Biological Assessment

Pursuant to the Endangered Species Act of 1973

NTH Consultants, Ltd.
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Informal Consultation
Prepared For:

Asama Coldwater Manufacturing, Inc.
Coldwater, Michigan

Project No. 16-060341
July 30, 2007

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July 30, 2007
NTH Project No. 16-060341

Ms. Rachel Rineheart
United States Environmental Protection Agency
77 West Jackson, Blvd., AR-18J
Chicago, IL 60604

Re: Biological Assessment Report for Asama Coldwater Manufacturing (ACM)
Coldwater, MI

Dear Ms. Rineheart:

This letter transmits the Biological Assessment Report prepared by NTH Consultants, Ltd (NTH) on behalf of Asama Coldwater Manufacturing (ACM) with respect to ACM's Coldwater, Michigan, foundry project. The Assessment Report is submitted by NTH on behalf of ACM to satisfy the requirements of U.S. EPA's Recommended Scope of Analysis (Roadmap) prepared to implement the requirements of Section 7 of the Endangered Species Act of 1973 (ESA), received by ACM on June 12, 2007.

NTH has completed the activities set forth in the Roadmap. The results of the Biological Assessment demonstrate that impacts to all media are well below established benchmarks and that operation of the facility will pose no adverse impact to any of the species of concern. In fact, many hazards quotients are orders of magnitude below the established benchmarks.

ACM appreciates the time that you have taken to work on the Roadmap and explain the information needed for the Biological Assessment. ACM has given the analysis requirements extensive attention and resources and has proceeded diligently to complete the enclosed Assessment Report in a timely manner. As you are aware, while MDEQ's Air Permit approval has allowed ACM to proceed with construction of the foundry project, it cannot operate the new expansion foundry facility unless U.S. EPA has conducted its consultation under the ESA. ACM submits that the attached Assessment Report and associated investigations support a finding by U.S. EPA that the project will cause no adverse impact to the identified species of concern. ACM further submits that it is crucial to the financial health of ACM, their suppliers, contractors, and affiliate organizations that the new facility commences operation not later than the fourth quarter of 2007. In view of this objective, and the enclosed findings demonstrating no adverse impact, we respectfully request that U.S. EPA complete its consultation as soon as possible. In this regard, we would appreciate your assistance in completing your review of this report by August 31, 2007. Please do not hesitate to contact me if you have any questions regarding this letter or the enclosed report.

We appreciate the time you have taken to work with ACM to properly conduct this assessment and look forward to receiving concurrence from you regarding our results and conclusion.

Sincerely,

NTH Consultants, Ltd.

Jeffrey P. Jaros
Project Manager

cc: Dan Drinan, Asama Coldwater Manufacturing
David Preston, Varnum Riddering Schmidt Howlett, LLP

JPJ/mjb
Enclosure

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APPENDICES

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1.0 INTRODUCTION

Asama Coldwater Manufacturing, Inc. (ACM) operates an iron foundry located at 180 Asama Parkway, Coldwater, Michigan. The facility is currently operating pursuant to the terms and conditions of Permit No. 139-96C and ROP No. MI-ROP-N5814-2006. On September 11, 2006, ACM submitted an application to the Michigan Department of Environmental Quality for a major modification to the existing facility. Specifically, ACM has proposed to expand the current iron making capabilities of the facility through the addition of a new foundry. On January 16, 2007, ACM received approval under Permit to Install (PTI) No. 280-06 to construct the new expansion foundry adjacent to the existing foundry. The new foundry will consists of two (2) electric induction furnaces, pouring areas, pouring stations, and a sand mold system comprised of automated conveyors, and mold cooling and automated shakeout lines. Each furnace will hold approximately 11 tons of scrap metal and the hourly production rate will be a maximum of 16.5 tons/hour for both furnaces combined.

The ACM facility is located in an attainment area for all criteria pollutants subject to regulation under the Clean Air Act (CAA). The existing ACM foundry/facility is a major stationary source as defined in the Prevention of Significant Deterioration (PSD) regulations codified under 40 CFR 52.21 and the new expansion foundry is a major modification of the existing major source. As detailed in the original application support document, the expansion is subject to PSD review because it will result in a significant net increase in emissions of carbon monoxide (CO), particulate matter (PM_{10}), and volatile organic compounds (VOC).

The existing facility is considered an area source of hazardous air pollutants (HAPs). The new expansion foundry will be considered a major source of HAPs, and therefore, the affected sources at the expansion foundry are subject to the applicable National Emission Standards for Hazardous Air Pollutants (NESHAP) for Iron and Steel Foundries, 40 CFR Part 63, Subparts A and EEEEE for new affected sources upon startup of the new foundry. In addition, the existing foundry will become subject to the NESHAP Subpart EEEEE for existing affected sources 3 years after startup of the new expansion foundry.

1.1 MODIFICATION TO EXISTING PERMIT NO. 280-06

ACM has submitted to MDEQ an application to modify PTI No. 280-06 as a result of minor engineering changes on July 20, 2007. Since the time of the issuance of PTI No. 280-06, ACM has brought in a new engineering firm to design the equipment layout for the new expansion area and there have been changes to the design that required minor revisions to the permit. MDEQ reports that a copy of the application has been forwarded to U.S. EPA, Region V, which contains these engineering changes. Overall, the total mass emissions from the new foundry and operations have not changed. Instead, due to changes in the ductwork and collection hoods, and volumetric flows of the various air quality control system baghouses, emissions of certain pollutants have been rerouted. The modeling performed in support of this biological assessment for the species of concern includes all new changes to the facility layout, equipment design, and ductwork.

The following is a brief list of the engineering changes that have occurred since the approval of PTI No. 280-06 and which are addressed in the permit application technical support document submitted on July 20, 2007:

- Baghouse Flow Rates
    - Mold Cooling & Shakeout Baghouse increases from 35,800 acfm to 61,200 acfm
    - Casting Cooling & Finishing Baghouse decreases from 75,800 to 65,360 acfm
- Building layout and stack location changes that affect dispersion modeling results
- Stack heights for all new stacks will be increased to 118 feet from the various heights that are currently in the permit (and some minor changes in diameters)

1.2 ENDANGERED SPECIES ACT

Section 7 of the Endangered Species Act of 1973 (ESA), as amended, provides for interagency consultation between the United States Fish and Wildlife Service (FWS) and each federal agency that is undertaking an action to ensure that such action is not likely to have an adverse impact on any federally listed threatened or endangered species.

In this circumstance, the issuance of a permit by the state of Michigan pursuant to the PSD regulations found at 40 CFR 52.21 has triggered the requirements for an informal consultation. The U.S. EPA administers a PSD program to issue permits for major sources of certain regulated air pollutants. To facilitate the issuance of such permits, the U.S. EPA either delegates authority to the state to administer the PSD program and issue permits or approves a State Implementation Plan under which a state administers its own state PSD program. The state of Michigan has been granted delegated status for implementation of the federal PSD program by the U.S. EPA and issues such federal permits on behalf of the agency. Therefore, issuance of PSD permits by a delegated state is considered a federal action and triggers the informal consultation process.

1.3 ENDANGERED SPECIES ACT CONSULTATION

In December 2006, MDEQ was informed by the United States Environmental Protection Agency (U.S. EPA) that an assessment of the impact of air emissions on certain federally listed endangered species reported to have been sighted in Branch County was required. Specifically, pursuant to Section 7 of the Endangered Species Act of 1973 (ESA), as amended, the U.S. EPA had initiated the informal consultation process. Subsequently, ACM was granted approval by MDEQ to begin construction of the new facility. The approval letter indicated that ACM cannot operate the new facility unless U.S. EPA has conducted its consultation under Section 7 of the ESA regarding the permit.

In late December 2006, ACM was informed by MDEQ that U.S.EPA had initiated the informal consultation process and was requiring an assessment of potential impacts on the federally listed endangered species in Branch County. Beginning in January 2007, ACM, NTH Consultants, Ltd. (NTH), and Varnum, Riddering, Schmidt, & Howlett (Varnum) began the dialogue process to define the Recommended Scope of Analysis (Roadmap) for conducting the endangered species evaluation for the ACM facility. From January through June 2007, several discussions, conference calls, and one meeting at Region 5 headquarters in Chicago took place before the final Roadmap was presented to ACM on June 12, 2007.

This assessment fulfills the requirements contained in the Roadmap, received June 12, 2007, and demonstrates that no adverse effect to any federally listed threatened or endangered species will occur as a result of the proposed new foundry expansion at Asama Coldwater Manufacturing in Coldwater, MI.

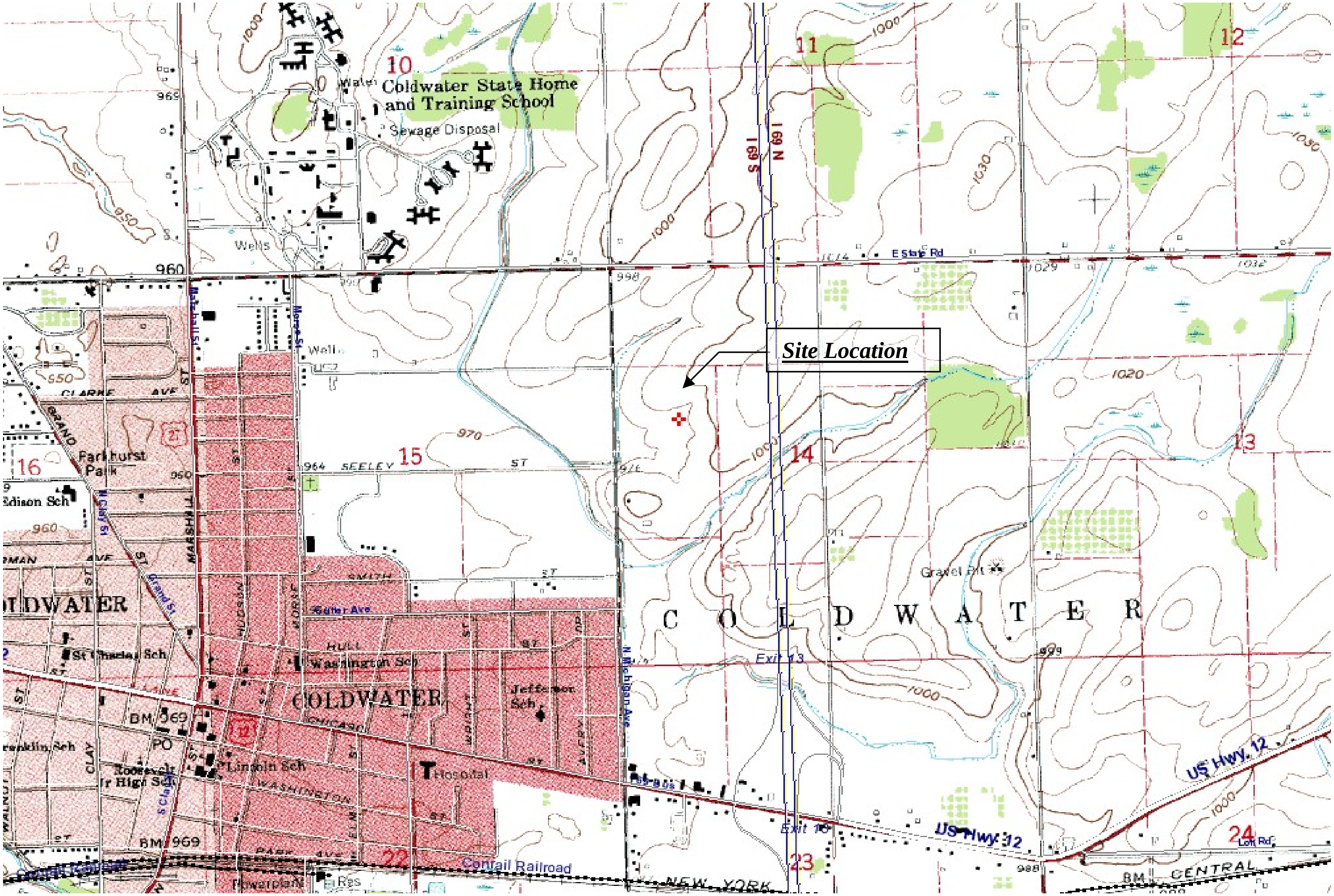
This assessment report is presented in five sections, including the Introduction in Section 1. Section 2 presents a site location and project description that provides an overview of the proposed project and location. Section 3 provides an overview of the scope of analysis regarding the biological assessment and Section 4 provides a summary of the results. Section 5 provides a summary of the literature search that was conducted to identify possible effects of lead and manganese on the listed species. Section 6 provides the conclusions of the biological assessment.

A copy of the U.S. EPA Recommended Scope of Analysis (Roadmap) is presented in Appendix A. Appendix B provides a summary of the emission rates and parameters used in the deposition modeling. The media-specific calculations and spreadsheets are supplied in Appendix C and the summary of the results of the modeling and ecological assessment is provided in Appendix D.

2.0 SITE LOCATION AND PROJECT DESCRIPTION

ACM is located in central Branch County, Coldwater, Michigan, in an industrial park adjacent to several small, light industrial operations engaged in various manufacturing and machining processes. A four-lane interstate highway is located to the east of the plant site property boundary. Coldwater is a city of 10,500 surrounded by agricultural property/operations. A site location map is included as Figure 2-1.

ACM manufactures and machines disc brakes and knuckles for the automotive industry. As a result of market economics for vehicles for which these parts are produced, ACM must expand its current operational capacity and install additional facilities. The new foundry will be constructed adjacent to the existing facility and on the same property, and will contain two (2) 11-ton electric induction furnaces, a metal casting department, and a green sand mold-making department used for creating molds for the castings. The new foundry will be used to produce gray iron, and similar to the existing facility, will utilize clean scrap iron, pig iron and in-house foundry returns.



Note: The topographic excerpt is from the Coldwater East 7.5-min. U.S.G.S. quadrangle. The scale of the map is 1.0" = 1,812 ft (552.3 m).

Figure 2-1. Asama Coldwater Manufacturing, Inc. Facility Site Location Map

3.0 SCOPE OF ANALYSIS

This section describes the scope of analysis used to conduct the biological assessment pursuant to Section 7 of the ESA. The scope of analysis follows the recommended guidelines developed by the U.S. EPA and outlined in the Roadmap transmitted to NTH from U.S. EPA in June 2007. The scope included emission estimates for air pollutants, dispersion and deposition modeling, an ecological risk assessment, and literature search.

3.1 ROADMAP

Starting in January 2007, ACM began discussing the scope of the Roadmap with U.S. EPA and what species would require a biological assessment for impacts of air emissions from the new ACM foundry. Several discussions between ACM's technical consultant, ACM's legal representative, ACM and U.S. EPA occurred between January 2007 and June 2007 until the Roadmap was drafted in final form by U.S. EPA and forwarded to ACM. During this time, several discussions between U.S. EPA and the East Lansing Field Office of the FWS occurred to identify Chemicals of Potential Concern (COPCs) and those species to be addressed by the assessment.

The Roadmap developed by U.S. EPA established the protocol to be followed when performing the biological assessment. It recommends that the draft Screening Level Risk Assessment (SLERA) Protocol for Hazardous Waste Combustion Facilities (EPA530-D-99-001A, August 1999) should be referenced and followed for conducting the biological assessment. Furthermore, the Roadmap describes the recommended benchmarks to be used, modeling protocol, assessment area, background levels, pollutants to consider, impacts to consider, listed species, and details of a literature search for additional information regarding the effects of the COPCs on the listed species.

3.2 CHEMICALS OF POTENTIAL CONCERN

The COPCs to be addressed as part of the ESA are Hazardous Air Pollutants (HAPs). The assessment was directed in the Roadmap to evaluate the identified HAPs that readily partition to particulate form (i.e., those that have low volatility or vapor pressure). To determine whether a HAP partitions to particulate form, the fraction of COPC air concentration in the vapor phase (Fv) is referenced. Values for many COPCs are found in Appendix A-2 of the Screening Level Ecological Risk Assessment (SLERA) Protocol for Hazardous Waste Combustion Facilities.

Most of the HAPs from the new foundry operations are highly volatile and are emitted in vapor phase and have Fv values of 0. In fact, the only HAPs emitted from the new foundry in particulate form are lead and manganese. Table 3-1 presents the HAPs associated emission rates and Fv values for each process associated with the new foundry.

Table 3-1. HAP Emission Rates and Fraction of COPC in Vapor Phase

Pollutant	MP Baghouse Outlet Stack (lb/hr)[1]	MCS Baghouse Outlet Stack	SS Baghouse Outlet Stack	COPC in Vapor Phase (Fv)[2]
Benzene	0.24	3.20	1.02	***0.0***
Toluene	0.028	1.10	0.52	***0.0***
Phenol	ND	1.16	0.12	***0.0***
Napthalene	0.007	0.53	0.27	***0.0***
m,p-Xylene	0.008	0.48	0.29	***0.0***
o-Xylene	0.003	0.18	0.16	***0.0***
Hexane	0.023	0.18	0.053	***0.0***
o-Cresol	ND	0.23	ND	***0.0***
Ethyl Benzene	0.005	0.12	0.12	***0.0***
Styrene	0.003	0.0086	0.11	***0.0***
Acetaldehyde	0.003	0.081	0.053	***0.0***
2-Methylnaphthalene	0	0.37	0.17	***0.0***
1-Methylnaphthalene	0	0.198	0.14	***0.0***
Manganese	0.0037	0	0	***1.0***
Lead	0.009	0	0	***1.0***

[1] The hourly emission rates are based upon a melt rate of 16.5 tons per hour.

