



Location Restrictions Demonstrations

**DTE Electric Company
Belle River Power Plant Diversion Basin
Coal Combustion Residual Unit**

4505 King Road
China Township, Michigan

October 2018



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Coal Combustion Residual Unit**

*4505 King Road
China Township, Michigan*

October 2018

*Prepared For
DTE Electric Company*

A handwritten signature in black ink, appearing to read "Graham Crockford".

Graham Crockford, C.P.G.
Senior Project Geologist

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David B. McKenzie, P.E.
Senior Project Engineer

TRC | DTE Electric Company

Final

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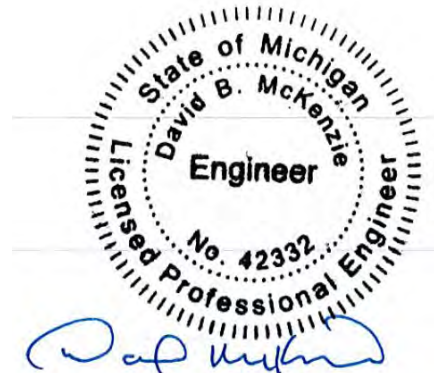
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Certification

I, the undersigned Michigan Professional Engineer, hereby certify that I am familiar with the technical requirements of Title 40 Code of Federal Regulations Part 257 Subpart D (§257). I also certify that it is my professional opinion that, to the best of my knowledge, information, and belief, that the information in this demonstration is in accordance with current good and accepted engineering practice(s) and standard(s) and meets the requirements of §257.60 through §257.64.

For the purpose of this document, “certify” and “certification” shall be interpreted and construed to be a “statement of professional opinion.” The certification is understood and intended to be an expression of my professional opinion as a Michigan Licensed Professional Engineer, based upon knowledge, information, and belief. The statement(s) of professional opinion are not and shall not be interpreted or construed to be a guarantee or a warranty of the analysis herein.



Seal/Date 10/15/18

David B McKenzie, P.E.

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Section 1

Background

The purpose of this document is to determine whether the Coal Combustion Residual (CCR) Diversion Basin (DB) at the Belle River Power Plant (BRPP) is in compliance with the location restrictions outlined in the Environmental Protection Agency's (EPA) final CCR rule [Title 40 Code of Federal Regulations Parts 257 and 261] Subpart D - "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" (§257.60 through §257.64, federal rule). The DB is considered a CCR surface impoundment according to the federal rule (§257.53).

This document includes information from a desktop study and well installation activities as well as engineering calculations to demonstrate that the DB is in compliance with placement above the uppermost aquifer criteria (§257.60), and location criteria with respect to wetlands (§257.61), fault areas (§257.62), seismic impact zones (§257.63), and unstable areas (§257.64).

Supporting documents are provided in appendices to this demonstration.

1.1 Facility and CCR Unit Information

The BRPP was constructed in the early 1980s, and is located in Section 13, Township 4 North, Range 16 East, at 4505 King Road, China Township in St. Clair County, Michigan. Prior to construction, the BRPP property was generally wooded and farmland. The property has been used continuously as a coal fired power plant since Detroit Edison Company (now DTE Electric) began power plant operations at BRPP in 1984 and is generally constructed over a natural clay-rich soil base. The DB, an incised CCR surface impoundment located west of the BRPP near the Webster Drain, has been in use at the BRPP since it began operation. Water flows into the DB from the North and South bottom ash basins (BABs) through a network of pipes and ditches. The DB discharges to the St. Clair River with other site wastewater in accordance with a National Pollution Discharge Elimination System (NPDES) permit.

1.2 Site Setting

A groundwater monitoring system has been established for the BRPP DB CCR unit as detailed in the Groundwater Monitoring System Summary Report – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin Coal Combustion Residual Units (GWMS Report) (TRC, October 2017). The detection monitoring well network for the DB CCR unit currently consists of six monitoring wells that are screened in the uppermost aquifer. The monitoring well boring logs are included in Appendix A.

The BRPP DB CCR unit is located approximately one-mile west of the St. Clair River. The DB is incised into the native clay to an elevation of 576 ft MSL. In general, the BRPP DB CCR unit is initially underlain by at least 130 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The silty clay-rich till is then underlain by two to seven feet of silt between the till and the underlying shale bedrock (not an aquifer) confining unit. Groundwater was encountered within this silt at the shale bedrock interface representing a potential confined uppermost aquifer in the BRPP DB CCR unit.

A definitive groundwater flow direction with a mean gradient in 2016 and 2017 of 0.003 foot/foot to the west-northwest within the uppermost aquifer is evident around the BRPP DB CCR unit; however, potential groundwater flow within this silt-rich uppermost aquifer is very slow (on the order of one-half foot per year).

Section 2

Location Restrictions

The location restrictions designated in the federal CCR rule are presented below with a corresponding demonstration to show compliance with each restriction. The location restrictions include placement above the uppermost aquifer, wetlands, fault areas, seismic impact zones, and unstable areas. Supporting information for the demonstrations is included in the appendices.

2.1 §257.60 – Placement above the Uppermost Aquifer

The federal CCR rule requires that CCR units such as the BRPP DB must be constructed with a base that is located no less than 1.52 meters (five feet) above the upper limit of the uppermost aquifer, or must demonstrate that there will not be an intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in the groundwater elevations (including the seasonal high water table. As stated in Section 1.2 (above), the DB is incised into the native clay to an elevation of 576 ft MSL. The uppermost aquifer is the sand rich unit found at an elevation of 453 to 498 ft MSL. The DB and the uppermost aquifer are separated by at least 82 ft of native low permeability clay. Cross-sections showing the basin bottom elevation and the depth to the uppermost aquifer are included in Appendix B.

Based on this demonstration, BRPP DB is located greater than five feet above the upper limit of the uppermost aquifer, and there is not a hydraulic connection between the DB and the underlying groundwater caused by normal fluctuation in groundwater level. Therefore, the DB is in compliance with the requirements of §257.60.

2.2 §257.61 – Wetlands

The CCR location standards restrict existing and new CCR surface impoundments from being located in wetlands, as defined at 40 CFR 232.2 (40 CFR 257.61(a)). Wetlands are defined in 40 CFR 232.2 *Waters of the United States (3)(iv)* as, "...those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." TRC reviewed National Wetland Inventory (NWI) Maps and Michigan Resource Information System (MIRIS) Land Cover Maps archived and available through Michigan Department of Natural Resources (MDNR) Michigan Resource Inventory Program (MRIP) to ascertain whether or not the BRPP DB is located in wetlands.

