrubber Sump		
			n-Hexane	0.00378
R0381	P	2807 - 91-CG-119 A/B Bag Filters		
			n-Hexane	0.0006
R0382	P	2808 - 91-RG-119 A/B Bag Filters		
			n-Hexane	0.0006
R0383	A	2809 - Poly III Sump		
			n-Hexane	0.0018205
			Ethyl Chloride	0.017445
R0384	A	2811 - Trilene Sump		
			n-Hexane	0.0006
R0385	A	2812 - Flexzone Sump		
			n-Hexane	0.0168385
			Ethyl Chloride	0.129701
R0388	P	37 - Crude Ketone Storage SV-08		
			Methyl isobutyl ketone	0.2541375
R0389	P	38 - Ketone Storage Tank SV-15		
			Methyl isobutyl ketone	0.2315475
R0390	P	39 - Ketone Separator		
			Methyl isobutyl ketone	0.0056475
R0391	P	43 - Water Storage Tank SV-06		
			Methyl isobutyl ketone	0.0001825

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0393	P	78 - Ketone Overflow Tank SV-013		
			Methyl isobutyl ketone	0.0056475
R0396	P	81 - Ketone Storage Tank SV-17		
			Methyl isobutyl ketone	0.2993175
R0397	P	82 - Product Storage PV-35		
			Methyl isobutyl ketone	0.0056475
R0399	P	84 - Product Storage PV-37		
			Methyl isobutyl ketone	0.0056475
R0402	P	149 - Vent Condenser PV-209 & PV-213		
			Methyl isobutyl ketone	0.2259
R0403	P	156 - BHT Flare		
			Methanol	0.035447
			1,1-Dimethylhydrazine	0.001115
			Methyl isobutyl ketone	0.13554
			Toluene	0.7798485
			Methanol	0.035447
			Aniline	0.0000325
			Acetonitrile	0.016158
			Methanol	0.035447
			Methanol	0.035447
			Methanol	0.035447
			Methanol	0.035447
			Methanol	0.035447

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Cresols (mixed)	0.0071125
R0405	P	259 - Flexzone Feed Tank FV-04		
			Methyl isobutyl ketone	0.001295
R0406	P	260 - UBOB/DPA Catch Tank FV-01		
			Methyl isobutyl ketone	0.000053
R0409	P	267 - Ketone Separator SV-202		
			Methyl isobutyl ketone	0.001265
R0410	P	269 - Product Storage PV-39		
			Methyl isobutyl ketone	0.0056475
R0412	P	273 - New Blend Tank PV-40		
			Methyl isobutyl ketone	0.0056475
R0413	P	274 - Product Hold Tank FV-02		
			Methyl isobutyl ketone	0.0013665
R0415	P	6001 - Reactor PR-06A		
			Methyl isobutyl ketone	0.0395325
R0416	P	6002 - Reactor PR-06B		
			Methyl isobutyl ketone	0.0395325
R0417	P	6003 - Reactor PR-06C		
			Methyl isobutyl ketone	0.011295
R0420	P	6008 - Product Rework Tank RV-201		

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Methyl isobutyl ketone	0.909248
R0421	P	6010 - Product Railcar Loading		
			Methyl isobutyl ketone	0.09036
R0422	P	6011 - Flexzone Truck Loading		
			Methyl isobutyl ketone	0.604283
R0423	P	6012 - Ketone Truck Loading		
			Aniline	0.000003
			Toluene	0.0000205
R0424	P	6020 - Flexzone Drumming Station		
			Methyl isobutyl ketone	0.0056475
R0425	P	6021 - Pelletizer FG-10		
			Methyl isobutyl ketone	0.0056475
R0431	P	6051 - Effluent Surge Tank		
			Methyl isobutyl ketone	0.773708
R0438	P	407-Finishing Vent		
			Ethylene Dichloride	0.8080235
R0440	P	405 -Dehumidification Column		
			Ethylene Dichloride	0.4476005
			Ethylene Dichloride	0.295155
			Ethylene Dichloride	0.1036855
			Ethylene Dichloride	0.0833265
			Ethylene Dichloride	0.1036855
			Ethylene Dichloride	1.0718965

