

Appendix C: Michigan Toxic Emissions Inventory

INTRODUCTION

The State of Michigan conducted its 2001 portion of the Great Lakes Region air toxic emissions inventory by collecting new point source throughput and emissions data for the 2001 inventory year. The area source emissions data were forwarded from the 1999 Great Lakes Regional Air Toxics Emissions Inventory. On-road and off-road mobile source air toxic emissions were also forwarded from the 1999 regional inventory.

This inventory covers all measured point sources from the 2001 calendar year Michigan Air Emissions Reporting System (MAERS). For completeness emissions data from fourteen area source categories reported in the 1999 regional inventory have been carried forward. They are; agricultural pesticides, architectural surface coatings, autobody refinishing, consumer commercial solvents, dry cleaning, gasoline marketing, graphic arts, halogenated solvent degreasing, human cremation, industrial surface coatings, lamp breakage, lamp recycling, residential wood burning, and structure fires. Landfills were included in the point source inventory. On-road and off-road mobile source air toxic emissions obtained from the EPA Draft Version 3 of the 1999 NEI are also included.

The 2001 point source inventory is a new, bottom up, emissions estimate for all of Michigan's eighty-three counties. Emphasis that was placed on MERCURY emissions in the 1999 inventory effort led to adding MERCURY emission factors to 19 new SCC codes used in preparing the 2001 point source inventory.

Michigan followed the *Air Toxic Emissions Inventory Protocol for the Great Lakes Commission* in developing its inventory. The Factor Information Retrieval System (FIRE), reference tables from the Regional Air Pollutant Inventory Development System (RAPIDS), emission factors specific to the State of Michigan, and individual stack tests, were used as sources of emission factors and constants. MAERS and RAPIDS software along with some spreadsheets were used to estimate emissions.

POINT EMISSIONS DATA SOURCES

Data for point source emissions were collected by the Michigan Department of Environmental Quality (DEQ), Air Quality Division (AQD) as part of its annual air emissions inventory process. A facility air emissions report is required by the administrative rules of the Michigan Department of Environmental Quality, under authority of Act 348, P.A. 1965, and by Section 182 (a) (3) (B) of the Clean Air Act. Data was collected from 1888 facilities under these reporting requirements. This data is deemed to be of high accuracy as it has been quality assured and used for criteria pollutant fee billings. A shortcoming is that the data collected contains little reported toxic pollutant emission information. Michigan does not have a strong toxic emissions reporting requirement.

Operator supplied criteria pollutant data was used in MAERS to estimate toxic emissions for the processes within each facility. The FIRE tables contain emission factors for both criteria and toxic air pollutants specific to the SCC code representing the process used by the facility. When the throughput for a specific processed material is multiplied times the pollutant specific emission factor an estimate of the air emissions for that pollutant are produced. When adjusted due to process control equipment or other process variables, the net emissions of that pollutant are produced. Annualized contributions from each specific process are added to all of the other like emissions and the inventory develops. This same procedure is used for all of the processes for all of the sources in the state to build the annual inventory.

There is a problem soon encountered when building a toxic pollutant inventory in this manner. Not all of the needed toxic pollutant emission factors are present in all of the SCC code related factor tables. The most common problem is that of gaseous toxic pollutants such as formaldehyde or ethylbenzene. In many emission factor tables all of the gaseous pollutants are lumped together as a single pollutant called VOC (volatile organic compounds). This works fine for describing criteria pollutant data where groups of similar pollutant types are all that is required. It does not work well for estimating toxic air pollutants where the emphasis is on individual compounds and not groups. The EPA has a set of VOC pollutant concentration factors known as the Speciate Tables. These tables represent the average composition of the VOC for a specific SCC code such as open top degreasers. There are eight or ten common degreasing agents used in open top degreasers. If all of the VOC's from 1000 degreasers are grouped together and the composite VOC analyzed, the result will be a fair representation of the relative contribution of each individual agent. These factors could then be applied to a composite of 2500 degreasers and would result in a worthwhile estimate of each component. If the Speciate factors are applied to the VOC generated from a single degreaser, the results would be meaningless. A single degreaser would probably only use one or two degreasing agents but would be charged with using all of them. For this reason, Speciate Factors are not used in developing the Michigan point source toxic air pollutant inventory.

There is one more emission factor type that was used in the Michigan inventory. That is the State Specific emission factor. These factors are derived in order to supplement the FIRE emission factors. They are used in exactly the same way as the FIRE factors but are Michigan derived instead of EPA derived. They come from many different data sources, but typically, are from certified stack tests, surrogates used from similar processes, engineering judgment, controlled factors substituted to become uncontrolled factors, developed because Michigan uses a different throughput MATERIAL than may be used with the FIRE factors, negotiated with industrial associations, different factor needed because Michigan uses a different calculation algorithm than the EPA, etc. In every case these emission factors are chosen over any EPA factor.