As shown on the map in Appendix C, soils at and in the vicinity of the site are designated primarily as wetland soils, most likely due to the proximity of the site to the St. Clair River. NWI (2005) recognizes areas 250 ft north of the DB and ¼ mile west of the DB as wetlands. These areas are not immediately adjacent to the DB, and therefore, there is no risk of impact to these areas from the DB operations.

Based on TRC's review of wetland inventory resources and current site conditions, TRC is of the opinion that the BRPP DB is not located in an area exhibiting wetland characteristics, and any continued operations at the DB will have no potential to impact any wetlands near the CCR unit. TRC also concludes that, due to its use as an NPDES treatment unit, the basin is not a wetland, as defined in 40 CFR 232.2.

2.3 §257.62 – Fault areas

The federal CCR rule requires that CCR units not be located within 60 meters (200 feet) of the outermost damage zone of a fault that has had displacement in Holocene time (within the most recent 11,700 years) unless the owner or operator demonstrates that an alternative setback distance of less than 60 meters (200 feet) will prevent damage to the structural integrity of the CCR unit. As shown on the U.S. Quaternary Folds and Faults Database Map (USGS, accessed 9/7/2018) in Appendix D, no faults have been mapped near the BRPP DB.

Evidence of active faulting during the Holocene in the BRPP DB area is not supported by this determination; therefore, the BRPP DB is in compliance with the requirements of §257.62.

2.4 §257.63 – Seismic Impact Zones

The federal CCR rule requires that CCR units not be located in seismic impact zones unless the owner or operator demonstrates that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site. The federal CCR rule defines a seismic impact zone as "an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitation pull (g), will exceed 0.10 g in 50 years."

To determine whether the BRPP DB is located in a seismic impact zone, the USGS Earthquake Hazards Program was consulted to determine the earthquake hazard for the BRPP. The 2015 National Earthquake Hazards Reduction Program U.S. seismic design maps website (USGS 2015; Appendix E) indicates a mapped peak ground acceleration of 0.043 g for the BRPP DB area. Using the default site adjustment factor results in a design peak ground acceleration of 0.068 g in 50 years. Since this calculation indicates that the design peak ground acceleration

value will not exceed 0.10 g in 50 years, the BRPP DB is not located in a seismic impact zone, and therefore the DB is in compliance with the requirements of §257.63.

2.5 §257.64 – Unstable Areas

The federal CCR rule requires that CCR units not be located in an unstable area unless the owner or operator demonstrates that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted. Factors associated with soil conditions resulting in significant differential settlement, geologic or geomorphologic features, and human-made features or events must be evaluated to determine compliance. This demonstration was performed by reviewing geotechnical data, local geology, topography, and evaluating humanmade features in the area of the BRPP DB.

Geotechnical explorations performed at the BRPP area identified clay with lenses of silt and sand. The clayey soils overlie shale bedrock. These observations suggest that there are no unstable soil or underlying bedrock conditions proximal to the site.

Geological and geomorphological information was reviewed to determine potential unstable areas at the BRPP BABs. There is no geological or geomorphological information to suggest the presence of unstable areas at the DB.

Evidence of unstable areas due to soil conditions resulting in significant differential settling, geologic or geomorphologic features, or human-made features or events is not supported by this determination; therefore, BRPP DB is not located in an unstable area. The DB is in compliance with the requirements of §257.64.

Section 3

Conclusions

Based on the evaluation provided in this demonstration, the BRPP DB is in compliance with the location restrictions provided in §257.60 through §257.64 of the CCR rule. No additional action, justification, or demonstration is required to document compliance with the location restrictions provided in the CCR rule after this demonstration has been placed into the operating record, posted to the publicly-accessible website, and government notifications provided.

Section 4

References

- TRC October 2017. Groundwater Monitoring System Summary Report – DTE Electric Company Belle River Power Plant Detention Basin Coal Combustion Residual Unit.
- TRC January 2018. Annual Groundwater Monitoring Report – DTE Electric Company Belle River Power Plant Detention Basin Coal Combustion Residual Unit.
- United States Fish and Wildlife Service. 2010. “Wetlands Mapper.” National Wetlands Inventory. Available online at <http://geohazards.usgs.gov/deaggint/2008/>. Accessed [8/17/2018].
- United States Geological Survey (USGS). 2015. U.S. Seismic Design Maps: 2015 National Earthquake Hazards Reduction Program Provisions. Available Online at <http://earthquake.usgs.gov/designmaps/beta/us/>. Accessed [8/16/2018].
- USGS. U.S. Quaternary Faults and Fold Database. USGS Geologic Hazards Science Center, Golden, CO Available online at <https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=db287853794f4555b8e93e42290e9716/>. Accessed [9/7/2018].

Appendix A

Monitoring Well Boring Logs



WELL CONSTRUCTION LOG

WELL NO. MW-16-01

Page 1 of 2

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 2/29/16	Date Drilling Completed: 2/29/16	Project Number: 231828.0003
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 588.17	TOC Elevation (ft) 591.30	Total Depth (ft bgs) 120.0
Boring Location: Approximately 188 feet off road to the S, W of bottom ash basins. N: 471155.70 E: 13625546.02		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 4/13/16 08:45	
				Depth (ft bgs) 14.52

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	60		5	<p>SILTY CLAY WITH GRAVEL mostly clay, little to some silt, little fine to coarse gravel, few fine sand, low plasticity, dark gray (10YR 4/1), moist, medium stiff.</p> <p>CLAY mostly clay, trace fine to coarse gravel, high plasticity, brown (10YR 5/3), moist, stiff.</p> <p>Change to dark gray (10YR 4/1), very stiff at 5.0 feet.</p> <p>Change to soft at 8.0 feet.</p>	CL-ML			<p>Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.</p> <p>Original boring abandoned due to compromised screen. Redrilled and installed at survey location noted above within 10 feet of original location.</p>
2 CS	50		10	<p>Change to no gravel, dark gray (10YR 4/1) mottled with brown (10YR 5/3), very soft at 10.0 feet.</p>				
3 CS	100		20	<p>Change to dark gray (10YR 4/1) at 20.0 feet.</p>	CL			
4 CS	100		35					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

