ConocoPhillips

Wood River Refinery

P. O. Box 76

900 South Central Avenue
Roxana, Illinois 62084

April 17, 2007

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Ms. Rachel Rineheart
U.S. EPA Region 5
77 W Jackson Blvd, AR-18J
Chicago, IL 60604-3507

RE: Endangered Species Act Deposition Modeling Results and Discussion for CORE Project
WRB Refining – Wood River Refinery, Roxana, Illinois
Facility ID 119090AAA

Dear Ms. Rineheart:

ConocoPhillips Company (ConocoPhillips) operates the WRB Refining Wood River Refinery located in Roxana, Illinois. This facility has submitted a construction permit application for a Coker and Refinery Expansion (CORE) project and is currently awaiting issuance of the final construction permit from the Illinois Environmental Protection Agency (IEPA). As part of the construction permitting process for this project, ConocoPhillips is required to conduct an Endangered Species Act (ESA) Consultation for the emission increases related to the CORE project. Enclosed is the report summarizing the ESA impact analysis completed to evaluate potential impacts on endangered or threatened species from the CORE project. Please note that this report also addresses emission increases related to the CORE project from the ConocoPhillips Wood River Products Terminal in Hartford, Illinois.

The Wood River Refinery appreciates the U.S. EPA's timely review of the deposition modeling results and discussion for the ESA Consultation and issuance of a concurrence letter indicating that there is no impact on endangered or threatened species from the CORE project. If you have any questions or comments, please contact me at (618) 255-2418.

Sincerely,

David W. Dunn

David Dunn
Director, Environmental

Enclosures

cc: Mr. Michael Coffey, U.S. Fish & Wildlife Service
Mr. Jason Schnepp, IEPA

ENDANGERED SPECIES ACT DEPOSITION MODELING RESULTS AND DISCUSSION
WRB REFINING, LLC ▪ WOOD RIVER REFINERY
CONOCOPHILLIPS ▪ WOOD RIVER PRODUCTS TERMINAL

Prepared by:

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April 16, 2007

Project 072601.0006

Trinity Consultants

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EXECUTIVE SUMMARY

On March 17, 2006 the United States Environmental Protection Agency (USEPA) issued a brief to the Environmental Appeals Board stating that all permit applications triggering federal action, such as Prevention of Significant Deterioration (PSD), in delegated states (e.g., Illinois) are required to conduct an Endangered Species Act Consultation (ESA) if it is determined that there may be an effect on endangered or threatened species. Trinity Consultants, Inc. (Trinity) has prepared this ESA analysis in order to supplement the permit application for the Coker and Refinery Expansion (CORE) project. The purpose of this report is to provide the results of the deposition modeling and concentration calculations as well as an evaluation of the anticipated effect of the compounds of potential concern (COPCs) on endangered or threatened species of concern. Note that this analysis addresses possible impacts at both the WRB Refining, LLC Wood River Refinery and the ConocoPhillips Wood River Products Terminal.

For all metals, polycyclic aromatic hydrocarbons (PAH), and volatile hazardous air pollutants (volatile HAPs), the concentration from background and project increases are less than the ESL for each media or the concentration increase from the project at the fence line or appropriate target receptor is less than 1% of the background concentration. Similarly, total concentrations of sulfur dioxide and carbon monoxide from project increases plus background do not exceed the ESLs for those COPCs. Therefore, it has been determined that no impact to endangered or threatened species is likely to occur due to the emissions of these COPCs from the project. Also, while EPA has not yet provided the ozone analysis for this project, it is not anticipated that there will be an impact to endangered or threatened species based on the project being obligated to meet the non-attainment area volatile organic material (VOM) offset requirements for this COPC.

The one COPC that may be of concern based on emission increases from the CORE project is nitrogen oxides. As shown in the summary in Appendix F, the current representative urban area background concentration exceeds the ESL. Therefore, any increase in emissions related to the project added to the background number would also exceed the ESL. However, as stated previously in the emission rate discussion of this report, based on guidance from United States Fish and Wildlife Service (FWS), only project increases were taken in account during the initial deposition modeling and impact analysis. In reality, the overall emissions from the Wood River Refinery will decrease as a result of this project. This is due to the fact that the refinery will be installing additional oxides of nitrogen (NO_x) emission controls on two of its existing catalytic cracking units. This will reduce emissions from those currently operating units by 980.4 tons of NO_x per year. When taking into account the increases in NO_x emissions from new emission units as well as the decreases from the additional control on existing units, there will be an overall net decrease of 47.5 tons per year of NO_x emissions upon startup of the proposed equipment (not including contemporaneous emission changes). Therefore, it is not anticipated that NO_x emissions resulting from the CORE project will have an impact on endangered or threatened species.

1. INTRODUCTION

On March 17, 2006 the USEPA issued a brief to the Environmental Appeals Board stating that all permit applications triggering federal action, such as PSD, in delegated states (e.g., Illinois) are required to conduct an Endangered Species Act Consultation (ESA) if it is determined that there may be an effect on endangered or threatened species. The Wood River Refinery submitted an initial application to the Illinois Environmental Protection Agency (IEPA) on May 12, 2006 for a PSD and Nonattainment New Source Review (NANSR) permit at the Wood River Refinery in Roxana, Illinois.[1] In order to supplement the permit application for this project with the information required for the ESA Consultation, Trinity has performed deposition modeling and environmental media concentration calculations for a number of COPCs. The purpose of this report is to provide the results of the deposition modeling and concentration calculations as well as an evaluation of the anticipated effect of the COPCs on endangered or threatened species of concern. Note that this analysis addresses possible impacts at both the WRB Refining, LLC Wood River Refinery and the ConocoPhillips Wood River Products Terminal.

[1] This application was subsequently revised on October 17, 2006 and January 31, 2007. The application revisions included, in part, the incorporation of proposed modifications occurring at the ConocoPhillips Wood River Products Terminal in Hartford, Illinois as part of the PSD/NANSR project. A construction permit application for the proposed modifications at the Wood River Products Terminal was submitted on November 21, 2006.

2. Background and Reference Information Used in Analysis

Ms. Rachel Rineheart of USEPA Region 5 provided a recommended scope of analysis to follow in order to conduct the deposition modeling as well as evaluate the results obtained from the modeling. A copy of this recommended scope is included in Appendix A to this report. Based on the recommendation of EPA Region 5, the majority of the procedures and information that Trinity has used both for the deposition modeling and the follow-up evaluation closely followed the *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*.[2] Although this protocol was originally designed specifically for Hazardous Waste Combustion facilities, it has broad applicability in conducting modeling and evaluating chemical effects on species of concern. During subsequent meetings between USEPA Region 5 and the FWS several requirements originally included in the ESA recommended scope of analysis have been modified. A discussion of these modifications has been included in the pertinent sections of this report.

[2] U.S. EPA, Office of Solid Waste. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume 1*. EPA 530-D-99-001A. August 1999.

3. Emission Rates of Compounds of Potential Concern

Based on the recommended scope of analysis provided by EPA Region 5, the compounds of potential concern (COPCs) from the Wood River Refinery CORE project included ozone, sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM), and hazardous air pollutants (HAPs). During additional discussions with EPA Region 5 and Mr. Mike Coffey from the United States Fish and Wildlife Service (FWS), it was decided that the main compounds of concern were heavy metals, organic HAPs, and NO_x. A brief analysis of the additional COPCs has also been included in this report. Emission rates used for the deposition modeling analysis for all criteria pollutants were identical to the annual emission rates presented in the PSD/NANSR application submitted to the IEPA. Emission rates for HAPs were calculated based on the same procedures as were described for criteria pollutant emission calculations in the PSD/NANSR application. The emission rates are conservative, that is the highest emission rates realistically expected from the CORE project. A summary of the calculation methods for each source type is provided below:

- ▲ Boilers and heaters – Emission rates were calculated using emission factors from AP-42, Section 1.4. The emission rates used in this analysis were based on the potential emission rates for each boiler and heater. Since most of the boilers/heaters in the CORE project are existing units, the emission rates are conservative because the baseline actual emissions were not subtracted from the potential emission rates.
- ▲ Cooling water towers – Emissions rates were calculated using site-specific composition data. The emission rate is based on the maximum design circulation rate for each cooling water tower and the emission rates for each tower are therefore conservative.
- ▲ Coke handling and storage – Emission rates were calculated based on composition data obtained from a ConocoPhillips material safety data sheet (MSDS) for coke. The emission factors for coke handling and storage are conservative based on the percentage of nickel listed in the MSDS for coke. Since the MSDS listed a nickel composition of $<0.05\%$, we conservatively assumed that coke had a nickel composition of 0.05% for all emission calculations.
- ▲ Storage tanks – MSDSs were used to determine the percentage of volatile HAPs from the total VOM emission rate. The emission rates calculated for storage tanks were conservative based on the composition information from the MSDSs. In order to calculate the composition of each pollutant of concern, the highest value in the composition range from each MSDS was used.
- ▲ Fugitive equipment leaks – Emissions were calculated based on a percentage of the VOM emission rate for each unit area. The emission rates calculated were very conservative based on site-specific data. Historical data showed an approximate concentration of 5% for benzene from fugitive equipment leaks and 1% for hexane. In order to calculate the emission rates from fugitive equipment leaks, concentration rates of 10% were assumed for both benzene and hexane.
- ▲ Wastewater treatment plant – Emission rates were calculated based on site-specific composition data. The emission rate is based on the maximum water flow through the wastewater treatment plant and is therefore a conservative assumption.

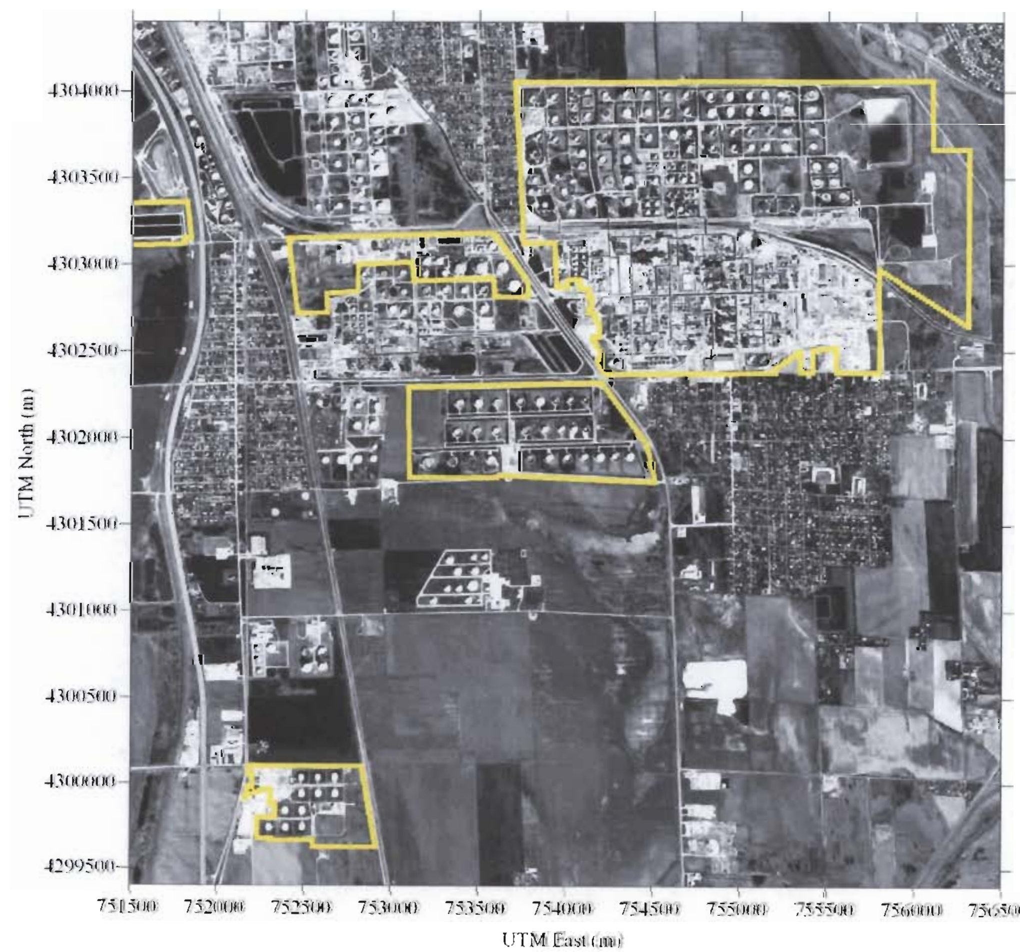
For the purposes of the ESA Consultation, only potential emission increases from the project have been used (i.e., emission decreases have not been taken into account). Please note that this is a very conservative approach for estimating emission increases. The net emission change for most pollutants (i.e., NO_x, SO_2, and PM) will be substantially less than is shown in this analysis due to the proposed installation of emission controls on several existing emission units. When including the effects of proposed emission controls, the project-related net emission change for NO_x will be a decrease of 47.5 tpy; for SO_2, a decrease of 9,583.1 tpy. For PM, the project-related net emission change will be an increase of 197.9 tpy which is 40% less than the sum of the potential emission increases alone (329.2 tpy). Note that the project-related net emission changes listed above for NO_x, SO_2, and PM do not include contemporaneous emission changes not related to the CORE project.

The modeling procedures and assumptions described in Sections 4.1 through 4.7 of this analysis are based on the approach used to model carbon monoxide emission increases for the PSD analysis that was provided in the Modeling Addendum submitted to the IEPA on February 26, 2007. Additional information regarding deposition modeling is included in Section 4.8. Please note that the modeling input and output files and supporting data will be submitted under separate cover to the IEPA.

4.1 LOCATION OF FACILITY

Wood River Refinery is located on Highway 111 in the City of Roxana in Madison County, Illinois. The Wood River Products Terminal is located approximately two miles southwest of the refinery. Figure 4-1 contains an area map showing the Wood River Refinery and Wood River Products Terminal fencelines overlaid onto an aerial photograph of the area. The area map shows the refinery and terminal locations relative to predominant geographical features such as nearby highways, railroads, streams, and rivers.

FIGURE 4-1. AERIAL PHOTOGRAPH OF WOOD RIVER REFINERY AND SURROUNDING AREA



4.2 Dispersion Model Selection

The AMS/EPA Regulatory Model (AERMOD), Version 04300, was used with the *BREEZE™ AERMOD Suite* software, provided by Trinity, to calculate ground-level concentrations.

4.3 UTM Coordinate System

In all modeling analysis input and output data files, the locations of emission sources, structures, and receptors are represented in the Universal Transverse Mercator (UTM) coordinate system. The U.S. EPA and IEPA require that coordinates for dispersion modeling analyses be represented in the UTM system. The UTM grid was originally created by the Defense Mapping Agency of the United States as a special grid for military use throughout the world.[3] In this grid, the world is divided into 60 north-south zones, each covering a strip 6° wide in longitude. The Roxana area of west-central Illinois is located in UTM Zone 15. In each UTM Zone, coordinates are measured north and east in meters. The northing values are measured continuously from zero at the Equator in a northerly direction. A central meridian through the middle of each 6° zone is assigned an easting value of 500.000 kilometers (km). Grid values to the east of this central meridian, as in the case of the Wood River Refinery and Wood River Products Terminal, are greater than 500.000 km and grid values to the west of this central meridian are less than 500.000 km. The center of the Wood River Refinery property is located near UTM coordinates 754.000 km East and 4,303.000 km North. All building, tank, emission point, and fence line locations digitized from Wood River Refinery and Wood River Products Terminal plot plans were converted to equivalent UTM coordinates. All UTM location information was input into the model using a consistent datum system (i.e., NAD83).[4]

4.4 Meteorological Data

Meteorological data for use in AERMOD was processed using the AERMOD meteorological preprocessor (AERMET) for the years 2001 through 2005. The 2001 through 2005 raw meteorological data for use in AERMET included surface meteorological data (wind speed, wind direction, temperature, and cloud cover) from the National Weather Service (NWS) station at the Lambert – St. Louis International Airport (WBAN Station 13994) and upper air data from Lincoln/Springfield (WMO Station 74560).

The years 2001 through 2005 were selected, as these were the most recent five consecutive years for which the availability of data for the station was greater than 90 percent per year. The EPA's meteorological monitoring guidelines require 90 percent data availability as part of meeting the monitoring data quality assurance requirements.[5] Also, the EPA's modeling guidelines recommend using the most recent, readily available 5-year period in a meteorological data analysis.[6]

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[3] U.S. Department of the Interior and the U.S. Geological Survey Earth Science Information Center (ESIC), The Universal Transverse Mercator (UTM) Grid Factsheet, May 1993.

[4] Illinois EPA, *The Art and Science of the PSD Air Quality Analysis - The Modeling Perspective (Draft)* (Springfield, IL: Illinois EPA, November 29, 2005).

[5] Environmental Protection Agency, 2000. Meteorological Monitoring Guidance for Regulatory Applications. EPA-454/R-99-005

[6] Federal Register Vol. 68, No. 72; *Revision to the Guideline on Air Quality Models: Adoption of a Preferred Long Range Transport Model and Other Revisions; Final Rule*, April 15, 2003.

The meteorological data were processed using default AERMET options and built-in AERMET quality assurance and data substitution options. AERMET generates two files for use in AERMOD. One file is a file of surface scalar parameters and the other file consists of vertical profiles of meteorological data.

As part of the AERMET meteorological data processing, a land use/land cover (LULC) analysis was required. The LULC analysis determined the seasonal albedo, daytime Bowen ratio, and surface roughness that were used in AERMET. A circle with a 3-kilometer (km) radius was centered on the meteorological station at the Lambert – St. Louis Airport. This circle was then split into 4 sectors based on the predominant land use types present in each sector. The percentage of each of land use type within each of these sectors was determined based on the land use types listed in the AERMET User's Guide. These percentages were then multiplied by the corresponding seasonal albedo, daytime Bowen ratio, and surface roughness and summed in order to get a single value for each seasonal parameter per sector.

4.5 LAND USE AND SELECTION OF DISPERSION OPTION

The three surface characteristics of albedo, Bowen ratio, and surface roughness were required to compute atmospheric fluxes and stability, which were then used in the boundary layer calculations. Each surface characteristic may be specified by month, season, or year. These values were calculated by weighing the parameters as provided in Tables 4-1 through 4-3 of the AERMET User's Guide[7] by the percentage of land use types that are present within 3 km of the surface data meteorological station (Lambert – St. Louis International Airport).

