Health Consultation

RESPONSE TO PUBLIC COMMENTS

Public Health Implications of Inhalation of Manganese in Downriver Soils
(Cities of River Rouge and Ecorse)

WAYNE COUNTY, MICHIGAN

EPA FACILITY ID: MID004320479

MARCH 26, 2009

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

Michigan Department of Community Health
Under A Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Acronyms and Abbreviations

µg	microgram
µm	micrometer (micron)
AQD	Air Quality Division
ATSDR	Agency for Toxic Substances and Disease Registry
COPD	chronic obstructive pulmonary disorder
EPA	U.S. Environmental Protection Agency
Ev	emission due to vehicle traffic
Ew	emission due to wind
IE	Integrated Environmental, Inc.
m^3	cubic meter
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
mg	milligram
MRI	magnetic resonance imaging
MRL	Minimal Risk Level
MS	multiple sclerosis
NA	not applicable
PEF	Particulate Emission Factor
PM2.5	particulate matter with aerodynamic diameter of 2.5 micrometers or less
PM10	particulate matter with aerodynamic diameter of 10 micrometers or less
ppm	parts per million
PSIC	Particulate Soil Inhalation Criteria
Q/C	air-dispersion factor
RfC	Reference Concentration
RRD	Remediation and Redevelopment Division
TSD	Technical Support Document
TSG	Toxics Steering Group
TSP	Total Suspended Particulate
U.S. Steel	U.S. Steel Corporation
V	vegetative cover
Weston	Weston Solutions of Michigan, Inc.

Summary

The cities of River Rouge and Ecorse, in Wayne County, Michigan, have been impacted, historically and currently, by airborne manganese deposition to soil. The Michigan Department of Environmental Quality (MDEQ) requested assistance in determining the level of public health threat posed by the inhalation of airborne manganese-contaminated soil. Some soil samples collected within the cities exceeded the MDEQ Particulate Soil Inhalation Criteria (PSIC; adjusted for source size) for manganese.

The public health hazard posed by the contaminated soil is indeterminate. There are other, on-going sources of manganese to ambient air in this area. Long-term ambient air monitoring suggests that local air levels of manganese may be unacceptable, however further information is necessary for making appropriate comparisons. Ambient air data for River Rouge are reported as Total Suspended Particulates (TSP), whereas the acceptable air concentration for manganese is based on particulate matter less than 10 microns in aerodynamic diameter (PM10), which is a subset of TSP. Thus, the TSP data likely overestimate the ambient PM10 manganese levels. Also, it is not clear to what extent the soil contamination contributes to the air levels. Additionally, MDEQ is currently reviewing the derivation of the manganese PSIC, so that the best available and most up-to-date science is used.

MDEQ should continue monitoring ambient air locally, adding collection of PM10. MDEQ should consider using a site-specific PSIC to determine compliance with the criterion.

Purpose and Health Issues

The purpose of this document is to respond to community health concerns and public comments regarding the draft health consultation for the site (ATSDR 2007). MDEQ requested assistance from the Michigan Department of Community Health (MDCH) in assessing the risk to people living in an area impacted, historically and currently, by airborne manganese deposition to soil. Questions received during the public meeting held for this site, and MDCH's responses, are in the *Community Health Concerns* section of this document. Comments received on the draft health consultation, and MDCH's responses, are in Appendix C.

MDCH conducted this health consultation for the federal Agency for Toxic Substances and Disease Registry (ATSDR) under a cooperative agreement. ATSDR conducts public health activities (assessments/consultations, advisories, education) at sites of environmental contamination and concern. ATSDR is primarily an advisory agency. Therefore, its reports usually identify what actions are appropriate to be undertaken by the regulatory agency overseeing the site, other responsible parties, or the research or education divisions of ATSDR. As such, ATSDR recommendations may not encompass all types of federal and state requirements from a regulatory perspective. Thus, the purpose of a health consultation is not to evaluate or confirm regulatory compliance but to determine if any potentially harmful exposures are occurring or may occur in the future.

Background

The "downriver" area of Greater Detroit is south-southwest of the city of Detroit, along the Detroit River (Figure 1). This region has historically supported, and continues to support, heavy

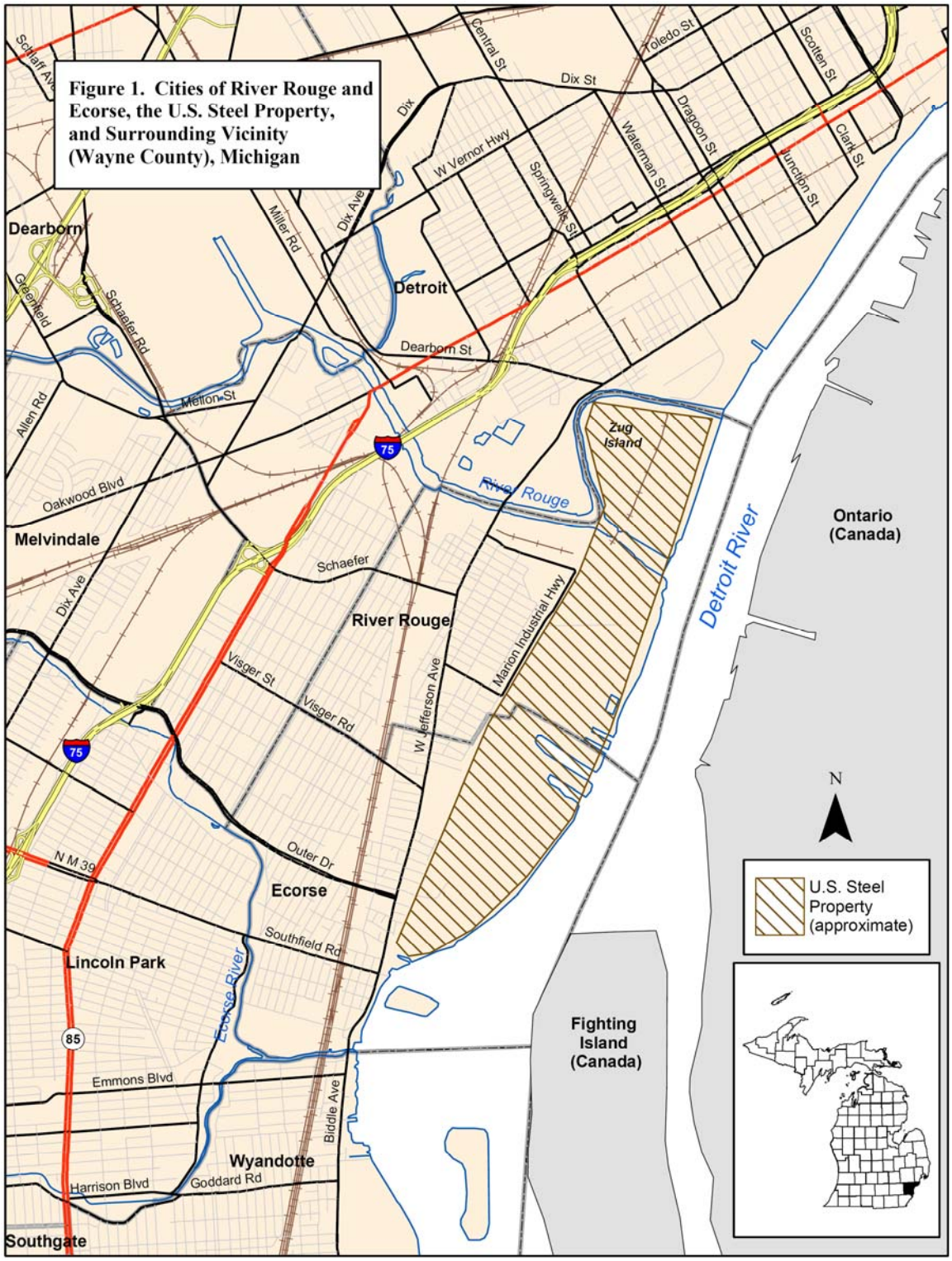


Figure 1. Cities of River Rouge and Ecorse, the U.S. Steel Property, and Surrounding Vicinity (Wayne County), Michigan
Dearborn
Detroit
Melvindale
River Rouge
Ecorse
Lincoln Park
Wyandotte
Southgate
Zug Island
Fighting Island (Canada)
Ontario (Canada)
Detroit River
Rouge River
Ecorse River
Dix Ave
Miller Rd
Schaefer Rd
Greenfield
Allen Rd
Melton St
Oakwood Blvd
Schaefer
Visger St
Visger Rd
W Jefferson Ave
Marion Industrial Hwy
Outer Dr
N M 39
Southfield Rd
Emmons Blvd
Biddle Ave
Harrison Blvd
Goddard Rd
Dearborn St
Dix St
W Vernor Hwy
Springwells St
Waterman St
Dragoon St
Junction St
Toledo St
Scotten St
Clark St
Central St
Dix
N
U.S. Steel Property (approximate)
75
85

industry, including steel mills. In February 2005, the city of River Rouge provided MDEQ with environmental data collected by its consultant, Integrated Environmental, Inc. (IE), in support of a class-action suit the city had filed against U.S. Steel Corporation (U.S. Steel). The city of Ecorse has also filed suit against U.S. Steel. (These lawsuits stem from a nuisance-dust issue.) The main plant of the U.S. Steel Great Lakes Works facility lies along the Detroit River directly east of the cities of River Rouge and Ecorse (Figure 1). U.S. Steel also has a facility on Zug Island, northeast of the cities across the River Rouge (RTI 2006).

Following review of the IE data, the MDEQ Remediation and Redevelopment Division (RRD) directed its consultant, Weston Solutions of Michigan, Inc. (Weston), to conduct further soil investigation. MDEQ defined the Downriver Soil Study Area as the area including the cities of River Rouge and Ecorse (Figure 2). The Study Area does *not* include the nearby U.S. Steel Great Lakes Works facility. Both the IE and the Weston data indicated that some soil concentrations of manganese were greater than the MDEQ Residential Particulate Soil Inhalation Criterion (PSIC), adjusted for source size. The results of the IE sampling and the Weston sampling are discussed in the *Environmental Contamination* section of this document. The PSIC criteria for manganese are discussed in Appendix A.

On November 13, 2006, toxicologists from MDCH and MDEQ met with the RRD project manager and Weston to discuss the data collected to-date and future activities. MDCH and MDEQ staff toured the Downriver Soil Study Area following the meeting.

MDCH released a draft health consultation for public comment on August 1, 2007 and conducted a public meeting for the cities of River Rouge and Ecorse on September 19, 2007 to discuss the findings. Staff from the MDEQ Air Quality Division (AQD) and RRD served as additional resource people at the meeting.