[2] The values for Fv were taken from Appendix A-2 of the SLERA protocol. No value for 2-Methylnaphthalene or 1-Methylnaphthalene was provided. Review of reference materials regarding these chemicals indicates that both are highly volatile.

3.3 AIR DISPERSION AND DEPOSITION MODELING

Modeling was performed to predict impacts of lead and manganese in both the soil and air. The general guidance provided in chapter 3 of the SLERA Protocol was followed to assess fate and transport of COPCs and predict concentrations and deposition rates. The U.S. EPA approved AERMOD model was used for both dispersion and deposition modeling.

AERMOD is a steady-state Gaussian model capable of handling multiple source inputs and producing both concentration and deposition impacts from point, area, volume, and open-pit sources. AERMOD is also capable of handling numerous source configurations, building inputs, receptor grids and elevated terrain. It is capable of producing both ambient air concentrations and deposition impacts.

Receptor Grid

Consistent with the ambient impact analysis used to support the air permit application, both the dispersion and deposition modeling utilized the following receptor grid configuration:

- Fence Line Receptors: Receptors were placed along the secured facility property boundaries at 25 meter spacing.
- Near-field Cartesian Receptor Grid: Receptors were placed at 25 meter spacing from the secured area boundaries outward to 500 m from the center of the facility sources.
- Mid-field Cartesian Receptor Grid: Receptors were placed at 50 meter spacing from the boundary of the Near-field grid out to 1.25 km from the center point.
- Far-field Cartesian Receptor Grid: Receptors were placed at 100 meter spacing from the boundary of the Mid-field grid outward to 3 km.

This receptor grid was chosen to identify the maximum ground level impacts from the dispersion and deposition modeling. Such a domain configuration ensures that the potential worst-case impacts were identified, evaluated, and used for the ecological fate calculations for both soil and water.

Meteorological Data

The modeling analyses have been conducted using readily available and representative hourly meteorological data. The MDEQ – Air Quality Division has recently determined representative surface characteristics and has prepared pre-processed "AERMOD-ready" surface and upper air MET data files, including precipitation data, for use in both dispersion and deposition AERMOD modeling.

The appropriate AQD pre-processed, "AERMOD-ready" dataset (i.e. data processed using AERMET) was obtained from the AQD for a full 5-year period for the Branch County Memorial Airport (Station #11675) in Coldwater, MI. As mentioned previously, the 5-year data set utilized in this modeling analysis was for the years 2002 through 2006, and the main surface station height is given as 292 meters above Mean Sea Level (MSL). The upper air station processed with this data is White Lake (Station #94847) for the years 2002-2006.

3.3.1 Deposition Modeling

Wet and dry deposition modeling was performed to determine the total deposition of lead and manganese. Since lead and manganese are only emitted in the particle form (particle bound) and do not require vapor phase portioning, no gas-vapor partitioning of emissions or modeling was necessary.

As was presented in Table 3-1, lead and manganese emissions are only expected from the MP process as a result of melting and pouring operations and these emissions are controlled by a fabric filter (baghouse). Deposition modeling requires knowledge of the particle size distribution for the wet and dry deposition calculations. Particle size affects the terminal velocity and rate of deposition of the COPCs. Information regarding the particle-size distribution from an electric induction furnace with fabric filter control was not available and ACM does not have site-specific testing information. Therefore, the U.S. EPA emission factor database found in Section 12.10 – Gray Iron Foundries (updated May 2003) of the *AP-42, fifth edition, Compilation of Air Pollutant Emission Factors* was used. As a particle size distribution for an electric induction furnace with fabric filter control was not available, the particle-size distribution for a cupola furnace controlled by a baghouse was used as a surrogate.

3.3.2 Particulate Aerodynamic Distribution – Source Pathway Parameters (Pb and Mn)

Particulate deposition modeling was conducted for the lead and manganese emissions associated with the new gray iron foundry. AERMOD allows the use of two different methods for determining dry deposition velocities based on the predominant particle size distribution. The method used is dependant upon how much information is available for particle size breakdowns for a given source. Method 1 is used, generally, when the particle size distribution is known or if greater than 10% of the total mass has a diameter of 10 µm or larger. Method 2 is used when the particle size distribution is not well known and if less than 10% of the mass is in particles with a diameter of 10 µm or larger.

For the purposes of this modeling, ACM has estimated that the aerodynamic distribution of particulate emissions from the new gray iron foundry electric induction furnace and associated baghouse are similar to that provided in Chapter 12.10 – *Gray Iron Foundries (May 2003 revision*) of the AP-42 document. Specifically, ACM has used the aerodynamic distribution of particulate that is listed in Table 12.10-9 of Chapter 12.10 for a cupola furnace controlled by a baghouse (see Table 3-2 below). Although Table 12.10-9 estimates that only 5% of the total mass of particulates emitted will have a diameter greater than 10 um, the particulate distribution is available and ACM has decided to use Method 1 to estimate the dry deposition of particle bound lead and manganese in order to provide more accurate results.

The following is a discussion of how the size distributions are used to determine the model input parameters in the Source (SO) pathway for the new furnace.

Expected Particle Size Distribution – Electric Induction Furnace

Lead is only emitted in the particle form and does not readily volatize to the vapor state. Therefore, it is reasonable that the size distribution for lead from an electric induction furnace with fabric filter control will be similar to the particle size distribution of flue gas exiting a cupola furnace with fabric filter to control particulate emissions. Similarly, manganese emissions will be in particulate form and should have the same particle size distribution.

The mean particle size (D_{mean} or D_{mm}) for each of the particle size ranges has been calculated according to the following formula, which is Equation 3-1 obtained from Chapter 3 of the September 2005 Human Health Risk Assessment Protocol (2005 HHRA Protocol, which updated the 1998 draft protocol) for Hazardous Waste Combustion Facilities. Chapter 3 of the 2005 HHRA Protocol outlines specifics about performing deposition modeling for risk assessment purposes. As noted below in Table 3-2, the overall lower and upper bounds for the particle size distribution have been assumed to be 0 µm and 30 µm, respectively.

$$\mathrm{D}_{\mathrm{mean}} = \left[0.25 * \left(D_1^3 + D_1^2 * D_2 + D_1 * D_2^2 + D_2^3\right)\right]^{(1/3)}$$

Where:

$\mathrm{D}_{\mathrm{mean}}$ (or D_{mm}) = mass mean particle diameter for the particle size category, µm
D_1 = lower bound cut of the particle size category, µm
D_2 = upper bound cut of the particle size category, µm

The following is an example calculation for the mean particle size for the size category between 15 µm and 30 µm. As shown in the example calculation, the mean particle size for this particle size category is equal to 22.58 µm.

$$\mathrm{D}_{\mathrm{mean}} = \left[0.25\ \mu\mathrm{m}*\left(15\ \mu\mathrm{m}^3 + 15\ \mu\mathrm{m}^2*30\ \mu\mathrm{m} + 15\ \mu\mathrm{m}*30\ \mu\mathrm{m}^2 + 30\ \mu\mathrm{m}^3\right)\right]^{(1/3)}$$

$$\mathrm{D}_{\mathrm{mean}} = \left[0.25*\left(50{,}625\ \mu\mathrm{m}\right)\right]^{(1/3)} = \left[12{,}656.25\ \mu\mathrm{m}\right]^{(1/3)} = 22.58\ \mu\mathrm{m}$$

Table 3-2 summarizes the mean particle diameters and the associated mass fractions of particulate emissions for each particle range based upon aerodynamic distribution information contained in Table 12.10-9 of the AP-42 document.

Table 3-2. Summary of Particle Size Distribution for an Electric Induction Furnace Based Upon Table 12.10-9 of the AP-42 for a Cupola Furnace (w/ Baghouse Control)

Lower Range of Particle Diameter (µm)	Upper Range of Particle Diameter (µm)	Mean Particle Diameter For Cumulative Range[1] (µm)	Cumulative Mass % < Lower Range of Particle Diam	Fraction of Mass Within Range
15.0	30.0	23.30	100.0%	0.00
10.0	15.0	12.66	95.0%	0.05
5.0	10.0	7.76	94.9%	0.00
2.5	5.0	3.88	94.9%	0.00
2.0	2.5	2.25	94.2%	0.01
1.0	2.0	1.55	91.5%	0.03
0.5	1.0	0.77	83.4%	0.08
0.0	0.5	0.31	n/a	0.83
Totals		-----	***100%***	***1.00***

[1] Mean particle sizes represent the mean size for the size ranges associated with a given mass %. For the fraction above 15 µm in diameter, the upper bound of the size range has been assumed to be 30 µm. For the fraction less than 0.625 µm in diameter, the lower bound of the size range has been assumed to be 0 µm.

From Table 3-2, the mean particle diameter for each range (D_{mean} or D_{mm}) was used as Source (SO) pathway model inputs for both lead and manganese. The mass fractions listed in the far right column of Table 43-2 were also used.

As indicated in Chapter 3 of the 2005 HHRA Protocol, to determine the mass weighting for each of the mean particle sizes for particle-bound materials that may condense onto the surface of particulate matter, the mass fraction must be expressed as a fraction of the total surface area of the particle. Fractional areas have been assigned to each of the mean particle sizes presented in Table 3-2 according to the methodology contained in Chapter 3 of the 2005 HHRA Protocol (Section 3.2.3). The following is a brief summary of this procedure, followed by an example calculation for the 12.66 µm mean particle size.

1. Determine the mean particle radius by dividing the mean diameter by 2.
2. Determine the ratio of the surface area to the volume. Treating the particle as a sphere, this parameter is calculated by dividing 3 by the radius (S/V = 3/radius).
3. Determine a mass weighted proportion of available surface area. This parameter is calculated by multiplying the S/V ratio for a given mean particle size by the weight (mass) fraction associated with the mean particle size.
4. Sum the proportion of available surface areas for all of the mean particle sizes.
5. Divide the proportion of available surface area for each mean particle size by the total proportion of available surface area to determine a fraction surface area value for each of the mean particle sizes.

Example calculation:

$$Radius_{12.664\ \mu m} = \frac{12.66\ \mu m}{2} = 6.332\ \mu m$$

$$S/V\ Ratio_{12.664\ \mu m} = \frac{3}{radius} = \frac{3}{6.33\ \mu m} = 0.474$$

$$Proportion\ \ of\ available\ surface\ area_{12.664\ \mu m} = S/V{*}mass\ fraction = 0.474{*}0.05 = 0.0237$$

$$The\ sum\ of\ all\ proportions\ of\ available\ surface\ areas = 16.70\ ,\ \ therefore:$$

$$Fraction\ of\ surface\ area_{23.30\ \mu m} = \frac{0.0237}{16.70} = 0.0014$$

Thus, the fractional area associated with the particle bound lead or manganese having a mean particle diameter of 12.664 µm is equal to 0.0014. The preceding calculations were repeated for each of the mean particle sizes presented in Table3-2. Table 3-3 presents the fractional surface area associated with each of the mean particle sizes presented in Table 3-2. These values were used as the mass fractions in the Source (SO) pathway parameters for the new electric induction furnace for the particle dry deposition.

Table 3-3. Surface Area Weighting of Mass Fractions for Particle-Bound Modeling For The New Electric Induction Furnace (based on Baghouse Control) [1]

Mean Particle Diameter (μm) [2]	Mean Particle Radius (μm)	Surface Area / Volume	Fraction of Total Mass	Proportion Available Surface Area	Fraction of Total Surface Area [2]
23.304	11.65	0.26	0.000	0.000	0.000
12.664	6.33	0.47	0.050	0.024	0.001
7.768	3.88	0.77	0.001	0.0008	0.000
3.884	2.24	1.34	0.000	0.000	0.000
2.259	1.13	2.65	0.007	0.019	0.001
1.554	0.56	5.31	0.027	0.14	0.009
0.777	0.39	7.72	0.081	0.63	0.038
0.315	0.16	19.05	0.834	15.89	0.95
Totals	----	----	----	4.39	1.00

[1] Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (Section 3.2.3). U.S. EPA Office of Solid Waste and Emergency Response. EPA530-R-05-006, September 2005.

[2] Values represent model input parameters in the SO Pathway.

Particle Density Parameters

Lastly, to complete the information needed in the model Source (SO) pathway, a particle density (g/cm^3) must be entered for each particle diameter entry. For purposes of this modeling, ACM assumed a default particle density for both the lead and manganese particle modeling runs (default = 1.0 g/cm^3) as recommended in the U.S. EPA's 2005 HHRA Protocol.

3.4 ECOLOGICAL RISK ASSESSMENT

The Roadmap specifies factors to be considered as part of the ESA analysis to assess the potential impact of the emissions from the proposed foundry expansion. A copy of the Roadmap is included in Appendix A.

Three threatened or endangered species have been reported to have been sighted in the past within Branch County. The Indiana Bat (Myotis sodalist), Copperbelly Water Snake (Nerodia erthrogaster neglecta), and Mitchell's Satyr Butterfly (Neonympha mitchelli) were identified as species of concern for this analysis by USFWS.

Benchmark and Media Identification

Benchmarks and media to be considered for the ESA were identified in the Roadmap. The benchmarks for this assessment are the media specific ecological screening levels, when available. When ecological screening levels are unavailable, consideration of risk-based criteria developed from available no-observed-adverse-effect-level (NOAEL) toxicological endpoints for appropriate surrogate species may be considered. The media concentrations to be considered for this assessment were identified as short-term air concentrations and long-term soil, surface-water, sediment and plant concentrations.

Natural Resources Impacts

The ESA evaluation therefore considered potential short-term and long-term impacts of both lead (Pb) and manganese (Mn) emissions from the proposed ACM expansion. For short-term exposures, 1-hour, 8-hour, and 24-hour averaging time based air concentrations determined by the modeling discussed above were considered. For the assessment of impacts of long-term exposure, the Roadmap directed ACM to use portions of the U.S. EPA 's draft Screening Level Ecological Risk Assessment (SLERA) Protocol for Hazardous Waste Combustion Facilities (EPA-530-D-99-001A) as guidance for this assessment.

The SLERA document contains equations in Chapter 3 to estimate impacts to soil, surface water, sediments, and plants based on emissions over extended periods of time. The equations, the various input data, and calculations are summarized in Appendix C.

4.0 IMPACT ANALYSIS

The impact analysis for the fate and transport of COPCs consists of two primary exercises: 1. dispersion and deposition modeling of COPCs; and 2. Calculation of ecological risk using the results of the modeling. As mentioned previously, dispersion and deposition modeling was performed for both lead and manganese to predict the concentrations of each pollutant in air and to estimate the rate each pollutant will deposit onto soils and surface water. These results are then used in the ecological risk equations to determine the concentration of each pollutant in soils and water and comparing to benchmark levels such as statewide background concentrations for soils in Michigan.

4.1 RESULTS OF DISPERSION AND DEPOSITION MODELING

Modeling was performed to predict the worst-case short-term and long-term impacts over a period of 5 years. Short-term impacts were defined in the Roadmap as a 1-hour, 8-hour, 24-hour averaging period, whereas long-term was defined as annual. For each averaging period, the highest predicted off-property impact was determined for each of 5 years and the highest impact predicted from five years was used in the ecological assessment. Meteorological data for the years 2002-2006 defined the 5-year data period.

The modeling demonstrated that both the ambient air concentrations and deposition rates of lead and manganese are very low when compared to the Ecological Benchmarks. Further, since these represent worst-case impacts for each pollutant and averaging period, impacts are generally close to the facility property. None of the species of concern (Indiana bat, Copperbelly water snake, and Mitchell's Satyr butterfly) are known to exist in these areas or have been sited. In fact the closest sighting of any of these species was approximately 9 km from the facility.

A summary of the modeling results is presented in Tables 4-1 and 4-2, and is also included in Appendix B.

Table 4-1. Summary of Dispersion and Deposition Modeling Impacts for Manganese (Mn)

	1-Hour				8-Hour				24-Hour				Annual			
Year	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**
2002	1.7573	0.23828	1.75373	0.01080	1.77822	0.91893	1.79343	0.00771	2.18296	1.20446	2.20304	0.00557	7.12302	32.38980	34.63102	0.00061
2003	1.81397	0.19276	1.81397	0.01045	2.31832	0.84265	2.31832	0.00762	2.32182	1.32258	2.32183	0.00441	8.38270	27.00953	29.22033	0.00044
2004	2.46104	0.21132	2.46104	0.04048	2.54679	0.69702	2.54770	0.00642	2.54933	1.11411	2.54933	0.00442	8.75463	31.41746	33.38078	0.00058
2005	1.40279	0.22698	1.40279	0.01059	1.74254	0.93442	1.74394	0.00658	1.74254	1.65821	1.75458	0.00427	8.58203	25.82490	26.64958	0.00042
2006	3.53388	0.20628	3.53388	0.01066	3.53388	0.96852	3.53388	0.00742	3.53393	1.75931	3.53412	0.00392	9.75844	24.97492	27.81139	0.00043
MAX	**3.53388**	**0.23828**	**3.53388**	**0.01080**	**3.53388**	**0.96852**	**3.53388**	**0.00771**	**3.53393**	**1.75931**	**3.53412**	**0.00557**	**9.75844**	**32.38980**	**34.63102**	**0.00061**

Table 4-2. Summary of Dispersion and Deposition Modeling Impacts for Lead (Pb)

	1-Hour				8-Hour				24-Hour				Annual			
Year	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**	**Wet Deposition Dydw (ug/m^2)**	**Dry Deposition Dydp (ug/m^2)**	**Total Deposition Dydt (ug/m^2)**	**Air Concentration Cyp (ug/m^3)**
2002	4.23443	0.57534	4.23443	0.02609	4.29356	2.21878	4.33028	0.01862	5.27083	2.90821	5.31931	0.01346	17.19874	78.20609	83.61766	0.00147
2003	4.37989	0.46543	4.37989	0.02523	5.59766	2.03460	5.59766	0.01840	5.60611	3.19341	5.60613	0.01066	20.24031	65.21530	70.55334	0.00107
2004	5.51596	0.18326	5.51596	0.01211	5.60934	1.02029	5.61033	0.00766	5.66899	1.49889	5.69296	0.00362	18.86028	33.39951	38.12216	0.00042
2005	3.38708	0.54805	3.38078	0.02558	4.20740	2.25618	4.21072	0.01588	4.20740	4.00379	4.23648	0.01031	20.72154	62.35500	64.34622	0.00101
2006	8.53266	0.49806	8.53266	0.02574	8.53266	2.33852	8.53266	0.01790	8.53277	4.24791	8.53324	0.00947	23.56206	60.30270	67.15144	0.00105
MAX	**8.53266**	**0.57534**	**8.53266**	**0.02609**	**8.53266**	**2.33852**	**8.53266**	**0.01862**	**8.53277**	**4.24791**	**8.53324**	**0.01346**	**23.56206**	**78.20609**	**83.61766**	**0.00147**

4.2 ECOLOGICAL RISK ASSESSMENT

The SLERA document presents various equations to estimate impacts to soil, surface water, sediments, and plants based on emissions and depositional modeling over extended periods of time.