The MAERS database includes facility SIC and NAICS codes to identify industry type, and SCC codes to identify process type, control equipment and control efficiencies for each process. Fuel and material throughputs are collected for each process within the facility. SCC codes from all sources were matched against available emission factors from FIRE Versions 6.1, 6.22, or 6.23. Facility specific emission factors were used preferentially when available. State specific emission factors were selected over FIRE factors. Sources with no FIRE or State specific emission factors were assumed to be included in the area source emission calculations.

POINT SOURCE EMISSIONS

The 2001 Michigan point source data was collected from each facility, quality audits were performed, and the data was imported into the Michigan Air Emissions Reporting System (MAERS). MAERS was then used to make emission estimates for the toxic air pollutants of interest to the Regional Inventory. A calculation was made for every SCC code identified process which had state specific or generic FIRE toxic pollutant emission factors, a proper corresponding throughput material and amount. These calculations produced annual emission estimates for 133 different point source toxic air pollutants. The calculated results were exported in National Emissions Inventory (NEI) format for analysis. A second quality assurance audit was performed which found several data manipulation and emission factor discrepancies. Once corrected the inventory was compared to the Michigan 1999 point source inventory.

The Michigan toxic pollutant inventory is finally beginning to stabilize. The past reported regional inventories have been produced with a state inventory system which has been undergoing development and implementation. MAERS was introduced as a new pollutant inventory system in 1998. When MAERS started it was not completely functional, it was not completely tested, its data reference tables were incomplete and in many instances not available, the calculation algorithms were incomplete and it was the first time a detailed toxic pollutant inventory was even attempted to be produced by our Emissions Reporting and Assessment Unit. Even in its infant stages a point source inventory was produced for 1998 and 1999. After the 1999 inventory it was realized how many shortcomings were inherent in the inventory system that had been developed. Over the next two years MAERS was enhanced. Literally thousands of emission factors were introduced. The calculation mechanism was corrected to allow the proper emission reductions due to process control equipment. State pollutant specific emission factors were implemented to help fill in some of the gaps where previously there was a void that would not produce any emission estimates. And finally, the MAERS emission factor table was normalized by allowing only one MATERIAL CODE / UNIT CODE combination to be used for any given SCC code described process. This allowed the successful calculation of hundreds of emission factors which previously could not be used for emission estimates. The net result of which is the Michigan portion of the 2001 Great Lakes Regional Toxic Air Emissions Inventory.

As would be expected with all of the available added emission factors the toxic emissions increased. The 1999 point source inventory was reported at a total of 55,220,000 pounds of toxic emissions. It was discovered while producing the 2001 inventory that two extra pollutants, namely, METHANE and NITROUS OXIDE with a combined total of 7,239,000 pounds of emissions had over-inflated the 1999 reported inventory. Correcting this oversight reduces the 1999 inventory to 47,981,000 pounds. The 2001 air toxics inventory is estimated at 54,915,000 pounds. This is an increase of 6,934,000 pounds as a result of the development work done between the 1999 and the 2001 inventories. Recording the largest change, 12,281,000 pounds, HYDROCHLORIC ACID increased to an estimated 44,555,000 pounds, up from a 1999 estimated 32,274,000 pounds. Other leading increases were; HYDROGEN FLUORIDE up 1,441,000 pounds, METHYLENE CHLORIDE up 994,000 pounds, COKE OVEN EMISSIONS up 468,000 pounds, BENZENE up 141,000 pounds, LEAD up 65,198 pounds, and CYANIDE up 56,890 pounds. On the other hand many pollutants were estimated with reduced emissions.

TOLUENE emissions reduced the most to 411,500 pounds down from a 1999 estimated 3,945,800 pounds. Other leading reductions were; FORMALDEHYDE down 2,507,000 pounds, XYLENES (MIXED ISOMERS) down 872,000 pounds, STYRENE down 711,000 pounds, METHANOL down 282,000 pounds, N-HEXANE down 245,000 pounds, BENZ(A)ANTHRACENE down 181,000 pounds, TETRACHLOROETHYLENE down 128,000 pounds, TRICHLOROETHYLENE down 104,000 pounds, and GLYCOL ETHERS down 59,000 pounds. The other some 117 pollutants were estimated to have relatively close emission values between the 1999 and 2001 inventories.

A Word of Caution to Trend Analyzers

Because of the program developments, additions, corrections, table reconstructions, and emission estimating algorithms which took place in the Michigan Air Emissions Reporting System, the data which has been generated, and becomes the 2001 Michigan Air Toxics Emissions Inventory should not be compared to earlier inventory years for the purpose of trend analysis. Instead this 2001 point source air toxics emissions inventory should be considered as the base year for future toxic emissions comparisons.

AREA SOURCE EMISSIONS

Agricultural Pesticides

The Regional Protocol was followed. State specific emission factors for ATRAZINE and TRIFLURALIN were obtained from Michigan State University.

Architectural Surface Coating

This category was estimated consistent with the Regional Protocol.

