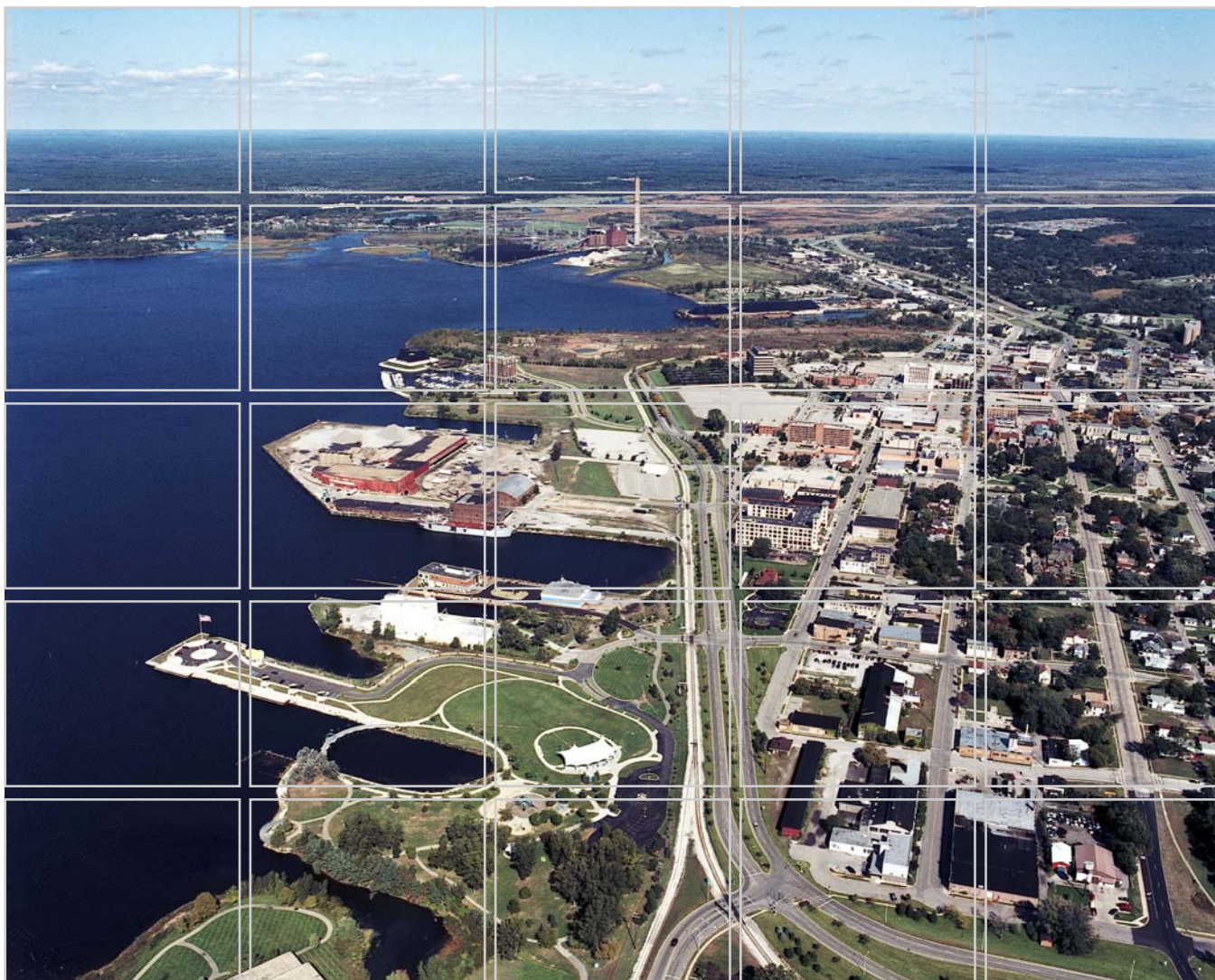




Summary Report Area-Wide Assessment of Historic Fill of Muskegon Lake Shoreline Muskegon, Michigan

September 2008

Prepared for:
City of Muskegon
933 Terrace Street
Muskegon, Michigan 49433-0536

Prepared by:
Environmental Resources Management
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Superior Environmental Corp.
1128 Franklin Street
Marne, Michigan 49435

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1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

In July 1995, the City of Muskegon received a grant from the Michigan Department of Environmental Quality's (MDEQ) Site Assessment Fund Grant Program (Grant No. 94-31) to undertake environmental assessment activities along the Muskegon Shoreline to facilitate economic development. A portion of these funds was earmarked to pay for a study of the fill materials that were placed along the southern shoreline of Muskegon Lake from the 1800s through the mid-1900s. Previous studies in Muskegon and other communities have shown that historic fill materials often contain concentrations of heavy metals and other substances that exceed the MDEQ's generic residential cleanup criteria (GRCC) established under Part 201 of P.A. 451 of 1994, as amended, and the associated Administrative Rules ("Part 201").

1.2 OBJECTIVES

The objectives of the Muskegon Shoreline historic fill investigation were to:

1. Identify the location (horizontal/landward boundary and depth) of the historic fill material within the Area-Wide study boundaries;
2. Determine the general nature of the fill material (e.g., types of fill);
3. Determine the contaminant characteristics of the predominant types of fill material;
4. Assess the potential risks to human health and the environment the fill material poses; and
5. Evaluate appropriate measures to manage these conditions on an area-wide basis rather than on a site-by-site basis.

Utilizing the data obtained from this effort, a framework was developed to provide incentives for redevelopment of the properties located within the historic fill area. These redevelopment incentives include:

- Reduce uncertainties/risks with respect to environmental issues related to historic fill;
- Reduce environmental transaction costs;
- Provide time savings in transactions;
- Provide data that can be used to evaluate protection of public health, safety, welfare, and environment in the redevelopment of the lakefront properties with respect to historic fill issues.

The Area-Wide assessment of historic fill characteristics was performed in two phases by Environmental Resources Management (formerly Dell Engineering) and Superior Environmental. Based on an evaluation of the data set resulting from this study, property located within the entire Study Area appears to meet the Part 201 “facility” definition as a result of the presence of historic fill. As a result of such a determination, obligations and requirements of Part 201 need to be considered by owners, operators, developers, and prospective purchasers of properties in the Study Area. It should be noted that the threshold for the “facility” designation is based upon exceedances of residential cleanup criteria. Although the data indicate a potential residential direct contact exposure hazard in the study area, no exposure hazards were identified for commercial or industrial land use, based upon current MDEQ exposure assumptions and resultant cleanup criteria.

To reduce environmental transaction costs and provide time savings in transactions, Part 201 Baseline Environmental Assessment and Due Care information has been provided in this document, and can be used in part by owners, operators, developers, and prospective purchasers of these properties to meet their obligations under Part 201.

This document was prepared for informational purposes only and is not, by itself, intended to satisfy any requirement of Part 201 of Act 451 or other applicable regulations that may pertain to owners, operators, developers, or prospective purchasers of properties in the Study Area. This information is not intended to satisfy the “due diligence” or “appropriate inquiry” requirements of any applicable statute or standard. This study focused on the historic fill only (excluding lake sediments and dredge spoils previously placed along the shoreline); therefore, there may be other site-specific environmental issues on properties within the Study Area that are not addressed herein.

Users of this information are encouraged to review the reports entitled *Phase I Assessment of Fill Characteristics* dated July 1998 and *Phase II Area Wide Assessment of Fill Characteristics of Muskegon Shoreline* dated September 2003 for additional information to support this Summary Report. These reports are available at the City of Muskegon Planning Department, on the City of Muskegon website at www.muskegon-mi.gov, and the Michigan Department of Environmental Quality’s Remediation and Redevelopment Division, Grand Rapids District Office. It should be noted that as additional studies are completed, the boundary of the

historic fill area may change. Users of this information are encouraged to review City/MDEQ records to determine whether more recent assessments of the historic fill have been completed subsequent to those documented herein.

2.0 OVERVIEW OF FINDINGS

2.1 DESCRIPTION OF STUDY AREA

Figure 1 (Appendix A) depicts the boundary of the Area-Wide assessment of fill characteristics (the “Study Area”). The Study Area extends from the west at McCracken Street (near the Grand Trunk Terminal Dock site) northeasterly for approximately three (3) miles to the south branch of the Muskegon River. A total of 169 soil and 16 groundwater samples representative of the historic fill were collected from the Study Area as part of this Area-Wide assessment and for other investigations of individual properties supported by the City’s SAF grant. Sampling was conducted between 1996 and 2001. Sample locations are depicted on Figure 2 included in Appendix A.

2.2 DESCRIPTION OF HISTORIC FILL

The historic fill encountered during the study generally consisted of industrial fill (containing dark-colored foundry sands, slag, core sands, coal, cinders, etc.) or construction fill (containing glass, concrete, wood, metal, etc.). In addition, the Study Area also included fill that appeared to be clean soil with no observation of industrial or construction fill. Native soils below the historic fill were generally indicated by orangish-brown sand or a peat layer (potentially indicative of former wetlands/surface waters). In some areas, wood debris associated with former lumbering activities was present between the industrial fill and native soils. The vertical extent of the historic fill is generally less than 15 feet below the ground surface. The estimated landward extent of the historic fill is illustrated on Figure 2 (gray shading). The fill boundary extends inland most significantly at areas of former surface water bodies, including Ryerson Creek and the south branch of the Muskegon River. The historic fill is present along nearly the entire stretch of the 3-mile Study Area. It should be emphasized that an objective of this study was to define the landward boundary/extent of major filling activities that occurred along the lakeshore through soil sampling and a review of historic maps and land use. Therefore, there may be other areas within the City that contain similar historic fill that are not depicted on Figure 2.

This study was not intended to characterize lake sediments or dredge spoils potentially placed in the study area. Additional investigation would be needed to determine the presence of and/or characterize potential sediments or dredge spoils.

SOIL SAMPLING RESULTS

Soil/fill samples were analyzed for one or more of the following parameters suspected of being present in the historic fill: heavy metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), cyanide, phenol, and formaldehyde. These analytes were selected based on the foundry-related nature of the fill materials, and based on data collected prior to the Area-Wide study. A summary of soil sampling results compared to MDEQ's GRCC is presented in Table 1 of Appendix B (GRCC per Part 201 Administrative Rules promulgated 12/21/02 and Remediation & Redevelopment Division Operational Memorandum #1, Attachment 1, 1/23/06).

As expected, the fill materials exhibited a wide range of contaminant concentrations. Metals (all except barium), PAHs, and formaldehyde were detected in one or more samples at concentrations exceeding Part 201 GRCC (drinking water protection, groundwater/surface water interface protection, direct contact, particulate inhalation, and/or indoor air inhalation values). PCBs, cyanide, and phenols were not detected in most of the soil samples, and where detected, all concentrations are below Part 201 GRCC.

GROUNDWATER SAMPLING RESULTS

Groundwater samples collected from the Study Area were analyzed for contaminants present in soil samples at concentrations exceeding Part 201 GRCC (i.e., metals, PAHs, and formaldehyde). Groundwater samples were collected using "low flow" purge techniques. The intent of the groundwater sampling was to determine if the contaminants detected in the fill have affected groundwater quality in the Study Area. A summary of groundwater sampling results compared to Part 201 GRCC is presented in Table 2 of Appendix B. These results indicate no detectable PAHs or formaldehyde in any of the groundwater samples. Of the metals analyzed, only chromium, manganese, and zinc were present at detectable concentrations. Of these detections, only manganese was present at a concentration exceeding Part 201 GRCC (drinking water criteria), with exceedances in 10 of the 16 samples. It is noted that manganese concentrations in groundwater exceed the aesthetic drinking water criterion; however, concentrations do not exceed the health-based drinking water criterion. No GSI criteria exceedances were noted in the groundwater samples.

A statistical evaluation of soil sampling results was performed in order to:

- Determine whether it can be concluded that property located within the Study Area meets the Part 201 definition of “facility” (i.e., a location with contaminants present in concentrations exceeding GRCC) due to the presence of historic fill; and
- Determine average (i.e., 95% upper confidence limit/UCL) contaminant concentrations in the historic fill to evaluate potential human health exposure hazards for Part 201 “due care” purposes.

2.5.1

Comparison of Soil Sampling Results to 95% UCLs

Average/95% UCL concentrations were calculated only for those parameters exceeding Part 201 cleanup criteria for applicable human health exposure scenarios (i.e., direct contact and particulate inhalation), which include arsenic, lead, manganese, benzo(a)pyrene, and dibenzo(a,h)anthracene. According to the S3TM guidance document, use of statistics is not appropriate to evaluate the indoor air inhalation pathway (e.g., for formaldehyde). Drinking water exposures were not considered since it is anticipated that properties within the Study Area will be subject to Muskegon’s drinking water ordinance which prohibits use of groundwater as a drinking water source.

The average/95% UCL concentrations for lead and arsenic are presented on Table 1 in Appendix B. A discussion of the methodology used to calculate the UCLs is presented in the *Summary of Statistical Analysis* document included in Appendix C. The statistical evaluation indicated calculation of 95% UCLs is not appropriate for manganese, benzo(a)pyrene, and dibenzo(a,h)anthracene. A comparison of the 95% UCLs for lead and arsenic to generic residential and commercial/industrial direct contact criteria indicates no exceedances.

This 95% UCL evaluation suggests that the historic fill in the Study Area could pose a direct contact hazard in a residential/recreational/Commercial I land use setting; however, no exposure hazard is identified for other commercial or industrial land uses.

2.5.2

Evaluation of Part 201 “Facility” Designation

A range and frequency analysis was performed to determine whether it can be concluded that the Study Area, considering all of the data collected, is a “facility” per Part 201 based on typical contaminant levels measured

in the fill material. Table 3 in Appendix B provides a summary of the range of contaminant concentrations detected in the historic fill and the number of samples with exceedances of GRCC. Although highly varied, the range and frequency analysis reveals that concentrations of several metals, PAHs, and/or formaldehyde exceed the GRCC in 148 out of 169 soil samples (88%). In addition, manganese concentrations exceed GRCC in 10 out of 16 groundwater samples (63%). It is noted that manganese concentrations in groundwater exceed the aesthetic drinking water criterion; however, concentrations do not exceed the health-based drinking water criterion.

Based on the frequency of exceedances, it appears appropriate to conclude that properties within the Study Area with historic fill meet the definition of a “facility” per Part 201. As such, owners/operators, developers, and prospective purchasers should be cognizant of the Part 201 regulations, including liability protections provided by Baseline Environmental Assessments and Due Care obligations resulting from having knowledge that property is a “facility”. However, individual property owners/operators and prospective purchasers may choose to “opt out” of the facility designation for certain properties by developing data sufficient to demonstrate that their parcel of property within the historic fill Study Area is not a Part 201 “facility”.

Part 201 provides for a process that enables new owners/operators of properties that meet the “facility” definition to obtain cleanup liability protection from the State of Michigan. These protections are available if an adequate baseline environmental assessment (BEA) is conducted that documents existing conditions at the time of purchase/occupancy, and provides a means of distinguishing the existing contamination from potential contamination resulting from future releases of hazardous substances. These new owners/operators must also meet “due care” obligations, as described in Section 4.0.

To facilitate incorporation of data from this study into future BEAs prepared for properties within the Study Area, a summary of the “Known Contamination” section per MDEQ’s 11 March 1999 *Instructions for Preparing and Disclosing Baseline Environmental Assessments and Section 7a Compliance Analyses to the Michigan Department of Environmental Quality and for Requesting Optional Determinations* has been prepared (see Appendix D). This information provides a general overview of contaminant levels and the nature and extent of the historic fill. The information in Appendix D only addresses known contamination related to the historic fill and does not address any site-specific releases or contamination issues. Therefore, BEAs conducted on properties located within the historic fill Study Area must incorporate site-specific information in addition to the information in Appendix D.

Part 201 imposes certain “due care” obligations on owners/operators of “facilities”. Due to the presence of historic fill, properties within the Study Area are therefore subject to Part 201 due care obligations, unless site-specific evaluations allow for an “opt-out” of the “facility” designation. In general, Part 201 due care obligations may include one or more of the following:

- Maintain written Due Care Documentation (per Rule 1003[5]);
- Provide notices of migrating contamination;
- Undertake measures to protect site occupants and third parties from unacceptable exposures to site contamination;
- Take reasonable precautions against the reasonably foreseeable acts or omissions of a third party;
- Prevent exacerbation of contamination;
- Mitigate risks from erosion of contaminated surface soils to surface water and storm sewers.

