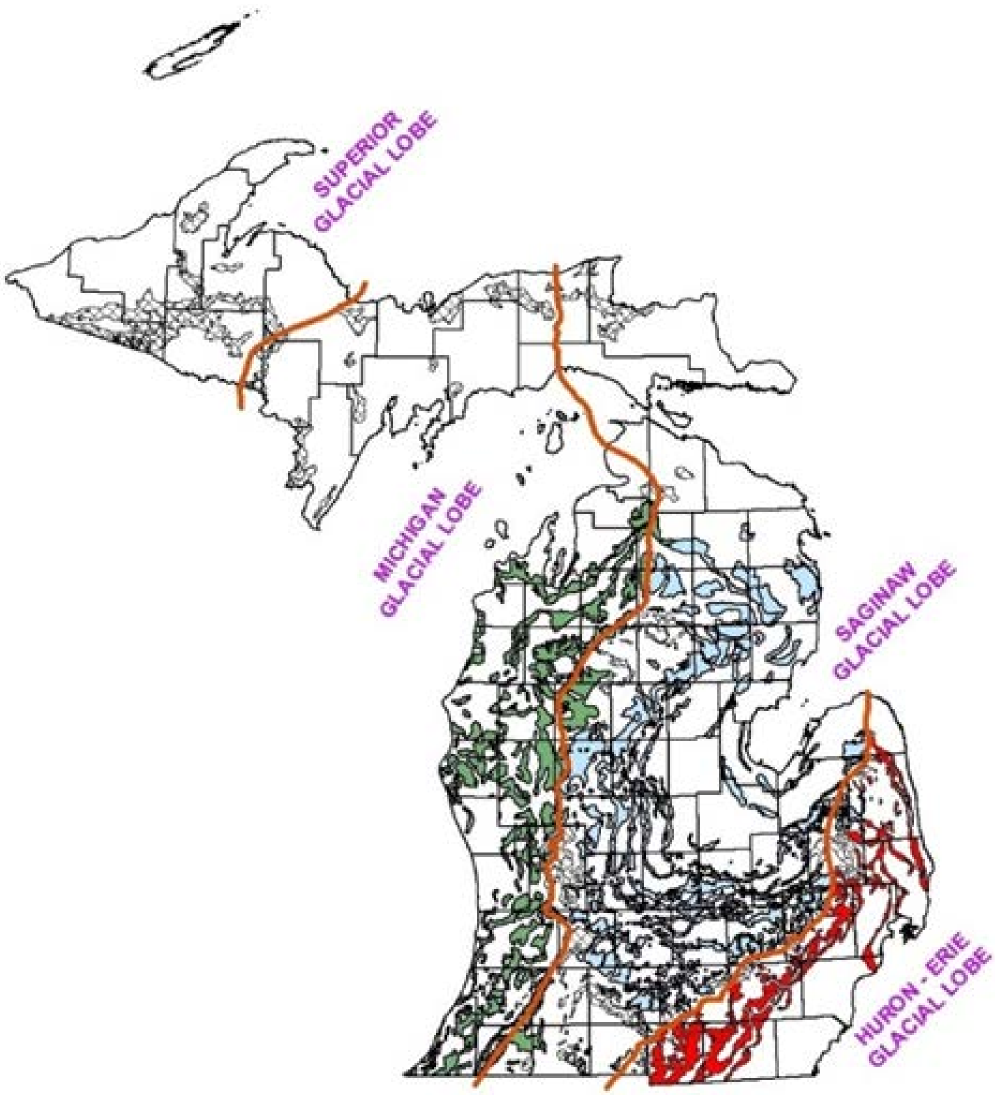
REMEDIATION AND REDEVELOPMENT DIVISION

SOIL BACKGROUND and USE OF THE 2005 MICHIGAN BACKGROUND SOIL SURVEY

RESOURCE MATERIALS



Prepared by:

Michigan Department of Environment, Great Lakes, and Energy
Remediation and Redevelopment Division
525 West Allegan Street
Lansing, Michigan 48933
September 2019
Revised January 2023

REMEDIATION AND REDEVELOPMENT DIVISION

In order to promote a consistent and informed approach for Michigan Department of Environment, Great Lakes, and Energy (EGLE) staff, this document was developed to provide information to EGLE staff and contractors on methodology and applications for the determination of background concentrations of metals in soil.

This document is available as a technical reference to assist any party interested in the determination of background concentrations of metals in the soil at a site to evaluate if response actions are warranted or if the metals can be attributed to naturally occurring sources.

This document is explanatory and does not contain any regulatory requirements. It does not establish or affect the legal rights or obligations for the determination of background concentrations of metals in the soil. It does not have the force or effect of law and is not legally binding on the public or the regulated community. Any regulatory decisions made by EGLE regarding background concentrations of metals in the soil will be made by applying the governing statutes and administrative rules to relevant facts.

Approved: Kathleen Shirey

Kathleen Shirey, Acting Division Director
Remediation and Redevelopment Division
October 4, 2019

TABLE OF CONTENTS **page no.**

PURPOSE

The primary goal of Michigan's cleanup programs is to protect human health and the environment from current and potential threats posed by uncontrolled releases of hazardous substances (contamination). Contamination at a site[1] may originate from releases attributable to the site in question, as well as contamination that originated from other sources, including natural sources not attributable to the specific site releases under investigation. In some cases, the same hazardous substance associated with a release is also a background constituent.

If contaminants at a site are the result of a release and exceed generic cleanup criteria, remediation or due care obligations are typically required. If the contaminant is present due to natural conditions, cleanup or due care obligations are not required under Michigan's cleanup statutes, even if the concentrations exceed the risk-based generic cleanup criteria. Consequently, it may be important in the management of a site to determine whether or not the presence of a contaminant represents natural background conditions.

Background has been defined for the Michigan cleanup programs since 1990 as the concentration or level of a hazardous substance which exists in the environment at or regionally proximate to a site that is not attributable to any release at or regionally proximate to the site. The options available to demonstrate that a hazardous substance is not present at a level that exceeds soil background concentration are included with the statutory definition of background[2].

An evaluation of local background soil concentrations may be appropriate at a site whenever it is suspected that metal contaminants detected above applicable cleanup criteria may be equal to, or less than, natural background soil concentrations. Consistent with statutory and rule provisions, when the background concentration for a hazardous substance is greater than the calculated generic cleanup criteria, the criterion is the background concentration[3].

The purpose of this document is to describe the applicability of the 2005 Michigan Background Soil Survey (MBSS) in the demonstration of naturally occurring background metals concentrations for a property. In addition, the 2015 update to the MBSS is included as an appendix to this document and may be used consistent with the provisions for the 2005 MBSS.

Some contaminants, both manmade and natural, are ubiquitous in the environment due to human activities. Examples include polycyclic aromatic hydrocarbons (PAHs), lead, and dioxins. Low levels that exist in the environment due to human activities not associated with any specific release are termed anthropogenic background. Michigan statutes and rules do not recognize comparisons with anthropogenic background concentrations as a basis for determining a cleanup criterion in place of a generic criterion. However, when delineating the boundaries of contamination attributable to a release, anthropogenic background concentrations may be useful. They may be used to help establish the area where liability for cleanup may exist by defining where the chemical concentrations from the release become indistinguishable from concentrations present from other, non-specific sources. Developing background concentrations is also useful in this context (i.e., establishing the nature and extent of the release), despite the somewhat different objective from concentration comparisons with natural background. Developing anthropogenic background concentrations, if useful in this context should be discussed with project managers to ensure its acceptability for site delineation.

[1] For the purpose of this document, the term "site" is being used as a general reference to a property with environmental contamination and is not intended to be applied as it is statutorily defined in the Natural Resources and Environmental Protection Act (NREPA), PA 451 of 1994, as amended.

[2] Sec. 20101(1)(e)

[3] Sec. 20120a(10); Part 201 Administrative Rules, Cleanup Criteria Requirements for Response Activity, Michigan Administrative Code, 2013 AACS R 299.1 – R 299.50

1.0 INTRODUCTION

In Michigan, metals are commonly detected in soil at sites of contamination. However, the detection of metals in the soil does not necessarily indicate that the metals were released from man-made sources. The presence of metals in Michigan's soil may be naturally occurring as a result of Michigan's unique geology and glacial history.

The 2005 *Michigan Background Soil Survey (2005 MBSS)* is one resource to determine background concentrations for naturally occurring metals. Part 201, Environmental Remediation, of Natural Resources and Environmental Protection Act, 1994 PA 451, was amended in 2015 to include methods to establish background concentrations using the 2005 MBSS. The data provided in the 2005 MBSS is a compilation of soil sampling data from regulated facilities and samples collected and analyzed by the state incorporated into a soil background database. Additional data from the United States Geological Survey (USGS) and the United States Army Corps of Engineers (USACE) is also included in the 2005 MBSS. In 2014, additional soil sampling data from locations that represent background conditions were collected from files of the EGLE Remediation and Redevelopment Division (RRD), and the 2005 MBSS was updated in 2015 by the department. The use of the methods for the 2005 MBSS[4] are appropriate for the 2015 update of the MBSS.

Michigan's unique geology and glacial history has resulted in the deposition of many naturally occurring metals in soils. The ice moving across Michigan followed four individual flow paths, called glacial lobes. Because these glacial lobes have varying points of origin and traverse different types of bedrock, the resulting glacial sediments have varying chemical characteristics based on source rock influences.

The soil metals concentrations presented in the 2005 MBSS were compiled from limited locations across the state and a number of geographic areas did not have background soil information. Due to the variability in the concerns at each of the locations where the soil background samples were collected, different suites of metals were analyzed, and a uniform set of analytical data for each hazardous substance listed is not available.

2.0 USE OF THE 2005 MICHIGAN BACKGROUND SOIL SURVEY

The *2005 MBSS* includes the 25 metals listed below for which there are published typical background ranges.

Aluminum	Cadmium	Lead	Molybdenum	Strontium
Antimony	Chromium	Lithium	Nickel	Thallium
Arsenic	Cobalt	Magnesium	Selenium	Titanium
Barium	Copper	Manganese	Silver	Vanadium
Beryllium	Iron	Mercury	Sodium	Zinc

Statistical analyses of the sample data for each of the compounds listed, where available, was completed with subcategories for topsoil, sand, and clay and defined by Michigan's four glacial lobe areas.

A description of the methods to establish a metal background concentration utilizing the 2005 MBSS is located within the background definition[5]. In Appendix A of this document is a flowchart that outlines the methods for utilizing the 2005 MBSS, or the 2015 update, pursuant to this provision. The *2005*

[4] Sec. 20101(1)(e)(ii)
[5] Sec. 20101(1)(e)(ii)

MBSS, or the 2015 update, may be used to determine background concentrations where there is sufficient information that meets all of the following conditions:

- **Same Glacial Lobe** – Source rock composition is critical in determining the makeup of the glacial drift from which it has originated. The 2005 MBSS identifies four different glacial lobes, Huron-Erie, Saginaw, Michigan, and Superior, with source rock variations that influence the concentrations of metals present in the deposited drift materials. The survey identifies the variations in metals concentrations based upon glacial lobes and depicts the geographic areas affected by each lobe. Background soil evaluation data comparisons should be consistent with the glacial lobe for the geographic area for which the demonstration is being made.

- **Similar Soil Type –** Soil type influences the concentrations of metals present. For simplicity's sake, the 2005 MBSS categorizes soils into three broad types: sand, clay, and topsoil. Sandy soils typically have lower metals concentrations, while clays tend to have higher naturally occurring concentrations of metals. Topsoil can vary depending on the composition of the soil horizons below this layer. When performing a background demonstration, the values published for similar soils should be used.

- **Specific Metal Data Available** – Due to the nature of the data compiled for the 2005 MBSS, the database lacks populations of data for specific metals; there are some areas where no metals samples were collected. For example, antimony was not analyzed in any of the topsoil samples collected across the state. For this case, the use of the 2005 MBSS is not appropriate for demonstrating background concentrations for antimony in topsoil.

Tables 2, 3, and 4 of the 2005 MBSS include the standard deviation of the substances that have an arithmetic or geometric mean in the glacial lobes that have at least nine samples. However, the 2005 MBSS does not contain the two standard deviations of the arithmetic or geometric mean, nor does it include the 97.5 quantile for the hazardous substances with nonparametric medians, both of which are specifically identified in the background definition. Included in Appendix B of this document are updated Tables 2, 3, and 4 with the two standard deviations and the 97.5 quantiles calculated using the data from the 2005 MBSS for each soil type and glacial lobe. Appendix D of this document includes modified Tables 2, 3, and 4 for the MBSS 2015 Update that includes the two standard deviations, 97.5 quantiles and highlighted numbers showing the appropriate number to use for a background concentration.

The 2005 MBSS contains combined statewide data columns on Tables 2, 3, and 4 that are not appropriate for use in demonstrating background concentrations. This is due to significant data gaps across the state, which has widely varied geology, where entire blocks of counties or most of the Upper Peninsula have no information.

Another method to establish background concentrations allows for the use of the 2005 MBSS in a manner that is approved by the department[6]. The sole use of the uppermost value in the typical range of data in Table 1 is not approved unless it is the lesser of the values indicated in 20101(1)(e)(ii)(A) or (B). Contact the EGLE project manager to discuss any other proposed methods to utilize the 2005 MBSS.

Soil analytical data from the area for which the background demonstration is being performed is needed to complete the comparison and show consistency with the conditions described in the *2005 MBSS*.

When a background concentration has been established utilizing the MBSS, site concentrations will generally be compared to the established background concentrations on a point-by-point basis.

[6] Sec.20101(1)(e)(ii)(C)

Statistical analysis of the site metals data may be conducted and used for comparison to the established background concentration; however, the method for the site data statistical analysis must be proposed on a case-by-case basis if EGLE approval of a response action is being sought.

Certain sites may contain more than one metal in the soil. Multiple methods included in the background definition to establish background concentrations may be used for different metals for the same site.

The MBSS may be an appropriate and useful resource for comparing geographic, geological, and analytical information to demonstrate background concentrations in an area that is unaffected by a release of hazardous substances.