Soil Concentrations

SLERA utilizes six integrated equations to determine the potential soil concentration of the chemical of concern. The equations require inputs that are default numbers, site-specific numbers, and chemical specific numbers. Details on the equations, various default assumptions, and selected site-specific input parameters are included in Appendix C.

Surface Water Concentrations

SLERA utilizes eighteen integrated equations to determine the potential surface-water concentration of the chemical of concern. The equations require inputs that are default numbers, site-specific numbers, and chemical specific numbers. Details on the equations, various default assumptions, and selected site-specific input parameters are included in Appendix C.

Sediment Concentrations

SLERA utilized one equation that is based on terms that have been previously defined and calculated.

Plant Concentrations

SLERA utilizes three integrated equations to determine the potential plant concentration of the chemical of concern. The equations require inputs that are default numbers, site-specific numbers, and chemical specific numbers. The equations in the SLERA document require various input data, details on the various default assumptions and selected site-specific input parameters are included in Appendix C.

Literature Search for Ecological Benchmark Data

U.S. EPA directed ACM to conduct a Literature Search to determine if applicable ecological benchmarks existed for lead and manganese. U.S. EPA recommended in the road map the following resources:

- U.S. EPA Region 5's, Resource Conservation and Recovery Act Ecological Screening Levels (http://www.epa.gov/RCRIS-Region-5/ca/ESL.pdf)
- U.S. EPA Ecological Soil Screening Levels (http://www.epa.gov/ecotox/ecossl)
- RATL: A Database of Reptile and Amphibian Toxicology Literature by Canadian Wildlife (http://dsp-psd.communications.gc.ca/Collection/CW69-5-357E.pdf)
- U.S. EPA 's aquatic life criteria (http://www.epa.gov/waterscience/criteria/aqlife.html)

NTH additionally searched the following database (search terms included lead, manganese, action level, screening level, ecological, plant, sediment, air, soil, surface-water)

- IRIS http://www.epa.gov/iris/
- RAIS http://rais.ornl.gov/
- ATSDR http://www.atsdr.cdc.gov/
- CDC http://www.cdc.gov/
- NIOSH http://www.cdc.gov/niosh/
- OHSA http://www.osha.gov/
- MDEQ http://www.michigan.gov/deq

NTH also cross referenced several of the support documents for SLERA including Human Health and Ecological Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Waste Background Document July 1999.

Based on the literature and database review the available ecological benchmarks were identified for lead and manganese. The table below lists the ecological benchmarks and other relevant comparison criteria.

Table 4-3 Ecological Benchmarks

Chemical	Air	Soil	Water	Sediment	Plant
Lead (Pb)	30 ug/m^3 [5] 1.5 ug/m^3 [13]	53.7 ug/kg [1] 21,000 ug/kg [6] 1,700,000 ug/kg [8] 11,000 ug/kg [9]	1.17 ug/L [1] 10 ug/L [15]	35,800 ug/kg [1] 21,000 ug/kg [6]	Mammals 24 ug/kg plant tissue [2] 120,000 ug/kg [7]
Manganese (Mn)	2,800 ug/m^3 [3] 50 ug/m^3 [14]	72,000 ug/kg [4] 440,000 ug/kg [6] 450,000 ug/kg [11] 4,000,000 ug/kg [12]	3,600 ug/L [4] 1,900 ug/L [15]	440,000 ug/kg [6]	220,000 ug/kg [10]

[1] U.S. EPA, Region 5, RCRA Ecological Screening Levels August 22, 2003

[2] Human Health and Ecological Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Waste Background Document July 1999 Appendix J p J-21

[3] ATSDR Toxicological Profile for Manganese p. 27

[4] Michigan Department of Environmental Quality Part 201 Criteria Protective of Human Drinking Water values

[5] OSHA action level www.osha.gov

[6] Michigan Department of Environmental Quality estimated naturally occurring level in Michigan soils established as a Statewide default Background Concentration.

[7] U.S. EPA 's Ecological Soil Screening Levels for lead, Plants, March 2005, OSWER Directive 9285.7-70

[8] U.S. EPA 's Ecological Soil Screening Levels for lead, Soil Invertebrates, March 2005, OSWER Directive 9285.7-70

[9] U.S. EPA 's Ecological Soil Screening Levels for lead, Wildlife (lowest value protective of both Avian or Mammalian species), March 2005, OSWER Directive 9285.7-70 – This ECO-SSL was determined to be protective of avian insectivore species, an ECO-SSL for a mammalian insectivore was estimated as 56,000 ug/kg.

[10] U.S. EPA 's Ecological Soil Screening Levels for Manganese, Plants, April 2007, OSWER Directive 9285.7-71

[11] U.S. EPA 's Ecological Soil Screening Levels for Manganese, Soil Invertebrates, April 2007, OSWER Directive 9285.7-71

[12] U.S. EPA 's Ecological Soil Screening Levels for lead, Wildlife (lowest value protective of both Avian or Mammalian species), April 2007, OSWER Directive 9285.7-71. This ECO-SSL was determined to be protective of Mammalian ground insectivore species, an ECO-SSL for an avian insectivore ground species was estimated as 4,300,000 ug/kg.

[13] Federal NESHAP for lead

[14] Michigan Department of Environmental Quality, Air Quality Division's air toxics ITSL screening level.

[15} Michigan Department of Environmental quality, Water Bureau's Rule 57 risk-based water quality criteria, protective of aquatic life, wildlife, and human health.

As discussed above, the results were based on worst-case scenarios for short-term and long-term exposures. Short-term results were separated into 1-hour, 8-hour and 24-hour exposure scenarios. Long-term results were based on 50 years of ACM operation and separated into soil, surface-water, sediment and plant concentrations. Table 4-4 lists the modeled worst-case short-term air concentrations:

Table 4-4 Worst-case Short-term Concentrations

Chemical	1-hour (ug/m³)	8-hour (ug/m³)	24-hour (ug/m³)
Lead (Pb)	0.026	0.017	0.013
Manganese (Mn)	0.011	0.077	0.056

Table 4-5 lists the predicted worst-case long-term concentrations based on depositional modeling and accumulation over a 50 year period.:

Table 4-5 Worst-case Long-term Concentrations (Accumulation period of 50 years)

Chemical	Soil (mg/kg)	Surface Water (mg/L)	Sediments (mg/kg)	Plants (mg/kg wet weight)
Lead (Pb)	0.017	0.0010	0.92	0.0024
Manganese (Mn)	0.0069	0.00042	0.38	0.00098

5.0 SUMMARY AND CONCLUSIONS

5.1 ANALYSIS OF IMPACT

To assess the potential impact on each subject organism in the environment, the short-term and long-term values were compared to the ecological benchmark on a chemical-by-chemical basis. The information summarized on Table 5-1 provides a comparison of the modeled/calculated concentrations in various media with the selected benchmarks. The results of the various comparisons are discussed in the following paragraphs.

5.2 SHORT-TERM AIR CONCENTRATIONS

The highest concentration for lead exposure occurred at the 1-hour averaging time interval was 0.026 ug/m^3, the highest at the 24-hour averaging time was 0.013 ug/m^3, and the highest annual value was 0.0015 ug/m^3. The federal NESHAP for lead is 1.5 ug/m^3 (which is a 3-month averaging time); this limit is protective of human health and the environment. A predicted worst-case air concentration would have a hazard quotient (HQ) of less than 0.004, which indicates the expansion foundry's emissions should have no adverse impact on human health, animals, or insects.

The highest concentration for manganese exposure occurred at the 1-hour averaging time was 0.11 ug/m^3, and a 24-hour averaging time was 0.13 ug/m^3. The Agency for Toxic Substances and Disease Registry (ATSDR) toxicity profile for Manganese has established a NOAEL of 2,800-ug/m^3 based on laboratory testing on rodents, which should therefore be protective animals and insects. In addition, the Michigan Department of Environmental Quality Air Quality Division has established an air toxics screening level of 50 ug/m^3 (24-hr avg. time). A predicted worst-case air concentration would have a HQ of less than 0.003, which indicates the expansion foundry's emissions will not have an adverse impact on human health, animals, or insects.

Table 5-1 Comparison of predicted worst case media concentrations to Selected Ecological Benchmarks

Estimated long-term concentrations accumulated over 50 years using predicted "worst case" deposition						Selected Ecological Benchmarks and Hazard Quotients (HQ)							
Chemical	**Modeled Maximum Air Conc. 24-hour avg. time (ug/m³)**	**Modeled Soil Conc. (ug/kg)**	**Modeled Surface water Conc. (ug/l)**	**Modeled Sediment Conc. (ug/kg)**	**Modeled Plant Conc. (ug/kg wet weight)**	**Air (ug/m³)**	**HQ Air**	**Water (ug/l)**	**HQ Water**	**Sediment (ug/kg)**	**HQ Sediment**	**Soil (ug/kg)**	**HQ Soil**
Lead	0.0056	16.6	1.0	916	2.4	1.5 [4]	0.0037	1.17 [1] 10 [3]	0.67 0.1	35800 [1]	0.026	53.7 [1] 11,000 [2]	0.3 0.002
Manganese	0.13	6.9	0.4	380	0.98	50 [5]	0.0026	1,900 [3]	0.008	NA		220,000 [2]	3.1E-5

Footnotes:

[1] U.S. EPA Region 5, RCRA Ecological Screening Levels

[2] Lowest value identified as U.S. EPA Ecological Soil Screening levels (ug/kg dry weight in soil) see table below

[3] MDEQ Rule 57 risk based water quality criteria protective of aquatic life, wildlife, and human health

[4] Federal NESHAP for lead

[5] Michigan Department of Environmental Quality, Air Quality Division's air toxics ITSL

Table 5-2 U.S. EPA Ecological Soil Screening Levels (ug/kg dry weight in soil)

Chemical	Plants	Soil Invertebrates	Avian Wildlife	Mammalian Wildlife
Lead	120,000	1,700,000	11,000	56,000
Manganese	220,000	450,000	4,300,000	4,000,000

5.3 ESTIMATED LONG-TERM EXPOSURE (ACCUMULATION TIME: 50 YEARS)

5.3.1 Soil

The predicted increased soil lead concentration resulting from the foundry expansion's emissions at the "worst-case" deposition point over a 50-year accumulation period concentration is 16.6 ug/kg. U.S. EPA Region 5's, Resource Conservation and Recovery Act Ecological Screening Level for lead in soil is 53.7 ug/kg. As shown in Table 5-2, the U.S. EPA 's Ecological Soil Screening Level for lead in soil protective of plants soil invertebrates, avian wildlife and mammalian wildlife is 11,000 ug/kg. This level would have a HQ of less than 0.7 to as low as 0.002, which indicates the expansion foundry's emissions will not result in any adverse impact in soil on human health, animals, or insects.

The predicted increased soil manganese concentration resulting from the foundry expansion's emissions at the "worst-case" deposition point over a 50-year accumulation period concentration is 6.9 ug/kg. As showed in Table 5-2, the U.S. EPA 's Ecological Soil Screening Level for manganese in soil protective of plants, soil invertebrates, avian wildlife and mammalian wildlife is 220,000 ug/kg. The predicted deposition level would have a HQ of less than 0.00003, which indicates the expansion foundry's manganese emissions will not result in any adverse impact in soil on human health, animals, or insects.

5.3.2 Surface Water

The worst-case deposition modeling for lead would suggest a concentration in surface water of 1.02 ug/l after 50 years based upon deposition rates at the point of maximum impact. U.S. EPA Region 5's, Resource Conservation and Recovery Act Ecological Screening Level for lead in surface water is 1.17 ug/l; a risk-based level protective of aquatic life, human health, and the environment calculated by the Michigan Department of Environmental Quality, Water Bureau is 10 ug/l. The predicted deposition level would have a HQ of less than 0.9, which indicates the expansion foundry's lead emissions over a 50 year accumulation period will not result in any adverse impact in surface water on aquatic life, human health, wildlife, or the environment.

The worst-case deposition modeling for manganese predicts a concentration in surface water of 0.42 ug/l after 50 years based upon deposition rates at the point of maximum impact. A risk-based level protective of aquatic life, human health, and the environment calculated by the Michigan Department of Environmental Quality, Water Bureau is 1,900 ug/l. The predicted deposition level would have a HQ of less than 0.008, which indicates the expansion foundry's manganese emissions over a 50 year accumulation period will not result in any adverse impact in surface water on aquatic life, human health, wildlife, or the environment.

5.3.3 Sediments

The worst-case deposition modeling for lead would suggest a concentration in sediments of 916 ug/kg after 50 years. U.S. EPA Region 5's, Resource Conservation and Recovery Act Ecological Screening Level for lead in sediments is 35,800 ug/kg. The predicted deposition level would have a HQ of less than 0.03 which indicates the expansion foundry's lead emissions over a 50 year accumulation period will not result in any adverse impact in sediments on aquatic life, wildlife, or the environment.

The worst-case deposition modeling for manganese would suggest a concentration in sediments of 380 ug/kg after 50 years. Although an ecological benchmark was not determined for manganese in sediments, the U.S. EPA 's Ecological soil screening level for manganese in soil protective of plant growth, soil invertebrates, and wildlife is greater than 220,000 ug/kg.

5.3.4 Plants

The predicted concentration for lead in plants based on worst-case modeling estimates is 2.4 mg/kg from accumulated lead in soil over 50 years. According to U.S. EPA 's Background Document Human Health and Ecological Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Waste (July 1999) calculated that a plant lead level of 24 ug/kg was protective of mammalian species. As shown in Table 5-2, the U.S. EPA's Ecological Soil Screening Level for soil protective of plants has been estimated at 120,000 ug/kg.

The predicted concentration for manganese in plants based on worst-case modeling estimates is 0.981 ug/kg after 50 years. As shown in Table 5-2, the U.S. EPA 's Ecological Soil Screening Level for soil protective of plants has been estimated at 220,000 ug/kg.

5.4 CONCLUSIONS

ACM has addressed the issues identified in the Roadmap for a screening level Ecological Risk Assessment for its proposed expansion at the Coldwater, Michigan facility. Throughout this process, worst-case scenarios were used to determine maximum potential impacts to the environment, to assess threatened and endangered species that may be found in Branch County. Based upon the worst-case scenario assessment, it is apparent that the emissions from the expansion of the ACM plant will have a negligible impact on the environment and pose no additional risk to threatened and endangered species because short-term and long-term impacts are well below the available ecological screening levels, and/or risk-based environmental limits developed by environmental regulatory agencies.

APPENDIX A

U.S. EPA RECOMMENDED SCOPE OF ANALYSIS (ROADMAP)

Recommended Scope of Analysis
for
Endangered Species Evaluation
Asama Coldwater Manufacturing Plant -- Foundry Expansion Project

March 1, 2007

Purpose of analysis:

The analysis is intended to determine whether the emissions from the proposed expansion to the Asama Coldwater Manufacturing (ACM) Plant may affect federally listed threatened and endangered species in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 USC 1531 et seq) (Act). This scope of analysis, or roadmap, incorporates USEPA's ecological risk assessment process to address the decision points in section 7 of the Act. Portions of the USEPA's draft Screening Level Ecological Risk Assessment (SLERA) Protocol for Hazardous Waste Combustion Facilities (EPA 530-D-99-001A) provide guidance for this analysis. Although this guidance was developed to assess the impact of hazardous waste combustion facilities on the environment, it offers general approaches that may be helpful for assessing the fate of chemicals released to the air from various types of industrial facilities.

Overall, the evaluation should focus on only those emissions from the proposed expansion at the facility. To complete this analysis an understanding of the background concentrations and deposition patterns is needed. The anticipated emissions from permitted, but not yet operational, facilities other than ACM should be included in background. The anticipated concentration in air or deposition at sites that have the potential for supporting listed species should be compared against no observed adverse effects level (NOAEL) benchmarks thought to be protective of the appropriate group (e.g., threatened and endangered species). The evaluation should look at the incremental addition in the context of background concentrations.