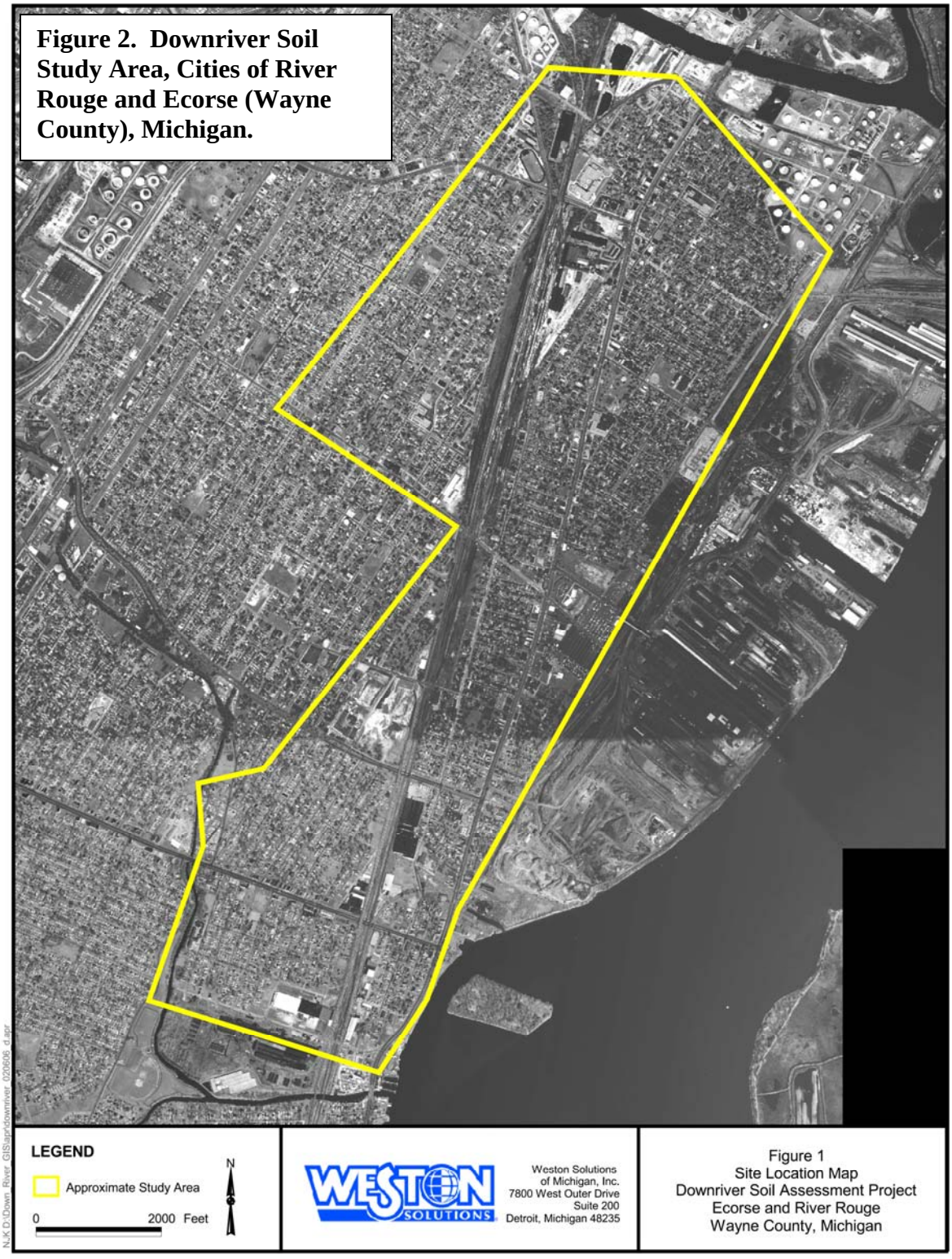
Discussion

Environmental Contamination

From June 2001 through May 2004, IE conducted environmental sampling for the city of River Rouge. IE gathered soil, dust (indoor and outdoor), ponded water (from puddles), and ambient air data. IE sampled soils in River Rouge, Ecorse, Delray, southwest Detroit, Plymouth, and Northville (IE 2005). This consultation reviews only the soil data from River Rouge, Ecorse, and the portion of "southwest Detroit" that was within the Downriver Soil Study Area.

In December 2005, Weston conducted soil sampling in the cities of River Rouge and Ecorse. According to Weston's Summary Report of this phase of the investigation, the two consultants had different sampling methodologies. IE reportedly collected samples from medians or near-curb areas from the top 1 inch of soil, targeting bare ground locations (considered more likely to contain elevated levels of metals). IE further biased their sampling by clustering some sample locations in two parks. Conversely, Weston used a statistical sampling approach, which minimized bias, and collected samples without regard to the presence or absence of surface vegetation cover. Weston's sampling depth was 0 to 3 inches (Weston 2006, 2007). Although statistical testing of the two datasets indicated that the data can be combined (S. Hoin, MDEQ

Figure 2. Downriver Soil Study Area, Cities of River Rouge and Ecorse (Wayne County), Michigan.



RRD, personal communication, 2008), MDCH chose to keep the datasets separate due to the differing methodologies.

In 2007, Weston collected additional soil samples in residential areas to gain a better understanding of how the manganese was distributed vertically within the soils and how concentrations varied laterally. The results of this investigation confirmed that there were locations within the Downriver Soil Study Area where soil concentrations exceeded the residential PSIC (S. Hoin, MDEQ RRD, personal communication, 2009). The report for this phase of the investigation is not yet finalized.

The MDEQ generic PSIC values, as presented in the agency's clean-up criteria tables, are intended for a source area of one-half acre (MDEQ 2004). For other source area sizes, a modifier is applied to the one-half-acre generic value to obtain the applicable PSIC value. Appendix A contains further discussion regarding modifiers and other PSIC considerations. The Downriver Soil Study Area covers about 900 acres. Although nearly all soil sampling locations were in residential/commercial areas, one sample was taken from an industrial property. Table 1 shows the manganese soil concentrations in the Downriver Soil Study Area, the generic (for one-half acre) residential and industrial PSIC, the modifier for a 1,000-acre source size, and the 1,000-acre residential and industrial PSIC.

The exposure route of concern at this site is inhalation of airborne manganese, regardless of source. MDCH asked the MDEQ AQD for local ambient air monitoring data for manganese particulates to determine if there were concentrations of manganese that triggered concern. MDEQ maintains an air monitoring station in the city of River Rouge. The station has been at its current location since 1971, however air data for metals have been collected only since 1994. Table 2 shows the average (annualized) ambient air concentrations for manganese, reported as Total Suspended Particulates (TSP), at the River Rouge station for the years 1994 through 2008.

Table 2 also compares reported ambient air concentrations to the U.S. Environmental Protection Agency (EPA) Reference Concentration (RfC) and the ATSDR chronic Minimal Risk Level (MRL) for manganese.[1] The RfC and the chronic MRL represent long-term air exposure concentrations below which adverse human health effects should not be expected. (More discussion regarding these comparison values and the health effects of excessive exposure to manganese is in the *Toxicological Evaluation* section of this document.) Note that the comparison values are based on "PM10" (particulate matter less than 10 microns in aerodynamic diameter) and not TSP. The EPA Office of Air Quality Planning and Standards recommends the use of PM10 for risk assessment (EPA 2002). However, only about 25 national air monitoring sites report PM10 metals whereas about 73 sites report TSP to EPA's Air Quality System database (EPA 2006). MDEQ historically has collected TSP metals at most of its air monitoring

[1] MDEQ PSIC criteria are derived using the state's air toxics screening levels: the Initial Threshold Screening Level (ITSL), for non-carcinogens, or the Secondary Risk Screening Level (SRSL), for cancer-causing compounds (MDEQ 2007). If the EPA has established an RfC and there is no indication that the chemical is carcinogenic, then the ITSL is determined from the RfC (MDEQ 2002a). Manganese is not carcinogenic, therefore its ITSL is equal to its RfC. In this document, MDCH refers to the RfC with the understanding that the discussion pertains also to the ITSL.

Table 1. Manganese soil concentrations in the Downriver Soil Study Area (cities of River Rouge and Ecorse), Wayne County, Michigan, and comparison to one-half-acre and 1,000-acre PSIC. (Concentrations in parts per million [ppm]. Data collected June 2001 through December 2005.)

Data source	**No. samples**	**Concentration Range**	**Background Manganese Soil Concentration in Michigan**	**Applicable PSIC for 1/2-acre**		**Modifier for 1,000 acres[E]**	**Applicable PSIC for 1,000 acres (No. exceedances)**	
				Residential	*Industrial[D]*		*Residential*	*Industrial[D]*
IE	99[A]	134 – 22,900	440	3,300	1,500	0.35	1,155 (40)	525 (1)
Weston	181[B,C]	150 – 6,000	440	3,300	NA[C]	0.35	1,155 (15)	NA[C]

References: MDEQ 2007; IE 2005; Weston 2006, 2007

Acronyms/Abbreviations:

IE Integrated Environmental, Inc.
NA not applicable
PSIC Particulate Soil Inhalation Criterion
Weston Weston Solutions of Michigan, Inc.

Notes:

A. All but 1 of the IE sampling locations were located in residential/commercial areas. The soil sample taken from the industrial area had the highest manganese concentration. Residential samples are compared to the residential criterion, industrial samples are compared to the industrial criterion.
B. Weston "No. samples" includes duplicates. If both a sample and its duplicate exceeded the criterion, MDCH only counted it as one exceedance.
C. All Weston sampling locations were located in residential areas and therefore were not compared to the industrial criterion.
D. Industrial PSIC typically are more restrictive than Residential PSIC. See Appendix A for further discussion.
E. Generic value is multiplied by modifier to obtain applicable PSIC.

Table 2. Average annual ambient air concentrations of manganese, as Total Suspended Particulates, in River Rouge, Michigan, from 1994 to 2008, and comparison to federal regulatory or screening values. (Concentrations reported in micrograms per cubic meter [$\mu g/m^3$]. Bolded years exceeded at least one comparison value.)

Year	No. measurements	Average concentration	RfC[A] (Exceeded?)	Chronic MRL[A] (Exceeded?)
1994	30	0.07	0.05 (yes)	0.04 (yes)
1995	30	0.05	0.05 (no)	0.04 (yes)
1996	29	0.06	0.05 (yes)	0.04 (yes)
1997	28	0.05	0.05 (no)	0.04 (yes)
1998	20	0.08	0.05 (yes)	0.04 (yes)
1999	29	0.06	0.05 (yes)	0.04 (yes)
2000	27	0.06	0.05 (yes)	0.04 (yes)
2001	48	0.07	0.05 (yes)	0.04 (yes)
2002	54	0.07	0.05 (yes)	0.04 (yes)
2003	55	0.10	0.05 (yes)	0.04 (yes)
2004	56	0.07	0.05 (yes)	0.04 (yes)
2005	61	0.07	0.05 (yes)	0.04 (yes)
2006	58	0.06	0.05 (yes)	0.04 (yes)
2007	60	0.06	0.05 (yes)	0.04 (yes)
2008	57	0.08	0.05 (yes)	0.04 (yes)

References: MDEQ, unpublished data, 2006, 2008, 2009; EPA 1993; ATSDR 2000

Acronyms/Abbreviations:

MRL Minimal Risk Level

RfC Reference Concentration

Note:

A. RfC and MRL values are based on PM10 (particulate matter less than 10 microns in aerodynamic diameter). This comparison should be used for screening purposes only and not to determine regulatory compliance.

stations, although PM10 and PM2.5 (particulate matter less than 2.5 microns in aerodynamic diameter) metals are collected at some sites. The River Rouge air monitoring location has not collected PM10 or PM2.5 historically (MDEQ 2005). The TSP data are used as a screen: if the ambient air TSP value exceeds the RfC, further investigation is needed to determine whether the PM10 value exceeds the RfC.

