Ambient Air Levels of Manganese in Southeast Michigan: Evaluation and Recommendations by the AQD Manganese Workgroup

Prepared by the
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Appendix A: Emission Unit Specific 2007 Manganese Emission Estimates

EXECUTIVE SUMMARY

The Michigan Department of Environmental Quality (DEQ), Air Quality Division (AQD) is pursuing a greater understanding of the causes and magnitude of elevated ambient air manganese levels in the Detroit area and opportunities for risk reduction. This initiative was prompted by ambient air monitoring data, which demonstrated elevated levels at some of the Detroit monitoring sites.

This report is organized in a series of sequential issue discussions that progressively narrow the scope of the manganese analyses. Issues addressed by the AQD Manganese Workgroup (Workgroup) presented in this report are:

- Why should we be concerned about manganese?
- Do we have manganese ambient levels above the health protective benchmark?
- If there is a health concern, what locations have high measurements?
- What is the source of manganese impacting the above areas?
- Are there specific facilities that are contributing the majority of manganese in the above areas?
- What specific processes are emitting manganese at these facilities?
- What options are available to reduce manganese emissions at these processes?

From the Workgroup's analysis discussed in this report, the following conclusions are drawn:

1. Preliminary findings from a recent comprehensive environmental study of manganese exposed adults in Marietta, Ohio may support concerns about manganese exposure. Similar manganese concentrations and industrial manganese sources are found in the Marietta and Detroit areas.

2. Elevated levels of manganese represent a health concern, based on annual average ambient air concentrations of 0.05 $\mu g/m^3$ as an appropriate health protective benchmark.

3. Manganese values at four Detroit area monitoring sites show recent levels at or above the health protective benchmark: Dearborn, North Delray, South Delray and River Rouge. High manganese levels elsewhere in the Midwest are in urban environments, especially near steel-related production facilities.

4. Analysis of wind direction on high concentration days often points to manganese emissions from large point sources as major contributors.

5. Point source emissions contribute well over 99% of estimated manganese emissions in Wayne County. The vast majority of point source emissions originate with steel facilities, namely Severstal and United States Steel (US Steel).

6. Steel industry emission values are likely significantly underestimated, as condensable emissions are not included. In addition, these values are likely somewhat underestimated due to assumed high capture and control efficiencies used in emission calculations.

7. Comparison of periods of reduced steel production with ambient data from the four monitoring sites reinforces the correlation between steel production and manganese levels.

8. Considering the production/ambient correlation, the very high percentage of emissions from steel production, the likely underestimated emissions from this sector, and the wind analysis on high concentration days, it is reasonable to conclude that steel production at Severstal and US Steel is the primary cause of elevated manganese concentrations at the Detroit area monitors.

9. The primary manganese emitting processes at Severstal and US Steel are the LRF/LMF, BOF (Basic Oxygen Furnace), blast furnaces, hot metal transfer and desulfurization, pits and (US Steel only) boilers. Based on emissions, it is most productive to evaluate emission reductions at the LRF/LMF, BOF, and blast furnaces.

10. Additional emission reduction measures are available at the primary emitting processes. Considerable control is also possible from measures that address condensable emissions. FGD (Flue gas desulfurization) or lime injection at baghouses are the most viable significant reduction option.

The Workgroup recommends both Severstal and US Steel upgrade their baghouses with lime injection systems. Baghouse detection devices and additional hooding are also recommended. The uncertainties in emission estimates and limited ambient monitoring coverage result in secondary recommendations on monitoring, source testing, emissions inventory development, and involvement of stakeholders.

1.0 INTRODUCTION

1.1 Purpose of the Manganese Initiative

The DEQ AQD is pursuing a greater understanding of the causes and magnitude of elevated ambient air manganese levels in the Detroit area and opportunities for risk reduction. This initiative was prompted by ambient air monitoring data, which demonstrated elevated levels at some of the Detroit monitoring sites.

The Detroit Air Toxics Initiative (DATI) Risk Assessment Report (DEQ, 2005) evaluated the human health risks associated with monitored ambient air levels of air toxics from 2001-2002 in the Detroit area. The DATI study found that annual average levels of manganese in total suspended particulate-manganese (TSP-Mn) at four Detroit monitoring sites exceeded the health protective benchmark value of 0.05 micrograms per cubic meter (µg/m^3). Those annual average TSP-Mn levels and locations were: South Delray (0.27 µg/m^3), Dearborn (0.20 µg/m^3), North Delray (0.09 µg/m^3), and River Rouge (0.08 µg/m^3). The study also reported that annual average manganese levels in particulate matter less than 10 microns in diameter (PM_{10}-Mn) for 2003 and 2004, measured only at the Dearborn monitor, also exceeded the 0.05 µg/m^3 health protective benchmark value by a factor of approximately two. Other key findings of the study related to manganese were:

- The levels of TSP-Mn at Dearborn and South Delray were about an order of magnitude higher than at other sites both within the Detroit area and nationally, suggesting that there may be local emission sources of significance.
- The highest monitored annual average levels of TSP-Mn were about 180 times lower than the adverse effect level that was utilized to derive the health protective benchmark.
- The health protective benchmark incorporates an uncertainty factor of 1000 because crucial information regarding human toxicity from inhalation exposure is lacking. In particular, there is a concern for potential accumulation of manganese in the brain and potential neurodevelopmental effects in fetuses and children, and a lack of information to evaluate those concerns. Therefore, potential effects at exposures somewhat above the health protective benchmark are not well understood.
- Exceedance of the health protective benchmark signifies a reduction in the margin of safety between the monitored levels and the levels known to cause toxic effects, which is a concern.
- Considering the above findings, and given the potential neurotoxic effects of manganese, prudent public health policy would suggest focusing on the reduction of ambient manganese levels as a priority.

Therefore, the DATI study identified manganese as one of the top ten air toxic compounds of concern in the Detroit area and a priority on which to focus for risk reduction efforts. It should also be noted that there are only a limited number of manganese monitoring sites in Detroit, and it is not known if there may be locations with significantly higher ambient air manganese levels than determined by the available monitoring data.

In response to the DATI findings, the AQD included an initiative in its fiscal year 2007 (FY07) Strategic Plan to address environmental impacts of manganese in Southeast Michigan. The AQD's goal for this initiative was to analyze and identify ways to reduce, where possible, emissions of manganese from existing sources. An AQD workgroup with representatives from the Air Quality Evaluation Section, Permit Section, and Southeast Michigan District Office was formed to work on this effort.

The AQD Manganese Workgroup (Workgroup) began meeting in January 2007. The Workgroup was charged with identifying significant sources of manganese air emissions in Southeast Michigan and providing recommendations for further actions to reduce emissions. Completion of the Workgroup's report was delayed to incorporate more recent ambient air monitoring data and to evaluate the impact of Manganese reductions in steel production in Detroit with the recent economic downturn. This report provides a summary of the Workgroup's analyses of available data and information, as well as recommendations for reducing emissions of manganese.

1.2 Organization of Report

This report is organized in a series of sequential issue discussions that progressively narrow the scope of the manganese analyses. Issues addressed by the Workgroup and presented in this report are:

- Why should we be concerned about manganese?
- Do we have manganese ambient levels above the health protective benchmark?
- If there is a health concern, what locations have high measurements?
- What is the source of manganese impacting the above areas?
- Are there specific facilities that are contributing the majority of manganese in the above areas?
- What specific processes are emitting manganese at these facilities?
- What options are available to reduce manganese emissions at these processes?

A main component of the Workgroup's task was to identify significant sources of manganese air emissions in Southeast Michigan. Since the elevated levels of manganese were found only at monitoring sites in Wayne County, the Workgroup limited their evaluation to this area. The approach taken for this effort was to first evaluate existing ambient monitoring data, and then further refine and supplement that data through the evaluation of the emissions inventory and various other information sources such as relevant stack testing data, source operating reports, and other documents.

The health effects of manganese, the appropriate level for a health protective benchmark, and a recent detailed health study in an elevated manganese area are discussed in Chapter 2.0. The Workgroup evaluated manganese monitoring data for Michigan and other states to help identify spatial variability and trends and to provide a comparison of manganese levels in Michigan with other states. This information is provided in Chapter 3.0. To help identify significant sources of manganese, the Workgroup also evaluated wind and pollution rose data. The information is included in Chapter 4.0. The emission inventory for manganese is found in Chapter 5.0. The correlation between the shutdown/slowdown in steelmaking operations in 2009 and manganese levels is examined in Chapter 6.0. Manganese-emitting processes at key facilities impacting Wayne County monitors are identified in Chapter 7.0. Manganese reduction options for these processes are discussed in Chapter 8.0. The conclusions of the Workgroup after consideration of all information are found in Chapter 9.0 and recommendations are in Chapter 10.0.

2.0 MANGANESE HEALTH EFFECTS AND HEALTH PROTECTIVE BENCHMARK

Unlike many other air toxic compounds, manganese is an essential dietary element necessary for growth and development. Most individuals receive adequate supplies of manganese through their diet and water consumption. The risk of exposure and adverse effects is primarily from inhalation of manganese rather than ingestion. This risk could occur from exposure to elevated air concentrations of manganese, such as levels found in some heavily industrialized areas in the US. Inhalation of air contaminated with particulate matter (PM) containing manganese can be a significant source of manganese exposure to the general public. Elevated levels could result in a health hazard to those individuals living in close proximity to sources emitting manganese into the air.

The health endpoint of greatest concern from inhalation exposure to manganese is neurotoxicity. Occupational studies have found that workers exposed to very high concentrations of manganese (>5 mg/m^3) can develop a Parkinson-like neurological syndrome known as manganism. Occupational studies have found deficits in motor skills (such as finger-tapping, reaction time, hand-eye coordination, etc.) with chronic exposures to manganese levels as low as 27 µg/m^3 (ATSDR, 2009). Studies in laboratory mammals suggest that manganese particles that are inhaled and deposited in the nasal region may be directly transported to the brain via the olfactory nerve. The relevance of this phenomenon to humans is unclear, but it does raise concerns regarding the total particulate manganese exposure (TSP) rather than just the $PM_{2.5}$ or PM_{10} manganese exposure.

The assessment of the public health significance of ambient air manganese levels involves three key considerations: the ambient air concentration, the averaging time, and the particle size range of the measured value. Similarly, an appropriate health protective benchmark should account for those factors. Since manganese is not an EPA criteria pollutant, there is no National Ambient Air Quality Standard (NAAQS) for manganese. Rather, manganese is one of the “air toxics” included on the EPA’s Hazardous Air Pollutants (HAPs) list and regulated as a Toxic Air Contaminant (TAC) by the AQD. In lieu of a NAAQS for manganese, a health protective benchmark level is needed for comparison to ambient air data to characterize the public health significance of the levels. The AQD utilizes an Initial Threshold Screening Level (ITSL) for manganese in the New Source Review air emission permitting program. The ITSL is a health-based value for the protection of the population, including sensitive subpopulations, over a lifetime. The ITSL of 0.05 µg/m^3 is adopted from the EPA IRIS Reference Concentration (RfC) for manganese of 0.05 µg/m^3. This value is many times lower than the level at which subtle neurological effects have been observed in healthy workers in occupational settings. It is designed to protect the general population from adverse effects, including sensitive subpopulations such as pregnant women and children. The AQD Toxics Unit, with assistance from an MDCH Toxicologist, reviewed the basis for the EPA RfC for manganese and reviewed the more recent toxicological literature and risk assessments by other agencies. The Toxics Unit concluded in 2009 that the ITSL and RfC value of 0.05 µg/m^3 was appropriate and defensible. Recently, Health Canada (2010) adopted a reference concentration of 0.05 µg/m^3 for inhaled manganese for the protection of the general population, including sensitive subgroups, for a lifetime without appreciable harm. The Agency for Toxic Substances and Disease Registry (ATSDR) recently decided to reaffirm their manganese chronic inhalation Minimal Risk Level (MRL) at 0.04 μg/m^3, rather than adopt a previously proposed value of 0.3 μg/m^3 (Johnson, 2010). Therefore, an ambient air concentration of 0.05 μg/m^3 is considered by the AQD as an appropriate health protective benchmark for comparison to monitored or modeled ambient air levels.

As part of the 2009 review of the manganese ITSL, the AQD Toxics Unit also determined that it was appropriate to change the averaging time for the manganese ITSL from 24 hours to annual. The key toxicity studies, including the study forming the basis for the ITSL, involved long-term exposure (multiple years), and the most sensitive adverse effects involved chronic neurological impairment. While an acute health protective benchmark for manganese is not available, the toxicological literature suggests that an ITSL of 0.05 μg/m^3 with an annual averaging time would be adequately protective for manganism or other adverse effects of manganese. Further, the ATSDR's MRL is "chronic;" i.e., for a period of 365 days or longer, which supports the protectiveness of an ITSL with an annual averaging time. Therefore, the decision to revise the averaging time from 24 hours to annual was considered to be reasonable and appropriate based on the key studies reviewed.