Benchmarks:

For these analyses, commonly accepted NOAEL benchmarks should be used. Where more than one appropriate benchmark can be found the more protective value should be used, unless an explanation is given to justify a less protective benchmark. When there is no commonly accepted benchmark, there should be a search of the scientific literature for relevant toxicity information to provide a basis for risk assessment for the species of concern. For the Indiana bat, the USEPA Region 5's, Resource Conservation and Recovery Act Ecological Screening Levels (http://www.epa.gov/RCRIS-Region-5/ca/ESL.pdf and the USEPA Ecological Soil Screening Levels (http://www.epa.gov/ecotox/ecossl) for mammalian insectivores may be used to determine benchmarks.

Modeling protocol:

Modeling should follow the general guidance provided in Chapter 3 of USEPA's SLERA protocol for assessing chemical fate and transport. The modeling should show air concentrations and, where appropriate, deposition for the types of air pollutants evaluated. The air emissions resulting from the project should be modeled at the facility level, not on a unit basis. Total impacts should be evaluated looking at the combined effects of the vapor phase, particle phase and particle-bound phase of pollutants. ISCST3 or AERMOD are acceptable models for this analysis. For chemicals amenable to deposition (i.e., chemicals with a lower vapor pressure than benzene), models in the SLERA guidance should be used to estimate concentrations in soil, sediment and surface water in conjunction with relevant fate and transport parameters. Those compounds with high vapor pressures that do not readily partition to particle deposition will be excluded from the analysis. This analysis should use the "Fv" values found in the SLERA guidance document. "Fv" values representing the fraction of the air concentration in the vapor phase for compounds of potential concern are presented in Appendix A-2. "Fv" values are unitless numbers that are calculated using the compound specific vapor pressure, solubility, and melting point.

Assessment Area:

A specific assessment area has not been identified for this project. The U.S. FWS has identified the listed species that may be present in the area, and the analysis for the initial ecological screening will assume that each species is exposed to the highest concentration in air, soil, water, and ingested plant tissue for each pollutant.

Background Levels:

Background levels of pollutants of concern should be located for soil, water and sediment. If actual values cannot be located, representative values may be used.

Suite of pollutants to consider:

The assessment should cover criteria pollutants and hazardous air pollutants (HAP) of potential interest for this proposed project. The HAPs emitted from this proposed project are the following:

Acetyldehyde
Benzene
o-Cresol
Ethyl Benzene
Hexane
1-Methylnapthalene
2-Methylnapthalene
Napthalene
Phenol
Styrene
Toluene
m,p-Xylenes
o-Xylene
Lead
Manganese

Types of impact to consider:

1. Short term: depending on the pollutant the investigation should compare worst 1-hr, 8-hr, and 24-hr concentrations in air with appropriate benchmarks for acute effects. For the Indiana bat, Copperbelly watersnake and the Mitchell's Satyr butterfly, the investigation should determine the impacts to food sources that may have taken up contaminants through soil, water and sediment, direct deposition on plants and plant tissue concentrations. To estimate the exposure to the Mitchell's Satyr butterfly, assume the amount deposited to plant surfaces is equal to 50% of the soil deposition value and add that number to an estimate for plant tissue concentrations of the contaminant resulting from root uptake.
2. Long term: depending upon the pollutant, the investigation should compare the worst 1-yr of 5 concentration in air or deposition on soil with appropriate benchmarks for chronic effects.
3. For compounds that may accumulate, the investigation should evaluate estimated total deposition over the life of the project. These concentrations should be compared against benchmarks.

Listed Species:

The following are the listed threatened and endangered species which may be present in the action area based on proximity to known occurrences and presence of suitable habitat:

1. Indiana Bat (*Myotis sodalis*): In Michigan, summering Indiana bats roost in trees in riparian, bottomland, and upland forests from approximately April 15 to September 15. Indiana bats may summer in a wide range of habitats, from highly altered landscapes to intact forests. Roost trees are typically found in patches of forests of varying size and shape, but have also been found in pastures, hog lots, fence rows, and residential yards. Indiana bats area often found in palustrine forested wetlands with an open understory.

2. Copperbelly Water Snake (*Nerodia erythrogaster neglecta*): Habitat for this species consists of bottomland forest, scrub/shrub and emergent wetlands, and the uplands around them (Conant 1949; Kingsbury 1996; Roe 2002; Herbert 2003; Roe et al. 2003, 2004). Although the species is a water snake, a substantial amount (1/4-1/3) of its time is spent away from water in the terrestrial forested part of its habitat..

3. Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*): Although this species' habitat requirements are not yet fully understood, this butterfly appears to be restricted to calcareous wetlands that range along a continuum from open fen, wet prairie, prairie fen, and sedge meadow to shrub-carr and tamarack savanna

Literature Search:

Conduct a literature search for the issues related to the effects of air pollutants on the listed species, on species within the same genus, and on species within the same family. For the copperbelly water snake, a search of "RATL: A Database of Reptile and Amphibian Toxicology Literature" developed by the Canadian Wildlife should be adequate (http://dsp-psd.communication.gc.ca/Collection/CW69-5-357E.pdf). If a search of this document does not provide benchmarks for the pollutants of concern, project impacts should be compared to U.S. EPA's aquatic life criteria (http://www.epa.gov/waterscience/criteria/aqlife.html). With respect to root uptake of contaminants, search for studies on the toxicity of heavy metals to plants to locate exposure concentrations and data on tissue concentration. Document the databases, search terms, and results. The source of all factual statements should be clearly indicated.

APPENDIX B

EMISSION RATE SUMMARY AND PARAMETERS USED IN DEPOSITION MODELING

Source: Table 12.10-9. Particle Size Distribution Data and Emission Factors for Gray Iron Foundries - CUPOLA FURNACE

Lower Range of Diam	Upper Range of Diam	Dmm	Cumulative Mass %	Fraction of Mass in Range
15.0	30.0	23.304	100.0%	0.00
10.0	15.0	12.664	95.0%	0.05
5.0	10.0	7.768	94.9%	0.00
2.5	5.0	3.884	94.9%	0.00
2.0	2.5	2.259	94.2%	0.01
1.0	2.0	1.554	91.5%	0.03
0.5	1.0	0.777	83.4%	0.08
0.0	0.5	0.315		0.83
			Total	1.00

2.5 or less
0.999

					diam/2 a	3/a b	c	b x c	
Particle Size		**Mass Percents and Mean Diameter**			**Surface Area Weighting (Particle Bound Modeling)**				
Lower Range of Diam (um)	**Upper Range of Diam (um)**	**Cumulative Mass % <= Lower Diam (Baghouse or ESP) (%)**	**Mass % Within Size Range (%)**	**Mean Diameter (um)**	**Mean Particle Radius (um)**	**Surface Area / Volume $(um)^{-1}$**	**Fraction of Total Mass**	**Proportion Available Surface Area**	**Fraction of Total Surface Area**
15.0	30.0	100.0%	0.0%	23.304	11.65	0.257	0.000	0.0000	0.0000
10.0	15.0	95.0%	5.0%	12.664	6.33	0.474	0.050	0.0237	0.0014
5.0	10.0	94.9%	0.1%	7.768	3.88	0.772	0.001	0.0008	0.0000
2.5	6.0	94.9%	0.0%	4.478	2.24	1.340	0.000	0.000	0.0000
2.0	2.5	94.2%	0.7%	2.259	1.13	2.656	0.007	0.019	0.0011
1.0	1.3	91.5%	2.7%	1.130	0.56	5.312	0.027	0.143	0.0086
0.5	1.0	83.4%	8.1%	0.777	0.39	7.724	0.081	0.626	0.0375
0.0	0.5		83.4%	0.315	0.16	19.049	0.834	15.887	0.9514
TOTAL		**----**	100.0%	**----**	**----**	**----**	**1.000**	16.70	1.00

Table 1. Modeling Results for Manganese (Mn)

Year	1-hour				8-hour				24-hour				Annual			
	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$
2002	1.75373	0.23828	1.75373	0.01080	1.77822	0.91893	1.79343	0.00771	2.18296	1.20446	2.20304	0.00557	7.12302	32.3898	34.63102	0.00061
2003	1.81397	0.19276	1.81397	0.01045	2.31832	0.84265	2.31832	0.00762	2.32182	1.32258	2.32183	0.00441	8.3827	27.00953	29.22033	0.00044
2004	2.46104	0.21132	2.46104	0.01048	2.54769	0.69702	2.5477	0.00642	2.54933	1.11411	2.54933	0.00442	8.75463	31.41746	33.38078	0.00058
2005	1.40279	0.22698	1.40279	0.01059	1.74254	0.93442	1.74394	0.00658	1.74254	1.65821	1.75458	0.00427	8.58203	25.8249	26.64958	0.00042
2006	3.53388	0.20628	3.53388	0.01066	3.53388	0.96852	3.53388	0.00742	3.53393	1.75931	3.53412	0.00392	9.75844	24.97492	27.81139	0.00043

Table 2. Modeling Results for Lead (Pb)

Year	1-hour				8-hour				24-hour				Annual			
	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$	Wet Deposition Dydw $\mathrm{ug/m^2}$	Dry Deposition Dydp $\mathrm{ug/m^2}$	Total Deposition Dydt $\mathrm{ug/m^2}$	Air Concentration Cyp $\mathrm{ug/m^3}$
2002	4.23443	0.57534	4.23443	0.02609	4.29356	2.21878	4.33028	0.01862	5.27083	2.90821	5.31931	0.01346	17.19874	78.20609	83.61766	0.00147
2003	4.37989	0.46543	4.37989	0.02523	5.59766	2.0346	5.59766	0.01840	5.60611	3.19341	5.60613	0.01066	20.24031	65.2153	70.55334	0.00107
2004	5.51596	0.18326	5.51596	0.01211	5.60934	1.02029	5.61033	0.00766	5.66899	1.49889	5.69296	0.00362	18.86028	33.39951	38.12216	0.00042
2005	3.38708	0.54805	3.38078	0.02558	4.2074	2.25618	4.21072	0.01588	4.2074	4.00379	4.23648	0.01031	20.72154	62.355	64.34622	0.00101
2006	8.53266	0.49806	8.53266	0.02574	8.53266	2.33852	8.53266	0.01790	8.53277	4.24791	8.53324	0.00947	23.56206	60.3027	67.15144	0.00105

APPENDIX C

MEDIA SPECIFIC CALCULATIONS AND SPREADSHEETS

Appendix C
Summary of Input Parameters

Soil Concentration Calculations for Lead and Manganese – Tables C-1 Lead and C-1 Manganese

SLERA utilizes six integrated equations to determine the potential soil concentration of the chemical of concern. The equations require inputs that are default numbers, site-specific numbers, and chemical specific numbers. The following is a list of default numbers utilized to generate the chemical specific potential soil concentration:

- BD – Soil bulk density 1.5 g/cm^3
- Vdv – Dry deposition velocity 3 m-g-s/cm-ug-yr
- Osw – Soil volumetric water constant 0.2 ml/cm^3
- R – Universal gas constant 0.00008205 atm-m^3/mol
- Ta – Ambient temperature 298 K
- Ps – Solids particle density 2.7 g/cm^3

The following is a list of site specific numbers used to calculate the chemical specific potential soil concentration and the basis for the number:

- Zs – Soil mixing zone depth 20 cm – SLERA's recommended number for tilted soil
- RO – Average annual surface runoff 25.4 cm/yr – Water Atlas of the United States, 1973.
- P – Average annual precipitation 76.2 cm/yr – Water Atlas of the United States, 1973.
- I – Average annual irrigation __ cm/yr
- Ev – Average annual evapotranspiration 63.5 cm/yr – Water Atlas of the United States, 1973.
- TD – Time 50 yr – Based on the expected lifetime of the manufacturing facility

The following is a list of chemical specific numbers used to calculate the potential soil concentration and the basis for that number

- Q – Chemical of Potential Concern (COPC) specific emission rate – modeling
    - Pb – 0.00113 g/s
    - Mn – 0.000468 g/s
- Fv – Fraction of COPC air concentration in vapor phase – SLERA Appendix A-2
    - Pb – 0.0 unitless
    - Mn – 0.0 unitless
- Cyv – Unitized yearly average air concentration from vapor phase – modeling
    - Pb – 0.0 ug-s/g-m^3
    - Mn – 0.0 ug-s/g-m^3
- Dywv – Unitized yearly average wet deposition from vapor phase – modeling
    - Pb – 0.0 s/m^2-yr
    - Mn – 0.0 s/m^2-yr
- Dydp – Unitized yearly average dry deposition from particle phase – modeling
    - Pb – 0.0692089 s/m^2-yr
    - Mn – 0.0692090 s/m^2-yr
- Dywp – Unitized yearly average wet deposition from particle phase – modeling
    - Pb – 0.0208514 s/m^2-yr
    - Mn – 0.0208510 s/m^2-yr
- ksg – degradation – SLERA Appendix A-2

    - Pb – 0 1/yr
    - Mn – 0 1/yr
- Kds – Soil-water partition coefficient SLERA Appendix A-2
    - Pb – 900 cm^3/g
    - Mn – 900 cm^3/g
- Da – Diffusivity of COPC in air – SLERA Appendix A-2
    - Pb – 0.0543 cm^2/s
    - Mn – 0.1330 cm^2/s
- H – Henry's Law constant – SLERA Appendix A-2
    - Pb – 0 atm-m^3/mol
    - Mn – 0 atm-m^3/mol

Water Deposition Calculations and Surface Water Concentrations for Lead and Manganese – Tables C-2 & C-3 Lead and C-2 & C-3 Manganese

SLERA utilizes eighteen integrated equations to determine the potential surface-water concentration of the chemical of concern. The equations require inputs that are default numbers, site-specific numbers, and chemical specific numbers. The following is a list of additional default numbers utilized to generate the chemical specific potential surface water concentration (terms utilized in previous equations were not repeated):

- Cd – Drag coefficient 0.0011 unitless
- W – Average annual wind speed 3.9 m/s
- Pa – density of air corresponding to water temperature 0.0012 g/cm^3
- Pw – density of water corresponding to water temperature 1 g/cm^3
- k – von Karman's constant 0.4
- lz – Dimensionless viscous sublayer thickness 4 unitless
- ua – Viscosity of air g/cm-s
- dbs – Depth of upper benthic sediment layer 0.03 m
- BS – Benthic solid concentration 1.0 g/cm^3
- Obs – Bed sediment porosity 0.6 L-water/L-sediment
- Twk – Water body temperature 298 K
- b – Empirical slope coefficient 0.125 unitless
- RF – USLE rainfall (or erosivity) factor 0.36 yr^{-1}
- K – USLE erodibility factor 0.36 ton/acre
- LS – USLE length-slope factor 1.5 unitless
- C – USLE cover management factor 0.1 unitless
- PF – USLE supporting practice factor 1.0 unitless

The following is a list of site specific numbers used to calculate the chemical specific potential surface water concentration and the basis for the number (terms utilized in previous equations were not repeated):

- Aw – Water body surface area 360,000 m^2 – Estimated off of aerial photos of the modeling limits
- Ai – Impervious watershed area receiving COPC deposition 2,250,000 m^2 – Estimated off of aerial photos of the modeling limits
- Al – Total watershed area receiving COPC deposition 36,000,000 m^2 – Estimated off of aerial photos of the modeling limits
- ER – Soil enrichment ratio 1 unitless – SLERA Appendix B

- TSS – Total Suspended Solids 10 mg/L – SLERA Appendix B
- Vfx – Average volumetric flow rate through water body 170700 m^3/yr – MDEQ Land and Water Management Division File No. 3169
- dwc – Depth of the water column 1 m – Based on visual observations north of ACM

The following is a list of chemical specific numbers used to calculate the potential surface water concentration and the basis for that number (terms utilized in previous equations were not repeated):

- Dywwv – Unitized yearly (waterbody and watershed) average wet deposition from vapor phase – modeling
  - Pb – 0.0 s/m^2-yr
  - Mn – 0.0 s/m^2-yr
- Dwtwp – Unitized yearly (waterbody and watershed) average total (wet and dry) deposition from particle phase – modeling
  - Pb – 0.073998 s/m^2-yr
  - Mn – 0.073996 s/m^2-yr
- Dw – Diffusivity of COPC in water – SLERA Appendix A-2
  - Pb – 0.00000628 cm^2/s
  - Mn – 0.00001523 cm^2/s
- Kdsw – Suspended sediment / surface water partition coefficient – SLERA Appendix A-2
  - Pb – 900 L/kg
  - Mn – 900 L/kg

Sediment Concentration Calculations for Lead and Manganese – Tables C-4 Lead and C-4 Manganese

SLERA utilized one equation that is based off of terms that have been previously defined and calculated.