As of the beginning of MDEQ's investigation, the U.S. Steel Great Lakes Works plant was an operating facility. Due to the current recession, U.S. Steel idled three plants at the end of 2009, including the Great Lakes Works plant (U.S. Steel, personal communication, 2009). There are other possible sources of manganese to the ambient air in the downriver area. Several of these include:

•air emissions from the Rouge Manufacturing Complex in Dearborn, about 5 miles west of River Rouge;

•dust from slag piles (industrial waste) on the E. C. Levy facility at the southern end of the U.S. Steel property;

•dust from erosion of fill material, on which much of the development along the waterfront reportedly is built;

•dust from erosion of soil containing naturally-occurring manganese;

•brake dust emissions from traffic in and near the area.

Thus, it cannot be readily determined from the air monitoring data what proportion of the manganese TSP concentration is from soil versus stack-, fugitive emission-, or other source-derived. However, the data in Table 2 indicate that airborne manganese particulates, as TSP, in the city of River Rouge have consistently exceeded comparison values, for PM10, set by regulatory and public health agencies. Exceeding a screening or comparison value does not necessarily mean that negative health effects are guaranteed but rather that exposure should be further evaluated. Evaluation of exposure pathways and exposed populations, as well as determining the manganese PM10 concentration in ambient air, is discussed below.

Exposure Pathways Analysis

To determine whether persons are, have been, or are likely to be exposed to contaminants, MDCH evaluates the environmental and human components that could lead to human exposure. An exposure pathway contains five elements:

- a source of contamination
- contaminant transport through an environmental medium
- a point of exposure
- a route of human exposure
- a receptor population

An exposure pathway is considered complete if there is evidence, or a high probability, that all five of these elements are, have been, or will be present at a site. It is considered either a potential or an incomplete pathway if there is a lower probability of exposure or there is no evidence that at least one of the elements above are, have been, or will be present. The exposure pathway elements for manganese particulates in ambient air in the cities of River Rouge and Ecorse are shown in Table 3.

Table 3. Exposure pathways analysis for manganese particulates in ambient air in and around the cities of River Rouge and Ecorse, Michigan.

Source	Environmental Transport and Media	Chemicals of Interest	Exposure Point	Exposure Route	Exposed Population	Time Frame	Exposure Likelihood
Emissions from steel mills, other industries	Contaminated soil (from historic emissions and deposition)	Manganese	Ambient air	Inhalation, ingestion	People living, working or visiting in the area within the plume from the emissions	Past	Complete
						Present	Complete
						Future	Potential
	Stack emissions	Manganese	Ambient air	Inhalation, ingestion	People living, working or visiting in the area within the plume from the emissions	Past	Complete
						Present	Complete
						Future	Potential
Fill material and slag piles	Contaminated soil	Manganese	Ambient air	Inhalation, ingestion	People living, working, or visiting in areas on or near fill material	Past	Complete
						Present	Complete
						Future	Potential
NOTE: THE PRESENCE OF A COMPLETE EXPOSURE PATHWAY IN THIS TABLE DOES NOT IMPLY THAT AN EXPOSURE WOULD BE SUBSTANTIVE OR THAT AN ADVERSE HEALTH EFFECT WOULD OCCUR.							

Former and current steel mills and other metal works facilities in and around the cities of River Rouge and Ecorse likely contributed to the elevated manganese in area soils. For example, MDCH conducted a health consultation for the former Mill Street Plant in Ecorse, which is a former steel mill being redeveloped for residential and commercial use (ATSDR 2005). The Mill Street Plant site, north of the Ecorse River and just outside of the Downriver Soil Study Area, had high manganese levels in on-site soils.[2] (Off-site soils were not evaluated). Due to the presence of manganese in area soils, River Rouge and Ecorse residents will likely continue to be exposed to manganese in airborne soils in the foreseeable future.

The U.S. Steel Great Lakes Works plant, currently idle, was an operating facility with stack emissions of manganese. Other area industries that may be contributing to manganese levels in ambient air in River Rouge and Ecorse include the facilities within the Rouge Manufacturing

[2] During the redevelopment of the Mill Street Plant property (on-going as of January 2, 2009), the responsible parties have Due Care obligations in which they must prevent exacerbation of existing contamination and unacceptable human exposures. Additional information regarding Due Care Requirements is available at: http://www.michigan.gov/documents/deq/deq-rrd-duecare-citizenguide_253063_7.pdf.

Complex, west of the Downriver Soil Study Area. River Rouge and Ecorse residents will likely continue to be exposed to manganese in ambient air from stack emissions in the foreseeable future.

Much of the development along the Detroit River is built on fill material (S. Hoin, MDEQ-RRD, personal communication, 2007). Fill material may contain slag (waste) from various industries, which often contains elevated concentrations of metals. It is possible that some of the manganese contamination of the soil in the River Rouge and Ecorse areas is due to the fill material and not soil. Area residents will likely continue to be exposed to airborne manganese from fill material in the foreseeable future.

Although the exposure route of concern at this site is inhalation, ingestion of airborne particulates often occurs following inhalation. Smaller particulates will usually deposit in the lungs and alveoli whereas larger particles may adhere to the trachea and throat lining. The mucosa moves the deposited material upward toward the mouth. When a person coughs, the particles are expelled from the upper respiratory tract and may be spit out or swallowed. A person may also experience oral exposure via incidental ingestion of contaminated soil. However, ingestion of manganese, as discussed in the *Toxicological Evaluation* section below, is of less public health concern than inhalation of the metal and is not considered an exposure pathway of concern in the Downriver Soil Study Area.

Dermal exposure to airborne manganese particulates is not considered a health concern and was omitted from the exposure pathway analysis in Table 3.

Toxicological Evaluation

Manganese

Manganese is a naturally occurring metal as well as an essential trace element. It is used in the manufacture of various types of steel, in the production of batteries, dietary supplements, and some pesticides and fertilizers. Many foods contain manganese, especially nuts, legumes, grains, and tea. Insufficient dietary manganese can lead to slowed blood clotting, skin problems, changes in hair color, and alterations in metabolism (ATSDR 2000).

Healthy humans maintain efficient control over ingested manganese in the body. The body absorbs and uses what is nutritionally necessary and excretes the remainder. Thus, ingested manganese has rarely been associated with toxicity (EPA 1996). Individuals who cannot efficiently excrete excess metals from their bodies, such as persons with liver disorders, may be more at risk to potential toxicity. Patients receiving total parenteral nutrition (elemental liquid-form nutrition delivered intravenously because the person cannot or should not obtain his nutritional needs via the gastrointestinal tract) may receive too much manganese and experience the less severe symptoms described below (ATSDR 2000).

Manganese miners or steel workers exposed to high levels of manganese dust in air may develop mental and emotional disturbances. Their body movements may become slow and clumsy. These symptoms, when associated with manganese exposure, describe a disease called "manganism." Although the clinical symptoms for this disease are similar to those expressed in Parkinson's disease, there are differences between the two, both in physical expression and area

of the brain affected. Manganic patients exhibit more frequent dystonia (slow, involuntary, irregular muscle contractions) and a tendency to fall forward. Parkinson's patients show a tendency to fall backward. Magnetic resonance imaging (MRI) of manganic patients reveals manganese deposits in a specific area of the brain. MRIs in Parkinson's patients do not reveal these deposits but, instead, show lesions in a different area of the brain (Bowler et al. 2007).

Less severe symptoms of excessive manganese exposure include difficulty in the following motor skills: holding one's hand steady, performing fast hand movements, and maintaining balance when tested (Roels et al. 1992, 1999; Mergler et al. 1994, 1999; Crump and Rousseau 1999; Lucchini et al. 1999; Beuter et al. 1999; ATSDR 2000; Bast-Pettersen et al. 2004). Exposed males may experience sexual dysfunction. Inhalation of manganese-containing dust may cause respiratory problems (ATSDR 2000).

The EPA RfC and the current ATSDR chronic MRL for manganese are both derived from data gathered in a study of neurological effects seen in workers exposed to manganese in a dry alkaline battery factory (Roels et al. 1992, EPA 1993, ATSDR 2000). The study identified the lowest level at which these effects were observed as 0.15 mg/m^3. When adjusted for a non-occupational setting (24 hours/day, 7 days/week, versus 8 hours/day for a 40-hour work week, and inhalation rate differences), the concentration becomes 0.05 mg/m^3. EPA regulators applied "uncertainty" (safety) factors to the adjusted concentration to account for inter-individual differences, lack of a no-effect level, less-than-chronic exposure, and gaps in the database. The resulting RfC was 0.05 $\mu g/m^3$ (or 0.00005 mg/m^3). Manganese concentrations seen at the River Rouge monitor are no more than twice the RfC and therefore at least 500 times less than the adjusted levels at which effects were detected in the Roels et al. (1992) study. This would suggest that exposure to airborne manganese at the levels detected in the River Rouge area would not likely result in the effects observed in the worker study. However, a worker population is typically in better health than the general population ("healthy worker effect"). Additionally, workers would be exposed intermittently, allowing for some recovery between workdays and over weekends, whereas environmental (residential) exposure is more likely to be continuous (Hudnell 1999).

Several of the worker studies considered by EPA when deriving the manganese RfC have since received additional data which may affect the RfC calculation. These studies include:

- Roels et al. (1999), updating Roels et al. (1992)
- Crump and Rousseau (1999), updating Roels et al. (1987)
- Bouchard et al. (2008), updating Mergler et al. (1994)
- Lucchini et al. (1999), updating earlier work by this group

Researchers sought to determine whether symptoms progressed over time with continued exposure or if they resolved after exposure stopped. The data are not clear. In 2007, MDEQ requested that EPA evaluate the new toxicological data for manganese and update the RfC as necessary (MDEQ 2007a). EPA is re-evaluating the RfC for manganese and may have an updated value in several years (R. Sills, MDEQ Air Quality Division, personal communication, 2008). ATSDR has issued a draft update to the Toxicological Profile for Manganese (2008), but it should be noted that the MRL is not a regulatory number.

As discussed earlier in this document, the RfC and MRL are derived from an "integrated respirable dust" (PM10) concentration and not from a TSP concentration (EPA 1993, ATSDR 2000). Smaller inhaled particulates usually deposit in the lungs and alveoli, where they can be absorbed into the bloodstream and distributed via the circulatory system. Most inhaled particles larger than 5 μm deposit in the upper airways (nose and trachea) or large lower airways (bronchioles) of the respiratory system (Bascom et al. 1996). It is not appropriate to compare TSP concentrations from ambient air monitoring data to the RfC or MRL for evaluating public health implications or for determining compliance with air quality standards. Although TSP would likely overestimate the risk, it can be used as an initial screen of the data (EPA 2006).

More recent toxicological data on the absorption of inhaled manganese suggests that manganese inhaled through the nose may deposit directly to the brain via the olfactory bulb, which is responsible for the sense of smell. Several rat studies have demonstrated this with particles *smaller* than PM10 (Henriksson et al. 1999, Brenneman et al. 2000, Dorman et al. 2002, Elder et al. 2006). Work by Fechter et al. (2002) suggests, however, that particles *larger* than PM10 (18 μm in their study) do not enter the rat brain via the olfactory pathway. When considering the likelihood of the olfactory route as a means of delivery of manganese to the human brain, one must consider the differences between rat and human respiratory systems. These differences are discussed in Appendix C. The anatomy and physiology of the rat respiratory system allows the olfactory pathway to be more relevant in this species.