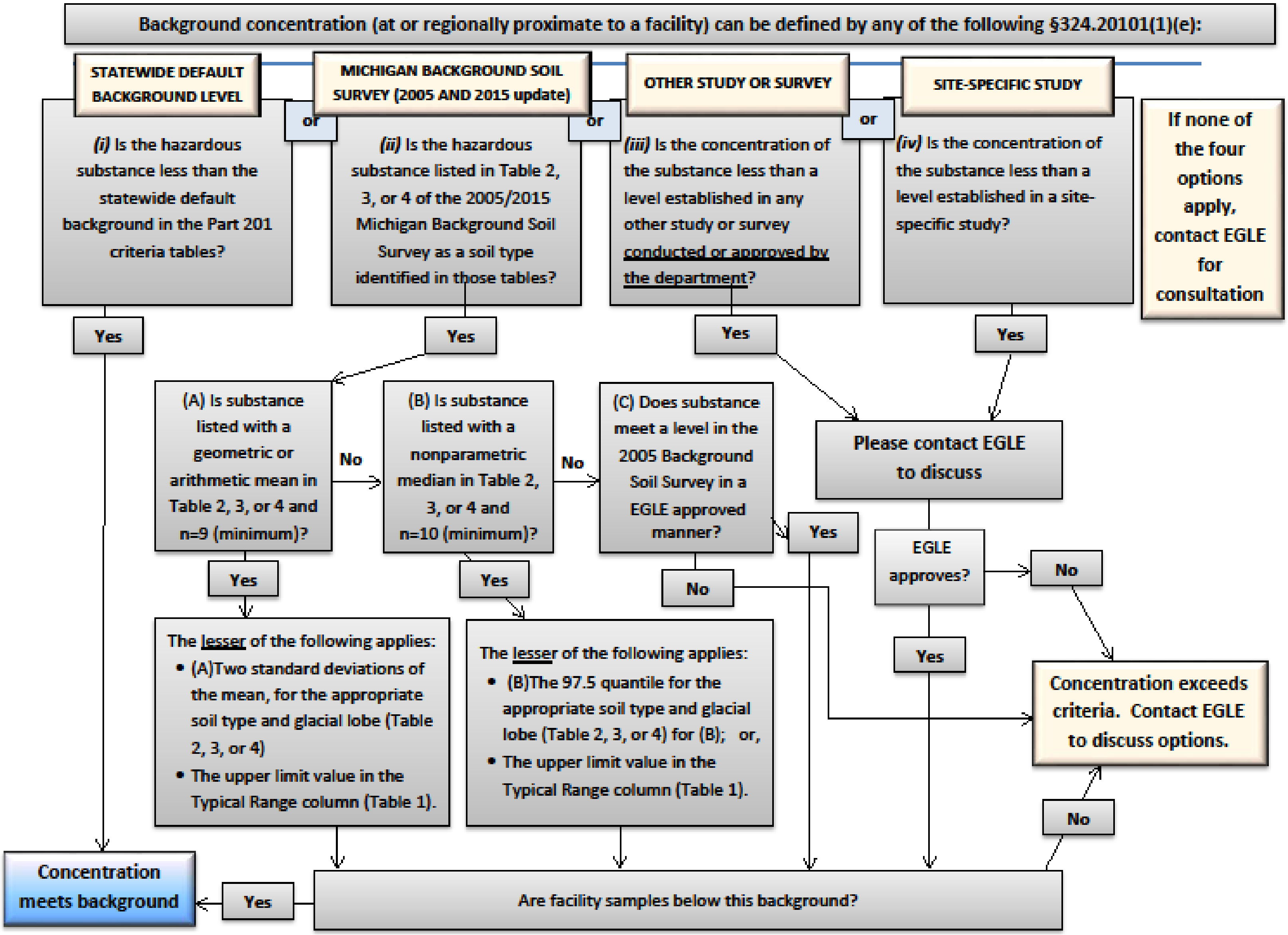
NOTE: If a site is also subject to corrective action under Michigan's Hazardous Waste Management Program (Part 111), please be aware that methods for demonstrating compliance with background concentration as defined under Section 324.20101(1)(e) cannot be automatically applied. Such sites may use site-specific background determinations (as approved by the Hazardous Waste Program) or the statewide default background levels listed in the September 28, 2012 Part 201 generic soil cleanup criteria and screening levels (Tables 2 and 3). This distinction is necessary until the U.S. Environmental Protection Agency approves Michigan to use the January 15, 2015 Part 201 definition for background concentration in its Hazardous Waste Management Program.

Appendix A

FLOW CHART

Background Concentration Flowchart

[per 324.20101(1)(e)]



REMEDIATION AND REDEVELOPMENT DIVISION

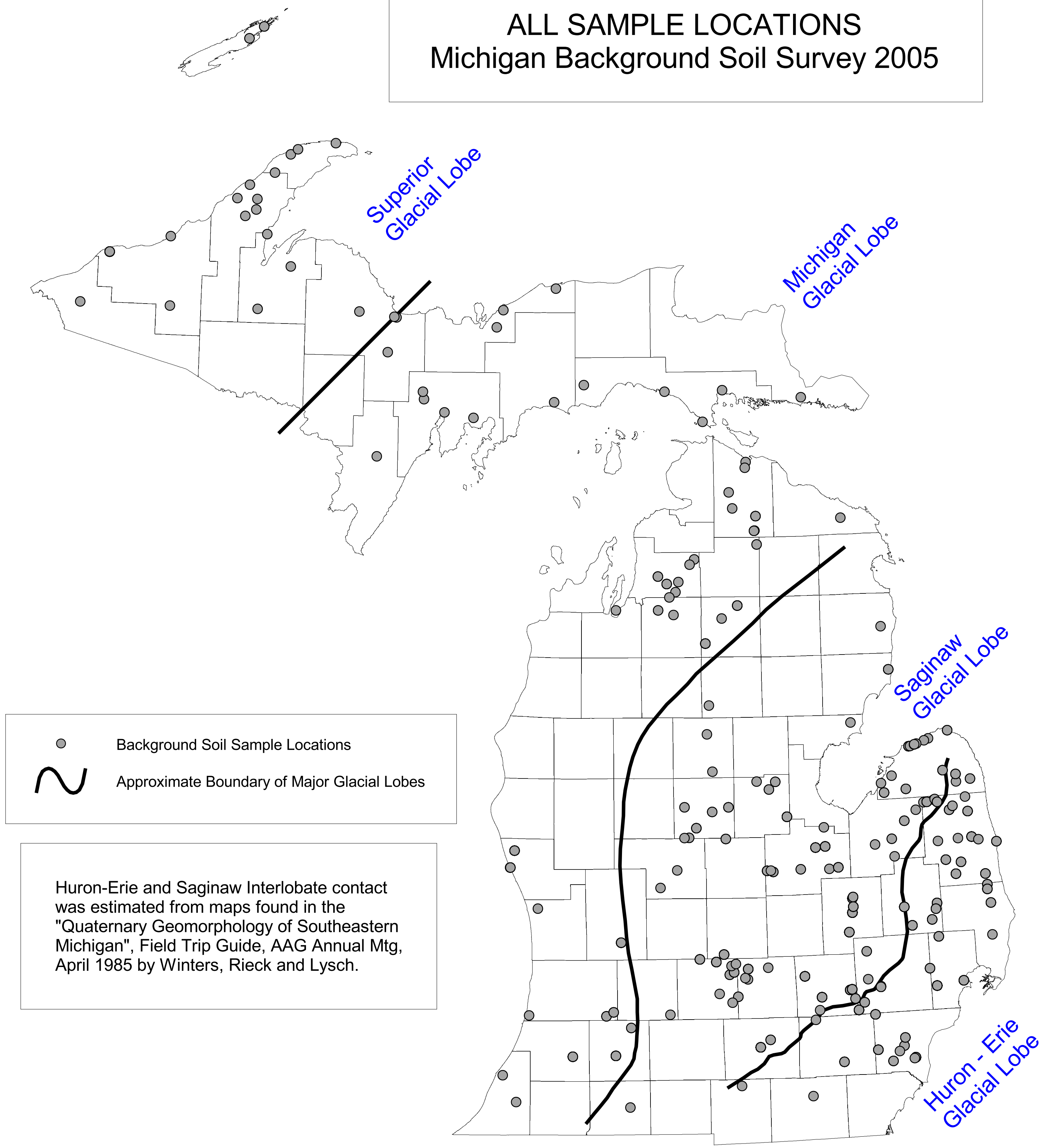
Appendix B

GLACIAL LOBE MAP

UPDATED TABLES 2, 3, AND 4

2005 Michigan Background Soil Survey

ALL SAMPLE LOCATIONS
Michigan Background Soil Survey 2005



Huron-Erie and Saginaw Interlobate contact was estimated from maps found in the "Quaternary Geomorphology of Southeastern Michigan", Field Trip Guide, AAG Annual Mtg, April 1985 by Winters, Rieck and Lysch.

FIGURE 1

Table 2 - TOPSOIL

METAL	Dist.	Part 201 Statewide Default Background	Table 1 Upper Range Value	HURON - ERIE LOBE			SAGINAW LOBE			MICHIGAN LOBE			SUPERIOR LOBE		
				n	Two Standard Deviations	97.5 Quantiles	n	Two Standard Deviations	97.5 Quantiles	n	Two Standard Deviations	97.5 Quantiles	n	Two Standard Deviations	97.5 Quantiles
Al	L	6,900	16,324	10	9,690	#	37	12,531	#	34	3,234	#	16	17,664	#
Sb	non	NA	2.5	0	--	--	0	--	--	0	--	--	0	--	--
As	L	5.8	27.7	47	15.2	#	93	13.2	#	39	4.67	#	18	3.80	#
Ba	L	75	220	15	248	#	42	78.3	#	39	68.1	#	16	163	#
Be	non	NA	1.8	2	--	--	12	#	0.37	0	--	--	0	--	--
Cd	non	1.2	2.5	15	#	2.0	42	#	*100% ND*	38	#	*100% ND*	18	#	*100% ND*
Cr	L	18	55	15	37.3	#	45	32.7	#	39	10.2	#	18	36.4	#
Co	non	6.8	12	10	#	7.0	29	#	6.2	32	#	*100% ND*	16	#	11.7
Cu	L	32	58	15	56.6	#	42	27.5	#	39	13.3	#	18	172	#
Fe	L	12,000	34,233	10	21,218	#	42	31,334	#	38	8,645	#	18	24,099	#
Pb	L	21	45	38	42.5	#	60	34.9	#	39	24.8	#	18	73.4	#
Li	L	9.8	41	10	10.7	#	34	14.7	#	32	#	3.9	18	10.8	#
Mg	L	NA	29875	2	--	--	8	--	--	0	--	--	0	--	--
Mn	L	440	1391	10	2,145	#	42	1,114	#	38	1,083	#	18	965	#
Hg	non	0.13	0.6	15	#	0.17	42	#	0.24	38	#	0.10	18	#	0.12
Mo	--	NA	*100% ND*	2	--	--	12	#	*100% ND*	0	--	--	0	--	--
Ni	L	20	39	11	19.5	#	42	16.6	#	38	--	--	18	70.4	#
Se	non	0.41	1.2	22	#	4.9	42	#	0.50	38	--	--	18	#	0.65
Ag	non	1	2	6	--	--	5	--	--	0	--	--	0	--	--
Na	N	NA	194.5	2	--	--	5	--	--	0	--	--	0	--	--
Sr	non	NA	150	0	--	--	7	--	--	0	--	--	0	--	--
Tl	non	NA	3.8	2	--	--	5	--	--	0	--	--	0	--	--
Ti	N	MNL	217	2	--	--	12	221	#	0	--	--	0	--	--
V	L	NA	89	2	--	--	12	30.5	#	0	--	--	0	--	--
Zn	N	47	75	23	79.0	#	45	61.3	#	39	27.4	#	18	100	#

All data are in mg/kg (ppm)

L	Lognormal distribution
N	Normal distribution
non	Nonparametric distribution
ND	Non-detect

Dist.	Distribution of Data
n	Number of Samples
NA	Not Applicable (no value listed in Part 201)
MNL	Metal Not Listed in Part 201
--	No value calculated (too few samples/detections)
(shaded)	Less than Table 1 Upper Value
#	Not appropriate calculation method
98 - 100% ND	Non-detect percentage too high to estimate a value - use Table 1

2005 MBSS

Table 3 - SAND

METAL	Dist.	Part 201 Statewide Default Background	Table 1 Upper Range Value	HURON - ERIE LOBE			SAGINAW LOBE			MICHIGAN LOBE			SUPERIOR LOBE		
				n	Two Standard Deviations	97.5 Quantiles	n	Two Standard Deviations	97.5 Quantiles	n	Two Standard Deviations	97.5 Quantiles	n	Two Standard Deviations	97.5 Quantiles
Al	L	6,900	16,324.0	2	--	--	54	8,677	#	34	8,449	#	3	--	--
Sb	non	NA	2.5	1	--	--	3	--	--	3	--	--	0	--	--
As	L	5.8	27.7	34	19.6	#	118	26.1	#	53	8.41	#	3	--	--
Ba	L	75	220.0	22	612	#	71	48.9	#	51	67.9	#	3	--	--
Be	non	NA	1.8	3	--	--	51	#	*98% ND*	6	--	--	0	--	--
Cd	non	1.2	2.5	22	#	2.0	67	#	1.6	39	#	2.0	3	--	--
Cr	L	18	55.0	22	20.3	#	90	20.0	#	67	18.4	#	3	--	--
Co	non	6.8	12.0	2	--	--	61	#	6.6	16	#	7.3	3	--	--
Cu	L	32	58.0	22	29.7	#	90	19.0	#	67	22.7	#	3	--	--
Fe	L	12,000	34,233.0	2	--	--	55	16,819	#	17	11,779	#	3	--	--
Pb	L	21	45.0	25	25.3	#	95	24.4	#	52	38.8	#	3	--	--
Li	L	9.8	41.0	2	--	--	62	11.0	#	11	23.3	#	3	--	--
Mg	L	NA	29,875.0	2	--	--	44	13,772	#	13	2,029.8	#	0	--	--
Mn	L	440	1,391.0	2	--	--	62	692	#	24	1,353	#	3	--	--
Hg	non	0.13	0.6	17	#	0.40	66	#	0.10	22	#	0.1	3	--	--
Mo	--	NA	*100% ND*	2	--	--	51	#	*100% ND*	6	--	--	0	--	--
Ni	L	20	39.0	8	--	--	78	22.2	#	40	18.3	#	3	--	--
Se	non	0.41	1.2	18	#	0.50	62	#	0.33	20	#	1.3	3	--	--
Ag	non	1	2.0	8	--	--	48	#	*100% ND*	13	#	0.7	0	--	--
Na	N	NA	194.5	2	--	--	44	166	#	12	168	#	0	--	--
Sr	non	NA	150.0	0	--	--	7	--	--	6	--	--	0	--	--
Tl	non	NA	3.8	3	--	--	46	#	3.6	9	--	--	0	--	--
Ti	N	MNL	217.0	2	--	--	44	207	#	0	--	--	0	--	--
V	L	NA	89.0	2	--	--	51	62.0	#	19	45.1	#	0	--	--
Zn	N	47	75.0	22	65.8	#	80	48.0	#	64	51.4	#	3	--	--

All data are in mg/kg (ppm)

L	Lognormal distribution
N	Normal distribution
non	Nonparametric distribution
ND	Non-detect

Dist.	Distribution of Data
n	Number of Samples
NA	Not Applicable (no value listed in Part 201)
MNL	Metal Not Listed in Part 201
--	No value calculated (too few samples/detections)
	Less than Table 1 Upper Value
#	Not appropriate calculation method
98 - 100% ND	Non-detect percentage too high to estimate a value - use Table 1