Signature:

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Checked By: C. Scieszka



WELL CONSTRUCTION LOG

WELL NO. MW-16-01

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SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS						
NUMBER AND TYPE	RECOVERY (%)													
5 CS	100		45	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, soft.	CL									
6 ST	100		50											
7 CS	100		55											
8 CS	80		65											
9 CS	100		75											
10 CS	100		85											
11 CS	100		95						SAND mostly fine sand, dark gray (10YR 4/1), saturated.	SP				
			100											
			100						End of boring at 100.0 feet below ground surface.					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC_CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-02

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Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 3/14/16	Date Drilling Completed: 3/15/16	Project Number: 231828.0003	
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 586.27	TOC Elevation (ft) 588.94	Total Depth (ft bgs) 100.0	Borehole Dia. (in) 6/4
Boring Location: 325 feet W of haul road, 5 feet N of road, N of bottom ash basins. N: 471409.06 E: 13625991.78		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc	
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 4/13/16 09:24		Depth (ft bgs) 16.07

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	80		5	CLAY mostly clay, few silt, few coarse gravel, medium plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), stiff.				Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
			7.0	Change to no gravel at 7.0 feet.				
2 CS	80		10	Change to high plasticity, dark gray (10YR 4/1), moist, very soft at 10.0 feet.				
			15					
			25					
3 CS	100		25					
			30					
			35					
4 CS	90		35					
			40					

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WELL CONSTRUCTION LOG

WELL NO. MW-16-02

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SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, few silt, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
6 CS	100		50	SILTY CLAY mostly clay, little to some silt, few fine sand, few fine to coarse gravel, high plasticity, dark gray (10YR 4/1), very soft.				
7 CS	50		55					
8 CS	100		60					
9 CS	100		65		CL-ML			
10 CS	100		70					
			75					
			80					
			85					
			90	CLAYEY SILT mostly silt, some clay, few fine sand, few coarse gravel, low plasticity, dark gray (10YR 4/1), moist, very soft.	ML-CL			
			95	SAND mostly fine to coarse sand, dark gray (10YR 4/1), saturated.				
			96.0	Change to fine sand at 96.0 feet.	SW			
			100	End of boring at 100.0 feet below ground surface.				

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-03

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Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 5/25/16	Date Drilling Completed: 5/31/16	Project Number: 231828.0003
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 588.03	TOC Elevation (ft) 590.66	Total Depth (ft bgs) 150.0
Boring Location: Approximately 100 feet W of haul road, N of bottom ash basins. N: 471391.78 E: 13626202.49		Personnel Logged By - J. Reed Driller - A. Goldsmith		Drilling Equipment: TSi 150cc
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time _____ Depth (ft bgs) _____ After Drilling: Date/Time 6/8/16 14:30 Depth (ft bgs) 12.82	

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	100		5	TOPSOIL SILTY CLAY mostly clay, some silt, few fine to medium sand, trace gravel, low to medium plasticity, dark gray (10YR 4/1) with trace orange mottling, moist, medium stiff to stiff.	CL-ML			Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
2 CS	100		10.5	Change to gray (10YR 5/1) at 10.5 feet. CLAY mostly clay, few silt, trace to few fine to medium sand, medium plasticity, gray (10YR 5/1), moist, soft to medium stiff.	CL			
3 CS	100		25	Change to trace to few fine to coarse sand at 25.0 feet.	CL			
4 CS	100		41.5	Change to trace fine to coarse sand at 41.5 feet.	CL			

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WELL CONSTRUCTION LOG

WELL NO. MW-16-03

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SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, few silt, trace fine to coarse sand, medium plasticity, gray (10YR 5/1), moist, soft to medium stiff.				
6 CS	90		50					
			55		CL			
			60	Change to stiff at 60.5 feet. Change to medium stiff at 62.0 feet.				
7 CS	100		65	SANDY CLAY mostly clay, little to some sand, few silt, gray (10YR 5/1), moist, soft to medium stiff.	CL			
			70	CLAY mostly clay, few silt, few fine to coarse sand, gray (10YR 5/1), moist, stiff. Change to coal fragments present at 67.5 feet. Change to no coal fragments present at 68.0 feet.	CL			
8 CS	90		75	1-inch thick interval of silty fine to coarse sand at 75.0 feet.				
			80	SANDY SILT mostly silt, little to some fine to medium sand, gray (10YR 5/1), moist, medium dense.	ML			
			85	CLAY mostly clay, few silt, few fine to coarse sand, low to medium plasticity, gray (10YR 5/1), moist, stiff.				
9 CS	100		90	Change to medium soft at 90.0 feet.	CL			
10 CS	100		95	Change to few fine gravel from 94.0 to 95.0 feet. Change to trace fine gravel, medium stiff to stiff at 95.0 feet.				
			100					



WELL CONSTRUCTION LOG

WELL NO. MW-16-03

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SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
11 CS	100		105	CLAY mostly clay, few silt, few fine to coarse sand, trace fine gravel, medium plasticity, gray (10YR 5/1), medium stiff to stiff.				
			110	Change to low plasticity, soft to medium stiff at 111.0 feet.				
12 CS	100		115		CL			
			120					
13 CS	100		125					
			130	SANDY CLAY mostly clay, little to some fine to medium sand, few silt, trace to few fine gravel, low to medium plasticity, gray (10YR 5/1), moist, medium stiff. SILTY SAND mostly fine to medium sand, little silt, gray (10YR 5/1), moist, loose.	CL SM			
14 CS	90		135	SAND mostly fine to medium sand, trace silt, gray (10YR 5/1), moist, loose.	SP			
			140	SILTY SAND mostly fine to medium sand, little silt, few clay, gray (10YR 5/1), moist, loose.	SM			
			145	SAND mostly fine to coarse sand, trace to few silt, trace to few clay, dark gray (10YR 4/1), moist to wet, loose.	SW			
15 CS	100		150	SILT mostly silt, few clay, trace coarse sand to fine gravel, gray (10YR 5/1), dry to moist, dense to very dense. SHALE weathered shale bedrock, dark gray. End of boring at 150 feet below ground surface.	ML			
			155					