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Ethylene Dichloride	1.114767
			Ethylene Dichloride	0.527543
			Ethylene Dichloride	0.1036855
			Ethylene Dichloride	0.1879385
R0441	P	406 -Celogen OT Centrifuge		
			Ethylene Dichloride	3.329386
R0446	P	9006 - Tar Trailer Loading		
			Aniline	0.02132
			Toluene	0.4697575
R0447	P	9022 - Railcar Loading		
			Toluene	0.0498935
R0472	P	0198a - Maintenance Sumps		
			Phenol	0.000004
			Methanol	1.625424
			Toluene	0.035773
R0473	P	124 - UBOB Separator Vent Condenser		
			Chlorobenzene	0.0000385
			Methyl Chloride	0.0266745
			Benzene	0.0029105
			Chlorobenzene	0.0000385
			Toluene	0.1279085
			Methanol	0.1117775
			Benzene	0.0029105
			Methyl Chloride	0.0266745
			Toluene	0.1279085
			Methanol	0.1117775
R0483	P	195 - UBOB Atmospheric Still Vent Scrubber		
			Chlorobenzene	0.0025915

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Methyl Chloride	4.3941045
			Benzene	0.065922
			Toluene	3.7783175
R0484	P	198 - Emergency Sumps		
			Toluene	0.0034095
			Methyl Chloride	0.000002
			Chlorobenzene	0.000018
			Methanol	0.036226
			Benzene	0.000002
			Phenol	0.000419
R0485	P	199 - Dried UBOB Storage		
			Methanol	0.000895
			Toluene	0.1831655
			Benzene	0.000162
			Aniline	0.0030205
			Methyl Chloride	0.0000195
			Chlorobenzene	0.0004245
R0488	P	204 - Reducer Toluene Condenser Vent		
			Methanol	0.0188945
			Benzene	0.0019655
			Chlorobenzene	0.0001325
			Methanol	0.0188945
			Aniline	0.0000005
			Aniline	0.0000005
			Aniline	0.0000005
			Methanol	0.0188945
			Aniline	0.0000005
			Benzene	0.0019655
			Methanol	0.0188945

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Chlorobenzene	0.0001325
			Toluene	0.2181545
			Benzene	0.0019655
			Toluene	0.2181545
			Toluene	0.2181545
			Toluene	0.2181545
			Chlorobenzene	0.0001325
			Methyl Chloride	0.0449595
			Methyl Chloride	0.0449595
			Chlorobenzene	0.0001325
			Methyl Chloride	0.0449595
			Methyl Chloride	0.0449595
			Benzene	0.0019655
R0493	P	206 - UBOB Drying Condenser Vent		
			Methanol	0.205632
			Benzene	0.0035345
			Benzene	0.0035345
			Aniline	0.00003
			Methyl Chloride	0.0059715
			Methanol	0.205632
			Methyl Chloride	0.0059715
			Toluene	0.4556195
			Aniline	0.00003
			Methanol	0.205632
			Methanol	0.205632
			Methanol	0.205632
			Benzene	0.0035345
			Methanol	0.205632
			Toluene	0.4556195
			Toluene	0.4556195

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Benzene	0.0035345
			Chlorobenzene	0.0002155
			Chlorobenzene	0.0002155
			Toluene	0.4556195
			Chlorobenzene	0.0002155
			Methyl Chloride	0.0059715
			Chlorobenzene	0.0002155
			Benzene	0.0035345
			Toluene	0.4556195
			Aniline	0.00003
			Chlorobenzene	0.0002155
			Aniline	0.00003
			Methyl Chloride	0.0059715
			Chlorobenzene	0.0002155
			Aniline	0.00003
			Aniline	0.00003
			Benzene	0.0035345
			Methyl Chloride	0.0059715
			Methyl Chloride	0.0059715
			Toluene	0.4556195
R0501	P	210 - Distilled UBOB Storage Tank		
			Aniline	0.0008475
			Methanol	0.000273
			Methyl Chloride	0.0000285
			Toluene	0.0620335
			Benzene	0.0001005
			Chlorobenzene	0.0001295
R0502	P	220 - Reactor Vent		
			Toluene	0.54151
			Toluene	0.54151