This due care information was prepared to assist owners/operators of properties within the Study Area in addressing the above due care obligations as they relate to the historic fill. Generic Due Care Documentation for residential/recreational and commercial/industrial land uses is provided in Appendix E. This generic Due Care Documentation addresses potential due care obligations only as they relate to the known contamination associated with the historic fill. A site-specific evaluation of due care obligations is warranted for individual property owners/operators within the Study Area if knowledge exists of other contamination issues.

The data collected and evaluated during this study indicates that the historic fill soils do not pose a threat to volatile or particulate inhalation (indoor or ambient) except as noted below. While soils could pose a threat to groundwater quality through leaching, this pathway can be addressed by prohibiting use of groundwater as a drinking water source and/or through the City’s groundwater use ordinance. Based upon the findings of this study, soils associated with the historic fill generally do not pose any exposure hazards for residential/recreational or commercial/industrial land use scenarios except as noted below. However, owners/operators within the Study Area must comply with soil movement provisions, as discussed in Section 4.2.

The data collected for this study generally indicate the historic fill does not pose a residential/recreational or commercial/industrial direct contact

hazards. This conclusion is supported by a statistical evaluation of the data that suggests metals do not pose a direct contact hazard (based on average/95% UCL calculations).

The statistical evaluation did not allow calculation of average/95% UCL concentrations for two PAH constituents (dibenzo(a,h)anthracene and benzo(a)pyrene) with residential/recreational direct contact exceedances. The sampling data indicate dibenzo(a,h)anthracene may pose a residential direct contact hazard primarily in the vicinity of the Muskegon Boilerworks and Fisher Padnos sites (the Fisher Padnos site is located near the far northeast boundary of the Study Area). The sampling data indicate sporadic exceedances of the residential/recreational direct contact criterion for benzo(a)pyrene throughout the study area. Although not conclusive, the data suggest *the potential for* direct contact exceedances in the historic fill for benzo(a)pyrene. This finding is more prevalent to the northeast of the West Michigan Steel site. Therefore, unless a site specific evaluation is conducted to rule out the direct contact pathway, it may be appropriate to take precautions to protect against direct contact exposures in residential/recreational land use scenarios (see discussion in Section 4.1).

It should be noted that subsequent to the investigation documented herein, MDEQ established a new methodology for lead analysis that involves determining fine and coarse fractions if the total lead concentration exceeds 75 mg/kg. Additional sampling for fine/coarse fractions would be needed to more conclusively determine potential lead exposure hazards. The precautions described herein for mitigating potential PAH direct contact exposures would also mitigate potential lead exposure hazards.

The conclusions regarding the absence of volatile indoor air inhalation hazards do not apply to the Terrace Point property, where formaldehyde was found at a concentration exceeding the Part 201 generic soil volatilization to indoor air inhalation criterion (SVIIC).

The conclusions regarding the absence of particulate ambient air inhalation hazards do not apply to the West Michigan Steel site, where manganese was found at a concentration exceeding the Part 201 generic particulate soil inhalation criterion (PSIC). Furthermore, since only a limited number of samples were analyzed for manganese, additional sampling for this constituent may be necessary to adequately evaluate due care obligations.

A site specific evaluation is needed to determine whether impacts are present related to sediments and/or dredge spoils. The Area-Wide study included only limited sampling for PCBs, and this sampling may be insufficient to properly evaluate potential PCB due care obligations.

4.1

DIRECT CONTACT EXPOSURE MITIGATION FOR RESIDENTIAL/RECREATIONAL LAND USE

Based on the contaminant sampling results and statistical evaluation of data described above, contaminant levels in the historic fill in certain portions of the study area could pose a direct contact hazard in a residential/recreational exposure scenario. This exposure hazard can be addressed by either of the following:

- Assuring exposed fill, if present, is sufficiently covered (i.e., a competent layer of clean soil or gravel, pavement, building cover, etc.; cover type/thickness to be determined based on a site specific land use evaluation); and
- Site-specific sampling to determine that the exposure risk does not exist.

It is believed that many properties within the Study Area with this type of land use may already have landscaping and/or paved surfaces that are sufficient to mitigate this exposure. However, if exposed historic fill exists on properties with residential/recreational land use, the above mitigation measures are recommended.

Contaminant levels in the historic fill soil samples do not indicate an exposure barrier is needed in a commercial/industrial exposure scenario; therefore, for this type of property use, no exposure barriers or cover would be required to address exposures to the historic fill. An exception is noted in the vicinity of the Muskegon Boiler Works site where additional investigation may be needed to evaluate whether PAHs pose a commercial/industrial direct contact hazard. Planned unit developments that rely on mixed land use should consider the various exposure settings within individual properties. Landscaping plans that include covering of the fill would be sufficient to mitigate the direct contact exposure risk, as long as the landscaping is maintained.

4.2

SOIL MOVEMENT LIMITATIONS

Relocation of fill soils within an individual property or off-site must be performed in accordance with Part 201 (e.g., Section 20120c) and/or other applicable regulations/requirements. A site-specific evaluation of applicable regulations/requirements must be performed prior to performing any soil relocation or off-site disposal.

This study does not address Muskegon Lake sediment quality or its adjoining creeks/drainage pathways. If dredging activities are planned,

sediment sampling must be performed to determine appropriate management of the dredge spoils.

4.3 NOTIFICATION REQUIREMENTS

Following is a summary of the Part 201 notification requirements pertaining to utility/easement holders, abandoned containers, and migrating contamination.

- **Utility/Easement Holders:** Rule 1013 requires that notice be provided to utility workers or other persons conducting activities within the “facility” if unacceptable exposure may exist. Part 201 GRCC applicable to utility worker exposures include groundwater contact criteria, flammability/explosivity screening levels, and acute inhalation screening levels. No exceedances of these criteria were documented in the Area-Wide fill investigation.

As a screen to evaluate potential utility worker soil direct contact hazards, results are compared to Part 201 industrial direct contact cleanup criteria. The industrial cleanup criteria are based on a long-term [21-year] exposure duration, and may be conservative in evaluating short-term utility worker exposures. Although metal concentrations at several individual sampling locations exceed the generic industrial direct contact criteria, the average/95% UCL concentrations are below industrial direct contact criteria. Therefore, historic fill within the Study Area does not appear to pose a utility worker direct contact exposure hazard. Based on this evaluation, a Rule 1013 notice does not appear to be required. This conclusion does not apply in the vicinity of the Muskegon Boiler Works site where additional investigation may be needed to evaluate whether PAHs pose a utility worker direct contact hazard.

- **Abandoned Containers:** The Area-Wide investigation did not identify any discarded/abandoned containers associated with historic fill; thus, a Rule 1015 notice regarding discarded/abandoned containers does not appear to be required. However, owners/operators should perform a site-specific evaluation to address potential abandoned containers that are unrelated to the historic fill.
- **Migrating Contamination:** A Rule 1017 Notice of Migration of Contamination may be required for some properties in the Study area based on the potential for manganese to migrate off-site/to adjacent surface waters (i.e., Muskegon Lake, Ryerson Creek, Ruddiman Creek) at concentrations exceeding Part 201 GRCC. It is recommended that a site-specific evaluation be performed to determine potential Rule 1017 notification requirements.

Fill material consisting of industrial fill (containing dark-colored foundry sands, slag, core sands, coal, cinders, etc.) and construction fill (containing glass, concrete, wood, metal, etc.) was placed along the southern shoreline of Muskegon Lake from the 1800s through the mid-1900s. An Area-Wide assessment of this historic fill material was performed from 1996 through 2001 with the following objectives:

- Identify the location and extent of historic fill;
- Characterize the types of contaminants in the historic fill;
- Determine concentrations of contaminants in the historic fill and surrounding groundwater;
- Evaluate appropriate measures to manage these conditions on an Area-Wide basis and provide for protection of public health, safety, welfare, and environment; and
- Provide information on the historic fill that will facilitate redevelopment and reuse of affected properties along the Muskegon Lakefront.

Significant findings from the Area-Wide investigation include the following:

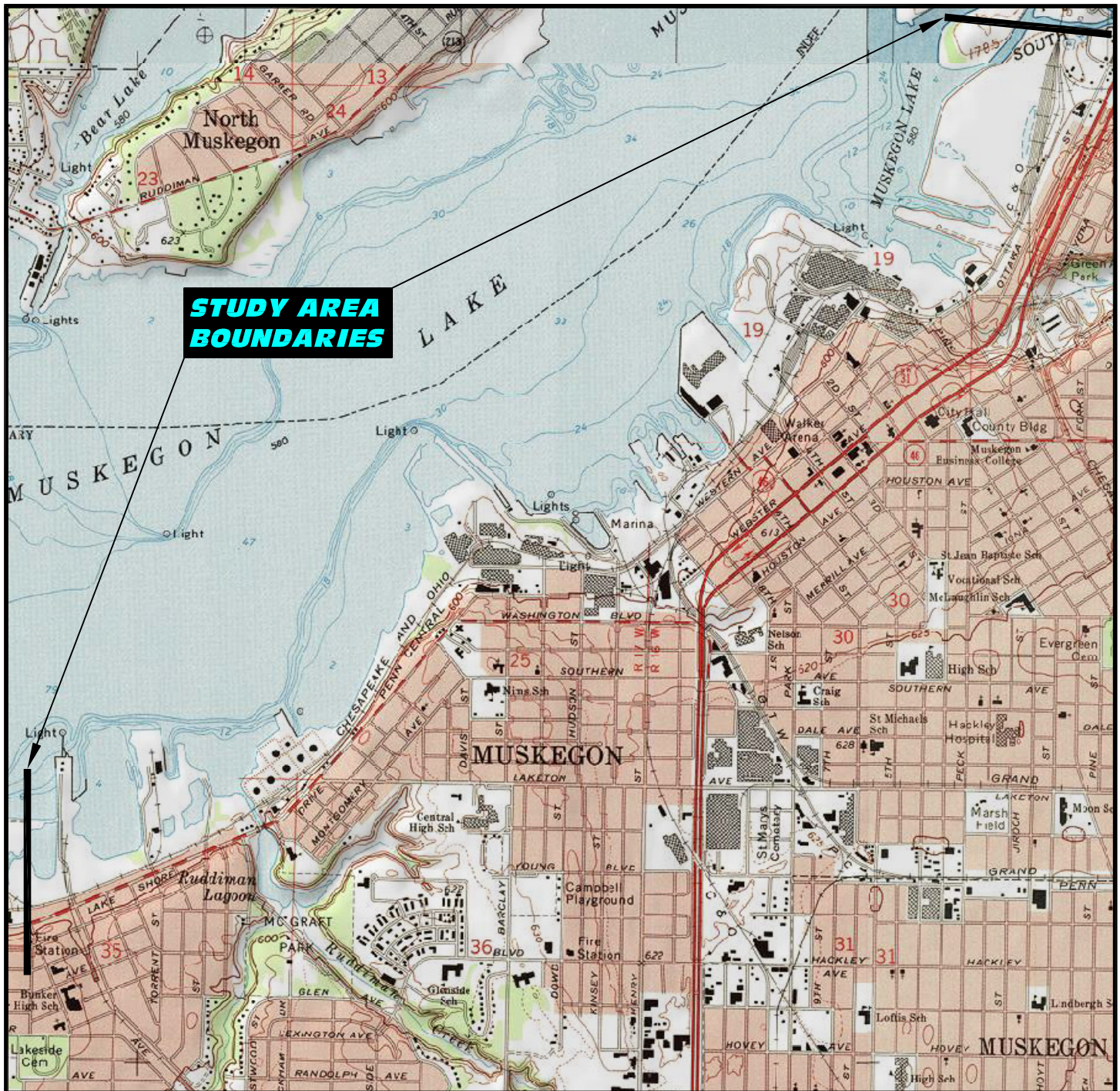
- Concentrations of heavy metals (arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc), PAHs, and/or formaldehyde exceed one or more of the Part 201 GRCC (drinking water protection, groundwater/surface water interface protection, direct contact, particulate inhalation and/or indoor air inhalation values) in the majority (88%) of the historic fill samples.
- PCBs, cyanide, and phenols were not detected in most of the historic fill samples, and where detected, concentrations are below Part 201 GRCC in all samples (sampling was not performed to characterize sediments or dredge spoils).
- Contaminants associated with the historic fill (primarily PAHs) may pose a residential/recreational direct contact hazard in certain portions of the study area; no other residential/recreational exposure hazards were identified (as described in Section 4.0, exceptions are noted on/in the vicinity of the West Michigan Steel, Terrace Point, Muskegon Boilerworks, and Fisher Padnos sites). This assessment assumes use of groundwater as a drinking water source is/will be prohibited.
- Contaminants associated with the historic fill do not pose a hazard for commercial/industrial land use based upon current Part 201 rules and

MDEQ guidance (excluding groundwater/drinking water use, as described above). An exception is noted in the vicinity of the Muskegon Boiler Works site where additional investigation may be needed to evaluate whether PAHs (primarily benzo(a)pyrene) pose a commercial/industrial direct contact hazard.

- Contaminants in the historic fill do not appear to be leaching to groundwater at concentrations exceeding GRCC except for manganese, which was found at concentrations exceeding Part 201 generic residential drinking water cleanup criteria in 16 out of 20 groundwater samples (the potential for an elevated background condition was not evaluated).
- Results of the Area Wide fill characterization suggest that it is appropriate to conclude that properties within the Study Area are “facilities” per Part 201, absent site-specific data demonstrating that a parcel is not a “facility”.
- An exposure barrier (clean soil/gravel layer, pavement, building cover) or a site-specific evaluation of the direct contact risks is recommended (if a barrier is not already present) to mitigate potential unacceptable direct contact exposures for residential/recreational property uses within the Study Area.
- Generic Baseline Environmental Assessment and Due Care information has been prepared and may be of assistance to current/prospective owners and operators in meeting the requirements of Part 201 of P.A. 451 of 1994, as amended.

This report was prepared for the sole and exclusive benefit and use of the City of Muskegon. If a Third Party is provided with this report, it shall be for informational purposes only, without the right to rely and shall not give rise to any legal relationship between the City or authors and such Third Party.

Appendix A
Figures



**STUDY AREA
BOUNDARIES**

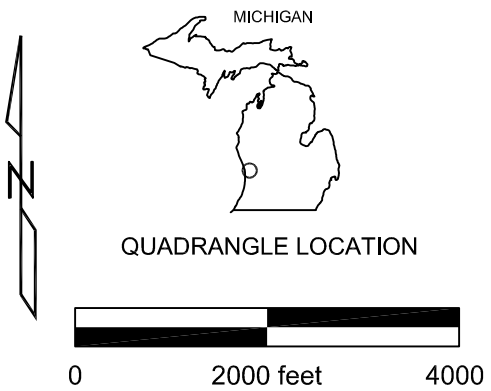


FIGURE 1
SITE LOCATION MAP

MUSKEGON AREA WIDE

Section: Various,
Town: 10 North, Range: 16 West,
City of Muskegon,
Muskegon County, Michigan



Adapted from 7.5 minute topographic quadrangle:
Muskegon West & East, 1982.