WELL CONSTRUCTION LOG

WELL NO. MW-16-04

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Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 3/7/16	Date Drilling Completed: 3/8/16	Project Number: 231828.0003	
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 587.50	TOC Elevation (ft) 590.51	Total Depth (ft bgs) 130.0	Borehole Dia. (in) 6/4
Boring Location: 200 feet from W corner of road, S of bottom ash basins. N: 470893.74 E: 13625876.34		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc	
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 4/13/16 09:31		Depth (ft bgs) Depth (ft bgs) 13.91

SAMPLE	NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
	1	CS	80	5	CLAY mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), very stiff. Change to no gravel at 1.0 feet. Change to stiff at 10.5 feet. Change to dark gray (10YR 4/1), very soft at 12.0 feet.	CL			Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
	2	CS	100	15					
	3	CS	100	25					
	4	CS	100	35					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

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WELL CONSTRUCTION LOG

WELL NO. MW-16-04

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SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), very soft.				
6 CS	100		55		CL			
			60	Change to few coarse gravel at 60.0 feet.				
7 CS	100		65					
			70					
			75	SILTY CLAY mostly clay, little to some silt, trace fine sand, medium plasticity, dark gray (10YR 4/1), very stiff.	CL-ML			
8 CS	100		75	SILT mostly silt, trace to few fine sand, non plastic, dark gray (10YR 4/1), saturated, stiff.	ML			
			80	SAND mostly fine sand, few medium to coarse sand, dark gray (10YR 4/1), moist.	SP			
			80	SANDY CLAY mostly clay, some fine sand, high plasticity, dark gray (10YR 4/1), moist.	CL			
			85	SILTY CLAY mostly clay, some silt, high plasticity, dark gray (10YR 4/1), stiff.	CL-ML			
9 CS	100		85	CLAYEY SILT mostly silt, some clay, low plasticity, dark gray (10YR 4/1), stiff.	ML-CL			
			90	SILTY CLAY mostly clay, some silt, high plasticity, dark gray (10YR 4/1), stiff.				
			95		CL-ML			
10 CS	100		95					
			100	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), very soft.	CL			

SOIL BORING WELL CONSTRUCTION LOG 231828 0003 0000.GPJ TRC_CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-04

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SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
11 CS	100		105	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), very soft.	CL			
12 CS	100		115	SILT mostly silt, few fine sand, nonplastic, dark gray (10YR 4/1), saturated, stiff.	ML			
13 CS	100		125	SAND mostly fine sand, dark gray (10YR 4/1), saturated.	SP			
			130	End of boring at 130.0 feet below ground surface.				
			135					
			140					
			145					
			150					
			155					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC_CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-05

Page 1 of 3

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 3/3/16	Date Drilling Completed: 3/4/16	Project Number: 231828.0003	
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 588.32	TOC Elevation (ft) 590.82	Total Depth (ft bgs) 150.0	Borehole Dia. (in) 6
Boring Location: S end of haul road, W of diversion basin. N: 470378.15 E: 13626342.79		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc	
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 4/13/16 09:55		
			Depth (ft bgs)	Depth (ft bgs) 14.37	

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	80		5	<p>CLAY WITH GRAVEL mostly clay, few to some coarse gravel, high plasticity, dark grayish brown (10YR 4/2), moist, very stiff.</p> <p>CLAY mostly clay, few fine to coarse gravel, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, hard.</p> <p>Change to no gravel, very stiff at 4.0 feet.</p>	CL			Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
			10	Change to dark gray (10YR 4/1), very soft at 10.0 feet.				
2 CS	100		15					
			20					
			25	Change to medium stiff at 26.0 feet.				
			30	Change to very soft at 28.0 feet.				
3 CS	100		25					
			30					
4 CS	100		35					
			40					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

Signature:

Firm: TRC Environmental Corporation 734.971.7080
1540 Eisenhower Place Ann Arbor, Michigan Fax 734.971.9022

Checked By: C. Scieszka



WELL CONSTRUCTION LOG

WELL NO. MW-16-05

Page 2 of 3

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
				SILTY CLAY mostly clay, little to some silt, medium plasticity, dark gray (10YR 4/1), very soft.	CL-ML			
6 ST	100		50	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.				
7 CS	100		55					
			60	Change to few fine to coarse gravel at 60.0 feet.	CL			
8 CS	100		65	Change to medium stiff at 65.0 feet.				
			67.5	Change to stiff at 67.5 feet.				
			70	SILTY CLAY mostly clay, some silt, few fine to coarse gravel, high plasticity, very dark gray (10YR 3/1), very stiff.				
9 CS	100		75	Change to low plasticity, black (10YR 2/1), hard at 77.0 feet.				
			80		CL-ML			
			85	Change to few to little fine sand at 85.5 feet.				
			90	CLAY mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, very soft.				
			93.5	Change to medium stiff at 93.5 feet.				
11 CS	100		95	Change to soft at 97.5 feet.	CL			
			100					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-05

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
12 CS	100		105	CLAY mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, soft.	CL			
13 CS	100		110-115					
14 CS	100		120-125					
15 CS	100		135	CLAYEY SILT mostly silt, some clay, medium plasticity, dark gray (10YR 4/1), wet, medium stiff.	ML-CL			
16 CS	90		145	SHALE dark gray (10YR 4/1), dry.				
			150	End of boring at 150.0 feet below ground surface.				
			155					



WELL CONSTRUCTION LOG


WELL NO. MW-16-06

Page 1 of 3

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 3/10/16	Date Drilling Completed: 3/11/16	Project Number: 231828.0003
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 589.98	TOC Elevation (ft) 593.21	Total Depth (ft bgs) 140.0
Boring Location: 123 feet S of road connecting to haul road, E of diversion basin. N: 470439.03 E: 13626796.04		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 4/13/16 10:01 Depth (ft bgs) 14.45	

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	50		5	GRAVEL WITH SAND mostly gravel, some fine to coarse sand, brown (10YR 5/3), moist, dense. CLAY mostly clay, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, very stiff.				Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
			10	Change to few coarse gravel at 10.0 feet.				
2 CS	100		15	Change to dark gray (10YR 4/1), stiff at 12.0 feet. Change to very soft at 13.0 feet.				
			20					
3 CS	100		25					
			30					
4 CS	100		35					
			40					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

Signature:  Firm: TRC Environmental Corporation 734.971.7080
 1540 Eisenhower Place Ann Arbor, Michigan Fax 734.971.9022
 Checked By: C. Scieszka