Another key issue for the comparison of measured particle-bound manganese levels to the health protective benchmark is the particle size range. Historically, TSP-Mn was predominantly measured by the AQD and compared to the manganese ITSL to gauge the significance of the levels. However, the key toxicity study for the RfC and ITSL derivation measured both "total" manganese dust and "respirable" manganese dust, and it was the respirable dust manganese levels (with a median particle size of 5 μm) that were utilized in the risk assessment for the derivation of the RfC and ITSL value of 0.05 μg/m^3. Also, the EPA Region 5 preferentially utilizes PM_{10}-Mn monitoring data for comparison to the RfC (Caudill, 2010). The Health Canada (2010) reference concentration of 0.05 μg/m^3 for inhaled manganese specifies $PM_{3.5}$, because their key epidemiology study assessed that size fraction. The AQD has more recently collected PM_{10}-Mn as well as TSP-Mn data at monitoring sites. Although the relationship between PM_{10}-Mn and TSP-Mn levels varies, it may be generally stated from the Dearborn monitoring data (e.g., Figure 2) that the PM_{10}-Mn level has been approximately one-third to two-thirds of the TSP-Mn level. Therefore, the particle size range for the manganese monitoring data can have a significant impact on the interpretation of the public health significance of the measured levels. If PM_{10}-Mn monitoring data are available, they should be preferentially utilized over TSP-Mn data for comparison to the health protective benchmark. In lieu of PM_{10}-Mn data, TSP-Mn data may be utilized for comparison to the health protective benchmark, but it should be noted that this adds some degree of conservatism to the assessment.

Therefore, the assessment of the public health significance of measured manganese levels in the Detroit area utilizes as a health protective benchmark an annual average manganese level of 0.05 μg/m^3 (equivalent to the ITSL), preferentially based on PM_{10}-Mn data, or if lacking PM_{10} manganese data, conservatively based on TSP-Mn data.

Due to the lack of an acute inhalation health protective benchmark for manganese, the available 24-hour measured levels are not particularly useful in the characterization of the potential concerns for ambient air manganese levels. The highest 24-hour TSP-Mn levels reported in the DATI study were 1.94 μg/m^3 (South Delray) and 1.19 μg/m^3 (Dearborn). Although the significance of the peak 24-hour levels cannot be characterized in the risk assessment, the data can be useful in suggesting the presence of local significant emission sources.

2.1 Manganese Community Health Concerns

The Michigan Department of Community Health (MDCH, 2010; US DHHS, 2009) recently assessed the public health implications of the inhalation of manganese from elevated levels in downriver soils in River Rouge and Ecorse, Michigan. The recent ambient air PM_{10}-Mn levels measured in River Rouge were 0.020 to 0.028 μg/m^3 (annual average; the 95% UCL = 0.022 to 0.049 μg/m^3), which were below the RfC. They noted that, "Meteorological data and information regarding production levels at local steel manufacturers suggest that the increased ambient manganese may have been due to emissions from the steel mills and not from soil." They concluded that, "The ambient air concentration of manganese as PM_{10}, regardless of the source of manganese in the air, as measured in 2009 and the first half of 2010 at the River Rouge monitor and averaged on an annual basis, fell within acceptable health-based regulatory levels. Because the MRL exceedances were minor and have not continued, MDCH does not expect harm to public health."

Community health concerns for elevated ambient air manganese were recently evaluated for Marietta, Ohio (ATSDR, 2009) and the findings are relevant to the Detroit situation. Annual average ambient air levels of TSP-Mn were found to range from 0.07 to 0.16 μg/m^3 at four monitoring locations in Marietta near an industrial emission source. As previously noted, Detroit-area annual average TSP-Mn levels and locations in the DATI study were: South Delray (0.27 μg/m^3); Dearborn (0.20 μg/m^3); North Delray (0.09 μg/m^3); and, River Rouge (0.08 μg/m^3). The ATSDR indicated that there was concern for the Marietta levels, which exceeded the health protective benchmarks of 0.04 μg/m^3 (ATSDR MRL) and 0.05 μg/m^3 (EPA RfC). ATSDR (2009) noted that the highest level in Marietta was hundreds of times lower than the levels that caused measurable neurological health effects in occupational studies. However, they emphasized that communities are comprised of people of varying age and health status, and uncertainty exists regarding the impact of measured exposures on the health of residents of Marietta and other neighboring communities, particularly sensitive populations such as children (ATSDR, 2009). They concluded that, "Given the lack of information about the effects of chronic low level exposure to manganese and the well-characterized exposure of the community, it would be valuable to conduct a health study in this community to investigate whether there are health effects from this exposure." Given that the measured TSP-Mn levels in Detroit are similar to, or exceed, the levels in Marietta, the ATSDR (2009) conclusions appear to pertain to the Detroit situation also.

As a result of the ATSDR (2009) recommendations, the first comprehensive environmental study of manganese exposed adults in the US has recently been conducted for Marietta, Ohio and the comparison community of Mt. Vernon, Ohio. Preliminary results have recently become available (Kim et al., 2012; Bowler, 2010a; 2010b). While the overall results did not demonstrate adverse health effects from manganese in air and blood in Marietta residents, those residing closer to the emission source scored worse on several of the neuropsychological tests. The study used modeled ambient air concentrations from nearby industrial manganese emissions as a surrogate for exposure. The study found that exposure was associated with worse performance on tests of executive function, which refers to the ability needed for complex goal-directed behavior, responding to changes, ability to plan and anticipate outcomes, and self-monitoring and self-awareness. The study also found that higher exposure was associated with effects on mood, including higher obsessive-compulsive scores, more anxiety, phobic anxiety, paranoia ideation, and more symptoms overall. Individual self-reported symptoms were significantly different between the two towns; Marietta residents reported more anxiety symptoms, sensory symptoms and headaches, emotional symptoms, and movement problems (tightness of facial muscles) associated with Parkinsonism. Neurological assessment found that Marietta participants had slower movement (bradykinesia) and motor speed than Mt. Vernon participants. However, exposure did not have a consistent relationship with illness rates. The reported associations between exposure and the effects noted above appear inconsistent with the study conclusion that, “Overall, results of this epidemiologic study using random sampling, did not support findings of adverse health effects from manganese in air and blood in the town of Marietta.” (Bowler, 2010a). Kim et al. (2011) concluded that, “Subclinical findings on the Unified Parkinson’s Disease Rating Scale (UPDRS) and postural sway in the Mn-exposed group may possibly reflect early subtle effects of chronic low-level Mn exposure. However, the cross-sectional study design, the small to medium effect sizes, and the little biological plausibility are limiting the possibility of a causal relationship between the environmental Mn-air exposure and the early subclinical neurotoxic effects observed.” Once the study findings are further evaluated and published in greater detail, it will be important to consider the implications of the findings on the appropriateness of the health protective benchmark level and on the interpretation of the public health significance of the Detroit ambient air manganese levels. Until those further study details and data interpretations are available, the AQD finds that the preliminary findings support, or at least do not detract from, the importance of pursuing reductions in manganese emissions and ambient air levels in Detroit.

The DEQ followed up on the DATI (2005) study, which was based on 2001-2002 monitoring data, with an update based on 2006-2007 monitoring data (DEQ, 2010). The TSP-Mn levels were statistically significantly decreased from the 2001-2002 to the 2006-2007 study periods at South Delray, Dearborn, and North Delray. The magnitude of the decrease was 42% (South Delray), 35% (Dearborn) and 28% (North Delray). However, the 2006-2007 levels at these three sites and at River Rouge still exceeded the health protective benchmark of 0.05 $\mu g/m^3$ (annual average) by up to three-fold.

3.0 AMBIENT MONITORING OF MANGANESE: MICHIGAN, REGION 5, AND NATIONALLY

Traditionally, all monitoring for metals in particulate matter were conducted on the TSP size fraction. However, as technologies have advanced, the PM_{10} size fraction can be collected. Health studies have shown that the PM_{10} size fraction is appropriate for inhalation risk assessment. Since the toxic effects of manganese arise from the inhalation route, the PM_{10} fraction should preferably be used to compare to the health protective benchmark. Unfortunately, widespread PM_{10} monitoring for manganese did not start until 2009, so a trend analysis cannot be done on this data. Therefore, TSP-Mn is the appropriate data for examining the manganese trend in Southeast Michigan.

Table 1 shows which manganese size fraction each air monitoring site monitors.

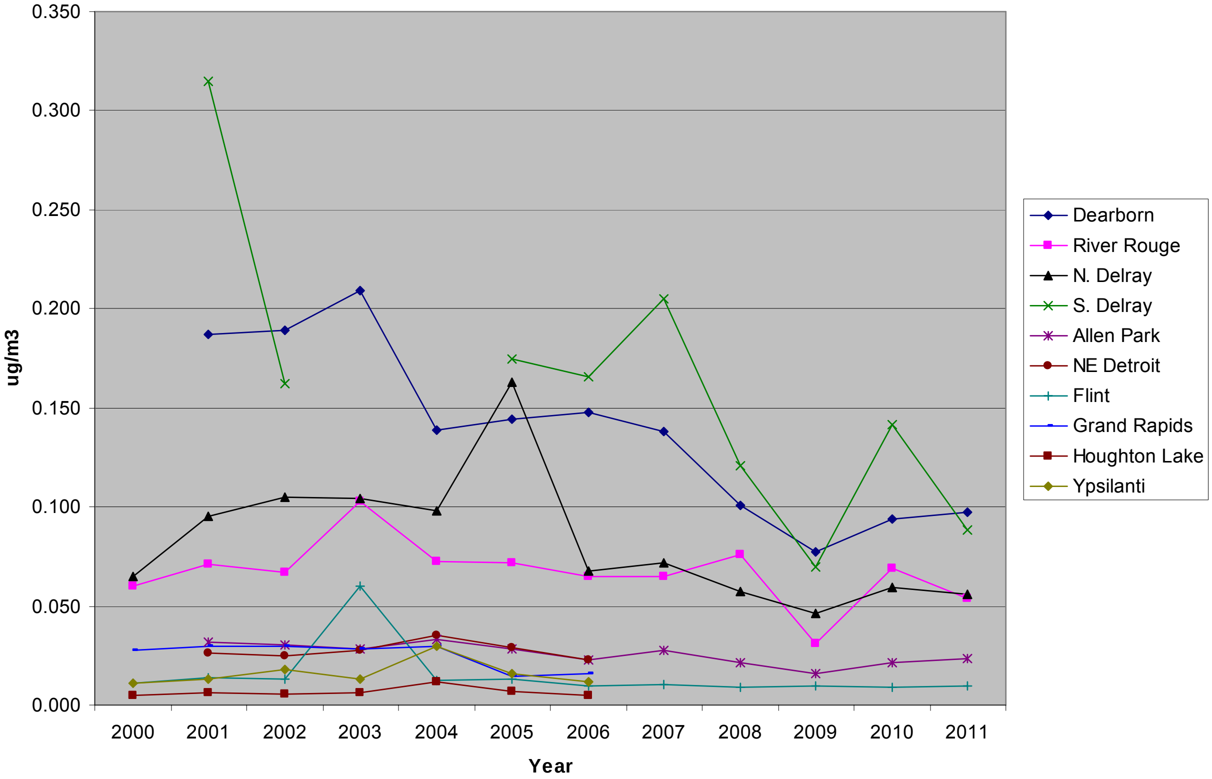
3.1 Manganese TSP Trends in Michigan

Michigan TSP-Mn air monitoring data collected between 2000 and 2011 consistently show four Detroit monitoring sites above the health protective benchmark of 0.05 $\mu g/m^3$. Manganese data for all Michigan sites is displayed in Figure 1. As stated earlier, the Dearborn PM_{10}-Mn level is generally one-third to two-thirds the value of the TSP-Mn (Figure 2). Therefore, not all of the Detroit monitoring sites would be above the health protective benchmark for the PM_{10} fraction. Except for Flint in 2003, other Michigan sites outside of the Detroit area remain steadily below the benchmark. The highest annual average concentrations have been measured at the South Delray and Dearborn sites. Although levels at South Delray and Dearborn have dropped since 2003, they remain consistently above the health protective benchmark level, higher than other Michigan sites, and some of the highest values measured within Region 5 and across the U.S. (USEPA, 2008) The reason for the increase between 2009 and 2010 is discussed later and is linked to changes in the steel industry. The Dearborn, South Delray, North Delray, and River Rouge sites show levels above the health protective benchmark.