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Methyl Chloride	0.177039
			Benzene	0.005115
			Methyl Chloride	0.177039
			Chlorobenzene	0.0005255
			Methyl Chloride	0.177039
			Methyl Chloride	0.177039
			Benzene	0.005115
			Methyl Chloride	0.177039
			Methyl Chloride	0.177039
			Benzene	0.005115
			Chlorobenzene	0.0005255
			Chlorobenzene	0.0005255
			Benzene	0.005115
			Chlorobenzene	0.0005255
			Methyl Chloride	0.177039
			Methyl Chloride	0.177039
			Chlorobenzene	0.0005255
			Benzene	0.005115
			Benzene	0.005115
			Toluene	0.54151
			Toluene	0.54151
			Chlorobenzene	0.0005255
			Chlorobenzene	0.0005255
			Toluene	0.54151
			Toluene	0.54151
			Benzene	0.005115
			Chlorobenzene	0.0005255
			Toluene	0.54151
			Toluene	0.54151
			Methyl Chloride	0.177039
			Toluene	0.54151

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Benzene	0.005115
			Chlorobenzene	0.0005255
			Benzene	0.005115
R0512	P	221 - Crude Methanol Vent Condenser and Scrubber		
			Toluene	0.000287
			Methyl Chloride	0.0000095
			Methyl Chloride	0.0000095
			Benzene	0.0000055
			Toluene	0.000287
			Methanol	0.000918
			Toluene	0.000287
			Aniline	0.0000125
			Methyl Chloride	0.0000095
			Aniline	0.0000125
			Aniline	0.0000125
			Benzene	0.0000055
			Methanol	0.000918
			Methanol	0.000918
			Benzene	0.0000055
R0516	P	222 - Reducer Toluene Condenser Vent		
			Toluene	0.940148
			Benzene	0.008171
			Aniline	0.0000015
			Methyl Chloride	0.179978
			Methanol	0.0755775
			Chlorobenzene	0.000582
R0517	P	225 - Intermediate NaTKB Storage Tank		
			Methanol	0.3351295
			Benzene	0.0000015

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Methyl Chloride	0.0012515
			Toluene	0.0002545
			Chlorobenzene	0.0000005
R0518	P	234 - Causticizer Vent		
			Toluene	0.3981245
			Methanol	0.0974305
R0520	P	236 - Causticizer Separator Vent		
			Methanol	0.1807895
			Toluene	0.7387485
R0523	P	261 - Distilled UBOB Storage		
			Chlorobenzene	0.0001125
			Methyl Chloride	0.000028
			Benzene	0.0000985
			Methanol	0.0002535
			Toluene	0.058642
			Aniline	0.0008025
R0524	P	28 - Fresh Toluene Storage Tank		
			Toluene	0.291365
R0525	P	282 - Toluene Seal Pot		
			Toluene	0.0375525
R0526	P	33 - UBOB Drying Still Feed Tank		
			Methanol	0.144361
			Toluene	0.38228
			Methyl Chloride	0.0045355
			Methyl Chloride	0.0045355
			Benzene	0.002607
			Benzene	0.002607
			Toluene	0.38228

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Chlorobenzene	0.0002655
			Methanol	0.144361
			Chlorobenzene	0.0002655
R0528	P	413 - Methanol Column Receiver		
			Methanol	0.079392
			Toluene	0.000059
R0529	P	558 - UBOB Toluene Storage Condenser Vent		
			Methyl Chloride	0.0947
			Methyl Chloride	0.0947
			Aniline	0.0000005
			Methanol	0.034855
			Aniline	0.0000005
			Aniline	0.0000005
			Methyl Chloride	0.0947
			Methyl Chloride	0.0947
			Methanol	0.034855
			Aniline	0.0000005
			Methanol	0.034855
			Methyl Chloride	0.0947
			Benzene	0.0017
			Benzene	0.0017
			Benzene	0.0017
			Benzene	0.0017
			Benzene	0.0017
			Aniline	0.0000005
			Aniline	0.0000005
			Chlorobenzene	0.000293
			Chlorobenzene	0.000293
			Methanol	0.034855
			Chlorobenzene	0.000293