WELL CONSTRUCTION LOG

WELL NO. MW-16-06

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SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, very soft.				
6 CS	100		55		CL			
7 CS	100		65					
			70	SILTY CLAY mostly clay, some silt, medium plasticity, dark gray (10YR 4/1), moist, medium stiff.	CL-ML			
				SAND mostly fine sand, few coarse sand, dark gray (10YR 4/1), moist.	SP			
8 CS	100		75	SILTY CLAY mostly clay, some silt, medium plasticity, dark gray (10YR 4/1), moist, medium stiff.				
			80		CL-ML			
9 CS	80		85					
			90	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.				
10 CS	70		95		CL			
			100					



WELL CONSTRUCTION LOG

WELL NO. MW-16-06

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
11 CS	100		105	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
12 CS	100		110-115					
13 CS	100		125	SILTY CLAY mostly clay, some silt, medium plasticity, dark gray (10YR 4/1), moist, medium stiff.	CL-ML			
14 CS	100		130-135					
			135	SILT mostly silt, dark gray (10YR 4/1), saturated, very soft.	ML			
			140	SHALE dark gray (10YR 4/1), hard, brittle.				
			140	End of boring at 140.0 feet below ground surface.				
			145					
			150					
			155					



WELL CONSTRUCTION LOG

WELL NO. MW-16-07

Page 1 of 3

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 3/8/16	Date Drilling Completed: 3/9/16	Project Number: 231828.0003
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 589.89	TOC Elevation (ft) 592.58	Total Depth (ft bgs) 140.0
Boring Location: 326 feet S of road connecting to haul road, E of diversion basin. N: 470233.47 E: 13626858.79		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 4/13/16 11:56	
				Depth (ft bgs) 14.13

SAMPLE	NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
	1	60		5	CLAY mostly clay, few coarse gravel, high plasticity, brown (10YR 5/3) mottled with dark gray (10YR 4/1), very stiff.				Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
				5	Change to dark gray (10YR 4/1) mottled with brown (10YR 5/3) at 5.0 feet.				
				10	Change to dark gray (10YR 4/1) at 11.0 feet.				
				13	▼ Change to moist, very soft at 13.0 feet.				
	2	100		15					
	3	100		25					
	4	100		35					
				40					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

Signature: *C. Scieszka* Firm: TRC Environmental Corporation 734.971.7080
 1540 Eisenhower Place Ann Arbor, Michigan Fax 734.971.9022

Checked By: C. Scieszka



WELL CONSTRUCTION LOG

WELL NO. MW-16-07

Page 2 of 3

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
6 ST	100		50					
7 CS	100		55	SILTY CLAY mostly clay, little silt, high plasticity, dark gray (10YR 4/1), moist, soft.	CL-ML			
8 CS	100		65	CLAYEY SILT mostly silt, little to some clay, few fine to coarse sand, low plasticity, dark gray (10YR 4/1), moist.	ML-CL			
			66	SAND mostly fine to coarse sand, dark gray (10YR 4/1), moist, loose.	SW			
			67	CLAYEY SILT mostly silt, little to some clay, few fine to coarse sand, low plasticity, dark gray (10YR 4/1), moist.	ML-CL			
			70	SILTY CLAY mostly clay, little silt, high plasticity, dark gray (10YR 4/1), moist, soft. Change to few coarse gravel at 70.0 feet.				
9 CS	100		75					
10 CS	100		85		CL-ML			
11 CS	100		95					
			100					

SOIL BORING WELL CONSTRUCTION LOG 231825.0003.0000.GPJ TRC_CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-07

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SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
12 CS	100		105	SILTY CLAY mostly clay, little silt, high plasticity, dark gray (10YR 4/1), moist, soft.	CL-ML			
13 CS	80		110					
14 CS	100		125					
15 CS	100		130	SILT mostly silt, no plasticity, dark gray (10YR 4/1), saturated, loose. SHALE dark gray (10YR 4/1), brittle, hard.	ML			
			135	End of boring at 140.0 feet below ground surface.				
			140					
			145					
			150					
			155					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-08

Page 1 of 3

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 3/9/16	Date Drilling Completed: 3/10/16	Project Number: 231828.0003	
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 589.31	TOC Elevation (ft) 591.88	Total Depth (ft bgs) 140.0	Borehole Dia. (in) 6
Boring Location: 566.6 feet S of road connecting to haul road, E of diversion basin. N: 470002.90 E: 13626846.85		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc	
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 4/13/16 12:00		
			Depth (ft bgs)	Depth (ft bgs) 13.19	

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	50		5	CLAY WITH GRAVEL mostly clay, little coarse gravel, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, very stiff.	CL			Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
			10	CLAY mostly clay, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, very stiff.				
			15	Change to dark gray (10YR 4/1), very soft at 10.0 feet.				
2 CS	100		25		CL			
3 CS	100		35					
4 CS	100		40					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

Signature: Firm: TRC Environmental Corporation 734.971.7080
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Checked By: C. Scieszka



WELL CONSTRUCTION LOG

WELL NO. MW-16-08

Page 2 of 3

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
6 CS	100		55					
7 CS	80		65					
8 CS	100		75	SILTY CLAY mostly clay, some silt, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, soft.	CL-ML			
9 CS	100		85					
10 CS	60		95					
			100					



WELL CONSTRUCTION LOG

WELL NO. MW-16-08

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SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
11 CS	100		105	SILTY CLAY mostly clay, some silt, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, soft. Change to few fine sand at 105.5 feet.	CL-ML			
12 CS	100		110	Change to no sand at 110.0 feet.				
13 CS	100		125					
14 CS	100		130	SILT mostly silt, dark gray (10YR 4/1), saturated, very soft.	ML			
			135	SHALE dark gray (10YR 4/1), brittle, hard.				
			140	End of boring at 140.0 feet below ground surface.				
			145					
			150					
			155					



WELL CONSTRUCTION LOG

WELL NO. MW-16-09

Page 1 of 3

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 6/1/16	Date Drilling Completed: 6/1/16	Project Number: 231828.0003	
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 588.28	TOC Elevation (ft) 590.80	Total Depth (ft bgs) 150.0	Borehole Dia. (in) 6
Boring Location: E of bottom ash basins, E of haul road. N: 471284.45 E: 13626365.84		Personnel Logged By - J. Reed Driller - A. Goldsmith		Drilling Equipment: TSi 150cc	
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: _____ Date/Time _____ After Drilling: _____ Date/Time 6/9/16 15:13		Depth (ft bgs) 14.36

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	75		5	<p>TOPSOIL</p> <p>SILTY CLAY mostly clay, little to some silt, few fine to coarse sand, trace to few fine gravel, low plasticity, dark grayish brown (10YR 4/2), moist, stiff.</p>	CL-ML			Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
			10	<p>CLAY mostly clay, few silt, trace to few fine to coarse sand, medium plasticity, gray (10YR 5/1), moist, soft.</p>				
2 CS	85		15					
3 CS	100		25		CL			
4 CS	100		35	Change to trace to few fine gravel at 30.0 feet.				