Auto Body Refinishing

The regional protocol, alternate method two, was followed. National emissions for the category were allocated to the county level based on census estimates.

Consumer and Commercial Solvent Use

Michigan used the preferred method from the EIIP guidance.

Dry Cleaning

Michigan followed the Regional Protocol recommended EIIP guidance, alternative method two. Employment data for dry cleaning was only available for 13 counties. An emission factor was derived from the average per capita emissions of those 13 counties. This Michigan specific per capita emission factor was then applied to the remaining 70 counties.

Fluorescent Lamp Breakage

To estimate emissions of MERCURY from fluorescent lamp breakage, Michigan utilized the methodology from the *1999 Base Year Nonpoint Source National Emission Inventory for Hazardous Air Pollutants*, Appendix A, A-52.

Fluorescent Lamp Recycling

To estimate emissions of MERCURY from fluorescent lamp recycling, Michigan utilized the methodology set forth in the *1999 Base Year Nonpoint Source National Emission Inventory for Hazardous Air Pollutants*, Appendix A, A-30.

Gasoline Marketing (Stage I and II)

The Regional Protocol recommendation to utilize the EIIP guidance was followed. All gasoline marketing (stage I and stage II) emissions are included in this inventory.

Graphic Arts

The Regional Protocol recommending the use of the EIIP guidance was followed. Alternative method two, the per capita emission factor, was the method selected.

Halogenated Solvent Degreasing

Michigan selected the EIIP Alternative Method per the *Recommended Method for Solvent Cleaning Equipment* detailed in the protocol document as updated by Minnesota.

Human Cremation

Michigan followed the recommendations of the Regional Protocol. The human cremations per county for 1999 were obtained from the Michigan Department of Community Health. Emission factors from the NEI were then applied.

Industrial Surface Coating

In accordance with the Regional Protocol, Michigan used alternative method one of the EIIP guidance.

Residential Wood Burning

Michigan followed the methodology in the Regional Protocol using state energy data reports. However, to convert wood use from cords to tons, Michigan used the method proposed in the Emission Inventory Improvement Program (EIIP) guidance.

Structure Fires

Guidance from EIIP Volume III, Chapter 18: *Structure Fires*, was followed. The first alternative method for estimating emissions was used. Due to time constraints 1998 structure fire data was carried forward.

Landfills

This area source category was covered as a point source in Michigan's inventory. Once the area source emissions were estimated at the county level, the results were aggregated by pollutant for the entire state and carried forward to the 2001 Michigan Air Toxic Pollutant Inventory at the end of this report.

ON-ROAD MOBILE EMISSIONS

On-road mobile source air toxic emissions were obtained from the EPA Draft Version 3 of the 1999 NEI. The on-road mobile emissions were estimated by EPA. The latest draft version of the

EPA mobile source model MOBILE 6.2 was used by EPA to develop the emission factors used for the emissions estimates. The final estimated toxic emissions were then submitted to the Rapids QA/QC committee in the EPA NIF 2.0 format for quality assurance.

These emissions were calculated using seasonal emission factors generated by using EPA's MOBILE6.2 model and 1999 VMT calculated at the county/roadway type/vehicle type level. The VMT totals by county and roadway type needed to be allocated among the 28 MOBILE6 vehicle types. OTAQ provided EPA a national allocation of HPMS to MOBILE56 vehicle categories. This was done based on the distribution of the 1999 rural and urban VMT among the six HPMS vehicle types found in Table VM-1 ("Annual Vehicle Distance Traveled in Miles and Related Data - 1999 - by Highway Category and Vehicle Type") of FHWA's *Highway Statistics 1999* and a mapping of these HPMS vehicle categories to the 28 MOBILE6 vehicle types, provided by OTAQ.

Within the MOBILE6.2 model, six HAPs (benzene, formaldehyde, acetaldehyde, 1,3 butadiene, acrolein, and methyl tertiary butyl ether [MTBE]) can be calculated directly by including detailed fuel parameters within the MOBILE6.2 scenario descriptions. These fuel parameters are: sulfur content, olefins content, aromatics content, benzene content, E200 and E300 value, oxygenate content by type, and oxygenate sales fraction by type. Since these fuel parameters are area-specific, EPA developed county-level inputs for each of these parameters for summer and winter gasoline. MOBILE6.2 also has a command (ADDITIONAL HAPS) which allows the user to enter emission factors or air toxic ratios for additional air toxic pollutants. Emission factors for an additional 29 HAPs were calculated by EPA with MOBILE6.2 through the use of external data files specifying emission factors for these pollutants in one of three ways: as fractions of VOC, fractions of PM, or by supplying the basic emission factors (primarily used for metals and metal compounds).

OFF-ROAD MOBILE EMISSIONS

The off-road mobile source air toxic emissions were obtained from the EPA Draft Version 3 of the 1999 NEI. The final estimated toxic emissions were submitted to the Rapids QA/QC committee in the EPA NIF 2.0 format for quality assurance.