A detailed land use analysis based on a 1992 National Land Cover Data (NLCD) map[8] and a recent aerial photograph was used to define the land use characteristics for the area within a 3 km radius of the airport. The 1992 National Land Cover Dataset used in this analysis was the most recent land use data available and included 21 classes of land-cover data derived from Landsat 7 satellite imagery, ancillary data, and derivatives using a decision tree.

[7]U.S. Environmental Protection Agency, *AERMET User's Guide*, Office of Air Quality Planning and Standards, EPA-454/B-03-002, November 2004.

[8]NLCD map downloaded from the USGS Multi-Resolution Land Characteristics (MRLC) website http://gisdata.usgs.net/website/MRLC/

The percentages of each of these 21 classifications were developed by tabulating the land use type for each sector of the 3 km circle. Figure 4-2 is the graphical representation of the 1992 NLCD land use data obtained from the MRLC website for the 3 km area surrounding the airport; Figure 4-3 is an aerial photograph of the same area.

FIGURE 4-2. 1992 NLCD MAP

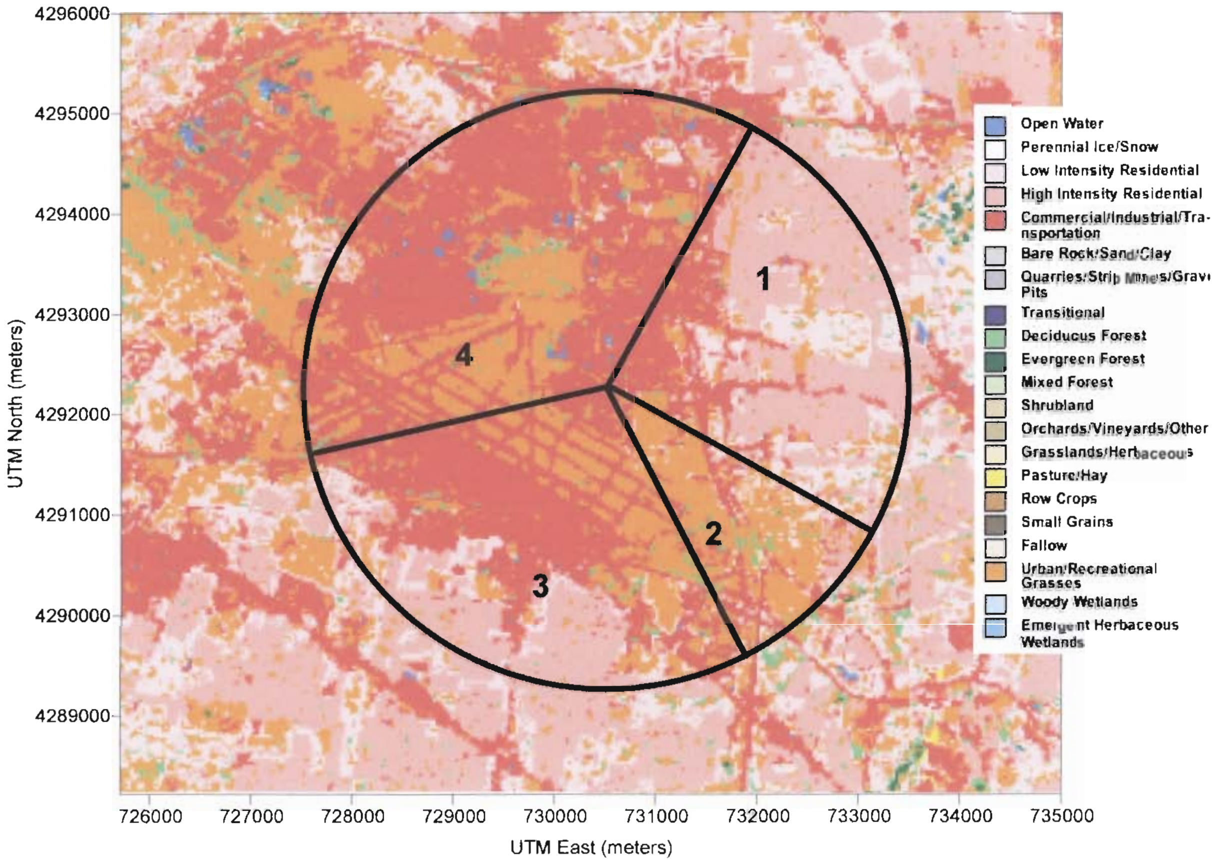
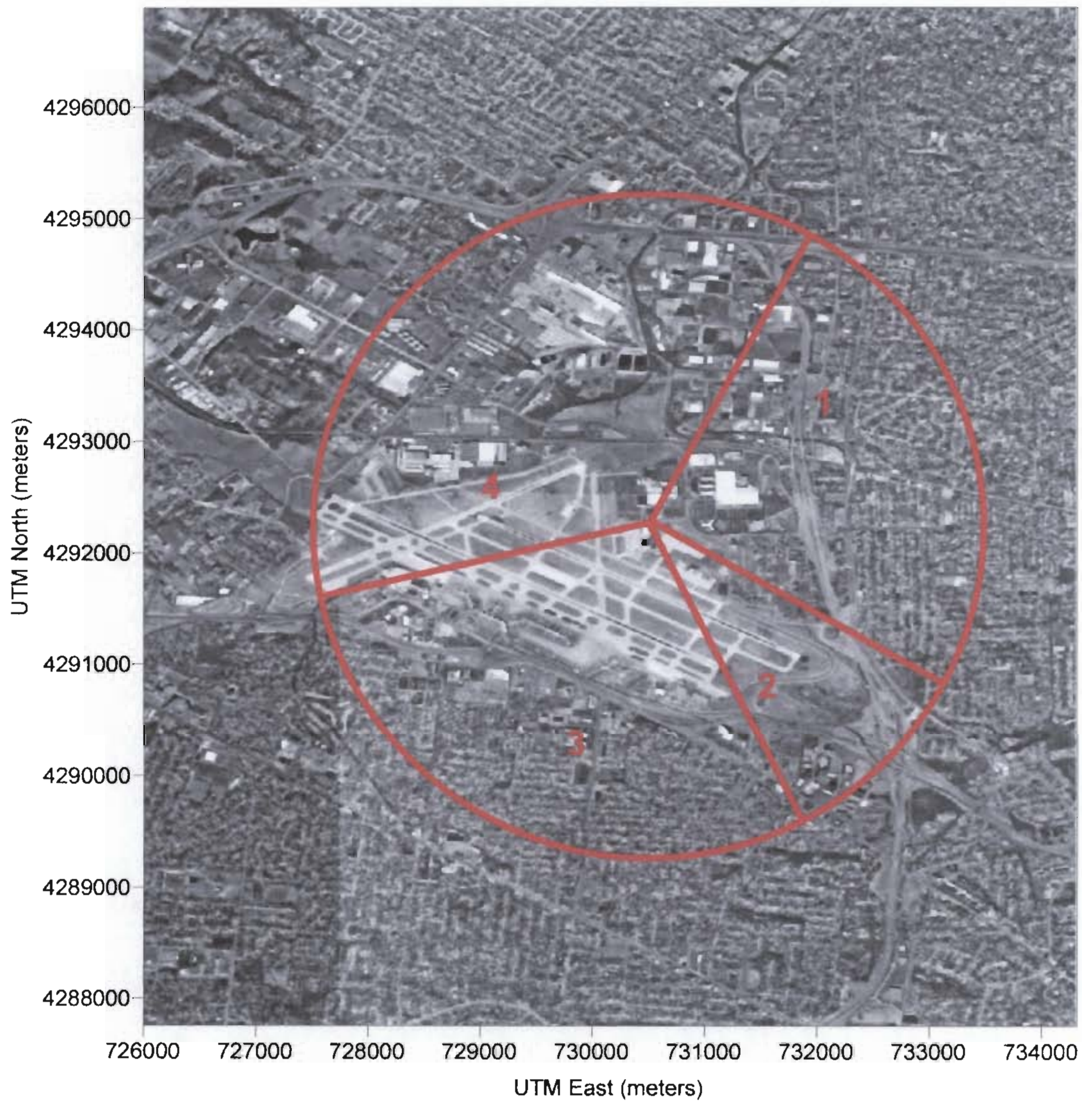


FIGURE 4-3. AERIAL PHOTOGRAPH OF LAMBERT AIRPORT – ST. LOUIS AND SURROUNDING AREA



The AERMET User's Guide provides eight land use classifications; consequently, each NLCD classification was assigned to an AERMET classification such that the data could be utilized when processing the meteorological data using AERMET. Table 4-1 provides a summary of which NLCD classifications are included in each AERMET classification.

TABLE 4-1. LAND USE CLASSIFICATIONS

1992 NLCD Classifications	AERMET Classifications
Open Water Perennial Ice/Snow	Water (fresh and sea)
Low Intensity Residential High Intensity Residential Commercial/Industrial/Transportation Bare Rock/Sand/Clay	Urban Desert Shrubland
Quarries/Strip Mines/Gravel Pits Transitional Deciduous Forest	 Deciduous Forest
Evergreen Forest	Coniferous Forest
Mixed Forest Shrubland	
Orchards/Vineyards	
Grasslands/Herbaceous	Grassland
Pasture/Hay	Cultivated Land
Row Crops Small Grains Fallow Urban/Recreational Grasses	
Woody Wetlands Emergent Herbaceous Wetlands	Swamp

Table 4-2 of this report provides the result of weighting the parameters as provided in the AERMET User's Guide (Tables 4-1 through 4-3), by the land-use shown in Figures 4-2 and 4-3 of report.

TABLE 4-2. AERMET INPUT VALUES

Sector (degrees)	Season	Albedo	Daytime Bowen Ratio	Surface Roughness
Sector 1 (29° - 119°)	Winter	0.35	1.50	0.99
	Spring	0.14	0.99	0.99
	Summer	0.16	1.99	0.99
	Autumn	0.18	1.99	0.99
Sector 2 (119° - 154°)	Winter	0.57	1.50	0.11
	Spring	0.14	0.37	0.14
	Summer	0.20	0.65	0.29
	Autumn	0.18	0.83	0.15
Sector 3 (154° - 258°)	Winter	0.40	1.50	0.80
	Spring	0.14	0.86	0.81
	Summer	0.17	1.68	0.84
	Autumn	0.18	1.73	0.81
Sector 4 (258° - 29°)	Winter	0.47	1.50	0.51
	Spring	0.14	0.65	0.52
	Summer	0.18	1.24	0.61
	Autumn	0.18	1.35	0.53

4.6 BUILDING WAKE EFFECTS (DOWNWASH)

The purpose of a building downwash analysis is to determine if the plume discharged from a stack will become caught in the turbulent wake of a building (or other structure), resulting in downwash of the plume. The downwash of the plume can result in elevated ground-level concentrations.

The EPA provides guidance for determining whether building downwash will occur in *Guideline for Determination of Good Engineering Practice Stack Height.*[9] The minimum stack height not subject to the effects of downwash (called the Good Engineering Practice or GEP stack height) is defined by the following formula:

$$GEP = H + 1.5L$$

Where: GEP = the minimum GEP stack height
H = the height of the structure
L = the lesser dimension of the structure (height or projected width)

[9] EPA, Office of Air Quality Planning and Standards. *Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised).* Research Triangle Park, North Carolina. EPA 450/4-80-023R. June, 1985.

Stacks located more than 5L from any building are not subject to the effects of building downwash. The Building Profile Input Program (BPIP) with Plume Rise Model Enhancements (PRIME) was used to determine the building downwash characteristics for each stack in 10-degree directional intervals. The PRIME version of BPIP features enhanced plume dispersion coefficients due to turbulent wake and reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increase entrainment in the wake. For PRIME downwash analyses, the building downwash data included the following parameters for the dominant building: building height, building width, building length, x-dimension building adjustment, and y-dimension building adjustment.

4.7 TERRAIN ELEVATIONS

The base elevation of the facility is approximately 443 feet (135 meters) above mean sea level as determined from the 7.5 minute United States Geological Survey (USGS) maps for the site. Terrain elevations in the area of the facility are relatively flat. Terrain elevations were input into the air quality model using Digital Elevation Model (DEM) data for the facility and surrounding area. Please note that although the raw data DEM files are in multiple datums (i.e., NAD27 and NAD83), these data files are all synchronized to one consistent datum (i.e., NAD83) when imported through the AERMAP feature.

4.8 ADDITIONAL INFORMATION RELATED TO DEPOSITION MODELING

Two different categories of models were run depending on whether the COPC was in particulate or gaseous form. Particulate COPCs include all heavy metals (other than vapor forms of mercury) and PAH. Gaseous COPCs include NO_x, SO_2, hexane, benzene, elemental mercury, and divalent mercury.

4.8.1 PARTICLE DEPOSITION

Particle deposition is calculated by algorithms in AERMOD that account for the gravitational settling and removal by deposition of particulates. In addition to hourly precipitation data, these algorithms require a particle size distribution and particle density be assigned for each emission source.

All particulate COPCs had emissions from combustion sources. The particle size distribution from combustion was assumed to be PM less than one micron based on AP-42, Section 1.4 for natural gas combustion. The particle density for each metal was assumed to be that of the pure metal, except that the density of particulate mercury was assumed to be mercuric chloride.

In addition to combustion, based on site specific data nickel is conservatively assumed to compose 0.05 percent of the particulate emissions from aggregate handling, crusher operation, the delayed coking unit process, and from vehicle traffic on paved and unpaved roads. The particle size distributions were obtained from AP-42 Sections, and the density was assumed to be that of petroleum coke. In addition to combustion sources, manganese is emitted from cooling tower drift loss. The particle size distribution and density of the water droplets from the cooling water tower drift were calculated according to methods outlined in literature[10].

[10] R. N. Meroney. *CFD Prediction of Cooling Tower Drift Loss.* Journal of Wind Engineering and Industrial Aerodynamics, 94(6), 463-490.

4.8.2 Gaseous Deposition

Gaseous deposition requires additional source parameters for dry and wet deposition of gaseous COPCs, including the diffusivity in air, diffusivity in water, cuticular resistance, and Henry's Law constant. Values for gaseous COPCs were based on USEPA model support documents[11] and other standard reference texts.

The gaseous deposition algorithms also require additional inputs in the AERMOD control options, including seasonal and land use parameters. Seasonal categories were assigned to each calendar month based on local observations. Predominant land use categories were assigned for each 10-degree wind sector based upon a recent aerial photograph of the facility and surrounding area. Lastly, a dimensionless reactivity factor is assigned based on based on USEPA guidance documents[12].

4.8.3 Receptor Grids

In the air dispersion modeling analysis, ground-level concentrations were calculated within two receptor grids. These grids covered a region extending 10 km from all edges of the facility fenceline. The grids are spaced as follows:

1) a "fenceline" grid consisting of evenly-spaced receptors 25 m apart placed along the facility fenceline;
2) a "coarse" grid containing 1-km spaced receptors extending 10 km from the fenceline.

4.8.4 Additional Receptor Locations

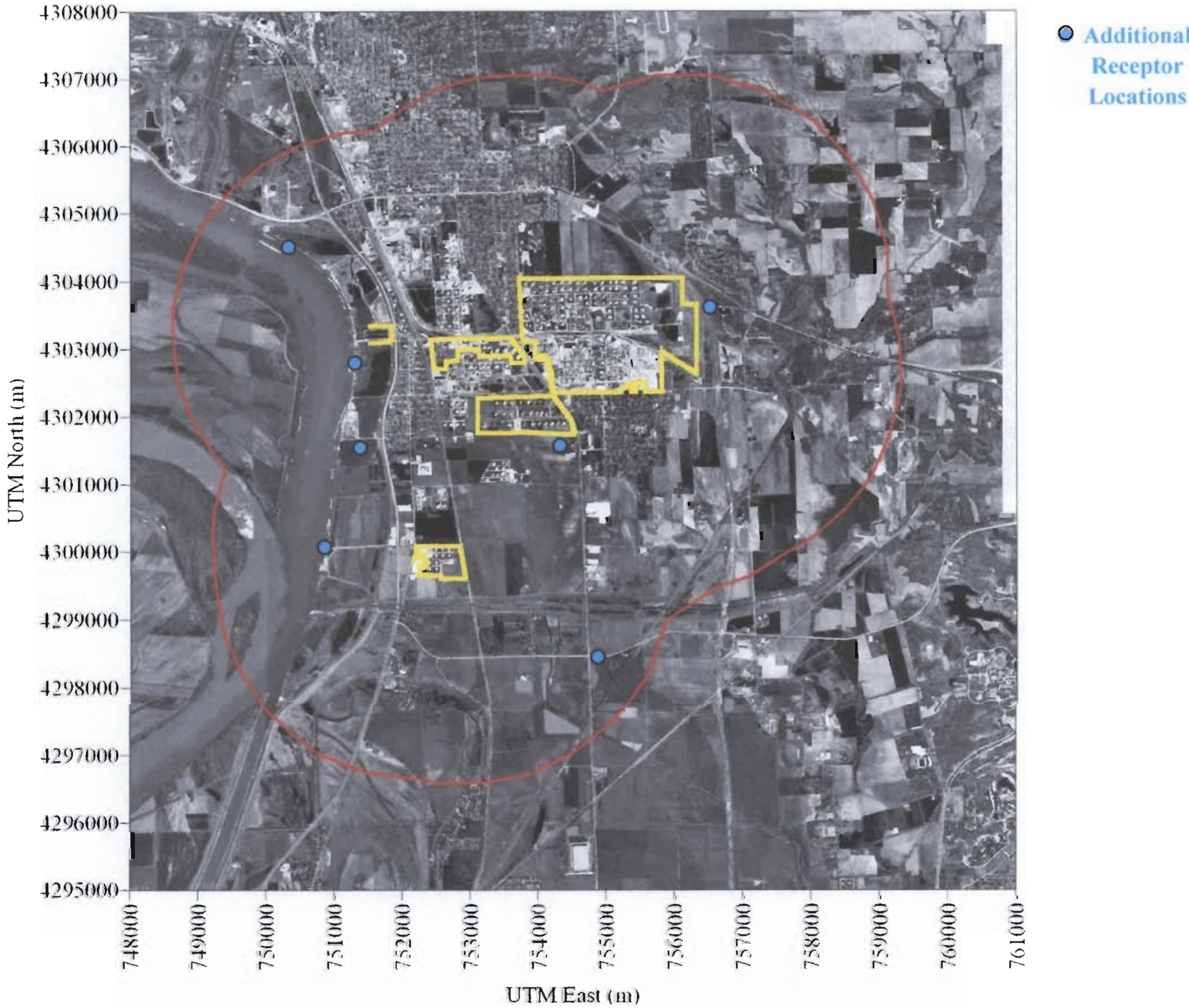
Seven additional discrete receptors were added to the original receptor grid used for the air dispersion modeling. The first three receptors are located in wooded areas around the facility (i.e., east by the facility recreation area and two areas south of the refinery), and the other four receptors are located along the river to the west of the facility (i.e., southwest of the refinery, west of the barge loading, west of the Wood River Products Terminal, and northwest of the refinery). The selected additional receptor locations include areas identified as potential foraging and roosting habitat as described in Section 5. Also, as discussed with USFWS the area of greatest concern was identified as the treed area between the levee and the Mississippi River.[13] See Figure 4-4 for locations of additional receptors.