Children's Health Considerations

Children may be at greater risk than adults from exposure to hazardous substances at sites of environmental contamination. Children engage in activities such as playing outdoors and hand-to-mouth behaviors that could increase their intake of hazardous substances. They are shorter than most adults, and therefore breathe dust, soil, and vapors found closer to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures are high enough during critical growth stages. Fetal development involves the formation of the body's organs. Injury during key periods of prenatal growth and development could lead to malformation of organs (teratogenesis), disruption of function, and premature death. Exposure of the mother could lead to exposure of the fetus, via the placenta, or affect the fetus because of injury or illness sustained by the mother (ATSDR 1998). Thus, children can experience substantially greater exposures to toxicants in soil, water, or air than adults can.

Children do not appear to be any more or less sensitive than adults to the toxic effects of manganese, whether exposure is via ingestion or inhalation. Daily oral intake of small amounts of manganese is needed for growth and good health in children (ATSDR 2000).

Other Populations of Concern

Some of the human data suggest that males may be more susceptible to the neurotoxic effects of manganese than females (Mergler et al. 1999a, 1999b; Beuter et al. 1999; Takser et al. 2003; Erikson et al. 2005).

Both human and animal data suggest that older individuals may be more susceptible to manganese's neurotoxic effects (Crump and Rousseau 1999, Gibbs et al. 1999, Beuter et al. 1999, Erikson et al. 2005).

Persons with liver problems may have difficulty maintaining correct levels of manganese in their bodies. They may not be able to excrete excess ingested manganese efficiently, which could allow blood levels of the nutrient to increase, leading to deposition in the brain (ATSDR 2000).

Community Health Concerns

In its Class Action Complaint against U.S. Steel, the city of River Rouge did not allege public health complaints. Rather, the suit listed potential health effects (similar to the *Toxicological Evaluation* section of this consultation) and nuisance dust events (Charfoos and Christenson 2004).

At the September 19, 2007 public meeting, attendees posed several questions to MDCH:

1. **What are the effects of inhaled manganese on the upper respiratory system? Does it increase the susceptibility to pneumonia?**

The concentrations of manganese in the air in the Downriver Soil Study Area should not affect the respiratory system. In occupational studies, workers exposed to manganese dust have displayed respiratory symptoms, including pneumonia, but these effects, when they occur, are seen at much higher concentrations than reported in the River Rouge air data. Dust in general can be an irritant to the lungs, regardless of its manganese content.

2. **Can exposure to manganese increase the risk of multiple sclerosis (MS)?**

Although MS is a disease involving the nervous system, and excess exposure to manganese can affect the brain, studies have not established a connection between the two. MS is the scarring along nerve fibers that results from the myelin, the protective covering of the fibers, being destroyed or otherwise lost. This scarring can happen anywhere in the body. Manganese's effect on the nervous system appears to occur only in the brain. Research on manganese's action in the brain indicates that the metal does not attack the myelin.

3. **Would wearing a dust mask be a good method of decreasing exposure to manganese in airborne dust?**

If there is a lot of airborne dust, regardless of the chemicals present in the dust, it may be prudent to wear a dust mask when conducting outdoor activities, such as lawn mowing. This is especially true if you have a pre-existing condition such as chronic obstructive pulmonary disorder (COPD) or asthma.

4. **Are there other chemical emissions associated with manganese? In other words, if manganese is present, what other chemicals can be expected?**

Because manganese occurs naturally, it will always be present to some degree in soil and air. An urban environment, such as the Downriver Soil Study Area, generally will have higher concentrations than suburban or rural areas due to the nature and degree of use of the area. Other chemicals, such as volatile compounds (solvents, gasoline components, engine exhaust), may also be present, depending on the surrounding industries.

5. Can exposure to manganese increase the risk of developing lupus?

Research suggests that *deficient* amounts of manganese may actually exacerbate lupus symptoms.

6. Can exposure to manganese increase the risk of cancer?

There is no evidence that manganese contributes to an increased risk of any type of cancer in humans.

7. Fishermen and kids use Belanger Park, between U.S. Steel and Detroit Edison, along the river. Could exposure to manganese there be putting them at risk?

Air levels of manganese at Belanger Park likely are quite similar to those measured at the River Rouge monitoring station. Park users are at no greater risk than local residents.

8. Could garden produce absorb the manganese, then transfer it to humans eating that produce?

Manganese occurs naturally in the soil and, at varying concentrations, in food. Also, manganese is an essential nutrient, and most people eliminate excess through normal metabolism. It is not likely that food-producing plants would absorb levels of manganese that would be harmful to those eating the produce.

9. There are slag waste piles at the southern end of U.S. Steel's property (E.C. Levy). The wind blows dust off these piles into the surrounding neighborhoods. It makes it very difficult for some people to breathe comfortably.

MDCH discussed this concern with the MDEQ Waste and Hazardous Materials Division and AQD. The piles are exempt from Part 115 rules, which address waste, unless it can be documented that the slag is blowing off-site (MDEQ 2002b). Photographs of dust blowing off the piles and samples of fallout, collected and analyzed appropriately, would provide evidence for potential air-quality enforcement actions (B. Sia, MDEQ-AQD, personal communication, 2007).

AQD is aware of complaints of fugitive dust in this area but these are attributed to a local scrap metal processor and not U.S. Steel or E.C. Levy. MDEQ has cited the processor for clean-air violations and have ordered them to submit a compliance plan (T. Seidel, MDEQ-AQD, personal communication, 2009).

Conclusions

The public health hazard posed by the inhalation of manganese-contaminated soil in the cities of River Rouge and Ecorse remains indeterminate. (Appendix B describes ATSDR's public health hazard categories.) It is evident that ambient air has contained levels of manganese *as TSP* that exceeded the RfC for some years. However, it is necessary to know PM10 levels of manganese to determine public health implications. As indicated earlier in this document, the public health concern in question is the inhalation of harmful amounts of airborne manganese. If PM10 levels of manganese in the Downriver Soils Study Area, as measured at the River Rouge monitoring station, are within acceptable limits, there would not be a public health concern. However, there may be regulatory issues that would still need to be resolved.

Recommendations

1. Continue ambient air monitoring at the River Rouge station, adding the collection and analysis of PM10 metals.
2. If feasible, determine the increment that each source of airborne manganese contributes to ambient air levels in the Downriver Soil Study Area.
3. Develop site-specific PSIC (residential and industrial) for manganese for the Downriver Soil Study Area, as appropriate.

Public Health Action Plan

1. MDEQ Air Quality Division will continue monitoring for manganese (as TSP), as well as arsenic, cadmium, nickel, and carbonyls, at the River Rouge air monitoring location. As of January 22, 2009, MDEQ has begun collecting PM10 samples at this location and analyzing for manganese.
2. MDCH will re-evaluate the public health implications of exposure to manganese in the Downriver Soils Study Area once sufficient PM10 data are collected.
3. A multi-divisional MDEQ air-monitoring workgroup deliberated on whether each source's contribution to airborne manganese to the Downriver Soil Study Area could be determined. The workgroup also discussed whether an air-monitoring study was feasible. The workgroup concluded that the complexity of the site, with its many possible sources, would result in too much uncertainty and not benefit the investigation. This recommendation will not be carried out (R. Sills, MDEQ-AQD, personal communication, 2008).
4. MDEQ will decide whether derivation of a site-specific PSIC is appropriate.

If any citizen has additional information or health concerns regarding this public health consultation, please contact the MDCH Division of Environmental and Occupational Epidemiology at 1-800-648-6942. ATSDR and MDCH remain available for further consultation on this site.

Preparers of Report

Michigan Department of Community Health
Division of Environmental and Occupational Epidemiology

Christina Bush, Toxicologist
Toxicology and Response Section

ATSDR Region 5 Office

Mark Johnson
Office of Regional Operations

ATSDR Division of Health Assessment and Consultation

Trent LeCoultre, Technical Project Officer
Cooperative Agreement Program Evaluation Branch

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Certification

This **Public Health Implications of Inhalation of Manganese in Downriver Soils (Cities of River Rouge and Ecorse) Health Consultation** was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures. Editorial review was completed by the cooperative agreement partner.

Technical Project Officer, Cooperative Agreement Program Evaluation Branch (CAPEB), Division of Health Assessment and Consultation (DHAC), ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Team Leader, CAPEB, DHAC, ATSDR

Appendix A. Particulate Soil Inhalation Criteria: Considerations for the Downriver Soil Study Area

The MDEQ Particulate Soil Inhalation Criteria (PSIC) address the emission and dispersion of contaminated soil particulates into the ambient air. The PSIC identify concentrations of hazardous substances in soil that, upon becoming airborne particulates, are not expected to impact ambient air at levels that may cause adverse human health effects. The criteria are intended to be protective of chronic human health effects and may not be protective of other endpoints such as acute human health effects, odors, physicals hazards, nuisance dust conditions, or ecological impacts (MDEQ 2007b).

To calculate the PSIC for non-cancer-causing chemicals, such as manganese, MDEQ assumes that the contaminated soil is the only source of the chemical (versus fugitive or stack emissions, or other sources). The agency also considers exposure frequency and duration, the MDEQ air screening level for the chemical of interest, and the **Particulate Emission Factor (PEF).** The PEF relates the concentration of a particulate contaminant in ambient air to the corresponding concentration of contaminant in soil, accounting for its emission and subsequent dispersion. The PEF is affected by several parameters: an **air-dispersion factor**, **emission due to vehicle traffic**, **emission due to wind**, and the **vegetative cover** on the source area (MDEQ 2007b).

The default values for the **air-dispersion factor (Q/C)** and **emission due to vehicle traffic (Ev)** are derived using a half-acre source area size. Thus, PSIC values in the MDEQ criteria tables are for a one-half acre source size (MDEQ 2004). MDEQ air modelers have determined dispersion factors and corresponding modifiers for source area sizes different from one-half acre. Larger source areas result in a modifier less than 1, whereas smaller source areas result in a modifier greater than 1. For large sites under investigation, risk assessors first apply the 1,000-acre modifier (0.35) to the generic one-half acre PSIC value in the Part 201 criteria tables to obtain a screening value. (Note that a screening value is *not* a clean-up value.) Areas with soil concentrations exceeding the screening value are identified as source areas. Individual source area sizes are summed to yield a total source area size. The modifier for the source size closest to this sum is then applied to the generic (half-acre) PSIC, resulting in the PSIC applicable to the site. Those areas exceeding the applicable PSIC are targeted for remedial action consideration (MDEQ 2007b).

As discussed in this health consultation, the Downriver Soil Study Area is approximately 900 acres. However, if soils on the U.S. Steel Great Lakes Works property are also considered, since they may be impacting local ambient air as well, the total acreage under investigation could exceed 1,500 acres. (The main plant area for U.S. Steel, in the city of Ecorse, is 682 acres. This does not include the hot strip mill facility, in the city of River Rouge, nor the facilities on Zug Island [RTI 2006].) A modifier calculated for a 1,500-acre potential source area could result in a screening value below expected background concentrations. If this occurs, then the background value may be used in place of the screening value. However, the 1,000-acre may be the maximum modifier value used for screening purposes (D. Ries, MDEQ-RRD, personal communication, 2009).