Plant Concentration Calculations for Lead and Manganese – Tables C-5 Lead and C-5 Manganese

SLERA utilizes three integrated equations to determine the potential plant concentration of the chemical of concern. The equations require inputs that are default numbers, site-specific numbers, and chemical specific numbers. The following is a list of additional default numbers utilized to generate the chemical specific potential plant concentration (terms utilized in previous equations were not repeated):

- Rp – Interception fraction of the edible portion of plant 0.5 – SLERA Appendix B
- Fw – Fraction of COPC wet deposition that adheres to plant surfaces 0.6 – SLERA Appendix B
- Kp – Plant surface loss coefficient 18/yr – SLERA Appendix B
- Tp – Length of plant exposure to deposition per harvest of edible portion of plant 0.12 yr – SLERA Appendix B
- Yp – Yield or standing crop biomass of edible portion of the plant (productivity) 0.24 kg DW/m^2 – SLERA Appendix B

The following is a list of chemical specific numbers used to calculate the potential plant concentration and the basis for that number (terms utilized in previous equations were not repeated):

- Bv – Air-to-plant biotransfer factor – SLERA Appendix C
    - Pb – 0.0 unitless
    - Mn – 0.0 unitless
- BCFr – Plant-soil biotransfer factor – SLERA and ERD-AG-003 p. 5
    - Pb – 0.045 unitless
    - Mn – 0.05 unitless

http://ims.rsgis.msu.edu/
Maps for determining surface water area, impervious surface area
A 6 kilometer by 6 kilometer grid was used for the air modeling therefore the same grid was utilized for determining the surface water area and the impervious surface area
Surface water area 2% or 720,000 meters squared
Impervious surface area 25% or 9,000,000 meters squared

Assumptions
Time 50 years for annual
Average Volumetric Flow Through 11.46 cfm
Depth of water column 1 meter

TABLE C - 1 LEAD
SOIL CONCENTRATION CALCULATIONS FOR LEAD

0.016569	Cs	COPC concentration in soil (mg COPC / kg soil)						
		Cs = {Ds * [1-exp(-ks*tD)]}/ks						
0.000339	Ds	Depositional term (mg/kg-yr)	100	100	Units conversion factor ((m^2-mg)/(cm^2-kg))			
		Ds = [(100 * Q) / (Zs * BD)] * [Fv * (0.31536 * Vdv * Cyv + Dywv) + (Dywp + Dydp) * (1 - Fv)]	0.00113	Q	COPC specific emission rate (g/s)			
			20	Zs	Soil mixing zone depth (cm) Appendix B p. B-4			
			1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-4			
			0.0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appenidx A-2			
			0.31536	0.31536	Units conversion factor ((m-g-s)/(cm-ug-yr))			
			3	Vdv	Dry Deposition Velocity (cm/s) Appendix B p. B-5			
			0	Cyv	Unitized yearly average air concentration from vapor phase (ug-s/g-m^3)			
			0	Dywv	Unitized yearly average wet deposition from vapor phase (s/m^2 year)			
			0.0692089	Dydp	Unitized yearly average dry deposition from particle phase (s/m^2 year)			
			0.0208514	Dywp	Unitized yearly average wet deposition from particle phase (s/m^2 year)			
0.00	ks	COPC soil loss constant due to all processes (1/yr)	0	ksg	degradation (1/yr) Appendix A-2			
Most conservative ks = 0		ks = ksg + kse + ksr + ksl + ksv	0	kse	erosion (1/yr) Appendix B p. B-11			
			0.000941	ksr	runoff (1/yr)	25.4	RO	Average annual surface runoff cm/yr [1]
			Most conservative ksr = 0		krs = (RO/(Osw*Zs))*(1/(1+(Kds*BD/Osw)))	0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-21
						20	Zs	Soil mixing zone depth (cm) Appendix B p. B-21
						900	Kds	Soil-water partition coefficient (cm^3/g) Appendix A-2
						1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-22
			0	ksl	leaching (1/yr)	76.2	P	Average annual precipitation (cm/yr) [2]
			Most conservative ksl = 0		ksl = (P+I-RO-Ev)/(Osw*Zs*(1.0+(BD*Kds/Osw)))		I	Average annual irrigation (cm/yr)
						25.4	RO	Average annual surface runoff (cm/yr) [1]
						63.5	Ev	Average annual evapotranspiration (cm/yr) [3]
						0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-27
						20	Zs	Soil mixing zone depth (cm) Appendix B p. B-27
						900	Kds	Soil-water partition coefficient (cm^3/g) Appendix A-2
						1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-28
			0	ksv	volatilization (1/yr)	31,536,000	31,536,000	Unit conversion factor (s/yr)
			Most conservative ksv = 0		ksv = ((31536000*H)/(Zs*Kds*R*Ta*BD))*(Da/Zs)*(1-(BD/Ps)-Osw)	0	H	Henry's Law constant (atm-m^3/mol) Appendix A-2
						20	Zs	Soil mixing zone depth (cm) Appendix B p. B-32
						900	Kds	Soil-water partition coefficient (cm^3/g) Appendix A-2
						0.00008205	R	Universal gas constant atm-m^3/mol-K Appendix B p. B-32
						298	Ta	Ambient air temperature (K) Appendix B p. B-32
						1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-33
						0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-34
						2.7	Ps	Solids particle density (g/cm^3) Appendix B p. B-33
						0.0543	Da	Diffusivity of COPC in air (cm^2/s) Appendix A-2
50	tD	Total time period over which deposition occurs (yr)	50	tD	Time (yr) Appendix B p. B-3			

References

[1]	RO	Plate 21 Surface-Water Runoff, Water Atlas of the United States, 1973	10 inches =25.4 cm
[2]	P	Plate 3 Precipitation by State, Water Atlas of the United States, 1973	30 inches = 76.2 cm
[3]	Ev	Plate 13 Potential Evapotranspiration, Water Atlas of the Unites States. 1973	25 inches = 63.5 cm

TABLE C-2 LEAD
WATER DEPOSITION CALCULATIONS FOR LEAD

188.2279	Lt	Total COPC load to the water body (including deposition, runoff and erosion) (g/yr)
		Lt = Ldep+Ldif+Lri+Lr+Le

30.10239	Ldep	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)	0.00113	Q	COPC emission rate (g/s)
		Ldep =Q*(Fv*Dywwv+(1-Fv)*Dytwp)*Aw	0.0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appendix A-2
			0	Dywwv	Unitized yearly (water body and watershed) average wet depostion from vapor phase (s/m^2-yr)
			0.073998	Dytwp	Unitized yearly (water body and watershed) average total (wet and dry) deposition from particle phase (s/m^2-yr)
			360000	Aw	Water body surface area (m^2)

0	Ldif	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)	0	Kv	Overall COPC transfer rate coefficient (m/yr)
		Ldiff = (Kv*Q*Fv*Cywv*Aw*1*10^-6)/(H/(R*Twk))	0.00113	Q	COPC emission rate (g/s)
			0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appendix A-2
			0	Cywv	Unitized yearly (water body and watershed) average air concentration from vapor phase (ug-s/g-m^3)
			360000	Aw	Water body surface area (m^2)
			0.000001	0.000001	Units conversion factor (g/ug) Appendix B p. B-44
			0.0	H	Henry's Law constant (atm-m^3/mol) Appendix A-2
			0.00008205	R	Universal gas constant (atm-m^3/mol-K) Appendix B p. B-46
			298	Twk	Water body temperature (K) Appendix B p. B-46

0	Kv	Overall COPC transfer rate coefficient (m/yr)	131.4397894	Kl	Liquid-phase transfer coefficient (m/yr) (lakes)
		Kv = ((Kl^-1+(Kg*(H/(R*Twk)))^-1)^-1)*(Tc^(Twk-293))	380110.65	Kg	Gas-phase transfer coefficient (m/yr) (lakes)
			0.0	H	Henry's Law constant (atm-m^3/mol) Appendix A-2
			0.0000821	R	Universal gas constant (atm-m^3/mol-K) Appendix B p. B-88
			298	Twk	Water body temperature Appendix B p. B-88
			1.026	Tc	Temperature correction factor Appendix B p. B-88

131.4397894	Kl	Liquid-phase transfer coefficient (m/yr) (lakes)	0.00000628	Dw	Diffusivity of COPC in water (cm^2/s) Appendix A-2
		Kl = ((Cd^0.5)*W)*((Pa/Pw)^0.5)*((k^0.33)/lz)*((uw/(Pw*Dw))^-0.67)*(3.1536*10^7)	0.0011	Cd	Drag coefficient (unitless) Appendix B p. B-92
			3.9	W	Average annual wind speed (m/s) Appendix B p. B-92
			0.0012	Pa	Denisty of air corresponding to water temperature (g/cm^3) Appendix B p. B-93
			1	Pw	Denisty of water corresponding to water temperature (g/cm^3) Appendix B p. B-93
			0.4	k	von Karman's constant Appendix B p. B-93
			4	lz	Dimensionless viscous sublayer thickness (unitless) Appendix B p. B-93
			0.0169	uw	Viscosity of water corresponding to water temperature (g/cm-s) Appendix B p. B-93

380110.65	Kg	Gas-phase transfer coefficient (m/yr) (lakes)	0.0011	Cd	Drag coefficient (unitless) Appendix B p. B-96
		Kg = ((Cd^0.5)*W)*((k^0.33)/lz)*((ua/(Pa*Da))^-0.67)*(3.1536*10^7)	3.9	W	Average annual wind speed (m/s) Appendix B p. B-96
			0.4	k	von Karman's constant Appendix B p. B-96
			4	lz	Dimensionless viscous sublayer thickness (unitless) Appendix B p. B-96
			0.000181	ua	Viscosity of air (g/cm-s) Appendix B p. B-97
			0.0012	Pa	Density of air (g/cm^3) Appendix B p. B-97
			0.0543	Da	Diffusivity of COPC in air (cm^2/s) Appendix A-2

0	Lri	Runoff load from impervious surface (g/yr)	0.00113	Q	COPC emission rate (g/s)
		Lri = Q*(Fv*Dywwv*(1-Fv)*Dytwp)*Ai	0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appendix A-2
			0	Dywwv	Unitized yearly average wet deposition from vapor phase (over watershed) (s/m^2-yr)
			0.073998	Dytwp	Unitized yearly average wet total (wet and dry) deposition from particle phase (over watershed) (s/m^2-yr)
			2250000	Ai	Impervious watershed area receiving COPC deposition (m^2)

TABLE C-2 LEAD
WATER DEPOSITION CALCULATIONS FOR LEAD

157.7934	Lr	Runoff load from pervious surface (g/yr)	25.4	RO	Average annual surface runoff (cm/yr)
		Lr = RO*(Al-Ai)*((Cs*BD)/(Osw+Kds*BD))*0.01	36000000	Al	Total watershed area receiving COPC deposition (m^2)
			2250000	Ai	Impervious watershed area receiving COPC deposition (m^2)
			0.016568686	Cs	COPC concentration in soil (mg/kg) (soil table)
			1.5	BD	Soil bulk density (g/cm^3) Appendix B p. B-53
			0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-53
			900	Kds	Soil-water partitioning coefficient (cm^3/g) Appendix A 2
			0.01	0.01	Units conversion factor (kg-cm^2/mg-m^2) Appendix B p. B-53

0.332198	Le	Soil erosion load (g/yr)	0.004357692	Xe	Unit soil loss (kg/m^2-yr)	0.36	RF	USLE rainfall (or erosivity) factor (yr^-1)
					Xe = RF*K*LS*C*PF*(907.18/4047)	0.36	K	USLE erodibility factor (ton/acre) Appendix B p. B-63 if site specific is not available the default value is 0.36
						1.5	LS	USLE length-slppe factor (unitless) Appendix B p. B-63 if site specific is not available the default value is 1.5
						0.1	C	USLE cover management factor (unitless) Appendix B p. B-64 if site specific is not available the default value is based on landuse (0.1, 0.7, or 1.0)
						1.0	PF	USLE supporting practice factor (unitless) Appendix B p. B-64 if site specific is not available the default value is 1.0
						907.18	907.18	Unit conversion factor (kg/ton)
						4047	4047	Unit conversion factor (m^2/acre)
		Le = Xe*(Al-Ai)*SD*ER*((Cs*Kds*BD)/(Osw+Kds*BD))*0.001	36000000	Al	Total watershed area receiving COPC deposition (m^2)			
			2250000	Ai	Impervious watershed area receiving COPC deposition (m^2)			
			0.136346324	SD	Watershed sediment delivery ratio (unitless)	1.2	a	Empirical intercept coefficient (unitless) 0.6 to 2.1 depending on watershed area Appendix B p. B-68
					SD = a*(Al^-b)	36000000	Al	Watershed area receiving COPC deposition (m^2)
						0.125	b	Empirical slope coefficient (unitless) Appendix B p. B-69
			1	ER	Soil enrichment ratio (unitless) 1 Inorganics or 3 for Organics			
			0.016568686	Cs	COPC concentration in soil (mg/kg) (soil table)			
			900	Kds	Soil-water partitioning coefficient (cm^3/g) Appendix A 2			
			1.5	BD	Soil bulk density (g/cm^3) Appendix B p. B-59			
			0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-59			
			0.001	0.001	Units conversion factor (g/mg) Appendix B p. B-59			

References

[1]	RO	Plate 21 Surface-Water Runoff, Water Atlas of the United States, 1973	10 inches =25.4 cm
[2]	dwc	Based on visual observation of creek to the north of ACM	1 m

TABLE C-3 LEAD
SURFACE WATER CONCENTRATION CALCULATIONS FOR LEAD

0.0276936	Cwtot	Total water body COPC concentration (including water column and bed sediments) (g COPC/m^3 water body)
		Cwtot = Lt/(Vfx*fwc+kwt*Aw*(dwc+dbs))
188.22794	Lt	Total COPC load to the water body (including deposition, runoff and erosion) (g/yr) from Water(Lt) spreadsheet
170700	Vfx	Average volumetric flow rate through water body (m^3/yr)
0.963999	fbs	Fraction of total water body COPC concentration in the benthinic sediment (unitless)
0.036001	fwc	Fraction of total water body COPC concentration in the water column (unitless)
		fwc = ((1+Kdsw*TSS*10^-6)*(dwc/dz))/(((1+Kdsw*TSS*10^-6)*(dwc/dz))+((Obs+Kdbs*BS)*(dbs/dz)))
0.0017569	kwt	Overall total water body COPC dissipation rate constant (yr^-1)

900	Kdsw	Suspended sediments/surface water partition coefficient (L/kg) Appendix A-2
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-76
0.000001	10^-6	Units conversion factor (kg/mg)
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of the upper benthic sediment layer (m) Appendix B p. B-77
1.03	dz	Total water body depth (m) (dwc+dbs) Appendix B p. B-77
1.0	BS	Benthic solid concentration (g/cm^3 equivalent to kg/L) Appendix B p. B-77
0.6	Obs	Bed sediment porosity (Lwater/Lsediment) Appendix B p. B-78
900	Kdbs	Bed sediment/sediment pore water partition coefficient (L/kg) Appendix A-2
0.036001	fwc	Fraction of total water body COPC concentration in the water column (unitless)
0	kv	Water column volatilization rate constant (yr^-1)
		kv = Kv/(dz*(1+Kdsw*TSS*10^-6))

0	Kv	Overall COPC transfer rate coefficient (m/yr) from Water(Lt) sheet
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of the upper benthic sediment layer (m) Appendix B p. B-83
1.03	dz	Total water body depth (m) (dwc+dbs) Appendix B p. B-84
900	Kdsw	Suspended sediments/surface water partition coefficient (L/kg) Appendix A-2
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-84
0.000001	10^-6	Units conversion factor (kg/mg)

TABLE C-3 LEAD
SURFACE WATER CONCENTRATION CALCULATIONS FOR LEAD

		kwt = fwc*kv+fbs*kb
360000	Aw	Water body surface area (m^2)
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of upper benthic sediment layer (m) Appendix B p. B-73

0.963999	fbs	Fraction of total water body COPC concentration in the benthinic sediment (unitless)
0.0018225	kb	Benthic burial rate constant (yr^-1)
		kb = ((Xe*Al*SD*10^3-Vfx*TSS)/(Aw*TSS))*((TSS*10^-6)/(BS*dbs))

0.00435769	Xe	Unit soil loss (kg/m^2-yr) from Water(Lt) sheet
36000000	Al	Total watershed area receiving deposition (m^2)
0.13634632	SD	Sediment delivery ratio (unitless) from Water(Lt) sheet
1,000	10^3	Units conversion factor (g/kg) Appendix B p. B-100
170700	Vfx	Average volumetric flow rate through water body (m^3/yr)
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-101
360000	Aw	Water body surface area (m^2)
0.000001	1*10^-6	Units conversion factor (kg/mg) Appendix B p. B-101
1.0	BS	Benthic solid concentration (g/cm^3 equivalent to kg/L) Appendix B p. B-101
0.03	dbs	Depth of the upper benthic sediment layer (m) Appendix B p. B-102

0.0010269	Cwctot	Total COPC concentration in water column (mg COPC/L water column
		Cwctot = fwc*Cwtot*((dwc+dbs)/dwc)
0.036001	fwc	Fraction of total water body COPC concentration in the water column (unitless)
0.0276936	Cwtot	Total water body COPC concentration (including water column and bed sediments) (g COPC/m^3 water body)
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of upper benthic sediment layer (m) Appendix B p. B-106

0.0010177	Cdw	Dissolved phase water concentration (mg/L)
		Cdw = Cwctot/(1+Kdsw*TSS*10^-6)
0.000001	10^-6	Units conversion factor (kg/mg)
0.0010269	Cwctot	Total COPC concentration in water column (mg COPC/L water column
900	Kdsw	Suspended sediments/surface water partition coefficient (L/kg) Appendix A-2
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-109

TABLE C-4 LEAD
SEDIMENT CONCENTRATION CALCULATIONS FOR LEAD

0.915972	Csed	COPC concentration in bed sediment (mg/kg)
		Csed = fbs*Cwtot*(Kdbs/(Obs+Kdbs*BS))*((dwc+dbs)/dbs)
0.963999	fbs	Fraction of total water body COPC concentration in the benthinic sediment (unitless)
0.027694	Cwtot	Total water body COPC concentration (including water column and bed sediments) (g COPC/m^3 water body)
900	Kdbs	Bed sediment/sediment pore water partition coefficient (L/kg) Appendix A-2
0.6	Obs	Bed sediment porosity (Lwater/Lsediment) Appendix B p. B-112
1.0	BS	Benthic solid concentration (g/cm^3 equivalent to kg/L) Appendix B p. B-113
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of upper benthic sediment layer (m) Appendix B p. B-113