[11] M.L. Wesely, P.V. Doskey, and J.D. Shannon. *Deposition Parameterizations for the Industrial Source Complex (ISC3) Model.* Argonne National Laboratory. ANL/ER/TR-01/003. June, 2002.

[12] *AERMOD Deposition Algorithms – Science Document (Revised Draft).* From the U.S. EPA documentation of the AERMOD-PRIME with Deposition version 03273.

[13] Discussion from January 4, 2007 meeting between Mr. Mike Coffey (FWS), Ms. Rachel Rinehart (EPA Region 5), Mr. David Dunn (ConocoPhillips), and Ms. Kristine Davies (Trinity).

FIGURE 4-4. LOCATIONS OF ADDITIONAL RECEPTORS USED IN DEPOSITION MODEL



The species described below were identified by EPA Region 5 as being species of concern with respect to the CORE project. Detailed habitat descriptions were provided by the FWS and are included in Appendix B.

BALD EAGLE (*Haliaeetus leucocephalus*) – The Bald Eagle is on the list of threatened species and is listed as breeding and wintering in Madison County. Habitat includes tall trees near larger bodies of water (e.g., lakes, rivers, seacoasts).

INDIANA BAT (*Myotis sodalis*) – The Indiana Bat is on the list of endangered species and has been observed in Madison County. Habitat includes caves and trees. Although most of the area surrounding the Wood River Refinery and Wood River Products Terminal would not be considered good habitat for the Indiana Bat due to the large amount of residential, industrial, and agricultural areas within the radius of impact considered for this analysis, there are stands of trees located along the river to the southwest of the facility that FWS requested be considered as possible foraging areas where the Indiana bat may be found up to 25% of the time.[14]

GRAY BAT (*Myotis grisescens*) – The Gray Bat is also on the list of endangered species and is known to occur in Madison County. Habitat includes caves and trees. Similar to the Indiana Bat, the stands of trees located along the river were considered as possible foraging areas where the Gray Bat may be found up to 25% of the time.

PALLID STURGEON (*Scaphirhynchus albus*) – The Pallid Sturgeon is on the list of endangered species and is found in the Mississippi River downstream of the confluence with the Missouri River.

DECURRENT FALSE ASTER (*Boltonia decurrens*) – The Decurrent False Aster is on the list of threatened species and is known to occur in Madison County. The species is found in disturbed alluvial soils.

EASTERN PRAIRIE FRINGED ORCHID (*Platanthera leptostachya*) – The Eastern Prairie Fringed Orchid is on the list of threatened species. It has not been observed in Madison County. The Eastern Prairie Fringed Orchid occurs in mesic to wet prairies. Based on information from both FWS and EPA Region 5, this species is not typically found in the southern half of Illinois. See Illinois county map in Appendix C for information on counties with observed occurrences of the Eastern Prairie Fringed Orchid.

PRAIRIE BUSH CLOVER (*Lespedeza leptostachya*) – The Prairie Bush Clover is on the list of threatened species. It has not been observed in Madison County. The Prairie Bush Clover occurs in dry to mesic prairies with gravelly soil. Based on information from both FWS and EPA Region 5, this species is not typically found in the southern half of Illinois. See Illinois county map in Appendix C for information on counties with observed occurrences of the Prairie Bush Clover. Additionally, most of the area surrounding the Wood River Refinery is seasonally flooded with silt and sandy loam soil. Therefore, it would not necessarily be considered good habitat for the Prairie Bush Clover.

[14]Discussion from January 4, 2007 meeting between Mr. Mike Coffey (FWS), Ms. Rachel Rinehart (EPA Region 5), Mr. David Dunn (ConocoPhillips), and Ms. Kristine Davies (Trinity).

The pollutants described below were identified by EPA Region 5 as being COPCs to consider with respect to the ConocoPhillips CORE project.

6.1 PM, HEAVY METALS, AND PAH

Although particulate matter (PM) was included in the ESA recommended scope of analysis from EPA Region 5, this COPC as a whole was not analyzed for impacts to the species of concern. Instead, the most toxic components of PM were analyzed individually and compared to toxicity reference values. This is based on guidance from the SLERA protocol which states "PM dose-response information to evaluate risk of particulate matter to ecological receptors is limited. For this reason, U.S. EPA OSW [Office of Solid Waste] does not recommend that PM be evaluated as a separate COPC in a risk assessment. However, PM is useful as an indicator parameter for other contaminants…"[15] The protocol further states that Polycyclic Aromatic Hydrocarbons (PAHs) and the presence of metals are generally the only concern with respect to PM.[16] Therefore, the following COPCs were considered for the particulate analysis:

- Heavy metals (i.e., arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium), and
- Polycyclic Aromatic Hydrocarbons.

Soil, water, and sediment concentrations for heavy metals were calculated using the methodology outlined in Section 3.11 and Appendix B of the SLERA protocol. When available, chemical specific data were obtained from Appendix A of the protocol. Since no data were available for cobalt and manganese, chemical data for the worst case metal (i.e., beryllium) were used. Chromium emissions from the project were conservatively considered to be 100% hexavalent chromium due to the increased toxicity for chromium in this valence state. All recommended default values listed in Appendix B of the SLERA protocol were used in determining media concentrations. Detailed calculations performed for determining media concentrations is included in Appendix D to this report.

For heavy metals, background concentrations in soil were obtained from the Title 35 of the Illinois Administrative Code (IAC) Section 742 Appendix A, Table G. Background concentrations for water in the Mississippi River were obtained from water quality data provided by EPA Region 5. Water data from the St. Louis station was used due to the large amount of available data at this location versus other nearby locations. Sediment background data were obtained from EPA's Storet Data Warehouse.[17]

Screening levels for all of the metals, with the exception of manganese were provided by EPA Region 5. Manganese Ecological Screening Levels (ESLs) were obtained from the Alaska Department of Environmental Conservation's (ADEC's) *User's Guide for Risk-Based Screening in*

[15] U.S. EPA, Office of Solid Waste. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume 1.* EPA 530-D-99-001A. August 1999. Pg. 2-67

[16] U.S. EPA, Office of Solid Waste. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume 1.* EPA 530-D-99-001A. August 1999. Pg. 2-50

[17] Information obtained from EPA's website - http://www.epa.gov/storet/dw_home.html

Alaskan Ecological Risk Assessment[18]. Also considered in the analysis were toxicity reference values (TRVs) from the SLERA protocol where available.

6.2 VOLATILE HAZARDOUS AIR POLLUTANTS

Several different volatile HAPs may potentially be emitted from the CORE project. To evaluate the impacts of this group, two volatile HAPs were selected and analyzed. The selected HAPs, benzene and hexane, are expected have the highest emission rates of any pollutants within the volatile HAP category. Due to the conservative assumptions used in estimating the maximum benzene and hexane emissions, the selected pollutants represent approximately 93% of the total potential volatile HAP emissions.

Soil, water, and sediment concentrations for benzene and hexane were calculated using the methodology outlined in Section 3.11 and Appendix B of the SLERA protocol. For benzene, chemical specific data were obtained from Appendix A of the protocol. Reference data for hexane were obtained from the EPA's *Industrial Waste Air Model Background Document*[19]. All recommended default values listed in Appendix B of the SLERA protocol were used in determining media concentrations. Detailed calculations performed for determining soil, water, and sediment concentrations is included in Appendix D to this report.

For hexane and benzene, considerably less data on background concentrations and ESLs were available. For background concentrations in the soil, data on remediation action levels for industrial/commercial properties from the IEPA Toxicity Assessment Unit were used for hexane[20] and benzene.[21] In this case, remediation action levels for industrial/commercial properties were chosen to use as background data rather than those for residential properties, since the levels for industrial/commercial properties are higher. Due to the fact that the background levels are added to the project increase prior to comparing to the ESL, it is more conservative to use the higher levels. Background concentrations for water in the Mississippi River were obtained from water quality data provided by EPA Region 5. Water data from the St. Louis station was used due to the large amount of available data at this location versus other nearby locations. Background concentrations for hexane in water were obtained from IEPA groundwater remediation objectives.[22]

The ESLs for benzene were available from the data provided by EPA Region 5. For hexane, the only ESL available was for water and was obtained from ADEC's *User's Guide for Risk-Based Screening in Alaskan Ecological Risk Assessment.*

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[18] User's Guide for Ecological Risk-Based Screening in Alaskan Ecological Risk Assessment, submitted to Mr. Dennis Harwood of ADEC by Shannon & Wilson, Inc., December 2001.

[19] U.S. EPA, Office of Solid Waste and Emergency Response. *Industrial Waste Air Model Technical Background Document*. EPA 530-R-02-010. August 2002

[20] IEPA, Toxicity Assessment Unit. *Soil Remediation Objectives for Industrial/Commercial Properties, Non-TACO Chemicals (Table B)*. October 1, 2004

[21] 35 Illinois Administrative Code, Section 742.Appendix B.Table B: Tier 1 Soil Remediation Objectives for Industrial/Commercial Properties.

[22] IEPA, Toxicity Assessment Unit, *Groundwater Remediation Objectives for Chemicals Not Listed in TACO.* October 1, 2004.

6.3 Nitrogen Oxides

For nitrogen oxides (NO_x), results were compared to the ESL provided by EPA Region 5 and FWS using data gathered for the ExxonMobil ESA. A copy of the information provided by EPA Region 5 and FWS has been provided in Appendix E. Since the ExxonMobil project was located in an urban setting similar to the location of the Wood River Refinery and Wood River Products Terminal, FWS determined that the NO_x background data from the ExxonMobil ESA could also be utilized in the ConocoPhillips analysis. Unlike the metal and volatile HAP media concentration calculations where additional media concentration calculations were used following deposition modeling, the nitrogen deposition from the modeling was used directly and compared to the ESL for NO_x. Details of the calculations performed for NO_x are included in Appendix D.

6.4 Sulfur Dioxide

For sulfur dioxide (SO_2), the method of analysis, background data, and ESL were also provided by EPA Region 5 and FWS using data gathered from the ExxonMobil ESA[23]. Air concentrations were used to compare project emissions plus background to the appropriate screening level. Background concentrations were updated to include the latest data available from IEPA's Annual Air Quality Report for 2005. Details of the calculations performed for SO_2 are included in Appendix D.

6.5 Carbon Monoxide

For carbon monoxide (CO), the method of analysis was similar to that of SO_2. As was the case with the sulfur emissions, air concentrations were used to compare project emissions plus background to the appropriate screening level. Background concentrations were obtained from the latest data available from IEPA's Annual Air Quality Report for 2005. In the case of CO emissions no data were available for screening levels, therefore, the ESL was considered to be the National Ambient Air Quality Standards (NAAQS) for CO. The modeled CO concentrations were compared to both the 1-hour and 8-hour NAAQS for CO. Details of the calculations performed for CO are included in Appendix D.

6.6 Ozone

Although the recommended scope of analysis provided by EPA Region 5, states that the EPA will provide the analysis for ozone for the project, this section has been included to supply additional information that may be useful in conducting the analysis.

The Wood River Refinery is located in a moderate non-attainment area for the 8-hour ozone standard. The VOM emissions from the CORE project have been incorporated into the IEPA's State Implementation Plan (SIP) modeling for the St. Louis non-attainment area. In order to satisfy the requirements for the New Source Review (NSR) program, the Wood River Refinery is required to obtain emission offsets for VOM at a ratio greater than 1.15:1 (i.e., 1.15 tons per year of VOM offsets per 1 ton per year of allowable VOM emission increase) prior to operation of the proposed changes to the facility. These offsets must be obtained from the St. Louis ozone non-attainment area, thereby reducing the impact of VOM/ozone increases from the CORE project. In addition, the Wood River Refinery and Wood River Products Terminal will implement Lowest Achievable Emission Rate (LAER) control technology for VOM in order to fulfill the requirements of the NA NSR permits for the CORE project.

[23] Letter dated September 29, 2005 from Ms. Pamela Blakely (USEPA) to John Rogner (USFWS)

According to the recommended scope of analysis provided by EPA Region 5, in order to determine if there is an impact to the species of concern, background levels should be added to expected concentrations related to the emissions increases from the project. The total should then be compared to the appropriate ESL. In a number of cases, the background concentrations of the COPC exceed the ESL without the addition of emissions from the project. In these cases, project increases were compared to directly to background data. An overall summary of the results is provided in Appendix F to this report.

7.1 METAL HAPS AND PAHS

The results from the deposition modeling analysis show that deposition to media for beryllium, selenium, mercury, and PAHs from the CORE project will be zero. Therefore, no further analysis was performed on these COPCs and no impacts are expected to occur.

Deposition modeling results for the other metals were used to calculate media concentrations for soil, water and sediment using the methods described in Section 6.1. For arsenic, chromium, cobalt and lead the highest modeled depositions, typically found at the facility fence line, were used to determine the media concentration. For manganese, cadmium and nickel, the highest value at any of the appropriate target receptors was used in the calculation of media concentrations. Due to the fact that in all cases the soil background concentrations for the metal HAPs were higher than the ESLs, the potential concentrations of metal HAPs calculated to be deposited from the project were compared to directly to background concentrations. The estimated soil concentrations from the project increases compared to background for all metal HAPs was much less than 1%. It is anticipated that these values would be within the variability of the normal background concentrations. For water concentrations, all metal compound concentrations, with the exception of manganese, were below the ESL. Manganese concentrations from the CORE project that would be potentially deposited in water were less than 1% of the background water concentration. Sediment deposition results were added to background and compared to ESLs when available. Potential deposition concentrations of arsenic, cadmium, lead, manganese, and nickel were all less than 1% of the background concentration. The potential chromium concentration when added to background was less than the ESL. No background concentration was available for cobalt, however, the estimated deposition concentration, related to the project increases, was much less than the ESL for that COPC. Therefore, no impacts to endangered or threatened species are expected to occur due to emissions of arsenic, cadmium, chromium, cobalt, lead, manganese, or nickel from the CORE project.

7.2 VOLATILE HAPS

Similar to the metal HAPs, deposition modeling results for benzene and hexane were used to calculate soil, water, and sediment concentrations using the methods described in Section 6.2. The highest modeled concentration for both COPCs was used in the media concentration analysis.
The background concentrations used in the analysis were higher than the ESLs for soil, therefore, the estimated concentrations due to deposition were compared directly to background. Both benzene and hexane concentrations from the CORE project were less than 1% of background for soil. For water, the benzene concentration added to background was less than the ESL, while hexane was less than 1% of the background concentration. No background levels were available for comparison to

background sediment concentrations; however, the potential concentration from the CORE project of both COPCs was nine to ten orders of magnitude below the respective ESLs. Therefore, no impacts to endangered or threatened species are expected to occur due to emissions of volatile HAPs.

7.3 Sulfur Dioxide

Sulfur dioxide concentrations were modeled and compared against ESL concentrations in air, consistent with the reference value provided by EPA Region 5. The concentration of SO_2 from the project, when added to background, was 16.3 $\mu g/m^3$. This is less than the 19 $\mu g/m^3$ ESL provided by EPA Region 5. Therefore, it has been determined that no impacts to endangered or threatened species are expected to occur due to emissions of SO_2.

7.4 Carbon Monoxide

As with SO_2, carbon monoxide concentrations were modeled and compared against ESL concentrations in air. The concentration of CO from the project when added to background for the 1-hr averaging period is 5.9 ppm and for the 8-hr averaging period is 4.0 ppm. Both of these values are less than the NAAQS values, 35 ppm and 9 ppm respectively, that were used for the ESLs. Therefore, it has been determined that no impacts to endangered or threatened species are expected to occur due to emissions of CO.

7.5 Ozone

While EPA has not yet provided the ozone analysis for this project, it is also not anticipated that there will be an impact to endangered or threatened species based on the project being obligated to meet the non-attainment area VOM offset requirements for this COPC. These offsets should ensure that the CORE project will not contribute to any increase in ozone concentration in the non-attainment area.

7.6 Nitrogen Oxides

The single COPC that may be of concern based on emission increases from the CORE project is NO_x. As shown in the summary in Appendix F, the concentration increase related to the project is 0.0933 $g/m^2/yr$ and the representative urban area background concentration is 0.71 $\mu g/m^3$. Since the background concentration already exceeds the ESL, any increase in emissions related to the project added to the background number would also exceed the ESL. However, as stated previously in the emission rate discussion of this report, based on guidance from FWS, only project increases were taken in account during the initial deposition modeling and impact analysis. In reality, the overall emissions from the Wood River Refinery will decrease as a result of this project. This is due to the fact that the refinery will be installing additional NO_x emission controls on two of its existing catalytic cracking units. This will reduce emissions from those currently operating units by 980.4 tons of NO_x per year. When taking into account the increases in NO_x emissions from new emission units as well as the decreases from the additional control on existing units, there will be an overall net decrease of 47.5 tons per year of NO_x emissions upon startup of the proposed equipment (not including contemporaneous emission changes). Therefore, it is not anticipated that NO_x emissions from the CORE project resulting in nitrogen deposition to the soil will have an impact on endangered or threatened species.

7.7 Summary

Based on the data provided in this report, it has been determined that no impact on endangered or threatened species should occur as a result of the CORE project. This conclusion is based on the following information:

- For the Eastern Prairie Fringed Orchid and the Prairie Bush Clover there is both negligible habitat in the area and lack of observed species in the region.
- Foraging habitat surrounding the refinery may be available for the Indiana Bat and the Gray Bat, however, these species are likely to spend only about 25% of their time in these foraging areas.
- The media concentrations relative to the ESLs or background data for most COPCs were very low.
- The emission estimation approach used in this analysis is conservative; that is, the net emission change for most COPCs will be substantially less than is shown in this analysis due to the proposed installation of emission controls on several existing emission units.