Ev assumes that the vehicles in question are passenger automobiles. For the generic industrial PSIC, MDEQ assumes more vehicle traffic (50 round trips per day for industrial, versus 10 for residential) over longer (45 meters versus 20), unpaved driveways at industrial sites. (This is why the Industrial PSIC is more restrictive, or lower, than the Residential PSIC.) At facilities where trucks and other heavy equipment are expected to be present, further facility-specific evaluation is necessary to derive an appropriate industrial Ev (MDEQ 2007b). If the U.S. Steel Great Lakes Works property were included in the site assessment for the Downriver Soil Study Area, it would be necessary to derive a site-specific industrial Ev.

Emission due to wind (Ew) and **vegetative cover (V)** are considered together when determining the PEF. The default Ew uses meteorological data from three sites that MDEQ uses routinely for air modeling and considers representative of wind conditions in Michigan. For facililty-specific calculations, wind data can be taken from the nearest airport with meteorological equipment or can be gathered locally. Unless the percent vegetative cover is known, 50 percent is used for the V value (MDEQ 2007b).

The source area may include both on-site (such as an industrial site) and off-site (areas to which emissions were deposited, such as residential neighborhoods) soils. MDEQ-RRD requires the evaluation of potential off-site migration of contamination and risk to off-property receptors. Contamination emitted from all source areas likely will commingle in ambient air and may result in a concentration different than that from a single source area. Source areas must be adequately characterized to determine if the variability in the data indicates considering the individual source areas separately (MDEQ 2007b).

MDEQ guidance regarding the compliance with the PSIC states that ambient air monitoring may be used to determine that contaminant concentrations in facility soils will not result in unacceptable inhalation exposures at Part 201 facilities (MDEQ 2007b). However, there are several possible sources of manganese to the ambient air in the Downriver Soil Study Area, as mentioned in the body of this health consultation. It may be difficult to determine one facility's compliance with the PSIC unless the contribution of each manganese source to ambient air levels can be determined. A multi-divisional MDEQ air-monitoring workgroup deliberated on whether each source's contribution to airborne manganese to the Downriver Soil Study Area could be determined. The workgroup also discussed whether an air-monitoring study was feasible. The workgroup concluded that the complexity of the site, with its many possible sources, would result in too much uncertainty.

The interagency Toxics Steering Group (TSG), composed of toxicologists from MDEQ and MDCH, formed a workgroup in 2006 to review the derivation and application of the manganese PSIC. This work did not pertain specifically to the Downriver Soil Study Area but encompassed all areas in Greater Detroit that may be impacted by manganese-contaminated soils. The workgroup plans to finish its review and present its findings to the full TSG in early 2009.

Appendix B. ATSDR Public Health Hazard Categories

Depending on the specific properties of the contaminant(s), the exposure situations, and the health status of individuals, a public health hazard may occur. Sites are classified using one of the following public health hazard categories:

Urgent Public Health Hazard
This category applies to sites that have certain physical hazards or evidence of short-term (less than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. These sites require quick intervention to stop people from being exposed. ATSDR will expedite the release of a health advisory that includes strong recommendations to immediately stop or reduce exposure to correct or lessen the health risks posed by the site.

Public Health Hazard
This category applies to sites that have certain physical hazards or evidence of chronic (long-term, more than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. ATSDR will make recommendations to stop or reduce exposure in a timely manner to correct or lessen the health risks posed by the site.

Indeterminate Public Health Hazard
This category applies to sites where critical information is lacking (missing or has not yet been gathered) to support a judgment regarding the level of public health hazard. ATSDR will make recommendations to identify the data or information needed to adequately assess the public health risks posed by this site.

No Apparent Public Health Hazard
This category applies to sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but the exposures are not at levels likely to cause adverse health effects. ATSDR may recommend any of the following public health actions for sites in this category:

- cease or further reduce exposure (as a preventive measure)
- community health/stress education
- health professional education
- community health investigation.

No Public Health Hazard
This category applies to sites where no exposure to site-related hazardous substances exists. ATSDR may recommend community health education for sites in this category.

For more information, consult Chapter 9 and Appendix H in the 2005 ATSDR Public Health Assessment Guidance Manual (http://www.atsdr.cdc.gov/HAC/PHAManual/index.html).

Appendix C. MDCH Response to Public Comments Received on Draft Health Consultation

This appendix contains two letters received from U.S. Steel, containing comments supplied by their consultant, followed by MDCH's responses to the comments. Within the second letter (dated October 1, 2007) were several appendices:

- Appendix A of the letter consisted of paper copies of the scientific articles pertaining to epidemiological studies. Although listed in Dr. Beck's references (and in the *References* section of the health consultation), they are not individually included here.
- Similarly, the articles in Appendix B of the letter are listed in the references but not included individually.
- Appendix C was the September 18, 2007 letter and comments from U.S. Steel/Dr. Beck, included earlier in this section.

The comments in the letter dated October 1, 2007 were not enumerated as they were in the September 18, 2007 letter. Therefore, the format of the responses will appear different.

Great Lakes Works
No. 1 Quality Drive
Ecorse, Michigan 48229

September 18, 2007

Christina Bush
Michigan Department of Community Health
Division of Environmental Health
Lansing, Michigan 48909

Dear Ms. Bush,

Enclosed are comments regarding the "Health Consultation – Public Health Implications of Inhalation of Manganese in Downriver Soils (Cites of River Rouge and Ecorse), Wayne County, Michigan." These comments on the Health Consultation (HC) were prepared on behalf of United States Steel Corporation by Barbara D. Beck, Ph.D., DABT and her colleagues at Gradient Corporation.

Dr. Beck has significant experience in evaluating exposures and risks of metals, and of manganese in particular, in the environment. She has published extensively in the areas of metal toxicology and risk for many years. She is also a member of the Scientific Advisory Committee to the Manganese Health Research Program (HRP), a research program funded by the US Department of Defense. The role of the committee is to provide technical direction on key areas of research regarding health effects of manganese. Dr. Beck has also conducted laboratory research regarding the toxicological effects of particulates on the lungs of rodents. Thus, Dr. Beck and her colleagues are well-qualified to provide comments on the HC.

Gradient's overall conclusion is that the HC is reasonable and well-supported scientifically in places; however, other parts of the document are based on an incomplete review of the literature and are not well-supported. They further observe that a fuller, more nuanced analysis of the scientific literature and the site data would lead to the conclusion that manganese concentrations in downriver soils are highly unlikely to present a public health hazard.

Please feel free to call or email Dr. Beck (617-395-5000; bbeck@gradientcorp.com) with any questions on this analysis.

Sincerely yours,

Mark C. Barnes
Manager, Environmental Control
United States Steel Corporation

Comments on the Health Consultation – Public Health Implications of Inhalation of Manganese in Downriver Soils (Cities of River Rouge and Ecorse) Wayne County, Michigan

Prepared for
U. S. Steel – Great Lakes Works
1 Quality Drive
Ecorse, Michigan

Prepared by
Gradient Corporation
20 University Road
Cambridge, MA 02138

September 19, 2007

Table of Contents

1 Introduction

This report provides comments from Gradient Corporation on the Health Consultation (HC) "Public Health Implications of Inhalation of Manganese in Downriver Soils (Cities of River Rouge and Ecorse), Wayne County, Michigan," prepared by the Michigan Department of Community Health (MDCH). The HC is reasonable and well-supported scientifically in places; however, other parts of the document are based on an incomplete review of the literature and are not well-supported. We believe that a fuller, more nuanced analysis of the scientific literature and the site data would lead to the conclusion that manganese concentrations in downriver soils are highly unlikely to present a public health hazard. The bases for this conclusion is provided in the comments below.

2 Comments

Comment 1 (pg. 4 Summary, end of 1st ¶; pg. 14, middle of 1st ¶)

The Summary on page 4 states that "Also, toxicological studies suggest that Total Suspended Particulate (TSP) manganese inhaled through the nose and absorbed directly to the brain may be a more relevant exposure pathway than particulate matter inhaled into the lungs and absorbed into systemic circulation. Thus, it is also not clear whether TSP should be the appropriate dose metric to evaluate risk or if the current metric (particular matter less than 10 microns, or PM_{10}) is correct." This statement is reflected on page 14 as well, where the HC says "More recent data on the absorption of inhaled manganese suggests that manganese inhaled through the nose may deposit directly to the brain *via* the olfactory bulb, which is responsible for the sense of smell (ATSDR, 2000; Dorman *et al.*, 2002; Elder *et al.*, 2006). It is not clear if the neurotoxic effects seen in humans are due to absorption *via* the olfactory bulb, *via* deposition to the alveoli, or a combination of the two....MDEQ has requested that EPA evaluate the new toxicological data and determine the appropriate dose metric: TSP or PM_{10}."

These statements are overly broad and require clarification. Although, in general, respirable particulates are more toxicologically relevant than TSP for evaluating systemic effects from the inhalation pathway, a review of the studies cited in these sections of the HC, and those referenced within (Henriksson *et al.*, 2000; Vitarella *et al.*, 2000; and Brenneman *et al.*, 2000), provides evidence to suggest that the most appropriate size fraction for evaluating the toxicity of inhaled manganese is uncertain. These studies suggest that, in the rodent, manganese may enter the brain directly through the

olfactory pathway, thereby bypassing the blood-brain barrier; however, interpreting these results as evidence that, in humans, TSP may be a better dose metric than PM_{10} is premature, particularly given that the studies were done in rats with either respirable manganese aerosols (≤ 2.5 µm) (Dorman *et al.*, 2002; Vitarella *et al.*, 2000; and Brenneman *et al.*, 2000), solid ultrafine particulates (UFP) (0.03 µm in diameter) (Elder *et al.*, 2006), or intranasal instillation of TSP (Henriksson *et al.*, 2000), a route that is toxicologically questionable with regard to the inhalation pathway. Furthermore, Elder *et al.* (2006) note that solid particles > 0.2 µm may not reach the brain *via* the olfactory tract, suggesting that, even for the olfactory route, smaller particles (possibly smaller than PM_{10}) may be more biologically and toxicologically relevant than TSP. In addition, although the HC indicates that "...studies suggest that TSP ... may be a more relevant exposure pathway than particulate matter," none of the studies explicitly suggest that the results indicate that TSP may be a better dose metric than PM_{10} for toxicological evaluation of manganese.

It is worth noting that in either case, whether a revised Reference Concentration (RfC) is based on TSP or PM_{10}, it is important to compare the appropriate data to the manganese RfC. PM_{10} data should be compared to an RfC based on PM_{10} (as correctly presented in the HC), or TSP data should be compared to an RfC based on TSP.