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

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Checked By: M. Powers



WELL CONSTRUCTION LOG

WELL NO. MW-16-09

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, few silt, trace to few fine to coarse sand, trace to few fine gravel, medium plasticity, gray (10YR 5/1), moist, soft.				
			50	Change to soft to medium stiff at 50.0 feet.				
6 CS	100		60					
			65					
			70	Change to soft at 70.0 feet.				
			75		CL			
			80	Change to medium stiff to stiff at 80.0 feet.				
			85	Change to stiff at 85.0 feet.				
7 CS	100		90					
			95					
			100					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC_CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-09

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
8 CS	75		105	CLAY mostly clay, few silt, trace to few fine to coarse sand, trace to few fine gravel, medium plasticity, gray (10YR 5/1), moist, stiff. Change to medium stiff at 105.0 feet.				
9 CS	80		110					
			115					
			120		CL			
			125					
10 CS	100		130					
			135					
			140	SAND mostly fine sand, trace silt, dark gray (10YR 4/1), moist, loose.	SP			
			145	SAND WITH GRAVEL mostly fine to coarse sand, little to some fine to medium gravel, trace to few silt, trace to few clay, dark gray (10YR 4/1), moist to wet, loose.	SW			
11 CS	80		150	SHALE weathered, gray (10YR 5/1), brittle.				
			150	End of boring at 150.0 feet below ground surface.				
			155					



WELL CONSTRUCTION LOG

WELL NO. MW-16-10

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Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 6/2/16	Date Drilling Completed: 6/3/16	Project Number: 231828.0003	
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 589.25	TOC Elevation (ft) 592.26	Total Depth (ft bgs) 150.0	Borehole Dia. (in) 6
Boring Location: S end of haul road, W/NW of diversion basin. N: 470532.54 E: 13626417.00		Personnel Logged By - J. Reed Driller - A. Goldsmith		Drilling Equipment: TSi 150cc	
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 6/9/16 07:45		Depth (ft bgs) Depth (ft bgs) 15.30

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	50		5	TOPSOIL CLAY mostly clay, few silt, trace to few fine to coarse sand, dark grayish brown (10YR 4/2), moist, medium stiff to stiff.				Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
2 CS	90		15	Change to gray (10YR 5/1) at 11.0 feet. Change to soft to medium stiff at 12.0 feet.				
3 CS	95		25	Change to soft at 25.0 feet.				
4 CS	100		35	Change to few fine to coarse sand, medium stiff at 30.0 feet. Change to dark gray (10YR 4/1) at 32.0 feet. Change to soft at 35.0 feet.	CL			

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

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Checked By: M. Powers



WELL CONSTRUCTION LOG

WELL NO. MW-16-10

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	100		45	CLAY mostly clay, few silt, trace to few fine to coarse sand, dark gray (10YR 4/1), moist, soft.				
6 CS	100		55		CL			
7 CS	100		65					
8 CS	100		75	CLAY WITH SAND mostly clay, little fine to coarse sand, few silt, trace gravel, dark gray (10YR 4/1), moist, very stiff. Change to few to little medium to coarse sand, low to medium plasticity, stiff at 75.0 feet.	CL			
9 CS	100		85	CLAYEY SAND mostly fine to coarse sand, some clay, dark grayish brown (10YR 4/2), moist, medium dense. SAND mostly fine to medium sand, dark grayish brown (10YR 4/2), moist, loose.	SC SP			
10 CS	100		95	SANDY CLAY mostly clay, little to some fine to coarse sand, few silt, medium plasticity, dark grayish brown (10YR 4/2), moist, medium stiff to stiff.	CL			
			100	CLAY WITH SAND mostly clay, little fine to coarse sand, few silt, medium plasticity, dark grayish brown (10YR 4/2), moist, medium stiff to stiff.	CL			



WELL CONSTRUCTION LOG

WELL NO. MW-16-10

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
11 CS	100		105	CLAY WITH SAND mostly clay, little fine to coarse sand, few silt, medium plasticity, dark grayish brown (10YR 4/2), moist, medium stiff to stiff.	CL			
			110	SANDY CLAY mostly clay, little to some fine to coarse sand, few silt, medium plasticity, dark grayish brown (10YR 4/2), moist, medium stiff.	CL			
12 CS	100		115	SAND mostly medium to coarse sand, dark gray (10YR 4/1), moist, loose.	SP			
			120	CLAY mostly clay, little sand, few to little silt, dark gray (10YR 4/1), moist, stiff.				
13 CS	95		125					
			130		CL			
14 CS	95		135					
			140					
15 CS	50		145	GRAVELLY SILT mostly silt, some fine to coarse gravel, few clay, few sand, low to medium plasticity, dark gray (10YR 4/1), moist, soft.	ML			
			150	SILTY CLAY hard, dark gray (10YR 4/1), hardpan, brittle.	CL-ML			
			150	SHALE dark gray. End of boring at 150.0 feet below ground surface.				
			155					
			160					



WELL CONSTRUCTION LOG


WELL NO. MW-16-11

Page 1 of 3

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 6/3/16	Date Drilling Completed: 6/6/16	Project Number: 231828.0003	
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 589.03	TOC Elevation (ft) 591.54	Total Depth (ft bgs) 150.0	Borehole Dia. (in) 6
Boring Location: S of haul road, W of diversion basin. N: 470251.34 E: 13626438.92		Personnel Logged By - J. Reed Driller - A. Goldsmith		Drilling Equipment: TSi 150cc	
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 6/21/16 07:45		Depth (ft bgs) Depth (ft bgs) 14.47