APPENDIX A

EPA REGION 5 RECOMMENDED SCOPE OF ANALYSIS

Recommended Scope of Analysis
for Endangered Species Evaluation
ConocoPhillips Wood River Refinery – CORE Project

December 8, 2006

Purpose of analysis:

The analysis is intended to determine whether the proposed modifications to the Wood River Refinery are likely to directly or indirectly adversely affect federally listed species. This recommended scope of analysis or roadmap recommends using USEPA's ecological risk assessment process to inform the decision points in section 7 of the Endangered Species Act. Portions of the USEPA's draft Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 530-D-99-001A) provides useful guidance for this analysis. Although this guidance was designed specifically to assess the impact of hazardous waste combustion facilities, it offers general approaches for assessing the fate of chemicals released to the air that can be applied to all types of industrial facilities.

Overall, the evaluation should focus on increased emissions from the facility. To complete this analysis we need an understanding of the background concentrations and deposition patterns. The anticipated emissions from permitted but not yet operational facilities ConocoPhillips should be included in background. The anticipated concentration in air or deposition at sites supporting listed species should be compared against NOEL (No observed effects level) benchmarks thought to be protective of the appropriate group (e.g., plants). The evaluation should look at the incremental addition in the context of background concentrations.

Benchmarks:

For these analyses, commonly accepted NOEL (no observed effects levels) benchmarks should be used. Where more than one benchmark can be found the most conservative value should be used, unless an explanation is given to justify a less conservative 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.

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 deposition rates for all pollutants (where appropriate). 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, 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.

Assessment Area:

For the chemicals amenable to deposition, the majority should deposit within a 3 km radius of the facility. We recommend using the maximum deposition value within that 3 km radius in performing the analysis.

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 all air pollutants emitted from the facility including ozone, sulfur compounds, oxides of nitrogen, carbon monoxide, particulates, and hazardous air pollutants. USEPA will provide the analysis for ozone for this project.

Types of impact to consider:

1. Short term, depending on pollutant compare worst 1 hr, 8 hr, and 24 hr. concentration in air with appropriate bench marks for acute effects. A discussion of each pathway should be included with an explanation of which is considered most sensitive. This includes, but is not limited to, impact to physical structures, cuticle uptake, stomatal uptake, root uptake, and particulate clogging of stomates for plant species. For the bald eagle and the Inidana bat determine the exposure to via food sources that would be taking up contaminants through soil, water and sediment.
2. Long term, depending upon pollutant compare worst 1 yr of 5 concentration in air or deposition on soil with appropriate bench marks for chronic effects.
3. For compounds that may accumulate, evaluate estimated total deposition over life of project. These concentrations should be compared against benchmarks.

Listed Species:

The following species may occur within a short distance of the facility:

1. Bald Eagle (*Haliaeetus leucocephalus*)
2. Indiana Bat (*Myotis sodalist*): can occur in caves, mines and forage in small stream corridors with well developed riparian woods and upland forests.
3. Eastern Prairie Fringed Orchid (*Platanthera leucophaea*): can occur in Mesic to wet prairies.
4. Prairie Bush Clover (*Lespedeza leptostachya*): can occur in Dry to mesic prairies with gravelly soil.

5. Decurrent False Aster (*Boltonia decurrens*): occur in flood plain wetlands.
6. Gray Bat (*Myotis grisescens*): occur in Caves and mines; rivers & reservoirs adjacent to forests.
7. Pallid Sturgeon (*Scaphirhynchus albus*): occur in large rivers.

ConocoPhillips may rely on GIS data to exclude certain species from the analysis. The eastern prairie fringed orchid would most likely be associated with wet meadows or wet prairies not in a stream or river floodplain; however, it may also occur on mesic prairie habitat. We suggest using the National Wetlands Inventory (NWI) and the Land Use and Land Cover map to determine if suitable habitat is present. The NWI code that best illustrates the wet prairie habitat would be the PEM series outside of the 100 year floodplain. On the Land Use and Land Cover maps, look for nonagricultural grassland.

To rule out the prairie bush clover use the Land Use and Land Cover map. Look for nonagricultural grasslands. If there are none, than the prairie bush clover can be excluded.

To rule out the Indiana Bat, look for grassy field, stream corridors and forested, non-developed areas. If there are none, then the Indiana Bat may be ruled out.

APPENDIX B

HABITAT DESCRIPTIONS

Habitat Descriptions for Federal Threatened and Endangered Species in Madison County, Illinois

The threatened **bald eagle** (*Haliaeetus leucocephalus*) is listed as breeding and wintering in Madison County. Breeding eagles are usually found near large water bodies usually in emergent canopy trees. During the winter, this species feeds on fish in the open water areas created by dam tailwaters, the warm water effluents of power plants, and municipal and industrial discharges, or in power plant cooling ponds. The more severe the winter, the greater the ice coverage and the more concentrated the eagles become. They roost at night in groups in large trees adjacent to the river in areas that are protected from the harsh winter elements. They perch in large shoreline trees to rest or feed on fish. There is no critical habitat designated for this species. The eagle may not be harassed, harmed, or disturbed when present nor may nest trees be cleared.

The endangered **Indiana bat** (*Myotis sodalis*) is known to occur in Madison County. Indiana bats are considered to potentially occur in any area with forested habitat.

Indiana bats migrate seasonally between winter hibernacula and summer roosting habitats. Winter hibernacula include caves and abandoned mines. Females form nursery colonies under the loose bark of trees (dead or alive) and/or cavities, where each female gives birth to a single young in June or early July. A single colony may utilize a number of roost trees during the summer, typically a primary roost tree and several alternates. The species or size of tree does not appear to influence whether Indiana bats utilize a tree for roosting provided the appropriate bark structure is present.

During the summer, the Indiana bat frequents the corridors of small streams with riparian woods as well as mature upland forests. It forages for insects along stream corridors, within the canopy of floodplain and upland forests, over clearings with early successional vegetation (old fields), along the borders of croplands, along wooded fencerows, over farm ponds, and in pastures.

Suitable summer habitat in Illinois is considered to have the following characteristics within a ½ mile radius of a project site:

1) forest cover of 15% or greater;
2) permanent water;
3) one or more of the following tree species: shagbark and shellbark hickory that may be dead or alive, and dead bitternut hickory, American elm, slippery elm, eastern cottonwood, silver maple, white oak, red oak, post oak, and shingle oak with slabs or plates of loose bark;
4) potential roost trees with 10% or more peeling or loose bark

If the project site contains any habitat that fits the above description, it may be necessary to conduct a survey to determine whether the bat is present.

The **gray bat** (*Myotis grisescens*) is also listed as endangered in Madison County where it inhabits caves both summer and winter. A search for both these species should be made prior to any cave-impacting activities. If habitat is present or Indiana bats or gray bats are known to be present, they must not be harmed, harassed, or disturbed, and this field office should be contacted for further assistance.

The **decurrent false aster** *(Boltonia decurrens)* is listed as threatened and known to occur in Madison County, Illinois (Mississippi River floodplain). It occupies disturbed alluvial soils in the floodplains of the Illinois River and may potentially occur in its tributaries that have suitable habitat. Decurrent false aster is an early successional species that requires either natural or human disturbance to create and maintain suitable habitat and individual populations may change from year to year. There is no critical habitat listed for this species in Illinois.

The **eastern prairie fringed orchid** *(Platanthera leucophaea)* is listed as threatened and considered to potentially occur statewide in Illinois based on its historical records and habitat distribution, but we are unaware of any record for Madison County. It occupies mesic to wet grassland habitats. There is no critical habitat designated for this species. Federal regulations prohibit any commercial activity involving this species or the destruction, malicious damage, or removal of this species from Federal land or any other lands in knowing violation of State law or regulation, including State criminal trespass law. Growth of the prairie fringed orchid begins in May and flowering occurs in July. This species should be searched for whenever wet prairie remnants or other wet meadows are encountered.

The **prairie bush clover** (*Lespedeza leptostachya*) is listed as threatened and considered to potentially occur statewide in Illinois based on its historical records and habitat distribution, but is not listed as currently occurring in Madison County. It occupies dry to mesic prairies with gravelly soil. There is no critical habitat designated for this species. Federal regulations prohibit any commercial activity involving this species or the destruction, malicious damage, or removal of this species from Federal land or any other lands in knowing violation of State law or regulation, including State criminal trespass law. This species should be searched for whenever prairie remnants are encountered.

The endangered **pallid sturgeon** (*Scaphirhynchus albus*) is found in the Mississippi River downstream of its confluence with the Missouri River. Illinois counties with known occurrences include the stretch of river below the Mel Price Lock and Dam 26, including Madison County. The Chain of Rocks area in Madison County is a known spawning ground for this species. Little is known of its habitat preferences; however, it is suspected that sand/gravel bars may be utilized for spawning.

PLANT SPECIES MAPS FOR ILLINOIS COUNTIES

FIGURE C-1.
IL COUNTIES WITH KNOWN OCCURRENCES – EASTERN PRAIRIE FRINGED ORCHID

FIGURE C-2.
IL COUNTIES WITH KNOWN OCCURRENCES – PRAIRIE BUSH CLOVER

MEDIA CONCENTRATION CALCULATIONS

Table D1-1. Arsenic Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (EPA Region 5, RCRA)	Freshwater TRV*	Freshwater Sediment TRV*	Terrestrial Plant TRV*	Mammal TRV*	Bird TRV*	Project Increase Percent of Background
Soil (mg/kg)	1.14E+00	1.30E+04	1.30E+04	5.70E+03			1.00E+03			0.01%
Water (mg/L)	4.67E-06	2.36E+00	2.36E+00	1.48E+02	1.50E+02					N/A
Sediment (mg/kg)	1.43E-04	9.89E+03	9.89E+03	9.79E+03		6.00E+03				0.00%

Notes:
Background concentrations for soil obtained from 35 IAC 742 Appendix A, Table G for counties within MSA
Background concentrations for water obtained using USGS data for Mississippi River below St. Louis. Value listed is mean value. Data provided by USEPA Region 5.
Ecological screening levels obtained from USEPA Region 5
Sediment background levels obtained from EPA's Storet Data Warehouse. Value listed represents average background level for Madision and St. Clair counties for data from 2000-2007.

*Appendix E of SLERA Protocol

Table D1-2. Arsenic Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**1.14E-03**	COPC concentration in soil (mg COPC/kg soil)
tD	**1.00E+02**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**3.33E-05**	Deposition term (mg COPC/kg soil/yr)
$Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]$		
	1.00E+02	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-14)
	3.15E-01	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3.00E+00	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	0.00E+00	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	1.00E-05	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00E+00	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**2.72E-02**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	0.00E+00	COPC loss constant due to biotic and abiotic degradation (yr-1) (SLERA Protocol Table A-2-14[1])
kse	0.00E+00	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	2.72E-02	COPC loss constant due to surface runoff (yr^{-1})
ksl	7.61E-18	COPC loss constant due to leaching (yr^{-1})
ksv	0.00E+00	COPC loss constant due to volatilization (yr^{-1})
ksr	**2.72E-02**	COPC loss constant due to surface runoff (yr^{-1})
$ksr = RO / (q_{sw} * Z_s) * \{1/[1 + (Kd_s * BD/q_{sw})]\}$		
RO	2.54E+01	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	3.10E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-14[2])
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**7.61E-18**	COPC loss constant due to leaching (yr^{-1})
$ksl = (P + I - RO - E_v) / \{q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]\}$		
P	8.89E+01	Annual average precipitation (cm/yr) (NOAA)
I	0.00E+00	Average annual irrigation (cm/yr) (Assumed to be zero due to low irrigation percentage in Illinois)
RO	2.54E+01	Average annual surface runoff (cm/yr)
E_v	6.35E+01	Average annual evapotranspiration (cm/yr)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	3.10E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-14)
ksv	**0.00E+00**	
$ksv = [3.1536 \times 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]$		
	3.15E+07	Units conversion factor (s/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-14)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	3.10E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-14)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_a	2.98E+02	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.70E+00	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	1.07E-01	Diffusivity of COPC in air (cm^2/s) (SLERA Protocol Table A-2-14)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

Wet and dry deposition rates represent the highest value modeled at any receptor.

Assumes all arsenic is in particle phase.

Table D1-3. Arsenic Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**1.37E+03**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**4.00E+01**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4.00E+06	Water body surface area (m^2) (estimate based on 3 km radius around facility)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-14)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	1.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**0.00E+00**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	0.00E+00	Overall transfer rate coefficient (m/yr)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-14)
Cvp	0.00E+00	Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-14)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**2.75E+02**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-14)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	1.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2) (estimate based on aerial photo)
L_R	**7.72E+02**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * Cs * BD/(q_{sw} + Kd_s * BD) * 0.01$		
RO	2.54E+01	Average annual surface runoff (cm/yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2) (estimate based on 3 km radius around facility)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
Cs	1.14E-03	COPC concentration in soil (mg/kg)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	3.10E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-14)
	1.00E-02	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**2.84E+02**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
ER	1.00E+00	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	1.14E-03	COPC concentration in soil (mg/kg)
Kd_s	3.10E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-14)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	1.00E-03	Units conversion factor (g/mg)
L_I	**0.00E+00**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**2.54E+01**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	3.00E+02	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	3.60E-01	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[1])
LS	1.50E+00	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7)
C	7.00E-01	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1.00E+00	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	9.07E+02	Units conversion factor (kg/ton)
	4.05E+03	Units conversion factor (m^2/acre)
SD	**1.19E-01**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.20E+00	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[2])
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
b	1.25E-01	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1]Based on available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4, therefore used default value of 0.36.

[2]Watershed area estimated to be receiving COPC is 43 sq. mi. based on 3 km radius around facility.

(shaded) Assume no vapor phase contributions for arsenic.

Table D1-4. Arsenic Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**6.20E-09**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**1.37E+03**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**2.97E+11**	Average volumetric flow rate through water body (m^3/yr) (Average value for 1980-2005 from water quality data provided by EPA Region 5)
f_{wc}	**7.45E-01**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = (1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	2.55E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	3.10E+01	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-14[1])
TSS	3.00E+02	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	1.00E-06	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	6.00E-01	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	3.10E+01	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-14[1])
k_{wt}	**0.00E+00**	Overall total water body COPC dissipation rate constant (yr^{-1})
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	7.45E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	0.00E+00	Water column volatilization rate constant (yr^{-1})
f_{bs}	2.55E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	0.00E+00	Benthic burial rate constant (yr^{-1})
A_w	**4.00E+06**	Water body surface area (m^2)
k_v	**0.00E+00**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	0.00E+00	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74E+00	Depth of water column (m)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	3.10E+01	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-14)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
	1.00E-05	Units conversion factor (kg/mg)
K_v	**0.00E+00**	Overall COPC transfer rate coefficient (m/yr)
$K_v = \{K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}\}^{-1} * q^{(Twk - 293)}$		
K_L	1.06E+03	Liquid-phase transfer coefficient (m/yr)
K_G	3.65E+04	Gas-phase transfer coefficient (m/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-14)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.03E+00	Temperature correction factor (unitless) (value from SLERA Protocol Table B-2-13)
K_L	**1.06E+03**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT(10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	1.46E-05	Diffusivity of COPC in water (cm^2/s) (SLERA Protocol Table A-2-14)
u	2.13E+00	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**3.65E+04**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (value from SLERA Protocol Table B-2-15)
k_b	**0.00E+00**	Benthic burial rate constant (yr^{-1})[4,6]
$k_b = [(X_e * A_L * SD * 10^3 - Vf_x * TSS) / (A_W * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
Vf_x	2.97E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
A_W	4.00E+06	Water body surface area (m^2)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1] Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2] Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range

[3] Based on minimum navigation channel depth of 9 ft. required by Corps of Engineers.

[4] Assume COPC does not dissipate based on Henry's Law constant of zero.

[5] Current velocity ranges from 3-7 ft/s based on information from various sources.

[6] Since the watershed area receiving COPC is several orders of magnitude less than the volumetric flow rate through the water body, k_b is assumed to be zero instead of negative.

(shaded) Assumes no vapor phase contributions for arsenic.

Table D1-5. Arsenic Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**4.67E-09**	Total COPC concentration in water column (mg/L)
	f_{wc}	7.45E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	6.20E-09	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D1-6. Arsenic Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**4.63E-09**	Dissolved phase water concentration (mg/L)
	C_{wctot}	4.67E-09	Total COPC concentration in water column (mg/L)
	Kd_{sw}	3.10E+01	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-14)
	TSS	3.00E+02	Total suspended solids concentration (mg/L)

Table D1-7. Arsenic Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**1.43E-07**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**2.55E-01**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**6.20E-09**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**3.10E+01**	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-14)
q_{bs}	**6.00E-01**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.00E+00**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**3.00E-02**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

D2-1. Cadmium Summary

	Concentration from Project
Soil (µg/kg)	0.00E+00
Water (µg/L)	0.00E+00
Sediment (µg/kg)	0.00E+00

Notes:
Deposition rate represents the highest value modeled at any river receptor.

Table D2-2. Cadmium Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**0.00E+00**	COPC concentration in soil (mg COPC/kg soil)
tD	**1.00E+02**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**0.00E+00**	Deposition term (mg COPC/kg soil/yr)
Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]		
	1.00E+02	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-35)
	3.15E-01	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3.00E+00	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	0.00E+00	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	0.00E+00	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00E+00	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**1.97E-04**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	0.00E+00	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (SLERA Protocol Table A-2-35[1])
kse	0.00E+00	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	1.97E-04	COPC loss constant due to surface runoff (yr-1)
ksl	5.51E-20	COPC loss constant due to leaching (yr^{-1})
ksv	0.00E+00	COPC loss constant due to volatilization (yr^{-1})
ksr	**1.97E-04**	COPC loss constant due to surface runoff (yr-1)
ksr = RO / (q_{sw} * Z_s) * {1/[1 + (Kd_s * BD/q_{sw})]}		
RO	2.54E+01	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	4.30E+03	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-35)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**5.51E-20**	COPC loss constant due to leaching (yr^{-1})
ksl = (P + I - RO - E_v) / {q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]}		
P	8.89E+01	Annual average precipitation (cm/yr) (NOAA)
I	0.00E+00	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	2.54E+01	Average annual surface runoff (cm/yr)
E_v	6.35E+01	Average annual evapotranspiration (cm/yr)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	4.30E+03	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-35[2])
ksv	**0.00E+00**	
ksv = [3.1536 x 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]		
	3.15E+07	Units conversion factor (s/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-35)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	4.30E+03	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-35)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_a	2.98E+02	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.70E+00	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	8.16E-02	Diffusivity of COPC in air (cm^2/s) (SLERA Protocol Table A-2-35)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

Deposition rate represents the highest value modeled at any river receptor.