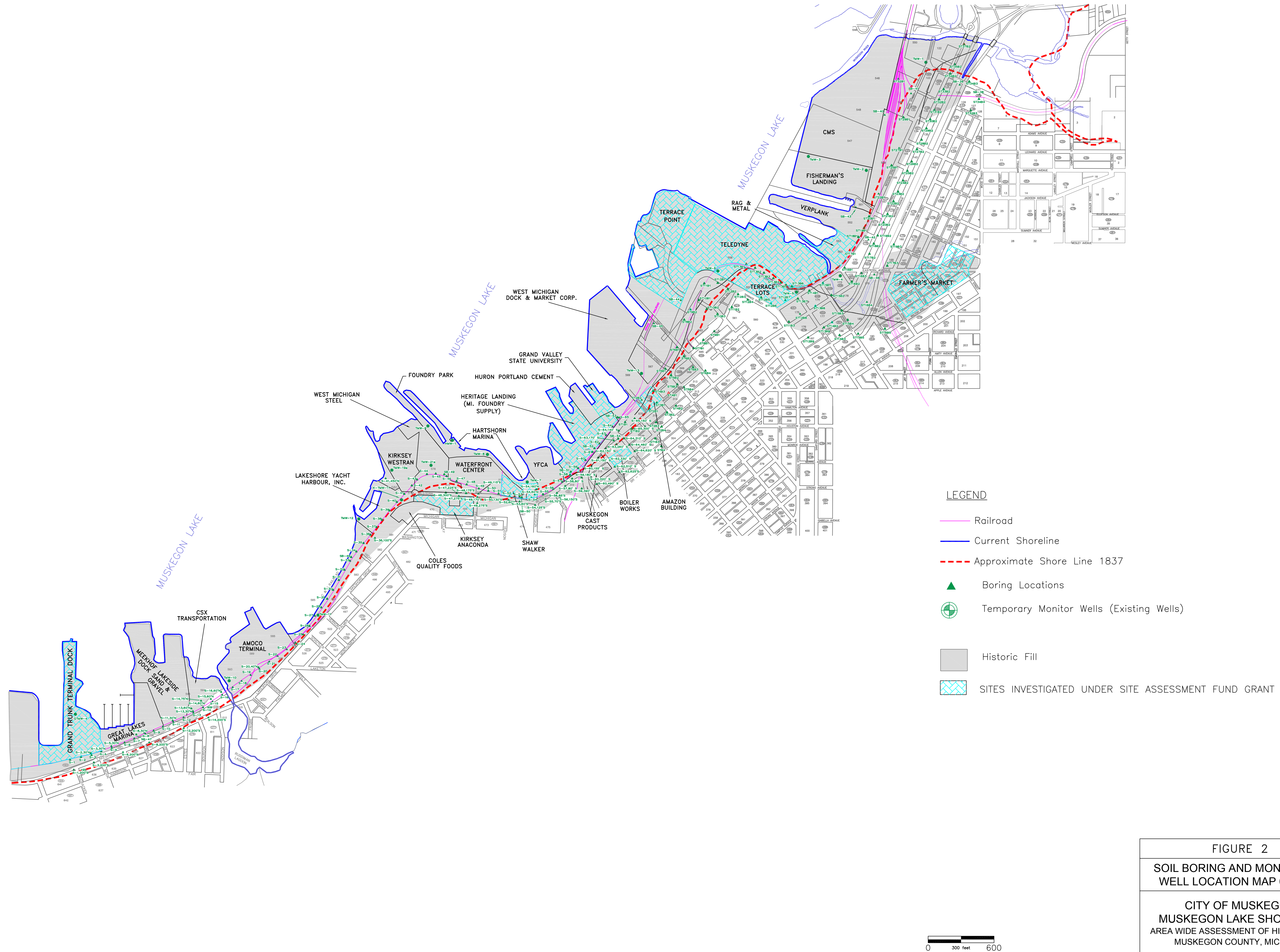


FIGURE 2

SOIL BORING AND MONITORING
WELL LOCATION MAP 09/23/08

CITY OF MUSKEGON
MUSKEGON LAKE SHORELINE
AREA WIDE ASSESSMENT OF HISTORIC FILL
MUSKEGON COUNTY, MICHIGAN

scale	as shown	date drawn	03/22/96
project mgr.	SM	drawn by	IRC
dwg #	MK1246-EQ	revised	dal 10/08/03

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Appendix B
Tables

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								Data Evaluation				S-1	S-3, 200'S	S-3, 30'N	S-5, 30'N	S-7	S-8, 200'S	S-9
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	95% UCL	Maximum Concentration	Location of Maximum Concentration	Total Number Analyzed	(1'-2') 12-18-96	(2'-3') 2-25-97	(2'-3') 12-17-96	(2'-3') 12-17-96	(2'-3') 12-17-97	(3'-4') 2-25-97	(1.5'-2.5') 12-17-96
METALS (ug/kg)																			
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	4,290	40,000	ST32-B1	169	9,100	64	420	9,600	8,300	690	16,000
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NC	450,000	FarmMkt SB-16	48	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	NC	26,000	S-49	168	53	18	ND	2,700	76	370	8,100
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	NC	260,000	ST12-B1	169	7,000	380	1,300	14,000	7,300	2,600	13,000
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	NC	600,000	SB-52	169	20,000	360	1,600	59,000	26,000	4,900	59,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	125,000	1,300,000	ST29-B1	169	31,000	300	2,200	9,600	77,000	19,000	150,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NC	7,300,000	SB-49	30	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NC	4,400	BlrWks SB-12	57	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NC	69,000	SB-52	39	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NC	1,200	Amazon SB-2	48	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NC	4,400	FarmMkt SB-16	45	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	NC	3.4E+06	SB-52	169	28,000	4,700	4,900	250,000	93,000	22,000	280,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																			
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	NC	13,000	SB-43	115	NA	NA	NA	ND	NA	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	NC	4,200	SB-40	115	NA	NA	NA	ND	NA	ND	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	NC	5,800	ST27-B1	116	NA	NA	NA	ND	NA	ND	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	NC	12,000	SB-40	116	NA	NA	NA	780	NA	600	920
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	NC	13,000	SB-40	116	NA	NA	NA	750	NA	370	940
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	NC	13,000	SB-41	115	NA	NA	NA	760	NA	390	820
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	NC	12,000	SB-41	116	NA	NA	NA	ND	NA	ND	ND
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	NC	14,000	SB-41	116	NA	NA	NA	ND	NA	480	840
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	NC	13,000	SB-40	116	NA	NA	NA	1,000	NA	ND	1,200
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	NC	4,600	SB-41	115	NA	NA	NA	ND	NA	ND	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	NC	91,000	BlrWks SB-11	116	NA	NA	NA	1,400	NA	1,500	2,100
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	NC	2,800	SB-52	116	NA	NA	NA	ND	NA	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	NC	11,000	SB-41	116	NA	NA	NA	165	NA	ND	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	NC	18,000	SB-47	116	NA	NA	NA	ND	NA	ND	520
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	NC	17,000	ST27-B1	116	NA	NA	NA	1,500	NA	730	1,600
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	NC	74,000	BlrWks SB-11	116	NA	NA	NA	1,100	NA	1,300	1,900
MISC. (ug/kg)																			
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NC	230	SB-46	45	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NC	990	SB-43	32	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NC	15,000	TerrcPt MW-3	52	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																			
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NC	1,400	TMW-2	46	NA	NA	NA	NA	NA	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

NA = Not Analyzed/ Insufficient Data Information Available to Determine

NL = Non-Leaching Chemical Under Most Soil Conditions

NV = Not Likely To Volatilize Under Most Soil Conditions

GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								S-11, 30°N	S-12, 200°S	S-13, 60°N	S-15, 60°N	S-17	S-17	S-19	S-21	S-23	S-23	S-25	S-27
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(1'-2') 12-18-96	(2.5'-3.5') 2-25-97	(2'-3') 12-18-96	(3'-4') 12-18-96	(0.5'-1.5') 2-20-97	(3'-4') 4-14-97	(1'-2') 2-20-97	(0'-1') 2-20-97	(0'-1') 2-20-97	(3.5'-4') 4-14-97	(3'-4') 2-21-97	(3.5'-4') 2-21-97
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	870	140	7,000	660	3,300	470	770	3,400	2,100	1,300	860	990
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	18	5.2	ND	ND	30	290	34	67	28	340	490	690
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	2,200	1,100	5,500	2,400	4,600	1,700	2,200	3,900	3,000	2,200	2,700	3,600
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	2,600	870	66,000	1,900	20,000	1,900	2,900	45,000	15,000	3,900	9,500	10,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	3,700	1,300	20,000	2,200	320,000	4,000	5,800	99,000	35,000	5,300	33,000	11,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	24,000	2,000	13,000	6,300	40,000	6,200	15,000	150,000	31,000	6,400	23,000	95,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	NA	NA	940	NA	NA	NA	ND	NA	NA	NA	NA	NA
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	NA	NA	910	NA	NA	NA	ND	NA	NA	NA	NA	NA
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

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GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								S-29	S-31	S-33	S-35	S-37	S-38	S-38	S-39	S-40	S-41	S-42	S-43
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(2'-3') 2-21-97	(2'-3') 2-21-97	(1'-2') 2-21-97	(2'-3') 2-21-97	(1'-2') 3-7-97	(2'-3') 3-7-97	(4'-5') 3-26-97	(1'-1.5') 3-7-97	(2.5'-3.5') 3-10-97	(1'-2') 3-10-97	(2'-2.5') 3-10-97	(3'-4') 3-10-97
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	680	ND	3,000	1,300	2,100	2,000	540	4,000	2,000	3,400	4,600	950
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	520	ND	1,400	1,400	1,300	1,000	11	2,000	950	910	4,600	1,100
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	5,600	690	8,700	9,200	6,000	7,900	2,300	12,000	4,500	24,000	24,000	6,000
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	5,300	21,000	26,000	21,000	24,000	17,000	1,000	32,000	15,000	75,000	75,000	8,400
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	3,700	27,000	36,000	31,000	16,000	12,000	82	83,000	15,000	55,000	360,000	22,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	11,000	70,000	37,000	53,000	18,000	34,000	4,400	140,000	19,000	17,000	97,000	11,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	ND	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.
Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.
¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.
* = Criteria based on 5 meter source thickness.
** = Referenced cleanup criteria are for Cr⁶⁺ (except background).
(B) = Background default value replaces cleanup criterion
ND = Below Detection Limit
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Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								S-44	S-45	S-46	S-46	S-47	S-48	S-48, 175'S	S-49	S-50, 130'S	S-51	S-52	S-53
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(3'-4') 3-10-97	(4.5'-5') 3-10-97	(1'-2') 3-10-97	(3'-4') 3-26-97	(1'-2') 3-10-97	(1'-1.5') 3-10-97	(6'-7') 3-12-97	(1'-2') 3-10-97	(2'-3') 3-11-97	(.5'-1.5') 3-17-97	(1'-2') 3-17-97	(2'-3') 3-17-97
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	2,300	1,500	7,000	590	1,500	2,700	680	1,800	1,200	2,700	980	2,600
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	1,800	1,500	11,000	21	940	1,400	25	26,000	1,200	2,500	800	2,300
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	7,400	3,300	11,000	2,000	5,000	5,800	8,100	4,300	8,600	13,000	3,900	10,000
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	10,000	23,000	34,000	810	21,000	24,000	2,200	20,000	10,000	47,000	8,600	45,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	16,000	15,000	52,000	150	27,000	61,000	ND	72,000	34,000	240,000	15,000	120,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	26,000	22,000	120,000	5,400	27,000	76,000	8,000	47,000	36,000	240,000	24,000	97,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	440
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	600
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	ND	NA	NA	NA	NA	NA	NA	1,000	NA	NA	NA	2,700
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	ND	NA	NA	NA	NA	NA	NA	1,100	NA	NA	NA	2,000
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	ND	NA	NA	NA	NA	NA	NA	1,000	NA	NA	NA	2,000
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	ND	NA	NA	NA	NA	NA	NA	580	NA	NA	NA	1,300
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	ND	NA	NA	NA	NA	NA	NA	1,000	NA	NA	NA	2,400
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	ND	NA	NA	NA	NA	NA	NA	1,100	NA	NA	NA	2,700
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	860
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	ND	NA	NA	NA	NA	NA	NA	1,800	NA	NA	NA	3,800
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	ND	NA	NA	NA	NA	NA	NA	590	NA	NA	NA	1,500
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	ND	NA	NA	NA	NA	NA	NA	350	NA	NA	NA	1,200
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	ND	NA	NA	NA	NA	NA	NA	1,300	NA	NA	NA	2,800
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	ND	NA	NA	NA	NA	NA	NA	1,500	NA	NA	NA	2,700
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

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GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								S-54	S-54, 125'S	S-55	S-56, 85'S	S-57, 80'S	S-58	S-59	S-60	S-61	S-62	S-63, 170'S	S-64
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(1'-2') 3-17-97	(1'-2') 3-18-97	(1'-2') 3-17-97	(1'-2') 3-17-97	(1'-2') 3-17-97	(1.5'-2.5') 3-17-97	(2'-3') 3-18-97	(3'-4') 3-18-97	(1'-2') 3-18-97	(2'-3') 3-18-97	(1'-2') 3-19-97	(1'-2') 3-18-97
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	2,100	830	1,000	1,500	940	3,000	730	3,800	4,800	1,200	2,900	3,400
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	1,600	610	560	690	620	2,300	610	3,700	2,900	25,000	10,000	2,000
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	5,200	4,500	2,400	5,100	3,900	9,400	2,800	41,000	8,800	5,000	68,000	7,500
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	26,000	3,200	13,000	7,200	5,700	57,000	5,000	200,000	28,000	24,000	180,000	27,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	49,000	28,000	28,000	35,000	13,000	250,000	8,500	29,000	66,000	57,000	340,000	49,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	77,000	15,000	28,000	34,000	18,000	200,000	16,000	44,000	87,000	77,000	700,000	78,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	NA	NA	NA	NA	NA	1,600	NA	NA	NA	NA	ND	NA
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	ND	NA
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	NA	NA	NA	NA	NA	3,700	NA	NA	NA	NA	ND	NA
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	NA	NA	NA	NA	NA	7,400	NA	NA	NA	NA	1,100	NA
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	NA	NA	NA	NA	NA	4,900	NA	NA	NA	NA	1,100	NA
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	NA	NA	NA	NA	NA	3,800	NA	NA	NA	NA	1,000	NA
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	NA	NA	NA	NA	NA	3,200	NA	NA	NA	NA	580	NA
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	NA	NA	NA	NA	NA	5,600	NA	NA	NA	NA	910	NA
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	NA	NA	NA	NA	NA	6,800	NA	NA	NA	NA	1,200	NA
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	NA	NA	NA	NA	NA	1,800	NA	NA	NA	NA	380	NA
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	NA	NA	NA	NA	NA	13,000	NA	NA	NA	NA	1,800	NA
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	NA	NA	NA	NA	NA	2,100	NA	NA	NA	NA	ND	NA
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	NA	NA	NA	NA	NA	3,500	NA	NA	NA	NA	650	NA
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	NA	NA	NA	NA	NA	1,300	NA	NA	NA	NA	2,300	NA
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	NA	NA	NA	NA	NA	12,000	NA	NA	NA	NA	1,700	NA
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	NA	NA	NA	NA	NA	11,000	NA	NA	NA	NA	1,100	NA
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