The aircraft source category includes all aircraft types used for public, private, and military purposes. This includes four types of aircraft:

Commercial, Air Taxis, General Aviation, and Military

Commercial aircraft include those used for transporting passengers, freight, or both. Commercial aircraft tend to be larger aircraft powered with jet engines. Air taxis carry passengers, freight, or both, but usually are smaller aircraft and operate on a more limited basis than the commercial carriers. The national air taxi fleet includes both jet and propeller-driven aircraft. General aviation includes most other aircraft used for recreational flying and personal transportation. Aircraft that support business travel, usually on an unscheduled basis, are included in the category of general aviation. Most of the general aviation fleet is made up of propeller-driven aircraft, though smaller business jets can also be found in this category. Military aircraft cover a wide range of aircraft types such as training aircraft, fighter jets, helicopters, and jet- and propeller-driven cargo planes of varying sizes. It should also be noted that this inventory includes emission estimates for aircraft support vehicles and engines typically found at airports

such as aircraft refueling vehicles, baggage handling vehicles and equipment, aircraft towing vehicles, passenger buses, larger portable generators, and other airport vehicles as derived from the NONROAD model.

EPA has developed guidance for inventorying aircraft emissions associated with an aircraft's landing and takeoff (LTO) cycle. The cycle begins when the aircraft approaches the airport on its descent from cruising altitude, lands, taxis to the gate, and idles during passenger deplaning. It continues as the aircraft idles during passenger boarding, taxis back out onto the runway for subsequent takeoff, and ascent (climb-out) to cruising altitude. Thus, the five specific operating modes in an LTO are:

Approach, Taxi/idle-in, Taxi/idle-out, Takeoff and Climb-out

During each mode of operation, an aircraft engine operates at a fairly standard power setting for a given aircraft category. Emissions for one complete cycle are calculated using emission factors for each operating mode for each specific aircraft engine combined with the typical period of time the aircraft is in the operating mode. HAP emission estimates were developed by EPA for all aircraft types except military aircraft. Because of the diversity of military aircraft operations, representative HAP emission factors could not be identified or developed.

The FAA's airport activity statistics for certified air carriers only documents activity of American flagged carriers. EPA/OTAQ provided aircraft-specific data for foreign flagged air carriers. EDMS (generates estimates for hydrocarbons (HC), NO_x, CO, and SO_x). The HC estimates were converted to VOC. In this effort, all of the default time-in-mode (TIM) values incorporated in the EDMS (FAA's *Emissions and Dispersion Modeling System Ver. 4.0*) were used. EDMS did not have a default TIM value for the period that an aircraft is taxiing and idling. In this effort, a TIM value of 26 minutes was used for taxiing and idling; this value was obtained from EPA State Implementation Plan (SIP) guidance on estimating aircraft emissions. Not all of the aircraft included in the FAA activity report could be matched to the aircraft in the EDMS. For those aircraft that could not be matched directly, their LTOs were applied to an average LTO-based emission factor developed from the aircraft that could be matched directly. HAP emission estimates for all aircraft were estimated by applying speciation profiles to national level VOC or PM₁₀ emissions estimates. Lead emission estimates were handled differently. Lead emissions are primarily associated with leaded aviation fuel used in piston driven aircraft associated with general aviation. The lead estimates developed in this inventory were derived by combining DOE annual aviation gasoline usage data with the lead content of aircraft fuel (assumed to be 2.0 g/gal.), and applying a 75% retention value to reflect the lead that is retained in the engine or exhaust system.

National aircraft emission estimates were allocated to individual counties by EPA using airport activity data derived from the FAA Terminal Area Forecast System (TAF) database of over 2,000 airports in the United States (DOT, 2001c). A GIS database obtained from the Bureau of Transportation Statistics (BTS) (DOT, 2001d) contained airport level data with latitude and longitude coordinates. These two data sources were matched to identify the county in which each airport is located. Using airport-specific LTO data, the percentage of national activity was then calculated by EPA for each airport for each aircraft type (i.e., commercial, air taxis, general aviation, and military), as noted in the following equation.

Airport X Percentage of National LTO by aircraft type = LTO at airport X by aircraft type
National LTO by aircraft type

National aircraft emissions for each aircraft type were allocated by EPA to specific airports by using the LTO percentages (see equations below):

Airport X Emissions = Airport X Percentage by Aircraft Type Pollutant by Aircraft Type*

Where there were multiple airports in a given county, EPA simply summed these emissions to provide a county level emissions estimate.

Other Categories Estimated

The commercial marine vessel (CMV) source category includes all boats and ships used either directly or indirectly in the conduct of commerce or military activity. These vessels range from 20-foot charter boats to large tankers and military vessels which can exceed 1,000 feet in length (EPA, 1989). In spite of the broad range of vessels represented by this category, a number of common characteristics allow for the use of simple emission estimation methods. The majority of vessels in this category are powered either by diesel engines or steam turbines. The predominant fuel used is oil, both distillate (diesel) and residual grades. It can be assumed that CMVs powered by diesel engines predominantly use distillate fuel oil or higher grade residual oils, and those powered by steam turbines use residual fuel oil. The CMV source category does not include recreational marine vessels, which are vessels less than 100 feet in length, most being less than 30 feet, and powered by either inboard or outboard engines. Emissions from recreational marine vessels are included in the other non-road source category.