Table 1: Manganese Monitoring Sites

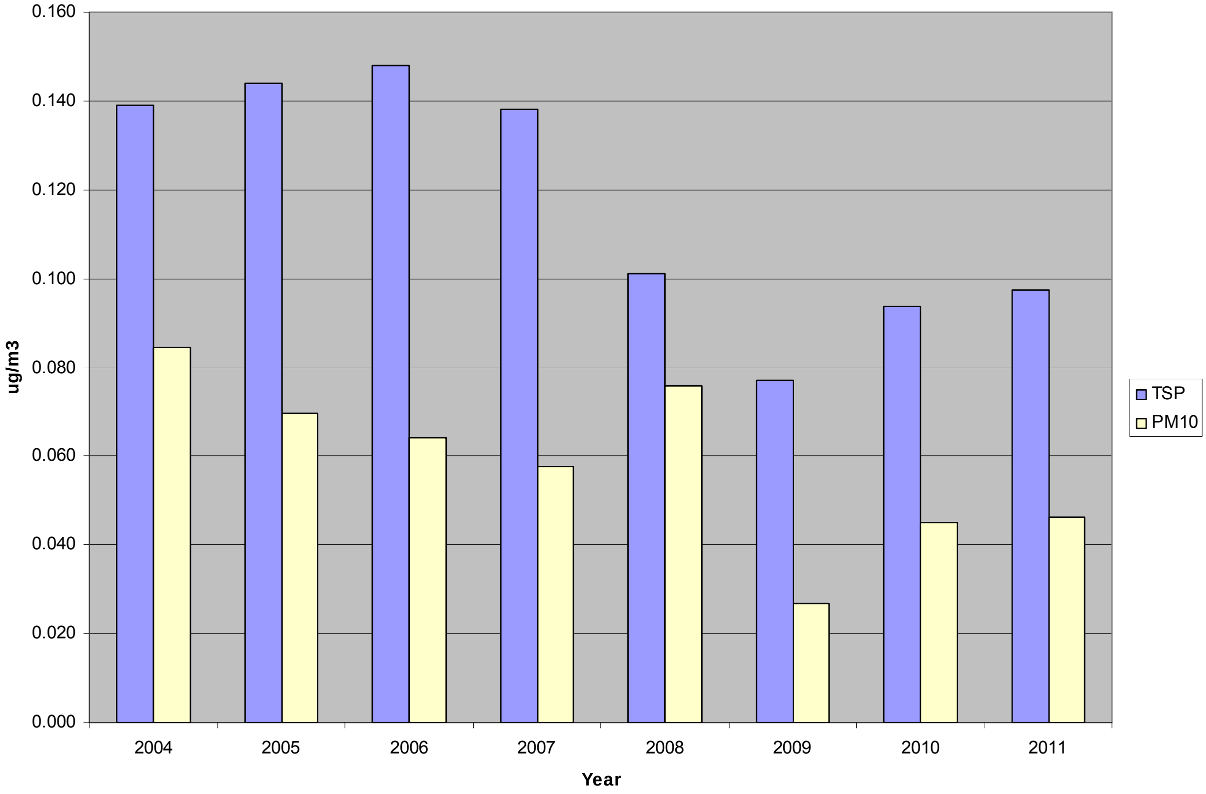
Site	TSP-Mn	PM_{10}-Mn	$PM_{2.5}$-Mn
Dearborn	X	X	X
Allen Park	X	X	X
N Delray	X	X	X
S Delray	X		
River Rouge	X	X	
Flint	X		

Figure 1: Manganese (TSP) Levels in Michigan, Annual Averages



Comparisons between TSP-Mn and PM_{10}-Mn measurements can be made at Dearborn, as PM_{10}-Mn analysis began in 2004. Figure 2 compares the manganese levels from TSP-Mn and PM_{10}-Mn at the Dearborn site. This shows that PM_{10}-Mn was above the health benchmark from 2004 through 2008. In 2009, PM_{10}-Mn fell below the health benchmark. However, in 2010 and 2011 the PM_{10}-Mn increased again and is only slightly below the health benchmark. The relationship between recent measurements and recession-related industrial production levels is examined later in this report.

Figure 2: Dearborn TSP-Mn and PM_{10}-Mn, Annual Averages



PM_{10}-Mn measurements began in 2009 for three other Detroit Area sites; Allen Park, North Delray, and River Rouge. Figure 3 shows the comparison between TSP-Mn and PM_{10}-Mn for those sites.

Figure 3: TSP-Mn to PM$_{10}$-Mn Comparisons, Annual Averages

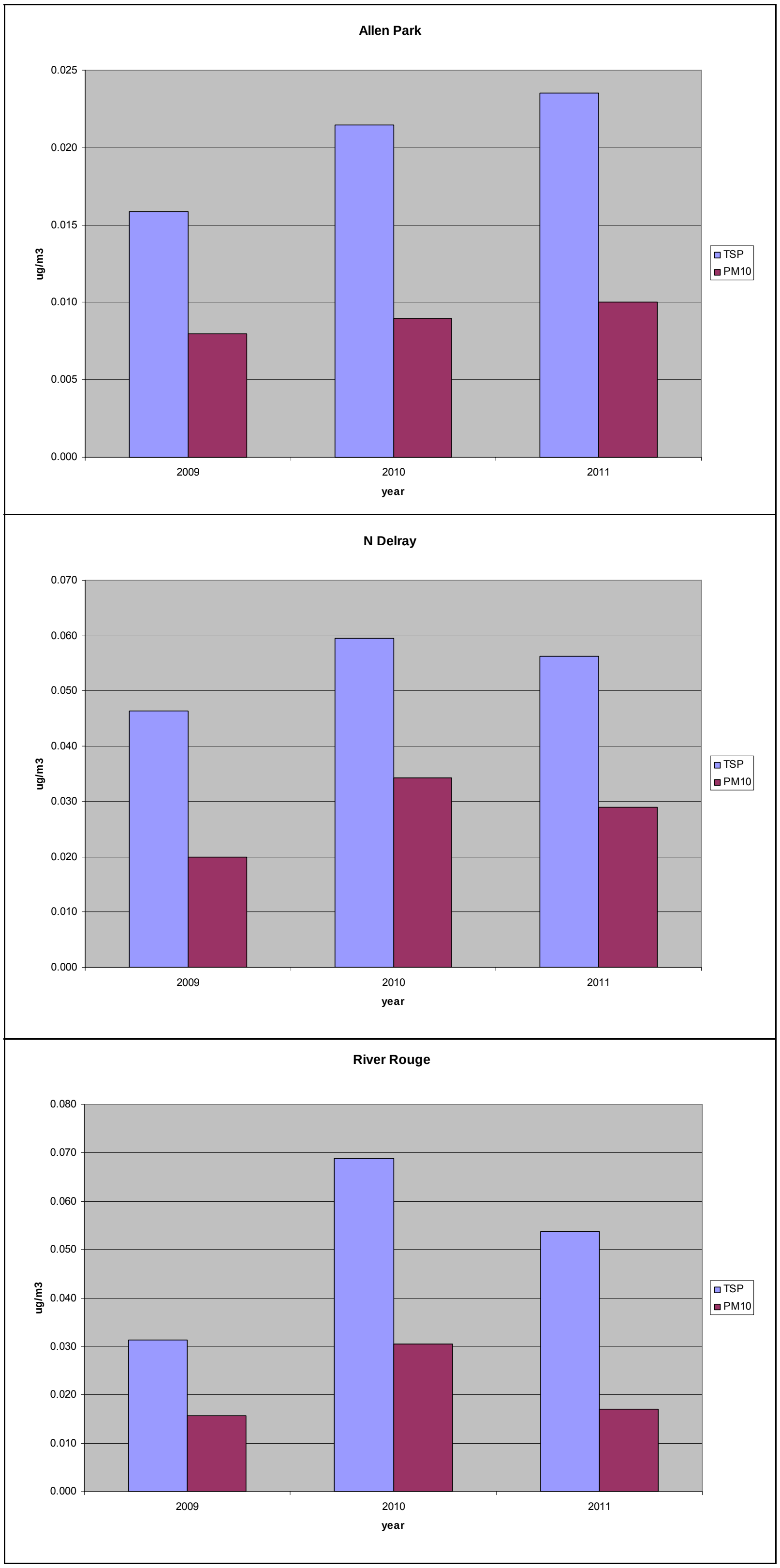
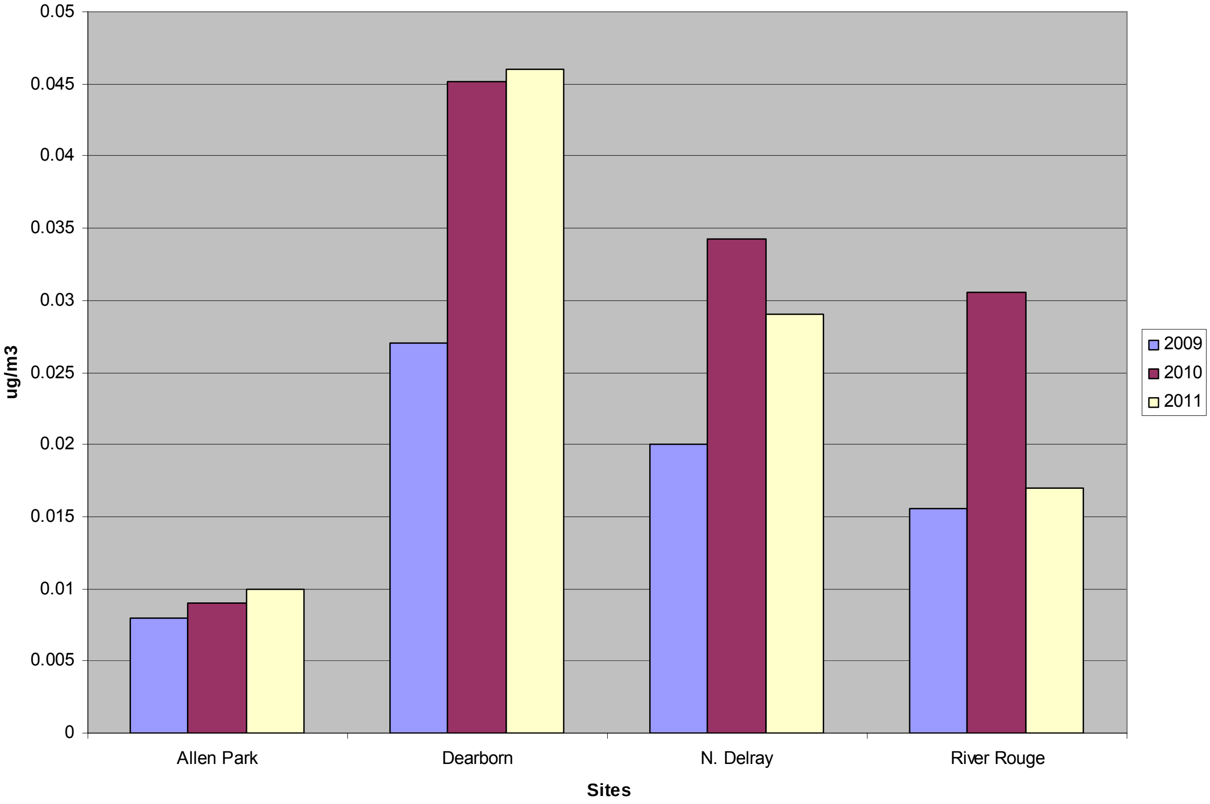


Figure 4 shows the PM_{10}-Mn levels for all the Detroit area sites. As can be seen, the PM_{10}-Mn levels increased at all sites between 2009 and 2010. This can likely be attributed to the restarting of the US Steel plant and increased production at the Severstal plant. The inter-relationship between the steel mill production and monitoring data is discussed later in this report.

Figure 4: 2009-2011 PM_{10}-Mn Annual Averages at Detroit Monitoring Sites



3.2 Manganese TSP Data for the EPA Region 5 States and Nationally

In its 2008 Report on the Environment, the EPA reported Region 5 TSP-Mn median concentrations (µg/m^3) by land use category as follows, based on 2006 monitoring data (USEPA, 2008):

Commercial & high-traffic areas (n=16)	0.024
Industrial (n=24)	0.046
Residential (n=15)	0.024
Agriculture & Forest (n=3)	0.02

Metals data were collected at three Region 5 sites during the 2005 Urban Air Toxics Monitoring Program (USEPA, 2005):

Northbrook in Chicago, IL (NBIL) residential, suburban;
Minneapolis, MN (MIMN) commercial, urban; and
Madison, WI (MAWI) residential, urban.

Of the 11 metals monitored at all 15 UATMP sites in 2005, manganese was one of the top three metal pollutants (TSP Mn ≈ 0.025 µg/m^3); PM_{10} Mn ≈ 0.010 µg/m^3). Manganese was identified as a pollutant of national interest based on the number of exceedances for monitored concentrations over the applicable screening level at the 15 sites that monitored for metals. Additionally, the EPA National Scale Air Toxics Assessment (NATA) has identified manganese as a regional driver of non-cancer risk.

Summary Statistics for Region 5 Sites with Measured Manganese
(2005 Urban Air Toxics Monitoring Report)

TSP Manganese Sampling Statistics (µg/m^3)

Monitoring Site	Number of Samples	Annual Average
NBIL	61	0.014
MIMN	46	0.016
MAWI	31	0.012

As described in Section 2.1, monitoring in four locations near an industrial source in Marietta, Ohio found average TSP-Mn levels of 0.07 to 0.16 µg/m^3.

3.3 Summary of Ambient Monitoring Compared to the Health Protective Benchmark

Ambient monitoring demonstrates that manganese remains a pollutant of concern. Ambient manganese TSP concentrations are above the annual health protective benchmark of 0.05 µg/m^3 at four southeast Michigan sites. In 2011, annual ambient manganese levels (measured as total suspended particulate) remain above the annual health protective benchmark of 0.05 µg/m^3 monitoring sites at Dearborn, South Delray, River Rouge, and North Delray.

In Wayne County, the AQD currently operates six monitors that measure TSP-Mn, four monitors that measure PM_{10}-Mn and three that measure $PM_{2.5}$-Mn. Samples are collected every six days. This extensive monitoring network is needed due to the complexity and extent of sources emitting manganese.

From 2003 through 2009, annual TSP-Mn levels dropped at the Dearborn site and, to a lesser extent, at the River Rouge site. This could be a result of controls enacted resulting from permitted modifications to processes and process equipment or it could be a result of the recent economic downturn and the reduction in steel production. In 2010 and 2011 ambient levels were higher than 2009 at all four elevated sites, with the most significant increases at the South Delray and River Rouge sites.

Elevated levels of manganese have been found at the Dearborn, South Delray, North Delray and River Rouge monitoring sites. The TSP-Mn values are above the health protective benchmark. While PM_{10}-Mn data is preferred for comparison to the health protective benchmark, the PM_{10} monitoring for three of the four sites (all except Dearborn) started in 2009 and are insufficient at this time for trend analysis. When 10 years of PM_{10}-Mn data is available at Dearborn, by the end of 2014, robust trends analysis can be performed on the data to determine the impact of recent controls on the steel mill. High levels elsewhere appear to be in urban environments, especially near steel-related production facilities.