2005 MBSS

Table 4 - CLAY

METAL	Dist.	Part 201 Statewide Default Background	Table 1 Upper Range Value	HURON - ERIE LOBE n	HURON - ERIE LOBE Two Standard Deviations	HURON - ERIE LOBE 97.5 Quantiles	SAGINAW LOBE n	SAGINAW LOBE Two Standard Deviations	SAGINAW LOBE 97.5 Quantiles	MICHIGAN LOBE n	MICHIGAN LOBE Two Standard Deviations	MICHIGAN LOBE 97.5 Quantiles	SUPERIOR LOBE n	SUPERIOR LOBE Two Standard Deviations	SUPERIOR LOBE 97.5 Quantiles
Al	**L**	**6,900**	16,324.0	23	**12,631**	#	51	**13,795**	#	6	--	--	3	--	--
Sb	**non**	**NA**	2.5	8	--	--	0	--	--	12	#	*100% ND*	0	--	--
As	**L**	**5.8**	27.7	126	**36.6**	#	224	**17.9**	#	17	**6.95**	#	3	--	--
Ba	**L**	**75**	220.0	104	**277**	#	48	**110**	#	6	--	--	3	--	--
Be	**L**	**NA**	1.8	11	**1.9**	#	9	--	--	12	#	**0.5**	0	--	--
Cd	**N**	**1.2**	2.5	128	#	**3.4**	108	#	**2.5**	16	#	**2.0**	3	--	--
Cr	**L**	**18**	55.0	107	**62.8**	#	111	**37.1**	#	17	**23.0**	#	3	--	--
Co	**N**	**6.8**	12.0	29	**14.0**	#	22	**13.4**	#	6	--	--	3	--	--
Cu	**L**	**32**	58.0	103	**48.2**	#	103	**28.0**	#	17	**27.0**	#	3	--	--
Fe	**L**	**12,000**	34,233.0	26	**24,544**	#	24	**29,099**	#	6	--	--	3	--	--
Pb	**L**	**21**	45.0	126	**30.3**	#	125	**71.5**	#	17	**47.9**	#	3	--	--
Li	**L**	**9.8**	41.0	29	**40.9**	#	22	**40.6**	#	4	--	--	3	--	--
Mg	**N**	**NA**	29,875.0	0	--	--	8	--	--	2	--	--	0	--	--
Mn	**L**	**440**	1,391.0	29	**767**	#	52	**584**	#	6	--	--	3	--	--
Hg	**non**	**0.13**	0.6	97	#	**0.63**	54	#	*98% ND*	5	--	--	3	--	--
Mo	--	**NA**	*100% ND*	3	--	--	9	--	--	0	--	--	0	--	--
Ni	**N**	**20**	39.0	100	**45.0**	#	105	**36.7**	#	6	--	--	3	--	--
Se	**non**	**0.41**	1.2	94	#	**1.0**	43	#	**1.3**	16	#	**1.7**	3	--	--
Ag	**non**	**1**	2.0	61	#	**1.9**	28	#	**1.0**	12	#	**1.5**	0	--	--
Na	**N**	**NA**	194.5	0	--	--	8	--	--	2	--	--	0	--	--
Sr	**non**	**NA**	150.0	3	--	--	1	--	--	0	--	--	0	--	--
Tl	**non**	**NA**	3.8	8	--	--	8	--	--	1	--	--	0	--	--
Ti	**N**	**MNL**	217.0	0	--	--	8	--	--	0	--	--	0	--	--
V	**L**	**NA**	89.0	4	--	--	9	**62.1**	#	2	--	--	0	--	--
Zn	**N**	**47**	75.0	126	**83.1**	#	97	**65.7**	#	6	--	--	3	--	--

All data are in mg/kg (ppm)

L	Lognormal distribution
N	Normal distribution
non	Nonparametric distribution
ND	Non-detect

Dist.	Distribution of Data
n	Number of Samples
NA	Not Applicable (no value listed in Part 201)
MNL	Metal Not Listed in Part 201
--	No value calculated (too few samples/detections)
(shaded)	Less than Table 1 Upper Value
#	Not appropriate calculation method
98 - 100% ND	Non-detect percentage too high to estimate a value - use Table 1

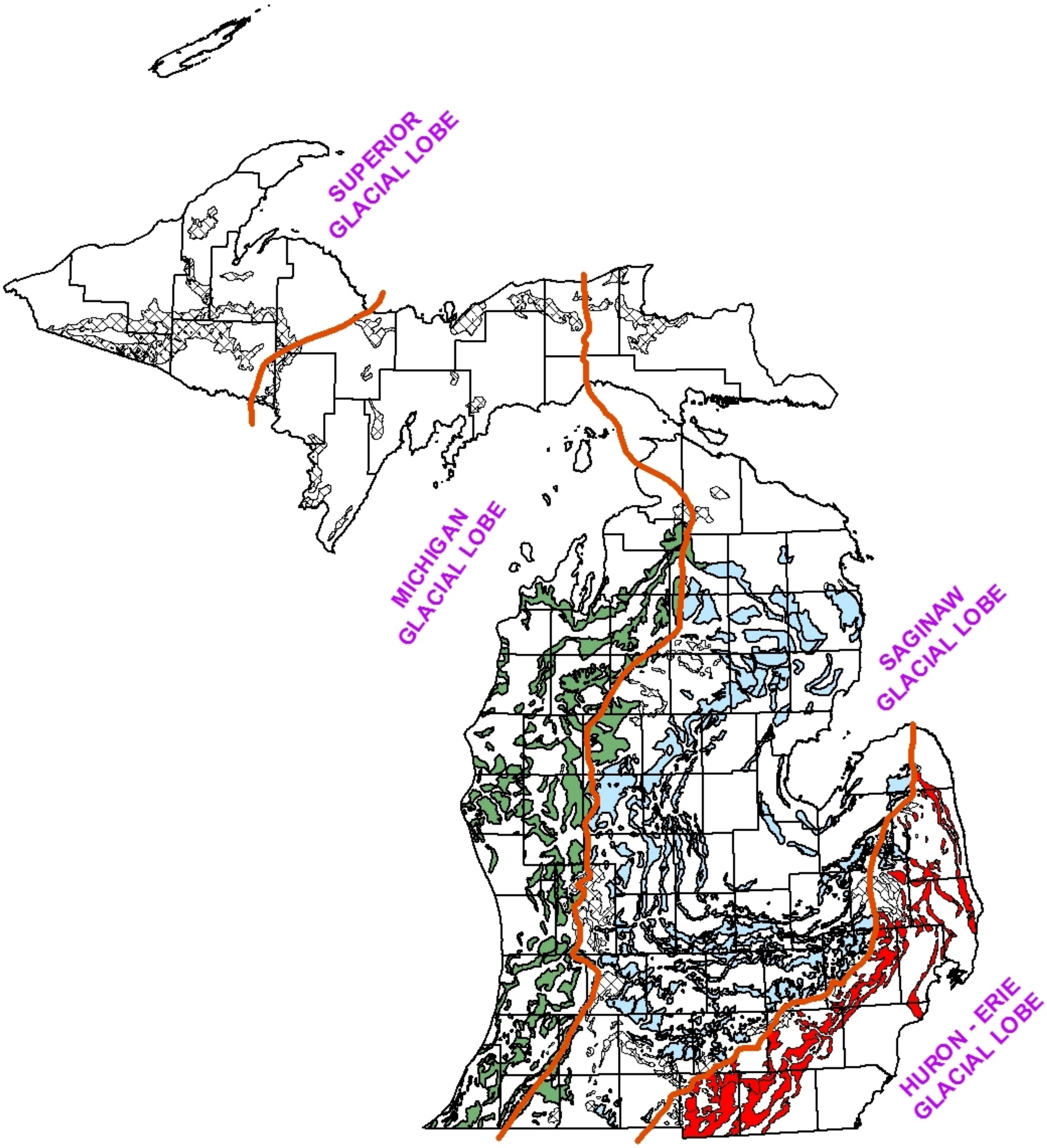
2005 MBSS

Appendix C

Michigan Background Soil Survey
(Updated 2015)

The Michigan Department of Environmental Quality (MDEQ) was reorganized and renamed as the Michigan Department of Environment, Great Lakes, and Energy (EGLE) on April 22, 2019. Because this report reflects activities prior to this date, references to DEQ remain and are understood to refer to EGLE.

MICHIGAN BACKGROUND SOIL SURVEY
(Updated 2015)



Permit & Corrective Action Unit
Hazardous Waste Section
Office of Waste Management & Radiological Protection

Michigan Background Soil Survey 2015 Update

Introduction

In 1991, the Michigan Department of Natural Resources (MDNR) released a compilation of soil sampling data that represented what is assumed to be the naturally occurring background concentration of metals in Michigan soils. The data were presented in the "Michigan Background Soil Survey" (MBSS) in April 1991 and after the creation of the Michigan Department of Environmental Quality (MDEQ) the 2005 version was published. In 2014, additional soil sampling data from locations that represent background conditions were collected from files of the Remediation and Redevelopment Division (RRD), and the MBSS 2005 has been updated in 2015 by the MDEQ [(1)].

History

During the mid-1980s, closure plans were submitted to the state pursuant to cleanups and corrective action work at regulated hazardous waste treatment, storage, and disposal facilities. In order to assure that soil removal performed to achieve clean closure was accomplished, standards were established that mandated the removal of contaminants until concentrations were non-detectable or within the naturally occurring background range. Therefore, facilities undergoing closure or corrective action for metals were required to submit analyses of soil from their specific location to determine the criteria to be met, which is statistically equivalent to the local, un-impacted background conditions. In order to evaluate the validity of these site-specific background values, a Michigan soil background database was compiled. That background soils database included information gathered by regulated facilities, as well as samples collected and analyzed by the state.

Background soil data from the regulated facilities were obtained using standard sampling and analytical techniques at the time of collection, which were approved by the state, usually as part of a closure plan or remediation efforts. Common analytical methods from EPA/SW-846 were used (EPA method 200.7, SW-846 method series 6000/7000, etc.). Samples collected by the state were analyzed by an approved contract laboratory, or through the State of Michigan Environmental Laboratory. Some data included was from United States Geological Survey (USGS) and the Army Corp of Engineers. All results represent a total (environmentally available) metals analysis.

Data Reduction

The background soil data for each metal has been reviewed in two basic ways. The first is looking at the data by general soil type. Based usually on a visual observation, and occasionally a soil classification system, soil samples were divided into the following general soil types: topsoil, sand or clay. The other breakdown was by geographic location, using glacial geology distinctions. In Michigan there were several different glacial ice sheets (lobes) that covered distinct areas. The glacial lobes have varying points of origin and traverse differing types of bedrock, and thus the resulting glacial sediments could have varying chemical characteristics based on source rock influences. The assumed boundaries of the glacial lobes have been revised for the 2015 update based on additional information resources [(2)]. Summary statistics are presented for general soil types and for broad geographic areas based on the location of major glacial lobes.

Since the data comes from investigations at different sites, each with various parameters of concern, the suite of metals analyzed was not the same in each case. Depending on how commonly the metal was a pollutant of concern, and the number of samples taken for site-specific background determinations, each metal will have a different total number of individual samples and number of sites/locations the samples came from.

Statistics

A basic statistical analysis was performed for each metal represented in the database [3]. First, the percentage of non-detect values was determined, followed by analysis of the underlying distribution of the data. Finally, summary statistics such as the mean, median, standard deviation, quantiles and the range of concentrations for a metal were calculated with normal, lognormal, or nonparametric methods as appropriate.

In terms of detection limits, metals with 0 – 15 % non-detect results had a value equal to one half (1/2) of the respective detection limit substituted for calculation of summary statistics (Al, As, Ba, Cr, Cu, Fe, Mg, Mn, Sr, Ti, V, Zn). Metals with 15 - 50% non-detect results had summary statistics calculated using Cohen's adjustment (Co, Li, Na, Ni, Pb). For metals with over 50% non-detects, a nonparametric method was used (Ag, Be, Cd, Hg, Mo, Sb, Se, Tl).

The data distribution was analyzed using graphical techniques (histogram, probability plot, box plot) and the Shapiro-Francia or Shapiro-Wilk Goodness-of-Fit test. For simplicity's sake, only normal or lognormal distributions were checked and the best fit to the respective metals' data was chosen. Subsequently, summary statistics were calculated as appropriate for a normal, lognormal, or nonparametric distribution. Tables are attached that list the summary statistics for each metal.

Summary

The MBSS is meant to provide a resource for information regarding the concentration of naturally occurring metals that can be expected in various general soil types and geographic areas of Michigan. Site-specific data is recommended to get the best representation of a local background concentration.

Contact Information

If there are any questions, or a desire to obtain data, please contact those listed below:

Dale Bridgford 517-284-6556 bridgfordd@michigan.gov

Attachments

Table 1	Statewide Information – all data combined
Tables 2, 3, 4	Topsoil, Sand and Clay - typical range of concentrations
Figure 1	All Sample Locations and glacial lobe boundaries
Figures 2, 3, 4	Topsoil, Sand and Clay - sample locations

TABLE 1 - Statewide Information

METAL	Number of samples	Sites	Percent Non-detect	Assumed Distribution of Data	{a} Mean (mg/kg)	{b} Standard Deviation	Median (mg/kg)	{c} Typical Range of data (mg/kg)
Aluminum (Al)	508	171	0 %	Lognormal	3085	2.317	3205	594 - 16014
Antimony (Sb)	259	82	83.8 %	Non-para	na	na	< 0.30	<0.04 - 11.5
Arsenic (As)	1795	490	6.3 %	Lognormal	2.5	3.088	2.8	< 0.3 - 22.8
Barium (Ba)	1241	401	2.0 %	Lognormal	20.2	2.981	21.7	2.4 - 172
Beryllium (Be)	390	155	71.3 %	Non-para	na	na	< 0.21	<0.09 – 1.0
Cadmium (Cd)	1347	413	69.9 %	Non-para	na	na	< 0.23	<0.05 – 2.0
Chromium (Cr)	861	247	12.5 %	Lognormal	5.7	3.197	6.1	< 0.6 - 55.6
Cobalt (Co)	1161	426	18.4 %	Cen-Log	4.9	2.378	5.1	<0.9 – 26.8
Copper (Cu)	1393	437	7.4 %	Lognormal	6.2	2.920	7.3	<8 - 50.6
Iron (Fe)	568	197	0 %	Lognormal	5533	2.537	5825	86 - 34311
Lead (Pb)	1619	482	18.0 %	Cen-Log	4.0	3.192	5.0	<0.4 - 38.9
Lithium (Li)	312	124	28.5 %	Cen-Log	3.8	3.231	3.5	<0.4 - 37.9
Magnesium (Mg)	248	88	0 %	Lognormal	1884	4.508	1715	98 - 36049
Manganese (Mn)	574	209	0 %	Lognormal	121	3.240	152	12 - 1212
Mercury (Hg)	1168	414	89.1 %	Non-para	na	na	< 0.05	<0.01 - 0.5
Molybdenum (Mo)	275	116	89.1 %	Non-para	na	na	< 1	<0.25 – 5.0
Nickel (Ni)	850	255	18.8 %	Cen-Log	7.4	2.788	8.2	<1- 55.2
Selenium (Se)	1209	420	77.3 %	Non-para	na	na	< 0.44	<0.05 – 1.3
Silver (Ag)	973	320	92.2 %	Non-para	na	na	<0.20	<0.03 – 1.4
Sodium (Na)	216	76	31.9 %	Cen-Log	58.7	3.041	85	<6.6 - 519
Strontium (Sr)	81	51	0 %	Non-para	na	na	31	1.7 - 150
Thallium (Tl)	369	124	90.2 %	Non-para	na	na	< 0.50	<0.08 – 2.7
Titanium (Ti)	97	41	0 %	Normal	118	45.0	108	28 - 208
Vanadium (V)	406	167	1.7 %	Lognormal	9.9	2.500	9.9	1.6 - 59.6
Zinc (Zn)	1392	433	2.2 %	Lognormal	18.3	2.593	22	3 - 118

{a} For lognormal distributions, this represents the geometric mean. For normal distributions this represents the arithmetic mean. The mean was not estimated for data with non-parametric distributions (greater than 50% non-detect).