Table D2-3. Cadmium Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**0.00E+00**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**0.00E+00**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4.00E+06	Water body surface area (m^2) (estimate based on aerial photo)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-35)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00E+00	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**0.00E+00**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)[1]
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	#DIV/0!	Overall transfer rate coefficient (m/yr)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-35)
Cvp		Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-35)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**0.00E+00**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-35)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00E+00	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
L_R	**0.00E+00**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(q_{sw} + Kd_s * BD)] * 0.01$		
RO	2.54E+01	Average annual surface runoff (cm/yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
Cs	0.00E+00	COPC concentration in soil (mg/kg)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	4.30E+03	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-35)
	1.00E-02	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**0.00E+00**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
ER	1.00E+00	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	0.00E+00	COPC concentration in soil (mg/kg)
Kd_s	4.30E+03	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-35)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	1.00E-03	Units conversion factor (g/mg)
L_I	**0.00E+00**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**2.54E+01**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	3.00E+02	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	3.60E-01	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[2])
LS	1.50E+00	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[3])
C	7.00E-01	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1.00E+00	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	9.07E+02	Units conversion factor (kg/ton)
	4.05E+03	Units conversion factor (m^2/acre)
SD	**1.19E-01**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.20E+00	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[4])
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
b	1.25E-01	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1] Assume vapor phase COPC diffusion load to water body is zero for Nickel.

[2] Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.

[3] Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.

[4] Watershed area estimated to be receiving COPC is 43 sq. mi.

Table D2-4. Cadmium Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**0.00E+00**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**0.00E+00**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.62E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**2.82E-01**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	7.18E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	4.30E+03	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-35[1])
TSS	3.00E+02	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	6.00E-01	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	4.30E+03	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-35[1])
k_{wt}	**0.00E+00**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	2.82E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	0.00E+00	Water column volatilization rate constant (yr^{-1})
f_{bs}	7.18E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.32E+11	Benthic burial rate constant (yr^{-1})
A_w	**4.00E+06**	Water body surface area (m^2)
k_v	**0.00E+00**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	#DIV/0!	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74E+00	Depth of water column (m)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	4.30E+03	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-35)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	**#DIV/0!**	Overall COPC transfer rate coefficient (m/yr)
$K_v = \{K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}\}^{-1} * q^{(Twk - 293)}$		
K_L	5.57E+02	Liquid-phase transfer coefficient (m/yr)
K_G	3.65E+04	Gas-phase transfer coefficient (m/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-35)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.03E+00	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**5.57E+02**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT(10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	9.45E-06	Diffusivity of COPC in water (cm^2/s) (SLERA Protocol Table A-2-35)
u	9.14E-01	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**3.65E+04**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.32E+11**	Benthic burial rate constant (yr^{-1})
$k_b = [X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_W * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
Vf_x	1.62E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
A_W	4.00E+06	Water body surface area (m^2)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1] Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2] Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3] Based on minimum depth required by Corps of Engineers

[4] Assume COPC does not dissipate based on Henry's Law constant of zero.

[5] Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D2-5. Cadmium Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**0.00E+00**	Total COPC concentration in water column (mg/L)
	f_{wc}	2.82E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	0.00E+00	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D2-6. Cadmium Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**0.00E+00**	Dissolved phase water concentration (mg/L)
	C_{wctot}	0.00E+00	Total COPC concentration in water column (mg/L)
	Kd_{sw}	4.30E+03	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-35)
	TSS	3.00E+02	Total suspended solids concentration (mg/L)

Table D2-7. Cadmium Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**0.00E+00**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**7.18E-01**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**0.00E+00**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**4.30E+03**	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-35)
q_{bs}	**6.00E-01**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.00E+00**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**3.00E-02**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

Table D3-1. Chromium Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (EPA Region 5, RCRA)	Freshwater TRV*	Freshwater Sediment TRV*	Terrestrial Plant TRV*	Mammal TRV*	Bird TRV*	Project Increase Percent of Background
Soil (mg/kg)	5.00E+00	1.62E+04	1.62E+04	4.00E+02			1.80E+01			0.03%
Water (mg/L)	7.15E-05	1.17E+00	1.17E+00	4.20E+01	1.10E+01					N/A
Sediment (mg/kg)	7.33E-04	1.94E+04	1.94E+04	4.34E+04		2.60E+04				N/A

Notes:
Background concentrations for soil obtained from 35 IAC 742 Appendix A, Table G for counties within MSA
Background concentrations for water obtained using USGS data for Mississippi River below St. Louis. Value listed is mean value. Data provided by USEPA Region 5.
Sediment background levels obtained from EPA's Storet Data Warehouse. Value listed represents average background level for Madision and St. Clair counties for data from 2000-2007.
Ecological screening levels obtained from USEPA Region 5. Levels listed are for total chromium.

*Appendix E of SLERA Protocol. Freshwater Sediment TRV is for total chromium. All other values are for hexavalent chromium.

Table D3-2. Chromium Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**5.00E-03**	COPC concentration in soil (mg COPC/kg soil)
tD	**1.00E+02**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**3.00E-04**	Deposition term (mg COPC/kg soil/yr)
Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]		
	1.00E+02	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-53)
	3.15E-01	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3.00E+00	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	0.00E+00	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	9.00E-05	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00E+00	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**5.99E-02**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	0.00E+00	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (SLERA Protocol Table A-2-53[1])
kse	0.00E+00	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	5.99E-02	COPC loss constant due to surface runoff (yr-1)
ksl	1.68E-17	COPC loss constant due to leaching (yr^{-1})
ksv	0.00E+00	COPC loss constant due to volatilization (yr^{-1})
ksr	**5.99E-02**	COPC loss constant due to surface runoff (yr-1)
ksr = RO / (q_{sw} * Z_s) * {1/[1 + (Kd_s * BD/q_{sw})]}		
RO	2.54E+01	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.40E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-53)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**1.68E-17**	COPC loss constant due to leaching (yr^{-1})
ksl = (P + I - RO - E_v) / {q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]}		
P	8.89E+01	Annual average precipitation (cm/yr) (NOAA)
I	0.00E+00	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	2.54E+01	Average annual surface runoff (cm/yr)
E_v	6.35E+01	Average annual evapotranspiration (cm/yr)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	1.40E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-53[2])
ksv	**0.00E+00**	
ksv = [3.1536 x 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]		
	3.15E+07	Units conversion factor (s/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-53)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.40E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-53)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_a	2.98E+02	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.70E+00	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	1.36E-01	Diffusivity of COPC in air (cm^2/s) (SLERA Protocol Table A-2-53)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

Deposition rates represent the highest value modeled at any target receptor.

Table D3-3. Chromium Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**1.15E+04**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**3.60E+02**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4.00E+06	Water body surface area (m^2) (estimate based on aerial photo)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-53)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	9.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**0.00E+00**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)[1]
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	#DIV/0!	Overall transfer rate coefficient (m/yr)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-53)
Cvp		Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-53)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**2.48E+03**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-53)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	9.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
L_R	**7.42E+03**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(q_{sw} + Kd_s * BD)] * 0.01$		
RO	2.54E+01	Average annual surface runoff (cm/yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
Cs	5.00E-03	COPC concentration in soil (mg/kg)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	1.40E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-53)
	1.00E-02	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**1.23E+03**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
ER	1.00E+00	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	5.00E-03	COPC concentration in soil (mg/kg)
Kd_s	1.40E+01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-53)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	1.00E-03	Units conversion factor (g/mg)
L_I	**0.00E+00**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**2.54E+01**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	3.00E+02	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	3.60E-01	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[2])
LS	1.50E+00	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[3])
C	7.00E-01	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1.00E+00	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	9.07E+02	Units conversion factor (kg/ton)
	4.05E+03	Units conversion factor (m^2/acre)
SD	**1.19E-01**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.20E+00	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[4])
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
b	1.25E-01	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1] Assume vapor phase COPC diffusion load to water body is zero.

[2] Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.

[3] Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.

[4] Watershed area estimated to be receiving COPC is 43 sq. mi.

Table D3-4. Chromium Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**7.90E-08**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**1.15E+04**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.62E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**8.95E-01**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	1.05E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	1.40E+01	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-53[1])
TSS	3.00E+02	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	6.00E-01	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	1.40E+01	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-53[1])
k_{wt}	**0.00E+00**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	8.95E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	0.00E+00	Water column volatilization rate constant (yr^{-1})
f_{bs}	1.05E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.32E+11	Benthic burial rate constant (yr^{-1})
A_w	**4.00E+06**	Water body surface area (m^2)
k_v	**0.00E+00**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	#DIV/0!	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74E+00	Depth of water column (m)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	1.40E+01	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-53)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	**#DIV/0!**	Overall COPC transfer rate coefficient (m/yr)
$K_v = \{K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}\}^{-1} * q^{(Twk - 293)}$		
K_L	7.20E+02	Liquid-phase transfer coefficient (m/yr)
K_G	3.65E+04	Gas-phase transfer coefficient (m/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-53)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.03E+00	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**7.20E+02**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT(10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	1.58E-05	Diffusivity of COPC in water (cm^2/s) (SLERA Protocol Table A-2-53)
u	9.14E-01	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**3.65E+04**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.32E+11**	Benthic burial rate constant (yr^{-1})
$k_b = [X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_W * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
Vf_x	1.62E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
A_W	4.00E+06	Water body surface area (m^2)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1] Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2] Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3] Based on minimum depth required by Corps of Engineers

[4] Assume COPC does not dissipate based on Henry's Law constant of zero.

[5] Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D3-5. Chromium Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**7.15E-08**	Total COPC concentration in water column (mg/L)
	f_{wc}	8.95E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	7.90E-08	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D3-6. Chromium Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**6.86E-08**	Dissolved phase water concentration (mg/L)
	C_{wctot}	7.15E-08	Total COPC concentration in water column (mg/L)
	Kd_{sw}	1.40E+01	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-53)
	TSS	3.00E+02	Total suspended solids concentration (mg/L)

Table D3-7. Chromium Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**7.33E-07**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**1.05E-01**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**7.90E-08**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**1.40E+01**	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-53)
q_{bs}	**6.00E-01**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.00E+00**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**3.00E-02**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

Table D4-1. Cobalt Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (EPA Region 5, RCRA)	Project Increase Percent of Background
Soil (µg/kg)	3.33E+00	8.90E+03	8.90E+03	1.40E+02	0.04%
Water (µg/L)	7.13E-06	3.00E+00	3.00E+00	2.40E+01	N/A
Sediment (µg/kg)	1.78E-03	N/A	N/A	5.00E+04	N/A

Notes:
Background concentrations for soil obtained from 35 IAC 742 Appendix A, Table G for counties within MSA
Background concentrations for water obtained using USGS data for Mississippi River below St. Louis. Value listed is mean value. Data provided by USEPA Region 5.
Ecological screening levels obtained from USEPA Region 5

Table D4-2. Cobalt Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**3.33E-03**	COPC concentration in soil (mg COPC/kg soil)
tD	**1.00E+02**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**3.33E-05**	Deposition term (mg COPC/kg soil/yr)
Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]		
	1.00E+02	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
	3.15E-01	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3.00E+00	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	0.00E+00	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	1.00E-05	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00E+00	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**8.47E-06**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	0.00E+00	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (No data available. Assume same value as other metal HAPs)
kse	0.00E+00	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	8.47E-06	COPC loss constant due to surface runoff (yr-1)
ksl	2.37E-21	COPC loss constant due to leaching (yr^{-1})
ksv	0.00E+00	COPC loss constant due to volatilization (yr^{-1})
ksr	**8.47E-06**	COPC loss constant due to surface runoff (yr-1)
ksr = RO / (q_{sw} * Z_s) * {1/[1 + (Kd_s * BD/q_{sw})]}		
RO	2.54E+01	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**2.37E-21**	COPC loss constant due to leaching (yr^{-1})
ksl = (P + I - RO - E_v) / {q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]}		
P	8.89E+01	Annual average precipitation (cm/yr) (NOAA)
I	0.00E+00	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	2.54E+01	Average annual surface runoff (cm/yr)
E_v	6.35E+01	Average annual evapotranspiration (cm/yr)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume same value as other metal HAPs)
ksv	**0.00E+00**	
ksv = [3.1536 x 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]		
	3.15E+07	Units conversion factor (s/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (No data available. Assume same value as other metal HAPs)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_a	2.98E+02	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.70E+00	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	0.00E+00	Diffusivity of COPC in air (cm^2/s) (Equation equals zero due to Henry's law constant, assume diffusivity is zero)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

Table D4-3. Cobalt Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**1.15E+03**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**4.00E+01**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4.00E+06	Water body surface area (m^2) (estimate based on aerial photo)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	1.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**0.00E+00**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)[1]
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	#DIV/0!	Overall transfer rate coefficient (m/yr)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
Cvp		Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (No data available. Assume same value as other metal HAPs)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**2.75E+02**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	1.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
L_R	**6.99E-01**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(q_{sw} + Kd_s * BD)] * 0.01$		
RO	2.54E+01	Average annual surface runoff (cm/yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
Cs	3.33E-03	COPC concentration in soil (mg/kg)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
	1.00E-02	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**8.29E+02**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
ER	1.00E+00	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	3.33E-03	COPC concentration in soil (mg/kg)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	1.00E-03	Units conversion factor (g/mg)
L_I	**0.00E+00**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**2.54E+01**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	3.00E+02	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	3.60E-01	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[2])
LS	1.50E+00	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[3])
C	7.00E-01	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1.00E+00	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	9.07E+02	Units conversion factor (kg/ton)
	4.05E+03	Units conversion factor (m^2/acre)
SD	**1.19E-01**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.20E+00	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[4])
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
b	1.25E-01	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1]Assume vapor phase COPC diffusion load to water body is zero for Nickel.

[2]Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.

[3]Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.

[4]Watershed area estimated to be receiving COPC is 43 sq. mi.

Table D4-4. Cobalt Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**2.64E-08**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**1.15E+03**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.62E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**2.68E-01**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	7.32E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	1.00E+05	Suspended sediments/surface water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
TSS	3.00E+02	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	6.00E-01	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	1.00E+05	Bed sediment/sediment pore water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
k_{wt}	**0.00E+00**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	2.68E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	0.00E+00	Water column volatilization rate constant (yr^{-1})
f_{bs}	7.32E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.32E+11	Benthic burial rate constant (yr^{-1})
A_w	**4.00E+06**	Water body surface area (m^2)
k_v	**0.00E+00**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	#DIV/0!	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74E+00	Depth of water column (m)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	1.00E+05	Suspended sediments/surface water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs emitted from process - chromium)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	**#DIV/0!**	Overall COPC transfer rate coefficient (m/yr)
$K_v = \{K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}\}^{-1} * q^{(Twk - 293)}$		
K_L	0.00E+00	Liquid-phase transfer coefficient (m/yr)
K_G	3.65E+04	Gas-phase transfer coefficient (m/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (No data available. Assume same value as other metal HAPs)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.03E+00	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**0.00E+00**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT(10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	0.00E+00	Diffusivity of COPC in water (cm^2/s) (Diffusivity value not used since Henry's Law constant equals zero in K_v equation, assume zero.)
u	9.14E-01	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**3.65E+04**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.32E+11**	Benthic burial rate constant (yr^{-1})
$k_b = \{X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_W * TSS)\} * [TSS * 10^{-6} / (BS * d_{bs})\}$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
Vf_x	1.62E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
A_W	4.00E+06	Water body surface area (m^2)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1]Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2]Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3]Based on minimum depth required by Corps of Engineers

[4]Assume COPC does not dissipate based on Henry's Law constant of zero.

[5]Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D4-5. Cobalt Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**7.13E-09**	Total COPC concentration in water column (mg/L)
	f_{wc}	2.68E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	2.64E-08	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D4-6. Cobalt Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**2.37E-11**	Dissolved phase water concentration (mg/L)
	C_{wctot}	7.13E-09	Total COPC concentration in water column (mg/L)
	Kd_{sw}	1.00E+05	Suspended sediments/surface water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
	TSS	3.00E+02	Total suspended solids concentration (mg/L)

Table D4-7. Cobalt Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$

C_{sed}	**1.78E-06**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**7.32E-01**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**2.64E-08**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**1.00E+05**	Bed sediment/sediment pore water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
q_{bs}	**6.00E-01**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.00E+00**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**3.00E-02**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

Table D5-1. Lead Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (EPA Region 5, RCRA)	Freshwater TRV*	Freshwater Sediment TRV*	Terrestrial Plant TRV*	Mammal TRV*	Bird TRV*	Project Increase Percent of Background
Soil (mg/kg)	1.91E+01	3.60E+04	3.60E+04	5.37E+01			4.60E+03			0.05%
Water (mg/L)	4.41E-05	7.00E-02	7.00E-02	1.17E+00	2.50E+00					0.06%
Sediment (mg/kg)	8.08E-03	5.32E+04	5.32E+04	3.58E+04		3.10E+04				0.00%

Notes:

Background concentrations for soil obtained from 35 IAC 742 Appendix A, Table G for counties within MSA

Background concentrations for water obtained using USGS data for Mississippi River below St. Louis. Value listed is mean value. Data provided by USEPA Region 5.

Sediment background levels obtained from EPA's Storet Data Warehouse. Value listed represents average background level for Madision and St. Clair counties for data from 2000-2007.