4.0 WIND AND POLLUTION ROSE DATA

4.1 Methodology

To help identify sources contributing to elevated levels of manganese, the monitoring and meteorological data for 2008-2009 were analyzed to determine if correlations could be found between high measured manganese concentrations and wind direction or wind speed. Manganese levels were measured at most monitoring sites on a once every six day schedule. This resulted in approximately 60 days per year for which levels of manganese were measured at these sites for a total of 120 samples per site over the two-year period. All days with manganese levels above 0.050 µg/m^3 at each site were examined in detail for the wind direction for every hour of the day and the average wind speed for the day. The wind directions were sorted into 16 different bins and then each bin was tallied for the day. This separated the wind into 22 degree increments corresponding to N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, and NNW. This allowed for the assignment of individual sources corresponding to the wind direction impacting individual sites. The wind speeds were then sorted by average wind speed for the 24-hour period into two categories. Days with wind speeds less than four knots were classified as calm days and were screened out of the wind direction analysis because the wind direction is not reliable under no or low wind conditions. High manganese levels on these days are due to the lack of dispersion of the emissions and can be attributed to the closest sources. The second category is days with winds greater than four knots, as the direction is reliable and the wind speeds are sufficient to transport emissions over a greater distance.

Based on the inventory of primary sources in Section 5, the two steel mills (Severstal and US Steel) were related to ambient data based on this wind analysis.

4.2 Results

Dearborn:

During the two year time period of 2008-2009, the Dearborn site had 78 days where the manganese level was over 0.05 µg/m^3. Of these days, 28 days were on calm wind days, and 50 days were non-calm wind days. Calm days indicate a local source; i.e., Severstal, and high manganese levels are a result of the air remaining over the monitor. For the 50 non-calm wind days, 32 days were impacted by Severstal, six days were impacted by US Steel, three days were impacted by Severstal and US Steel, seven days were impacted by a NW wind that might be Severstal/Ford (which needs further investigation), and one day was impacted by at NE wind with an unknown source. This particular day was also high at North and South Delray, but not at River Rouge.

North Delray:

During 2008-2009, the North Delray site had 48 days where the manganese level was over 0.05 µg/m^3. Of these days, 27 were calm wind days, 21 were non-calm wind days. Calm days indicate a local source; i.e., US Steel. For the 21 non-calm wind days, nine days were impacted by US Steel, seven days were impacted by Severstal, three days were impacted by US Steel and Severstal, and two days were impacted by a NE wind.

South Delray:

During 2008-2009, the South Delray site had 72 days where the manganese level was over 0.05 µg/m^3. Of these days, 40 were calm wind days, 32 were non-calm wind days. Calm days indicate a local source; i.e., US Steel. For the 32 non-calm wind days, 12 days were impacted by US Steel, 15 days were impacted by Severstal, four days were impacted by US Steel and Severstal, and one day was impacted by NE winds.

River Rouge:

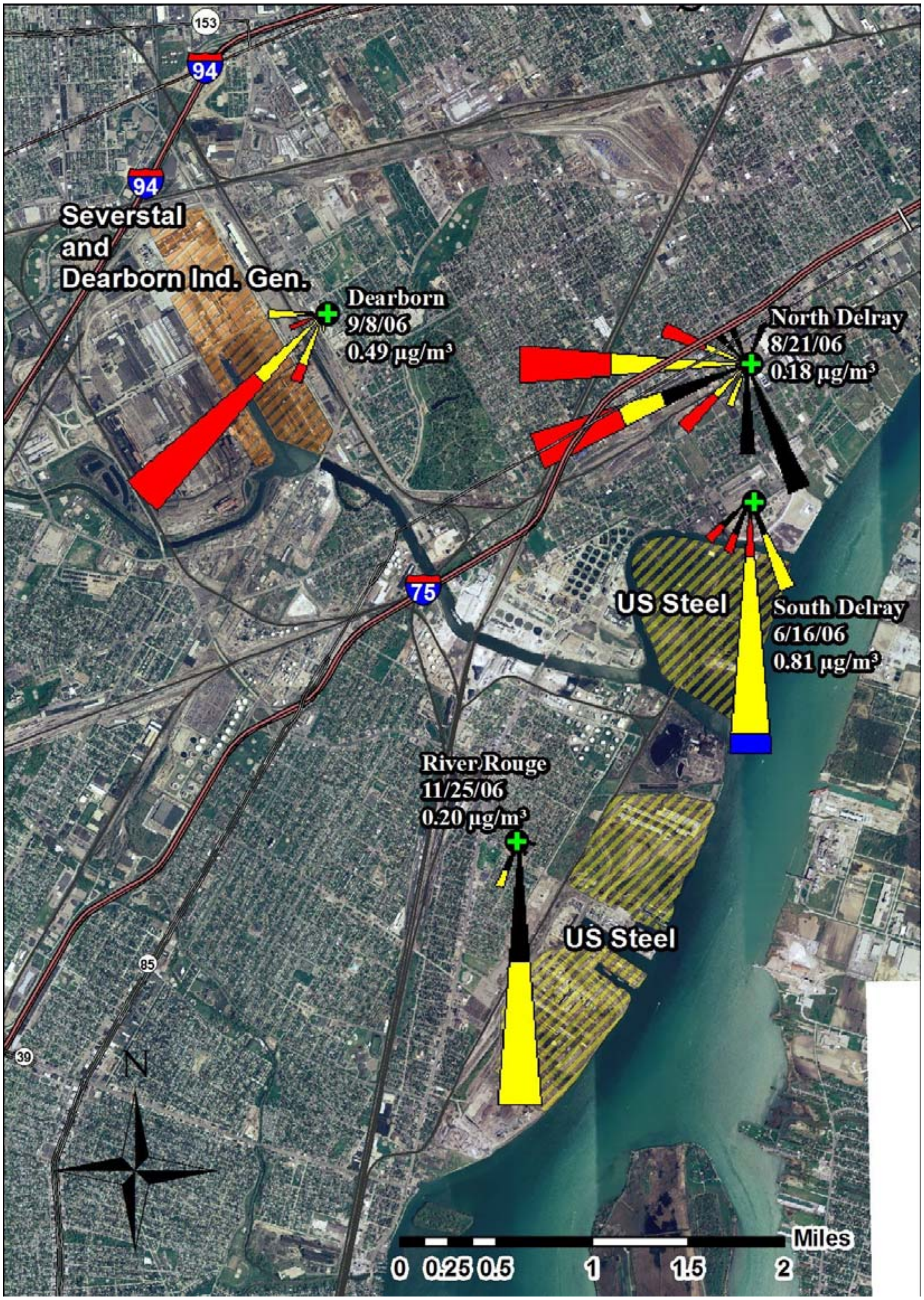
During 2008-2009, the River Rouge site had 37 days where the manganese level was over 0.05 µg/m^3. Of these days, 26 were calm wind days, 11 were non-calm wind days. Calm days indicate a local source; i.e., US Steel. For the 11 non-calm wind days, eight days were impacted by US Steel, and three days were impacted by Severstal.

Summary:

The primary source contributor on high manganese days at the Dearborn site was Severstal; at the South Delray site it was US Steel. At the North Delray and River Rouge sites, US Steel had a major contribution, with some influence from Severstal as well.

Since steel mill operations were reduced for parts of 2008-2009, the 2006 monitoring data was examined to see if there were any major shifts in source impacts. The highest monitored manganese day for each site is shown in Figure 5 with the corresponding pollution rose.

Figure 5: Wind roses for days with the highest measured manganese concentration at the Dearborn, North Delray, South Delray, and River Rouge monitor sites in 2006.



5.0 DESCRIPTION OF 2007 MANGANESE EMISSIONS FOR WAYNE COUNTY

This section describes the development of a manganese emissions inventory for Wayne County, with special consideration of the downriver area.

5.1 Point Sources

The downriver area of Wayne County has a number of potential sources of manganese emissions. These source types include steel mills and interrelated processes, power plants, sludge incineration, material handling, and asphalt plants. These activities pose the potential for elevated ambient concentrations of manganese in the downriver area.

Emissions data for point sources were obtained from facilities reporting to the Michigan Air Emission Reporting System (MAERS) for 2007. In MAERS, standardized emission factors are applied to actual process throughput data to estimate annual emissions. Point source emissions include non-stack or fugitive emissions as well as stack emissions. MAERS can also incorporate source-specific data (based on stack tests or material balance assumptions), when available, to estimate emissions. Once the emitting sources and their emissions are identified, quality assurance is performed on the emission inventory. In development of any pollutant-specific inventory it is prudent to perform quality assurance. In the case of manganese, it is necessary since manganese emission factors are not available for all processes.

Ambient monitoring near steel mills detects manganese in the PM, PM_{10}, and $PM_{2.5}$ size ranges. However, this study has focused on respirable manganese (PM_{10}-Mn) where it was possible (based on data and/or emission factor availability).

Manganese is present in the emissions of a number of different processes, as described below. A list of sources and their emissions is provided in Appendix A.

5.1.1 Steel Mills

Several aspects of steelmaking result in manganese emissions, as manganese is an additive in steelmaking as well as a component of coke used in steelmaking. As an alloy in the steelmaking process, manganese enters the process as low-grade ore charged to the blast furnace. It is the predominant metal HAP in casting emissions. Iron ore fines, blast furnace flue dust, mill scale, and other materials generated during steelmaking contain manganese. Manganese is released during combustion of blast furnace gas, as well as during the combustion of fossil fuels since it occurs naturally in these fuels. Manganese is also emitted when manganese-bearing slag is processed or transported.

The following companies comprise the steelmaking operations in Wayne County:

Severstal (A8640)
US Steel Great Lakes (A7809)/ EES Coke

Severstal North America, Inc. operates an integrated steel mill in Dearborn. Operations include two operational blast furnaces, a waste oxides reclamation facility, a basic oxygen furnace (BOF) shop, two continuous casters, two ladle refinery facilities (LRFs), a hot strip mill, and cold mill operations.

United States Steel Great Lakes Works (US Steel) operates an integrated steel mill that includes the Main Plant Area, the 80-inch Hot Strip Mill, and the Zug Island operations. The 80-inch Hot Strip Mill facility includes the hot strip finishing and shipping building, scale pit, coil storage and shipping building, slab yard, and 80-inch hot strip mill. The following steelmaking operations are located at the Main Plant: No. 2 basic oxygen process (#2 BOP), vacuum degasser, ladle metallurgical facility (LMF), pickle line, electrogalvanizing line, No. 4 tandem cold mill, annealing furnace, and boiler house. The Zug Island operation includes two operating blast furnaces, one coke battery, coke by-product recovery plant and two boiler houses. The coke battery on Zug Island is owned and operated by EES Coke, a DTE Energy Company. Manganese emissions from EES Coke were not considered significant in the RTI study (discussed further below), but this may be the result of the lack of manganese emission factors for coke batteries. Until better data become available, the work group concurs with the RTI finding although further investigation may be warranted.

5.1.2 The RTI Study

A study of steel mill emissions in the Detroit downriver area was conducted by RTI International in 2006 under contract with the EPA (USEPA 2006). The two steel mills, US Steel and Severstal, were the focus of the study. The purpose of the study was to improve the quality of reported emissions.

Although the primary focus of the RTI study was $PM_{2.5}$ and other criteria pollutant emissions, the study also provided information regarding the calculation of manganese emissions. The RTI study set out to quantify particulate emissions and recommend possible control measures. The methodologies used to quantify and control particulate emissions could be used for manganese as well.

The RTI report challenged many of the assumptions made by the steel companies with respect to quantifying emissions. These assumptions were reviewed by the AQD. Many of the companies' assumptions were judged to be valid. However, there were some critical assumptions that were judged to be questionable and warranted further AQD review. The recalculated emissions based on this review process were incorporated into this report.

One critical factor in the estimation of emissions is the accuracy of percent capture efficiency for various steelmaking processes. Capture efficiency is very difficult to estimate for steelmaking processes, particularly for the basic oxygen process. A value of 95% capture or greater was reported by the steel companies, although capture efficiencies as low as 75% may be justified as discussed in the RTI report. In general, capture efficiencies no greater than 95% were used in this study to estimate emissions from these steelmaking processes.

Manganese emission estimates for the two steel mills are reported in Appendix A.

5.1.3 Condensable Emissions in the Steel Industry

Condensable particulate matter is defined by the EPA as the particulate material that is in the vapor phase at stack conditions but which condenses and/or reacts upon cooling and dilution in the ambient air to form solid or liquid PM immediately after discharge from the stack. Condensable emissions are often the unknown component in emission inventory development; most emission factors identify “filterable” emissions (those which can be obtained from a filter), but not “condensable” emissions. A review of past Severstal stack test results indicates that condensable emissions of particulate are significant, compared to the filterable portion. In general, condensable manganese emissions can be higher then the filterable manganese emissions from certain steel processes (Telesz, 2012). Condensable emissions of manganese were measured at levels much higher than previously estimated or anticipated. The most significant outcome of these tests is that blast furnace emissions are a major contributor to total manganese emissions at Severstal, along with the BOF operations and ladling.

Stack testing for condensable emissions has not yet been conducted for other steelmaking processes. However, the testing conducted by Severstal illustrates the need to continue pursuing stack testing as a means of quantifying manganese emissions, particularly for processes suspected to have high condensable emissions.

Emission factors available for steelmaking processes, as identified by Standard Classification Codes (SCCs), typically consider only the filterable portion of particulate emissions and not the condensable portion. Review of the emission factors used by US Steel and Severstal indicates their major emitting processes where condensable emissions are not identified in EPA FIRE:

Process	SCC
Ladling	3-03-009-99
BOF ESP (Blowing)	3-03-009-13
BOF Tapping	3-03-009-17
BOF Charging	3-03-009-16
Blast Furnace (casthouse)	3-03-008-21
BOP Hot Metal Transfer	3-03-009-15
BOP Hot Metal Desulfurization	3-03-009-20
Slag Tapping and Dumping	3-03-009-23
Slag Processing	3-03-009-24
Scarfing	3-03-009-32

Stack testing is the only reliable method of determining the portion of manganese emissions that is condensable. Because of the lack of reliable data on condensable emissions for the 2007 emission inventory, condensable emissions were not specifically considered in the quantification of emissions for this study, although their significance is recognized for any future emission inventory development efforts.