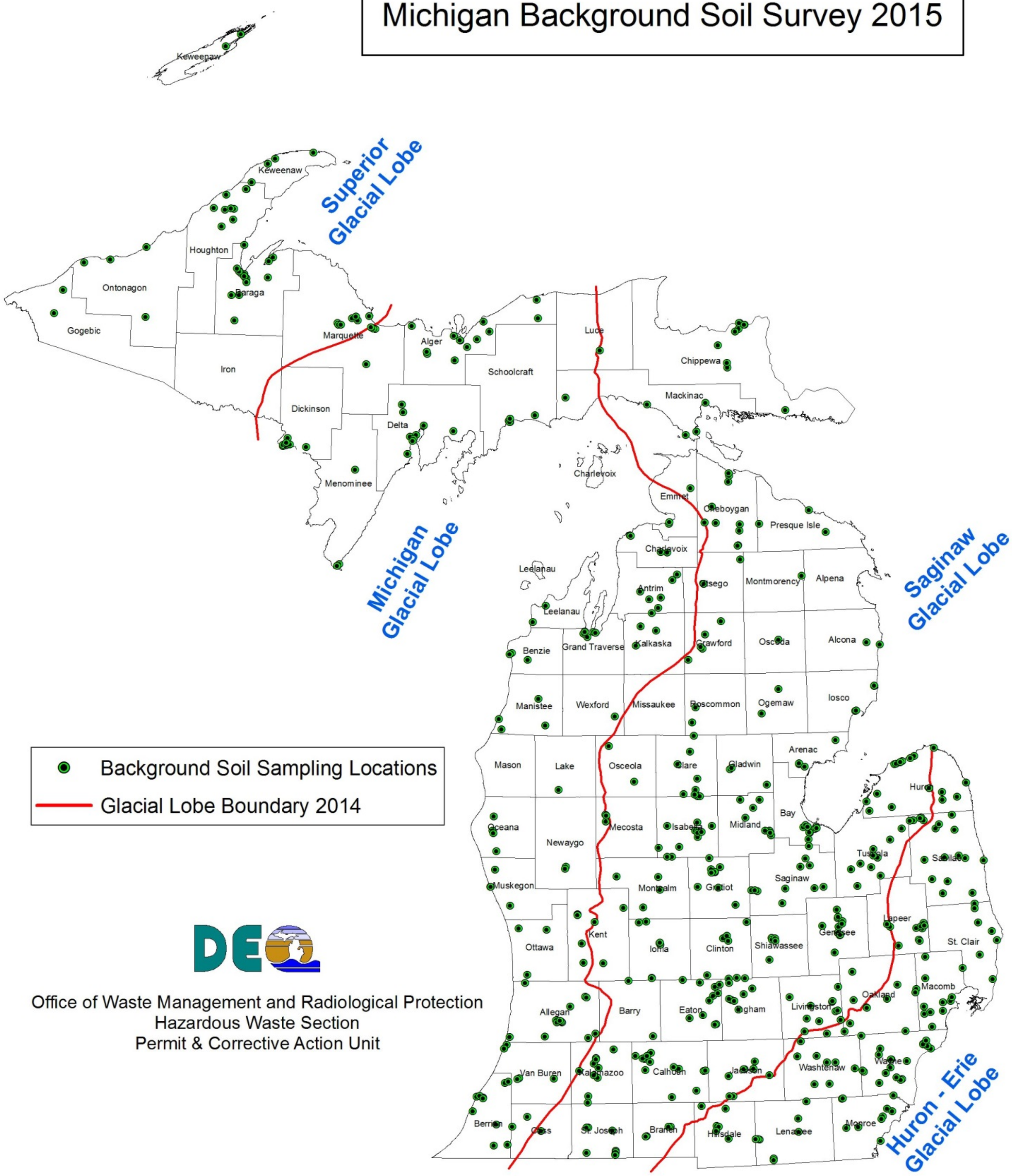
{b} For lognormal distributions, this represents the geometric standard deviation and is unit-less. The standard deviation is not estimated for data with non-parametric distributions.

{c} Typical range given is the central 95% of the data, or two standard deviations, calculated using the appropriate normal or lognormal formulas. The non-parametric range is based on the 2.5th and 97.5th quantiles of the data set.

na = not applicable for nonparametric data distribution
Non-para = nonparametric (> 50% non-detect)
Cen-Log – censored lognormal (<15 – <50% non-detect)

FIGURE 1

ALL SAMPLING LOCATIONS
Michigan Background Soil Survey 2015



MDEQ-2015 MBSS

TABLE 2 – TOPSOIL

	Dist.	Glacial Lobe Area																				Statewide						
		HURON - ERIE					SAGINAW					MICHIGAN					SUPERIOR					TOPSOIL – Combined Statewide Data						
		n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	min	max	x	SD	1 SD	**2 SD**
Al	L	11	4554	1.439	6553	**9294**	47	2253	2.236	5038	**10908**	25	1041	1.751	1823	**3121**	15	3488	2.110	7360	**15072**	98	340	9950	2141	2.330	4989	**11237**
Sb	Np	0	--	--	--	**--**	1	--	--	--	**--**	0	--	--	--	**--**	0	--	--	--	**--**	1	--	--	--	--	--	**--**
As	L	51	5.7	1.630	9.3	**14.9**	103	2.2	2.357	5.2	**11.8**	29	1.0	2.149	2.1	**4.5**	17	1.4	1.707	2.4	**4.0**	200	<0.25	34	2.4	2.537	6.1	**14.9**
Ba	L	16	40	2.602	104	**261**	52	22.7	1.876	42.6	**77.9**	29	13.5	2.242	30.3	**65.7**	17	41.4	1.749	72.4	**124**	114	<2.2	103	23.6	2.272	53.6	**118**
Be	Np	2	<0.20	--	--	**--**	13	<0.30	--	0.31	**0.71**	0	--	--	--	**--**	0	--	--	--	**--**	15	<0.20	0.84	<0.30	--	0.3	**0.69**
Cd	Np	16	<2.0	--	2.0	**2.0**	52	<2.0	--	<2.0	**<2.0**	29	<2.0	--	<2.0	**<2.0**	17	<2.0	--	<2.0	**<2.0**	114	<0.12	2.0	<2.0	--	<2.0	**2.0**
Cr	L	19	13.1	1.698	22.2	**37.0**	53	5.3	2.459	13.0	**30.9**	29	3.2	1.851	5.9	**10.7**	17	7.7	2.227	17.1	**37.0**	118	<0.70	36	5.7	2.438	13.9	**32.7**
Co	Np	11	<5.0	--	5.7	**7.0**	39	<5.0	--	<5.0	**6.1**	23	<5.0	--	<5.0	**<5.0**	15	<5.0	--	6.1	**11.8**	88	<2.5	14	<5.0	--	<5.0	**7.0**
Cu	L	16	9.9	2.343	23.2	**52.5**	53	4.3	2.377	10.2	**23.5**	29	2.4	2.308	5.5	**12.4**	17	31.3	2.290	71.7	**159**	115	<0.50	82.5	5.6	3.270	18.3	**57.1**
Fe	L	11	9476	1.473	13958	**20244**	51	4439	2.540	11275	**27590**	29	2175	1.840	4002	**7186**	17	5247	2.060	10809	**21632**	108	320	22300	4065	2.431	9882	**23185**
Pb	CL	42	11.6	1.973	22.9	**43.9**	67	8.0	1.968	15.7	**30.2**	29	6.9	1.825	12.6	**22.4**	17	12.1	2.524	30.5	**74.3**	155	<2.3	66.2	9.1	2.048	18.6	**37.1**
Li	V	11	4.3	1.581	6.8	**10.6**	43	2.3	2.581	5.9	**14.8**	23	< 2.0	--	2.3	**3.0**	17	2.9	1.932	5.6	**10.5**	94	<2.0	12	2.2	2.363	5.2	**11.9**
Mg	L	5	3184	2.088	6648	**13489**	5	1410	1.829	2579	**4604**	0	--	--	--	**--**	0	--	--	--	**--**	10	490	8900	2119	2.152	4560	**9517**
Mn	L	11	524	2.224	1165	**2510**	52	113	2.891	327	**905**	29	109	3.441	375	**1228**	17	154	2.413	372	**866**	109	3.0	1500	137	3.154	432	**1302**
Hg	Np	16	<0.10	--	0.10	**0.16**	52	<0.10	--	<0.10	**0.4**	29	<0.10	--	<0.10	**0.10**	17	<0.10	--	<0.10	**0.12**	114	<0.05	0.5	<0.10	--	<0.10	**0.27**
Mo	Np	2	<5.0	--	--	**--**	12	<5.0	--	<5.0	**<5.0**	0	--	--	--	**--**	0	--	--	--	**--**	14	<5.0	<5.0	<5.0	--	<5.0	**<5.0**
Ni	V	12	9.3	3.7	13.0	**16.6**	52	< 5.0	--	9.0	**14.0**	29	<5.0	--	<5.0	**7.1**	17	8.2	3.012	24.7	**71.2**	110	<3.5	47	4.3	2.448	10.5	**24.9**
Se	Np	23	<0.5	--	1.3	**4.7**	51	<0.50	--	<0.50	**0.65**	29	<0.50	--	<0.50	**0.53**	17	<0.50	--	<0.50	**0.65**	120	<0.05	8	<0.50	--	<0.50	**1.3**
Ag	Np	6	<0.25	--	0.75	**1.6**	5	<0.25	--	<0.25	**<0.25**	0	--	--	--	**--**	0	--	--	--	**--**	11	<0.20	1.7	<0.25	--	0.35	**1.4**
Na	V	2	125	--	--	**--**	5	92	24.6	117	**140**	0	--	--	--	**--**	0	--	--	--	**--**	7	<65	130	101	25.9	127	**153**
Sr	Np	0	--	--	--	**--**	7	106	--	148	**156**	0	--	--	--	**--**	0	--	--	--	**--**	7	73	157	106	--	148	**156**
Tl	Np	2	<1.0	--	--	**--**	5	<1.0	--	<1.0	**<1.0**	0	--	--	--	**--**	0	--	--	--	**--**	7	<1.0	<1.0	<1.0	--	<1.0	**<1.0**
Ti	N	2	94.5	--	---	**--**	12	133	43.9	177	**219**	0	--	--	--	**--**	0	--	--	--	**--**	14	73	210	127	42.8	170	**211**
V	L	2	21	--	--	**--**	12	14.1	1.483	20.9	**30.5**	0	--	--	--	**--**	0	--	--	--	**--**	14	<8.0	28	14.9	1.480	22.1	**32.1**
Zn	L	27	39.8	1.770	70.4	**122**	53	18.5	2.057	38.1	**76.1**	29	9.7	2.207	21.4	**45.8**	17	36.7	2.039	74.8	**148**	126	<2.5	99	20.6	2.400	49.4	**115**

Data in mg/kg
Dist. = Distribution of data (CL – Censored Lognormal, L-Lognormal, Np- Nonparametric, N- Normal, V-various).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg)

Data Range	Lognormal Distribution	Normal Distribution	Nonparametric equivalent
1 SD	(x)(SD)	x + (1)SD	84^{th} quantile
2 SD	$(x)(SD)^{1.96}$	x+ (1.96)SD	97.5^{th} quantile

FIGURE 2

TOPSOIL SAMPLING LOCATIONS
Michigan Background Soil Survey 2015
(Includes 2005 Survey Data)