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	50		5	TOPSOIL CLAY mostly clay, few silt, trace to few sand, few gravel, low to medium plasticity, dark grayish brown (10YR 4/2), moist, stiff.				Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
			10	Change to trace gravel at 8.0 feet.				
2 CS	70		15	Change to gray (10YR 5/1) at 12.0 feet. Change to no gravel at 13.0 feet.				
			20	Change to medium stiff at 21.0 feet.	CL			
3 CS	90		25					
			30					
4 CS	90		35	Change to soft to medium stiff at 34.5 feet.				
			40					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC_CORP.GDT 7/14/16

Signature:  Firm: TRC Environmental Corporation 734.971.7080
1540 Eisenhower Place Ann Arbor, Michigan Fax 734.971.9022

Checked By: M. Powers



WELL CONSTRUCTION LOG

WELL NO. MW-16-11

Page 2 of 3

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
5 CS	90		45	CLAY mostly clay, few silt, trace to few sand, medium plasticity, gray (10YR 5/1), moist, soft to medium stiff.	CL			
			50	Change to medium stiff at 49.0 feet.				
6 CS	100		55					
			60	Change to soft at 60.0 feet.				
7 CS	100		65					
			70	Change to trace gravel, soft to medium stiff at 70.0 feet.				
8 CS	100		75	Change to medium stiff at 75.0 feet.				
			80					
9 CS	90		85					
			90					
10 CS	90		95	Change to medium stiff to stiff at 95.0 feet.				
			100					

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16



WELL CONSTRUCTION LOG

WELL NO. MW-16-11

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
NUMBER AND TYPE	RECOVERY (%)							
11 CS	85		105	<p>CLAY mostly clay, few silt, trace to few sand, trace gravel, low to medium plasticity, gray (10YR 5/1), moist, medium stiff to stiff.</p> <p>Change to medium stiff at 110.0 feet.</p>	CL			
12 CS	80		115					
13 CS	85		125					
14 CS	90		135					
15 CS	90		145					
			140	<p>SANDY CLAY mostly clay, some fine sand, few silt, dark gray (10YR 4/1), moist.</p> <p>CLAY mostly clay, few silt, trace to few sand, trace gravel, low to medium plasticity, gray (10YR 5/1), moist, medium stiff.</p> <p>SHALE dark gray.</p>	CL			
			150	End of boring 150.0 feet below ground surface.				
			155					



WELL CONSTRUCTION LOG

WELL NO. MW-16-11A

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 5/11/17	Date Drilling Completed: 5/12/17	Project Number: 231828.0003
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 589.5	TOC Elevation (ft) 591.66	Total Depth (ft bgs) 142.0
Boring Location: North of fuel oil tank number 2, between berm and fence.		Personnel Logged By - J. Krenz Driller - A. Goldsmith		Drilling Equipment: TSi 150cc
Civil Town/City/or Village: China Township	County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time 5/15/17 08:38	
				Depth (ft bgs) 17.79

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	90			CLAY mostly clay, trace gravel, medium plasticity, dark grayish brown (10YR 4/2), mottled with dark yellowish brown (10YR 4/6), medium stiff, moist, plant roots to 0.5 feet.				Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
2 CS	60		10					
			19.0	▼ Change to high plasticity, gray (10YR 5/1), soft at 19.0 feet.				
3 CS	70							
4 CS	70				CL			
5 CS	100							
6 CS	100							
7								

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC CORP.GDT 8/21/17

Signature: *Paul Krenz* Firm: TRC Environmental Fax

Checked By: C. Scieszka



WELL CONSTRUCTION LOG

WELL NO. MW-16-11A

Page 2 of 2

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 8/21/17

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS		
NUMBER AND TYPE	RECOVERY (%)									
CS	100			CLAY mostly clay, trace fine to medium gravel, high plasticity, gray (10YR 5/1), medium stiff, moist.	CL					
			70	Change to few fine to coarse gravel at 70.0 feet.						
8 CS	100									
			80	Change to trace fine sand at 80.0 feet.						
9 CS	90									
			90							
10 CS	70									
			100							
11 CS	100									
			110							
12 CS	100									
			120							
13 CS	100			Change to trace medium to coarse gravel at 126.0 feet.						
			130							
14 CS	60			SILT mostly silt, trace clay, dark gray (10YR 4/1), dense, saturated.				ML		
			140	SILTY CLAY mostly clay, some silt, few to little fine to coarse gravel, medium to low plasticity, dark gray (10YR 4/1), moist, medium stiff, inclusions of shale bedrock.	CL-ML					
15 CS	100			BEDROCK shale, weathered, gray (10YR 4/1). End of boring at 142.0 feet below ground surface.						
			150							



SOIL BORING LOG

BORING NO. SB-16-01

Page 1 of 3

Facility/Project Name: DTE Electric Company Belle River Power Plant		Date Drilling Started: 3/1/16	Date Drilling Completed: 3/1/16	Project Number: 231828.0003
Drilling Firm: Stock Drilling	Drilling Method: Sonic	Surface Elev. (ft) 588.69	TOC Elevation (ft) ---	Total Depth (ft bgs) 150.0
Boring Location: Corner of E connecting road off haul road, E of bottom ash basins.		Personnel Logged By - A. Knutson Driller - A. Goldsmith		Drilling Equipment: TSi 150cc
Civil Town/City/or Village: China Township		County: St. Clair	State: MI	Water Level Observations: While Drilling: Date/Time After Drilling: Date/Time
				Depth (ft bgs) Depth (ft bgs)

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
1 CS	50		5	<p>CLAY WITH GRAVEL mostly clay, little fine to coarse gravel, few fine sand, high plasticity, dark gray (10YR 4/1), mottled with brown (10YR 5/3), moist, very stiff.</p> <p>CLAY mostly clay, trace fine sand, high plasticity, dark gray (10YR 4/1), mottled with brown (10YR 5/3), moist, very stiff.</p>	CL		Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to total depth.
			10	Change to stiff at 10.0 feet.			
2 CS	100		15	Change to no sand, dark gray (10YR 4/1), very soft at 13.0 feet.			
3 CS	100		25		CL		
4 CS	100		35				
			40				

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.GPJ TRC_CORP_GDT 7/14/16

Signature: 	Firm: TRC Environmental Corporation 1540 Eisenhower Place Ann Arbor, Michigan	734.971.7080 Fax 734.971.9022
Checked By: <u>M. Powers</u>		