Ecological screening levels obtained from USEPA Region 5

*Appendix E of SLERA Protocol

Table D5-2. Lead Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**0.02**	COPC concentration in soil (mg COPC/kg soil)
tD	**100**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**0.00**	Deposition term (mg COPC/kg soil/yr)
$Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]$		
	100	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	0.0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-128)
	0.31536	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	0.00000	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00000	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	0.00006	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00000	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**9.41E-04**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	0	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (SLERA Protocol Table A-2-128[1])
kse	0	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	9.41E-04	COPC loss constant due to surface runoff (yr-1)
ksl	2.6312E-19	COPC loss constant due to leaching (yr^{-1})
ksv	0.00E+00	COPC loss constant due to volatilization (yr^{-1})
ksr	**0.0009406**	COPC loss constant due to surface runoff (yr-1)
$ksr = RO / (q_{sw} * Z_s) * \{1/[1 + (Kd_s * BD/q_{sw})]\}$		
RO	25.4	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	9.00E+02	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-128)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**2.6312E-19**	COPC loss constant due to leaching (yr^{-1})
$ksl = (P + I - RO - E_v) / \{q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]\}$		
P	88.9	Annual average precipitation (cm/yr) (NOAA)
I	0	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	25.4	Average annual surface runoff (cm/yr)
E_v	63.5	Average annual evapotranspiration (cm/yr)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-128[2])
ksv	**0**	
$ksv = [3.1536 \times 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]$		
	3.1536E+07	Units conversion factor (s/yr)
H	0.0	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-128)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-128)
R	8.205E-05	Universal gas constant (atm-m^3/mol-K)
T_a	298	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.7	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	5.43E-02	Diffusivity of COPC in air (cm^2/s) (SLERA Protocol Table A-2-128)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

Table D5-3. Lead Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**7088.33112**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**240**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4,000,000	Water body surface area (m^2) (estimate based on aerial photo)
F_v	0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-128)
Dwvp	0.00000	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00006	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**0**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)[1]
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	#DIV/0!	Overall transfer rate coefficient (m/yr)
F_v	0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-128)
Cvp		Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	0	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-128)
R	8.205E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	298	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**1652.08069**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-128)
Dwvp	0	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00006	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	27,534,678	Impervious watershed area receiving COPC deposition (m^2)
L_R	**444.931662**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(q_{sw} + Kd_s * BD)] * 0.01$		
RO	25.4	Average annual surface runoff (cm/yr)
A_L	110,138,712	Total watershed area receiving COPC deposition (m^2)
A_I	27534678.1	Impervious watershed area receiving COPC deposition (m^2)
Cs	0.01908821	COPC concentration in soil (mg/kg)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-128)
	0.01	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**4751.31877**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	25.4198695	Unit soil loss (kg/m^2-yr)
A_L	110138712	Total watershed area receiving COPC deposition (m^2)
A_I	27534678.1	Impervious watershed area receiving COPC deposition (m^2)
SD	0.11856015	Watershed sediment delivery ratio (unitless)
ER	1	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	0.01908821	COPC concentration in soil (mg/kg)
Kd_s	900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-128)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	0.001	Units conversion factor (g/mg)
L_I	**0**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**25.4198695**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	300	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	0.36	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[2])
LS	1.5	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[3])
C	0.7	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	907.18	Units conversion factor (kg/ton)
	4047	Units conversion factor (m^2/acre)
SD	**0.11856015**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.2	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[4])
A_L	110138712	Total watershed area receiving COPC deposition (m^2)
b	0.125	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1]Assume vapor phase COPC diffusion load to water body is zero for Lead.

[2]Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.

[3]Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.

[4]Watershed area estimated to be receiving COPC is 43 sq. mi.

Table D5-4. Lead Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**1.3116E-07**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**7088.33112**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.6241E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**0.3327613**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	0.6672387	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	900	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-128[1])
TSS	300	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.0	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	0.6	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	900	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-128[1])
k_{wt}	**0**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	0.3327613	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	0	Water column volatilization rate constant (yr^{-1})
f_{bs}	0.6672387	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.3193E+11	Benthic burial rate constant (yr^{-1})
A_w	**4000000**	Water body surface area (m^2)
k_v	**0**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	#DIV/0!	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74	Depth of water column (m)
d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	900	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-128)
TSS	300	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	**#DIV/0!**	Overall COPC transfer rate coefficient (m/yr)
$K_v = [K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}]^{-1} * q^{(Twk - 293)}$		
K_L	453.799425	Liquid-phase transfer coefficient (m/yr)
K_G	36500	Gas-phase transfer coefficient (m/yr)
H	0	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-128)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	298	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.026	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**453.799425**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT(10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	6.28E-06	Diffusivity of COPC in water (cm^2/s) (SLERA Protocol Table A-2-128)
u	0.9144	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**36500**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.3193E+11**	Benthic burial rate constant (yr^{-1})
$k_b = [X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_W * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	25.4198695	Unit soil loss (kg/m^2-yr)
A_L	110138712	Total watershed area receiving COPC deposition (m^2)
SD	0.11856015	Watershed sediment delivery ratio (unitless)
Vf_x	1.6241E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	300	Total suspended solids concentration (mg/L)
A_W	4000000	Water body surface area (m^2)
BS	1.0	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1]Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2]Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3]Based on minimum depth required by Corps of Engineers

[4]Assume COPC does not dissipate based on Henry's Law constant of zero.

[5]Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D5-5. Lead Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**4.4122E-08**	Total COPC concentration in water column (mg/L)
	f_{wc}	0.3327613	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	1.3116E-07	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D5-6. Lead Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**1.1925E-08**	Dissolved phase water concentration (mg/L)
	C_{wctot}	4.4122E-08	Total COPC concentration in water column (mg/L)
	Kd_{sw}	900	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-128)
	TSS	300	Total suspended solids concentration (mg/L)

Table D5-7. Lead Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**8.0844E-06**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**0.6672387**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**1.3116E-07**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**900**	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-128)
q_{bs}	**0.6**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.0**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**0.03**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

Table D6-1. Manganese Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (ADEC)*	Freshwater TRV*	Freshwater Sediment TRV*	Terrestrial Plant TRV*	Mammal TRV*	Bird TRV*	Project Increase Percent of Background
Soil (mg/kg)	6.66E+00	6.36E+05	6.36E+05	1.00E+02			5.00E+02	1.04E+03	.	0.00%
Water (mg/L)	1.43E-05	1.30E+00	1.30E+00	8.00E-02	8.00E-02				8.00E-02	0.00%
Sediment (mg/kg)	3.57E-03	1.16E+06	1.16E+06							0.00%

Notes:
Deposition rates represent the highest value modeled at any target receptor.
Background concentrations for soil obtained from 35 IAC 742 Appendix A, Table G for counties within MSA
Background concentrations for water obtained using USGS data for Mississippi River below St. Louis. Value listed is mean value. Data provided by USEPA Region 5.
Sediment background levels obtained from EPA's Storet Data Warehouse. Value listed represents average background level for Madision and St. Clair counties for data from 2000-2007.
Ecological screening levels obtained User's Guide for Risk-Based Screening in Alaskan Ecological Risk Assessment

*Alaska Department of Environmental Conservation

Table D6-2. Manganese Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**6.66E-03**	COPC concentration in soil (mg COPC/kg soil)
tD	**1.00E+02**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**6.67E-05**	Deposition term (mg COPC/kg soil/yr)
$Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]$		
	1.00E+02	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
	3.15E-01	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3.00E+00	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	0.00E+00	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	2.00E-05	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00E+00	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**8.47E-06**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	0.00E+00	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (No data available. Assume same value as other metal HAPs)
kse	0.00E+00	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	8.47E-06	COPC loss constant due to surface runoff (yr-1)
ksl	2.37E-21	COPC loss constant due to leaching (yr^{-1})
ksv	0.00E+00	COPC loss constant due to volatilization (yr^{-1})
ksr	**8.47E-06**	COPC loss constant due to surface runoff (yr-1)
$ksr = RO / (q_{sw} * Z_s) * \{1/[1 + (Kd_s * BD/q_{sw})]\}$		
RO	2.54E+01	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**2.37E-21**	COPC loss constant due to leaching (yr^{-1})
$ksl = (P + I - RO - E_v) / \{q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]\}$		
P	8.89E+01	Annual average precipitation (cm/yr) (NOAA)
I	0.00E+00	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	2.54E+01	Average annual surface runoff (cm/yr)
E_v	6.35E+01	Average annual evapotranspiration (cm/yr)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
ksv	**0.00E+00**	
$ksv = [3.1536 \times 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]$		
	3.15E+07	Units conversion factor (s/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-52)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-52)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_a	2.98E+02	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.70E+00	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	0.00E+00	Diffusivity of COPC in air (cm^2/s) (Equation equals zero due to Henry's law constant, assume diffusivity is zero)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

Deposition rates represent the highest value modeled at any target receptor.

Table D6-3. Manganese Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**2.29E+03**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**8.00E+01**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4.00E+06	Water body surface area (m^2) (estimate based on aerial photo)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	2.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**0.00E+00**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)[1]
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	#DIV/0!	Overall transfer rate coefficient (m/yr)
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
Cvp		Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-52)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**5.51E+02**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	0.00E+00	Fraction of COPC air concentration in vapor phase (No data available. Assume same value as other metal HAPs)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	2.00E-05	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
L_R	**1.40E+00**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(q_{sw} + Kd_s * BD)] * 0.01$		
RO	2.54E+01	Average annual surface runoff (cm/yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
Cs	6.66E-03	COPC concentration in soil (mg/kg)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
	1.00E-02	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**1.66E+03**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
ER	1.00E+00	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	6.66E-03	COPC concentration in soil (mg/kg)
Kd_s	1.00E+05	Soil-water partition coefficient (cm^3/g) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	1.00E-03	Units conversion factor (g/mg)
L_I	**0.00E+00**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**2.54E+01**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	3.00E+02	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	3.60E-01	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[2])
LS	1.50E+00	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[3])
C	7.00E-01	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1.00E+00	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	9.07E+02	Units conversion factor (kg/ton)
	4.05E+03	Units conversion factor (m^2/acre)
SD	**1.19E-01**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.20E+00	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[4])
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
b	1.25E-01	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1] Assume vapor phase COPC diffusion load to water body is zero for Nickel.

[2] Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.

[3] Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.

[4] Watershed area estimated to be receiving COPC is 43 sq. mi.

Table D6-4. Manganese Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**5.27E-08**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**2.29E+03**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.62E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**2.68E-01**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	7.32E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	1.00E+05	Suspended sediments/surface water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
TSS	3.00E+02	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	6.00E-01	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	1.00E+05	Bed sediment/sediment pore water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs emitted from process - beryllium)
k_{wt}	**0.00E+00**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	2.68E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	0.00E+00	Water column volatilization rate constant (yr^{-1})
f_{bs}	7.32E-01	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.32E+11	Benthic burial rate constant (yr^{-1})
A_w	**4.00E+06**	Water body surface area (m^2)
k_v	**0.00E+00**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	#DIV/0!	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74E+00	Depth of water column (m)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	1.00E+05	Suspended sediments/surface water partition coefficient (L/kg) (No data available. Assume worst case of for metall HAPs emitted from process - chromium)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	#DIV/0!	Overall COPC transfer rate coefficient (m/yr)
$K_v = [K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}]^{-1} * q^{(Twk - 293)}$		
K_L	1.23E+03	Liquid-phase transfer coefficient (m/yr)
K_G	3.65E+04	Gas-phase transfer coefficient (m/yr)
H	0.00E+00	Henry's Law constant (atm-m^3/mol) (No data available. Assume same value as other metal HAPs)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.03E+00	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**1.23E+03**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT (10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	4.63E-05	Diffusivity of COPC in water (cm^2/s) (Diffusivity value not used since Henry's Law constant equals zero in K_v equation, assume zero.)
u	9.14E-01	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**3.65E+04**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.32E+11**	Benthic burial rate constant (yr^{-1})
$k_b = [X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_w * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
Vf_x	1.62E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
A_W	4.00E+06	Water body surface area (m^2)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1] Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2] Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3] Based on minimum depth required by Corps of Engineers

[4] Assume COPC does not dissipate based on Henry's Law constant of zero.

[5] Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D6-5. Manganese Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**1.43E-08**	Total COPC concentration in water column (mg/L)
	f_{wc}	2.68E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	5.27E-08	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D6-6. Manganese Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**4.74E-11**	Dissolved phase water concentration (mg/L)
	C_{wctot}	1.43E-08	Total COPC concentration in water column (mg/L)
	Kd_{sw}	1.00E+05	Suspended sediments/surface water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAF
	TSS	3.00E+02	Total suspended solids concentration (mg/L)

Table D6-7. Manganese Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**3.57E-06**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**7.32E-01**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**5.27E-08**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**1.00E+05**	Bed sediment/sediment pore water partition coefficient (L/kg) (No data available. Assume worst case of for metal HAPs
q_{bs}	**6.00E-01**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.00E+00**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**3.00E-02**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

Table D7-1. Nickel Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (EPA Region 5, RCRA)	Freshwater TRV*	Freshwater Sediment TRV*	Terrestrial Plant TRV*	Mammal TRV*	Bird TRV*	Project Increase Percent of Background
Soil (mg/kg)	4.24E+01	1.80E+04	1.80E+04	1.36E+04			2.50E+04			0.24%
Water (mg/L)	9.41E-05	3.34E+00	3.34E+00	2.89E+01	5.20E+01					N/A
Sediment (mg/kg)	2.01E-02	2.29E+04	2.29E+04	2.27E+04		1.60E+04				0.00%
Dose (mg/kg BW-day)								5.00E+04	6.50E+04	

Notes:
Used highest deposition at any river receptor.
Background concentrations for water obtained using USGS data for Mississippi River below St. Louis. Value listed is mean value. Data provided by USEPA Region 5.
Background concentrations for soil obtained from 35 IAC 742 Appendix A, Table G for counties within MSA
Ecological screening levels obtained from USEPA Region 5
Sediment background levels obtained from EPA's Storet Data Warehouse. Value listed represents average background level for Madision and St. Clair counties for data from 2000-2007.

*Appendix E of SLERA Protocol

Table D7-2. Nickel Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**0.04**	COPC concentration in soil (mg COPC/kg soil)
tD	**100**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**0.00**	Deposition term (mg COPC/kg soil/yr)
Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]		
	100	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	0.0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-145)
	0.31536	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	0.00000	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00000	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	0.00013	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00000	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**4.46E-04**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	0	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (SLERA Protocol Table A-2-145[1])
kse	0	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	4.46E-04	COPC loss constant due to surface runoff (yr-1)
ksl	1.2465E-19	COPC loss constant due to leaching (yr^{-1})
ksv	0.00E+00	COPC loss constant due to volatilization (yr^{-1})
ksr	**0.00044558**	COPC loss constant due to surface runoff (yr-1)
ksr = RO / (q_{sw} * Z_s) * {1/[1 + (Kd_s * BD/q_{sw})]}		
RO	25.4	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-145)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**1.2465E-19**	COPC loss constant due to leaching (yr^{-1})
ksl = (P + I - RO - E_v) / {q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]}		
P	88.9	Annual average precipitation (cm/yr) (NOAA)
I	0	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	25.4	Average annual surface runoff (cm/yr)
E_v	63.5	Average annual evapotranspiration (cm/yr)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	1,900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-145[2])
ksv	**0**	
ksv = [3.1536 x 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]		
	3.1536E+07	Units conversion factor (s/yr)
H	0.0	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-145)
Z_s	20	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-145)
R	8.205E-05	Universal gas constant (atm-m^3/mol-K)
T_a	298	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.7	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	1.26E-01	Diffusivity of COPC in air (cm^2/s) (SLERA Protocol Table A-2-145)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

Used highest deposition at any river receptor.

Table D7-3. Nickel Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**15117.8032**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**520**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4,000,000	Water body surface area (m^2) (estimate based on aerial photo)
F_v	0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-145)
Dwvp	0.00000	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00013	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**0**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)[1]
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	#DIV/0!	Overall transfer rate coefficient (m/yr)
F_v	0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-145)
Cvp		Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	0	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-145)
R	8.205E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	298	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**3579.50815**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	0	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-145)
Dwvp	0	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00013	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	27,534,678	Impervious watershed area receiving COPC deposition (m^2)
L_R	**467.986382**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(q_{sw} + Kd_s * BD)] * 0.01$		
RO	25.4	Average annual surface runoff (cm/yr)
A_L	110,138,712	Total watershed area receiving COPC deposition (m^2)
A_I	27534678.1	Impervious watershed area receiving COPC deposition (m^2)
Cs	0.04238208	COPC concentration in soil (mg/kg)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	1900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-145)
	0.01	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**10550.3086**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	25.4198695	Unit soil loss (kg/m^2-yr)
A_L	110138712	Total watershed area receiving COPC deposition (m^2)
A_I	27534678.1	Impervious watershed area receiving COPC deposition (m^2)
SD	0.11856015	Watershed sediment delivery ratio (unitless)
ER	1	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	0.04238208	COPC concentration in soil (mg/kg)
Kd_s	1900	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-145)
BD	1.5	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	0.2	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	0.001	Units conversion factor (g/mg)
L_I	**0**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**25.4198695**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	300	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	0.36	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[2])
LS	1.5	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[3])
C	0.7	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	907.18	Units conversion factor (kg/ton)
	4047	Units conversion factor (m^2/acre)
SD	**0.11856015**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.2	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[4])
A_L	110138712	Total watershed area receiving COPC deposition (m^2)
b	0.125	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1]Assume vapor phase COPC diffusion load to water body is zero for Nickel.

[2]Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.

[3]Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.

[4]Watershed area estimated to be receiving COPC is 43 sq. mi.

Table D7-4. Nickel Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**3.1058E-07**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**15117.8032**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.6241E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**0.29970636**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	0.70029364	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	1,900	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-145[1])
TSS	300	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.0	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	0.6	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	1,900	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-145[1])
k_{wt}	**0**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	0.29970636	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	0	Water column volatilization rate constant (yr^{-1})
f_{bs}	0.70029364	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.3193E+11	Benthic burial rate constant (yr^{-1})
A_w	**4000000**	Water body surface area (m^2)
k_v	**0**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	#DIV/0!	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74	Depth of water column (m)
d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	1,900	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-145)
TSS	300	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	**#DIV/0!**	Overall COPC transfer rate coefficient (m/yr)
$K_v = \{K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}\}^{-1} * q^{(Twk - 293)}$		
K_L	691.92743	Liquid-phase transfer coefficient (m/yr)
K_G	36500	Gas-phase transfer coefficient (m/yr)
H	0	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-145)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	298	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.026	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**691.92743**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT (10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	1.46E-05	Diffusivity of COPC in water (cm^2/s) (SLERA Protocol Table A-2-145)
u	0.9144	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**36500**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.3193E+11**	Benthic burial rate constant (yr^{-1})
$k_b = [X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_W * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	25.4198695	Unit soil loss (kg/m^2-yr)
A_L	110138712	Total watershed area receiving COPC deposition (m^2)
SD	0.11856015	Watershed sediment delivery ratio (unitless)
Vf_x	1.6241E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	300	Total suspended solids concentration (mg/L)
A_W	4000000	Water body surface area (m^2)
BS	1.0	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1]Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2]Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3]Based on minimum depth required by Corps of Engineers

[4]Assume COPC does not dissipate based on Henry's Law constant of zero.