The CMV emission estimates in this inventory were developed by EPA for the Draft Version 3 1999 National Emissions Inventory (NEI) using a “top-down” approach. This means that the estimates were developed at the national level and allocated to individual counties using appropriate surrogates. The fuel usage data were derived from documents that support recent marine diesel rules. HAP speciation profiles were applied to the VOC and PM emission estimates. Unfortunately, there are very few data available to characterize HAP emissions from CMVs, therefore “alternative” speciation profiles were used in this inventory effort. For diesel-powered vessels, the speciation profiles were for heavy-duty diesel vehicles (HDDV) and were obtained from information in *Evaluation of Factors That Affect Diesel Exhaust Toxicity* (Truex and Norbeck, 1998). For steam-driven vessels, speciation profiles for stationary industrial and commercial boilers were considered to be appropriate surrogates. The boiler speciation data were obtained from the EPA’s Industrial Combustion Coordinated Rulemaking (ICCR) program (Porter, 1998; EPA, 1996). To calculate PAH emissions associated with diesel marine engines. Speciation profiles were developed by OTAQ to individually estimate emissions for the 16-PAH compounds. For distillate oil-fueled CMVs, PAH/PM_{2.5} speciation profiles were obtained from Colorado’s Northern Front Range Air Quality Study (NFRAQS) report, and are based on test data for heavy duty diesel vehicles.

For steamships, speciated PAH data are not currently available, therefore aggregate 7-PAH and 16-PAH emission factors were used. National HAP emissions were disaggregated into port and

underway emission estimates, based on assumptions used in the EPA's SIP guidance that 75% of distillate fuel and 25% of residual fuel is consumed within the port, the remaining fuel is consumed while underway. To allocate emissions to individual counties, National port emissions were assigned to the 150 largest U.S. ports based on activity data obtained from the *Waterborne Commerce of the United States, Part 5-Waterways and Harbors National Summaries* (U.S. Army Corps of Engineers, 2001). This reference included data for Puerto Rico and the Virgin Islands. The percentage of total traffic for each port was calculated by dividing the port-level traffic by the total traffic. This approach slightly over estimates port emissions for the 150 ports included in this inventory as emissions are not allocated to the smaller ports omitted from this list. Underway emissions were allocated to the 1999 county-level by applying county-specific waterway activity factors expressed as thousand ton miles to the national estimate. Using GIS software, county borders were overlaid with the U.S. waterway network to determine the waterway length in each county. Each county was then assigned a weighting factor by summing the product of the waterway length (miles) in the county and the waterway-cargo traffic (tons) for each segment of the waterway, and then dividing this sum by the national total. It is recognized that there are some inconsistencies with the BTS, GIS data for other inventory years, therefore the 1999 weight factors are used in all inventory years. To allocate emissions to ports with underway emissions, two methods were employed. Where shorelines intersected with counties, emissions were assigned based upon shoreline length. Where this was not possible, a weighted average of tonnage miles was divided equally among the counties that had a shipping lane within close proximity of a county. Underway emissions were then added to in-port emissions to get county level CMV emission estimates.

The locomotive emission estimates in this inventory were developed by EPA for the Draft Version 3 1999 National Emissions Inventory (NEI). The locomotive source category includes railroad locomotives powered by diesel-electric engines. A diesel-electric locomotive uses 2-stroke or 4-stroke diesel engines and alternator or generator to produce the electricity required to power its traction motors. The locomotive source category does not include locomotives powered by electricity or steam. Emissions associated with the operation of electric locomotives would be included in the point source utility emission estimate. It is believed that the number of wood or coal driven steam locomotives is currently very small; therefore, these types of locomotives are not included in this inventory. The locomotive source category is further divided up into five categories: line haul class I, class I yard, line haul class II/III, passenger, and commuter. The national rail estimates were divided up between the subcategories based on ratios calculated from fuel data obtained from the American Association of Railroads for each subcategory.

HAP emissions were estimated in two ways. First, HAP emission factors were combined with the amount of distillate fuel oil used by locomotives. The HAP emission factors were obtained from *Diesel Fuel Effects on Locomotive Exhaust Emissions* (Fritz, 2000) and from *Baseline Emission Inventory of HAP Emissions from MACT Sources - Interim final Report, 1998* (Porter, 1998). Where emission factors are not available, HAP emissions were estimated by applying speciation profiles to the VOC or PM estimates. The speciation profiles were derived from *Evaluation of Factors that Affect Diesel Exhaust Toxicity* Steve,(Truex and Norbeck, 1998), and data provided by OTAQ (Scarbro, 2001 and 2002).