As noted above, although the studies suggest that the olfactory route may make a significant contribution to brain manganese levels following manganese inhalation exposure in rats, the relevance of these observations to humans is questionable for the following reasons:

- There are considerable differences in the nasal and brain anatomy and physiology of rats and humans. As pointed out by Dorman *et al.* (2002), in the rat, the olfactory bulb accounts for a relatively large portion of the central nervous system as compared to humans. In addition, the olfactory mucosa in rats represents about 50% of the total nasal epithelium, as compared to only 5% of the human nasal epithelium. These differences suggest that the olfactory pathway in humans is likely to be less important as compared to rats.
- Dorman *et al.* (2002) also indicate that there is compelling evidence to suggest that the striatum of the human brain is the primary target for manganese neurotoxicity, and not the olfactory bulb and tract. In addition, as shown in Dorman *et al.* (2002), Brenneman *et al.* (2000), and Vitarella *et al.* (2000), olfactory transport does not contribute significantly to manganese delivery to the rat striatum.
- Although Henriksson *et al.* (2000) showed a slight increase in manganese in the striatum, as discussed in Dorman *et al.*, (2002), it is not clear if this was from olfactory transport,

or a result of systemic transport *via* injured tissue in the olfactory tract resulting from the instillation.

- Elder *et al.* (2006) observed an increase in manganese in the striatum as well, but discusses that this could be due to the small size of the particulate manganese used in the study (UFP = 0.03 μm). The article discusses that axons of the olfactory neurons narrow to a diameter of 0.2 μm and are tightly packed where they pass through the cribiform plate (perforated structure that supports the olfactory bulb and allows passage of olfactory nerves). The authors suggest that solid particles need to be < 0.2 μm to pass through the cribiform plate from the olfactory tract.

Thus, the HC needs to more clearly articulate rodent/human differences that complicate identification of the most appropriate size for purposes of toxicological evaluation and to state explicitly that the inhalation studies were done with respirable size particulate (≤ 2.5 μm) manganese. The HC should also state that more research is needed prior to drawing conclusions regarding the appropriate particle size for evaluating the toxicity of inhaled manganese, and the significance of the olfactory pathway in humans.

Comment 2 (General)

The last sentence of the Summary on page 4 says "Exposure to elevated levels of airborne manganese particulates is a public health concern and should be addressed." There are several similar statements in the HC, listed below.

- pg. 12, first ¶, last sentence – "Due to the presence of manganese-contaminated soil, River Rouge and Ecorse residents will likely continue to be exposed to elevated levels of manganese in airborne soils in the foreseeable future."
- pg. 12, second ¶, last sentence – "River Rouge and Ecorse residents will likely continue to be exposed to elevated levels of manganese in ambient air from stack emissions in the foreseeable future."
- pg. 13, first ¶, last sentence – "Area residents will likely continue to be exposed to elevated levels of manganese in airborne fill material in the foreseeable future."
- pg. 15, third sentence in the Conclusion – "It is evident that ambient air has contained elevated levels of manganese as TSP for some years."
- pg. 15, Recommendation #4 – "Reduce exposure to elevated levels of airborne manganese particulates in the cities of River Rouge and Ecorse."

These statements are not supported by recent toxicological data on manganese inhalation (see Comment 5). A review of these data suggests that a revised manganese RfC would very likely be higher than the current RfC. Since the MDEQ (Michigan Dept. of Environmental Quality) Initial Threshold

Screening Level (ITSL) equals the current RfC, and the MDEQ Particulate Soil Inhalation Criterion (PSIC) is calculated based on the current RfC, an increase in the manganese RfC would result in a less stringent ITSL and PSIC for manganese. Therefore, the levels of manganese in the air and soil would very likely not be considered "elevated," and the levels in ambient air would very likely not be considered a "public health concern" once the new manganese inhalation data are considered. In addition, the above statements are inconsistent with the discussion in the HC (2nd ¶ on page 14) that indicates that it "may not be appropriate" to compare total suspended particulate (TSP) manganese concentrations to the manganese RfC (derived from respirable dust [PM_{10}]) when evaluating public health implications, and that this comparison "will likely overestimate risk."

As written, these statements in the HC imply that manganese levels in air and soil are elevated and there is a public health concern. This is likely to be inaccurate once PM_{10} data are compared to the current RfC and/or new manganese toxicological and epidemiological data are considered. MDCH needs to discuss the possibility that the manganese RfC could become less stringent and that the current comparison of TSP data to the RfC is very likely an overestimate of risk.

Comment 3 (pg. 9, 1st ¶)

Table 1 of the HC compares the manganese soil concentrations to the generic PSIC (3,300 mg/kg; based on a one-half acre source size) and screening value PSIC (1,155 mg/kg; based on multiplying the generic PSIC by a modifier of 0.35 for a 1,000-acre source size, as described in MDEQ, 2007), but provides minimal discussion of the comparison or the bases of these values. There is some discussion in Appendix A, but we recommend that MDCH provide a brief discussion in the main text of the bases of both values and how one should interpret these comparisons, particularly that the screening-level PSIC is intended to be used to determine source size, and is not intended to be applied as a clean-up value (as discussed in Appendix A of the HC).

We recommend that the MDCH revise the HC to include a discussion of how the screening-level PSIC will be used to derive the applicable site-specific PSIC; this discussion would put the values in Table 1 into better context. For example, as discussed in Appendix A, MDEQ guidance (MDEQ, 2007) recommends identification of areas with soil concentrations exceeding the screening-level PSIC as the potential source area, and summing the sizes of these potential source areas to come up with a new source area size. A new modifier, based on the new source area size, is then applied to the generic PSIC again to derive another screening-level PSIC value. Although not discussed in Appendix A or explicitly

in the MDEQ guidance (MDEQ, 2007), we suggest that this new screening-level PSIC value should then be compared to all soil concentrations that exceeded the 1st screening-level PSIC to see if any of the soil concentrations are now below the new screening value, and whether a new source size should be determined. This process should be repeated iteratively until the source size remains constant. Once the source size cannot be further decreased, the modifier closest to this source size (as presented in the MDEQ PSIC guidance, MDEQ, 2007) should then be applied to the generic PSIC to determine the applicable site-specific PSIC. The applicable site-specific PSIC, if exceeded, would then be used for risk-management and/or remediation decisions.

In addition, The MDEQ guidance (MDEQ, 2007) states that "For non-contiguous source areas, the concentration in each source area cannot be compared to the PSIC for each source area without considering the combined effect of all source areas....The resulting modified PSIC provides a conservative screen since the airborne contaminants emitted from the non-contiguous source areas would likely be more greatly dispersed over the entire source and non-source areas than would be the case if all source areas were contiguous." In addition, we suggest that when determining the final source size to be applied to the site-specific PSIC, there should also be some consideration of how likely it is that all areas combined could contribute to the same air concentration of manganese. If, for example, the individual source areas are very spread out, and there are large areas of cleaner soil in between these sources, it may not be appropriate to sum all of the individual source sizes, but rather to use the largest of each area as the source size.

A discussion similar to that provided here, describing the different PSICs and how they are used to derive the site-specific PSIC, should be included in the main text of the HC. The HC should also point out that, unlike the screening-level PSICs that are used to determine source size, comparison of the applicable site-specific PSIC to soil concentrations on a point-by-point basis is not appropriate. The reason is that manganese in air from resuspended soil reflects concentrations of manganese averaged over an area wider than any individual sample location. A more appropriate comparison for evaluating exposure and risk is an average concentration over a relevant surface area.

Finally, the HC should also emphasize that each PSIC is based on the same air concentration of manganese presumed to be protective of human health; *i.e.*, they each derive from the manganese MDEQ ITSL of 0.05 $\mu g/m^3$. The differences in the PSICs have only to do with different potential source sizes and MDEQ's recommendation on how source size should factor into calculation of the PSIC.

Comment 4 (Appendix A-2, last 2 sentences of 1st full ¶)

This section of Appendix A states "A modifier calculated for a 1,500-acre potential source area could result in a screening value below expected background concentrations. If this occurs, then the screening value would default to the background value." Derivation of a PSIC as low as the background manganese soil concentration should be carefully considered before being applied as a site-specific PSIC. For example, the PSICs are based on particulate emission factors (PEF) that relate the concentration of particulates in soil to particulates in air, and assume that dispersion is due to wind-blown soil and resuspension from vehicle traffic. It is important to derive a site-specific PSIC that not only reflects the appropriate source size and air concentration that is presumed to be protective of human health, but also reflects exposures that are likely to occur at the site. Therefore, the potential for soil resuspension from wind erosion and vehicle traffic should be considered on a site-specific basis. If the site is predominantly paved or covered in some way that prevents significant soil dispersion, the PEF, and therefore the PSIC, should be adjusted to appropriately reflect those features.

Comment 5 (pg. 13-14)

Although the Toxicological Evaluation section of the HC discusses the rat inhalation studies regarding the olfactory route, this section is incomplete. Specifically, the Toxicological Evaluation section does not discuss the recent toxicological and human epidemiological data on manganese inhalation. The US Environmental Protection Agency's (US EPA) most recent assessment of the RfC for manganese was completed in 1993 (US EPA, 1996), and was based on a 1992 occupational manganese inhalation study (Roels *et al.*, 1992). There have been a substantial number of additional studies published in the scientific literature since 1993. For example, several particularly relevant studies are: Chia *et al.*, 1993; Mergler *et al.*, 1994; Hochberg *et al.*, 1996; Gibbs *et al.*, 1999; Lucchini *et al.*, 1999; Crump and Rousseau, 1999; Deschamps *et al.*, 2001; Bast-Pettersen *et al.*, 2004; and Young *et al.*, 2005. In the study by Gibbs *et al.* (1999), 75 manganese exposed workers, from a manganese metal-producing plant in northern Mississippi, were compared with 75 closely matched control workers from a nearby plant with no known history of occupational exposure to manganese. The authors indicated that the two plants had common medical, safety, and industrial hygiene services, and individual matching was primarily based on gender, race, age, and salary. The mean manganese air concentration in respirable dust, from personal air monitoring for the exposed workers, was 66 $\mu g/m^3$. The manganese-exposed and control workers were administered multiple neuropsychological tests, including hand-eye coordination, hand steadiness, complex reaction time, and rapidity of finger tapping. No significant effects of

manganese exposure were found on any neurobehavioral test, resulting in a No Observed Adverse Effect Level (NOAEL) of 66 $\mu g/m^3$. Deschamps *et al.* (2001) found no neurobehavioral effects for 138 manganese exposed enamels-production workers, as compared to 137 controls. The mean respirable exposure concentration was 57 $\mu g/m^3$ and the maximum concentration was 293 $\mu g/m^3$. The authors concluded that "long exposure to low levels of manganese (approximately 200 $\mu g/m^3$) showed no significant disturbance of neurological performance."

The implication of these new epidemiological studies is reflected in a study by Clewell *et al.*, 2003. These investigators used the Roels *et al.* (1992) and Gibbs *et al.* (1999) studies to derive a statistical lower bound on a Benchmark Dose (BMDL) of 200 $\mu g/m^3$ from both studies (4,000-fold less restrictive than the current manganese RfC). As discussed in US EPA's Benchmark Dose Technical Guidance Document (US EPA, 2000), the BMDL approach is generally a preferable alternative to the NOAEL/LOAEL (Lowest Observed Adverse Effect Level) approach for derivation of an RfC. It is worth noting that even if one were to apply the uncertainty factors (UFs) that US EPA typically applies in derivation of RfCs (in this example the largest UFs that would be applied would be a UF of 10 for database limitations,[1] and a UF of 10 for intraspecies variability), an RfC based on the BMDL derived by Clewell *et al.* (2003), based on the stated assumptions regarding UFs, would be 2 $\mu g/m^3$, 40-fold less stringent than the current manganese RfC.