[5]Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D7-5. Nickel Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**9.4102E-08**	Total COPC concentration in water column (mg/L)
	f_{wc}	0.29970636	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	3.1058E-07	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	0.03	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D7-6. Nickel Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**1.4045E-08**	Dissolved phase water concentration (mg/L)
	C_{wctot}	9.4102E-08	Total COPC concentration in water column (mg/L)
	Kd_{sw}	1900	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-145)
	TSS	300	Total suspended solids concentration (mg/L)

Table D7-7. Nickel Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**2.0099E-05**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**0.70029364**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**3.1058E-07**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**1900**	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-145)
q_{bs}	**0.6**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.0**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**0.03**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

Table D8-1. Benzene Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (EPA Region 5, RCRA)	Project Increase Percent of Background
Soil (mg/kg)	2.70E+01	1.00E+05	1.00E+05	2.55E+02	0.03%
Water (mg/L)	1.01E-08	2.00E-01	2.00E-01	1.14E+02	N/A
Sediment (mg/kg)	1.55E-08	N/A	N/A	1.42E+02	N/A

Notes:
Background concentration for soil assumed to be remediation objective for industrial/commercial properties from IAC 742 Appendix B, Table B (ingestion).
Background concentrations for water obtained using USGS data for Mississippi River below St. Louis. Value listed is mean value. Data provided by USEPA Region 5.
Ecological screening levels obtained from USEPA Region 5

*Appendix E of SLERA Protocol

Table D8-2. Benzene Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**2.70E-02**	COPC concentration in soil (mg COPC/kg soil)
tD	**1.00E+02**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**1.48E+01**	Deposition term (mg COPC/kg soil/yr)
$Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]$		
	1.00E+02	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-18)
	3.15E-01	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3.00E+00	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	4.70E+00	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	0.00E+00	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00E+00	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**5.49E+02**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	3.89E+00	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (SLERA Protocol Table A-2-18)
kse	0.00E+00	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	1.12E+00	COPC loss constant due to surface runoff (yr-1)
ksl	3.14E-16	COPC loss constant due to leaching (yr^{-1})
ksv	5.44E+02	COPC loss constant due to volatilization (yr^{-1})
ksr	**1.12E+00**	COPC loss constant due to surface runoff (yr-1)
$ksr = RO / (q_{sw} * Z_s) * \{1/[1 + (Kd_s * BD/q_{sw})]\}$		
RO	2.54E+01	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	6.20E-01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-18)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**3.14E-16**	COPC loss constant due to leaching (yr^{-1})
$ksl = (P + I - RO - E_v) / \{q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]\}$		
P	8.89E+01	Annual average precipitation (cm/yr) (NOAA)
I	0.00E+00	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	2.54E+01	Average annual surface runoff (cm/yr)
E_v	6.35E+01	Average annual evapotranspiration (cm/yr)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	6.20E-01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-18)
ksv	**5.44E+02**	
$ksv = [3.1536 \times 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]$		
	3.15E+07	Units conversion factor (s/yr)
H	5.49E-03	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-18)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	6.20E-01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-18)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_a	2.98E+02	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.70E+00	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	1.17E-01	Diffusivity of COPC in air (cm^2/s) (SLERA Protocol Table A-2-18)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

Table D8-3. Benzene Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	**7.67E+05**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**0.00E+00**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4.00E+06	Water body surface area (m^2) (estimate based on aerial photo)
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-18)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00E+00	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**1.28E-02**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	6.14E+02	Overall transfer rate coefficient (m/yr)
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-18)
Cvp	4.70E+00	Yearly average air concentration from vapor phase from model (over water body) ($\mu g/m^3$)
H	5.49E-03	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-18)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**0.00E+00**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-18)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00E+00	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
L_R	**7.51E+05**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(\theta_{sw} + Kd_s * BD)] * 0.01$		
RO	2.54E+01	Average annual surface runoff (cm/yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
Cs	2.70E-02	COPC concentration in soil (mg/kg)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
θ_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	6.20E-01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-18)
	1.00E-02	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**1.66E+04**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(\theta_{sw} + Kd_s * BD)] * 0.001$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
ER	3.00E+00	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	2.70E-02	COPC concentration in soil (mg/kg)
Kd_s	6.20E-01	Soil-water partition coefficient (cm^3/g) (SLERA Protocol Table A-2-18)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
θ_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	1.00E-03	Units conversion factor (g/mg)
L_I	**0.00E+00**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**2.54E+01**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	3.00E+02	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	3.60E-01	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[1])
LS	1.50E+00	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[2])
C	7.00E-01	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1.00E+00	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	9.07E+02	Units conversion factor (kg/ton)
	4.05E+03	Units conversion factor (m^2/acre)
SD	**1.19E-01**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.20E+00	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[3])
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
b	1.25E-01	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1]Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.
[2]Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.
[3]Watershed area estimated to be receiving COPC is 43 sq. mi.

Table D8-4. Benzene Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**1.02E-11**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**7.67E+05**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.62E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**9.80E-01**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	2.04E-02	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	4.65E+00	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-18)
TSS	3.00E+02	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	6.00E-01	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	2.48E+00	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-18)
k_{wt}	**6.78E+09**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	9.80E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	2.21E+02	Water column volatilization rate constant (yr^{-1})
f_{bs}	2.04E-02	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.32E+11	Benthic burial rate constant (yr^{-1})
A_w	**4.00E+06**	Water body surface area (m^2)
k_v	**2.21E+02**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	6.14E+02	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74E+00	Depth of water column (m)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	4.65E+00	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-18)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	**6.14E+02**	Overall COPC transfer rate coefficient (m/yr)
$K_v = \{K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}\}^{-1} * q^{(Twk - 293)}$		
K_L	5.78E+02	Liquid-phase transfer coefficient (m/yr)
K_G	3.65E+04	Gas-phase transfer coefficient (m/yr)
H	5.49E-03	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-18)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.03E+00	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**5.78E+02**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT(10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	1.02E-05	Diffusivity of COPC in water (cm^2/s) (SLERA Protocol Table A-2-18)
u	9.14E-01	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**3.65E+04**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.32E+11**	Benthic burial rate constant (yr^{-1})
$k_b = [X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_W * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
Vf_x	1.62E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
A_W	4.00E+06	Water body surface area (m^2)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1]Assume pH = 8.0 based on water quality data provided by EPA Region 5

[2]Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3]Based on minimum depth required by Corps of Engineers

[4]Assume COPC does not dissipate based on Henry's Law constant of zero.

[5]Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D8-5. Benzene Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**1.01E-11**	Total COPC concentration in water column (mg/L)
	f_{wc}	9.80E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	1.02E-11	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D8-6. Benzene Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**9.97E-12**	Dissolved phase water concentration (mg/L)
	C_{wctot}	1.01E-11	Total COPC concentration in water column (mg/L)
	Kd_{sw}	4.65E+00	Suspended sediments/surface water partition coefficient (L/kg) (SLERA Protocol Table A-2-18)
	TSS	3.00E+02	Total suspended solids concentration (mg/L)

Table D8-7. Benzene Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**1.55E-11**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**2.04E-02**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**1.02E-11**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**2.48E+00**	Bed sediment/sediment pore water partition coefficient (L/kg) (SLERA Protocol Table A-2-18)
q_{bs}	**6.00E-01**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.00E+00**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**3.00E-02**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

Table D9-1. Hexane Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level (See Notes)	Project Increase Percent of Background
Soil (mg/kg)	4.11E+01	1.20E+08	1.20E+08	N/A	0.00%
Water (mg/L)	4.26E-09	2.10E+03	2.10E+03	5.80E-01	0.00%
Sediment (mg/kg)	1.34E-08	N/A	N/A	3.96E+01	N/A

Notes:
Background concentrations for soil obtained from soil remediation objectives for industrial/commercial properties for non-TACO chemicals (from IEPA Toxicity Assessment Unit
Background concentration for water obtained from groundwater remediation objectives for chemicals not listed in TACO for Class II (non-potable) water (from IEPA Toxicity Assesment Unit - October 1, 2004).
Ecological screening level for water obtained from User's Guide for Risk-Based Screening in Alaskan Ecological Risk Assessment (December 2001)
Ecological screening level for sediment obtained from EPA Region 3 Ecological Risk Assessment Freshwater Sediment Screening Benchmark

Table D9-2. Hexane Soil Concentration

Cs = Ds * [1 - exp(-ks * tD)] / ks		
Cs	**4.11E-02**	COPC concentration in soil (mg COPC/kg soil)
tD	**1.00E+02**	Time period over which deposition occurs (yr) (default value from SLERA Protocol Table B-1-1)
Ds	**1.64E+01**	Deposition term (mg COPC/kg soil/yr)
$Ds = 100/(Z_s * BD) * [F_v (0.31536 * Vdv * Cvp + Dwvp) + (Ddpp + Dwpp) * (1 - F_v)]$		
	1.00E+02	Units conversion factor (m^2-mg/cm^2-kg)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-1, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-1)
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (Assumed based on other volatile compounds in SLERA protocol)
	3.15E-01	Units conversion factor (m-g-s/cm-mg-yr)
Vdv	3.00E+00	Dry deposition velocity (cm/s) (default value from SLERA Protocol Table B-1-1)
Cvp	5.21E+00	Yearly average air concentration from vapor phase from model (mg/m^3)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (g/m^2-yr)
Ddpp	0.00E+00	Yearly average dry deposition from particle phase from model (g/m^2-yr)
Dwpp	0.00E+00	Yearly average wet deposition from particle phase from model (g/m^2-yr)
ks	**4.00E+02**	COPC soil loss constant due to all soil processes (yr^{-1})
ks = ksg + kse + ksr + ksl + ksv		
ksg	1.58E+01	COPC loss constant due to biotic and abiotic degradation (yr^{-1}) (Industrial Waste Air Model Technical Background Document Table B-73)
kse	0.00E+00	COPC loss constant due to soil erosion (yr^{-1}) (default value from SLERA Protocol Table B-1-2)
ksr	5.52E-01	COPC loss constant due to surface runoff (yr-1)
ksl	1.54E-16	COPC loss constant due to leaching (yr^{-1})
ksv	3.84E+02	COPC loss constant due to volatilization (yr^{-1})
ksr	**5.52E-01**	COPC loss constant due to surface runoff (yr-1)
$ksr = RO / (q_{sw} * Z_s) * \{1/[1 + (Kd_s * BD/q_{sw})]\}$		
RO	2.54E+01	Average annual surface runoff (cm/yr) (USGS)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-4)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-4, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.40E+00	Soil-water partition coefficient (cm^3/g) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[3]
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-4)
ksl	**1.54E-16**	COPC loss constant due to leaching (yr^{-1})
$ksl = (P + I - RO - E_v) / \{q_{sw} * Z_s * [1.0 + (BD * Kd_s / q_{sw})]\}$		
P	8.89E+01	Annual average precipitation (cm/yr) (NOAA)
I	0.00E+00	Average annual irrigation (cm/yr) (Assumed due to low irrigation percentage in Illinois)
RO	2.54E+01	Average annual surface runoff (cm/yr)
E_v	6.35E+01	Average annual evapotranspiration (cm/yr)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-5)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-5, use 1 cm for untilled and 20 cm tilled soil)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-5)
Kd_s	1.40E+00	Soil-water partition coefficient (cm^3/g) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[3]
ksv	**3.84E+02**	
$ksv = [3.1536 \times 10^7 * H / (Z_s * Kd_s * R * T_a * BD)] * [D_a / Z_s] * [1 - (BD/r_s) - q_{sw}]$		
	3.15E+07	Units conversion factor (s/yr)
H	1.40E-02	Henry's Law constant (atm-m^3/mol) (Industrial Waste Air Model Technical Background Document Table B-73)
Z_s	2.00E+01	Soil mixing zone depth (cm) (per SLERA Protocol Table B-1-6, use 1 cm for untilled and 20 cm tilled soil)
Kd_s	1.40E+00	Soil-water partition coefficient (cm3/g) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[3]
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_a	2.98E+02	Ambient air temperature (K) (default value from SLERA Protocol Table B-1-6)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
r_s	2.70E+00	Solids particle density (g/cm^3) (default value from SLERA Protocol Table B-1-6)
D_a	7.30E-02	Diffusivity of COPC in air (cm^2/s) (Industrial Waste Air Model Technical Background Document Table B-73)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-1-6)

[1]Assume ND = 0.

[2]Assume pH = 8.0 based on water quality data provided by EPA Region 5

[3]Per Appendix A of the SLERA Protocol, partitiion coefficients are based on Koc value for chemical. No chemical-specific data were available for hexane, so data for chemical with closest Koc value was used.

Table D9-3. Hexane Load to Water Body

$L_T = L_{DEP} + L_{Dif} + L_{RI} + L_R + L_E + L_I$		
L_T	5.90E+05	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
L_{DEP}	**0.00E+00**	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
$L_{DEP} = A_w * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
A_w	4.00E+06	Water body surface area (m^2) (estimate based on aerial photo)
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-172)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00E+00	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
L_{Dif}	**6.30E-03**	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)[1]
$L_{Dif} = (K_v * F_v * Cvp * 1.0 \times 10^{-6})/(H/(R*T_{wk}))$		
K_v	6.92E+02	Overall transfer rate coefficient (m/yr)
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (Assumed based on other volatile compounds in SLERA protocol)
Cvp	5.21E+00	Yearly average air concentration from vapor phase from model (over water body) (mg/m^3)
H	1.40E-02	Henry's Law constant (atm-m^3/mol) (Industrial Waste Air Model Technical Background Document Table B-73)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-3)
L_{RI}	**0.00E+00**	Runoff load from impervious sources (g/yr)
$L_{RI} = A_I * [F_v * Dwvp + (1-F_v) * Dwdpp]$		
F_v	1.00E+00	Fraction of COPC air concentration in vapor phase (SLERA Protocol Table A-2-172)
Dwvp	0.00E+00	Yearly average wet deposition from vapor phase from model (over water body)(g/m^2-yr)
Dwdpp	0.00E+00	Yearly average total (wet and dry) deposition from particle phase from model (over water body) (g/m^2-yr)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
L_R	**5.62E+05**	Runoff load from pervious sources (g/yr)
$L_R = RO * (A_L - A_I) * [(Cs * BD)/(q_{sw} + Kd_s * BD)] * 0.01$		
RO	2.54E+01	Average annual surface runoff (cm/yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
Cs	4.11E-02	COPC concentration in soil (mg/kg)
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-5)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-5)
Kd_s	1.40E+00	Soil-water partition coefficient (cm3/g) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[5]
	1.00E-02	Units conversion factor (kg-cm^2/mg-m^2)
L_E	**2.80E+04**	Soil erosion load (g/yr)
$L_E = X_e * (A_L - A_I) * SD * ER * [(Cs * Kd_s * BD)/(q_{sw} + Kd_s * BD)] * 0.001$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
A_I	2.75E+07	Impervious watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
ER	3.00E+00	Soil enrichment ratio (unitless) (Per SLERA Protocol Table B-2-6, value is 1 for Inorganic COPC's and 3 for Organic COPC's)
Cs	4.11E-02	COPC concentration in soil (mg/kg)
Kd_s	1.40E+00	Soil-water partition coefficient (cm3/g) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[5]
BD	1.50E+00	Soil bulk density (g/cm^3) (default value from SLERA Protocol Table B-2-6)
q_{sw}	2.00E-01	Soil volumetric water content (mL/cm^3) (default value from SLERA Protocol Table B-2-6)
	1.00E-03	Units conversion factor (g/mg)
L_I	**0.00E+00**	Internal transfer load (g/yr) (default value from SLERA Protocol Section 3.11.2.1)
X_e	**2.54E+01**	Unit soil loss (kg/m^2-yr)
$X_e = RF * K * LS * C * PF * (907.18/4047)$		
RF	3.00E+02	Universal Soil Loss Equation (USLE) rainfall (or erosivity) factor (yr^{-1}) (Highest value from range listed in SLERA Protocol Table B-2-7)
K	3.60E-01	USLE erodibility factor (ton/acre) (Default value from SLERA Protocol Table B-2-7[2])
LS	1.50E+00	USLE length-slope factor (unitless) (default value for representative watershed from SLERA Protocol Table B-2-7[3])
C	7.00E-01	USLE cover management factor (unitless)(Value based on agricultural row cropland from SLERA Protocol Table B-2-7)
PF	1.00E+00	USLE supporting practice factor (unitless) (Assumes no erosion control measures are in place)
	9.07E+02	Units conversion factor (kg/ton)
	4.05E+03	Units conversion factor (m^2/acre)
SD	**1.19E-01**	Watershed sediment delivery ratio (unitless)
$SD = a * (A_L)^{-b}$		
a	1.20E+00	Empirical intercept coefficient (unitless) (Value from Table B-2-8 based on watershed area[4])
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
b	1.25E-01	Empirical slope coefficient (unitless) (default value from Table B-2-8)

[1]Assume vapor phase COPC diffusion load to water body is zero for Lead.

[2]Based on other available data, silty loam soils such as those found in this watershed have K values ranging from 0.25 - 0.4.

[3]Majority of watershed area has slopes 0% - 10%, therefore default value of 1.5 LS is used.

[4]Watershed area estimated to be receiving COPC is 43 sq. mi.

[5]Per Appendix A of the SLERA Protocol, partitiion coefficients are based on Koc value for chemical. No chemical-specific data were available for hexane, so data for chemical with closest Koc value was used.