TABLE C-5 LEAD
PLANT CONCENTRATION CALCULATIONS FOR LEAD

0.002269	Pd	Plant concentration due to direct deposition (mg/kg WW)
		Pd = (1000*Q*(1-Fv)*(Dydp+(Fw*Dywp))*Rp*(1.0-EXP(-kp*Tp))*0.12)/(Yp*Kp)
1000	1000	Units conversion factor mg/g App. B-116
0.00113	Q	COPC-specific emission rate g/s
0	Fv	Fraction of COPC air concentration in vapor phase (unitless)
0.069209	Dydp	Unitized yearly average dry depostion from particle phase (s/m^2-yr)
0.5	Rp	Interception fraction of the edible portion of plant App B-117
0.6	Fw	Fraction of COPC wet deposition that adheres to plant surfaces (unitless) App B-118
0.020851	Dywp	Unitized yearly average wet depostion from particle phase (s/m^2-yr)
18	kp	Plant surface loss coefficient (1/yr) App B-119
0.12	Tp	Length of plant exposure to deposition per harvest of edible portion of plant (yr) App B-120
0.12	0.12	Dry weight to wet weight conversion factor (unitless) App B-120
0.24	Yp	Yield or standing crop biomass of edible portion of the plant (productivity) (kg DW/m^2) App B-121

0	Pv	Plant concentration due to air-to-plant transfer (mg/kg WW (equivalent to ug/g)
		Pv = Q*Fv*0.12*((Cyv*Bv)*(pa))
0.00113	Q	COPC-specific emission rate g/s
0	Fv	Fraction of COPC air concentration in vapor phase (unitless)
0	Cyv	Unitized yearly ait concentration from vapor phase (ug-s/g-m^3)
0	Bv	Air-to-plant biotransfer factor (unitless (ug/g plant tissue DW / ug/g air)) Appendix C p C-97
0.12	0.12	Dry weight to wet weight conversion factor (unitless)
0.0012	pa	Denisty of Air (g/m^3)

8.95E-05	Pr	Plant concentration due to root uptake (mg/kg WW)
		Pr = CS*BCFr*0.12
0.016569	Cs	COPC concentration in soil (mg/kg)
0.12	0.12	Dry weight to wet weight conversion factor (unitless)
0.045	BCFr	Plant-soil biotransfer factor (unitless (mg/kg plant DW / mg/kg soil) Appendix C p C-34

0.002359	Pt	Plant concentration due to all processes (mg/kg WW)
		Pt = Pd+Pv+Pr
0.002269	Pd	Plant concentration due to direct deposition (mg/kg WW)
0	Pv	Plant concentration due to air-to-plant transfer (mg/kg WW (equivalent to ug/g)
8.95E-05	Pr	Plant concentration due to root uptake (mg/kg WW)

TABLE C-1 MANGANESE
SOIL CONCENTRATION CALCULATIONS FOR MANGANESE

0.006862	Cs	COPC concentration in soil (mg COPC / kg soil)						
		Cs = {Ds * [1-exp(-ks*tD)]}/ks						
0.00014	Ds	Depositional term (mg/kg-yr)	100	100	Units conversion factor ((m^2-mg)/(cm^2-kg))			
		Ds = [(100 * Q) / (Zs * BD)] * [Fv * (0.31536 * Vdv * Cyv + Dywv) + (Dywp + Dydp) * (1 - Fv)]	0.000468	Q	COPC specific emission rate (g/s)			
			20	Zs	Soil mixing zone depth (cm) Appendix B p. B-4			
			1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-4			
			0.0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appendix A-2			
			0.31536	0.31536	Units conversion factor ((m-g-s)/(cm-ug-yr))			
			3	Vdv	Dry Deposition Velocity (cm/s) Appendix B p. B-5			
			0	Cyv	Unitized yearly average air concentration from vapor phase (ug-s/g-m^3)			
			0	Dywv	Unitized yearly average wet deposition from vapor phase (s/m^2 year)			
			0.0692090	Dydp	Unitized yearly average dry deposition from particle phase (s/m^2 year)			
			0.0208510	Dywp	Unitized yearly average wet deposition from particle phase (s/m^2 year)			
0.00	ks	COPC soil loss constant due to all processes (1/yr)	0	ksg	degradation (1/yr) Appendix A-2			
Most conservative ks = 0		ks = ksg + kse + ksr + ksl + ksv	0	kse	erosion (1/yr) Appendix B p. B-11			
			0.000941	ksr	runoff (1/yr)	25.4	RO	Average annual surface runoff cm/yr [1]
			Most conservative ksr = 0		krs = (RO/(Osw*Zs))*(1/(1+(Kds*BD/Osw)))	0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-21
						20	Zs	Soil mixing zone depth (cm) Appendix B p. B-21
						900	Kds	Soil-water partition coefficient (cm^3/g) Appendix A-2
						1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-22
			0	ksl	leaching (1/yr)	76.2	P	Average annual precipitation (cm/yr) [2]
			Most conservative ksl = 0		ksl = (P+I-RO-Ev)/(Osw*Zs*(1.0+(BD*Kds/Osw)))		I	Average annual irrigation (cm/yr)
						25.4	RO	Average annual surface runoff (cm/yr) [1]
						63.5	Ev	Average annual evapotranspiration (cm/yr) [3]
						0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-27
						20	Zs	Soil mixing zone depth (cm) Appendix B p. B-27
						900	Kds	Soil-water partition coefficient (cm^3/g) Appendix A-2
						1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-28
			0	ksv	volatilization (1/yr)	31,536,000	31,536,000	Unit conversion factor (s/yr)
			Most conservative ksv = 0		ksv = ((31536000*H)/(Zs*Kds*R*Ta*BD))*(Da/Zs)*(1-(BD/Ps)-Osw)	0	H	Henry's Law constant (atm-m^3/mol) Appendix A-2
						20	Zs	Soil mixing zone depth (cm) Appendix B p. B-32
						900	Kds	Soil-water partition coefficient (cm^3/g) Appendix A-2
						0.00008205	R	Universal gas constant atm-m^3/mol-K Appendix B p. B-32
						298	Ta	Ambient air temperature (K) Appendix B p. B-32
						1.5	BD	Soil bulk density (g/cm^3 soil) Appendix B p. B-33
						0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-34
						2.7	Ps	Solids particle density (g/cm^3) Appendix B p. B-33
						0.1330	Da	Diffusivity of COPC in air (cm^2/s) Appendix A-2
50	tD	Total time period over which deposition occurs (yr)	50	tD	Time (yr) Appendix B p. B-3			

References

[1]	RO	Plate 21 Surface-Water Runoff, Water Atlas of the United States, 1973	10 inches =25.4 cm
[2]	P	Plate 3 Precipitation by State, Water Atlas of the United States, 1973	30 inches = 76.2 cm
[3]	Ev	Plate 13 Potential Evapotranspiration, Water Atlas of the Unites States. 1973	25 inches = 63.5 cm

TABLE C-2 MANGANESE
WATER DEPOSITION CALCULATIONS FOR MANGANESE

77.95581	Lt	Total COPC load to the water body (including deposition, runoff and erosion) (g/yr)
		Lt = Ldep+Ldif+Lri+Lr+Le

12.46685	Ldep	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
		Ldep =Q*(Fv*Dywwv+(1-Fv)*Dytwp)*Aw

0.000468	Q	COPC emission rate (g/s)
0.0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appendix A-2
0	Dywwv	Unitized yearly (water body and watershed) average wet depostion from vapor phase (s/m^2-yr)
0.073996	Dytwp	Unitized yearly (water body and watershed) average total (wet and dry) deposition from particle phase (s/m^2-yr)
360000	Aw	Water body surface area (m^2)

0	Ldif	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)
		Ldiff = (Kv*Q*Fv*Cywv*Aw*1*10^-6)/(H/(R*Twk))

0	Kv	Overall COPC transfer rate coefficient (m/yr)
		Kv = ((Kl^-1+(Kg*(H/(R*Twk)))^-1)^-1)*(Tc^(Twk-293))

237.95938	Kl	Liquid-phase transfer coefficient (m/yr) (lakes)
		Kl = ((Cd^0.5)*W)*((Pa/Pw)^0.5)*((k^0.33)/lz)*((uw/(Pw*Dw))^-0.67)*(3.1536*10^7)

0.00001523	Dw	Diffusivity of COPC in water (cm^2/s) Appendix A-2
0.0011	Cd	Drag coefficient (unitless) Appendix B p. B-92
3.9	W	Average annual wind speed (m/s) Appendix B p. B-92
0.0012	Pa	Denisty of air corresponding to water temperature (g/cm^3) Appendix B p. B-93
1	Pw	Denisty of water corresponding to water temperature (g/cm^3) Appendix B p. B-93
0.4	k	von Karman's constant Appendix B p. B-93
4	lz	Dimensionless viscous sublayer thickness (unitless) Appendix B p. B-93
0.0169	uw	Viscosity of water corresponding to water temperature (g/cm-s) Appendix B p. B-93

692712.258	Kg	Gas-phase transfer coefficient (m/yr) (lakes)
		Kg = ((Cd^0.5)*W)*((k^0.33)/lz)*((ua/(Pa*Da))^-0.67)*(3.1536*10^7)

0.0011	Cd	Drag coefficient (unitless) Appendix B p. B-96
3.9	W	Average annual wind speed (m/s) Appendix B p. B-96
0.4	k	von Karman's constant Appendix B p. B-96
4	lz	Dimensionless viscous sublayer thickness (unitless) Appendix B p. B-96
0.000181	ua	Viscosity of air (g/cm-s) Appendix B p. B-97
0.0012	Pa	Density of air (g/cm^3) Appendix B p. B-97
0.1330	Da	Diffusivity of COPC in air (cm^2/s) Appendix A-2

0.0	H	Henry's Law constant (atm-m^3/mol) Appendix A-2
0.00008205	R	Universal gas constant (atm-m^3/mol-K) Appendix B p. B-88
298	Twk	Water body temperature Appendix B p. B-88
1.026	Tc	Temperature correction factor Appendix B p. B-88

0.000468	Q	COPC emission rate (g/s)
0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appendix A-2
0	Cywv	Unitized yearly (water body and watershed) average air concentration from vapor phase (ug-s/g-m^3)
360000	Aw	Water body surface area (m^2)
0.000001	0.000001	Units conversion factor (g/ug) Appendix B p. B-44
0.0	H	Henry's Law constant (atm-m^3/mol) Appendix A-2
0.00008205	R	Universal gas constant (atm-m^3/mol-K) Appendix B p. B-46
298	Twk	Water body temperature (K) Appendix B p. B-46

TABLE C-2 MANGANESE
WATER DEPOSITION CALCULATIONS FOR MANGANESE

0	Lri	Runoff load from impervious surface (g/yr)	0.000468	Q	COPC emission rate (g/s)			
		Lri = Q*(Fv*Dywwv*(1-Fv)*Dytwp)*Ai	0	Fv	Fraction of COPC air concentration in vapor phase (unitless) Appendix A-2			
			0	Dywwv	Unitized yearly average wet deposition from vapor phase (over watershed) (s/m^2-yr)			
			0.073998	Dytwp	Unitized yearly average wet total (wet and dry) deposition from particle phase (over watershed) (s/m^2-yr)			
			2250000	Ai	Impervious watershed area receiving COPC deposition (m^2)			
65.35138	Lr	Runoff load from pervious surface (g/yr)	25.4	RO	Average annual surface runoff (cm/yr)			
		Lr = RO*(Al-Ai)*((Cs*BD)/(Osw+Kds*BD))*0.01	36000000	Al	Total watershed area receiving COPC deposition (m^2)			
			2250000	Ai	Impervious watershed area receiving COPC deposition (m^2)			
			0.00686205	Cs	COPC concentration in soil (mg/kg) (soil table)			
			1.5	BD	Soil bulk density (g/cm^3) Appendix B p. B-53			
			0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-53			
			900	Kds	Soil-water partitioning coefficient (cm^3/g) Appendix A 2			
			0.01	0.01	Units conversion factor (kg-cm^2/mg-m^2) Appendix B p. B-53			
0.137583	Le	Soil erosion load (g/yr)	0.00435769	Xe	Unit soil loss (kg/m^2-yr)	0.36	RF	USLE rainfall (or erosivity) factor (yr^-1)
		Le = Xe*(Al-Ai)*SD*ER*((Cs*Kds*BD)/(Osw+Kds*BD))*0.001			Xe = RF*K*LS*C*PF*(907.18/4047)	0.36	K	USLE erodibility factor (ton/acre) Appendix B p. B-63 if site specific is not available the default value is 0.36
						1.5	LS	USLE length-slppe factor (unitless) Appendix B p. B-63 if site specific is not available the default value is 1.5
						0.1	C	USLE cover management factor (unitless) Appendix B p. B-64 if site specific is not available the default value is based on landuse (0.1, 0.7, or 1.0)
						1.0	PF	USLE supporting practice factor (unitless) Appendix B p. B-64 if site specific is not available the default value is 1.0
						907.18	907.18	Unit conversion factor (kg/ton)
						4047	4047	Unit conversion factor (m^2/acre)
			36000000	Al	Total watershed area receiving COPC deposition (m^2)			
			2250000	Ai	Impervious watershed area receiving COPC deposition (m^2)			
			0.13634632	SD	Watershed sediment delivery ratio (unitless)	1.2	a	Empirical intercept coefficient (unitless) 0.6 to 2.1 depending on watershed area Appendix B p. B-68
					SD = a*(Al^-b)	36000000	Al	Watershed area receiving COPC deposition (m^2)
						0.125	b	Empirical slope coefficient (unitless) Appendix B p. B-69
			1	ER	Soil enrichment ratio (unitless) 1 Inorganics or 3 for Organics			
			0.00686205	Cs	COPC concentration in soil (mg/kg) (soil table)			
			900	Kds	Soil-water partitioning coefficient (cm^3/g) Appendix A 2			
			1.5	BD	Soil bulk density (g/cm^3) Appendix B p. B-59			
			0.2	Osw	Soil volumetric water content (mL/cm^3) Appendix B p. B-59			
			0.001	0.001	Units conversion factor (g/mg) Appendix B p. B-59			

References

[1]	RO	Plate 21 Surface-Water Runoff, Water Atlas of the United States, 1973	10 inches =25.4 cm
[2]	dwc	Based on visual observation of creek to the north of ACM	1 m

TABLE C-3 MANGANESE
SURFACE WATER CONCENTRATION CALCULATIONS FOR MANGANESE

0.0114695	Cwtot	Total water body COPC concentration (including water column and bed sediments) (g COPC/m^3 water body)
		Cwtot = Lt/(Vfx*fwc+kwt*Aw*(dwc+dbs))
77.955809	Lt	Total COPC load to the water body (including deposition, runoff and erosion) (g/yr) from Water(Lt) spreadsheet
170700	Vfx	Average volumetric flow rate through water body (m^3/yr)
0.963999	fbs	Fraction of total water body COPC concentration in the benthinic sediment (unitless)
0.036001	fwc	Fraction of total water body COPC concentration in the water column (unitless)
		fwc = ((1+Kdsw*TSS*10^-6)*(dwc/dz))/(((1+Kdsw*TSS*10^-6)*(dwc/dz))+((Obs+Kdbs*BS)*(dbs/dz)))
0.0017569	kwt	Overall total water body COPC dissipation rate constant (yr^-1)

900	Kdsw	Suspended sediments/surface water partition coefficient (L/kg) Appendix A-2
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-76
0.000001	10^-6	Units conversion factor (kg/mg)
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of the upper benthic sediment layer (m) Appendix B p. B-77
1.03	dz	Total water body depth (m) (dwc+dbs) Appendix B p. B-77
1.0	BS	Benthic solid concentration (g/cm^3 equivalent to kg/L) Appendix B p. B-77
0.6	Obs	Bed sediment porosity (Lwater/Lsediment) Appendix B p. B-78
900	Kdbs	Bed sediment/sediment pore water partition coefficient (L/kg) Appendix A-2
0.036001	fwc	Fraction of total water body COPC concentration in the water column (unitless)
0	kv	Water column volatilization rate constant (yr^-1)
		kv = Kv/(dz*(1+Kdsw*TSS*10^-6))

0	Kv	Overall COPC transfer rate coefficient (m/yr) from Water(Lt) sheet
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of the upper benthic sediment layer (m) Appendix B p. B-83
1.03	dz	Total water body depth (m) (dwc+dbs) Appendix B p. B-84
900	Kdsw	Suspended sediments/surface water partition coefficient (L/kg) Appendix A-2
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-84
0.000001	10^-6	Units conversion factor (kg/mg)

TABLE C-3 MANGANESE
SURFACE WATER CONCENTRATION CALCULATIONS FOR MANGANESE

kwt = fwc*kv+fbs*kb

0.963999	fbs	Fraction of total water body COPC concentration in the benthinic sediment (unitless)
0.00182246	kb	Benthic burial rate constant (yr^-1)

kb = ((Xe*Al*SD*10^3-Vfx*TSS)/(Aw*TSS))*((TSS*10^-6)/(BS*dbs))

0.0043577	Xe	Unit soil loss (kg/m^2-yr) from Water(Lt) sheet
36000000	Al	Total watershed area receiving deposition (m^2)
0.1363463	SD	Sediment delivery ratio (unitless) from Water(Lt) sheet
1,000	10^3	Units conversion factor (g/kg) Appendix B p. B-100
170700	Vfx	Average volumetric flow rate through water body (m^3/yr)
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-101
360000	Aw	Water body surface area (m^2)
0.000001	1*10^-6	Units conversion factor (kg/mg) Appendix B p. B-101
1.0	BS	Benthic solid concentration (g/cm^3 equivalent to kg/L) Appendix B p. B-101
0.03	dbs	Depth of the upper benthic sediment layer (m) Appendix B p. B-102