5.1.4 Steel-related Processes

Manganese is emitted from the processing of manganese-bearing materials which are by-products of steelmaking, such as slag. For these processes, manganese emissions are determined as a percent of airborne particulate material released to the atmosphere. The following three facilities emit manganese as a result of processing manganese-bearing materials from steelmaking operations in Wayne County:

Edward C Levy Plant 6 (B4243)
Edward C Levy Plant 3 (B4364)
Edward C Levy Plant 1 (B3533)

Levy Plant 6 operates a BOF slag processing operation on Severstal's property and is entirely dependent on Severstal's slag for its raw material. The process plant extracts the metals from the slag and the metals are returned to the Severstal plant for reuse. The slag is crushed and screened to produce different sizes of finished product. Other processes include a blast furnace slag pit and a runway slag watering station.

The facility reports particulate emissions and manganese emissions are derived from information on the following processes: material transfer and conveying, hauling, bulk loading, crushing, screening, and aggregate storage. As discussed in Section 5.1.3, emission estimates do not account for the condensable portion.

Levy Plant 3 operates a BOF slag processing plant, a scrap beneficiation plant, and a debris plant. All of the plant's operations are entirely dependent on US Steel for their raw material. Plant 3 handles all of the steel slag from the BOF. The processing plant extracts the metals from the slag, which are returned to US Steel for reuse. The slag is crushed and screened to produce different sizes of finished product.

As with Plant 6, the following Plant 3 processes are reported to the emission inventory: material transfer and conveying, hauling, bulk loading, crushing, screening, and aggregate storage.

Levy Plant 1 processes blast furnace slag from US Steel. As with Plant 6, the following processes are reported to the emission inventory: material transfer and conveying, hauling, bulk loading, crushing, screening, and aggregate storage.

5.1.5 Combustion Sources

Manganese is emitted from the combustion of coal or oil used to generate electrical power, process steam, or heat. Although manganese is a trace constituent in these fuels, the amount of fuel burned, for power generation in particular, makes these facilities significant sources of manganese. Manganese is also emitted from the combustion of blast furnace gas, which is a by-product of steelmaking processes where manganese is used. For these types of facilities, manganese emissions are determined as a percent of manganese in fuel or material burned.

The following companies comprise the major combustion sources with respect to manganese in Wayne County:

Dearborn Industrial Generation (N6631)
Detroit Edison Co. Trenton Channel (B2811)
Detroit Edison Co. River Rouge (B2810)
Wyandotte Dept of Municipal Power (B2132)
Detroit Wastewater Treatment Plant (B2103)
GM Hamtramck (M4199)

Dearborn Industrial Generation has boilers designed to fire a mixture of up to 95% blast furnace gas and 5% natural gas (by heat input) or 100% natural gas. The blast furnace gas is received from Severstal as a by-product of their iron and steelmaking operations. Detroit Edison operates the Trenton Channel power plant, consisting primarily of five coal and oil-fired boilers. The Detroit Edison River Rouge power plant generates power from the burning of coal, natural gas, and blast furnace gas. It has a permit to burn coke oven gas. Blast furnace gas and coke oven gas are by-products of US Steel operations.

Wyandotte Department of Municipal Power operates a plant that burns coal, natural gas, and propane as fuel. It also burns tire-derived fuel. Manganese emissions are determined as a percent of manganese in fuel or material burned.

The Detroit Wastewater Treatment Plant has 14 sludge incinerators controlled by venturi and impingement tray scrubbers. Manganese emissions are the result of incineration of manganese-bearing sludge.

The General Motors Hamtramck assembly plant's primary manganese emission sources are the four coal-fired boilers. Manganese emissions are determined as a percent of manganese in fuel burned.

5.1.6 Material Processing Sources

Manganese is emitted from the processing of manganese-bearing material, which can be naturally-occurring in the material or as a manganese-enriched slag by-product of steelmaking. St. Mary's Cement, Inc (B3567) is the larger material processing source in Wayne County.

St. Mary's Cement operates a cement manufacturing facility that grinds cement clinker, limestone, gypsum, and blast furnace slag. The various cement products are sold in either bulk truck loads or in bags. The company does not operate any cement kilns. The estimated 2007 manganese emission from this source is 86.41 lbs/year, primarily from material grinding and handling operations. Manganese emissions for Nagle Paving Company are derived from allowed percent manganese in their permit conditions. Total manganese emissions for this facility are less than 50 pounds per year.

5.1.7 Summary of Point Source Emissions

Table 2 lists the highest emitting manganese point sources in Wayne County (emitting 30 pounds or more of manganese). Emission calculations are provided in Appendix A.

Table 2: Manganese Emission Source Totals, Wayne County

SRN	COMPANY	ADDRESS	2007 Estimated Manganese Emissions (#/yr)*
A8640	SEVERSTAL NORTH AMERICA INC	3001 MILLER ROAD	11722.84
A7809	US STEEL	NO 1 QUALITY DRIVE	4656.49
B2811	THE DETROIT EDISON COMPANY TRENTON	4695 W JEFFERSON AVE	700.21
B2103	DETROIT WASTEWATER TREATMENT PLANT	9300 WEST JEFFERSON	565.30
B2810	DETROIT EDISON CO RIVER ROUGE	1 BELANGER PARK DRIVE	343.72
B4364	EDWARD C. LEVY CO PLANT 3	100 WESTFIELD	227.89
N6631	DEARBORN INDUSTRIAL GENERATION	2400 MILLER ROAD	166.16
B4243	EDW C LEVY CO PLANT 6	13800 MELLON	158.86
B2132	WYANDOTTE DEPT OF MUN SERVIC	2555 VAN ALSTYNE	111.73
B3533	EDWARD C LEVY COMPANY PLANT 1	8800 DIX AVENUE	91.44
B3567	ST MARY'S CEMENT INC	9333 DEARBORN STREET	86.41
M4199	GM HAMTRAMCK	2500 EAST GENERAL MOTORS BLVD	61.33
B2169	CARMUESE LIME/MARBLEHEAD LIME	25 MARION AVE	43.57
A4697	NAGLE PAVING CO	36780 AMRHEIN	42.67
M4768	FLAT ROCK METALS INC	22601 W HURON RIVER RD	31.77
B3195	CADILLAC ASHPALT LLC	670 SOUTH DIX AVENUE	31.33

* Where possible estimates of maganese emissions are PM10 based.

The following is a pie graph depicting the same information as the above table.

Figure 6: Percent of Total Manganese from Wayne County Sources

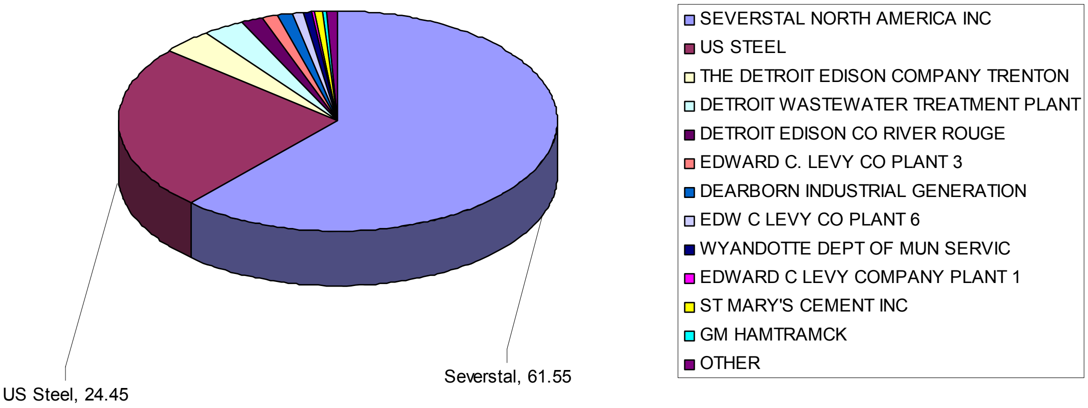


Figure 7 displays the manganese sources located in the downriver area and their proximity to manganese air monitoring locations.

Figure 7: Manganese Point Sources in the Downriver Area

5.2 Area Sources

In addition to point sources, the contribution of non-point sources of manganese was investigated.

A total of 64.53 pounds of manganese emissions were previously estimated for stationary area sources in Wayne County for 2005. Due to the low relative significance of the area source contribution to the overall emission inventory in Wayne County and the expectation that there should be little real world variation from year to year, the 2005 estimates have not been updated to reflect 2007 estimates. The various stationary area source categories of manganese emissions in Wayne County are shown in Table 3.

Table 3: Manganese Area Source Emissions, Wayne County

SCC	Emission Process Description	Manganese Lbs/yr
2104002000	Stationary Source Fuel Combustion - Residential Coal	28.03
2104004000	Stationary Source Fuel Combustion - Residential Distillate Oil	2.01
2104006010	Stationary Source Fuel Combustion - Residential Natural Gas	32.51
2104007000	Stationary Source Fuel Combustion - Residential LPG Propane	0.13
2104008001	Residential Woodburning: Fireplaces	0.69
2104008010	Residential Woodburning: Woodstoves	1.15
	TOTAL	64.53

5.3 Mobile Sources

In addition to point and area sources, the contribution of mobile sources of manganese was investigated.

A total of 78.4 pounds of manganese emissions were previously estimated for onroad and nonroad mobile sources in Wayne County for 2005. Due to the low relative significance of the mobile source contribution to the overall emission inventory in Wayne County and the expectation that there should be little real world variation from year to year, the 2005 estimates have not been updated to reflect 2007 estimates.

Table 4: Manganese Mobile Source Emissions, Wayne County

Source	Mn Emissions (lbs/yr)
Onroad	69.27
Offroad	9.13
Total	78.4

5.4 Soil Emissions

The 2005 Michigan Background Soil Survey reported a geometric mean soil concentration for manganese of 139 mg/kg (range = 14 to 1391 mg/kg; median = 190 mg/kg) based on 326 samples. Six sites were located in Wayne County. Topsoil-only samples from the Huron-Erie glacial lobe (n = 10) had a mean of 475 mg/kg.

On March 26, 2009, the US Department of Human Health Services (2009) released a Health Consultation for the cities of River Rouge and Ecorse on the public health implication of manganese in downriver soils. This report evaluated the level of public health threat posed by the inhalation of resuspended manganese in soils. Soil samples were analyzed by two different consultants. Both sets of results contained samples that exceeded the Residential Particulate Soil Inhalation Criteria (PSIC) (1 to 10% of samples collected and analyzed by Weston exceeded the PSIC while 13 to 40% of samples collected and analyzed by Integrated Environmental exceeded the PSIC). The Michigan Department of Community Health was unable to quantitatively determine the contribution of manganese in soils to the ambient air levels or potential for adverse health effects due to inhalation of resuspended soils. It remains unclear to what extent resuspension of historical and current ambient deposition to soils is impacting the monitors in question.

The DEQ's Remediation Division (RD) has considered the potential for conducting ambient air monitoring for manganese in conjunction with further soil sampling for manganese in an effort to determine the extent to which the areas with elevated topsoil manganese in the US Steel area are contributing to elevated airborne manganese levels to help determine if soil remediation is warranted. However, the AQD and RD have identified significant concerns with the ability to successfully conduct such an initiative, and it appears unlikely to proceed in the near future. The AQD's Southeast Michigan District Office has reported attempts to address fugitive dust emission problems with Omni Source, a scrap metal processor near the US Steel property; it is not clear if that could be a significant fugitive source of airborne manganese. In conclusion, it is possible that elevated soil manganese levels may be contributing to airborne manganese levels in some areas via erosion and resuspension, but the extent is unclear.

5.5 Emission Summary

Manganese emissions from point, area, and mobile sources are summarized in Table 5. As almost all is estimated as originating from point sources, especially a few facilities, this report will proceed to examine only those facilities.

Table 5: Manganese Emissions Summary, Wayne County

Source Type	Mn (lbs/yr)	Percent of total Mn
Point Source	19,043.69	99
Area Source	64.53	0.5
Mobile Source	78.40	0.5
Total	19,186.62	100

The results of the evaluation of point source emissions indicate that the steel industry is the primary source of manganese emissions in Wayne County. Steel mill emissions far exceed all other manganese-emitting sources. In 2007, manganese totals were 11,722.84 pounds for Severstal and 4,656.49 for US Steel. These two facilities alone account for over 86% of the point source manganese emissions and 85% of all manganese in the county. These figures do not include condensable manganese emissions which have been determined to be substantial especially from the steel industry. Therefore the manganese emissions are likely much higher for the steel mills than reported here.

The flow of materials and the relationship of sources in the downriver area are complex with respect to estimating manganese emissions. Materials that are by-products of one company's processes (such as manganese-bearing slag and blast furnace gas) are often utilized by neighboring companies. The ownership of these processes is not always clear, adding to the difficulty of accounting for all manganese emitting processes.