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GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								S-65	ST2-B2	ST4-B1	ST5-B1	ST6-B1	ST9-B2	ST10-B3	ST12-B1	ST12-B6	ST12-B7	ST12-B8	ST13-B1
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(1'-2') 3-19-97	(3') 12-16-96	(6') 12-16-96	(2') 12-17-96	(4') 12-17-96	(3') 12-19-96	(2') 12-19-96	(2.5') 12-20-96	(1.5') 12-31-96	(4') 12-31-96	(.5'-2') 3-7-97	(1') 1-8-97
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	4,100	4,000	2,500	1,800	10,000	6,400	1,200	5,700	880	5,600	3,400	21,000
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	2,300	300	250	390	780	1,200	240	2,000	180	22,000	2,000	4,700
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	5,700	8,800	6,300	12,000	11,000	8,100	49,000	100,000	3,600	31,000	8,900	35,000
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	22,000	20,000	80,000	26,000	41,000	32,000	11,000	110,000	9,600	51,000	130,000	230,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	29,000	59,000	890,000	56,000	230,000	54,000	37,000	51,000	43,000	150,000	340,000	310,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	29,000	46,000	77,000	72,000	150,000	82,000	30,000	160,000	28,000	150,000	130,000	410,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	NA	1,200	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	NA	ND	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	NA	2,000	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	NA	4,100	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	NA	6,000	NA	NA	420	NA	NA	NA	NA	NA	450	NA
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	NA	2,000	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	NA	1,700	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	NA	4,300	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	NA	4,200	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	NA	530	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	NA	8,700	NA	NA	610	NA	NA	NA	NA	NA	660	NA
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	NA	880	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	NA	2,300	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	NA	570	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	NA	8,600	NA	NA	390	NA	NA	NA	NA	NA	390	NA
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	NA	9,100	NA	NA	600	NA	NA	NA	NA	NA	560	NA
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.
Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.
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of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								ST13-B4	ST13-B8	ST14-B2	ST15-B1	ST16-B4	ST17-B1	ST19-B1	ST22-B1	ST25-B1	ST27-B1	ST29-B1	ST32-B1
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(1') 1-8-97	(4') 1-3-97	(6') 1-3-97	(2') 1-9-97	(1') 3-7-97	(2') 1-9-97	(2') 1-15-97	(.5'-2') 3-4-97	(.5'-2') 3-4-97	(.5'-2') 3-4-97	(0'-1') 3-4-97	(.5') 3-4-97
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	7,800	1,400	3,700	5,300	6,300	11,000	7,300	5,500	7,800	5,300	21,000	40,000
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	2,900	880	380	1,100	1,200	2,800	1,800	1,100	1,800	1,500	5,600	2,900
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	25,000	14,000	16,000	8,600	12,000	42,000	13,000	7,800	11,000	9,100	25,000	35,000
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	160,000	29,000	37,000	51,000	49,000	56,000	20,000	25,000	65,000	120,000	430,000	240,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	130,000	150,000	200,000	66,000	240,000	230,000	31,000	88,000	190,000	450,000	1.3E+06	310,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	180,000	120,000	110,000	57,000	250,000	260,000	150,000	78,000	150,000	120,000	590,000	390,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	NA	NA	NA	NA	ND	NA	NA	ND	NA	2,700	NA	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	NA	NA	NA	NA	ND	NA	NA	ND	NA	680	NA	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	NA	NA	NA	NA	ND	NA	NA	ND	NA	4,000	NA	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	NA	NA	NA	NA	ND	NA	NA	ND	NA	5,600	NA	ND
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	NA	NA	NA	NA	350	NA	NA	820	NA	7,100	NA	690
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	NA	NA	NA	NA	ND	NA	NA	ND	NA	2,400	NA	ND
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	NA	NA	NA	NA	ND	NA	NA	ND	NA	2,200	NA	ND
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	NA	NA	NA	NA	ND	NA	NA	480	NA	5,300	NA	ND
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	NA	NA	NA	NA	ND	NA	NA	520	NA	4,800	NA	ND
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	NA	NA	NA	NA	ND	NA	NA	ND	NA	ND	NA	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	NA	NA	NA	NA	470	NA	NA	860	NA	16,000	NA	810
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	NA	NA	NA	NA	ND	NA	NA	ND	NA	2,400	NA	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	NA	NA	NA	NA	ND	NA	NA	ND	NA	2,500	NA	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	NA	NA	NA	NA	ND	NA	NA	ND	NA	3,500	NA	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	NA	NA	NA	NA	ND	NA	NA	690	NA	17,000	NA	760
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	NA	NA	NA	NA	430	NA	NA	870	NA	14,000	NA	810
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.
Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.
¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.
* = Criteria based on 5 meter source thickness.
** = Referenced cleanup criteria are for Cr⁶⁺ (except background).
(B) = Background default value replaces cleanup criterion
ND = Below Detection Limit
NA = Not Analyzed/ Insufficient Data Information Available to Determine
NL = Non-Leaching Chemical Under Most Soil Conditions
NV = Not Likely To Volatilize Under Most Soil Conditions
GW = Groundwater; GSI = Groundwater/Surface Water Interface
Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								ST37-B2	SB-39	SB-40	SB-41	SB-43	SB-44	SB-45	SB-46	SB-47	SB-48	SB-49	SB-50
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(2') 3-4-97	(3') 10-19-00	(0'-2') 8-9-00	(0'-1') 8-9-00	(0'-4') 8-9-00	(1'-5') 8-30-00	(1'-4') 8-31-00	(2'-6') 8-31-00	(1'-3') 5-3-01	(1'-3') 5-3-01	(1'-3') 5-4-01	(1'-4') 5-4-01
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	18,000	980	1,400	85	2,100	1,300	680	610	5,500	2,200	2,600	3,400
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	6,800	48	300	790	380	77	17	130	1,000	440	79	340
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	67,000	5,900	11,000	8,100	13,000	6,700	6,700	3,500	7,400	5,600	64,000	7,300
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	210,000	9,300	110,000	120,000	15,000	5,600	4,900	11,000	43,000	19,000	33,000	24,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	15,000	79,000	190,000	470,000	51,000	9,000	6,800	41,000	120,000	40,000	32,000	55,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	32,000	160,000	440,000	190,000	320,000	55,000	78,000	90,000	110,000	7.3E+06	110,000
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	2,100	9,100	8,400	5,300	4,600	6,200	3,300	7,400	7,000	18,000	5,900
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	23,000	150,000	270,000	450,000	61,000	98,000	25,000	100,000	100,000	59,000	140,000	57,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	NA	ND	ND	ND	13,000	ND	ND	ND	240	ND	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	NA	ND	4,200	ND	640	ND	ND	ND	ND	ND	ND	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	NA	ND	1,400	1,300	2,300	350	ND	ND	290	ND	ND	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	NA	580	12,000	9,800	4,300	3,400	ND	350	420	260	290	860
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	NA	490	13,000	12,000	3,200	1,800	ND	ND	980	320	470	1,700
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	NA	ND	12,000	13,000	4,600	2,300	ND	ND	ND	210	360	1,200
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	NA	ND	7,500	12,000	3,000	2,700	ND	ND	ND	ND	ND	220
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	NA	450	12,000	14,000	4,600	2,700	ND	370	ND	280	350	1,100
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	NA	680	13,000	12,000	5,600	3,100	ND	470	510	250	320	890
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	NA	ND	3,900	4,600	1,100	590	ND	ND	ND	ND	ND	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	NA	1,300	18,000	15,000	12,000	4,900	ND	960	960	500	570	1,500
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	NA	ND	460	ND	1,600	ND	ND	ND	350	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	NA	ND	8,400	11,000	2,600	1,900	ND	ND	ND	ND	ND	260
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	NA	ND	3,200	1,000	1,100	590	ND	ND	18,000	250	ND	520
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	NA	780	5,000	7,600	14,000	1,400	ND	670	1,900	700	510	1,100
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	NA	1,100	13,000	11,000	9,000	4,800	ND	650	940	450	520	1,300
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	ND	ND	ND	ND	ND	ND	230	ND	ND	ND	ND
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	ND	ND	690	990	ND	ND	ND	ND	ND	ND	ND
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	ND	ND	ND	ND	3,700	7,500	ND	3,000	ND	9,100	ND
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	<266	<290	<300	<300	<390	<280	49	<1,330	<1,260	<1,190	<1,260

Notes:
Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.
Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.
¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.
* = Criteria based on 5 meter source thickness.
** = Referenced cleanup criteria are for Cr⁶⁺ (except background).
(B) = Background default value replaces cleanup criterion
ND = Below Detection Limit
NA = Not Analyzed/ Insufficient Data Information Available to Determine
NL = Non-Leaching Chemical Under Most Soil Conditions
NV = Not Likely To Volatilize Under Most Soil Conditions
GW = Groundwater; GSI = Groundwater/Surface Water Interface
Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								SB-51	SB-52	SB-53	SB-54	S-14	S-41	TMW-1	TMW-2	TMW-3	TMW-4	TMW-5	TMW-6
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(2'-4') 5-4-01	(3'-5') 5-4-01	(1'-3') 5-4-01	(1'-2') 5-8-01	10/16/00	10/16/00	(1'-5') 8-29-00	(3'-5') 8-29-00	(1'-5') 8-29-00	(1'-5') 8-29-00	(2'-7') 8-30-00	(1') 8-30-00
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	1,800	4,200	5,200	2,800	ND	ND	560	3,500	14,000	1,100	850	1,200
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	1,400	1,400	390	560	ND	ND	13	450	1,500	100	23	45
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	4,400	67,000	23,000	19,000	39,000	48,000	1,900	28,000	24,000	2,600	2,500	6,500
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	24,000	600,000	58,000	64,000	230,000	74,000	3,300	85,000	140,000	7,200	4,300	13,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	52,000	110,000	89,000	89,000	77,000	22,000	4,000	160,000	360,000	66,000	18,000	39,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	110,000	190,000	170,000	410,000	160,000	1.3E+06	28,000	480,000	440,000	29,000	52,000	120,000
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	5,500	69,000	17,000	16,000	24,000	30,000	1,200	23,000	20,000	1,700	1,600	5,200
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	59,000	3,400,000	140,000	280,000	110,000	41,000	6,600	240,000	550,000	57,000	15,000	54,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	430	ND	1,700	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	1,100	320	ND	ND	ND	1,100	ND	ND	ND	ND	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	3,900	190	2,800	490	890	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	480	8,100	790	7,600	1,500	3,900	1,200	ND	780	ND	ND	460
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	760	9,200	2,000	9,300	1,400	6,100	1,800	ND	650	ND	ND	370
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	530	5,300	1,400	7,300	780	3,500	1,600	ND	630	ND	ND	350
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	ND	2,000	230	1,000	890	5,500	2,800	ND	770	ND	ND	360
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	610	6,600	990	9,100	1,100	6,400	2,200	ND	760	ND	ND	450
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	470	7,900	1,000	7,800	2,200	4,400	1,600	ND	980	ND	ND	630
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	950	ND	ND	ND	1,300	760	ND	ND	ND	ND	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	810	13,000	1,900	12,000	2,800	5,200	1,300	ND	1,800	ND	ND	880
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	2,800	ND	1,400	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	ND	2,300	270	1,100	630	4,900	2,000	ND	560	ND	ND	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	260	6,100	1,300	3,000	4,000	ND	ND	ND	780	410	ND	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	730	16,000	1,200	15,000	4,500	3,000	ND	ND	1,600	460	ND	450
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	750	18,000	1,500	16,000	2,800	4,800	1,300	ND	1,200	ND	ND	780
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	<1,260	<1,260	<1,190	<238	<245	<238	<240	1,400	<250	<370	<250	<260

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

NA = Not Analyzed/ Insufficient Data Information Available to Determine

NL = Non-Leaching Chemical Under Most Soil Conditions

NV = Not Likely To Volatilize Under Most Soil Conditions

GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								TMW-7	TMW-8	TMW-9	TMW-10	TMW-11	TMW-12	TMW-13	Amazon Building		
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	(3'-4') 10-18-00	(3') 10-18-00	(5') 10-18-00	(2'-6') 10-18-00	(0'-1') 10-19-00	(0'-2') 5-3-01	(3'-5') 5-8-01	SB-2 (7')	SB-3 fill	SB-5
METALS (ug/kg)																		
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	2,300	2,000	3,500	1,100	1,700	2,800	ND	4,200	14,000	2,100
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA	60,000	210,000	36,000
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	110	190	130	240	82	4,900	2,500	180	2,300	ND
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	9,100	17,000	28,000	4,500	8,800	5,700	7,000	6,300	20,000	5,100
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	22,000	30,000	41,000	12,000	26,000	18,000	7,100	53,000	65,000	6,100
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	230,000	27,000	18,000	38,000	39,000	120,000	24,000	45,000	330,000	510,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	95,000	180,000	720,000	80,000	200,000	120,000	61,000	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA	330	220	ND
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	5,300	7,400	18,000	2,400	6,800	4,800	ND	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA	1,200	720	ND
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	89,000	38,000	43,000	40,000	3,600	150,000	26,000	150,000	570,000	19,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																		
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	ND	ND	690	ND	ND	ND	ND	ND	NA
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	ND	ND	1,600	ND	ND	ND	ND	ND	370
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	830	470	ND	3,400	820	ND	240	ND	ND	1,400
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	1,300	ND	ND	2,900	1,200	ND	330	ND	ND	1,600
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	790	ND	ND	1,800	610	ND	220	ND	ND	NA
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	650	ND	ND	1,900	550	ND	ND	ND	ND	800
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	930	ND	ND	2,700	870	ND	280	ND	ND	1,300
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	1,200	490	ND	3,700	1,000	ND	230	ND	ND	1,300
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	ND	ND	550	ND	ND	ND	ND	ND	NA
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	1,100	1,100	ND	8,000	1,200	ND	ND	ND	ND	3,000
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	ND	ND	630	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	610	ND	ND	1,600	490	ND	ND	ND	ND	750
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	690	ND	ND	ND	1,500	ND	ND	ND	ND	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	840	1,000	450	5,500	1,200	ND	320	ND	ND	530
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	1,100	960	ND	6,900	1,300	ND	380	ND	ND	2,100
MISC. (ug/kg)																		
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	ND	2,100	5,800	ND	ND	ND	ND	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																		
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	<259	<259	<273	<252	<252	<2,800	<252	NA	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

NA = Not Analyzed/ Insufficient Data Information Available to Determine

NL = Non-Leaching Chemical Under Most Soil Conditions

NV = Not Likely To Volatilize Under Most Soil Conditions

GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								Former Muskegon Boiler Works					Muskegon Farmers Market Property						
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	SB-3 (0-4')	SB-5 (0-4')	SB-11 (0-4')	SB-12 (0-4')	SB-13 (0-4')	SB-3 1.5'	SB-10 .5'	SB-11 .5'	SB-12 .5'	SB-14 .5'	SB-15 .5'	SB-16 .5'
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	2,300	3,100	12,000	2,600	1,400	1,900	1,500	3,700	870	3,100	2,900	1,300
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	43,000	37,000	110,000	73,000	71,000	32,000	21,000	56,000	230,000	140,000	92,000	450,000
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	190	210	740	680	1,000	2,800	300	1,300	1,300	360	400	3,500
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	2,700	4,400	27,000	4,500	5,700	220,000	23,000	60,000	37,000	9,000	7,400	48,000
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	23,000	62,000	140,000	140,000	47,000	240,000	38,000	130,000	440,000	16,000	21,000	460,000
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	50,000	88,000	330,000	480,000	140,000	84,000	600,000	220,000	340,000	38,000	28,000	190,000
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	180	400	230	4,400	270	880	ND	ND	500	ND	ND	250
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	240	ND	520	210	ND	ND	ND	ND	560	1,000	530	ND
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	ND	650	2,000	2,300	600	630	ND	ND	ND	ND	ND	4,400
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	75,000	76,000	220,000	240,000	82,000	45,000	9,800	36,000	55,000	3,600	4,000	120,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	ND	610	1,100	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	470	ND	2,000	2,100	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	1,100	ND	7,700	5,000	800	ND	ND	ND	72	ND	ND	ND
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	500	ND	3,000	1,700	350	ND	ND	ND	90	ND	ND	ND
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	880	ND	4,000	1,900	400	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	640	ND	9,100	4,600	860	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	870	ND	6,400	3,400	660	ND	ND	ND	61	ND	ND	ND
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	1,100	ND	9,000	5,600	1,100	ND	ND	ND	66	ND	ND	ND
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	ND	3,800	2,000	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	4,300	ND	91,000	88,000	11,000	67	ND	ND	130	ND	ND	ND
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	ND	710	1,200	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	510	ND	7,500	4,000	680	ND	ND	ND	ND	ND	ND	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	ND	ND	830	1,000	ND	ND	ND	ND	64	ND	ND	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	2,200	ND	10,000	12,000	1,400	42	ND	35	95	ND	ND	ND
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	3,600	ND	74,000	51,000	7,800	59	ND	ND	130	ND	ND	ND
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	ND	ND	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

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NV = Not Likely To Volatilize Under Most Soil Conditions

GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								Grand Trunk Terminal Dock (GTTD)										
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	SB-3 (6'-8')	SB-4 (0'-2')	SB-4 (6'-8')	SB-5 (0'-2')	SB-6/MW-3 (0'-2')	SB-6/MW-3 (6'-7')	SB-7 (0'-2')	SB-7 (6'-7')	SB-8 (6'-8')	SB-9 (0'-1.5')	SB-9 (4'-6')
METALS (ug/kg)																			
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	2,600	3,100	4,100	1,000	7,100	2,800	1,800	5,100	510	6,200	630
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	18,000	21,000	37,000	17,000	22,000	19,000	21,000	19,000	5,000	40,000	2,400
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	3,600	2,100	3,600	1,500	5,100	2,300	2,100	4,100	ND	4,900	NA
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	46,000	34,000	63,000	2,700	66,000	27,000	22,000	260,000	1,200	13,000	1,300
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	52,000	24,000	58,000	13,000	120,000	29,000	27,000	40,000	680	34,000	480
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	25,000	30,000	28,000	28,000	58,000	56,000	44,000	20,000	1,700	98,000	740
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	ND	ND	ND	650	ND	ND	ND	ND	ND	58	ND
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	74	72	150	130	93	71	81	79	ND	640	ND
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	ND	ND	ND	580	ND	2,400	ND	ND	ND	2,400	ND
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	20,000	85,000	57,000	13,000	140,000	100,000	57,000	86,000	2,900	150,000	2,100
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																			
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	ND	ND	ND	ND	ND	ND	ND	ND	930	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	ND	ND	ND	ND	ND	ND	ND	ND	780	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	ND	ND	ND	560	380	1,100	ND	ND	ND	2,100	ND
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	ND	ND	ND	ND	420	1,500	340	ND	ND	2,600	ND
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	ND	ND	ND	ND	390	1,200	ND	380	ND	2,200	ND
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	ND	ND	ND	ND	ND	830	ND	ND	ND	840	ND
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	ND	ND	ND	360	520	1,500	360	390	ND	2,000	ND
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	500	ND	ND	790	430	1,300	390	ND	ND	2,800	ND
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	ND	ND	ND	ND	460	ND	ND	ND	480	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	ND	ND	640	680	640	1,500	370	390	ND	4,000	ND
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	ND	ND	ND	ND	ND	870	ND	ND	ND	970	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	ND	ND	1,200	8,100	ND	ND	ND	ND	ND	1,700	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	ND	ND	860	3,400	490	660	ND	340	ND	2,400	ND
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	ND	ND	510	970	520	1,300	380	370	ND	3,600	ND
MISC. (ug/kg)																			
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	ND
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	ND
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	1.7	NA	NA	NA	NA	NA	NA	NA	NA	ND
POLYCHLORINATED BIPHENYLS (ug/kg)																			
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	<170	NA	NA	NA	NA	NA	NA	NA	NA	<24

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

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NL = Non-Leaching Chemical Under Most Soil Conditions

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GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								GTTD	Terrace Point Property										
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	SB-10/MW-4 (0'-1.5')	DSB-1 (3'-5')	DSB-1 (13'-15')	DSB-2 (3'-5')	DSB-2 (11'-13')	DSB-3 (3'-5')	DSB-3 (9'-11')	DSB-4 (6'-8')	DSB-5 (3'-5')	DSB-6 (7'-9')	SB-1 (0'-2')	SB-1 (10'-12')
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	7,800	3,600	2,600	6,700	2,600	6,600	2,400	3,200	3,900	4,700	650	1,500
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	53,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	5,400	19,000
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	7,200	390	ND	9	4.5	4,500	16	8.6	ND	19	ND	680
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	17,000	29,000	19,000	39,000	22,000	64,000	23,000	36,000	31,000	67,000	2,600	5,800
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	32,000	64,000	10,000	39,000	33,000	180,000	43,000	50,000	93,000	150,000	2,700	2,700
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	79,000	53,000	16,000	46,000	43,000	350,000	49,000	70,000	36,000	260,000	300	5,700
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	54	77	ND	28	27	50	65	410	25	ND	45	44
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	19,000	12,000	11,000	14,000	62,000	13,000	21,000	22,000	32,000	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	350	NA	NA	NA	NA	NA	NA	NA	NA	NA	45	77
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	110,000	130,000	30,000	79,000	110,000	1,200,000	110,000	56,000	34,000	52,000	4,500	12,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	2,200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	5,800	500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	7,900	1,200	360	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	7,800	1,000	380	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	4,400	1,400	340	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	1,400	750	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	4,500	1,200	370	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	8,500	1,300	430	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	1,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	1,600	2,400	770	420	ND	ND	ND	ND	430	590	ND	ND
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	1,800	750	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	1,100	550	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	2,600	1,100	580	340	ND	ND	ND	ND	360	570	ND	ND
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	10,000	2,000	660	370	ND	ND	ND	ND	520	480	ND	ND
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	790	1,200
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	ND	NA	NA	NA	NA	<810	<390	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for C₆⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

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Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								Terrace Point Property											
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	SB-2 (0.3'-2')	SB-2 (6'-8')	B-3 (0'-2')	SB-3 (14'-16')	B-4 (0'-2')	SB-4 (16'-18')	SB-5 (0'-2')	SB-5 (12'-14')	MW-1d (0.2'-2')	MW-1d (6'-8')	MW-2 (0'-2')	MW-2 (14'-16')
METALS (ug/kg)																				
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	7,200	5,700	4,100	2,500	2,700	2,900	1,600	3,100	3,100	1,700	3,000	1,500
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	25,000	31,000	43,000	18,000	29,000	35,000	19,000	23,000	46,000	27,000	21,000	44,000
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	4,700	3,000	2,500	1,300	1,800	1,000	1,100	1,800	2,400	800	1,600	860
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	97,000	42,000	36,000	6,000	29,000	6,100	14,000	6,500	42,000	10,000	19,000	5,200
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	110,000	71,000	67,000	3,100	44,000	7,200	20,000	3,100	58,000	2,500	37,000	6,400
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	25,000	41,000	39,000	21,000	430,000	44,000	22,000	8,800	120,000	6,500	29,000	8,400
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	130	84	100	55	55	47	43	42	230	62	79	46
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	100	160	180	120	140	280	200	400	150	62	110	140
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	690	ND
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	33,000	53,000	70,000	14,000	110,000	35,000	24,000	17,000	50,000	19,000	45,000	23,000
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																				
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	ND	ND	ND	410	ND	610	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	ND	ND	ND	540	ND	580	ND	ND	ND	ND	ND	340
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	ND	ND	ND	470	ND	450	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	ND	ND	ND	550	ND	500	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	ND	ND	ND	480	ND	610	ND	ND	ND	ND	ND	ND
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	ND	ND	ND	590	ND	710	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	420	ND	ND	690	350	1,300	ND	ND	ND	ND	ND	ND
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	ND	ND	ND	410	ND	420	ND	ND	ND	ND	ND	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	510	ND	ND	ND	ND	910	ND	ND	ND	ND	ND	ND
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	370	ND	ND	530	ND	1,000	ND	ND	ND	ND	ND	ND
MISC. (ug/kg)																				
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	ND	0.25	0.18	ND	ND	ND	ND	ND	0.51	ND	0.13	ND
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	8,100	10,000	1,700	840	2,600	1,200	830	1,900	4,200	990	780	3,400
POLYCHLORINATED BIPHENYLS (ug/kg)																				
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	<260	ND	NA	NA	NA	NA	NA	NA	NA	NA	<1,900

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

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Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

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Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								Terrace Point Property				GVSU - Lake Michigan Center									
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	MW-3 (0'-2')	MW-3 (14'-16')	TW-1 (0'-2')	TW-1 (14'-16')	S-3 (2.0'-3.0')	S-4 (4.0'-5.0')	SB-4 (2'-3')	SB-5 (0'-2')	SB-8 (1'-2')	SB-9 (0.5'-2.5')	SB-10 (0'-1.3')	SB-12 (0'-2')	SB-13 (0'-2')	
METALS (ug/kg)																						
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	9,000	4,000	4,200	1,400	290	270	NA	NA	4,700	NA	3,700	NA	2,500	
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	18,000	54,000	36,000	9,800	NA	NA	NA	NA	23,000	NA	24,000	NA	22,000	
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	2,100	2,500	2,700	650	3,200	3,100	NA	NA	1,400	NA	2,000	NA	870	
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	16,000	10,000	1,200	2,600	21,000	20,000	NA	NA	8,500	NA	27,000	NA	27,000	
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	45,000	5,300	64,000	3,100	39,000	25,000	NA	NA	24,000	NA	97,000	NA	140,000	
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	44,000	9,900	58,000	6,000	66,000	20,000	NA	NA	40,000	NA	120,000	NA	120,000	
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	66	ND	83	55	NA	NA	NA	NA	25	NA	21	NA	160	
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	79	25	170	190	NA	NA	NA	NA	360	NA	ND	NA	ND	
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	ND	ND	ND	ND	NA	NA	NA	NA	ND	NA	ND	NA	ND	
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	38,000	15,000	94,000	8,900	130,000	36,000	NA	NA	51,000	NA	310,000	NA	180,000	
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)																						
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	ND	NA	
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	ND	NA	
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	ND	NA	
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	ND	480	ND	810	NA	NA	ND	ND	620	ND	ND	ND	NA	
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	ND	480	ND	1,300	NA	NA	ND	ND	750	ND	ND	340	NA	
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	ND	440	ND	1,400	NA	NA	ND	ND	830	ND	ND	360	NA	
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	ND	410	ND	1,000	NA	NA	ND	ND	640	ND	ND	ND	NA	
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	ND	560	ND	1,200	NA	NA	ND	ND	910	ND	ND	340	NA	
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	ND	540	ND	1,300	NA	NA	ND	ND	740	ND	ND	ND	NA	
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	ND	ND	540	NA	NA	ND	ND	ND	ND	ND	ND	NA	
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	ND	960	ND	ND	NA	NA	ND	470	1,100	ND	ND	330	NA	
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND	ND	NA	
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	ND	380	ND	920	NA	NA	ND	ND	610	ND	ND	ND	NA	
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	ND	500	450	ND	NA	NA	ND	ND	ND	ND	ND	ND	NA	
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	ND	840	390	ND	NA	NA	ND	ND	850	ND	ND	ND	NA	
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	ND	750	ND	680	NA	NA	ND	390	1,200	ND	ND	380	NA	
MISC. (ug/kg)																						
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	ND	0.17	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	1,100	15,000	800	1,100	NA	NA	NA	NA	NA	NA	NA	NA	NA	
POLYCHLORINATED BIPHENYLS (ug/kg)																						
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	<1,400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

NA = Not Analyzed/ Insufficient Data Information Available to Determine

NL = Non-Leaching Chemical Under Most Soil Conditions

NV = Not Likely To Volatilize Under Most Soil Conditions

GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 1
Summary of Soil Analytical Results (ug/kg)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria								GVSU - Lake Michigan Center						
	Back-ground	Drinking Water Protection	GSI Protection	GW Contact	Indoor Air Inhalation	Ambient Air Inhalation	Particulate Inhalation*	Direct Contact	SB-19 (0.7'-2.5')	HAB-2 (0.6'-1.3')	HAB-7 (3'-4')	HAB-9 (1.5'-2')	HAB-10 (1'-2')	HAB-11 (1.5'-2.5')	HAB-12 (1.5'-2.5')
METALS (ug/kg)															
Arsenic	5,800	5,800 (B) ¹	70,000	2.0E+06	NV	NV	7.2E+05	7,600	NA	NA	NA	NA	NA	NA	NA
Barium	75,000	1.3E+06	NA	1.0E+09	NV	NV	3.3E+08	3.7E+07	NA	NA	NA	NA	NA	NA	NA
Cadmium	1,200	6,000	3,600	2.3E+08	NV	NV	1.7E+06	5.5E+05	NA	NA	NA	NA	NA	NA	NA
Chromium**	18,000	30,000	3,300	1.4E+08	NV	NV	2.6E+05	2.5E+06	NA	NA	NA	NA	NA	NA	NA
Copper	32,000	5.8E+06	75,000	1.0E+09	NV	NV	1.3E+08	2.0E+07	NA	NA	NA	NA	NA	NA	NA
Lead	21,000	7.0E+05	2.8E+06	NA	NV	NV	1.0E+08	4.0E+05	NA	NA	NA	NA	NA	NA	NA
Manganese	440,000	440,000 (B)	440,000 (B)	1.8E+08	NV	NV	3.3E+06	2.5E+07	NA	NA	NA	NA	NA	NA	NA
Mercury	130	1,700	130 (B)	47,000	48,000	52,000	2.0E+07	1.6E+05	NA	NA	NA	NA	NA	NA	NA
Nickel	20,000	1.0E+05	76,000	1.0E+09	NV	NV	1.3E+07	4.0E+07	NA	NA	NA	NA	NA	NA	NA
Selenium	410	4,000	410 (B)	7.8E+07	NV	NV	1.3E+08	2.6E+06	NA	NA	NA	NA	NA	NA	NA
Silver	1,000	4,500	1,000 (B)	2.0E+08	NV	NV	6.7E+06	2.5E+06	NA	NA	NA	NA	NA	NA	NA
Zinc	47,000	2.4E+06	47,000 (B)	1.0E+09	NV	NV	NA	1.7E+08	NA	NA	NA	NA	NA	NA	NA
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/kg)															
Acenaphthene	-	3.0E+05	4,400	9.7E+05	1.9E+08	8.1E+07	1.4E+10	4.1E+07	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	-	5,900	NA	440,000	1.6E+06	2.2E+06	2.3E+09	1.6E+06	ND	ND	ND	ND	ND	ND	ND
Anthracene	-	41,000	NA	41,000	1.0E+09	1.4E+09	6.7E+10	2.3E+08	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	-	NL	NL	NL	NV	NV	NA	20,000	ND	ND	ND	ND	ND	570	640
Benzo(b)fluoranthene	-	NL	NL	NL	NA	NV	NA	20,000	ND	ND	ND	ND	ND	590	ND
Benzo(k)fluoranthene	-	NL	NL	NL	NV	NV	NA	2.0E+05	ND	ND	ND	ND	ND	920	440
Benzo(g,h,i)perylene	-	NL	NL	NL	NV	NV	8.0E+08	2.5E+06	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	-	NL	NL	NL	NV	NV	1.5E+06	2,000	ND	ND	ND	ND	ND	690	450
Chrysene	-	NL	NL	NL	NA	NA	NA	2.0E+06	ND	ND	ND	ND	ND	770	770
Dibenzo(a,h)anthracene	-	NL	NL	NL	NV	NV	NA	2,000	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	-	7.3E+05	5,500	7.3E+05	1.0E+09	7.4E+08	9.3E+09	4.6E+07	ND	ND	ND	ND	ND	790	820
Fluorene	-	3.9E+05	5,300	8.9E+05	5.8E+08	1.3E+08	9.3E+09	2.7E+07	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	-	NL	NL	NL	NV	NV	NA	20,000	ND	ND	ND	ND	ND	ND	ND
Naphthalene	-	35,000	870	2.1E+06	2.5E+05	3.0E+05	2.0E+08	1.6E+07	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	-	56,000	5,300	1.1E+06	2.8E+06	1.6E+05	6.7E+06	1.6E+06	ND	ND	ND	ND	ND	ND	400
Pyrene	-	4.8E+05	NA	4.8E+05	1.0E+09	6.5E+08	6.7E+09	2.9E+07	ND	ND	ND	ND	ND	790	1,000
MISC. (ug/kg)															
Cyanide	390	4,000	390 (B)	2.5E+05	NV	NV	2.5E+05	12,000	NA	NA	NA	NA	NA	NA	NA
Phenol	-	88,000	4,200	1.20E+07	NV	NV	4.0E+10	1.2E+07	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	-	26,000	2,400	6.0E+07	12,000	23,000	2.4E+08	4.1E+07	NA	NA	NA	NA	NA	NA	NA
POLYCHLORINATED BIPHENYLS (ug/kg)															
Total PCBs	-	NL	NL	NL	3.0E+06	7.9E+06	5.2E+06	4,000	NA	NA	NA	NA	NA	NA	NA

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.
Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Health-based drinking water protection criterion for arsenic is 4,600 ug/kg.

* = Criteria based on 5 meter source thickness.

** = Referenced cleanup criteria are for Cr⁶⁺ (except background).

(B) = Background default value replaces cleanup criterion

ND = Below Detection Limit

NA = Not Analyzed/ Insufficient Data Information Available to Determine

NL = Non-Leaching Chemical Under Most Soil Conditions

NV = Not Likely To Volatilize Under Most Soil Conditions

GW = Groundwater; GSI = Groundwater/Surface Water Interface

Shaded values exceed one or more of the referenced MDEQ Generic Residential Criteria.