In addition, since 1993, several manganese inhalation studies have been conducted in animals to address the potential for developmental effects (Dorman *et al.*, 2005a, 2005b; Erikson *et al.*, 2005; HaMai *et al.*, 2006; Rindernecht *et al.*, 2005). These studies provide sufficient evidence to suggest that developmental effects from inhalation of manganese are not more sensitive endpoints than neurological effects.

As noted in the last sentence of the Toxicological Evaluation section, new data has prompted the MDEQ to request a reassessment of the manganese RfC. We recommend that the MDCH provide more discussion of recent manganese inhalation studies, and how these data could affect the reassessment of the manganese RfC.

[1] It should be noted that even the UF for database limitations may not be necessary due to the availability of developmental studies as discussed below.

Comment 6 (pg. 15, Recommendation #1)

Recommendation #1 states "Continue ambient air monitoring at the River Rouge locations, adding the collection of PM_{10} metals." We recommend clarifying this recommendation to also indicate that since US EPA's current manganese RfC is based on respirable data, the comparison of the RfC (and MDEQ's ITSL since it equals the RfC) to annual average PM_{10} data, as opposed to TSP data, is more appropriate.

Comment 7 (pg. 15, Recommendation #4)

Recommendation #4 states "Reduce exposure to elevated levels of airborne manganese particulates in the cities of River Rouge and Ecorse." See Comment 2 above. This recommendation is premature and not well-supported, as it implies that manganese levels in air and soil are elevated and there is a public health concern. Once PM_{10} data are compared to the current RfC, it is possible that there may be no exceedance of the RfC. In addition, consideration of new manganese toxicological data indicates that the RfC is likely to be overly stringent by more than an order of magnitude, in which case there would be no exceedance, even if the comparisons were ambient TSP to the respirable-based RfC. Therefore the conclusion of a public health concern is not well supported. We recommend that MDCH eliminate this particular statement in favor of a more nuanced conclusion that, while acknowledging the exceedance of the ITSL, recognizes that this exceedance is, because of the above-stated factors, highly unlikely to present a public health concern.

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Great Lakes Works
No. 1 Quality Drive
Ecorse, Michigan 48229

Date: Oct 1, 2007

SENT VIA ELECTRONIC AND OVERNIGHT MAIL

Christina Bush
Michigan Department of Community Health
Division of Environmental Health
Lansing, Michigan 48909
bushcr@michigan.gov

SUBJECT: Supplemental Comments regarding Health Consultation – Public Health Implications of Inhalation of Manganese in Downriver Soils (cities of River Rouge and Ecorse), Wayne County, Michigan

Dear Ms. Bush,

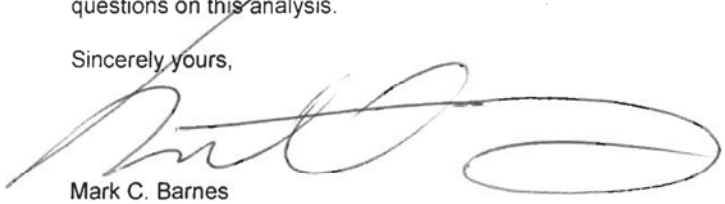
Enclosed are supplemental comments regarding the "Health Consultation – Public Health Implications of Inhalation of Manganese in Downriver Soils (cities of River Rouge and Ecorse), Wayne County, Michigan" (HC) based on a review of the presentation materials and transcript from the "Downriver Soils" (cities of River Rouge and Ecorse) Health Consultation – Community Meeting that was conducted by the Michigan Department of Community Health (MDCH) on September 19, 2007. At the Community Meeting, I provided you with a hard copy of comments prepared on behalf of United States Steel Corporation (U. S. Steel) by Barbara D. Beck, Ph.D., DABT, a principal at Gradient Corporation. These supplemental comments have similarly been prepared on behalf of U. S. Steel by Dr. Beck.

Dr. Beck has significant experience in evaluating exposures and risks of metals, and of manganese in particular, in the environment. She has published extensively in the areas of metal toxicology and risk for many years. She is also a member of the Scientific Advisory Committee to the Manganese Health Research Program (HRP), a research program funded by the US Department of Defense. The role of the committee is to provide technical direction on key areas of research regarding health effects of manganese. Dr. Beck has also conducted laboratory research regarding the toxicological effects of particulates on the lungs of rodents. Thus, Dr. Beck is well-qualified to provide comments on the HC.

Due to the copyright limitations on articles being submitted with these supplemental comments, the articles are being forwarded by overnight delivery only (as part of the complete hard copy supplemental comment submission on behalf of U. S. Steel).

Please feel free to call or email Dr. Beck (617-395-5000; bbeck@gradientcorp.com) with any questions on this analysis.

Sincerely yours,



Mark C. Barnes
Environmental Department
mcbarnes@uss.com

Gradient
CORPORATION

October 1, 2007

Ms. Christina Bush
Michigan Department of Community Health
Division of Environmental Health
Box 30195
Lansing, MI 48909

Re: Meeting Materials from the September 19, 2007 Michigan Department of Community Health (MDCH) Health Consultation – Community Meeting

Dear Ms. Bush:

I have reviewed a copy of your power point presentation and the transcript from the "Downriver Soils" (cities of River Rouge and Ecorse) Health Consultation – Community Meeting that was conducted by the Michigan Department of Community Health (MDCH) on September 19, 2007. After reviewing these materials, I thought it might be helpful to provide MDCH with some additional information and literature on the health effects of manganese. I recognize that you may already have some of these materials, in which case, of course, just use those articles that are new.

I first provide an overview of the recent manganese inhalation toxicology and epidemiology studies since US Environmental Protection Agency's (US EPA) most recent assessment of the manganese RfC in 1993. The current manganese RfC is based on a 1992 subchronic occupational manganese inhalation study, and is derived from a Lowest Observed Adverse Effect Level (LOAEL) (Roels *et al.*, 1992). A reassessment of the 1993 manganese RfC, using the studies discussed below, is likely to result in a less stringent value.

There are nine particularly relevant epidemiology studies since 1992 that I would like to bring to your attention (attached in Appendix A, and summarized in Table 1). Six of the nine studies resulted in LOAELs ranging from 96 $\mu g/m^3$ to 62,500 $\mu g/m^3$ (Chia *et al.*, 1993; Mergler *et al.*, 1994; Hochberg *et al.*, 1996; Lucchini *et al.*, 1999; Crump & Rousseau, 1999; and Bast-Petterson *et al.*, 2004). The remaining three studies resulted in NOAELs all approximately 60 $\mu g/m^3$ (respirable manganese) (Gibbs *et al.*, 1999; Deschamps *et al.*, 2001; and Young *et al.*, 2005). In the study by Gibbs *et al.* (1999), 75 workers from a manganese metal-producing plant were compared with 75 closely matched control workers, and no significant manganese exposure effects were found on any neurobehavioral test. Deschamps *et al.* (2001) found no neurobehavioral effects for 138 manganese exposed enamels-production workers, as compared to 137 controls. Both studies reflected chronic exposure durations (12.7 years and 20 years, respectively). Therefore, the results of these studies eliminate the need for an uncertainty factor (UF) of 10 for use of a LOAEL study, and a UF for use of a subchronic study.

In addition, several animal developmental studies have been published recently (attached in Appendix B) that provide evidence that developmental effects from inhalation of manganese are not more sensitive endpoints than neurological effects (Dorman *et al.*, 2005a, 2005b; Erikson *et al.*, 2005; Rindernect *et al.*, 2005; HaMai *et al.*, 2006). These studies provide evidence that a UF for lack of developmental studies would not be necessary upon reassessment of the manganese RfC.

It is also useful to keep in mind, when discussing the results of these studies with the concerned community, that the concentrations of manganese in the air in the cities of River Rouge

... University Road, Cambridge, MA 02138 • (617) 395-5000 • FAX: (617) 395-5001 • www.gradientcorp.com

and Ecorse (average of 0.10 $\mu g/m^3$ total suspended particulate [TSP]) are well below the occupational LOAEL that workers were exposed to in the Roels *et al.* (1992) study (150 $\mu g/m^3$ respirable manganese), and well below the occupational NOAELs in recent occupational studies (60 $\mu g/m^3$ respirable manganese) (Gibbs *et al.*, 1999; Deschamps *et al.*, 2001; and Young *et al.*, 2005).

In addition, as you indicated in the Health Consultation and at the community meeting, the manganese RfC is based on respirable manganese data and therefore a comparison of TSP manganese data to the RfC is an overestimate of risk. Your recommendation to collect PM_{10} data for comparison to the RfC is therefore appropriate. However, you also mention that recent animal studies suggest that TSP manganese uptake *via* the olfactory route may be a more relevant exposure pathway than PM_{10} manganese for effects on the central nervous system. A review of these studies (please see our detailed comments on the Health Consultation and relevant studies cited within; attached in Appendix C), suggests that the data are uncertain and that more research is needed prior to drawing conclusions regarding the appropriate particle size for evaluating the toxicity of inhaled manganese, and the significance of the olfactory pathway in humans. Moreover, regardless of whether a revised manganese RfC is based on TSP or PM_{10}, it is important to point out that the RfC needs to be compared to the appropriate data in order to make any meaningful conclusions about potential risks. As you note, PM_{10} data should be compared to an RfC based on PM_{10}. In addition, TSP data should be compared to an RfC based on TSP. The current comparison of TSP data to an RfC based on PM_{10} is not correct and is an overestimate of risk.

I would also like to point out that, although you correctly stated during the meeting that there is no evidence linking manganese exposure with multiple sclerosis, there were two other diseases (lupus and cancer) brought up during the meeting for which there is also no evidence of a link with inorganic manganese exposure. In addition, in one of your slides you indicated that workers exposed to manganese experience a disease called "manganism," having symptoms similar to Parkinson's disease. Although the symptoms are similar, it is important to be clear that manganism and Parkinson's disease are different, and that exposure to manganese does not cause Parkinson's disease. For example, Parkinson's disease is believed to be due to effects on the substantia nigra. Manganism, on the other hand, typically affects the globus pallidus and the substantia nigra is affected to a much lesser extent (ATSDR, 2000). Furthermore, it is important to make clear that manganism is characterized by serious clinical deficits and not just a poor response on a neurobehavioral test (such as finger tapping test). Moreover, manganism requires a very substantial exposure, with manganese concentrations typically on the order of 2-22 mg/m^3 for a long period of time (continuous exposure for 7 years or more) (ATSDR, 2000); these concentrations are at least 20,000-fold higher than the concentrations measured in the air in the Cities of River Rouge and Ecorse.

I hope you find this information helpful in putting the River Rouge and Ecorse manganese air and soil concentrations into a context that can be more easily understood by the community in terms of potential health risks. The concentrations of manganese in the air in the cities are quite low, particularly when considering that the average TSP concentrations in the cities are only 2-fold higher than the RfC which is based on PM_{10} data. Since by definition, PM_{10} concentrations will be lower than TSP concentrations, a comparison of annual average PM_{10} data could very likely fall below the current RfC. In addition, as discussed above, recent studies suggest that a reassessment of the manganese RfC could very likely result in a less stringent value.