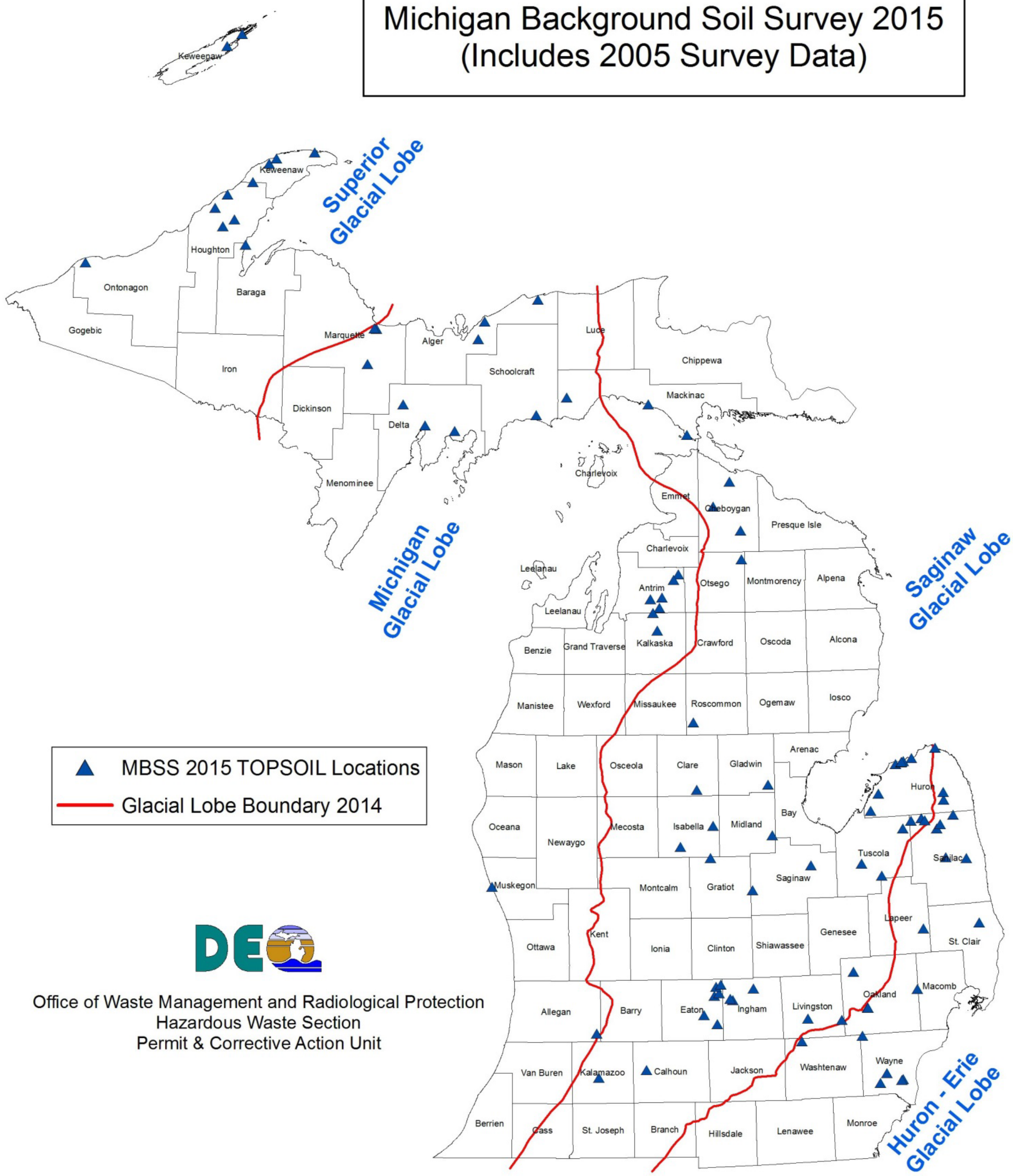


TABLE 3 – SAND

	Dist.	Glacial Lobe Area																				Statewide						
		HURON - ERIE					SAGINAW					MICHIGAN					SUPERIOR					SAND – Combined Statewide Data						
		n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	min	max	x	SD	1 SD	**2 SD**
Al	L	31	3024	1.667	5041	**8233**	162	2265	1.930	4371	**8218**	67	1842	1.850	3408	**6151**	26	5256	2.324	12215	**27446**	286	250	24900	2404	2.031	4883	**9639**
Sb	Np	15	<0.33	--	0.65	**8.7**	58	<0.42	--	< 1.0	**10.8**	50	<0.30	--	<2.9	**5**	57	<0.30	--	0.30	**1.9**	180	<0.08	12.9	<0.30	--	< 1.0	**5.9**
As	L	175	4.1	2.580	10.6	**26.3**	509	1.8	3.140	5.7	**17**	194	0.86	2.630	2.3	**5.7**	87	1.0	2.052	2.1	**4.1**	965	<0.05	40	1.7	3.189	5.4	**16.5**
Ba	L	103	28.1	2.713	76.2	**199**	374	12.4	2.350	29.1	**66.2**	199	8.4	2.784	23.4	**62.5**	85	18.9	2.399	45.3	**105**	761	<0.50	240	13.1	2.713	35.5	**92.6**
Be	Np	31	<0.20	--	0.51	**0.78**	125	<0.20	--	<1.0	**1.0**	74	<0.20	--	<0.50	**1.0**	57	<0.20	--	0.31	**0.86**	287	<0.04	2	<0.20	--	0.50	**1.0**
Cd	Np	97	<0.24	--	2.0	**2.0**	378	<0.2	--	2.0	**2.0**	214	<0.2	--	0.76	**2.0**	79	<0.2	--	0.20	**2.0**	768	<0.01	2.1	<0.20	--	2.0	**2.0**
Cr	L	67	4.1	2.778	11.4	**30.4**	219	3.7	2.347	8.7	**19.7**	100	1.7	3.401	5.8	**18.7**	60	3.1	2.782	8.6	**23.0**	446	<0.25	50	3.1	2.835	8.8	**23.9**
Co	CL	78	6.6	1.666	11.0	**17.9**	376	3.8	2.037	7.7	**15.3**	226	2.9	2.327	6.7	**15.2**	95	7.9	2.137	16.9	**35.0**	775	<0.50	36.7	4.1	2.265	9.3	**20.4**
Cu	L	116	6.5	1.928	12.5	**23.5**	397	3.6	2.412	8.7	**20.2**	210	2.9	3.282	9.5	**29.8**	92	12.7	3.139	39.9	**120**	815	<0.25	375	4.3	2.937	12.6	**35.5**
Fe	L	36	5863	1.934	11339	**21359**	165	4005	2.270	9091	**19972**	80	3032	1.973	5982	**11486**	60	7398	2.270	16793	**36891**	341	100	39000	4351	2.289	9959	**22054**
Pb	CL	132	6.1	2.017	12.3	**24.1**	429	2.8	2.586	7.2	**18.0**	245	1.8	3.206	5.8	**17.7**	155	1.4	4.357	6.1	**25.1**	961	<0.07	36	2.5	3.173	7.9	**24.0**
Li	V	7	3.5	--	7.3	**9.6**	101	2.8	2.232	6.2	**13.5**	22	2.3	2.287	5.3	**11.6**	18	9.7	8.1	17.8	**25.9**	148	<0.80	24.4	2.9	2.575	7.5	**18.5**
Mg	L	18	1411	3.341	4714	**15008**	112	1184	4.016	4755	**18063**	46	1288	3.868	4982	**18255**	26	2010	2.162	4346	**9110**	202	6.9	28000	1312	3.689	4840	**16946**
Mn	L	24	89.2	3.202	286	**873**	170	73.3	3.079	226	**664**	73	64.8	3.478	225	**745**	65	133	3.104	413	**1225**	332	1.0	3600	81.3	3.252	264	**820**
Hg	Np	102	<0.05	--	<0.10	**0.12**	320	<0.05	--	<0.10	**0.23**	188	<0.05	--	<0.10	**0.10**	82	<0.05	--	0.10	**0.11**	692	<0.01	1.2	<0.05	--	<0.10	**0.13**
Mo	Np	17	< 1.0	--	<5.0	**5.0**	95	<5.0	--	<5.0	**5.0**	45	<1.0	--	<5.0	**<5.0**	53	<1.0	--	1.0	**1.4**	210	<0.20	5.0	<1.0	--	<5.0	**5.0**
Ni	V	49	7.8	1.987	15.5	**30.0**	201	4.9	1.968	9.6	**18.5**	128	3.3	2.862	9.4	**25.9**	78	9.3	6.8	16.1	**22.9**	456	<0.08	39.9	4.8	2.469	11.9	**28.2**
Se	Np	109	<0.40	--	0.6	**3.9**	336	<0.35	--	0.54	**1.1**	175	<0.40	--	<0.50	**1.0**	74	<0.20	--	0.47	**0.91**	694	<0.05	4.4	<0.34	--	0.53	**1.2**
Ag	Np	92	<0.20	--	<0.89	**1.2**	296	<0.21	--	<0.50	**<2.0**	185	<0.15	--	<0.50	**0.79**	78	<0.10	--	0.19	**0.50**	651	<0.01	2.0	<0.18	--	<0.50	**1.1**
Na	V	17	<88	--	316	**487**	103	52.6	3.364	177	**567**	40	68.3	41.0	109	**150**	24	43.7	1.750	76.5	**131**	184	<1.9	680	50.9	2.978	152	**432**
Sr	Np	4	28	--	93	**141**	31	28	--	77	**150**	9	4.9	--	70	**94**	15	10	--	16	**72**	59	1.3	150	12.3	--	70	**150**
Tl	Np	39	<0.50	--	<2.7	**3.2**	127	<1.0	--	<1.0	**2.0**	63	<0.50	--	<1.0	**1.7**	58	<0.50	--	0.50	**1.2**	287	<0.02	6.1	<0.50	--	<1.0	**2.8**
Ti	N	4	150	45.5	196	**239**	58	115	40.3	155	**194**	12	111	54.8	166	**218**	0	--	--	--	**--**	74	13	250	117	43.3	160	**202**
V	L	39	9.7	2.020	19.6	**38.5**	145	7.6	2.245	17.1	**37.1**	77	5.2	2.305	12.0	**26.7**	59	15.8	2.251	35.6	**77.5**	320	<0.05	100	8.2	2.412	19.8	**46.1**
Zn	L	115	23.7	1.928	45.7	**85.8**	391	11.3	2.602	29.4	**73.6**	200	9.3	2.509	23.3	**56.4**	91	15.8	2.177	34.4	**72.6**	797	<0.50	95	12.4	2.558	31.7	**78.1**

Data in mg/kg
Dist. = Distribution of data (CL – Censored Lognormal, L-Lognormal, Np- Nonparametric, N- Normal, V-various).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg).

Data Range	Lognormal Distribution	Normal Distribution	Nonparametric equivalent
1 SD	(x)(SD)	x + (1)SD	84th quantile
2 SD	$(x)(SD)^{1.96}$	x+ (1.96)SD	97.5th quantile

FIGURE 3

SAND SAMPLING LOCATIONS
Michigan Background Soil Survey 2015
(Includes 2005 Survey Data)

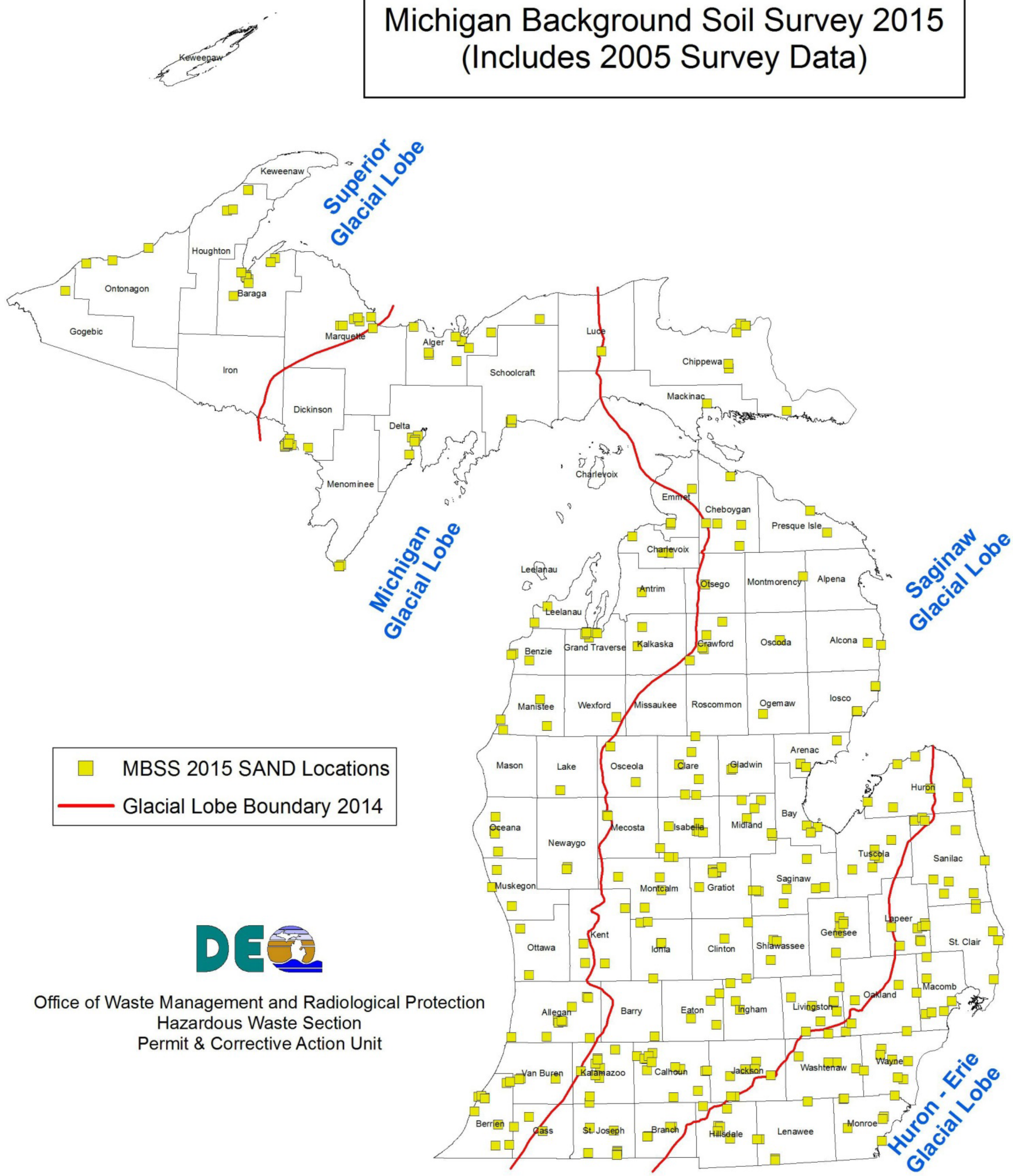


TABLE 4 – CLAY

	Dist.	Glacial Lobe Area																				Statewide						
		HURON - ERIE					SAGINAW					MICHIGAN					SUPERIOR					CLAY – Combined Statewide Data						
		n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	min	max	x	SD	1 SD	**2 SD**
Al	L	56	7445	1.615	12024	**19049**	62	6994	1.451	10148	**14508**	3	10430	1.577	16448	**25470**	3	9490	1.131	10733	**12080**	124	1240	19000	7318	1.530	11197	**16842**
Sb	Np	42	<0.52	--	11.3	**13**	33	<0.03	--	<0.5	**1.0**	3	<0.50	--	<3.6	**<50**	0	--	--	--	**--**	78	<0.04	14.4	<0.40	--	2.2	**13.0**
As	L	237	6.9	2.166	14.9	**31.4**	354	3.7	2.182	8.1	**17.1**	29	2.8	1.783	5.0	**8.7**	10	3.2	1.829	5.9	**10.4**	630	<0.20	88	4.6	2.298	10.6	**23.5**
Ba	L	166	64.4	1.903	123	**227**	171	37.6	2.334	87.8	**198**	25	30.5	1.905	58.1	**108**	4	51.8	3.338	173	**550**	366	<2.5	291	47.5	2.229	106	**229**
Be	V	35	0.48	1.744	0.84	**1.43**	42	0.26	2.608	0.68	**1.70**	5	<0.50	--	1.0	**1.0**	6	<1.0	--	2.2	**2.9**	88	<0.09	3.9	0.36	2.348	0.84	**1.9**
Cd	Np	196	<1.1	--	2.0	**3.1**	240	<0.50	--	2.0	**2.4**	25	<0.13	--	0.21	**2**	4	<1.0	--	<1.0	**<1.0**	465	<0.04	4.7	<0.66	--	2.0	**2.5**
Cr	L	139	16.9	2.168	36.6	**77.0**	141	11.5	1.971	22.7	**43.5**	8	11.0	2.608	28.7	**72.0**	9	29.4	1.543	45.4	**68.8**	297	<0.25	70	14.1	2.138	30.1	**62.5**
Co	CL	98	10.1	1.665	16.8	**27.4**	167	9.4	2.126	20.0	**41.2**	30	7.8	1.904	14.9	**27.6**	19	6.5	2.444	15.9	**37.5**	298	<0.20	85.1	9.3	2.019	18.8	**36.9**
Cu	L	192	14.2	1.840	26.1	**46.9**	232	11.1	1.722	19.1	**32.2**	29	7.9	1.760	13.9	**23.9**	10	19.4	2.066	40.1	**80.4**	463	<0.56	130	12.2	1.825	22.3	**39.7**
Fe	L	59	18110	1.438	26042	**36908**	52	11920	1.814	21623	**38301**	5	10620	1.701	18065	**30082**	3	10970	1.119	12275	**13674**	119	2100	32000	14560	1.690	24606	**40721**
Pb	CL	196	8.6	1.767	15.2	**26.2**	267	8.2	2.327	19.1	**42.9**	29	5.1	1.745	8.9	**15.2**	11	6.2	2.387	14.8	**34.1**	503	<0.86	32	8.1	2.097	17.0	**34.6**
Li	L	32	19.3	1.458	28.1	**40.4**	25	13.5	1.719	23.2	**39.0**	4	13.0	--	16.5	**16.9**	9	14.4	1.596	23.0	**36.0**	70	<3.5	77	15.9	1.611	25.6	**40.5**
Mg	L	20	11760	2.883	33904	**93692**	15	16700	3.269	54592	**170203**	1	24000	--	--	**--**	0	--	--	--	**--**	36	895	140000	13880	3.002	41668	**119706**
Mn	L	53	321	1.725	554	**935**	65	267	1.588	424	**661**	6	243	1.593	387	**605**	9	335	1.517	508	**758**	133	67	1200	290	1.648	478	**772**
Hg	Np	168	<0.06	--	<0.11	**0.58**	164	<0.07	--	<0.10	**0.5**	20	<0.05	--	0.10	**0.70**	10	0.11	--	0.55	**0.61**	362	<0.01	1.2	<0.06	--	<0.10	**0.57**
Mo	Np	14	<2.5	--	4.9	**5.0**	27	<1.0	--	<5.0	**5.0**	4	<3.0	--	<3.0	**<3.0**	6	<3.0	--	<3.0	**<3.0**	51	<0.22	5.0	<2.2	--	<5	**5.0**
Ni	V	140	23.0	10.2	33.2	**43.4**	126	18.9	8.7	27.6	**36.0**	9	10.8	2.001	21.6	**42.1**	9	18.0	6.3	24.3	**30.6**	284	<0.56	53	20.7	9.7	30.4	**40.1**
Se	V	189	<0.50	--	1.0	**1.2**	169	<0.50	--	0.60	**1.1**	27	<0.2	--	0.48	**1.5**	10	0.45	0.11	0.56	**0.67**	395	<0.05	2.4	<0.50	--	0.70	**1.2**
Ag	Np	139	<0.50	--	1.2	**6.0**	148	<0.20	--	<0.50	**1.0**	23	<0.10	--	<0.31	**0.50**	1	<0.5	--	--	**--**	311	<0.02	6.2	<0.25	--	<0.90	**2.8**
Na	V	10	114	240	354	**594**	14	186	1.382	257	**351**	1	--	--	--	**--**	0	--	--	--	**--**	25	<4.5	477	178	129	307	**436**
Sr	Np	6	102	--	150	**150**	1	100	--	--	**--**	2	110	--	--	**--**	6	100	--	150	**150**	15	53	150	100	--	150	**150**
Tl	Np	39	<0.56	--	1.1	**1.7**	33	<1.5	--	<1.5	**<1.5**	3	<0.50	--	<0.50	**<0.50**	0	--	--	--	**--**	75	<0.09	1.8	<0.50	--	<1.0	**1.6**
Ti	N	1	100	--	--	**--**	8	123	67.3	190	**255**	0	--	--	--	**--**	0	--	--	--	**--**	9	42	210	120	63.4	183	**244**
V	L	28	22.9	2.068	47.4	**95.1**	33	16.4	1.742	28.6	**48.7**	5	19.0	2.455	46.6	**110**	6	57.7	1.509	87.1	**129**	72	<4.3	150	21.0	2.050	43.1	**85.8**
Zn	L	218	43.9	1.537	67.5	**102**	212	27.8	1.841	51.2	**91.9**	29	24.0	1.705	40.9	**68.3**	10	26.8	2.819	75.5	**204**	469	<1.5	140	34.0	1.805	61.4	**108**