TABLE 2
Summary of Groundwater Analytical Results (ug/L)
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Part 201 Residential Cleanup Criteria						Sample Location/Date & Concentration							
	Drinking Water	Indoor Air Inhalation	GSI	GW Contact	Flammability & Explosivity	Acute Inhalation	TMW-1 7/26/01	TMW-2 7/23/01	TMW-3 7/23/01	TMW-4 7/24/01	TMW-5 7/24/01	TMW-7 7/24/01	TMW-8 7/26/01	TMW-9 7/26/01
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/L)														
	Varies	Varies	Varies	Varies	Varies	Varies	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
METALS (ug/L)														
Chromium**	100	NV	100	4.6E+05	ID	ID	5.3	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Manganese	50 ¹	NV	760	9.1E+06	ID	ID	BDL	740	620	BDL	BDL	450	330	390
Zinc	2,400	NV	170	1.1E+08	ID	ID	34	32	20	28	27	20	BDL	BDL
Other Metals	Varies	Varies	Varies	Varies	Varies	Varies	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CARBONYLS (ug/L)														
Formaldehyde	1,300	63,000	120	3.0E+07	ID	61,000	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

	Part 201 Residential Cleanup Criteria						Sample Location/Date & Concentration							
	Drinking Water	Indoor Air Inhalation	GSI	GW Contact	Flammability & Explosivity	Acute Inhalation	TMW-11 7/25/01	TMW-10 7/25/01	TMW-13 7/26/01	TMW-19s 7/26/01	TMW-21s 7/25/01	GTMW-4 7/25/01	HMW-1 7/26/01	K-TMW-11 7/26/01
POLYNUCLEAR AROMATIC HYDROCARBONS (ug/L)														
	Varies	Varies	Varies	Varies	Varies	Varies	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
METALS (ug/L)														
Chromium**	100	NV	100	4.6E+05	ID	ID	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Manganese	50 ¹	NV	760	9.1E+06	ID	ID	BDL	430	430	450	43	310	680	BDL
Zinc	2,400	NV	170	1.1E+08	ID	ID	BDL	BDL	BDL	BDL	BDL	BDL	20	31
Other Metals	Varies	Varies	Varies	Varies	Varies	Varies	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CARBONYLS (ug/L)														
Formaldehyde	1,300	63,000	120	3.0E+07	ID	61,000	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

¹ Value is the aesthetic drinking water criterion; health-based drinking water criterion is 860 ug/L.

** = Referenced cleanup criteria are presented for Cr⁶⁺.

BDL = Below Detection Limit

ID = Insufficient Data/Information Available to Develop Criteria

NV = Not Likely To Volatilize Under Most Soil Conditions

GW = Groundwater

GSI = Groundwater/Surface Water Interface

Shaded values exceed the referenced drinking water criterion.

TABLE 3
Range Frequency Analysis for Soil
Area-Wide Assessment of Historic Fill
of Muskegon Lake Shoreline
Muskegon, Michigan

	Number of Samples that Exceed Part 201 Cleanup Criteria														Total Number Samples Analyzed	Range				95% Upper Confidence Level (ug/kg)
	Groundwater Protection				Indoor Air Inhalation		Ambient Air Inhalation		Particulate Inhalation		Direct Contact					Low (ug/kg)		High (ug/kg)		
	RES Drinking Water	COM/IND Drinking Water	GSI	GW Contact	RES	COM/IND	RES	COM/IND	RES	COM/IND	RES	IND	COM III	COM IV		Lowest	Sample Number	Highest	Sample Number	
METALS																				
Arsenic	11	11	0	0	-0-	-0-	-0-	-0-	0	0	17	0	0	0	169	BDL	Several	40,000	ST32-B1	4,290
Cadmium	8	8	20	0	-0-	-0-	-0-	-0-	0	0	0	0	0	0	168	BDL	Several	26,000	S-49	NC
Chromium	31	31	-0-	0	-0-	-0-	-0-	-0-	0	0	0	0	0	0	169	380	S-3	260,000	ST12-B1	NC
Copper	0	0	30	0	-0-	-0-	-0-	-0-	0	0	0	0	0	0	169	360	S-3, 200'S	600,000	SB-52	NC
Lead	2	2	0	-0-	-0-	-0-	-0-	-0-	0	0	8	1	8	8	169	82	S-38	1,300,000	ST29-B1	125,000
Manganese	4	4	4	0	-0-	-0-	-0-	-0-	1	1	0	0	0	0	30	28,000	TMW-1	7,300,000	SB-49	NC
Mercury	1	1	14	0	-0-	-0-	-0-	-0-	0	0	0	0	0	0	57	BDL	Several	4,400	BlrWks SB-12	NC
Selenium	0	0	7	0	-0-	-0-	-0-	-0-	0	0	0	0	0	0	48	BDL	Several	1,200	Amazon SB-2	NC
Silver	0	0	10	0	-0-	-0-	-0-	-0-	0	0	0	0	0	0	45	BDL	Several	4,400	FarmMkt SB-16	NC
Zinc	1	0	92	0	-0-	-0-	-0-	-0-	-0-	-0-	0	0	0	0	169	2,000	S-12, 200'S	3,400,000	SB-52	NC
POLYNUCLEAR AROMATIC HYDROCARBONS																				
Acenaphthene	0	0	1	0	0	0	0	0	0	0	0	0	0	0	115	BDL	Several	13,000	SB-43	NC
Benzo(A)Pyrene	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	0	0	16	2	0	0	116	BDL	Several	14,000	SB-41	NC
Dibenzo(A,H)anthracene	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	3	0	0	0	115	BDL	Several	4,600	SB-41	NC
Fluoranthene	0	0	12	0	0	0	0	0	0	0	0	0	0	0	116	BDL	Several	91,000	BlrWks SB-11	NC
Naphthalene	0	0	19	0	0	0	0	0	0	0	0	0	0	0	116	BDL	Several	18,000	SB-47	NC
Phenanthrene	0	0	17	0	0	0	0	0	0	0	0	0	0	0	116	BDL	Several	17,000	ST27-B1	NC
MISC.																				
Formaldehyde	0	0	11	0	1	0	0	0	0	0	0	0	0	0	52	BDL	Several	15,000	T Point MW-3	NC

Notes:

Cleanup Criteria per RRD Operational Memorandum #1, Attachment 1, 1/23/06.

Where applicable, GSI Protection criteria for metals calculated using Muskegon Lake/receiving water hardness of 150 mg/L per RRD Operational Memorandum #5, 9/30/04.

Shaded values exceed one or more of the referenced cleanup criteria.

Only those parameters with exceedances of Part 201 residential cleanup criteria are presented in the table.

BDL = Below Detection Limit

GW = Groundwater

GSI = Groundwater/Surface Water Interface

NA = Not Analyzed/ Insufficient Data Information Available to Determine

NC = Not Calculated.

-0- = Exposure pathway not relevant or insufficient data.

COM = Commercial

IND = Industrial

RES = Residential

Appendix C
Summary of Statistical Analysis

SUMMARY OF STATISTICAL ANALYSIS
AREA-WIDE ASSESSMENT OF HISTORIC FILL
MUSKEGON LAKE SHORELINE
MUSKEGON, MICHIGAN

SEPTEMBER 2008

BACKGROUND

A statistical evaluation of historic fill soil sampling results was performed in order to determine average (i.e., 95% upper confidence limit/UCL) contaminant concentrations in the historic fill to evaluate potential human health exposure hazards for Part 201 “due care” purposes.

Average/95% UCL concentrations were calculated only for those parameters exceeding Part 201 cleanup criteria for applicable human health exposure scenarios (i.e., direct contact and particulate inhalation), which include arsenic, lead, manganese, benzo(a)pyrene, and dibenzo(a,h)anthracene. Use of statistics is not appropriate for evaluating potential indoor air inhalation concerns associated with formaldehyde according to the MDEQ guidance document entitled *Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria*, August 2002 (S3TM). Drinking water exposures were not considered since it is anticipated that properties within the study area will be subject to the City of Muskegon’s drinking water ordinance which prohibits use of groundwater as a drinking water source. A discussion of the methodology used to calculate the UCLs and the findings follows.

95% UPPER CONFIDENCE LIMIT CALCULATION

Based on the statistical evaluation performed, calculation of an average/95% CL concentration was appropriate only for arsenic and lead. The data set for the other constituents was not amenable to average/95% UCL calculations based on input from MDEQ statistician Sarah Hession and the MDEQ S3TM guidance document.

The methods initially used to calculate the 95% UCLs are generally consistent with those described in the MDEQ S3TM guidance document. The S3TM software was not used/available at the time the initial statistical evaluation was conducted (described below); however, a follow-up evaluation performed using the S3TM software indicated findings consistent with those described below.

One-hundred sixty-nine samples were analyzed for arsenic and lead. Less than 3% of concentrations were non-detect. The Central Limit Theorem states that, for large sample sizes, the mean will tend to be normally distributed regardless of the distribution of the sampled population. Accordingly, the arsenic and lead data sets are considered normally distributed pursuant to the Central Limit Theorem.

The arsenic and lead data sets were analyzed for the presence of outliers. Although the coefficient of variance test exceeded 1.0 (i.e., 1.2 and 1.6 respectively), probability plots do not suggest that any of the sampled populations have material outliers. As a result, the entire data set was used to calculate the 95% UCL using the Student's T test method. Results of this analysis reveal a 95% UCL of **4,290 ug/kg** for arsenic and **125,000 ug/kg** for lead. These 95% UCLs are below applicable GRCC as well as commercial/industrial direct contact criteria.

RANGE & FREQUENCY ANALYSIS

A range and frequency analysis was performed to determine whether it can be concluded that the Study Area, considering all of the data collected, is a "facility" per Part 201 based on typical contaminant levels measured in the fill material. Table 3 provides a summary of the range of contaminant concentrations detected in the historic fill and the number of samples with exceedances of GRCC. Although highly varied, the range and frequency analysis reveals that concentrations of several metals, PAHs, and/or formaldehyde exceed the GRCC in 148 out of 169 soil samples (88%). In addition, manganese concentrations exceed GRCC in 10 out of 16 groundwater samples (63%).

Based on the frequency of exceedances, it appears appropriate to conclude that properties within the Study Area with historic fill meet the definition of a "facility" per Part 201.

Appendix D
Baseline Environmental
Assessment Information

**KNOWN CONTAMINATION INFORMATION FOR
BASELINE ENVIRONMENTAL ASSESSMENTS**

**AREA-WIDE ASSESSMENT OF HISTORIC FILL
MUSKEGON LAKE SHORELINE
MUSKEGON, MICHIGAN**

SEPTEMBER 2008

General Note: The information presented herein is intended to satisfy a portion of the "Known Contamination" section for Baseline Environmental Assessments (BEAs) conducted on individual properties within the Area-Wide Study Area with respect to the historic fill. To determine whether contaminants other than those associated with the historic fill may be present on an individual property, all parties preparing BEAs must conduct a Phase I Environmental Site Assessment in accordance with ASTM Standard E1527-05/AAI or equivalent alternative assessment (see 18 March 1999 MDEQ document entitled "Instructions for Preparing and Disclosing Baseline Environmental Assessments and Section 7a Compliance Analyses to the Michigan Department of Environmental Quality and for Requesting Optional Determinations" or subsequent updates to this document). Other requirements of the "Known Contamination" section including identification of abandoned aboveground or underground storage tanks, barrels, containers or other receptacles containing hazardous substances must be addressed through separate inquiry for each property as part of the BEA.

1.0 INTRODUCTION

In July 1995, the City of Muskegon received a grant from the Michigan Department of Environmental Quality's (MDEQ) Site Assessment Fund Grant Program (Grant No. 94-31) to undertake environmental assessment activities along the Muskegon Lake Shoreline to facilitate economic development. A portion of these funds was earmarked to pay for a study of the fill materials that were placed along the southern shoreline of Muskegon Lake from the 1800s through the mid-1900s. Previous studies in Muskegon and other communities have shown that historic fill materials often contain concentrations of heavy metals and other substances that exceed the MDEQ's generic residential cleanup criteria (GRCC) established under Part 201 of P.A. 451 of 1994, as amended, and the associated Administrative Rules ("Part 201"). A map depicting the boundary of the historic fill assessment (the "Study Area") is included in Appendix A. The Study Area extends from the west at McCracken Street (near the Grand Trunk Terminal Dock site) northeasterly for approximately 3 miles to the south branch of the Muskegon River.

The objectives of this assessment were to define the extent of historic fill in the Study Area, to determine the general nature of the fill material, determine the contaminant characteristics of the predominant types of fill, assess the potential risks to human health and the environment, and to evaluate appropriate

measures to manage these risks on an area-wide basis rather than on a site-by-site basis. A total of 169 soil and 16 groundwater samples representative of the historic fill were collected from the Study Area as part of this Area-Wide assessment and for other investigations of individual properties supported by the City's SAF grant. Sample locations are depicted on the figure included in Appendix A.

The historic fill encountered during the study generally consisted of industrial fill (containing dark-colored foundry sands, slag, core sands, coal, cinders, etc.) or construction fill (containing glass, concrete, wood, metal, etc.). In addition, the Study Area also included fill that appeared to be clean soil with no observation of industrial or construction fill. Native soils below the historic fill were generally indicated by orangish-brown sand or a peat layer (potentially indicative of former wetlands/surface waters). In some areas, wood debris associated with former lumbering activities was present between the industrial fill and native soils. The vertical extent of the historic fill is generally less than 15 feet below the ground surface.

The samples collected were analyzed for a number of hazardous substances typical of historic fill. These generally included various metals, polynuclear aromatic hydrocarbons (PAHs), cyanide, phenols, formaldehyde, and polychlorinated biphenyls. The November 2003 *Summary Report, Area-Wide Environmental Assessment Of Historic Fill, Muskegon Lake Shoreline Muskegon, Michigan* concluded that historic fill is located beneath the Study Area that contains contaminants above the MDEQ's generic residential cleanup criteria (GRCC). As a result, properties with historic fill in the Study Area are "facilities" as that term is defined under Part 201.

2.0 HAZARDOUS SUBSTANCES IDENTIFIED AND GENERAL LOCATIONS

A summary of laboratory analytical results from samples of the historic fill is provided in Table 1. The following contaminants were detected at concentrations that exceed Part 201 GRCC:

<u>Hazardous Substance</u>	<u>C.A.S.#</u>	<u>Hazardous Substance</u>	<u>C.A.S.#</u>
Arsenic	7440-38-2	Silver	7440-22-4
Cadmium	7440-43-9	Zinc	7440-66-6
Chromium (total)	7440-47-3	Acenaphthene	83-32-9
Copper	7440-50-8	Benzo(a)pyrene	50-32-8
Lead	7439-92-1	Dibenzo(a,h)anthracene	53-70-3
Manganese	7439-96-5	Fluoranthene	206-44-0
Mercury	7439-97-6	Naphthalene	91-20-3
Selenium	7782-49-2	Phenanthrene	85-01-8
		Formaldehyde	50-00-0

Groundwater samples collected during the course of the environmental assessment do not reveal any contaminants above the MDEQ's GRCC, except for manganese (see Table 2).

Although the maximum concentrations of several hazardous substances exceed the MDEQ's GRCC, the ranges of concentrations are highly varied. Therefore, a statistical analysis was performed on the historic fill sampling results. The objectives of the statistical analysis were to:

- Further evaluate whether the contaminants in the historic fill are present at concentrations sufficient to define properties that contain this material as "facilities"; and
- Determine an average/95% upper confidence limit (UCL) for several contaminants that exceed MDEQ GRCC for human-health related exposure pathways.

A statistical evaluation was performed to determine whether average/95% UCL concentrations could be established for the compounds listed below.

Arsenic
Lead

Manganese
Benzo(a)pyrene

Dibenzo(a,h)anthracene

Based on the statistical evaluation, average/95% UCL concentrations were able to be calculated only for arsenic and lead. The calculated average/95% UCL concentrations for these metals (see Table 3) are below the Part 201 GRCC.

A range and frequency analysis was performed on the contaminants present in historic fill (see Table 3). This analysis indicates that one or more contaminants exceed GRCC in approximately 88% of samples. These findings support the conclusion that properties containing historic fill in the Study Area are "facilities" per Part 201.