The locomotive HAP emissions were allocated to the county level by using 1999 county-specific railroad traffic data (ton miles) obtained from the Department of Transportation (BTS, 2000). Using GIS software, county borders were overlaid with the US railroad network in order to determine the rail activity in each county for the specific SCCs. Each county was then assigned a weighted emissions factor by summing the product of the rail activity and the track-specific loading factor for each track, and then dividing this sum by the national total. GIS activity data for each county were available for each of the railroad category used in this inventory except yard locomotives. Inventories of yard locomotive activities have not been developed recently, therefore emissions for this category were spatially allocated to urban counties which had Class I railroad activity.

The other non-road source emission estimates in the inventory were obtained from the Draft Version 3 1999 NEI inventory. The other non-road mobile source category includes vehicles and equipment that normally are not operated on public roads nor provide transportation and are not considered aircraft, commercial marine vessels or locomotives. Note, the individual source categories included in this group parallel the source categories included in the NONROAD model. This includes categories such as lawn and garden equipment, agricultural equipment, logging equipment, construction equipment, airport service vehicles, locomotive maintenance vehicles, and recreational equipment (including recreational marine equipment). The other non-road vehicles and equipment include both diesel-powered and gasoline powered engines. Gasoline-powered engines can further be characterized into two engine categories, specifically 2- and 4-stroke engines.

Source emissions were estimated by EPA using a mixture of “top down” and “bottom up” approach. The emission estimates for metal HAPs, excluding lead, were estimated by EPA by applying emission factors to vehicle activity or fuel consumption data. For these metal HAP estimates, it was necessary to combine the 2- and 4-stroke engine-type categories into one category, called gasoline engines. Thus, metal HAP emissions for all gasoline engines, regardless of type, were based on the same metal emission factor. A national estimate of other non-road lead emissions was obtained by EPA by multiplying the average lead content of mobile fuel with the amount of fuel used nationally and the fraction of the fuel used by other non-road sources. Note, the lead content of fuel is very small and represents trace compounds in the extracted crude oil. The emission estimates for organic HAPs were developed by EPA by applying HAP/VOC speciation profiles to county-level VOC estimates. A number of different fuels are used in on-road vehicles. EPA assumed that these same fuels were used in other non-road applications. Currently, the on-road fuel parameters data are being updated by EPA to more accurately reflect different fuels used in each county. At the time this inventory was being developed by EPA, the updated fuel parameter data were not available such that this study does not include the newer data - future revision of the 1999 NEI non-road inventory will include the updated fuel parameters data.

RESULTS

The toxic emissions for Michigan are listed in the table following *References*. The values are expressed in total pounds per year of pollutant by inventory type. As indicated in the text, point source emissions were calculated at the process level, but have been aggregated to and are only reported at the state or county level. An electronic database of toxic emissions, NEI format, for

the state of Michigan, is available at the process level upon request. For additional information, contact the Michigan Department of Environmental Quality, Air Quality Division, Emissions Reporting and Assessment Unit, Constitution Hall, Third Floor, P.O. Box 30260, Lansing, Michigan, 48909, (517)-373-7023.

Michigan was only able to estimate emissions for 150 of the 213 toxic air pollutants of concern. A total of 8 pollutants were present but had emissions below our ability to record and were reported as having 0 emissions. This was due to lack of emission factors, throughput data, production or handling data, products no longer manufactured, products no longer used, or a lack of resources. For example Michigan was not able to produce area source emissions for *Traffic Markings* as we received MSDS data from the paint supplier too late to be included in the inventory. *References* and a toxic emissions summary table follow.

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Table C-1: Michigan 2001 Statewide Emissions (lb/yr)