Data in mg/kg
Dist. = Distribution of data (CL – Censored Lognormal, L-Lognormal, Np- Nonparametric, N- Normal, V-various).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg).

Data Range	Lognormal Distribution	Normal Distribution	Nonparametric equivalent
1 SD	(x)(SD)	x + (1)SD	84th quantile
2 SD	$(x)(SD)^{1.96}$	x+ (1.96)SD	97.5th quantile

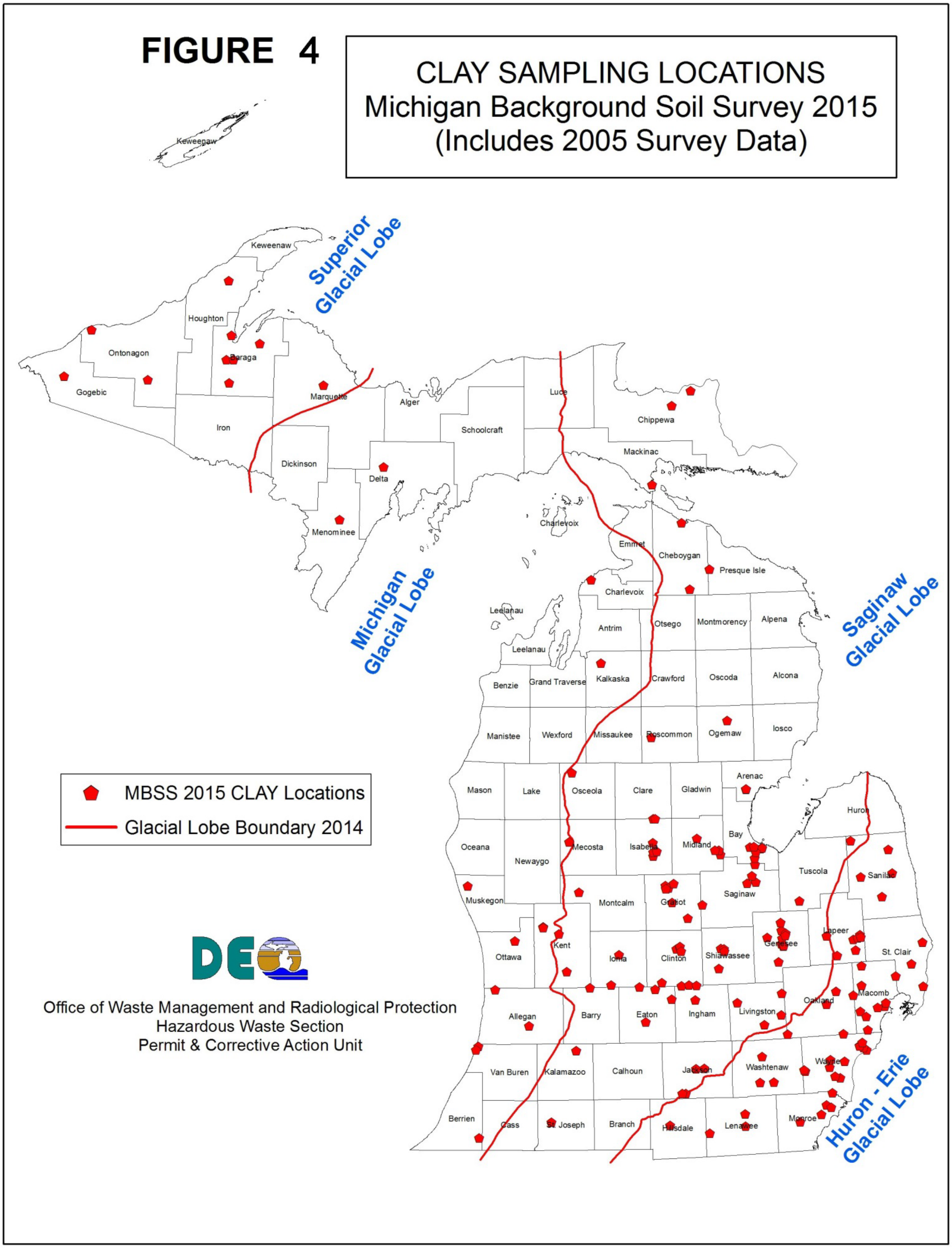


FIGURE 4

CLAY SAMPLING LOCATIONS
Michigan Background Soil Survey 2015
(Includes 2005 Survey Data)

References

(1) Background soil data:

a) The RRD Soil Background Technical Assistance Program Support (TAPS) Team was formed, that includes technical staff with backgrounds in geology, environmental engineering, quality assurance, soil science, chemistry and statistics, including a representative from each of DEQ's District offices. The TAPS Team developed the data collection Data Quality Objective (DQO). This team compiled and analyzed the new data to ensure that it met the data quality objectives specified. This TAPS team will work with stakeholders to ensure that the process is transparent and the results are technically sound.

b) Data was collected, organized, scanned and data entered into spreadsheets by Zachary Spots (student intern from Western Michigan University) and RRD staff in Lansing and the District offices.

c) A Data Quality Objective (DQO) dated September 20, 2013 was developed to describe how to collect new data and accept as valid natural background. Data collection followed this DQO. A separate DQO dated July 10, 2014 was completed address the statistical review of the data.

(2) Glacial Lobe Boundaries:

Black, R. F., Valderan glaciation in western upper Michigan, *in* Proceedings 12th International Association Great Lakes Research Conference, Ann Arbor, Michigan, 1969, p. 116-123.

Clayton, L., Attig, J., Mickelson, D., Johnson, M. D., and Syverson, K., 2006, Glaciation of Wisconsin, Wisconsin Geological and Natural History Survey Educational Series, Volume 36.

Esch, J., 2014, Draft bedrock topography map: Michigan Department of Environmental Quality, Office of Oil, Gas and Minerals.

Farrand, W. R., and Bell, D. L., 1982a, Quaternary geology of northern Michigan (map, 1: 500,000). Department of Geological Sciences, University of Michigan.

Farrand, W. R., and Bell, D. L., 1982b, Quaternary geology of southern michigan (map, 1: 500,000). Department of Geological Sciences, University of Michigan.

Farrand, W. R., and Eschman, D., 1974, Glaciation of the southern peninsula of Michigan: a review: Michigan Academician, v. 7, no. 1, p. 31-56.

Indiana Geological Survey, 1989, SURFICIAL_GEOL_MM49_IN: Quaternary Geologic Map of Indiana: Indiana Geological Survey, scale 1:500,000, polygon shapefile.

Kehew, A. E., Nicks, L. P., Kendzierski, S., and Straw, W. T., n.d., Glacial terrain map of St. Joseph County, Michigan: Western Michigan University, Department of Geology, Institute for Water Sciences, contributions by R. Christopher Gardner and Andrew Flint, cartography by Greg Anderson (WMU College of Arts & Sciences, GIS Research Center), scale 1:62,500.

Krist, F., 2012, Deglaciation of Michigan: detailed deglaciation Part 1. [Series of images created by Frank Krist, former Geography/Archeology grad student, and edited by Dr. Randal J. Schaetzl, Michigan State University, to help students understand the deglaciation history of Michigan, compiled for educational use only, and may not be reproduced without permission from Dr. Schaetzl (soils@msu.edu)].

Martin, H., 1957, Map of the surface formations of the Northern Peninsula of Michigan: Michigan Geological Survey Division Publication 49 [pt. 2], scale 1:500,000.

Martin, H. M., 1957-1958, "Outline of the Geologic History" series for 14 counties (Branch, Cheboygan, Hillsdale, Ingham, Kalamazoo, Lenawee, Mecosta, Midland, Oceana, Ogemaw, Ottawa, Roscommon, Saginaw and Shiawassee) and the Grand Traverse region.: Lansing, MI, Michigan Department of Conservation, Geological Survey Division.

MDNR, 1998, Template - Quaternary Geology: Lansing, MI, Michigan Department of Natural Resources.

MDTMB Center for Shared Solutions and Technology Partners, 2014, 1982 Quaternary Geology (shapefiles), *in* Michigan Department of Technology Management and Budget (MDTMB), ed.: Lansing, MI.

Ohio Division of Geological Survey, 2005, Glacial map of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,000,000.

Ontario Geological Survey, 1997, Quaternary geology, seamless coverage of the province of Ontario: Ontario Geological Survey, Data Set 14. (digital map).

Ontario Geological Survey, 2011, 1:250 000 scale bedrock geology of Ontario; Ontario Geological Survey, Miscellaneous Release–Data 126 - Revision 1.

Regis, R. S., 1997, Late Pleistocene glacial history of central Marquette and northern Dickinson counties [Doctor of Philosophy: Michigan Technological University.

Schaetzl, R. J., 2001, Late Pleistocene ice-flow direcions and the age of glacial landscapes in northern lower Michigan: Physical Geography, v. 22, no. 1, p. 28-41.

Shah, B. P., 1974, Glacial aggregate evaluation in Kalamazoo County and vicinity, Michigan, Research Report No. R-835: Lansing, MI, Michigan State Highway and Transportation Commission.

Wingard, N. E., 1971, Evaluation of aggregate sources of glacial origin - final report on a highway planning and research investigation conducted in cooperation with the U. S. Department of Transportation Federal Highway Administration, Research Report No. R-746: Lansing, MI, Michigan State Highway Commission.

Winters, H., Rieck, R., and Lusch, D., Quaternary geomorphology of southeastern Michigan, *in* Proceedings Field Trip Guide, AAG Annual Meeting1985, Department of Geography, Michigan State University East Lansing, MI, p. 104.

3) Statistics

Gilbert, R., 1987, Statistical Methods for Environmental Pollution Monitoring Gilbert: Van Nostrand Reinhold Company Inc., New York.

Insightful Corporation, 1988 [2003], S-PLUS 6.2 Professional [statistics software].

MDEQ RRD Soil Background Technical Assistance Program Support Team, 2014, Statistical review for Michigan counties supplemental soil background study 2014 DQO.

Millard, S. P., 2002, EnvironmentalStats for S-Plus: User's Manual for Version 2.0, Springer Science & Business Media.

Appendix D

MODIFIED TABLES 2, 3, AND 4

2005 Michigan Background Soil Survey UPDATED 2015

Table 2 - TOPSOIL

	Dist.	Part 201 Statewide Default Background	Table 1 Upper Range Value	Glacial Lobe Area											
				HURON - ERIE			SAGINAW			MICHIGAN			SUPERIOR		
				n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles
Aluminum (Al)	L	6,900	16,014	11	9,294	#	47	10,908	#	25	3,121	#	15	15,072	#
Antimony (Sb)	Np	NA	11.5	0	--	--	1	--	--	0	--	--	0	--	--
Arsenic (As)	L	5.8	22.8	51	14.9	#	103	11.8	#	29	4.5	#	17	4	#
Barium (Ba)	L	75	172	16	261	#	52	77.9	#	29	65.7	#	17	124	#
Beryllium (Be)	Np	NA	1	2	--	--	13	#	0.71	0	--	--	0	--	--
Cadmium (Cd)	Np	1.2	2	16	#	2	52	#	<2.0	29	#	<2.0	17	#	<2.0
Chromium (Cr)	L	18	55.6	19	37	#	53	30.9	#	29	10.7	#	17	37	#
Cobalt (Co)	Np	6.8	26.8	11	#	7	39	#	6.1	23	#	<5.0	15	#	11.8
Copper (Cu)	L	32	50.6	16	52.5	#	53	23.5	#	29	12.4	#	17	159	#
Iron (Fe)	L	12,000	34,311	11	20,244	#	51	27,590	#	29	7,186	#	17	21,632	#
Lead (Pb)	CL	21	38.9	42	43.9	#	67	30.2	#	29	22.4	#	17	74.3	#
Lithium (Li)	V	9.8	37.9	11	10.6	#	43	14.8	#	23	3	#	17	10.5	#
Magnesium (Mg)	L	NA	36,049	5	13,489	#	5	4,604	#	0	--	--	0	--	--
Manganese (Mn)	L	440	1,212	11	2,510	#	52	905	#	29	1,228	#	17	866	#
Mercury (Hg)	Np	0.13	0.5	16	#	0.16	52	#	0.4	29	#	0.1	17	#	0.12
Molybdenum (Mo)	Np	NA	5	2	--	--	12	#	<5.0	0	--	--	0	--	--
Nickel (Ni)	V	20	55.2	12	16.6	#	52	14	#	29	7.1	#	17	71.2	#
Selenium (Se)	Np	0.41	1.3	23	#	4.7	51	#	0.65	29	#	0.53	17	#	0.65
Silver (Ag)	Np	1	1.4	6	#	1.6	5	#	<0.25	0	--	--	0	--	--
Sodium (Na)	V	NA	519	2	--	--	5	140	#	0	--	--	0	--	--
Strontium (Sr)	Np	NA	150	0	--	--	7	#	156	0	--	--	0	--	--
Thallium (Tl)	Np	NA	2.7	2	--	--	5	#	<1.0	0	--	--	0	--	--
Titanium (Ti)	N	MNL	208	2	--	--	12	219	#	0	--	--	0	--	--
Vanadium (V)	L	NA	59.6	2	--	--	12	30.5	#	0	--	--	0	--	--
Zinc (Zn)	L	47	118	27	122	#	53	76.1	#	29	45.8	#	17	148	#