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Chlorobenzene	0.000293
			Chlorobenzene	0.000293
			Methanol	0.034855
			Toluene	0.3199275
			Toluene	0.3199275
			Toluene	0.3199275
			Toluene	0.3199275
			Toluene	0.3199275
			Chlorobenzene	0.000293
			Methyl Chloride	0.0947
			Methanol	0.034855
			Benzene	0.0017
			Toluene	0.3199275
R0537	P	6503 - UBOB Drying Still and Toluene Recovery		
			Chlorobenzene	0.0000015
			Methanol	0.002289
			Benzene	0.0000925
			Toluene	0.0048825
			Methyl Chloride	0.000488
R0540	P	6516 - Light Ends Feed Tank		
			Chlorobenzene	0.0001625
			Toluene	0.109615
			Methyl Chloride	0.030879
			Benzene	0.0008435
R0543	P	6522 - UBOB Vacuum Still Vent Scrubber		
			Toluene	5.961759
			Chlorobenzene	0.004729
			Benzene	0.0743515
R0546	P	6526 - Distilled UBOB Storage Vent		

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Benzene	0.0000935
			Chlorobenzene	0.00012
			Toluene	0.059269
			Methanol	0.0002535
			Aniline	0.0008145
			Methyl Chloride	0.0000265
R0551	P	6531 - Tank Truck and Railcar Loading Operations		
			Aniline	0.000062
			Toluene	0.0000285
R0553	P	6533 - Catalyst Filter Dump		
			Toluene	0.0000005
R0555	P	6595 - Rearranger Scrubber		
			Chlorobenzene	0.0064805
			Hydrochloric acid	0.0000305
			Methyl Chloride	0.414256
			Methanol	0.008014
			Methanol	0.0322145
			Methanol	0.0322145
			Methanol	0.0322145
			Methyl Chloride	0.414256
			Methyl Chloride	0.414256
			Toluene	1.084765
			Aniline	0.006912
			Benzene	0.005468
			Hydrochloric acid	0.0000305
			Toluene	1.084765
			Hydrochloric acid	0.0000305
			Toluene	1.084765
			Toluene	3.9330735

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0561	P	77 - Distilled UBOB Storage		
			Methanol	0.0002195
			Toluene	0.051418
			Methyl Chloride	0.0000185
			Chlorobenzene	0.00011
			Aniline	0.0007135
			Benzene	0.0000915
RB9RS	A	B9 Releases		
			Acetonitrile	0.0012
RDWRS	A	Deepwell Releases		
			Methanol	10.514
RF002	A	Equipment Fugitives		
			Chlorine	0.5894935
			Hydrochloric acid	0.3396525
RF004	A	5004 Fugitive Emissions		
			Maleic anhydride	0.058
RF007	A	319 - Fugitive Emissions		
			Carbon disulfide	0.992
			Methanol	0.08
			Toluene	9.514
			Hydrogen sulfide	0.245
			Chlorine	0.609
			Aniline	2.226
RF008	A	3002 - Fugitive Emissions		
			Cresols (mixed)	0.9903
			1,1-Dimethylhydrazine	0.3683
			Acetonitrile	0.513

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Maleic anhydride	0.024643
RF009	A	284 - Royalene/Trilene Semiworks Fugitive Emissions		
			n-Hexane	17.6184
RF010	A	2000 - Trilene I Fugitive Emissions		
			n-Hexane	0.8906285
RF011	A	6200 - Fugitive Emissions		
			Toluene	0.000012
			Aniline	0.0000225
			Methyl isobutyl ketone	1.4965885
RF012	A	409 -Fugitive Emissions		
			Ethylene Dichloride	2.456583
			Hydrochloric acid	0.6754505
RF013	A	6515 - UBOB Fugitive Emissions		
			Benzene	0.068501
			Aniline	0.07436
			Hydrochloric acid	1.520978
			Methanol	4.624648
			Chlorobenzene	0.0434
			Toluene	10.829488
			Methyl Chloride	0.015321
			Phenol	0.0261885
			Phosgene	0.000001
RFXIA	A	Flexzone Insignificant Activities		
			Methanol	1.05
ROTRS	A	OT Releases and Spills		
			Ethylene Dichloride	2.92518
			Hydrochloric acid	0.005