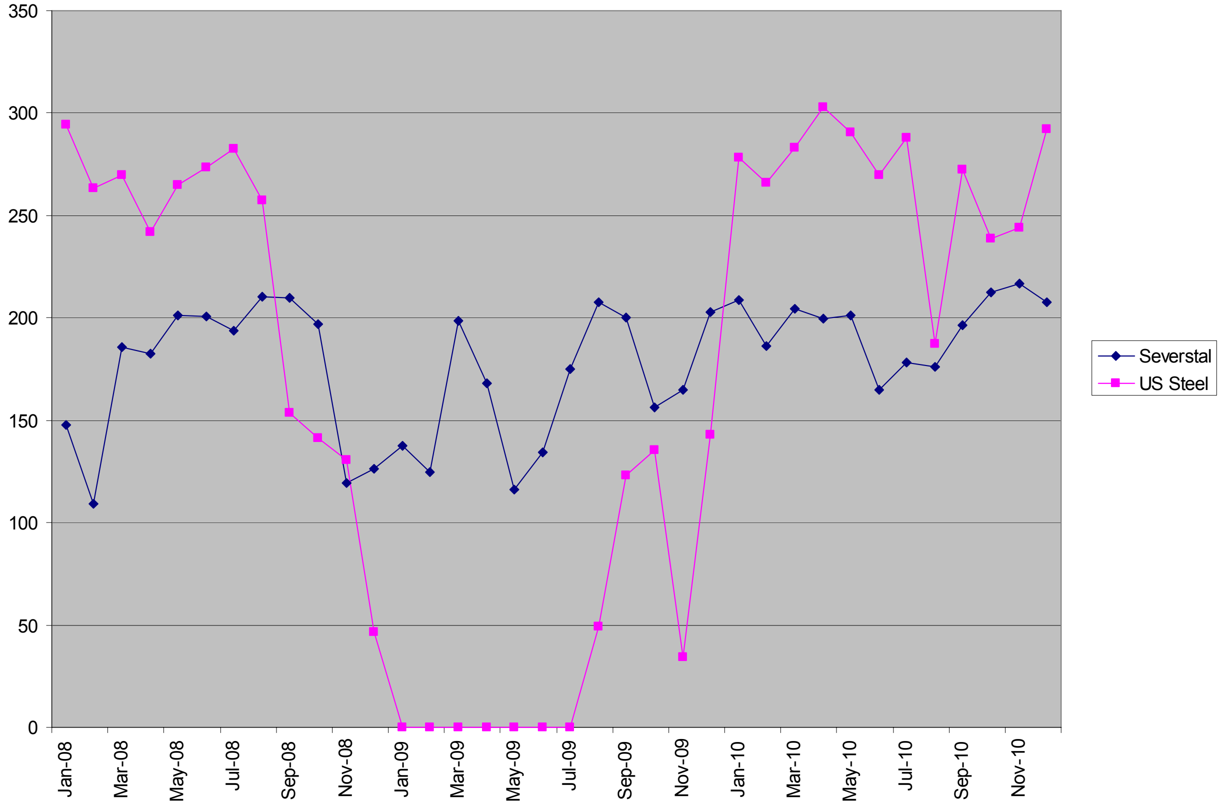
With respect to the steel industry, most estimates of emissions are based on certain assumptions, and this is especially true with respect to capture efficiency. This analysis has been completed assuming a relatively high capture/control efficiency. An evaluation of the validity of these assumptions is needed when emissions are reported, on an annual basis at a minimum. Documentation needs to be provided to validate assumptions regarding control efficiency, capture efficiency, settling, fugitive emissions from roof monitors and ground level sources, and condensable emissions.

6.0 RECENT TRENDS IN STEELMAKING AND MANGANESE

As indicated in Section 5 of this report, manganese emissions due to steelmaking and related industries are far greater than emissions from all other processes in the downriver area. Any reduction in steelmaking activities would be expected to result in reduced ambient levels of manganese.

During late 2008 and through most of 2009, steelmaking and related activities were adversely impacted by economic conditions resulting in a reduced demand for steel. A shutdown of steelmaking operations occurred at US Steel from January through July of 2009 and a reduced level of production occurred through the remainder of 2009. During this time Severstal also experienced a slowdown in steelmaking activities. Figure 8 shows the monthly production of steel for the two facilities for 2008 through 2010.

Figure 8: Monthly Steel Production 2008-2010 (Thousands of Tons)



Corresponding trends in ambient manganese levels were evaluated for this time period. Since TSP was measured at more sites than PM_{10} or $PM_{2.5}$, TSP-Mn was used to evaluate trends. Monthly average ambient levels were determined from available 24 hour measurements at the four individual monitoring sites. Figures 9 through 12 show the monthly manganese levels for this time period in comparison to steel company production rates, therefore the x-axis represents TSP-Mn in ng/m3 and Production in thousands tons.

Figure 9: Monthly Average TSP-Mn (ng/m^3) at Dearborn Compared to Steel Production at Severstal, 2008-2010

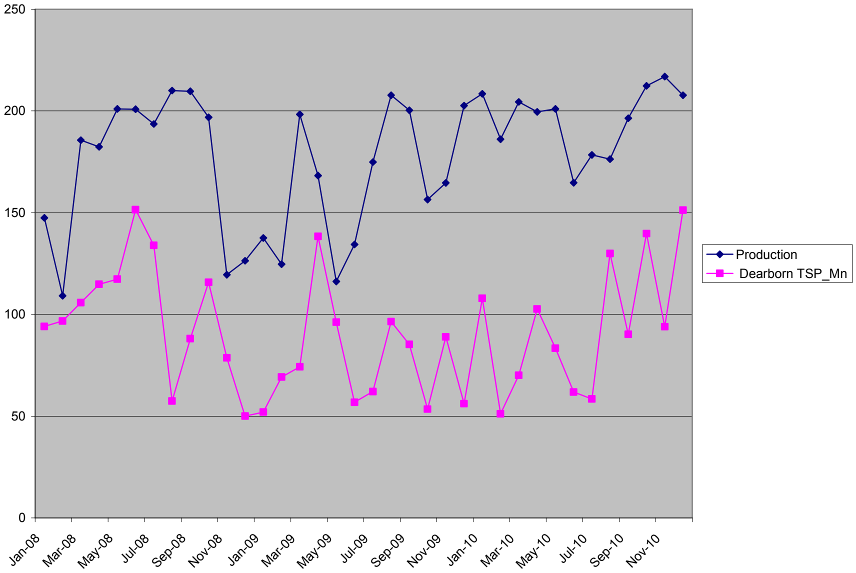


Figure 10: Monthly Average TSP-Mn (ng/m^3) at S Delray Compared to Steel Production at US Steel, 2008-2010

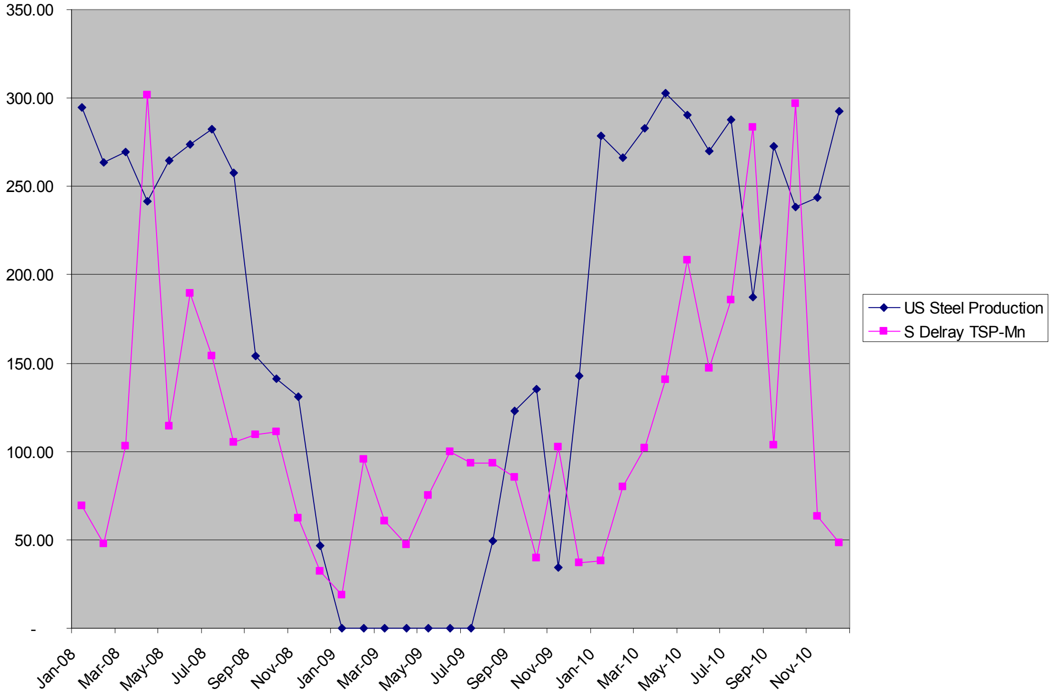


Figure 11: Monthly Average TSP-Mn (ng/m^3) at North Delray Compared to Steel Production at Severstal and US Steel, 2008-2010

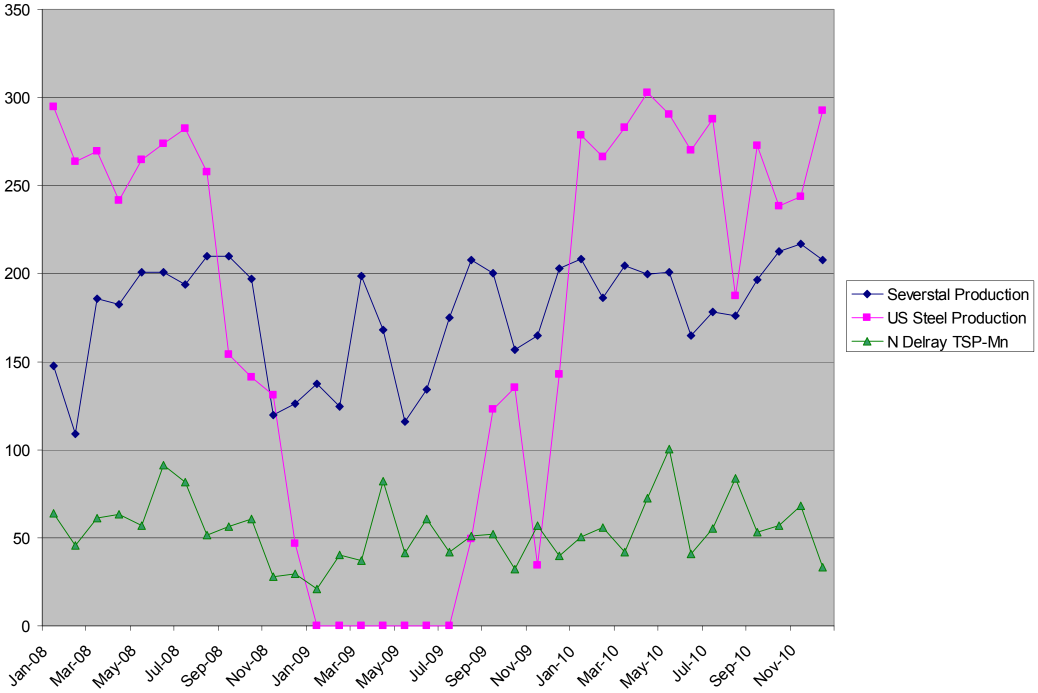
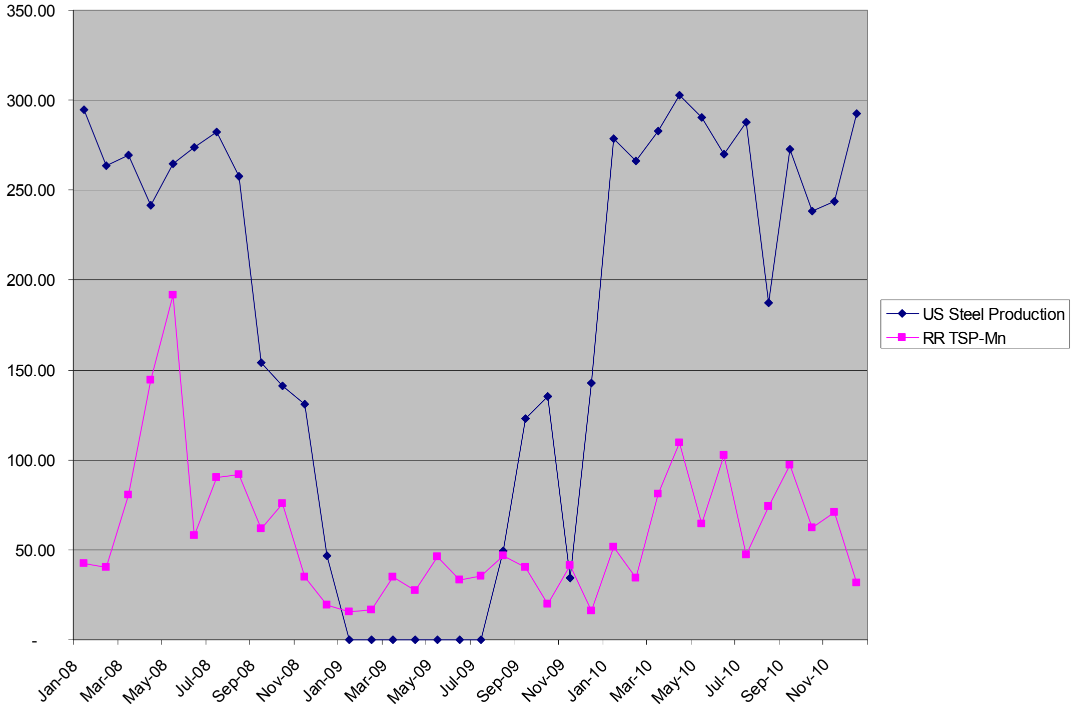


Figure 12: Monthly Average TSP-Mn (ng/m^3) at River Rouge Compared to Steel Production at US Steel, 2008-2010



The monitoring levels shown are averages of periodic daily samples taken on discreet days of the month and thus shorter term variations in production and measurements do not appear; nor is the impact of wind direction considered. Nonetheless, there is still considerable correlation between steel production and manganese levels. This is especially true at Dearborn with Severstal (Figure 9) and River Rouge with US Steel (Figure 12). Figure 10 clearly shows the decrease in manganese at the South Delray site during the shutdown of US Steel facilities on Zug Island.