Table D9-4. Hexane Water Body Concentration

$C_{wtot} = L_T / [Vf_x * f_{wc} + k_{wt} * A_W * (d_{wc} + d_{bs})]$		
C_{wtot}	**4.37E-12**	Total water body COPC concentration, including water column and bed sediment (mg/L)
L_T	**5.90E+05**	Total COPC load to the water body (including deposition, runoff, and erosion) (g/yr)
Vf_x	**1.62E+11**	Average volumetric flow rate through water body (m^3/yr)
f_{wc}	**9.63E-01**	Fraction of total water body COPC concentration that occurs in the water column (unitless)
$f_{wc} = [(1 + Kd_{sw} * TSS * 10^{-6}) * d_{wc}/d_z] / [(1 + Kd_{sw} * TSS * 1 \times 10^{-6}) * d_{wc}/d_z + (q_{bs} + Kd_{bs} * BS) * d_{bs}/d_z]$		
$f_{bs} = 1 - f_{wc}$		
f_{bs}	3.66E-02	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
Kd_{sw}	1.05E+01	Suspended sediments/surface water partition coefficient (L/kg) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[1]
TSS	3.00E+02	Total suspended solids concentration (mg/L)(High value for range listed in SLERA Protocol Table B-2-10[2])
	10e-6	Units conversion factor (kg/mg)
d_{wc}	2.74E+00	Depth of water column (m)[3]
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-10)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-10, $d_z = d_{wc} + d_{bs}$)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
q_{bs}	6.00E-01	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
Kd_{bs}	5.58E+00	Bed sediment/sediment pore water partition coefficient (L/kg) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[1]
k_{wt}	**1.22E+10**	Overall total water body COPC dissipation rate constant (yr^{-1})[4]
$k_{wt} = f_{wc} * k_v + f_{bs} * k_b$		
f_{wc}	9.63E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
k_v	2.49E+02	Water column volatilization rate constant (yr^{-1})
f_{bs}	3.66E-02	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
k_b	3.32E+11	Benthic burial rate constant (yr^{-1})
A_w	**4.00E+06**	Water body surface area (m^2)
k_v	**2.49E+02**	Water column volatilization rate constant (yr^{-1})
$k_v = K_v / [d_z * (1 + Kd_{sw} * TSS * 10^{-6})]$		
K_v	6.92E+02	Overall COPC transfer rate coefficient (m/yr)
d_{wc}	2.74E+00	Depth of water column (m)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-12, $d_z = d_{wc} + d_{bs}$)
Kd_{sw}	1.05E+01	Suspended sediments/surface water partition coefficient (L/kg) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[1]
TSS	3.00E+02	Total suspended solids concentration (mg/L)
	10e-6	Units conversion factor (kg/mg)
K_v	**6.92E+02**	Overall COPC transfer rate coefficient (m/yr)
$K_v = \{K_L^{-1} + [K_G * H/(R * T_{wk})]^{-1}\}^{-1} * q^{(Twk-293)}$		
K_L	6.27E+02	Liquid-phase transfer coefficient (m/yr)
K_G	3.65E+04	Gas-phase transfer coefficient (m/yr)
H	1.40E-02	Henry's Law constant (atm-m^3/mol) (SLERA Protocol Table A-2-172)
R	8.21E-05	Universal gas constant (atm-m^3/mol-K)
T_{wk}	2.98E+02	Water body temperature (K) (default value from SLERA Protocol Table B-2-13)
q	1.03E+00	Temperature correction factor (unitless) (default value from SLERA Protocol Table B-2-13)
K_L	**6.27E+02**	Liquid-phase transfer coefficient for flowing streams or rivers (m/yr)
$K_L = SQRT(10^{-4} * D_w * u / d_z) * 3.1536 \times 10^7$		
D_w	1.20E-05	Diffusivity of COPC in water (cm^2/s) (SLERA Protocol Table A-2-172)
u	9.14E-01	Current velocity (m/s)[5]
d_z	2.77E+00	Total water body depth (m) (Per SLERA Protocol Table B-2-14, $d_z = d_{wc} + d_{bs}$)
	3.15E+07	Units conversion constant (s/yr)
K_G	**3.65E+04**	Gas-phase transfer coefficient for flowing streams or rivers (m/yr) (default value from SLERA Protocol Table B-2-15)
k_b	**3.32E+11**	Benthic burial rate constant (yr^{-1})
$k_b = [X_e * A_L * SD * 10^3 - Vf_x * TSS / (A_W * TSS)] * [TSS * 10^{-6} / (BS * d_{bs})]$		
X_e	2.54E+01	Unit soil loss (kg/m^2-yr)
A_L	1.10E+08	Total watershed area receiving COPC deposition (m^2)
SD	1.19E-01	Watershed sediment delivery ratio (unitless)
Vf_x	1.62E+11	Average volumetric flow rate through water body (m^3/yr)
TSS	3.00E+02	Total suspended solids concentration (mg/L)
A_W	4.00E+06	Water body surface area (m^2)
BS	1.00E+00	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-16)
d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-16)

[1] Per Appendix A of the SLERA Protocol, partition coefficients are based on Koc value for chemical. No chemical-specific data were available for hexane, so data for chemical with closest Koc value was used.

[2] Values found for data from Mississippi River near St. Louis range from 50-350 mg/L, therefore used high end of SLERA default range.

[3] Based on minimum depth required by Corps of Engineers

[4] Assume COPC does not dissipate based on Henry's Law constant of zero.

[5] Current velocity ranges from 3-7 ft/s based on information from several sources.

Table D9-5. Hexane Concentration in Water Column

$C_{wctot} = f_{wc} * C_{wtot} * (d_{wc} + d_{bs}) / d_{wc}$			
C_{wctot}		**4.26E-12**	Total COPC concentration in water column (mg/L)
	f_{wc}	9.63E-01	Fraction of total water body COPC concentration that occurs in the water column (unitless)
	C_{wtot}	4.37E-12	Total water body COPC concentration, including water column and bed sediment (mg/L)
	d_{wc}	2.74E+00	Depth of water column (m)
	d_{bs}	3.00E-02	Depth of upper benthic sediment layer (m) (default value from SLERA Protocol Table B-2-17)

Table D9-6. Hexane Dissolved Phase Water Concentration

$C_{dw} = C_{wctot} / (1+Kd_{sw}*TSS*10^{-6})$			
C_{dw}		**4.13E-12**	Dissolved phase water concentration (mg/L)
	C_{wctot}	4.26E-12	Total COPC concentration in water column (mg/L)
	Kd_{sw}	1.05E+01	Suspended sediments/surface water partition coefficient (L/kg) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[1]
	TSS	3.00E+02	Total suspended solids concentration (mg/L)

[1]Per Appendix A of the SLERA Protocol, partitiion coefficients are based on Koc value for chemical. No chemical-specific data were available for hexane, so data for chemical with closest Koc value was used.

Table D9-7. Hexane Concentration in Bed Sediment

$C_{sed} = f_{bs} * C_{wtot} * [Kd_{bs}/(q_{bs} + Kd_{bs} * BS)] * [(d_{wc} + d_{bs})/d_{bs}]$		
C_{sed}	**1.34E-11**	COPC concentration in bed sediment (mg/kg)
f_{bs}	**3.66E-02**	Fraction of total water body COPC concentration that occurs in the benthic sediment (unitless)
C_{wtot}	**4.37E-12**	Total water body COPC concentration, including water column and bed sediment (mg/L)
Kd_{bs}	**5.58E+00**	Bed sediment/sediment pore water partition coefficient (L/kg) (Use chemical input for 2,4-Dichlorophenol - SLERA Protocol Table A-2-79)[1]
q_{bs}	**6.00E-01**	Bed sediment porosity ($L_{water}/L_{sediment}$) (default value from SLERA Protocol Table B-2-10)
BS	**1.00E+00**	Benthic solids concentration (g/cm^3) (equivalent to kg/L) (default value from SLERA Protocol Table B-2-10)
d_{wc}	**2.74E+00**	Depth of water column (m)*
d_{bs}	**3.00E-02**	Depth of upper benthic sediment layer (m) (default value from Table B-2-12)

[1]Per Appendix A of the SLERA Protocol, partitiion coefficients are based on Koc value for chemical. No chemical-specific data were available for hexane, so data for chemical with closest Koc value was used.

Table D10-1. NO_x Deposition Rate to Media

	Concentration from Project[1]	Background Concentration[2]	Total Concentration (Background & Project)	Ecological Screening Level[2]
Deposition rate to media ($g/m^2/yr$)	0.0933	0.71	0.80	0.5-1.0

[1]Highest conc at target receptor
[2]Data from Indeck/ExxonMobil ESAs - Annual Average

Table D11-1. SO_2 Concentration

	Concentration from Project[1]	Background Concentration[2]	Total Concentration (Background & Project)	Ecological Screening Level[3]
Concentration (μg/m^3)	3.78896	12.3	16.1	19

[1]Highest modeled concentration
[2]IEPA 2005 Air Quality Report - East St. Louis Monitor
[3]Data from Indeck/ExxonMobil ESAs - Annual Average

Table D12-1. CO Concentration

	Concentration from Project[1]	Background Concentration[2]	Total Concentration (Background & Project)	Ecological Screening Level[3]
Concentration 1-hr (ppm)	0.194	5.7	5.9	35
Concentration 8-hr (ppm)	0.151	3.8	4.0	9

[1]Highest modeled concentration
[2]IEPA 2005 Air Quality Report - East St. Louis
[3]National Ambient Air Quality Standard (NAAQS)

CO conversion from μg/m^3 to ppm (1-hr)

Highest conc	222.20193	μg/m^3
	0.22220193	mg/m^3
Temp	298	K
MW of CO	28.0006	
Pressure	760	mm Hg
	0.194	ppm

CO conversion from μg/m^3 to ppm (8-hr)

Highest conc	172.98817	μg/m^3
	0.17298817	mg/m^3
Temp	298	K
MW of CO	28.0006	
Pressure	760	mm Hg
	0.151	ppm

Appendix F

Summary of Results

Table F-1. Soil Concentration Summary for Hazardous Air Pollutants

	Concentration from Project (µg/kg)	Background Concentration (µg/kg)	Total Concentration (Background & Project) (µg/kg)	Ecological Screening Level (µg/kg)	Project Increase Percent of Background	Is project increase plus background less than ESL?	Is project increase less than 1% of background?
Arsenic	1.14E+00	1.30E+04	1.30E+04	5.70E+03	0.01%	No	Yes
Beryllium	0.00E+00	5.90E-01	5.90E-01	1.06E+03	0.00%	Yes	Yes
Cadmium	0.00E+00	6.00E+02	6.00E+02	2.22E+00	0.00%	No	Yes
Chromium	5.00E+00	1.62E+04	1.62E+04	4.00E+02	0.03%	No	Yes
Cobalt	3.33E+00	8.90E+03	8.90E+03	1.40E+02	0.04%	No	Yes
Lead	1.91E+01	3.60E+04	3.60E+04	5.37E+01	0.05%	No	Yes
Manganese	6.66E+00	6.36E+05	6.36E+05	1.00E+02	0.00%	No	Yes
Mercury	0.00E+00	6.00E-02	6.00E-02	1.00E+02	0.00%	Yes	Yes
Nickel	4.24E+01	1.80E+04	1.80E+04	1.36E+04	0.24%	No	Yes
Selenium	0.00E+00	4.80E-01	4.80E-01	2.76E+01	0.00%	Yes	Yes
Benzene	2.70E+01	1.00E+05	1.00E+05	2.55E+02	0.03%	No	Yes
Hexane	6.31E+01	1.20E+08	1.20E+08	N/A	0.00%	N/A	Yes

Notes:
1) For Beryllium, selenium, and PAH's the total wet and dry deposition from the models was zero. Therefore, no additional calculations were performed.
2) For mercury (divalent particle, divalent vapor, and elemental vapor), modeled air concentrations and deposition were zero. Therefore, no additional calculations were performed.

Table F-2. Water Concentration Summary for Hazardous Air Pollutants

	Concentration from Project (µg/L)	Background Concentration (µg/L)	Total Concentration (Background & Project) (µg/L)	Ecological Screening Level (µg/L)	Project Increase Percent of Background	Is project increase plus background less than ESL?	Is project increase less than 1% of background?
Arsenic	4.67E-06	2.36E+00	2.36E+00	1.48E+02	0.00%	Yes	Yes
Beryllium	0.00E+00	6.00E-02	6.00E-02	3.60E+00	0.00%	Yes	Yes
Cadmium	0.00E+00	2.67E-02	2.67E-02	1.50E-01	0.00%	Yes	Yes
Chromium	7.15E-05	1.17E+00	1.17E+00	4.20E+01	0.01%	Yes	Yes
Cobalt	7.13E-06	3.00E+00	3.00E+00	2.40E+01	0.00%	Yes	Yes
Lead	4.41E-05	7.00E-02	7.00E-02	1.17E+00	0.06%	Yes	Yes
Manganese	1.43E-05	1.30E+00	1.30E+00	8.00E-02	0.00%	No	Yes
Mercury	0.00E+00	8.33E-02	8.33E-02	1.30E-03	0.00%	No	Yes
Nickel	9.41E-05	3.34E+00	3.34E+00	2.89E+01	0.00%	Yes	Yes
Selenium	0.00E+00	1.34E+00	1.34E+00	5.00E+00	0.00%	Yes	Yes
Benzene	1.01E-08	2.00E-01	2.00E-01	1.14E+02	0.00%	Yes	Yes
Hexane	6.85E-09	2.10E+03	2.10E+03	5.80E-01	0.00%	No	Yes

Notes:
1) For Beryllium, selenium, and PAH's the total wet and dry deposition from the models was zero. Therefore, no additional calculations were performed.
2) For mercury (divalent particle, divalent vapor, and elemental vapor), modeled air concentrations and deposition were zero. Therefore, no additional calculations were performed.

Table F-3. Sediment Concentration Summary for Hazardous Air Pollutants

	Concentration from Project (µg/L)	Background Concentration (µg/L)	Total Concentration (Background & Project) (µg/L)	Ecological Screening Level (µg/L)	Project Increase Percent of Background	Is project increase plus background less than ESL?	Is project increase less than 1% of background?
Arsenic	1.43E-04	9.89E+03	9.89E+03	9.79E+03	0.00%	No	Yes
Beryllium	0.00E+00	N/A	N/A	N/A	N/A	N/A	N/A
Cadmium	0.00E+00	2.11E+03	2.11E+03	9.90E+02	0.00%	No	Yes
Chromium	7.33E-04	1.94E+04	1.94E+04	4.34E+04	0.00%	Yes	Yes
Cobalt	1.78E-03	N/A	N/A	5.00E+04	N/A	N/A	N/A
Lead	8.08E-03	5.32E+04	5.32E+04	3.58E+04	0.00%	No	Yes
Manganese	3.57E-03	1.16E+06	1.16E+06	0.00E+00	0.00%	No	Yes
Mercury	0.00E+00	1.50E+02	1.50E+02	N/A	N/A	N/A	N/A
Nickel	2.01E-02	2.29E+04	2.29E+04	2.27E+04	0.00%	No	Yes
Selenium	0.00E+00	N/A	N/A	N/A	N/A	N/A	N/A
Benzene	1.55E-08	N/A	N/A	1.42E+02	N/A	N/A	See note 3
Hexane	1.21E-08	N/A	N/A	3.96E+01	N/A	N/A	See note 3

Notes:

1) For Beryllium, selenium, and PAH's the total wet and dry deposition from the models was zero. Therefore, no additional calculations were performed.

2) For mercury (divalent particle, divalent vapor, and elemental vapor), modeled air concentrations and deposition were zero. Therefore, no additional calculations were performed.

3) For benzene and hexane no background data were available, however, the concentrations from the project are much less than the ESL for each pollutant.

Table F-4. Criteria Pollutant Summary

	Concentration from Project	Background Concentration	Total Concentration (Background & Project)	Ecological Screening Level	Is project increase plus background less than ESL?
NO_x ($g/m^2/yr$)	9.330E-02	0.71	0.80	0.5-1.0	See note
SO_2 ($\mu g/m^3$)	3.789E+00	12.3	16.1	19.0	Yes
CO 1-hr (ppm)	1.942E-01	5.7	5.9	35	Yes
CO 8-hr (ppm)	1.512E-01	3.8	4.0	9	Yes

Notes:
Refer to section 7.6 of report for further explanation of NO_x data.

APPENDIX E

DETERMINATION OF NITROGEN EFFECTS

Determination of Nitrogen Effects for ExxonMobil

The following provides a brief discussion of the potential adverse effects to leafy prairie clover, and eastern prairie fringed orchid from Nitrogen deposition. Information provided by ExxonMobil raises two questions: 1) Is 1g/m2/yr an appropriate threshold value above which we would conclude that a listed species would be adversely affected by a proposed action, but below which we would determine that the proposed action is not likely to adversely affect the listed species? 2) If that threshold value seems too high, what would be a more appropriate value?

ExxonMobil proposes a threshold value of 1 g/m2/yr for Nitrogen deposition based on WHO air quality guidelines for Europe, which indicated a critical load value (similar to a no adverse effects level or NOEL), or between 1 – 1.5 g/m2/yr. That value was associated with a decline in sensitive species in a species rich heathland.

ExxonMobil determined that the current background level of Nitrogen deposition is 0.71g/m2/yr., that Indeck adds a small fraction of 0.01g/m2/yr (based upon Calpuff modeling), and that the project would add 0.08 g/m2/yr, suggesting that the total Nitrogen deposition after construction of ExxonMobil will be 0.8g/m2/yr (below ExxonMobil's proposed threshold value of 1.0 g/m2/yr).

Weiss (1999) found that bay checkerspot butterfly populations had declined or become extirpated in areas with higher Nitrogen deposition. Sites that received Nitrogen deposition of 1.0-1.5 became invaded by introduced grasses (e.g., *Lolium*), which crowded out the butterfly's host plant. Sites that had deposition in the range of 0.4 to 0.6 g/m2/yr did not become invaded by introduced grasses. Serpentine soils are Nitrogen limited. Exxon Mobil indicated that the deposition values reported by Weiss may be low because wet deposition was not accounted for. However, our read of the paper indicated that the author did consider wet deposition, and that it is likely lower than estimated by ExxonMobil. Even if the wet deposition figure used by ExxonMobil is correct, and adverse affects are present at 1.1 g/m2/yr, and absent at 0.7g/m2/yr, that would suggest a threshold value below 1 g/m2/yr.

Stevens et al. (2004) found that for every 0.25 g/m2/yr, one could expect a reduction of a single species. ExxonMobil suggested that this paper may not be appropriate because it evaluated nitrogen deposition in acid grasslands. Stevens et al. (2000) show a regression with data points beginning at 0.5 g/m2/yr, and species diversity declining as nitrogen deposition increases beyond that point.

Wedin and Tilman (1996) looked at Nitrogen addition and noted that it was associated with the loss of species diversity, with the greatest losses occurring between 1 and 5 g/m2/yr. The graph they present shows losses beginning below an application of 1g/m2/yr. Chris Clark (Graduate Student in Tilman's lab at Cedar Creek, 2005 pers.comm.) indicated that the graph showing effects below 1 g/m2/yr was based upon an extrapolation. Based on their work they suggest that a threshold value of 0.5g/m2/yr may be appropriate (Clark 2005, pers.comm.).

Suding et al. 2005 examined a number of studies and concluded that species that are rare in their environment, or nitrogen fixers, or perennial are more likely to become extirpated than are other species.

Summary:
WHO indicates that 1-1.5g/m2/yr is sufficient to protect sensitive species in species rich heathlands, Weiss (1999) found that serpentine grasslands retained native species at deposition rates of 0.4 to 0.6 g/m2/yr, but had become invaded by non native grasses at 1.0 – 1.5 g/m2/yr, Stevens et al. (2004) indicated that on average, for every 0.25g/m2/yr of Nitrogen deposition a single species would be lost. Wedin and Tilman noted most losses in species diversity between 1 and 5 g/m2/yr. Clark (2005, pers.comm.) indicated that a threshold value of 0.5g/m2/yr may be appropriate. These studies suggest that losses in diversity, and increased abundance of weedy species, occurs at Nitrogen deposition rates below 1 g/m2/yr, likely between 0.5g/m2/yr and 0.7g/m2/yr.

This analysis suggests that there is reason to believe that the current background level of 0.71 g/m2/yr is close to a threshold value, and may already be causing losses in species diversity by favoring invasive species. ExxonMobil's addition of 0.08 g/m2/yr, when added to the background level, would put Nitrogen deposition at levels where studies show losses in biodiversity and increased abundance of invasive species. The presentation in these studies shows a linear effect, suggesting that ExxonMobil's addition would be noticeable.

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