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
RR003	P	138-Reactor Vent		
			Maleic anhydride	0.122755
RRYGC	A	Royalene Trilene GCXVII Activities		
			n-Hexane	1.5035
RRYRS	A	Releases and Spills		
			n-Hexane	0.232341
RSLIA	A	Services & Lab Insignificant Activities		
			Methyl isobutyl ketone	0.00188
			Toluene	0.3206855
			n-Hexane	0.020414
			Ethylene glycol	0.000575
			Methyl ethyl ketone	0.0151465
			Methyl Chloride	0.004956
			Ethyl benzene	0.157125
			Methanol	0.074141
			Carbon disulfide	0.0222835
			Xylenes (mixed)	0.759234
RTZGC	A	Thiazoles GCXVII Activities		
			Toluene	0.000028
			Aniline	0.0000015
RTZRS	A	Thiazoles Releases and Spills		
			Aniline	0.0000035
			Toluene	0.0000195
RUBGC	A	UBOB GCXVII Activities		
			Phenol	0.000002
			Benzene	0.0000045
			Methyl Chloride	0.0001045

Source ID	Source type (P=point, A=area, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Chlorobenzene	0.0000075
			Methanol	0.0593955
RUBIA	A	UBOB Insignificant Activities		
			Methanol	0.03978
			Toluene	0.0544575
			Hydrochloric acid	0.015429
			n-Hexane	0.033162
RUBRS	A	UBOB Releases		
			Toluene	1.03043

Appendix C

2009 Emissions Data

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0003	A	2053 Inventory Tank		
			n-Hexane	0.045733
			Ethyl Chloride	0.1746445
R0004	A	2054 Equalization Tank		
			n-Hexane	0.045733
			Ethyl Chloride	0.1746445
R0006	A	2056 Flocculation Tank		
			Ethyl Chloride	0.0037
			n-Hexane	0.000888
R0007	A	2057 Dissolved Air Floatation Unit		
			n-Hexane	5.7095365
			Ethyl Chloride	2.479061
R0012	A	2063 Sludge Holding Tank		
			Ethyl Chloride	0.0096205
R0014	A	2066 Effluent Lift Station Sump		
			Ethyl Chloride	0.00148
R0015	A	2067 Influent Lift Station Sump		
			Ethyl Chloride	0.00592
			n-Hexane	0.001776
R0087	P	400 -EDC Storage Tank		
			Ethylene Dichloride	0.000295
R0090	A	408 -Celogen OT/BHT Cooling Tower		
			Ethylene Dichloride	0.01924
R0091	P	7003 -CSA Storage Tank		
			Hydrochloric acid	0.0015
R0110	P	2905-Cummins Diesel Fire Pump		
			1,3-Butadiene	0.0000035

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
			Toluene	0.000035
			Naphthalene	0.0000075
			Benzene	0.0000805
			Acrolein	0.000008
			Formaldehyde	0.0001015
			Acetaldehyde	0.000066
			Xylenes (mixed)	0.0000245
R0111	P	2906-Detroit Diesel Fire Pump		
			Acrolein	0.0000005
			Acetaldehyde	0.0000045
			Xylenes (mixed)	0.000002
			Formaldehyde	0.0000075
			Naphthalene	0.0000005
			Benzene	0.000006
			Toluene	0.0000025
R0125	P	2933-Flexzone Emergency Generator		
			Benzene	0.000104
			Toluene	0.0000455
			Naphthalene	0.0000095
			Acetaldehyde	0.0000855
			1,3-Butadiene	0.0000045
			Acrolein	0.0000105
			Xylenes (mixed)	0.000032
			Formaldehyde	0.000132
R0144	A	2071 Settling Tank		
			n-Hexane	0.002664
			Ethyl Chloride	0.0111005
R0168	A	300 - Hold Tank		
			Ethylene Dichloride	0.003219
			Hydrochloric acid	0.0029825