Figure 13 shows that the decrease in manganese concentrations at the South Delray site is statistically significant. This can be seen by the decrease in the manganese mean concentration in 2009, the mean is shown by the notches in the boxes for each year. The error bars show the ninety fifth percentile of the data, while the * represent outliers and the ^{o} represent the highest value. Statistical analysis (Table 6) shows that decrease in manganese concentrations in 2009 is significant.

Figure 13: Yearly Mean Manganese at South Delray

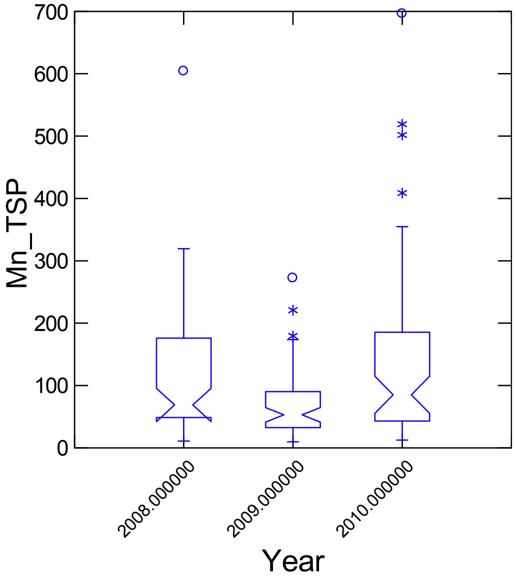


Table 6: Statistics on South Delray Manganese TSP Levels

Results for YEAR = 2,008.000

	SAMPLE_VALUE
N of Cases	57
Minimum	10.884
Maximum	604.057
Arithmetic Mean	120.772
Standard Deviation	112.441

Results for YEAR = 2,009.000

	SAMPLE_VALUE
N of Cases	61
Minimum	9.755
Maximum	272.324
Arithmetic Mean	69.548
Standard Deviation	54.289

Results for YEAR = 2,010.000

	SAMPLE_VALUE
N of Cases	57
Minimum	12.475
Maximum	696.459
Arithmetic Mean	141.759
Standard Deviation	144.384

7.0 MANGANESE EMITTING PROCESSES AT KEY FACILITIES

Manganese emissions can be estimated at various stages of steelmaking by measuring or estimating the percent manganese content of dusts or residues from a particular process. As discussed in Section 5, Severstal and US Steel are by far the main manganese sources, so further process analysis is limited to these facilities. Ladle metallurgy dust and BOF slag have the highest percentages of manganese in steel-making residues. Based on information on manganese content and AP-42 emission factors represented in FIRE 6.25, process-specific manganese emission estimates were developed for the largest point sources of manganese in Wayne County.

The following processes present at both Severstal and US Steel are primary emitters of manganese:

Ladle Refining
Basic Oxygen Facility (BOF) – tapping, charging, and blowing
Blast Furnace Processes – casthouse and heaters
Hot Metal Transfer and Desulfurization
Slag Pits
Boilers (US Steel only)

Table 7 displays manganese emissions for these and other manganese-emitting processes. This table is based on steel production that occurred in 2007. It does not account for condensables, which have not been quantified. If a different year's production was used, the emission levels would be different. It is very likely that these emission levels are under estimated, because of the condensable issue and fugitive emissions.

Table 7: Process-specific Manganese Emission Estimates

	Process	2007 Mn Emissions (lbs/yr)
Severstal	B BF Stoves (BFG)	27
	C BF Stoves (BFG)	36
	B BF Casthouse (Roof Monitor)	64
	C BF Casthouse (Roof Monitor)	65
	Reladling South - Stack	12
	Reladling South - Fugitives	6
	BOF ESP Stack	2,956
	BOF Tapping (Roof Monitor)	460
	BOF Slag Tap (Roof Monitor)	56
	BOF Charging (Roof Monitor)	45
	Desulfurization - Stack	22
	Desulfurization - Fugitives	12
	#1 LRF Stack	4,987
	#2 LRF Stack	2,850
	Hand Scarfing	94
	B BF Slag Pit	5
	Desulfurization Slag Pit	26
US Steel	Zug Island Boilerhouse No. 1	43
	Zug Island Boilerhouse No. 2	80
	Blast Furnace Gas Flare	86
	Blast Furnace B (casthouse)	4
	Blast Furnace B (Stove)	65
	Blast Furnace D (casthouse)	49
	Blast Furnace D (Stove)	48
	BOF Hot Metal Transfer	62
	BOF Hot Metal Desulfurization	358
	BOF Charging	218
	BOF Tapping	334
	BOF Blowing	1,115
	Ladle Metallurgy Facility (process)	11
	Blast Furnace B (slag pit)	173
	Blast Furnace D (slag pit)	162
	BOF Charging (Fugitive)	660
	BOF Tapping (Fugitive)	1,188

Control strategy development should be targeted toward highest emitting processes at these facilities. Of these processes, ladling processes at Severstal and BOF processes at both US Steel and Severstal are high emitters. Recent stack testing indicates that Severstal’s C Blast Furnace Casthouse is also a high emitter of manganese.

8.0 MANGANESE REDUCTION OPTIONS

Examination of control options are based on the following priority. Reduction strategies for processes with significant emission levels, including fugitive emissions and condensable emissions of manganese, should be considered. Thus options for control of ladling, BOF, and blast furnace casthouse processes at Severstal and US Steel are discussed.

The Workgroup reviewed conventional as well as innovative technologies for controlling emissions. Although this report focuses primarily on conventional technologies, the possibility of flue gas desulfurization (FGD) as a method of controlling condensable manganese is presented as an innovative technology. Condensable emissions of manganese are very significant and are not quantified in this report; therefore it is important to find a method by which they can be controlled. A full discussion of other innovative control technologies for particulate and manganese sources is included in the RTI report. This section will also examine specific control technologies on a process by process basis.

8.1 Flue Gas Desulfurization and Control of Condensable Emissions

As shown by stack test results, condensable emissions are a highly significant portion of total manganese emissions. Control of condensable manganese by FGD presents an opportunity to control manganese, PM_{10}, $PM_{2.5}$ and sulfur dioxide for processes where these emissions are present. FGD relies on wet scrubbing or spray-dry scrubbing technology using lime or limestone to remove sulfur dioxide from the gas stream. This approach would also reduce manganese PM_{10} and $PM_{2.5}$ by scrubbing, and allow condensation and removal of manganese PM_{10} and $PM_{2.5}$ emissions by reducing the temperature of the gas stream. This would result in a multipollutant control approach dealing with sulfur dioxide, manganese, PM_{10} and $PM_{2.5}$ emissions. Additional control efficiencies of 90% and 50% could be expected for filterable manganese and condensable manganese, respectively, with this technology. Furthermore, additional control efficiencies could be expected for filterable PM_{10} and $PM_{2.5}$ and condensable PM_{10} and $PM_{2.5}$ with this technology. The main draw back of this technology is the expense. It is estimated that installing an FGD system on the steel mills would cost around 45 million dollars.

8.2 Control Options for Steel Mill Ladling Processes

Consistent with the recommendations of the RTI report, emissions from the LMF (US Steel and LRF (Severstal) are a high priority because ferromanganese, as well as other alloys, is added at the LMF and/or LRF. The analysis of dust from these operations shows that it is enriched with manganese (i.e., higher concentrations of manganese than from collected dust at other processes). A major problem in controlling manganese emissions is that high temperatures prevent the condensation of metals, and results in a gas stream that may pass through particulate control equipment without capturing the emissions. Reducing the temperature of the particulate stream will improve the condensable particulate removal efficiency of fabric filter baghouses. One way to do this would be to add a lime injection system prior to the baghouse.

A lime injection system would allow for the removal of additional filterable manganese and some of the condensable manganese. It is less costly than the FGD system, while still having some of the co-benefit of SO_2 removal.

8.3 Control Options for Steel Mill BOF Stacks

Despite the fact that the BOF primary emissions at both Severstal and US Steel are controlled by ESPs, these are still major contributors to particulate emissions, and thus manganese. It may be possible to improve emission control efficiency by further cooling the BOF gases prior to entering the ESP. This could be accomplished using a lime injection system.

Careful monitoring and maintenance will ensure that ESPs operate consistently over time. Monitoring and maintenance are requirements of the Renewable Operating Permits for both steel mills, and enforcement of these requirements should continue to be high priority.

8.4 Control Options for Fugitive Emissions from Steel Mill BOF Charging and Tapping

BOF charging and tapping comprise significant emissions from both steel mills. The RTI report discusses control options for charging and tapping as follows:

"An EPA survey in the late 1990s indicated that eight BOF shops out of 20 in the United States had capture systems for BOF charging and tapping, and most exhausted to baghouses (one exhausted to a wet scrubber). Two of four Canadian integrated mills capture charging and tapping emissions, one exhausting to a baghouse and one to a scrubber. All of the BOF shops in the United Kingdom capture emissions from charging and tapping; they are exhausted to baghouses, scrubbers, or ESPs. In Japan, the emissions are captured and sent to baghouses, and in some cases, the building exhaust is controlled by roof-mounted ESPs. The European Commission defined their best available technique as efficient capture and evacuation to a baghouse or ESP. They state that a capture efficiency of 90 percent can be achieved."

Severstal installed capture hoods and a secondary control baghouse for the BOF in 2008. These improvements will result in improved capture control of charging, tapping and slag tapping emissions. Addition of lime injection in the baghouse could improve capture efficiency of condensables.

US Steel completed projects to improve capture and control systems in 2006, including the improvement of the capture of fugitive emissions from charging and tapping in the BOF shop, as well as enlarging the baghouse, and improving the capture of fugitive emissions from hot metal transfer and desulfurization and enlarging that baghouse. These projects will result in lower fugitive emissions and lower opacity at the BOF shop roof monitor. Addition of lime injection in the baghouse could improve capture efficiency of condensables.

Better information is needed to verify that capture and control systems are effective for both filterable and condensable particulate emissions. For example, US Steel assumes 99% capture and 70% settling for fugitive emissions from hot metal transfer and desulfurization, charging, and tapping. To verify the percent settling, US Steel should measure the amount of material settled in the BOF to demonstrate that such a settling number is feasible.

8.5 Control Options for Blast Furnace Casthouse Emissions

Suppression techniques and capture hoods vented to baghouses can be used to control emissions during blast furnace tapping. US Steel has capture systems and baghouses for all three blast furnaces. Severstal installed a dedicated capture system and baghouse for the C Blast Furnace Casthouse in 2007. This project will lower fugitive particulate and manganese emissions and opacity at the C Blast Furnace Casthouse roof monitors. If Severstal rebuilds the B Blast Furnace they must install a dedicated capture system and baghouse. Emissions could be further reduced if a lime injection system was added to the baghouses.

Better information is needed to verify that capture and control systems are effective for both filterable and condensable particulate emissions. Stack tests should be conducted to determine inlet and outlet manganese (Mn_{10}), PM_{10} and $PM_{2.5}$ emissions and the removal efficiencies for filterable and condensables for the baghouses. To verify percent settling, both Severstal and US Steel should measure the amount of material settled in the Blast Furnace Casthouse(s) to demonstrate that such settling number(s) are feasible. It should also be noted that significant sulfur dioxide emissions were found from the tapping operations of C Blast Furnace Casthouse at Severstal.

8.6 Summary of Control Options

Considerable manganese emissions result from high temperature gases passing through controls without emission capture. Use of FGD, while costly, presents an opportunity for a major reduction in emissions released, particularly of condensables. Adding lime injection to various existing baghouse systems is the alternate less costly recommendation.

9.0 CONCLUSIONS

From the Workgroup's analysis discussed in this report, the following conclusions are drawn:

- Elevated levels of manganese represent a health concern, based on annual average ambient air concentrations of 0.05 $\mu g/m^3$ as an appropriate health protective benchmark.

- Preliminary findings from a recent comprehensive environmental study of manganese exposed adults in Marietta, Ohio may support concerns about manganese exposure. Similar manganese concentrations and industrial manganese sources are found in the Marietta and Detroit areas.

- Manganese values at four Detroit area monitoring sites show recent levels at or above the health protective benchmark: Dearborn, North Delray, South Delray and River Rouge. High manganese levels elsewhere in the Midwest are in urban environments, especially near steel-related production facilities.

- Analysis of wind direction on high concentration days often points to manganese emissions from large point sources as major contributors.

- Point source emissions contribute well over 99% of estimated manganese emissions in Wayne County. The vast majority of point source emissions originate with steel facilities, namely Severstal and US Steel.

- Steel industry emission values are likely significantly underestimated, as condensable emissions are not included. In addition, these values are likely somewhat underestimated due to assumed high capture and control efficiencies used in emission calculations.

- Comparison of periods of reduced steel production with ambient data from the four monitoring sites reinforces the correlation between steel production and manganese levels.

- Considering the production/ambient correlation, the very high percentage of emissions from steel production, the likely underestimated emissions from this sector, and the wind analysis on high concentration days, it is reasonable to conclude that steel production at Severstal and US Steel is the primary cause of elevated manganese concentrations at the Detroit area monitors.

- The primary manganese emitting processes at Severstal and US Steel are the LRF/LMF, BOF, Blast Furnaces, hot metal transfer and desulfurization, and (US Steel only) boilers. Based on emissions, it is most productive to evaluate emission reductions at the LRF/LMF, BOF, and blast furnaces.

- Additional emission reduction measures are available at the primary emitting processes. Considerable control is also possible from measures that address condensable emissions. FGD or lime injection at baghouses are the most viable significant reduction options.