All data in mg/kg (ppm)

Dist.	Distribution of data
L	Lognormal distribution
N	Normal distribution
CL	Censored lognormal distribution
Np	Nonparametric distribution
V	Various distributions

n	Number of samples
SD	Arithmetic or geometric standard deviation, not applicable for nonparametric.
NA	Not Applicable (no value listed in Part 201)
MNL	Metal not listed in Part 201 Criteria
--	No value calculated due to too few samples/detections
#	Not appropriate calculation method
(grey cell)	Less than Table 1 Upper Range Value

2005 MBSS
Updated 2015

Table 3 - SAND

	Dist.	Part 201 Statewide Default Background	Table 1 Upper Range Value	Glacial Lobe Area											
				HURON - ERIE			SAGINAW			MICHIGAN			SUPERIOR		
				n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles
Aluminum (Al)	L	6,900	16,014	31	**8,233**	#	162	**8,218**	#	67	**6,151**	#	26	**27,446**	#
Antimony (Sb)	Np	NA	11.5	15	#	**8.7**	58	#	**10.8**	50	#	**5**	57	#	**1.9**
Arsenic (As)	L	5.8	22.8	175	**26.3**	#	509	**17**	#	194	**5.7**	#	87	**4.1**	#
Barium (Ba)	L	75	172	103	**199**	#	374	**66.2**	#	199	**62.5**	#	85	**105**	#
Beryllium (Be)	Np	NA	1	31	#	**0.78**	125	#	**1**	74	#	**1**	57	#	**0.86**
Cadmium (Cd)	Np	1.2	2	97	#	**2**	378	#	**2**	214	#	**2**	79	#	**2**
Chromium (Cr)	L	18	55.6	67	**30.4**	#	219	**19.7**	#	100	**18.7**	#	60	**23**	#
Cobalt (Co)	CL	6.8	26.8	78	**17.9**	#	376	**15.3**	#	226	**15.2**	#	95	**35**	#
Copper (Cu)	L	32	50.6	116	**23.5**	#	397	**20.2**	#	210	**29.8**	#	92	**120**	#
Iron (Fe)	L	12,000	34,311	36	**21,359**	#	165	**19,972**	#	80	**11,486**	#	60	**36,891**	#
Lead (Pb)	CL	21	38.9	132	**24.1**	#	429	**18**	#	245	**17.7**	#	155	**25.1**	#
Lithium (Li)	V	9.8	37.9	7	**9.6**	#	101	**13.5**	#	22	**11.6**	#	18	**25.9**	#
Magnesium (Mg)	L	NA	36,049	18	**15,008**	#	112	**18,063**	#	46	**18,255**	#	26	**9,110**	#
Manganese (Mn)	L	440	1,212	24	**873**	#	170	**664**	#	73	**745**	#	65	**1,225**	#
Mercury (Hg)	Np	0.13	0.5	102	#	**0.12**	320	#	**0.23**	188	#	**0.1**	82	#	**0.11**
Molybdenum (Mo)	Np	NA	5	17	#	**5**	95	#	**5**	45	#	**<5.0**	53	#	**1.4**
Nickel (Ni)	V	20	55.2	49	**30**	#	201	**18.5**	#	128	**25.9**	#	78	**22.9**	#
Selenium (Se)	Np	0.41	1.3	109	#	**3.9**	336	#	**1.1**	175	#	**1**	74	#	**0.91**
Silver (Ag)	Np	1	1.4	92	#	**1.2**	296	#	**<2.0**	185	#	**0.79**	78	#	**0.5**
Sodium (Na)	V	NA	519	17	**487**	#	103	**567**	#	40	**150**	#	24	**131**	#
Strontium (Sr)	Np	NA	150	4	#	**141**	31	#	**150**	9	#	**94**	15	#	**72**
Thallium (Tl)	Np	NA	2.7	39	#	**3.2**	127	#	**2**	63	#	**1.7**	58	#	**1.2**
Titanium (Ti)	N	MNL	208	4	**239**	#	58	**194**	#	12	**218**	#	0	**--**	**--**
Vanadium (V)	L	NA	59.6	39	**38.5**	#	145	**37.1**	#	77	**26.7**	#	59	**77.5**	#
Zinc (Zn)	L	47	118	115	**85.8**	#	391	**73.6**	#	200	**56.4**	#	91	**72.6**	#

All data in mg/kg (ppm)

Dist.	Distribution of data
L	Lognormal distribution
N	Normal distribution
CL	Censored lognormal distribution
Np	Nonparametric distribution
V	Various distributions

n	Number of samples
SD	Arithmetic or geometric standard deviation, not applicable for nonparametric.
NA	Not Applicable (no value listed in Part 201)
MNL	Metal not listed in Part 201 Criteria
--	No value calculated due to too few samples/detections
#	Not appropriate calculation method
(shaded)	Less than Table 1 Upper Range Value

2005 MBSS
Updated 2015

Table 4 - CLAY

	Dist.	Part 201 Statewide Default Background	Table 1 Upper Range Value	Glacial Lobe Area											
				HURON - ERIE			SAGINAW			MICHIGAN			SUPERIOR		
				n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles	n	2 SD	97.5 Quantiles
Aluminum (Al)	L	6,900	16,014	56	**19,049**	#	62	**14,508**	#	3	**25,470**	#	3	**12,080**	#
Antimony (Sb)	Np	NA	11.5	42	#	**13**	33	#	**1**	3	#	**<50**	0	**--**	**--**
Arsenic (As)	L	5.8	22.8	237	**31.4**	#	354	**17.1**	#	29	**8.7**	#	10	**10.4**	#
Barium (Ba)	L	75	172	166	**227**	#	171	**198**	#	25	**108**	#	4	**550**	#
Beryllium (Be)	V	NA	1	35	**1.43**	#	42	**1.7**	#	5	**1**	#	6	**2.9**	#
Cadmium (Cd)	Np	1.2	2	196	#	**3.1**	240	#	**2.4**	25	#	**2**	4	#	**<1.0**
Chromium (Cr)	L	18	55.6	139	**77**	#	141	**43.5**	#	8	**72**	#	9	**68.8**	#
Cobalt (Co)	CL	6.8	26.8	98	**27.4**	#	167	**41.2**	#	30	**27.6**	#	19	**37.5**	#
Copper (Cu)	L	32	50.6	192	**46.9**	#	232	**32.2**	#	29	**23.9**	#	10	**80.4**	#
Iron (Fe)	L	12,000	34,311	59	**36,908**	#	52	**38,301**	#	5	**30,082**	#	3	**13,674**	#
Lead (Pb)	CL	21	38.9	196	**26.2**	#	267	**42.9**	#	29	**15.2**	#	11	**34.1**	#
Lithium (Li)	L	9.8	37.9	32	**40.4**	#	25	**39**	#	4	**16.9**	#	9	**36**	#
Magnesium (Mg)	L	NA	36,049	20	**93,692**	#	15	**170,203**	#	1	**--**	**--**	0	**--**	**--**
Manganese (Mn)	L	440	1,212	53	**935**	#	65	**661**	#	6	**605**	#	9	**758**	#
Mercury (Hg)	Np	0.13	0.5	168	#	**0.58**	164	#	**0.5**	20	#	**0.7**	10	#	**0.61**
Molybdenum (Mo)	Np	NA	5	14	#	**5**	27	#	**5**	4	#	**<3.0**	6	#	**<3.0**
Nickel (Ni)	V	20	55.2	140	**43.4**	#	126	**36**	#	9	**42.1**	#	9	**30.6**	#
Selenium (Se)	V	0.41	1.3	189	**1.2**	#	169	**1.1**	#	27	**1.5**	#	10	**0.67**	#
Silver (Ag)	Np	1	1.4	139	#	**6**	148	#	**1**	23	#	**0.5**	1	**--**	**--**
Sodium (Na)	V	NA	519	10	**594**	#	14	**351**	#	1	**--**	**--**	0	**--**	**--**
Strontium (Sr)	Np	NA	150	6	#	**150**	1	**--**	**--**	2	**--**	**--**	6	#	**150**
Thallium (Tl)	Np	NA	2.7	39	#	**1.7**	33	#	**<1.5**	3	#	**<0.50**	0	**--**	**--**
Titanium (Ti)	N	MNL	208	1	**--**	**--**	8	**255**	#	0	**--**	**--**	0	**--**	**--**
Vanadium (V)	L	NA	59.6	28	**95.1**	#	33	**48.7**	#	5	**110**	#	6	**129**	#
Zinc (Zn)	L	47	118	218	**102**	#	212	**91.9**	#	29	**68.3**	#	10	**204**	#

All data in mg/kg (ppm)

Dist.	Distribution of data
L	Lognormal distribution
N	Normal distribution
CL	Censored lognormal distribution
Np	Nonparametric distribution
V	Various distributions

n	Number of samples
SD	Arithmetic or geometric standard deviation, not applicable for nonparametric.
NA	Not Applicable (no value listed in Part 201)
MNL	Metal not listed in Part 201 Criteria
--	No value calculated due to too few samples/detections
#	Not appropriate calculation method
(shaded)	Less than Table 1 Upper Range Value

2005 MBSS
Updated 2015

Appendix E

APPLICATION OF SOIL BACKGROUND IN FILL

2005 Michigan Background Soil Survey UPDATED 2015

APPENDIX E - Soil Background and Use of the 2005 Michigan Background Soil Survey

APPLICATION OF SOIL BACKGROUND FOR FILL MATERIAL

For this document, the following terms are defined:

Definitions:

Background concentration: Concentration or level of a hazardous substance that exists in the environment at or regionally proximate to a facility that is not attributable to any release (Section 20101(1)(e)).

Environmental contamination: Release of a hazardous substance, or the potential release of a discarded hazardous substance, in a quantity which is or may become injurious to the environment or to the public health, safety, or welfare (Section 20101(1)(p)).

Glacial lobe: Geographic area defined by characteristic glacial deposition of soil and rock by fingers or lobes of ice as the glacier advanced and retreated.

Natural fill: Fill that is entirely comprised of soil that is unaltered by human activity from when it was originally generated by natural processes and is not associated with a release.

- **Native fill:** Natural fill from the same glacial lobe area based on the glacial lobe areas depicted in the Michigan Background Soil Survey.
- **Non-native fill**: Natural fill from a different glacial lobe area based on the glacial lobe areas depicted in the Michigan Background Soil Survey.

Non-natural fill: Fill that is comprised of a mixture of soil and waste materials, e.g., coal, clinkers, slag, cement kiln dust, foundry sand, stamp sands, fly ash, etc.

Soil: An unconsolidated mixture of weathered rock, such as, sand, silt, clay, etc. that may contain organic matter, and is produced through natural processes.

TAPS Team: Technical Assistance and Program Support Team that provides technical advice based on subject area technical experience and knowledge, and/or guidance, or direction consistent with statute, rule and policy and procedure.

Purpose:

Background concentrations by definition are developed as the level of hazardous substance that exists in the environment[1]. Environment is defined as natural resources that includes land (soils) and groundwater[2]. The generic criteria, as referenced in the criteria tables, are

[1] Sec.20101(1)(e)
[2] Sec. 20101(1)(o)

developed for soil or groundwater[3]. The generic soil criteria include soil chemical and physical properties in their development. The provisions for developing generic cleanup criteria states that if the background concentration for a hazardous substance is greater than the generic cleanup criterion, the background concentration becomes the criterion[4].

Natural fill consists entirely of soil. Non-natural fill material contains soil (derived locally or brought onsite) and waste (e.g., coal ash, foundry sands, dredged spoils, and construction debris). The application of background to natural and non-natural fill materials may be acceptable when the fill material is soil, or it can be demonstrated that the mixture of soil and waste does not alter the soil properties used to develop criteria. EGLE has the ability to make a determination whether the presence of waste in soil represents "environmental contamination". EGLE may determine if the presence of waste in soil is not injurious to the environment or to the public health, safety, or welfare. This requires an official EGLE determination that the quantity and characteristics of waste in the soil would not likely affect soil properties and allow background concentrations to apply. If the waste in the soil is determined to represent environmental contamination and likely to affect soil properties, then soil background concentrations cannot apply.

This document details a process to determine whether soil background may replace generic or site-specific criteria if background concentrations exceed criteria in fill material. An EGLE site-specific determination through the TAPS Team is required to allow the use of soil background concentrations for a non-natural fill on a specific property. The information necessary for an EGLE determination and the review process is included in this document.

Statute and References:

Background concentration is defined in Section 20101(1)(e) of Part 201 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), as the concentration or level of a hazardous substance that exists in the environment at or regionally proximate to a facility that is not attributable to any release at or regionally proximate to the facility. All of the background concentrations in the Statewide Default Background Levels and the Michigan Background Soil Survey are based on naturally occurring concentrations, and do not represent anthropogenic concentrations. Section 20120a(10) states "If the . . . background concentration for a hazardous substance is greater than a cleanup criterion developed for a category pursuant to subsection (1), the criterion is the . . . background concentration, whichever is larger, for that hazardous substance in that category." This means that the background concentrations become criteria when the criteria are less than the background concentrations. Because the background concentration definition defines background as concentrations not attributable to any release, only naturally occurring background concentrations can become criteria.

[3] R 299.46-49 or Rules 46 -49

[4] Sec. 20120a(10)

APPENDIX E - Soil Background and Use of the 2005 Michigan Background Soil Survey

Natural Fill:

Natural fill is fill that is entirely comprised of soil that is unaltered by human activity from when it was originally deposited by natural processes and is not associated with a release. Natural fill can be native, indicating its origin is in the same glacial lobe area as its current location. The glacial lobe areas in Michigan are depicted in the Michigan Background Soil Survey. An example of native fill would be soil moved from an uncontaminated sand pit in Owosso, Michigan to a property in Ionia, Michigan, both cities being located within the Saginaw Glacial Lobe. Non-native fill is natural fill moved from one glacial lobe area into another glacial lobe area. An example of non-native fill would be natural fill moved from Caseville, Michigan, which is in the Saginaw Lobe, and placed on a property in Muskegon, Michigan, which is located in the Michigan Glacial Lobe.

Section 20101(1)(e) allows four different methods to determine background concentrations. Method (i) is the Statewide Default Background Levels (SDBLs) that are included with the table of Part 201 Generic Cleanup Criteria and Part 213 Risk Based Screening Levels. The SDBLs are applicable to native and non-native natural fill and can be used for any soil type for the entire state.