Appendix E

Due Care Information

- *Residential & Recreational Land Use*
- *Commercial & Industrial Land Use*

DUE CARE DOCUMENTATION
FOR
RESIDENTIAL AND RECREATIONAL LAND USE

AREA-WIDE ASSESSMENT OF HISTORIC FILL
MUSKEGON LAKE SHORELINE
MUSKEGON, MICHIGAN

SEPTEMBER 2008

1.0 INTRODUCTION

This Due Care Documentation was prepared for properties with residential and recreational land use that are located within the Muskegon Area-Wide Assessment of Historic Fill project (i.e., the “Study Area”). The Study Area includes a 3-mile section of the southern shoreline of Muskegon Lake (see Figures 1 and 2). This report can be used in conjunction with a site-specific due care evaluation to fulfill the requirements to maintain due care documentation per Rule 1003(5) of Part 201 of Michigan’s Natural Resources and Environmental Protection Act (PA 451 of 1994 as amended – “Part 201”).

This report has been prepared using a grant from the Michigan Department of Environmental Quality’s Site Assessment Fund (94-31) and was commissioned by the City of Muskegon in its efforts to facilitate economic development in the Study Area. The Area-Wide Assessment of Historic Fill was conducted between 1996 and 2001. Historic fill is generally defined as the material that was deposited between the late 1800s and 1950s to raise the elevation in the Study Area. The historic fill consists of construction debris, foundry sands, and other materials, and is generally contaminated with metals and polynuclear aromatic hydrocarbons (PAHs) at concentrations exceeding Part 201 generic residential cleanup criteria (GRCC). The historic fill is present at depths ranging from zero to 15 feet below grade.

The Area-Wide Assessment of Historic Fill only included characterization of historic fill material and groundwater from the same strata. As a result, this Due Care Documentation only identifies risk factors associated with contaminants in the historic fill. It does not address potential hazards that might be associated with contaminants from sources other than the historic fill (including sediments/dredge spoils previously placed along the shoreline).

A site-specific environmental site assessment (ESA) may be performed to determine whether there are, or are likely to be, other contaminants at individual

properties in the Study Area. Guidance for conducting a Phase I and II ESAs is established in the American Society of Testing and Materials (ASTM) Standard E1527-05 and E1903-97. These assessments may also be used to document that an individual property in the Study Area is not a “facility”.

2.0 HAZARDOUS SUBSTANCE INFORMATION

The historic fill encountered during the Area-Wide study generally consisted of industrial fill (containing dark-colored foundry sands, slag, core sands, coal, cinders, etc.) or construction fill (containing glass, concrete, wood, metal, etc.). In addition, the Study Area also included fill that appeared to be clean soil with no observation of industrial or construction fill. Native soils below the historic fill were generally indicated by orangish-brown sand or a peat layer (potentially indicative of former wetlands/surface waters). In some areas, wood debris associated with former lumbering activities was present between the industrial fill and native soils. The vertical extent of the historic fill is generally less than 15 feet below the ground surface.

The Area-Wide study and other MDEQ-funded investigations in the Study Area (i.e., at Site Assessment Fund properties) included the collection of nearly 170 samples of unsaturated historic fill and 16 samples of groundwater. The samples were analyzed for a number of hazardous substances typical of historic fill. These generally included various metals, PAHs, cyanide, phenols, formaldehyde, and polychlorinated biphenyls. Analytical results indicate a majority of the historic fill samples contain one or more of these hazardous substances at concentrations that exceed the MDEQ’s GRCC (see attached Tables 1 through 3). Hazardous substances present at concentrations exceeding GRCC include the following:

Arsenic	Mercury	Dibenzo(a,h)anthracene
Cadmium	Selenium	Fluoranthene
Chromium (total)	Silver	Naphthalene
Copper	Zinc	Phenanthrene
Lead	Acenaphthene	Formaldehyde
Manganese	Benzo(a)pyrene	

Groundwater samples collected during the Area-Wide Assessment of Historic Fill do not reveal any contaminants above the MDEQ’s GRCC, except for manganese, which was detected at concentrations exceeding the Part 201 generic residential drinking water cleanup criterion.

Although the maximum concentrations of several hazardous substances in the historic fill exceed the MDEQ’s GRCC, the ranges of concentrations are highly

varied. Therefore, a statistical evaluation of data was performed (i.e., calculation of “average” concentrations and conducting a range and frequency analysis).

A statistical evaluation was performed to determine whether average/95% UCL concentrations could be established for the compounds listed below.

Arsenic
Lead

Manganese
Benzo(a)pyrene

Dibenzo(a,h)anthracene

Based on the statistical evaluation, average/95% UCL concentrations were able to be calculated only for arsenic and lead. The calculated average/95% UCL concentrations for these metals (see Table 3) are below the Part 201 generic residential/recreational direct contact cleanup criteria.

The range and frequency analysis reveals that, although highly varied, concentrations of several metals, PAHs, and/or formaldehyde exceed the GRCC in 148 out of 169 soil samples (88%). In addition, manganese concentrations exceed GRCC in 10 out of 16 groundwater samples (63%).

Based on the frequency of GRCC exceedances in the historic fill, it appears appropriate to conclude that properties within the Study Area with historic fill meet the definition of a “facility” per Part 201. However, because historic fill is a variable substrate, individual parcels in the Study Area can be declassified as “facilities” if a demonstration is made that no historic fill is present, or that the historic fill on a specific property does not contain contaminants above MDEQ GRCC. The Part 201 “due care” requirements outlined herein may not apply if an individual parcel in the Study Area is determined not to be a “facility”.

3.0 APPLICABLE PROPERTY/LAND-USE

Although the Study Area is comprised of many different types of land-uses, this Due Care Documentation pertains only to residential and recreational uses, and certain commercial uses including the following:

- Single-family dwellings
- Condominiums and apartment buildings
- Day care centers
- Educational facilities
- Hospitals, elder care facilities, and nursing homes
- Recreational land-uses

Municipal water, sanitary sewer, storm sewer, natural gas, telephone, and electricity are available to properties within the Study Area. Although many properties contain surface barriers overlying historic fill, not all properties in the Study Area maintain these features.

4.0 EXPOSURE PATHWAY EVALUATION

Based on the anticipated land uses described above, the following exposure pathways are foreseeable in connection with historic fill in the Study Area:

- Direct contact with historic fill
- Contact with groundwater impacted by historic fill
- Inhalation of vapors emitted into indoor air
- Inhalation of vapors emitted into ambient air
- Inhalation of soil particulates
- Acute construction/utility worker inhalation of vapors emitted into enclosed spaces

It is presumed that groundwater is not used as a drinking water source in the Study Area; therefore, the drinking water pathway is not applicable. Use of groundwater as a drinking water source may be unsafe. The contaminants of concern in the historic fill do not pose any combustion or explosion hazards. It should be noted that only limited groundwater sampling was performed in the Study Area (16 locations along an approximately 3-mile area); thus, the potential for other/unknown contamination should be considered if activities are performed that may result in groundwater contact or pumping.

Potential exposure hazards posed by contaminants associated with historic fill are described below.

5.0 CONCLUSIONS

Based on a comparison of contaminant levels documented in historic fill to applicable GRCC, potential exposure hazards could occur through direct contact with historic fill and groundwater-surface water interface exposures. Accordingly, the following response activities/precautions should be implemented to comply with Part 201 due care requirements. These conclusions do not apply to the following sites: Terrace Point property (potential indoor air inhalation concerns related to formaldehyde), West Michigan Steel (potential

particulate ambient air inhalation hazards associated with manganese), or in the vicinity of the Muskegon Boiler Works and Fisher Padnos sites (potential direct contact exceedances).

1. **Direct Contact:** The sampling data indicate sporadic exceedances of the residential/recreational direct contact criterion for benzo(a)pyrene throughout the study area. Although not conclusive, the data suggest the *potential for* direct contact hazards. This finding is more prevalent to the northeast of the West Michigan Steel site. Therefore, unless a site specific evaluation is conducted to rule out the direct contact pathway, it may be appropriate to take precautions to protect against direct contact exposures. Potential direct contact hazards associated with the historic fill can be mitigated by creating or maintaining an exposure barrier over historic fill. The exposure barrier could consist of pavement, building floors, and/or clean fill (e.g., sand, topsoil, or gravel). A site specific evaluation should be performed to determine an appropriate exposure barrier type and thickness considering the future land use. Existing pavement, buildings, and/or clean soil may already be present over the historic fill to serve as an exposure barrier. Intermittent disruption of the exposure barrier for the purposes of short-term sub-grade construction activities is acceptable as long as the barrier is re-established upon completion of construction activities.

324.20107a(1)(b)
R.1013(1)(a)

2. **Construction/Utility Workers:** Although contaminant levels in historic fill do not indicate any construction/utility worker exposure hazards, as a precaution, workers should take measures to minimize soil-skin contact. This could include wearing gloves, boots, and long-sleeve pants/shirts. Smoking/eating should be avoided in work areas with exposed fill. Contractors should also take measures to minimize off-site tracking of historic fill on trucks/excavation equipment (e.g., brush-off excess soils, rinse equipment/tires, install gravel pad to allow release of soil on tires, etc.).

324.20107a(1)(c)

3. **Exacerbation:** Undertake measures to prevent exacerbation of the existing contamination, such as preventing spreading/relocating historic fill on-site or transporting historic fill to another property if not performed in

324.20107a(1)(a)
R.1007

accordance with Section 7a(1)(a) of Part 201 and Rule 1007. Historic fill removed from a property may require characterization and landfill disposal. Any soil relocation activities should include an evaluation of compliance with Part 201, including the notification requirements of Section 20120c.

4. **Third Party Precautions:** Take reasonable precautions against the reasonably foreseeable acts or omissions of a third party and the consequences that foreseeably could result from those acts or omissions. Examples include providing notice, as needed, to third parties whose actions involve excavation or grading of historic fill (i.e., construction and utility contractors) to comply with items #1 through #3 above. This notice can be made by providing the *Environmental Information Sheet* to third parties involved in activities described herein (attached). 324.20107a(1)(c)
5. **Record Keeping:** Maintain records of compliance with measures #1 through #4 above. R.1003(5)(a)(iv)

A site specific evaluation is needed to determine whether impacts are present related to sediments and/or dredge spoils. The Area-Wide study included only limited sampling for PCBs, and this sampling may be insufficient to properly evaluate potential PCB due care obligations.

It should be noted that subsequent to the investigation documented herein, MDEQ established a new methodology for lead analysis that involves determining fine and coarse fractions if the total lead concentration exceeds 75 mg/kg. Additional sampling for fine/coarse fractions would be needed to more conclusively determine potential lead exposure hazards. The precautions described herein for mitigating potential PAH direct contact exposures would also mitigate potential lead exposure hazards.

Notices pursuant to Rules 1013(6), 1015, and 1017 do not appear to be required for contaminants related to the historic fill for the following reasons:

- **R1013(6):** Contaminant levels documented in historic fill do not indicate exposure hazards to utility workers or other persons conducting activities in an easement, utility franchise, or pursuant to mineral rights (based on a comparison of results to Part 201 GRCC applicable to utility worker exposures, which includes groundwater contact criteria, flammability/explosivity screening levels, and acute inhalation screening levels). As a

screen to evaluate potential utility worker soil direct contact hazards, results were also compared to Part 201 industrial direct contact cleanup criteria. The industrial cleanup criteria are based on a long-term [21-year] exposure duration, and may be conservative in evaluating short-term utility worker exposures. Although metal concentrations at several individual sampling locations exceed the generic industrial direct contact criteria, the average/95% UCL concentrations are below industrial direct contact criteria. Therefore, it does not appear that historic fill poses a utility/construction worker direct contact hazard.

- **Rule 1015:** Although discarded or abandoned containers may be present on individual properties that will require notice pursuant to R.1015, they are not known to be a component of the area-wide historic fill.
- **Rule 1017:** A Rule 1017 Notice of Migration of Contamination may be required for some properties in the Study area based on the potential for manganese to migrate off-site/to adjacent surface waters (i.e., Muskegon Lake, Ryerson Creek, Ruddiman Creek) at concentrations exceeding Part 201 GRCC. It is recommended that a site-specific evaluation be performed to determine potential Rule 1017 notification requirements.

Because historic fill is a variable substrate, individual parcels in the Study Area can be declassified as “facilities” if the fill on their specific property does not contain contaminants above MDEQ GRCC. “Facility” declassification can be determined by either demonstrating there is no historic fill or that contaminants in the fill do not exceed MDEQ GRCC at a specific parcel in the Study Area. If an individual parcel in the Study Area is determined not to be a “facility”, this Due Care Documentation and the requirements outlined in it may not be applicable to that property.

Attachments

- Figures 1 – 2
- Tables 1 – 3
- *Environmental Information Sheet for Residential and Recreational Land Use*

ENVIRONMENTAL INFORMATION SHEET
FOR
RESIDENTIAL AND RECREATIONAL LAND USE

AREA-WIDE ASSESSMENT OF HISTORIC FILL
MUSKEGON LAKE SHORELINE
MUSKEGON, MICHIGAN

SEPTEMBER 2008

Environmental assessments conducted through the Muskegon Area-Wide Assessment of Historic Fill project have documented the presence of historic fill along a 3-mile section of the southern shoreline of Muskegon Lake. These assessments have also determined that the historic fill contains a number of contaminants at concentrations that exceed Michigan Department of Environmental Quality (MDEQ) generic residential cleanup criteria, and those properties containing historic fill are “facilities” as defined by Part 201 of the Michigan Natural Resources and Environmental Protection Act (PA 451 of 1994 as amended). As a result of this conclusion, certain precautions with respect to the historic fill should be undertaken at residential and recreational properties within the Study Area.

Historic fill is generally defined as the material that was deposited between the late 1800s and 1950s to raise the elevation in the Study Area. The historic fill encountered during the study generally consisted of industrial fill (containing dark-colored foundry sands, slag, core sands, coal, cinders, etc.) or construction fill (containing glass, concrete, wood, metal, etc.). In addition, the Study Area also included fill that appeared to be clean soil with no observation of industrial or construction fill. Native soils below the historic fill were generally indicated by orangish-brown sand or a peat layer (potentially indicative of former wetlands/surface waters). In some areas, wood debris associated with former lumbering activities was present between the industrial fill and native soils. The vertical extent of the historic fill is generally less than 15 feet below the ground surface.

A summary of precautions to be taken to mitigate potentially unacceptable exposures to historic fill on the subject property is provided below. These precautions apply only to residential/recreational exposures and temporary construction/utility workers. These precautions relate only to known contamination associated with the historic fill, and do not address any site-specific contamination present in addition to the historic fill. A site-specific evaluation of due care obligations is warranted if knowledge exists of other contamination issues on the subject property.

1. **Direct Contact:** Potential hazards posed by direct contact with historic fill can be mitigated by creating or maintaining an exposure barrier over historic fill. The exposure barrier could consist of pavement, building floors, and/or clean fill (e.g., sand, topsoil, or gravel). A site specific evaluation should be performed to determine an appropriate exposure barrier type and thickness considering the future land use. Existing pavement, buildings, and/or clean soil may already be present over the historic fill to serve as an exposure barrier. Intermittent disruption of the exposure barrier for the purposes of short-term, sub-grade construction activities is acceptable as long as the barrier is re-established upon completion of construction activities.
2. **Construction/Utility Workers:** Although contaminant levels in historic fill do not indicate any construction/utility worker exposure hazards, as a precaution, workers should take measures to minimize soil-skin contact. This could include wearing gloves, boots, and long-sleeve pants/shirts. Smoking/eating should be avoided in work areas with exposed fill. Contractors should also take measures to minimize off-site tracking of historic fill on trucks/excavation equipment (e.g., brush-off excess soils, rinse equipment/tires, install gravel pad to allow release of soil on tires, etc.). As a general precaution, dust control measures should be taken at all sites; however, this task is of increased importance at the West Michigan Steel property due to elevated manganese concentrations.
3. **Exacerbation:** Undertake measures to prevent exacerbation of the existing contamination, such as preventing spreading/relocating historic fill on-site or transporting historic fill to another property. Historic fill removed from the subject property may require characterization and landfill disposal. Any soil relocation activities should include an evaluation of compliance with Part 201, including the notification requirements of Section 20120c.
4. **Surface Water Hazards:** Undertake measures to mitigate off-property risks resulting from erosion of historic fill at the subject property into surface water and storm sewers.
5. **Drinking Water Hazards:** Groundwater in the Study Area may be unsafe for use as a drinking water source; therefore, groundwater should not be used for potable purposes.