Pollutant	Point	Area	Nonroad	Mobile	Total
1,1,1-TRICHLOROETHANE	2783.360363	5799978.225	0	0	5802761.585
1,1,2,2-TETRACHLOROETHANE	1627.353223	0	0	0	1627.353223
1,1,2-TRICHLOROETHANE	12.79717648	0	0	0	12.79717648
1,1-DICHLOROETHANE	1372.683483	0	0	0	1372.683483
1,2,4-TRICHLOROBENZENE	165	0	0	0	165
1,2-DIBROMOETHANE	120.1586588	0	0	0	120.1586588
1,2-DICHLOROETHANE	2013.690667	1981.903	0	0	3995.593667
1,3-BUTADIENE	921.0017599	0	782591.2907	1882742.29	2666254.582
1,3-DICHLOROPROPENE	47.13100669	1578204	0	0	1578251.131
1,4-DICHLOROBENZENE	20.82356109	768388.0269	0	0	768408.8505
1,4-DIOXANE	0.048057	98.6383	0	0	98.686357
2,2,4-TRIMETHYLPENTANE	1092.125669	246605.47	13553574.12	13836352.49	27637624.21
2,3,7,8-TETRACHLORODIBENZOFURAN	0.01699161	0	0	0	0.01699161
2,4-DINITROPHENOL	4.30645104	0	0	0	4.30645104
2,4-DINITROTOLUENE	9.60628428	0	0	0	9.60628428
2-CHLOROACETOPHENONE	240.1571149	0	0	0	240.1571149
2-NITROPROPANE	0	19.2344	0	0	19.2344
3,3-DICHLOROBENZIDENE	0	0	0	0	0
4,6-DINITRO-O-CRESOL	661	0	0	0	661
4-NITROPHENOL	667.5133767	0	0	0	667.5133767
ACENAPHTHENE	30.28312301	5347.89	1499.701124	2409.85	9287.724247
ACENAPHTHYLENE	1060.043954	113382.33	4150.385986	12785.88	131378.6399
ACETALDEHYDE	54375.79297	0	1253649.767	2193461.72	3501487.28
ACETAMIDE	0	1.1934	0	0	1.1934
ACETONITRILE	5583.880007	0	0	0	5583.880007
ACETOPHENONE	928.6223874	84.1379	0	0	1012.760287
ACROLEIN	19655.84974	66411.26	177112.627	305531.11	568710.8467
ACRYLIC ACID	0	0.0357	0	0	0.0357
ACRYLONITRILE	3014.939989	0	0	0	3014.939989
ALLYL CHLORIDE	0	0	0	0	0
ANILINE	0	0	0	0	0
ANTHRACENE	16.8796468	7487.18	1156.23287	2892.09	11552.38252
ANTIMONY	248.4394882	0	0	0	248.4394882
ARSENIC	10910.17048	0.7383	31.26287667	0	10942.17166
ASBESTOS	0	0	0	0	0
ATRAZINE	1	239138.31	0	0	239139.31
BENZ(A)ANTHRACENE	124.275805	10696.16	421.6649628	676.82	11918.92077
BENZENE	302100.3029	1627423.305	6244134.461	15215055.73	23388713.8
BENZIDINE	696	0	0	0	696
BENZO(A)PYRENE	10139.52584	2138.92	306.5463715	428.79	13013.78221
BENZO(B)FLUORANTHENE	3.72177635	3208.57	220.6627998	474.56	3907.514576
BENZO(G,H,I)PERYLENE	3779.047608	2138.92	1035.682845	852.45	7806.100453
BENZO(K)FLUORANTHENE	2.83925513	1069.26	202.7698318	474.56	1749.429087
BENZYL CHLORIDE	24015.71156	0	0	0	24015.71156
BERYLLIUM	771.0890493	0.034	0.6470321	0	771.7700814
BIPHENYL	185.5212821	0	0	0	185.5212821
BROMOFORM	1338.018208	0	0	0	1338.018208
BROMOMETHANE	5826.365792	2189758.012	0	0	2195584.378

Pollutant	Point	Area	Nonroad	Mobile	Total
CADMIUM	3166.490019	16.1193	9.05845229	0	3191.667771
CARBON DISULFIDE	5566.964944	0	0	0	5566.964944
CARBON TETRACHLORIDE	385.3159348	1433.3008	0	0	1818.616735
CARBONYL SULFIDE	153	0	0	0	153
CHLORINE	37493.43245	694300.0628	0	0	731793.4953
CHLOROBENZENE	1104.420395	706395.2068	0	0	707499.6272
CHLOROETHANE	1511.850321	84962.60278	0	0	86474.4531
CHLOROFORM	2251.228236	17893.2684	0	0	20144.49664
CHLOROPRENE	0	0	0	0	0
CHROMIUM	71921.83637	1.4672	0	0	71923.30357
CHROMIUM (VI)	272.7982762	0	35.16970171	388.84	696.8079779
CHRYSENE	43.87287931	6417.52	259.382321	376.39	7097.1652
COBALT	465.3342034	0	0	0	465.3342034
COKE OVEN EMISSIONS	472445.7889	0	0	0	472445.7889
COPPER	16648.64675	0	0	0	16648.64675
CUMENE	2217.571802	3023.71	0	0	5241.281802
CYANIDE	86051.02417	0	0	0	86051.02417
DIBENZO(A,H)ANTHRACENE	5.5452961	0	7.53675526	0.07	13.15205136
DIBENZOFURAN	0	72.992	0	0	72.992
DIBUTYL PHTHALATE	1638.18042	0	0	0	1638.18042
DIETHANOLAMINE	1420	0	0	0	1420
DIETHYLHEXYL PHTHALATE	340.8379528	0	0	0	340.8379528
DIMETHYL PHTHALATE	798	0	0	0	798
DIMETHYL SULFATE	1646.791654	0	0	0	1646.791654
DIMETHYLFORMAMIDE, N,N-	111	96867.15105	0	0	96978.15105
DIOCTYL PHTHALATE	3593.392427	0	0	0	3593.392427
ETHYLBENZENE	28151.97336	883578.4653	4287978.627	5876579.86	11076288.93
ETHYLENE GLYCOL	645.19	250822.0156	0	0	251467.2056
ETHYLENE OXIDE	1629.35	148942.9998	0	0	150572.3498
FLUORANTHENE	352.0883944	10696.16	2793.130012	3014.83	16856.20841
FLUORENE	8331.022549	12835.42	3855.6369	5026.86	30048.93945
FORMALDEHYDE	474154.9049	517289.5781	3187724.647	5843964.94	10023134.07
GLYCOL ETHERS (MISC.)	64568.85992	369816.597	0	0	434385.4569
HEXACHLOROETHANE	426	0	0	0	426
HYDROCHLORIC ACID	44555268.19	231194.1481	0	0	44786462.34
HYDROGEN FLUORIDE	5355806.878	127.0249	0	0	5355933.902
HYDROGEN SULFIDE	920	0	0	0	920
INDENO(1,2,3-C,D)PYRENE	4.15137042	0	311.0180811	238.45	553.6194516
ISOPHORONE	19900.73247	9340.9954	0	0	29241.72787
LEAD	150889.5855	17.3187	39003.21571	0	189910.1199
MANGANESE	181745.2031	109.1592	72.80901001	0	181927.1713
MERCURY	5920.591066	78.6589143	46.55152011	0	6045.8015
METHANOL	146299.1362	6288812.344	0	0	6435111.481
METHOXYCHLOR	250	0	0	0	250
METHYL CHLORIDE	28107.88791	70802.16677	0	0	98910.05468
METHYL ETHYL KETONE	66813.02931	2493516.731	0	0	2560329.76
METHYL HYDRAZINE	5832.387069	0	0	0	5832.387069
METHYL IODIDE	15.24043464	0	0	0	15.24043464
METHYL ISOBUTYL KETONE	10855.55792	2314596.144	0	0	2325451.702
METHYL METHACRYLATE	988.1631856	0	0	0	988.1631856
METHYL TERT BUTYL ETHER	3362.78558	212.0711	0	234985.86	238560.7167
METHYLENE CHLORIDE	1250041.076	1537048.97	0	0	2787090.045