Method (ii) is the use of the Michigan Background Soil Survey (MBSS). The background concentrations listed in both the 2005 MBSS and the MBSS Updated 2015 are broken down by glacial lobe area and by soil type. The background concentrations from the MBSS can be utilized for native and non-native natural fill <u>based on the glacial lobe placement location of the fill</u>. For example, if natural fill from the Saginaw Glacial Lobe was placed on a property in the Michigan Glacial Lobe, the background concentrations from the Michigan Glacial Lobe would apply to the fill. While the origin glacial lobe location of the natural fill is not necessary to utilize the MBSS, additional investigation may be necessary to confirm the soil is natural fill and not contaminated.

Method (iii) allows the use of a background concentration listed in a study or survey conducted or approved by the department. Up to the date of this document, a study or survey under Method (iii) has not been approved.

Method (iv) are background concentrations from a site-specific demonstration. EGLE approval is required for the use of naturally occurring background concentrations established under Method (iv) in accordance with Section 20120b(2). A site-specific background concentration established for a native soil that originated at that property, can be used for natural fill located at the same property and is the same soil type upon EGLE approval. For example, both sand and clay were brought to a property as natural fill. A site-specific background was established for the property using the native soil that originated at the property, which is sand. The site-specific background could be applied to the natural fill that is sand, if the site-specific background is higher than criteria. However, this site-specific background could not apply to the natural fill that was clay. It is important to note that a site-specific background concentration is approved to use only at the origin property. A site-specific background concentration established for native soil on the origin property cannot be used for soil that was moved from the origin property to another location. For example, a site-specific background concentration was established and approved for a native soil on a property in Muskegon (origin property). This native soil from Muskegon was then moved to another property to be used as fill material at a property in Benton Harbor. The site-specific background concentration only applies to the origin property in Muskegon, not to the location the soil was used as fill in Benton Harbor.

Non-natural Fill:

Non-natural fill is fill that is comprised of soil and any amount of waste, like coal, coal ash, clinkers, slag, cement kiln dust, foundry sand, fly ash, stamp sands, etc. Waste in soil can fundamentally alter soil properties like soil texture and soil chemistry that are used in developing criteria. By altering the texture of soil with wastes, such as slag or foundry sand, the naturally occurring metal concentration can be altered by changing how much metals are weathering and leaching out of the soil mixture. Additionally, Part 201 criteria are based on specific soil properties (e.g., adherence, absorption, etc.) and these properties can be changed by the addition of waste. Certain types of waste can alter the pH, such as cement kiln dust, allowing some naturally occurring metals, such as lead, to leach in alkaline conditions. There are methods to differentiate naturally occurring metals from metals related to the waste material (e.g., bioavailability, chromium speciation) that may be conducted.

In using a naturally occurring background concentration, it is assumed there is a certain amount of metal concentration that relates entirely to natural conditions. However, the assumption for how much of the metal contaminant in the soil is from naturally occurring concentrations can no longer be true when soil properties have been altered by waste. It is not appropriate to use the naturally occurring background concentrations to replace generic or site-specific criteria for facilities where waste has altered the soil properties.

Non-natural fill material may fall under the provisions outlined in Part 115, Solid Waste Management of NREPA. If fill material is entirely composed of Solid Waste as defined in Section 11506(1), soil background concentrations cannot apply to the fill. Solid Waste is defined as garbage, rubbish, ashes, incinerator ash, incinerator residue, street sweepings, municipal and industrial sludges, solid commercial waste, solid industrial waste, and animal waste. Further information, including exemptions from Solid Waste, can be found in Section 11506 of NREPA or by consulting with Materials Management Division (MMD) staff in the EGLE District office representing the location of the site. If there is written approval from EGLE's MMD under Section 11553 that is specifically for the fill material from a particular location that has been categorized as beneficial use by-product or inert material, further evaluation whether soil background concentrations can apply to the fill by the RRD is not necessary.

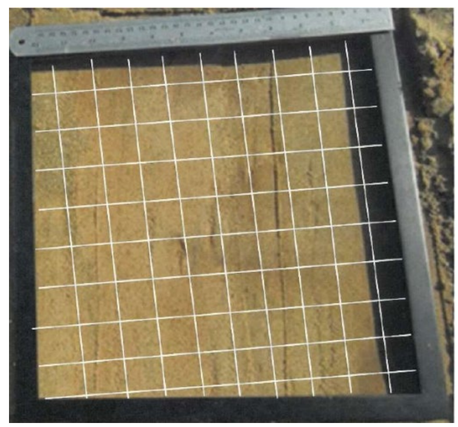
It is also prudent to determine if the site in question is a Hazardous Waste Treatment, Storage, or Disposal facility, where compliance with all Part 201 obligations may not address all environmental obligations at the site. Please see this map to see if your site is within one mile of a Hazardous Waste Treatment, Storage, or Disposal facility. If your site is within one mile of a Hazardous Waste Treatment, Storage, or Disposal facility, please consult with the MMD's Hazardous Waste Section for further information.

Submittal Contents for Determination of Use of Background for Non-natural Fill:

A person may request an EGLE determination to allow the use of soil background concentrations for a non-natural fill on a specific property only if there 10% or less waste present. **The full extent of the fill area(s) must be adequately characterized, including soil type, fill thickness and depth.** If eligible, the following information, as applicable, should be supplied to EGLE RRD in the district where the property with the non-natural fill is located in for review. If the non-natural fill contains less than 10% waste by weight or volume, after review of all factors listed and it is determined that the presence of the waste is not injurious to public health, safety, welfare and the environment, EGLE staff consistent with this process may determine that background concentrations may apply for the non-natural fill. A cover letter with the request for EGLE to determine whether background concentrations can apply to a non-natural fill must be included with each submittal. Timeframes for review should take all steps into consideration along with statutory deadlines, such as if this request was submitted with a No Further Action Report.

- **Property Information** - Facility or Site Name and ID for the property where the non-natural fill is located. Also include property address and proposed activities on the property.
- **Current and proposed land use** – Describe the current and proposed land use of the property where the non-natural fill is located.
- **Location and amount of non-natural fill material** – Provide site figures, boring logs and photographs to show where in the soil column the non-natural fill material is located and the horizontal and vertical extent of the fill material. Provide an estimate in cubic yards of the amount of non-natural fill material on the property.
- **Type(s) of waste** – Describe the type(s) of waste included in the non-natural fill (e.g. coal, clinkers, slag, CKD, foundry sand, fly ash, demolition debris, etc.). Please provide digital photographs or video of the non-natural fill in-situ with enough detail to show grain size, color, and waste type.

- **Quantity of waste** – Determine the percentage of waste in the non-natural fill. If the non-natural fill contains greater than 10% waste by volume or by dry weight, the non-natural fill is considered to be waste, soil background will not apply, and must be addressed instead with provisions under Part 115 or Part 111. Determinations of the quantity of waste may be made by weight if the waste is large enough in size to be manually segregated from the fill. The ASTM D6913/D6913M-17 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis testing method may be used for this analysis with the modification of obtaining the weight of the segregated waste. If the waste within the fill cannot be manually segregated, a visual method may be utilized. To assure the method will be acceptable, please contact the RRD state project manager for the area of the property of interest to discuss the proposed method. If the waste cannot be manually segregated from the soil matrix and the waste is visually indistinguishable from the soil matrix, soil background will not apply, and must be addressed instead with provisions under Part 115 or Part 111.



- **Source of non-natural fill** – Describe the source of the non-natural fill, if known. Include the property address, property owner information, and glacial lobe of both the waste and soil matrix. Provide the historic usage of the waste and non-natural fill source property and purpose it was placed on the current property.
- **Contaminants in non-natural fill** – Provide analytical results of the non-natural fill material compared to Generic Cleanup Criteria or Risk-Based Screening Levels. Describe the sampling protocol used to collect the samples and provide the laboratory analytical report with chain of custody. The samples will be analyzed at a minimum for Michigan Ten Metals (arsenic, barium, cadmium, total chromium (combined hexavalent and trivalent), copper, mercury, selenium, silver, and zinc. Additional metals may need to be added for analysis depending on the waste type. For example, if there is cement kiln dust mixed with the soil, the non-natural fill should also be analyzed for molybdenum, thallium and vanadium. Contact the RRD Project Manager if there are questions regarding appropriate analysis for a waste type. There also should be a representative number of samples analyzed for pH. Overall, there should be sufficient number of soil samples to adequately characterize the vertical and horizontal extent of non-natural fill that is located on the property.
- **Leaching potential** - Conduct leachate testing using Synthetic Precipitation Leaching Procedure (SPLP) on the non-natural fill material sample with the highest metals

concentration to determine the likelihood of metals contamination leaching from the non-natural fill and potentially entering groundwater or surface water. An analysis of the samples of the same non-natural fill that is leach tested must be conducted to determine concentrations of the metals in the non-natural fill prior to leaching. A separate non-natural fill sample cannot be subsequently collected after leaching is conducted and used to determine concentrations of metals. The laboratory data for the total metal concentrations in the non-natural fill needs to be provided with the laboratory data for concentrations leached from the non-natural fill.

Mercury, Non-Natural Fill and the Volatilization to Indoor Air Pathway (VIAP)

There is an additional process that can support the use of soil background concentrations to replace **mercury**[5] VIAP screening levels or site specific criteria in non-natural fill. For the VIAP, the key soil properties and characteristics that affect how the fill materials differ from soil for generic exposure assumptions are different from other pathways. The extent to which the media (e.g., fill materials) allows vapors to migrate through it is mainly dependent on particle or grain size, not other soil characteristics that would differ between native soils and common industrial fill materials. Therefore, where there is no other indication of a potential mercury release in fill materials, the statewide default background level or MBSS glacial lobe area sand background concentration may replace the mercury VIAP screening levels or site specific criteria when:

1. The non-natural fill material is not garbage, rubbish, street cleanings, municipal and industrial sludges, solid commercial waste, solid industrial waste, or animal waste as included in the solid waste definition of Part 115, but may include other common non-natural fill materials as defined by this document.
2. There has been a grain size analysis using a US Standard Sieve No 10, and 85% of the material (non-natural fill and/or soils) passes through the sieve.

This is a site-specific evaluation that would require department approval. A submittal for department approval should contain information regarding the location and amount of non-natural waste including the locations where samples were conducted as part of this process, confirmation that the waste contains defined non-natural materials, and documentation that the results of the grain size analysis resulted in 85% of the material passing through the sieve.

[5] Mercury is both naturally occurring and a volatile under Part 201 and Part 213 allowing the use of a background concentration for the VIAP.

APPENDIX E - Soil Background and Use of the 2005 Michigan Background Soil Survey

Frequently Asked Questions (FAQs):

The following are common questions asked about the use of soil background concentrations from Methods (i) through (iv) to replace criteria for fill material:

1. Is extra soil from construction work considered "fill"?
   Soil brought on to a property for construction is typically a sand backfill material, extracted from a local "sand and gravel pit". While some pits have been used to illegally dispose of waste, some pits are a source of uncontaminated fill material that could be considered natural fill. Extra soil that was removed from a property to accommodate construction could also be considered natural fill, if the soil was unaltered other than its removal from the ground and there has been no release at the property. Documentation of the source of the natural fill needs to be obtained for verification to ensure that it is not non-natural fill.

2. If there is non-natural fill that has metals concentration less than the soil background concentration, but greater than criteria, is cleanup required?
   This document provides a method for a person to request that soil background be applied to a particular non-natural fill material on a property. Without authorization from EGLE, soil background concentrations cannot replace criteria for non-natural fill. The necessity of remedial action for relevant pathways and exceedances of applicable criteria and/or response action to address an unacceptable exposure for a complete pathway will depend on the results of the site characterization.

3. Can you apply SDBLs or MBSS background concentrations for natural fill when the source of the natural fill is unknown? If so, what glacial lobe for the MBSS would you use if geographical source is unknown?
   Both the SDBLs and the MBSS background concentration can apply to natural fill from an unknown source. However, additional investigation may need to be conducted to confirm it is natural fill and does not contain waste or contaminants indicative of a release not associated with contaminants in the native soil on the property. The MBSS background concentration that can apply in this situation must be based on the glacial lobe(s) the natural fill is currently located in and the soil type of the natural fill.

4. What if the fill is MDOT Class II sand from a local source or a source within Michigan?
   In most cases, sand from a local sand and gravel pit can be considered natural fill and documentation of the source can be readily obtained. An exception would be if the pit

had been used for illegal disposal, causing a release. Commonly, the backfill material for large construction projects must be analyzed for both grain size and contaminants prior to the fill being brought onsite for this reason.

5. If natural fill (e.g. clay) excavated from the Huron-Erie lobe exceeds the MBSS background concentration for arsenic for that lobe, can it be moved within that lobe without creating a release?
   Section 20120a(10) states that a background concentration for a hazardous substance, if greater than a cleanup criterion, becomes the criterion for the hazardous substance. Using the MBSS, updated 2015, the arsenic background concentration for clay in the Huron-Erie lobe is 22,800 ug/kg. This concentration exceeds the arsenic Part 201 residential criteria for drinking water protection, groundwater surface water interface protection and direct contact, thus becomes the criteria. Using that information, if the arsenic concentration in the clay soil being excavated exceeds 22,800 ug/kg, then it exceeds all of the listed criteria, and the property is a Part 201 facility. Any relocation of this soil in any glacial lobe area, must comply with Section 20120c(1) or 21304b, relocation of contaminated soil, to avoid creating a new facility. Pursuant to Sections 20120c(1) or 21304b, contaminated soil shall not be relocated to a location that is not a facility or site.

6. For natural fill that is clay with concentrations of arsenic as high as 12,000 ug/kg, could that clay be used as fill at a property within the Saginaw Glacial Lobe? Within the Michigan Glacial Lobe?
   See the chart below. With the maximum MBSS background concentration for arsenic in clay soil in the Saginaw Glacial Lobe at 17,900 ug/kg exceeding the residential drinking water protection criteria, the groundwater surface water protection criteria and the residential direct contact criteria, the background concentration becomes all three of the criteria. The site concentration at 12,000 ug/kg does not exceed these criteria, thus as long as the concentrations of the arsenic in the natural fill was not related to any release or anthropogenic sources, the clay could be used as natural fill on properties within the Saginaw Glacial Lobe without creating a Part 201 facility.

   For properties in the Michigan Glacial Lobe, the maximum MBSS background concentration for arsenic in clay soil is 8,700 ug/kg, which still exceeds all three of the previously mentioned criteria and becomes the criteria. However, the clay from the Saginaw Glacial Lobe could NOT be used as natural fill on properties within the Michigan

Glacial Lobe without creating a new facility, as the arsenic concentration at 12,000 ug/kg exceeds criteria at 8,700 ug/kg.

UNITS ug/kg	MBSS Background Concentration - Clay, Saginaw Lobe		MBSS Background Concentration - Clay, Michigan Lobe		Residential Drinking Water Protection Criteria	Groundwater Surface Water Interface Protection Criteria	Residential Direct Contact Criteria
	2015	2005	2015	2005			
Arsenic	17,100	17,900	8,700	6,950	4,600	4,600	7,600