This Environmental Information Sheet was prepared as part of the Due Care Documentation for residential and recreational properties in the Muskegon Area-Wide Assessment of Historic Fill project. Additional information regarding Due Care and historic fill is available by contacting:

Michigan Dept. of Environmental Quality Grand Rapids District Office State Office Bldg. -- 350 Ottawa NW, Unit 10 Grand Rapids, MI 49503-2341 phone: (616) 356-0500 fax: (616) 356-0202	City of Muskegon 933 Terrace Street Muskegon, MI 49443 phone: (231) 724-6702 www.muskegon-mi.gov
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DUE CARE DOCUMENTATION
FOR
COMMERCIAL AND INDUSTRIAL LAND USE

AREA-WIDE ASSESSMENT OF HISTORIC FILL
MUSKEGON LAKE SHORELINE
MUSKEGON, MICHIGAN

SEPTEMBER 2008

1.0 INTRODUCTION

This Due Care Documentation was prepared for properties with commercial and industrial land use that are located within the Muskegon Area-Wide Assessment of Historic Fill project (i.e., the “Study Area”). The Study Area includes a 3-mile section of the southern shoreline of Muskegon Lake (see Figures 1 and 2). This report can be used in conjunction with a site-specific due care evaluation to fulfill the requirements to maintain due care documentation per Rule 1003(5) of Part 201 of Michigan’s Natural Resources and Environmental Protection Act (PA 451 of 1994 as amended – “Part 201”).

This report has been prepared using a grant from the Michigan Department of Environmental Quality’s Site Assessment Fund (94-31) and was commissioned by the City of Muskegon in its efforts to facilitate economic development in the Study Area. The Area-Wide Assessment of Historic Fill was conducted between 1996 and 2001. Historic fill is generally defined as the material that was deposited between the late 1800s and 1950s to raise the elevation in the Study Area. The historic fill consists of construction debris, foundry sands, and other materials, and is generally contaminated with metals and polynuclear aromatic hydrocarbons (PAHs) at concentrations exceeding Part 201 generic residential cleanup criteria (GRCC). The historic fill is present at depths ranging from zero to 15 feet below grade.

The Area-Wide Assessment of Historic Fill only included characterization of historic fill material and groundwater from the same strata. As a result, this Due Care Documentation only identifies risk factors associated with contaminants in the historic fill. It does not address potential hazards that might be associated with contaminants from sources other than the historic fill (including sediments/dredge spoils previously placed along the shoreline).

A site-specific environmental site assessment (ESA) may be performed to determine whether there are, or are likely to be, other contaminants at individual

properties in the Study Area. Guidance for conducting a Phase I and II ESAs is established in the American Society of Testing and Materials (ASTM) Standard E1527-05 and E1903-97. These assessments may also be used to document that an individual property in the Study Area is not a “facility”.

2.0 HAZARDOUS SUBSTANCE INFORMATION

The historic fill encountered during the Area-Wide study generally consisted of industrial fill (containing dark-colored foundry sands, slag, core sands, coal, cinders, etc.) or construction fill (containing glass, concrete, wood, metal, etc.). In addition, the Study Area also included fill that appeared to be clean soil with no observation of industrial or construction fill. Native soils below the historic fill were generally indicated by orangish-brown sand or a peat layer (potentially indicative of former wetlands/surface waters). In some areas, wood debris associated with former lumbering activities was present between the industrial fill and native soils. The vertical extent of the historic fill is generally less than 15 feet below the ground surface.

The Area-Wide study and other MDEQ-funded investigations in the Study Area (i.e., at Site Assessment Fund properties) included the collection of nearly 170 samples of unsaturated historic fill and 16 samples of groundwater. The samples were analyzed for a number of hazardous substances typical of historic fill. These generally included various metals, PAHs, cyanide, phenols, formaldehyde, and polychlorinated biphenyls. Analytical results indicate a majority of the historic fill samples contain one or more of these hazardous substances at concentrations that exceed the MDEQ’s GRCC (see attached Tables 1 through 3). Hazardous substances present at concentrations exceeding GRCC include the following:

Arsenic	Mercury	Dibenzo(a,h)anthracene
Cadmium	Selenium	Fluoranthene
Chromium (total)	Silver	Naphthalene
Copper	Zinc	Phenanthrene
Lead	Acenaphthene	Formaldehyde
Manganese	Benzo(a)pyrene	

Groundwater samples collected during the Area-Wide Assessment of Historic Fill do not reveal any contaminants above the MDEQ’s GRCC, except for manganese, which was detected at concentrations exceeding the Part 201 generic residential drinking water cleanup criterion.

In addition to the exceedances of GRCC, the maximum concentrations of several hazardous substances in the historic fill exceed the MDEQ's generic industrial cleanup criteria. In order to evaluate whether these exceedances pose an industrial direct contact exposure hazard, a statistical evaluation of data was performed (i.e., calculation of "average" concentrations). A range and frequency analysis were also performed to evaluate whether the presence of historic fill justifies classification of a property as a "facility" per Part 201.

A statistical evaluation was performed to determine whether average/95% UCL concentrations could be established for the compounds listed below.

Arsenic
Lead

Manganese
Benzo(a)pyrene

Dibenzo(a,h)anthracene

Based on the statistical evaluation, average/95% UCL concentrations were able to be calculated only for arsenic and lead. The calculated average/95% UCL concentrations for these metals (see Table 3) are below the Part 201 generic commercial/industrial direct contact cleanup criteria.

The range and frequency analysis reveals that, although highly varied, concentrations of several metals, PAHs, and/or formaldehyde exceed the GRCC in 148 out of 169 soil samples (88%).

Based on the frequency of GRCC exceedances in the historic fill, it appears appropriate to conclude that properties within the Study Area with historic fill meet the definition of a "facility" per Part 201. However, because historic fill is a variable substrate, individual parcels in the Study Area can be declassified as "facilities" if a demonstration is made that no historic fill is present, or that the historic fill on a specific property does not contain contaminants above MDEQ GRCC. The Part 201 "due care" requirements outlined herein may not apply if an individual parcel in the Study Area is determined not to be a "facility".

3.0 APPLICABLE PROPERTY/LAND-USE

Although the Study Area is comprised of many different types of land-uses, this Due Care documentation pertains only to commercial and industrial uses. These are properties where the primary activities are commercial or industrial and are zoned accordingly. Fencing, security personnel, or both must reliably restrict access to these types of properties. Specific examples of this type of land-use include the following:

- Manufacturing facilities
- Utilities
- Research and development facilities
- Bulk petroleum storage facilities
- Inactive or abandoned properties
- Warehouses
- Lumber Yards
- Retail gas and auto service stations and dealerships
- Retail businesses whose primary activities are conducted indoors
- Professional offices
- Banks
- Public office buildings
- Health clubs
- Barber/beauty salons
- Mortuaries
- Studios

Municipal water, sanitary sewer, storm sewer, natural gas, telephone, and electricity are available to properties within the Study Area.

4.0 EXPOSURE PATHWAY EVALUATION

Based on the anticipated land uses described above, the following exposure pathways are foreseeable in connection with historic fill in the Study Area:

- Direct contact with historic fill
- Contact with groundwater impacted by historic fill
- Inhalation of vapors emitted into indoor air
- Inhalation of vapors emitted into ambient air
- Inhalation of soil particulates
- Acute construction/utility worker inhalation of vapors emitted into enclosed spaces

It is presumed that groundwater is not used as a drinking water source in the Study Area; therefore, the drinking water pathway is not applicable. Use of groundwater as a drinking water source may be unsafe. The contaminants of concern in the historic fill do not pose any combustion or explosion hazards. It should be noted that only limited groundwater sampling was performed in the Study Area (16 locations along an approximately 3-mile area); thus, the potential for other/unknown contamination should be considered if activities are performed that may result in groundwater contact or pumping.

Potential exposure hazards posed by contaminants associated with historic fill are described below.

5.0 CONCLUSIONS

Based on a comparison of contaminant levels documented in historic fill to applicable generic industrial cleanup criteria, potential exposure hazards could occur through construction/utility work and groundwater-surface water interface exposures. Accordingly, the following response activities/precautions should be implemented to comply with Part 201 due care requirements. These conclusions do not apply to the West Michigan Steel site (potential particulate ambient air inhalation hazards associated with manganese), or in the vicinity of the Muskegon Boiler Works site (potential commercial/industrial PAH direct contact exceedances).

1. **Construction/Utility Workers:** Although contaminant levels in historic fill do not indicate any construction/utility worker exposure hazards, as a precaution, workers should take measures to minimize soil-skin contact. This could include wearing gloves, boots, and long-sleeve pants/shirts. Smoking/eating should be avoided in work areas with exposed fill. Contractors should also take measures to minimize off-site tracking of historic fill on trucks/excavation equipment (e.g., brush-off excess soils, rinse equipment/tires, install gravel pad to allow release of soil on tires, etc.). 324.20107a(1)(c)
2. **Exacerbation:** Undertake measures to prevent exacerbation of the existing contamination, such as preventing spreading/relocating historic fill on-site or transporting historic fill to another property if not performed in accordance with Section 7a(1)(a) of Part 201 and Rule 1007. Historic fill removed from a property may require characterization and landfill disposal. Any soil relocation activities should include an evaluation of compliance with Part 201, including the notification requirements of Section 20120c. 324.20107a(1)(a)
R.1007
3. **Third Party Precautions:** Take reasonable precautions against the reasonably foreseeable acts or omissions of a third party and the consequences that foreseeably could result from those acts or omissions. Examples include providing notice, as needed, to third parties whose actions involve excavation or grading of historic fill (i.e., construction and utility contractors) to comply with items #1 through #3 above. This notice can be made by providing 324.20107a(1)(c)

the *Environmental Information Sheet* to third parties involved in activities described herein (attached).

4. **Record Keeping:** Maintain records of compliance with measures #1 through #4 above. R.1003(5)(a)(iv)

A site specific evaluation is needed to determine whether impacts are present related to sediments and/or dredge spoils. The Area-Wide study included only limited sampling for PCBs, and this sampling may be insufficient to properly evaluate potential PCB due care obligations.

It should be noted that subsequent to the investigation documented herein, MDEQ established a new methodology for lead analysis that involves determining fine and coarse fractions if the total lead concentration exceeds 75 mg/kg. Additional sampling for fine/coarse fractions would be needed to more conclusively determine potential lead exposure hazards.

Notices pursuant to Rules 1013(6), 1015, and 1017 do not appear to be required for contaminants related to the historic fill for the following reasons:

- **Rule 1013(6):** Contaminant levels documented in historic fill do not indicate exposure hazards to utility workers or other persons conducting activities in an easement, utility franchise, or pursuant to mineral rights (based on a comparison of results to Part 201 GRCC applicable to utility worker exposures, which includes groundwater contact criteria, flammability/explosivity screening levels, and acute inhalation screening levels). As a screen to evaluate potential utility worker soil direct contact hazards, results were also compared to Part 201 industrial direct contact cleanup criteria. The industrial cleanup criteria are based on a long-term [21-year] exposure duration, and may be conservative in evaluating short-term utility worker exposures. Although metal concentrations at several individual sampling locations exceed the generic industrial direct contact criteria, the average/95% UCL concentrations are below industrial direct contact criteria. Therefore, it does not appear that historic fill poses a utility/construction worker direct contact hazard.
- **Rule 1015:** Although discarded or abandoned containers may be present on individual properties that will require notice pursuant to Rule 1015, they are not known to be a component of the area-wide historic fill.
- **Rule 1017:** A Rule 1017 Notice of Migration of Contamination may be required for some properties in the Study area based on the potential for manganese to migrate off-site/to adjacent surface waters (i.e., Muskegon

Lake, Ryerson Creek, Ruddiman Creek) at concentrations exceeding Part 201 GRCC. It is recommended that a site-specific evaluation be performed to determine potential Rule 1017 notification requirements.

Because historic fill is a variable substrate, individual parcels in the Study Area can be declassified as “facilities” if the fill on their specific property does not contain contaminants above MDEQ GRCC. “Facility” declassification can be determined by either demonstrating there is no historic fill or that contaminants in the fill do not exceed MDEQ GRCC at a specific parcel in the Study Area. If an individual parcel in the Study Area is determined not to be a “facility”, this Due Care Documentation and the requirements outlined in it may not be applicable to that property.

Attachments

- Figures 1 – 2
- Tables 1 – 3
- *Environmental Information Sheet for Commercial and Industrial Land Use*

ENVIRONMENTAL INFORMATION SHEET
FOR
COMMERCIAL & INDUSTRIAL LAND USE

AREA-WIDE ASSESSMENT OF HISTORIC FILL
MUSKEGON LAKE SHORELINE
MUSKEGON, MICHIGAN

SEPTEMBER 2008

Environmental assessments conducted through the Muskegon Area-Wide Assessment of Historic Fill project have documented the presence of historic fill along a 3-mile section of the southern shoreline of Muskegon Lake. These assessments have also determined that the historic fill contains a number of contaminants at concentrations that exceed Michigan Department of Environmental Quality (MDEQ) generic residential cleanup criteria, and those properties containing historic fill are “facilities” as defined by Part 201 of the Michigan Natural Resources and Environmental Protection Act (PA 451 of 1994 as amended). As a result of this conclusion, certain precautions with respect to the historic fill should be undertaken at commercial and industrial properties within the Study Area.

Historic fill is generally defined as the material that was deposited between the late 1800s and 1950s to raise the elevation in the Study Area. The historic fill encountered during the study generally consisted of industrial fill (containing dark-colored foundry sands, slag, core sands, coal, cinders, etc.) or construction fill (containing glass, concrete, wood, metal, etc.). In addition, the Study Area also included fill that appeared to be clean soil with no observation of industrial or construction fill. Native soils below the historic fill were generally indicated by orangish-brown sand or a peat layer (potentially indicative of former wetlands/surface waters). In some areas, wood debris associated with former lumbering activities was present between the industrial fill and native soils. The vertical extent of the historic fill is generally less than 15 feet below the ground surface.

A summary of precautions to be taken to mitigate potentially unacceptable exposures to historic fill on the subject property is provided below. These precautions apply only to commercial/industrial exposures and temporary construction/utility workers. These precautions relate only to known contamination associated with the historic fill, and do not address any site-specific contamination present in addition to the historic fill. A site-specific evaluation of due care obligations is warranted if knowledge exists of other contamination issues on the subject property.

1. **Direct Contact:** Although industrial direct contact criteria are exceeded at several individual sampling locations, average concentrations of lead and arsenic concentrations in historic fill are below direct contact cleanup criteria. Therefore, contaminants in historic fill do not pose any known commercial/industrial direct contact hazards. This conclusion does not apply in the vicinity of the Muskegon Boiler Works site where additional investigation may be needed to evaluate whether PAHs (primarily benzo(a)pyrene) pose a commercial/industrial direct contact hazard.
2. **Construction/Utility Workers:** Although contaminant levels in historic fill do not indicate any construction/utility worker exposure hazards, as a precaution, workers should take measures to minimize soil-skin contact. This could include wearing gloves, boots, and long-sleeve pants/shirts. Smoking/eating should be avoided in work areas with exposed fill. Contractors should also take measures to minimize off-site tracking of historic fill on trucks/excavation equipment (e.g., brush-off excess soils, rinse equipment/tires, install gravel pad to allow release of soil on tires, etc.). As a general precaution, dust control measures should be taken at all sites; however, this task is of increased importance at the West Michigan Steel property due to elevated manganese concentrations.
3. **Exacerbation:** Undertake measures to prevent exacerbation of the existing contamination, such as preventing spreading/relocating historic fill on-site or transporting historic fill to another property. Historic fill removed from the subject property may require characterization and landfill disposal. Any soil relocation activities should include an evaluation of compliance with Part 201, including the notification requirements of Section 20120c.
4. **Surface Water Hazards:** Undertake measures to mitigate off-property risks resulting from erosion of historic fill at the subject property into surface water and storm sewers.
5. **Drinking Water Hazards:** Groundwater in the Study Area may be unsafe for use as a drinking water source; therefore, groundwater should not be used for potable purposes.

This Environmental Information Sheet was prepared as part of the Due Care Documentation for commercial and industrial properties in the Muskegon Area-Wide Assessment of Historic Fill project. Additional information regarding Due Care and historic fill is available by contacting:

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