Please feel free to call or email me (617-395-5000; bbeck@gradientcorp.com) with any questions or comments.

Sincerely yours,

GRADIENT CORPORATION

Barbara D Beck

Barbara D. Beck, Ph.D., DABT, FATS
Principal

email: bbeck@gradientcorp.com

Attachments:
Appendix A – Epidemiological Studies
Appendix B – Developmental Animal Studies
Appendix C – Gradient Comments on the Health Consultation and Relevant Articles Cited in Comment #1

Table 1
Summary of Key Manganese Inhalation Epidemiological Studies Since 1992

Article	Exposure Level ($\mu g/m^3$)	Total or Respirable	Mean Exposure Duration (years)	NOAEL ($\mu g/m^3$)	LOAEL ($\mu g/m^3$)	Comments
Roels *et al.* (1992)	150 (geomean)	Respirable	5.3	NA	150	• Basis of current RfC for manganese (US EPA, 1996) • Study used by Clewell *et al.* (2003) to derive a BMDL
Chia *et al.* (1993)	1,590 (mean)	Total	7.4	NA	1,590	
Mergler *et al.* (1994)	122 (mean)	Respirable	16.7	NA	122	
Hochberg *et al.* (1996)	62,500 (lowest)	Total?	20.25	NA	62,500	
Gibbs *et al.* (1999)	66 (mean)	Respirable	12.7	66	NA	• Study used by Clewell *et al.* (2003) to derive a BMDL
Lucchini *et al.* (1999)	over 10 years, geomean changed from: 1597 - 239 (high) 152 - 256 (medium) 167 - 55 (low)	Total	15.7	NA	96	
Crump and Rousseau (1999)	970 (median)	Total	14	NA	970 (from Roels 1987, as presented in IRIS) (US EPA, 1996)	

Table 1 Summary of Key Manganese Inhalation Epidemiological Studies Since 1992						
Article	**Exposure Level ($\mu g/m^3$)**	**Total or Respirable**	**Mean Exposure Duration (years)**	**NOAEL ($\mu g/m^3$)**	**LOAEL ($\mu g/m^3$)**	**Comments**
Deschamps *et al.* (2001)	57 (mean)	Respirable	20	57	NA	
Bast-Pettersen *et al.* (2004)	301 (geomean)	Total	20.2	NA	301	
Young *et al.* (2005)	58 (median)	Respirable	10.8	58	NA	

Notes: *LOAEL = Lowest Observed Adverse Response Level*
NOAEL = No Observed Adverse Response Level

C-20

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Young, T; Myers, JE; Thompson, ML. 2005. "The nervous system effects of occupational exposure to manganese - measured as respirable dust – in a South African manganese smelter." *Neurotoxicology* 26(6):993-1000.

MDCH Response to Comments in September 18, 2007 letter from U.S. Steel

Comment 1: This comment focuses on whether Total Suspended Particulate (TSP) or Particulate Matter less than 10 microns [µm] in aerodynamic diameter (PM10) should be the appropriate dose metric when comparing air data to the RfC and on whether olfactory transport is a likely mechanism of delivering manganese to the brain in humans.

MDCH Response:
The RfC is based on a study by Roels et al. (1992) which used the respirable (generally less than 5 µm, which is PM10) fraction of the dust in a dry alkaline battery factory to derive a permissible exposure level. In their follow-up study, Roels et al. (1999) argue that total aerosol exposure should be assessed for systemic effects (e.g., tremor), whereas monitoring of the respirable fraction is more relevant for direct effects on the lung (e.g., manganese oxide-induced pneumonitis). However, work performed by Fechter et al. (2002) suggests that, while particles larger than PM10 (18 µm) may deposit in the upper airways, they do not enter the brain through the olfactory pathway, a route that has been suggested may be more important than absorption via the lungs (Henriksson et al. 1999, Brenneman et al. 2000). (The olfactory bulb is an area of the brain near the nasal cavity that is responsible for the sense of smell.) It is unclear whether manganese particles larger than PM10 can enter and affect the brain at all. By comparing manganese TSP to the RfC, one is being protective yet possibly overestimating any risk. Ideally, PM10 concentrations should be compared to the RfC. If PM10 data are unavailable, TSP data can be used to screen for potential exceedances of the RfC, with the understanding that exceedances would have to be further investigated.

Brenneman et al. (2000) developed a unilateral nasal occlusion model that allowed them to deliver an inhaled dose of manganese chloride aerosol to a rat through one nostril. The study demonstrated that the olfactory route contributed up to 90% of the tracer manganese that was found in the olfactory pathway. The size of the particles was 2.5 µm. Similar results were seen when using manganese phosphate aerosol with a particle size of 1.7 µm (Dorman et al. 2002). Elder et al. (2006) demonstrated that about 11.5% of manganese oxide ultra-fine particles (3-8 nanometers in diameter) that were deposited on the olfactory mucosa were translocated to the olfactory bulb. Fechter et al. (2002) exposed rats (nose only) to a manganese oxide aerosol with particulates that were either 1.3 µm or 18 µm. Even though there was greater nasal deposition of the larger particles, there was no increase in olfactory bulb manganese concentration in the large-particle group. The small-particle group had higher olfactory bulb manganese concentrations (but not statistically significant) than controls or the large-particle group. The researchers concluded that small-particle aerosol was taken up by the olfactory nerve and transported to the olfactory bulb much more efficiently than large-particle aerosol.

When considering the likelihood of the olfactory route as a means of delivery of manganese to the human brain, one must consider the differences between rat and human respiratory systems. As pointed out in U.S. Steel's comments, the rat olfactory bulb represents a large portion of the central nervous system. The nasal olfactory mucosa in a rat makes up about 50% of the total nasal epithelium, whereas the proportion is only about 5% in the human (Vitarella et al. 2000, Dorman et al. 2002). Rats are obligate nasal breathers (they must breathe through their noses) whereas humans can breathe through both the nose and mouth. About 16.5% of the inhaled air

stream reaches rat olfactory mucosa, whereas only about 5% reaches human olfactory mucosa (Brenneman et al. 2000). Modeling has predicted a pulmonary (lung) deposition efficiency of an aerosol with a particle size of 1.5 µm of about 35% for humans and rhesus monkeys, while the rat model showed much lower deposition efficiency (6%) due to higher nasal uptake. As well, rodents clear particles from the lung more quickly than either monkeys or humans (Dorman et al. 2005). These differences suggest that the olfactory pathway may be less relevant in humans.

MDCH has modified language in the health consultation regarding these issues.

Comment 2: This comment questions whether the current manganese RfC is appropriate, given new data that have been generated since the RfC was established. Additionally, U.S. Steel's consultant argues that, because the River Rouge air data are expressed as TSP and not PM10, it is unknown whether levels of manganese are truly "elevated" (greater than the RfC).

MDCH Response:
The EPA and ATSDR are reviewing their respective manganese inhalation reference values. The EPA may reach its conclusion within a few years (R. Sills, MDEQ Air Quality Division, personal communication, 2008). ATSDR has released a draft update of its Toxicological Profile for Manganese for public comment (2008), however the MRL is not a regulatory number.

MDCH reviewed recent studies of manganese toxicity, including follow-up work done on the Roels et al. (1992) cohort, on which the RfC currently is based, and on other cohorts from supporting studies (Roels et al. 1987, Mergler et al. 1994, Roels et al. 1999, Crump and Rousseau 1999, Bouchard et al. 2008; for a full list of papers reviewed, see the *References* section). MDCH is not a regulatory agency and cannot set an RfC. MDEQ is evaluating the data and determining whether the state will recalculate its screening value (currently the EPA RfC) for manganese (R. Sills, MDEQ Air Quality Division, personal communication, 2008). It would be inappropriate to speculate on if and how the RfC value may change rather than take action based on current environmental rules.

MDCH agrees that use of the term "elevated" is not appropriate at this time. The agency has changed the language in the health consultation regarding "elevated levels of manganese."

Comment 3: This comment suggests that MDCH discuss in more detail the application of the manganese PSIC. U.S. Steel's consultant also suggests that more explanation be placed in the main text of the health consultation.

MDCH Response:
MDCH is not a regulatory agency and, as such, does not implement environmental rules or make risk management decisions. MDEQ management ultimately is responsible for deciding how the PSIC will be interpreted and applied. MDCH has provided a copy of U.S. Steel's comments to MDEQ.

MDCH generally writes health consultations for the lay public and tries to make the documents readable and understandable for those without a scientific or technical background. Technical

discussions usually appear in appendices, for those interested in obtaining more detail. MDCH has edited text in the main document and the appendices to help clarify the discussion.

Comment 4: This comment expresses concern that a site-specific PSIC for the Downriver Soil Study Area reflect accurate site data and consider exposures that are likely to occur.

MDCH Response:
MDCH agrees that a site-specific criterion should be scientifically accurate. As stated previously, MDEQ management will have the ultimate authority on PSIC interpretation and application.

Comment 5: Similar to Comment 2, this comment raises concern that the current RfC may not reflect recent toxicological and epidemiological data.

MDCH Response:
Please refer to the response for Comment 2.

Comment 6: U.S. Steel's consultant recommends that ambient air monitoring be for PM10 so that an appropriate comparison can be made to the RfC.

MDCH Response:
MDCH made this recommendation previously as well as in this final document. This monitoring is now being done.

Comment 7: This comment indicates that the recommendation to "reduce exposure to elevated levels of airborne manganese particulates in the cities of River Rouge and Ecorse" is premature, since it is unknown whether manganese levels are truly "elevated" (above the RfC, as PM10).

MDCH Response:
MDCH agrees that the recommendation is premature and has adjusted the language in the health consultation accordingly.

MDCH Response to Comments in October 1, 2007 letter from U.S. Steel

Comment: Consider additional human epidemiology and animal developmental studies since establishment of 1993 RfC.

MDCH Response:
The references cited in this letter were cited in the previous (September 18, 2007) letter from U.S. Steel, above. Please refer to the response for Comment 2 from that letter.

Comment: Compare and contrast ambient air levels of manganese in the River Rouge/Ecorse area with levels shown to cause (or not cause) effects in occupational studies.

MDCH Response:
MDCH has added language in the *Toxicological Evaluation* section of the health consultation that addresses this comment.

Comment: Compare PM10 data to the RfC.

MDCH Response:
This concern was mentioned in the previous (September 18, 2007) letter from U.S. Steel, above. Please refer to the response for Comment 1 from that letter.

Comment: Provide information regarding manganese not being associated with increased lupus or cancer cases.

MDCH Response:
MDCH has added discussion in the *Community Health Concerns* section of the health consultation.

Comment: Indicate how manganism differs from Parkinson's disease.

MDCH Response:
MDCH has added discussion in the *Toxicological Evaluation* of the health consultation.

Certification

This **Public Health Implications of Inhalation of Manganese in Downriver Soils (Cities of River Rouge and Ecorse) Health Consultation** was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures. Editorial review was completed by the cooperative agreement partner.

Technical Project Officer, Cooperative Agreement Program Evaluation Branch (CAPEB), Division of Health Assessment and Consultation (DHAC), ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Team Leader, CAPEB, DHAC, ATSDR