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0170	A	305 - Clear Water Tank		
			Hydrochloric acid	0.0003755
			Ethylene Dichloride	0.0003185
R0171	A	306 - Lift Station		
			Hydrochloric acid	0.0004695
			Ethylene Dichloride	0.0037545
R0241	P	46 - Poly II Sample Collection Vent Stack		
			n-Hexane	14.9609475
R0242	A	48 - Poly I Wash Tank Sump 1		
			Ethyl Chloride	0.047361
			n-Hexane	0.007992
R0243	P	50 -Poly I Sample Collection Vent Stack		
			n-Hexane	14.9609475
R0244	A	52 - Poly II Wash Tank Sump 1		
			Ethyl Chloride	0.0614215
			n-Hexane	0.0111005
R0245	P	53 - Finishing II Dewatering Screen/Press Combined Vent		
			n-Hexane	4.7443485
R0246	A	54 - Finishing I Recycle Water Sump		
			n-Hexane	0.001776
R0247	P	55 - Finishing II Dryer A Zone 1 Vent		
			n-Hexane	4.8606615
R0248	P	58 - Finishing II Dewatering Screen/Press Combined Vent		
			n-Hexane	4.7443485
R0249	A	59 - Finishing II Recycle Water Drum		
			n-Hexane	0.001776

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0250	P	60 - Finishing II Dryer B Zone 1 Vent	n-Hexane	4.8606615
R0251	P	61 - Finishing II Dryer B Zone 2 Vent	n-Hexane	1.1264
R0252	P	65 - Additive Storage Tank	n-Hexane	0.7175215
R0253	P	66 - Additive Storage Tank	n-Hexane	0.7175215
R0254	P	67 - Dry Hexane Storage Tank Condenser	n-Hexane	0.369417
R0255	A	68 - Poly I Gel Floc Dewatering Screen Sump 2	n-Hexane	0.042181
R0256	A	69 - Poly II Filter Box Screen for PV-114	n-Hexane	0.155848
R0257	P	102 - Royalene Flare	n-Hexane	1.836474
R0258	P	157 - Finishing I Dryer C Zone 2 Vent	n-Hexane	1.1202785
R0259	P	159 - Finishing I A Dewatering Screen/Press Combined Vent	n-Hexane	5.0902265
R0260	P	160 - Finishing I Dryer C Zone 1 Vent	n-Hexane	4.8116875
R0261	P	169 - Finishing I Dewatering Screen/Press Combined Vent	n-Hexane	5.0902265
R0262	P	170 - Finishing I Dryer D Zone 2 Vent	n-Hexane	1.1202785

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0263	P	172 - Finishing I Dryer D Zone 1 Vent	n-Hexane	4.8116875
R0264	P	211 - Dry Hexane Storage Tank	n-Hexane	0.821864
R0265	P	212 - Dry Hexane Storage Tank	n-Hexane	0.7996635
R0266	P	245 - Finishing III A Dewatering Screen Vent	n-Hexane	0.208139
R0267	P	246 - Finishing III B Dewatering Screen Vent	n-Hexane	0.208139
R0268	P	247 - Finishing III Dryer A Feed Conveyor and Cyclone Vent	n-Hexane	15.2768015
R0269	P	248 - Finishing III Dryer B Feed Conveyor and Cyclone Vent	n-Hexane	15.2768015
R0270	P	249 - Finishing III Dryer A Zone 1 Vent	n-Hexane	3.838331
R0271	P	250 - Finishing III Dryer A Zone 3 Vent	n-Hexane	1.3773915
R0272	P	251 - Finishing III Dryer B Zone 1 Vent	n-Hexane	3.838331
R0273	P	252 - Finishing III Dryer B Zone 3 Vent	n-Hexane	1.3773915
R0274	P	254 - Poly III Sample Collection Vent Stack	n-Hexane	14.9609475
R0275	A	257 - Finishing III Water Drum		