360000	Aw	Water body surface area (m^2)
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of upper benthic sediment layer (m) Appendix B p. B-73

0.0004253	Cwctot	Total COPC concentration in water column (mg COPC/L water column
		Cwctot = fwc*Cwtot*((dwc+dbs)/dwc)
0.036001	fwc	Fraction of total water body COPC concentration in the water column (unitless)
0.0114695	Cwtot	Total water body COPC concentration (including water column and bed sediments) (g COPC/m^3 water body)
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of upper benthic sediment layer (m) Appendix B p. B-106

0.0004215	Cdw	Dissolved phase water concentration (mg/L)
		Cdw = Cwctot/(1+Kdsw*TSS*10^-6)
0.000001	10^-6	Units conversion factor (kg/mg)
0.0004253	Cwctot	Total COPC concentration in water column (mg COPC/L water column
900	Kdsw	Suspended sediments/surface water partition coefficient (L/kg) Appendix A-2
10	TSS	Total suspended solids concentration (mg/L) if no data is available a default value of 10 can be used Appendix B p. B-109

TABLE C-4 MANGANESE
SEDIMENT CONCENTRATION CALCULATIONS FOR MANGANESE

0.379356	Csed	COPC concentration in bed sediment (mg/kg)
		Csed = fbs*Cwtot*(Kdbs/(Obs+Kdbs*BS))*((dwc+dbs)/dbs)
0.963999	fbs	Fraction of total water body COPC concentration in the benthinic sediment (unitless)
0.011469	Cwtot	Total water body COPC concentration (including water column and bed sediments) (g COPC/m^3 water body)
900	Kdbs	Bed sediment/sediment pore water partition coefficient (L/kg) Appendix A-2
0.6	Obs	Bed sediment porosity (Lwater/Lsediment) Appendix B p. B-112
1.0	BS	Benthic solid concentration (g/cm^3 equivalent to kg/L) Appendix B p. B-113
1	dwc	Depth of the water column (m)
0.03	dbs	Depth of upper benthic sediment layer (m) Appendix B p. B-113

TABLE C-5 MANGANESE
PLANT CONCENTRATION CALCULATIONS FOR MANGANESE

0.00093984	Pd	Plant concentration due to direct deposition (mg/kg WW)
		Pd = (1000*Q*(1-Fv)*(Dydp+(Fw*Dywp))*Rp*(1.0-EXP(-kp*Tp))*0.12)/(Yp*Kp)
1000	1000	Units conversion factor mg/g App. B-116
0.000468	Q	COPC-specific emission rate g/s
0	Fv	Fraction of COPC air concentration in vapor phase (unitless)
0.069209	Dydp	Unitized yearly average dry depostion from particle phase (s/m^2-yr)
0.5	Rp	Interception fraction of the edible portion of plant App B-117
0.6	Fw	Fraction of COPC wet deposition that adheres to plant surfaces (unitless) App B-118
0.020851	Dywp	Unitized yearly average wet depostion from particle phase (s/m^2-yr)
18	kp	Plant surface loss coefficient (1/yr) App B-119
0.12	Tp	Length of plant exposure to deposition per harvest of edible portion of plant (yr) App B-120
0.12	0.12	Dry weight to wet weight conversion factor (unitless) App B-120
0.24	Yp	Yield or standing crop biomass of edible portion of the plant (productivity) (kg DW/m^2) App B-121

0	Pv	Plant concentration due to air-to-plant transfer (mg/kg WW (equivalent to ug/g)
		Pv = Q*Fv*0.12*((Cyv*Bv)*(pa))
0.000468	Q	COPC-specific emission rate g/s
0	Fv	Fraction of COPC air concentration in vapor phase (unitless)
0	Cyv	Unitized yearly ait concentration from vapor phase (ug-s/g-m^3)
0	Bv	Air-to-plant biotransfer factor (unitless (ug/g plant tissue DW / ug/g air)) Appendic C p 97 based all metals are zero
0.12	0.12	Dry weight to wet weight conversion factor (unitless)
0.0012	pa	Denisty of Air (g/m^3)

0.0000412	Pr	Plant concentration due to root uptake (mg/kg WW)
		Pr = CS*BCFr*0.12
0.00686205	Cs	COPC concentration in soil (mg/kg)
0.12	0.12	Dry weight to wet weight conversion factor (unitless)
0.05	BCFr	Plant-soil biotransfer factor (unitless (mg/kg plant DW / mg/kg soil) ERD-AG-003 p 5

0.00098101	Pt	Plant concentration due to all processes (mg/kg WW)
		Pt = Pd+Pv+Pr
0.00093984	Pd	Plant concentration due to direct deposition (mg/kg WW)
0	Pv	Plant concentration due to air-to-plant transfer (mg/kg WW (equivalent to ug/g)
0.0000412	Pr	Plant concentration due to root uptake (mg/kg WW)

APPENDIX D

SUMMARY OF ECOLOGICAL ASSESSMENT RESULTS

APPENDIX D - SELECTED BENCHMARK ECOLOGICAL SCREENING LEVELS

Worst Case, long-term concentrations accumulation over 50 years.						**Selected Comparison Benchmark Screening Levels**							
Chemical	**Modeled Maximum Air Concentration 24-hr. Avg. Time (ug/m3)**	**Modeled Soil Concentration (ug/kg)**	**Modeled Surface Water Concentration (ug/L)**	**Modeled Sediment Concentration (ug/kg)**	**Modeled Plant Concentration (ug/kg wet weight)**	**Air (ug/m3)**	**Est. Hazard Quotient Air**	**Water (ug/L)**	**Est. Hazard Quotient Water**	**Sediment (ug/kg)**	**Est. Hazard Quotient Sediment**	**Soil (ug/kg)**	**Est. Hazard Quotient Soil**
Lead	0.0056	16.6	1.0	916	2.4	1.5 [4]	0.0037	1.17 [1] 10 [3]	0.85	35800 [1]	0.026	53.7 [1] 11,000 [2]	0.3
									0.10				0.002
Manganese	0.13	6.9	0.4	380	0.98	50 [5]	0.0026	1,900 [3]	0.008	NA		220,000 [2]	3.1E-05

[1] US EPA Region 5, RCRA Ecological Screening Levels
[2] Lowest value identified as US EPA Ecological Soil Screening levels (ug/kg dry weight in soil) see table below
[3] MDEQ Rule 57 risk based water quality criteria protective of aquatic life, wildlife, and human health
[4] NESHAP for lead
[5] Michigan Department of Environmental Quality, Air Quality Division's air toxics ITSL

	US EPA Ecological Soil Screening levels (ug/kg dry weight in soil)			
Chemical	**Plants**	**Soil Invertebrates**	**Avian wildlife**	**Mammalian wildlife**
Lead	120,000	1,700,000	11,000	56,000
Manganese	220,000	450,000	4,300,000	4,000,000

Chemical	CAS No.	Air mg/m³	Water ug/l	Sediment[s] ug/kg	Soil[v] ug/kg
Hexachlorocyclopentadiene	77-47-4		77[b]	901	755
Hexachloroethane	67-72-1		**8**[a, z]	**584**[z]	596
Hexachlorophene	70-30-4		0.228[e]	2.31 e+5	199
Hexachloropropene	1888-71-7		-----	-----	
Hexanone [2-]	591-78-6	105	**99**[h, z]	**58.2**[z]	1.26 e+4
Indeno (1,2,3-cd) pyrene	193-39-5		4.31[b]	200[t]	1.09 e+5
Isobutyl alcohol	78-83-1	32.8	-----	-----	2.08 e+4[w]
Isodrin	465-73-6		3.09 e-2[e]	55.2	3.32[x]
Isophorone	78-59-1		**920**[d]	**432**	1.39 e+5
Isosafrole	120-58-1			-----	9940
Kepone	143-50-0		0.132[e]	3.31	32.7
Lead (Total)	7439-92-1		**1.17**[j, k, z]	**3.58 e+4**[u]	53.7
Mercury (Total)	7439-97-6		1.3 e-3[a]	174[r]	100[y]
Methacrylonitrile	126-98-7	3.38		-----	57[w]
Methane [bis(2-chloroethoxy)]	111-91-1		-----	-----	302[w]
Methapyrilene	91-80-5			-----	2780[w]
Methoxychlor	72-43-5		**0.019**[h]	**13.6**	19.9
Methyl bromide	74-83-9	26.5	**16**[d]	**1.37**	235[w]
Methyl chloride	74-87-3	2.63		-----	1.04 e+4[w]
Methyl ethyl ketone	78-93-3	642	**2200**[a, z]	**42.4**[z]	8.96 e+4[w]

Ecological Soil Screening Levels for Lead

Interim Final

OSWER Directive 9285.7-70

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

March 2005

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1.0 INTRODUCTION

Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs for wildlife are derived to be protective of the representative of the conservative end of the distribution in order to make estimates for local populations. The Eco-SSLs are conservative and are intended to be applied at the screening stage of an ecological risk assessment. These screening levels should be used to identify the contaminants of potential concern (COPCs) that require further evaluation in the site-specific baseline ecological risk assessment that is completed according to specific guidance (U.S. EPA, 1997, 1998, and 1999). The Eco-SSLs are not designed to be used as cleanup levels and United States (U.S.) Environmental Protection Agency (EPA) emphasizes that it would be inappropriate to adopt or modify these Eco-SSLs as cleanup standards.

The detailed procedures used to derive Eco-SSL values are described in separate documentation (U.S. EPA, 2003). The derivation procedures represent the collaborative effort of a multi-stakeholder team consisting of federal, state, consulting, industry, and academic participants led by the U.S. EPA, Office of Solid Waste and Emergency Response.

This document provides the Eco-SSL values for lead and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying lead concentrations in soil that may present an unacceptable ecological risk to terrestrial receptors. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances of the site. EPA may change this guidance in the future, as appropriate. EPA and state personnel may use and accept other technically sound approaches, either on their own initiative, or at the suggestion of potentially responsible parties, or other interested parties. Therefore, interested parties are free to raise questions and objections about the substance of this document and the appropriateness of the application of this document to a particular situation. EPA welcomes public comments on this document at any time and may consider such comments in future revisions of this document.

2.0 SUMMARY OF ECO-SSLs FOR LEAD

Lead is a naturally occurring element which can be found in all environmental media: air, soil, sediment, and water. The extent of occurrence of lead in the earth's crust is about 15 g/ton, or 0.002%. Lead occurs chiefly as a sulfide in galena. Other lead minerals include anglesite ($PbSO_4$), cerussite ($PbCO_3$), mimetite ($PbCl_2 \bullet 3Pb_3(AsO_4)_2$), and pyromorphite [$PbCl_2 \bullet 3Pb_3(PO_4)_2$)] (Budavari, 1996). Lead is released to the environment from coal-fired power plants, ceramic manufacturing, mining, ore processing, smelting of lead ores, refining, the production and use of lead alloys and compounds, recycling, combustion processes, industrial processes, and from disposal. Lead may also be deposited on land as slag, dust, sludge, and water treatment residues from manufacturing and waste treatment processes (NRCC, 1978, U.S. EPA, 1979).

Lead in soil is relatively immobile and persistent whether added to the soil as halides, hydroxides, oxides, carbonates, or sulfates (U.S. EPA, 1979). When released to soil, lead is normally converted from soluble lead compounds to relatively insoluble sulfate or phosphate derivatives. It also forms complexes with organic matter and clay minerals which limits its mobility. The efficient fixation of lead in soils limits the transfer of lead to aquatic systems. However, leaching of lead can be relatively rapid from some soils, especially at highly contaminated sites or landfills (Kayser et al., 1982). Lead is most available from acidic sandy soils which contain little material capable of binding lead (NRCC, 1978). Concentrations of lead in soil solution reach a minimum between pH 5 and 6 because metal-organic complexes form in this pH range. Only a small fraction of lead in lead-contaminated soil appears to be in water-soluble form (0.2-1%) (http://toxnet.nlm.nih.gov). The uptake of lead by plants also depends on other factors including cation exchange capacity, soil composition (e.g., organic matter content, calcium content), metal concentrations, precipitation, light, and temperature. Lead uptake by plants is favored at lower pH values and in soils with low organic carbon content (DeMayo et al, 1982).

Lead may also be found in soils as stable organic compounds or metallic lead or lead alloys from the use of lead shot or fishing weights. The Eco-SSLs are derived for the inorganic forms of lead found in soils and are not derived for either organic lead compounds or metallic lead shot. If these waste sources are suspected to be present or are present, then a site-specific evaluation of risks associated with these forms of lead will be required outside of the use of the Eco-SSL values.

Lead is not considered to be an essential element for plant growth and development. Lead inhibits growth, reduces photosynthesis (by inhibiting enzymes unique to photosynthesis), interferes with cell division and respiration, reduces water absorption and transpiration, accelerates abscission or defoliation and pigmentation, and reduces chlorophyll and ATP synthesis (U.S. EPA, 1979).

Lead is also not considered an essential element for birds or mammals. Clinical signs of lead toxicity in domestic animals are manifested differently for different species, but the overall signs are of encephalopathy preceded and accompanied by gastrointestinal malfunction (Booth and MacDonald, 1982). Behavorial signs of poisoning include anxiety, apprehension, hyperexcitability, vocalization, rolling of eyes, apparent fear or terror, possible belligerence, pressing of the head against a wall or post, attempts to climb a wall, sudden jumping into the air, frenzied or manical behavior (Booth and MacDonald, 1982). Locomotor disturbances of lead poisoning range from a stiff, stilted gait with ataxia and incoordination to rigidity of all postural muscles, swaying, and posterior weakness to compulsive hypermotility (circling, pacing, running). (Booth and MacDonald, 1982).

Lead can interfere with the synthesis of heme, thereby altering the urinary or blood concentration of enzymes and intermediates in heme synthesis or their derivatives. Thus, lead poisoning can lead to accumulation of non-heme iron and protoporphyrin-IX in red cells, an increase in delta-aminolevulinic acid (ALA) in blood and urine, an increase in urinary coproporphyrin, proporphyrin, and porphobilinogen, inhibition of blood ALA-dehydratase (ALA-D), and an increased proportion of immature red cells in the blood (reticulocytes and basophilic stippled cells (NIOSH, 1978). One of the characteristic cellular metabolic reactions in lead intoxication is the formation of intranuclear inclusion bodies, a discrete, dense-staining mass found in the liver parenchyma and in the tubular lining cells of the kidney (Clayton and Clayton, 1994). The intranuclear inclusion bodies are a lead protein complex that may have adaptive function in excessive lead exposure (NIOSH, 1978). Other signs of lead poisoning in domestic animals include rapid labored breathing, anorexia, weight loss, decreased milk production, dehydration, emaciation, fetal death with either resorption or abortion of the fetus, general weakness (Booth and MacDonald, 1982), paraplegia (WHO, 1977), mortality and impaired postnatal growth (Rattner et al., 1975), reduced pregnancy rate (Kennedy et al., 1975), and interference with resistance to infectious disease (Gainer, 1974) (http://toxnet.nlm.nih.gov).

The Eco-SSL values derived to date for lead are summarized in Table 2.1.

Table 2.1 Lead Eco-SSLs (mg/kg dry weight in soil)

Plants	Soil Invertebrates	Wildlife	
		Avian	Mammalian
120	1,700	11	56

Eco-SSL values for lead were derived for all receptor groups. The Eco-SSLs range from 11 mg/kg dry weight (dw) for avian wildlife to 1,700 mg/kg dw for soil invertebrates. The Eco-SSL values for lead for plants, soil invertebrates, and mammalian wildlife are higher than the 95th percentiles of reported background concentrations for both eastern and western U.S. soils (Figure 2.1) (at 38 and 32 mg/kg, respectively. The Eco-SSL value for lead for avian wildlife is, however, lower than the 50th percentile for reported background concentrations in eastern and western U.S. soils (Figure 2.1). Background concentrations reported for many metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003).

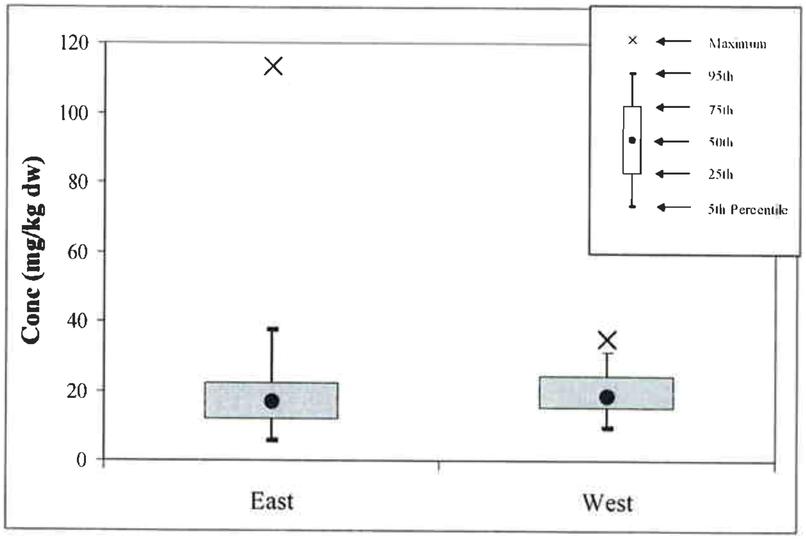

Figure 2.1 Typical Background Concentrations of Lead in U.S. Soils

Ecological Soil Screening Levels for Manganese

Interim Final

OSWER Directive 9285.7-71

**U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460**

April 2007

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1.0 INTRODUCTION

Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with and/or consume biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs are derived to be protective of the conservative end of the exposure and effects species distribution, and are intended to be applied at the screening stage of an ecological risk assessment. These screening levels should be used to identify the contaminants of potential concern (COPCs) that require further evaluation in the site-specific baseline ecological risk assessment that is completed according to specific guidance (U.S. EPA, 1997, 1998, and 1999). The Eco-SSLs are not designed to be used as cleanup levels and the United States (U.S.) Environmental Protection Agency (EPA) emphasizes that it would be inappropriate to adopt or modify the intended use of these Eco-SSLs as national cleanup standards.