Chapter 10, Recommendations, will attempt to provide direction for dealing with manganese issues.

10.0 RECOMMENDATIONS

The primary goal of this study is to assess the presence of airborne manganese in the downriver Detroit area and recommend measures to reduce its impact on human health and the environment. As the previous portion of this report identified the primary manganese-emitting facilities and processes along with emission reduction options, the recommendations target these processes and operations. In addition, the uncertainties in emission estimates and limited coverage of ambient measurements result in secondary recommendations.

10.1 Process-specific Recommendations

The Workgroup recommends that both Severstal and US Steel upgrade their baghouses with lime injection systems. Lime injection would increase the amount of condensable material that is captured by the baghouse. This would increase the collection efficiencies of the baghouse and remove more manganese from all baghouse-controlled processes. This would also have the co-benefit of reducing many other pollutants such as SO_2, mercury, and fine particulate. Baghouse leak detection devices should also be installed to insure that the baghouses are functioning properly.

Furthermore, the Workgroup recommends that the exhaust gases be further cooled prior to the baghouses and improvements in capture efficiency, where appropriate, are made to minimize fugitive manganese.

10.2 Ambient Monitoring

The Workgroup recommends that, at a minimum, the AQD should continue the current ambient monitoring program for manganese in the Detroit area. As resources allow, the AQD should consider new site locations and increased frequency of monitoring. The Workgroup recommends monitoring the three size categories of manganese: TSP-Mn, PM_{10}-Mn and $PM_{2.5}$-Mn. Trend analyses should be conducted to determine the effectiveness of control measures implemented in the downriver area.

10.3 Source Testing

To improve the inventory, better understand the sources of manganese, and verify emission reductions, sampling and analysis for manganese is recommended for the highest emitting processes. Testing for filterable particulate is required by the iron and steel manufacturing NESHAP - 40 CFR Part 63, Subpart FFFFF. It should be acknowledged that fugitive emissions are not easily tested or quantified; however, stack test results may help in quantifying fugitive emissions indirectly. The Workgroup recommends testing both the inlet and the outlet of the baghouses and ESPs to determine baghouse and ESP capture efficiencies for particulate and condensables. The Workgroup recommends testing, including condensables, for the following facilities and processes:

1. Severstal

Severstal has recently completed testing on the C BF Casthouse Emission Control Baghouse and BOF Shop Secondary Emission Baghouse in accordance with 40 CFR Sections 63.7840(e) and 63.9(h) (Integrated Iron and Steel Manufacturing NESHAP, 40 CFR Part 63, Subpart FFFFF). Further testing is recommended for the following operations including inlet and outlet condensable emissions from baghouses and ESPs:

- LMF baghouse
- C Blast Furnace Cathouse baghouse
- BOF Secondary baghouse
- BOF ESP
- Casthouse fugitives
- Desulfurization
- BOF fugitives
- Hot Metal Transfer fugitives
- B Blast Furnace Casthouse baghouse after installation
- Slag piles or Operational Storage Piles

2. US Steel

- BOF ESP
- Tapping BOF – baghouse
- Tapping and charging BOF – fugitives
- LMF
- Argon-oxygen decarburization
- Cast houses – baghouse
- Cast houses – fugitives
- Desulfurization
- Hot metal transfer- fugitives
- Scarfing
- Slag Piles or Operational storage piles

3. EES Coke

- Coke battery

4. Levy Facilities

- Verify control factor assumptions

5. Power Plants

- Detroit Edison Company – Trenton
- Dearborn Industrial Generation
- Detroit Edison Company – River Rouge

6. Detroit Wastewater Treatment Plant

   - Sewage Sludge Incinerators

Testing should be conducted to determine compliance with permit limits. In some instances companies have permits with manganese limits. However, most facilities only have particulate limits in their permits. Compliance with permit limits will ensure that control equipment is operating properly, reducing the likelihood of excess manganese emissions. If noncompliance is indicated, measures to achieve compliance will reduce ambient manganese levels.

Stack testing should include testing for condensable emissions. Stack testing results should be evaluated in light of the fact that the bulk of manganese emissions from most facilities are fugitive. Stack testing especially at the inlet of baghouses and ESPs will not determine actual fugitive emissions, but may give some general idea of the magnitude of the fugitive emissions.

Visible emissions monitoring should be expanded to address fugitive emissions, especially short term releases.

10.4 Emissions Inventory

The Workgroup recommends that a more accurate inventory be developed to better evaluate the impact of current manganese emissions and track progress towards reduction goals.

1. The AQD should pursue creation of an emission inventory for manganese, and consider mandatory reporting of emissions greater than a threshold value (i.e., 100 pounds per year based on hazard equivalence).

2. Increased reliance on test data is recommended. Sampling and testing should continue at steelmaking and other operations to ensure that quantification of emissions is accurate.

3. A greater effort should be made to verify reported emissions from large manganese sources. With respect to the steel industry, this includes evaluating control efficiencies, capture efficiencies, and other parameters.

4. An effort should be made by both steel mills to perform a mass balance to determine the net manganese introduced to the environment from the manganese enrichment process on an annual basis. This can be determined by subtracting the amount of manganese in steel from the amount of manganese received. This would be a first step in quantifying the contribution to airborne manganese levels, once collection from control devices is known.

5. The AQD and industry should develop a way to improve the quantification of condensable particulate matter from facilities.

10.5 Involvement of Stakeholders

The Workgroup recommends the formation of a stakeholder group, consisting of DEQ staff, US Steel and Severstal representatives (as well as other industrial source representatives), to pursue the above initiatives.

11.0 REFERENCES

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Appendix A – Emission Unit Specific 2007 Manganese Emission Estimates

A8640 - SEVERSTAL NORTH AMERICA

Emission Unit Name	2007 Mn Emissions (PPY)
B BF Stoves (BFG)	26.7
C BF Stoves (BFG)	35.59
B BF Casthouse (Roof Monitor)	64.84
C BF Casthouse (Roof Monitor)	64.96
C BF Casthouse (Roof/Baghouse)	17.61
Reladling South - STACK	12.22
Reladling South - FUGITIVES	6.3
BOF ESP Stack	2,955.84
BOF Tapping (Roof Monitor)	459.97
BOF Slag Tap (Roof Monitor)	55.94
BOF Charging (Roof Monitor)	45.35
Desulfurization - STACK	22.34
Desulfurization - FUGITIVES	12.48
#1 LRF Stack	4,986.82
#2 LRF Stack	2,849.61
Hand Scarfing	94.36
B BF Slag Pit	4.7
Desulfurization Slag Pit	25.76
	11740.5

A7809 – US STEEL

Emission Unit Name	2007 Mn Emissions (PPY)
Zug Island Boilerhouse No. 1 (Blast Furnace Gas Combustion)	43.06
Zug Island Boilerhouse No. 2 (Blast Furnace Gas Combustion)	80.05
Blast Furnace Gas Flare	86.12
Blast Furnace B (casthouse)	3.53
Blast Furnace B (Stove)	64.91
Blast Furnace D (casthouse)	49.38
Blast Furnace D (Stove)	48.34
BOF Hot Metal Transfer	34.36
BOF Hot Metal Desulfurization	84.02
BOF Charging	24.61
BOF Tapping	303.18
BOF Blowing	1,114.62
Ladle Metallurgy Facility (process)	11.89
Blast Furnace B (slag pit)	172.52
Blast Furnace D (slag pit)	162.38
BOF Charging (Fugitive)	374.25
BOF Tapping (Fugitive)	529.49
	3410.7

Appendix A – Emission Unit Specific 2007 Manganese Emission Estimates

B2811 - THE DETROIT EDISON COMPANY

EMISSION_UNIT_NAME	2007 Mn Emissions (PPY)
EU01	28.54
EU01	43.09
EU01	0.03
EU02	27.48
EU02	41.49
EU02	0.03
EU03	28.06
EU03	42.37
EU03	0.03
EU04	27.00
EU04	40.76
EU04	0.03
EU09	174.85
EU09	246.09
EU09	0.36
RGSLOCUM	0.01
	700.21

B2132 - WYANDOTTE DEPT OF MUN SERVICE

EMISSION_UNIT_NAME	2007 Mn Emissions (PPY)
EUUNIT5BLR	0.01
EUUNIT7BLR	111.49
EUUNIT8BLR	0.20
EUUNIT8BLR	0.02
	111.73

M4199 - GM HAMTRAMCK

EMISSION_UNIT_NAME	2007 Mn Emissio
EUELPOSYSTEM	0.05
EUPRIMERSURFACER	0.03
EUTOPCOATSYSTEM	0.05
EUWELDGRIND	9.13934
RGPOWERHOUSE	52.02
RGPOWERHOUSE	0.04
	61.33

B2810 - DETROIT EDISON CO

EMISSION_UNIT_NAME	2007 Mn Emissions (PPY)
EU02	0.00
EU03	57.07
EU03	115.15
EU03	0.02
EU03	0.38
EU04	58.49
EU04	112.09
EU04	0.15
EU04	0.35
EU05	0.02
RGRRGPPDG11	0.00
	343.72

B3195 - CADILLAC ASPHALT

EMISSION_UNIT_NAME	2007 Mn Emissions (PPY)
Asphalt Plant	31.33

A4697 - NAGLE PAVING

EMISSION_UNIT_NAME	2007 Mn Emissions (PPY)
Asphalt Plant	42.67

Appendix A – Emission Unit Specific 2007 Manganese Emission Estimates

N6631 - DEARBORN INDUSTRIAL GENERATION

EMISSION_UNIT _NAME	2007 Mn Emissions (PPY)
EUCTG1	0.37
EUCTG2	1.90
EUCTG3	2.13
EUBOILER1	0.00
EUBOILER1	38.63
EUBOILER2	0.00
EUBOILER2	43.35
EUBOILER3	0.00
EUBOILER3	40.64
EUBFGFLARE1	5.23
EUBFGFLARE2	33.89
EU3516GEN1	0.00
EU3516GEN2	0.00
	166.16

M4768 - FLAT ROCK METALS, INC

EMISSION_UNIT _NAME	2007 Mn Emissions (PPY)
EUFINISHLINE1	0.00
EUFINISHLINE2	0.00
EUFINISHLINE3	0.00
EUSPACEHEATERS	0.00
RGBOILERS12	0.03
EUROUGHLINE1	17.81
EUROUGHLINE2	13.93
	31.77

B2103 - DETROIT WASTEWATER TREATMENT PLANT

EMISSION_UNIT _NAME	2007 Mn Emissions (PPY)
EUBOILER1	0.01
EUBOILER2	0.01
EUBOILER3	0.00
EUINC01	38.13
EUINC01	0.00
EUINC02	0.00
EUINC02	58.19
EUINC03	18.67
EUINC03	0.00
EUINC04	36.50
EUINC04	0.00
EUINC05	47.10
EUINC05	0.00
EUINC06	53.01
EUINC06	0.00
EUINC07	78.16
EUINC07	0.00
EUINC08	33.85
EUINC08	0.00
EUINC09	50.70
EUINC09	0.00
EUINC10	0.00
EUINC10	0.00
EUINC11	0.01
EUINC11	0.00
EUINC12	54.75
EUINC12	0.00
EUINC13	93.60
EUINC13	0.00
EUINC14	2.61
EUINC14	0.00
	565.30

Appendix A – Emission Unit Specific 2007 Manganese Emission Estimates

B3567 - ST MARY'S CEMENT, INC

EMISSION UNIT NAME	2007 Mn Emissions (PPY)
EU-008	0.02
EU-009	0.65
EU-010	0.63
EU-011	0.63
EU-012	0.45
EU-013	2.94
EU-014	2.94
EU-015	4.50
EU-017	7.21
EU-019	5.05
EU-021	0.51
EU-021a	0.51
EU-022	0.51
EU-016	4.32
EU-018	6.92
EU-020	5.90
EU-023	5.09
EU-024	1.78
EU-025	0.24
EU-029	1.17
EU-030	1.17
RG-02	0.38
EU-040	0.05
EU-026	0.95
EU-001	9.11736
EU-002	2.58264
EU-003	3.94992
EU-004	7.29216
EU-005	1.21536
EU-006	1.97496
EU-007	1.67112
EU-031	3.096
EU-SLAGCONVEYOR	0.432
EU-SLAGSILO	0.216
EU-SLAGSPOUT	0.288
RG-01	0.003
	86.406

B3533 - EDWARD C LEVY COMPANY PLANT 1

EMISSION UNIT NAME	2007 Mn Emissions (PPY)
EUlevyplant1	7.468848
EUlevyplant1	2.287836
EUlevyplant1	63.7848
EUlevyplant1	7.468848
EUlevyplant1	1.721844
EUlevyplant1	8.711892
	91.444068

B4243 - EDW C LEVY CO PLANT 6

EMISSION UNIT NAME	2007 Mn Emissions (PPY)
Eulevyplant6	23.00298
Eulevyplant7	5.87916
Eulevyplant8	84.546
Eulevyplant9	23.00298
Eulevyplant10	2.6397
Eulevyplant11	19.7883
	158.86

B2169 - CARMUESE LIME/MARBLEHEAD LIME

EMISSION UNIT NAME	2007 Mn Emissions
euconvey/elev	0.1930762
eufluedust	0.024737
eufugitive	0.3654783
eulimeloadout	0.146015
rgkiln1&2	30.8763
rgkiln1&2	11.96743
	43.57

B4364 - EDWARD C. LEVY CO PLANT 3

EMISSION UNIT NAME	2007 Mn Emissions (PPY)
EUlevyplant3	29.85654
EUlevyplant3	3.15084
EUlevyplant3	143.77482
EUlevyplant3	29.85654
EUlevyplant3	2.8098
EUlevyplant3	20.42082
	229.87