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
			n-Hexane	0.001332
R0278	P	277 - Diene-Free Hexane Storage Tank		
			n-Hexane	0.64648
R0279	P	278 - Poly II Hexane Recovery Pot A		
			n-Hexane	0.932423
R0280	P	279 - Poly II Hexane Recovery Pot B		
			n-Hexane	0.932423
R0281	P	280 - Poly I Hexane Recovery Pot		
			n-Hexane	0.5816545
R0282	A	285 - Poly III Cooling Tower		
			n-Hexane	4.4148
R0283	P	290 - Poly III Hexane Recovery Pots		
			n-Hexane	0.932423
R0284	P	291 - Finishing 1 C Dryer Penthouse Vent		
			n-Hexane	17.3765585
R0285	P	292 - Finishing 1 D Dryer Penthouse Vent		
			n-Hexane	17.3765585
R0286	P	293 - Dry Hexane Storage Tank		
			n-Hexane	0.8027715
R0287	A	302 - Royalene Lift Station		
			n-Hexane	0.0106565
			Ethyl Chloride	0.0125805
R0288	A	307 - Recovery Cooling Tower		
			n-Hexane	0.3864
R0289	A	2002 - Trilene I Wash Tank Sampling/Disposal		
			n-Hexane	0.0062675

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0290	P	2003 - Trilene I Lab Hoods		
			n-Hexane	0.05659
R0292	P	2007 - Trilene I A Off Spec Charge Tank		
			n-Hexane	0.0006145
R0293	P	2008 - Trilene I B Off Spec Charge Tank		
			n-Hexane	0.0006145
R0300	A	2015 - Product Packing/Drum Loading		
			n-Hexane	0.215055
R0302	A	2017 - Trilene I Surface Water Sump 1		
			n-Hexane	0.0004915
R0303	A	2018 - Trilene I Process Sump 2		
			n-Hexane	0.0004915
R0304	A	2019 - Trilene I Surface Water Sump 3		
			Ethyl Chloride	0.0001025
			n-Hexane	0.000246
R0306	A	2021 - Trilene I Drum Storage Area		
			n-Hexane	0.003318
R0314	A	2201 - Poly I Monomer Compressor Oil Reservoir		
			n-Hexane	0.003108
R0315	A	2202 - Poly I Filter Box for Slurry Tank PV-14		
			n-Hexane	0.154072
R0318	A	2205 - Poly I Floc Water Hydrosieve Vent		
			n-Hexane	0.1771605
R0320	A	2207 - Poly I Recycle Water Drum Vent		
			n-Hexane	0.000888
R0321	A	2208 - Poly I Gel Floc Dewatering Screen Vent		

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
			n-Hexane	0.087914
R0322	P	2209 - Poly I Glycol Storage Tank Vent	Ethylene glycol	0.0000815
R0323	A	2210 - Poly I Lab Hood Vent	n-Hexane	0.000888
R0324	A	2215 - Poly I/II Lab Vent	n-Hexane	0.0115445
R0325	A	2216 - Poly I Sump and Trench	n-Hexane	0.000031
R0340	P	2301 - Finishing I Rework Tank	n-Hexane	0.000444
R0341	A	2302 - Finishing I Conveyors, delumpers, balers, wrappers	n-Hexane	0.373426
R0342	A	2401 - Poly II Monomer Compressor Oil Reservoir	n-Hexane	0.003108
R0345	A	2406 - Poly II Hydrosieve Vent	n-Hexane	0.114999
R0346	A	2407 - Poly II Hydrosieve Vent	n-Hexane	0.114999
R0347	A	2408 - Poly II Floc Tank Water Drum Vents	n-Hexane	0.048841
R0348	A	2410 - Poly II Recycle Water Drum Vent	n-Hexane	0.000444
R0351	A	2416 - Poly II Filter Box for PV-214	n-Hexane	0.155404
R0352	A	2501 - Finishing II Sump		

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
			n-Hexane	0.1518515
R0353	P	2502 - Finishing II Dryer A Cyclone Vent		
			n-Hexane	17.5387845
R0354	P	2503 - Finishing II Dryer B Cyclone Vent		
			n-Hexane	17.5387845
R0355	P	2504 - Finishing II Dryer A Zone 2 Vent		
			n-Hexane	1.1264
R0356	P	2505 - Finishing II Rework Tank		
			n-Hexane	0.000444
R0357	A	2506 - Finishing II Conveyors, delumpers, balers, wrappers		
			n-Hexane	0.376487
R0358	A	2507 - Finishing II Crumb Separator		
			n-Hexane	0.031081
R0359	A	2603 - Poly III Monomer Compressor		
			n-Hexane	0.003108
R0362	A	2608 - Poly III Recycle Water Tank		
			n-Hexane	0.049729
R0363	A	2610 - Poly III Gel Floc Dewatering Screen		
			n-Hexane	0.038185
R0364	A	2611 - Poly III Gel Floc Tank Dewatering Screen Sump 1		
			n-Hexane	0.00888
			Ethyl Chloride	0.0532815
R0365	P	2612 - Poly III Glycol Storage Tank Vent		
			Ethylene glycol	0.0000815
R0366	A	2613 - Poly III Lab Hood		
			n-Hexane	0.000888