Pollutant	Point	Area	Nonroad	Mobile	Total
M-XYLENE	2278.82038	27507.41	0	0	29786.23038
NAPHTHALENE	23998.83532	611836.8418	69402.78302	322698.33	1027936.79
N-HEXANE	236146.8887	5285243.38	2846576.514	4804463.35	13172430.13
NICKEL	18695.16754	10.8938	1956.735471	0	20662.79681
O-CRESOL	0	0	0	0	0
O-TOLUIDINE	0	0	0	0	0
O-XYLENE	432.2614555	169561.1786	0	0	169993.4401
P-CRESOL	0	0	0	0	0
PHENANTHRENE	3301.625865	41715.83	6248.031925	8278.79	59544.27779
PHENOL	170089.8245	0	0	0	170089.8245
PHOSGENE	0	0	0	0	0
PHOSPHORUS (YELLOW OR WHITE)	9170.179429	0	0	0	9170.179429
POLYCHLORINATED BIPHENYLS (PCBS)	1.98938228	0	0	0	1.98938228
POLYCHLORINATED DIBENZODIOXINS, TOTAL	0.12228166	0	0	0	0.12228166
POLYCHLORINATED DIBENZOFURANS, TOTAL	0.30893181	0	0	0	0.30893181
PROPIONALDEHYDE	14115.7644	0	301858.8697	327641.38	643616.0141
PROPYLENE DICHLORIDE	158.6874176	0	0	0	158.6874176
PROPYLENE OXIDE	3644.342481	0	0	0	3644.342481
P-XYLENE	146.4469651	27507.41	0	0	27653.85697
PYRENE	87.58267142	12835.42	3286.417338	4193.74	20403.16001
QUINONE	1525.547044	0	0	0	1525.547044
SELENIUM	3597.236453	0	15.85229172	0	3613.088745
STYRENE	124829.9639	12336.4907	319550.1483	1215201.15	1671917.753
TETRACHLOROETHYLENE	42225.52222	4667183.269	0	0	4709408.791
TOLUENE	411510.9054	8340921.108	32783202.24	40093765.91	81629400.16
TOLUENE-2,4-DIISOCYANATE	1585.930002	0	0	0	1585.930002
TRICHLOROETHYLENE	170112.8228	2135384.316	0	0	2305497.139
TRIETHYLAMINE	22162	8275.7071	0	0	30437.7071
TRIFLURALIN	0	51755.5	0	0	51755.5
VINYL ACETATE	17887.74201	0.4468	0	0	17888.18881
VINYL CHLORIDE	2805.479057	25328.5449	0	0	28134.02396
VINYLDENE CHLORIDE	120.2670443	1638.9058	0	0	1759.172844
XYLENES (MIXED ISOMERS)	105022.0488	5080514.703	17792076.45	22551106.38	45528719.58
Grand Total	54914754.71	55914339.48	83666358.64	114746063.5	309241516.3