The detailed procedures used to derive Eco-SSL values are described in separate documentation (U.S. EPA, 2003, 2005). The derivation procedures represent the collaborative effort of a multi-stakeholder group consisting of federal, state, consulting, industry, and academic participants led by what is now the U.S. EPA Office of Solid Waste and Emergency Response (OSWER).

This document provides the Eco-SSL values for manganese and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying manganese concentrations in soil that may present an unacceptable ecological risk to terrestrial receptors. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances of the site. EPA may change this guidance in the future, as appropriate. EPA and state personnel may use and accept other technically sound approaches, either on their own initiative, or at the suggestion of potentially responsible parties, or other interested parties. Therefore, interested parties are free to raise questions and objections about the substance of this document and the appropriateness of the application of this document to a particular situation. EPA welcomes public comments on this document at any time and may consider such comments in future revisions of this document.

2.0 SUMMARY OF ECO-SSLs FOR MANGANESE

Manganese is one of the most abundant trace elements in the lithosphere and is widely distributed in the environment in over 100 minerals, including various sulfides, oxides, carbonates, silicates, phosphates, and borates (ATSDR, 1998; HSDB). The most common manganese minerals include pyrolusite (manganese dioxide), romanechite, manganite (manganese (III) oxide), and hausmannite (manganese (II, III) oxide)(ATSDR, 1998; HSDB).

The principal uses of manganese are in the manufacturing of steel and alloys (ferromanganese and copper manganese)(Budvari,1996; HSDB). Manganese compounds may also be released to the environment through their use in batteries, electrical coils, ceramics, matches, glass, dyes, fertilizers (manganese sulfate), oxidizing agents, antiseptics (potassium permanganate), catalysts (manganous acetate), pesticides (potassium permanganate), pigments (manganese sulfate), antiknock agents (methylcyclopentadienyl manganese tricarbonyl), and as animal food additives (manganese sulfate, manganese carbonate). Other important anthropogenic sources of manganese include industrial emissions, combustion of fossil fuels, and landfills (Klaassen et al., 1995; Pisarczyk, 1995; Lewis, 1997; Reidies, 1990; Ashford, 1994; ATSDR, 1998; HSDB).

Manganese compounds are important soil constituents. In soils, redox reactions affect the sorption of manganese compounds which in turn have a considerable effect on soil properties such as cation exchange (Kabata-Pendias, 1992). Background concentrations reported for many metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003). Typical background concentrations of manganese in U.S. soils are plotted in Figure 2.1 for both eastern and western U.S. soils.

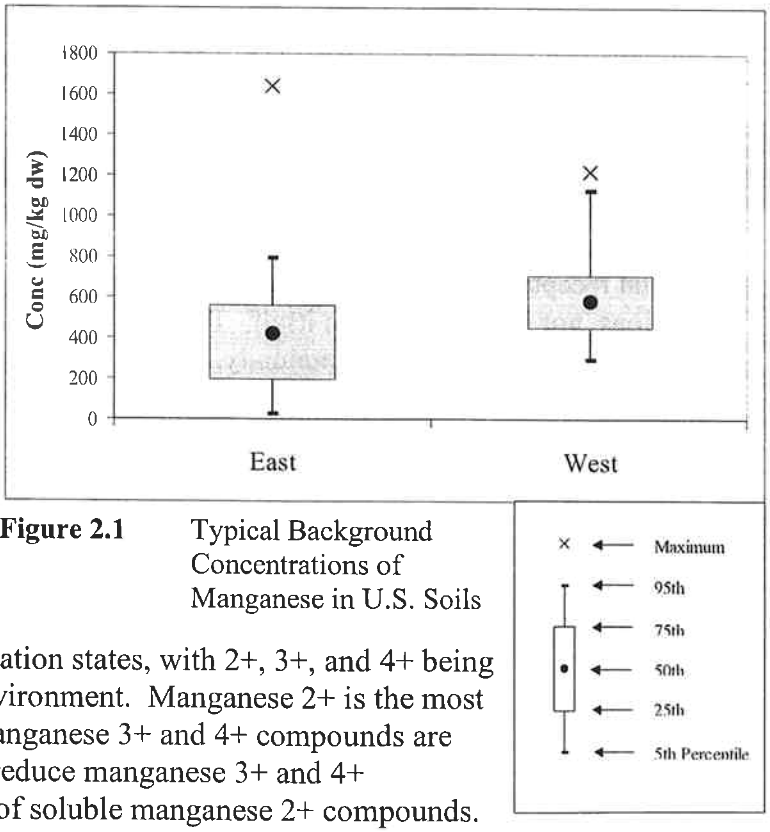


Figure 2.1 Typical Background Concentrations of Manganese in U.S. Soils

Manganese is multi-valent and can exist in the 2+, 3+, 4+, 6+, and 7+ oxidation states, with 2+, 3+, and 4+ being the dominant oxidation states in the environment. Manganese 2+ is the most stable oxidation state in water while manganese 3+ and 4+ compounds are immobile solids. Organic matter may reduce manganese 3+ and 4+ compounds, resulting in the formation of soluble manganese 2+ compounds. Insoluble manganese compounds are formed under aerobic conditions, and soluble compounds are formed under anaerobic conditions from reduction reactions by microorganisms. Soluble manganese compounds are relatively mobile and may leach into surface or ground water (Bodek et al. 1988; HSDB). Soluble manganese is released from soil through ion exchange when replaced by more strongly binding metals such as copper, zinc, or nickel (Bodek et al., 1988;

HSDB). Reducing soil pH and soil aeration increases the solubility of manganese in the soil (WHO 1981; HSDB). In soils, manganese is known to interact with a handful of other elements. Most prominently, manganese is observed to interfere with the availability of cobalt to plants from soils via a strong affinity of manganese oxides to native cobalt. Also, in acidic soils that contain a large amount of manganese, iron absorption by plants can be affected. Interactions also are known to occur between manganese and other heavy metals including cadmium, lead, zinc, and phosphorous (ATSDR, 1998; HSDB).

Manganese is an essential nutrient for both plants and animals. In animals, manganese is associated with growth, normal functioning of the central nervous system, and reproductive function. Specifically, manganese is associated with the formation of connective tissue and bone, carbohydrate and lipid metabolism, and embryonic development of the inner ear (WHO, 1981; HSDB). Manganese deficiency in animals is demonstrated by a reduced growth rate, skeletal abnormalities and abnormal reproductive function (NAP, 1980). Manganese nutritional requirements and typical concentrations in animal feed are discussed in Attachment 4-3 of the Eco-SSL guidance (U.S. EPA, 2003). High levels of manganese may produce neurotoxic responses such as hypoactivity, nervousness, tremors, and ataxia. Other reported effects include liver damage and decreased growth (Clayton and Clayton, 1981-82;1993-94; Venugopal and Luckey, 1978; HSDB).

Manganese is essential in plant nutrition for the oxidation-reduction process. Specifically, manganese participates in the oxygen-evolving system of photosynthesis and in the photosynthetic electron transport system. In the soluble form, manganese is easily taken up from soils by plants and is rapidly translocated throughout the plant. Manganese deficient plants exhibit decreased growth, interveinal chlorosis, necrotic spots on leaves, and browning of roots. Manganese toxicity is demonstrated in plants by iron chlorosis, leaf puckering, necrotic brown spots, and an uneven distribution of cholorphyll in older leaves (Kabata-Pendias, 1992).

The Eco-SSL values derived to date for manganese are summarized in Table 2.1.

Table 2.1 Manganese Eco-SSLs (mg/kg dry weight in soil)

Plants	Soil Invertebrates	Wildlife	
		Avian	Mammalian
220	450	4,300	4,000

Eco-SSL values were derived for all receptor groups. The Eco-SSL values for manganese range from 220 mg/kg dry weight (dw) for plants to 4,300 mg/kg dw for avian wildlife. The Eco-SSL for plants is less than the 5th percentile of reported background soil concentrations of manganese in western U.S. soils and less than the 50th percentile for eastern U.S. soils (Figure 2.1). The Eco-SSL for soil invertebrates is less than the 50th percentile for western U.S. soils and less than the 75th percentile for eastern U.S. soils (Figure 2.1). The Eco-SSLs for avian and mammalian wildlife are higher than reported range of background concentrations in both western and eastern U.S. soils.

Appendix D

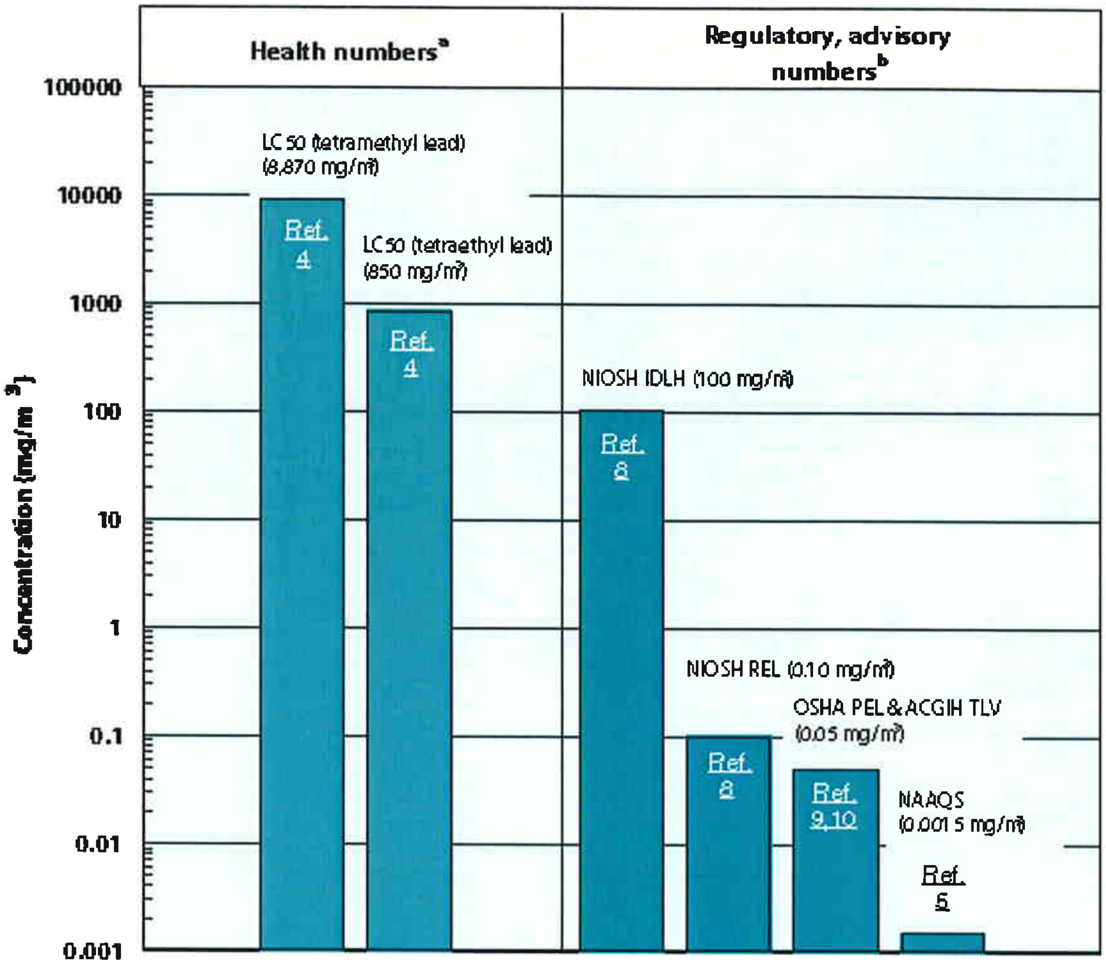
Rule 57 Water Quality Values
Surface Water Assessment Section
Michigan DEQ

NOTES:

All chemical specific values are in ug/L and expressed as total unless otherwise indicated
EXP = exponent in log base e
H = hardness (in mg/L)
ID = insufficient data to derive value
NLS = no literature search has been conducted
NA = not applicable
@ = Bioaccumulative Chemical of Concern
# = carcinogen
* = the lowest HNV, WV, HCV or FCV given for this chemical will
adequately protect the uses identified with "ID*"
CFa = acute conversion factor for cadmium = 1.136672-[(lnH)(0.04184)]
CFb = chronic conversion factor for cadmium = 1.101672-[(lnH)(0.04184)]
CFc = acute and chronic conversion factor for lead = 1.46203-[(lnH)(0.14571)]
D = value is expressed as dissolved
Modifications/additions to this spreadsheet compared to the previous one dated 6/9/05 are shaded

		HNV		HNV				HCV		HCV							
		Drink		Non-drink		WV		Drink		Non-drink		Final Chronic Value (FCV)			Final Acute Value (FAV)		
CAS #	PARAMETER NAME	Value	verif date	Value	verif date	Value	verif date	Value	verif date	Value	verif date	Value	@ hardness of 100	verif date	Value	@ hardness of 100	verif date
7439921	Lead	14	1200210	190	1200210	NA		NA		NA		(EXP(1.273*(LnH)-3.296))*CFc^{D}	1.0E+01	1199708	(EXP(1.273*(LnH)-1.1098))*CFc*2^{D}	1.8E+02	1199708
7439965	Manganese	3600	1199807	59000	1199807	NA		NA		NA		EXP(0.8784(lnH)+3.5199)	1.9E+03	1200110	EXP(0.8784(lnH)+4.9820)	8.3E+03	1200110

Lead



ACGIH TLV--American Conference of Governmental and Industrial Hygienists' threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.

LC_{50} (Lethal $Concentration_{50}$)--A calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.

NIOSH REL--National Institute of Occupational Safety and Health's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.

NIOSH IDLH -- NIOSH's immediately dangerous to life or health concentration; NIOSH recommended exposure limit to ensure that a worker can escape from an exposure condition that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from the environment.

NAAQS--National Ambient Air Quality Standard. NAAQS set by EPA for pollutants that are considered to be harmful to public health and the environment; the NAAQS for lead is 1.5 µg/m^3, maximum arithmetic mean averaged over a calendar quarter.

OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8-h workday or a 40-h workweek.

Michigan Air Toxics System
Initial Threshold Screening Level/Initial Risk Screening Level (ITSL/IRSL)
Toxics Screening Level Query Results

The results of your search are displayed below. Click any column heading to sort.
Click here to see descriptions of column headings.
If a number appears in the "notes" column for a given, chemical, see the definition on the bottom of this page.

It is possible to cut and paste the table below into a spreadsheet program for further manipulation.

Page **1** of **1** - **1** record(s) matched your criteria

CAS Number	Chemical Name	Notes	Status	ITSL (ug/m3)	Averaging Time	Second ITSL (ug/m3)	Second ITSL Avg Time	IRSL (ug/m3)	SRSL (ug/m3)	Carc Avg Time
7439965	manganese		FINAL	0.05	24 hr					

Back to Main Search Page

For issues related to ITSL/IRSL database content, contact Maggie Sadoff at sadoffm@michigan.gov or (517) 373-7046.

Michigan.gov Home | DEQ Home | Online Services | Permits | Programs | Site Map | Contact DEQ
State Web Sites | Privacy Policy | Link Policy | Accessibility Policy | Security Policy

ITSL/IRSL Field Descriptions	
CAS Number:	Chemical Abstracts Service number
Chemical Name:	Name of the chemical
Notes:	Special conditions which may apply to how screening levels are determined for specific chemicals. If a number appears in this column, see the bottom of the search results page for a description of what the number indicates.
Status:	Limits may be either Interim or Final
ITSL (ug/m3):	Initial Threshhold Screening Level - A concentration of toxic air contaminant in the ambient air which is used to evaluate noncarcinogenic health effects from a proposed new or modified process and which is calculated, for regulatory purposes, according to the procedure in R 336.1229(2).
Averaging Time:	Averaging period for the Initial Threshold Screening Level
Second ITSL (ug/m3):	Second Initial Threshold Screening Level
Second ITSL Avg Time:	Averaging period for the Second Initial Threshold Screening Level
IRSL (ug/m3):	Initial Risk Screening Level - the concentration of a possible, probable, or known human carcinogen in ambient air which has been calculated for regulatory purposes, according to the risk assessment procedures in R 336.1229(1), to produce an estimated upper-bound lifetime cancer risk of 1 in 1,000,000
SRSL (ug/m3):	Secondary Risk Screening Level - the concentration of a possible, probable, or known human carcinogen in ambient air which has been calculated for regulatory purposes, according to the risk assessment procedures in R 336.1229(1), to produce an estimated upper-bound lifetime cancer risk of 1 in 100,000
Carc Avg Time:	Averaging time period for the Initial Risk Screening Level and Secondary Risk Screening Level