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0369	A	2618 - Poly III Gel Floc Sump	n-Hexane	0.0186485
R0370	A	2619 - Poly III Lab Mill Vent	n-Hexane	0.005772
R0371	A	2704 - Finishing III Line A Dewatering Press Vent	n-Hexane	3.927096
R0372	A	2705 - Finishing III Line B Dewatering Press Vent	n-Hexane	3.927096
R0373	P	2714 - Finishing III Rework Tank	n-Hexane	0.000444
R0374	A	2715 - Finishing III Conveyors, delumpers, balers, wrappers	n-Hexane	0.327513
R0375	A	2716 - Finishing III Sump I	n-Hexane	0.049285
R0378	A	2804T - Recovery Scrubber Trench	n-Hexane	0.00666
R0379	A	2804 - Recovery "Cat K" Scrubber Sump	n-Hexane	0.00666
R0383	A	2809 - Poly III Sump	n-Hexane	0.003108
			Ethyl Chloride	0.0170205
R0384	A	2811 - Trilene Sump	n-Hexane	0.000888
R0385	A	2812 - Flexzone Sump	n-Hexane	0.0270845
			Ethyl Chloride	0.126543

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
R0386	A	2813 - New HCl Scrubber/VOCl3 Unloading/RV Blowdown		
			Hydrochloric acid	0.00814
R0438	P	407-Finishing Vent		
			Ethylene Dichloride	0.273085
R0440	P	405 -Dehumidification Column		
			Chlorobenzene	0.0002765
			p-Dichlorobenzene	0.0002765
			Ethylene Dichloride	1.016025
			Hydrochloric acid	0.0002765
R0441	P	406 -Celogen OT Centrifuge		
			Ethylene Dichloride	0.002636
RDWGC	A	Deepwell GCSVII Activities		
			Toluene	0.436613
			Benzene	0.0436615
			Ethylene Dichloride	0.001323
			Chlorobenzene	0.001323
RDWRS	A	Deepwell Releases		
			Ethylene Dichloride	0.0063
RF009	A	284 - Royalene/Trilene Semiworks Fugitive Emissions		
			n-Hexane	29.364
RF010	A	2000 - Trilene I Fugitive Emissions		
			n-Hexane	0.660525
RF012	A	409 -Fugitive Emissions		
			Ethylene Dichloride	2.456585
			p-Dichlorobenzene	0.0000005
			Chlorobenzene	0.0000005
			Hydrochloric acid	0.000085

Source ID	Source type (P=point, A=A, V=volume)	Source name	Pollutant	Emissions (tons/year)
ROTRS	A	OT Releases and Spills		
			Hydrochloric acid	0.0033
			Ethylene Dichloride	0.008045
ROTV3	A	OT - Decom Variance		
			Ethylene Dichloride	0.026635
RRYGC	A	Royalene Trilene GCXVII Activities		
			Ethyl Chloride	0.00037
			n-Hexane	2.40449
RRYRS	A	Royalene Releases and Spills		
			n-Hexane	0.02782
RSLIA	A	Services & Lab Insignificant Activities		
			Hydrochloric acid	0.000065

Vita

Keith E. Gordon was born in New Orleans, Louisiana in 1971. He graduated from Louisiana State University in 1996 with a Bachelor's of Science in Environmental Management Systems. He also served in the United States Marine Corps from 1992 to 2000. Mr. Gordon has worked in the environmental engineering profession for various organizations over fourteen years. These companies include Avondale Shipyards, Waterbury Companies, Chemtura Corporation and currently Lion Copolymer Geismar, LLC in Geismar, Louisiana. He presently lives in Baton Rouge, LA with his wife and three children.