SOIL BORING LOG

BORING NO. SB-16-01

Page 2 of 3

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC_CORP.GDT 7/14/16

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
NUMBER AND TYPE	RECOVERY (%)						
5 CS	100		45	CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.			
6 ST	100		50		CL		
7 CS	100		55				
			60	CLAY WITH SAND mostly clay, little fine to coarse sand, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
				CLAY mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
8 CS	100		65	SANDY SILT mostly silt, little to some fine to coarse sand, few clay, low plasticity, dark gray (10YR 4/1), moist, stiff.	ML		
			70	CLAY mostly clay, few fine to coarse gravel, dark gray (10YR 4/1), moist, medium stiff.			
				Change to no gravel, soft at 72.5 feet.			
9 CS	100		75				
			80				
				Change to few coarse gravel at 80.0 feet.			
10 CS	100		85		CL		
			90				
11 CS	100		95				
			100				



SOIL BORING LOG

BORING NO. SB-16-01

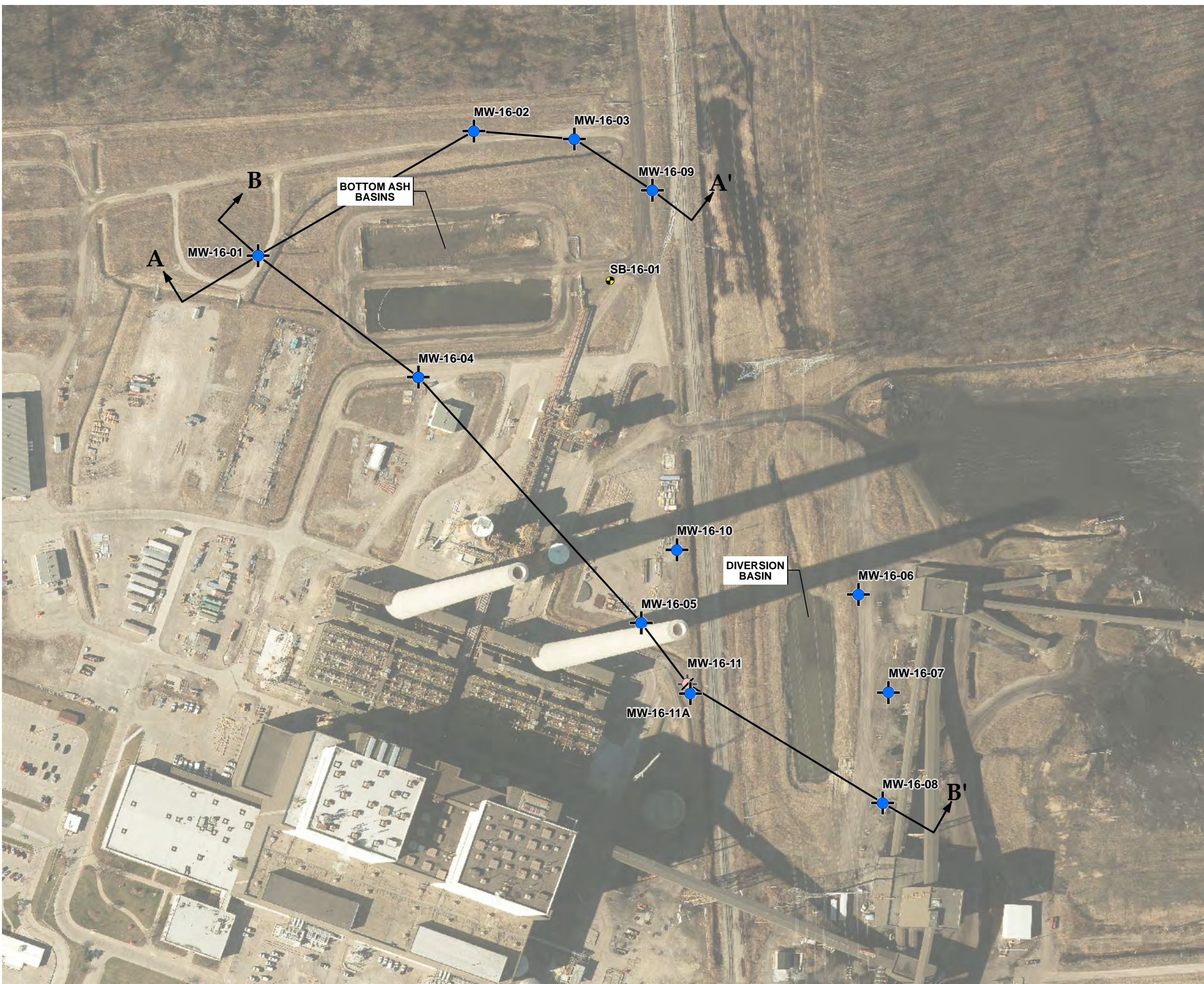
Page 3 of 3

SAMPLE		BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
NUMBER AND TYPE	RECOVERY (%)						
12 CS	100		105	CLAY mostly clay, few coarse gravel, dark gray (10YR 4/1), moist, soft.	CL		
13 CS	100		110				
14 CS	100		120				
15 CS	100		125	SILT mostly silt, few fine sand, non plastic, dark gray (10YR 4/1), moist.	ML		
16 CS	100		130				
			135	SHALE dark gray (10YR 4/1), dry.			
			140				
			145	End of boring at 150.0 feet below ground surface.			
			150				
			155				





SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.GPJ TRC CORP.GDT 7/14/16

Appendix B

Cross Sections

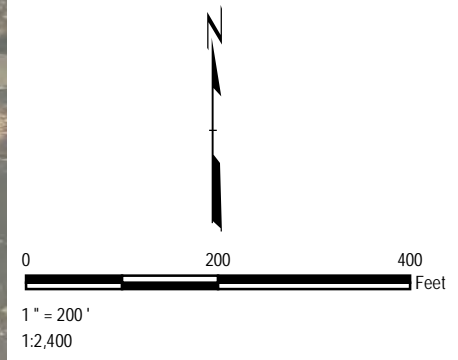


LEGEND

-  SOIL BORING
-  MONITORING WELL
-  DECOMMISSIONED MONITORING WELL
-  CROSS SECTIONS

NOTES

1. BASE MAP IMAGERY FROM ST. CLAIR COUNTY INFORMATION TECHNOLOGY DEPARTMENT WEBMAP, 2015.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, JUNE 2016, AND JUNE 2017.



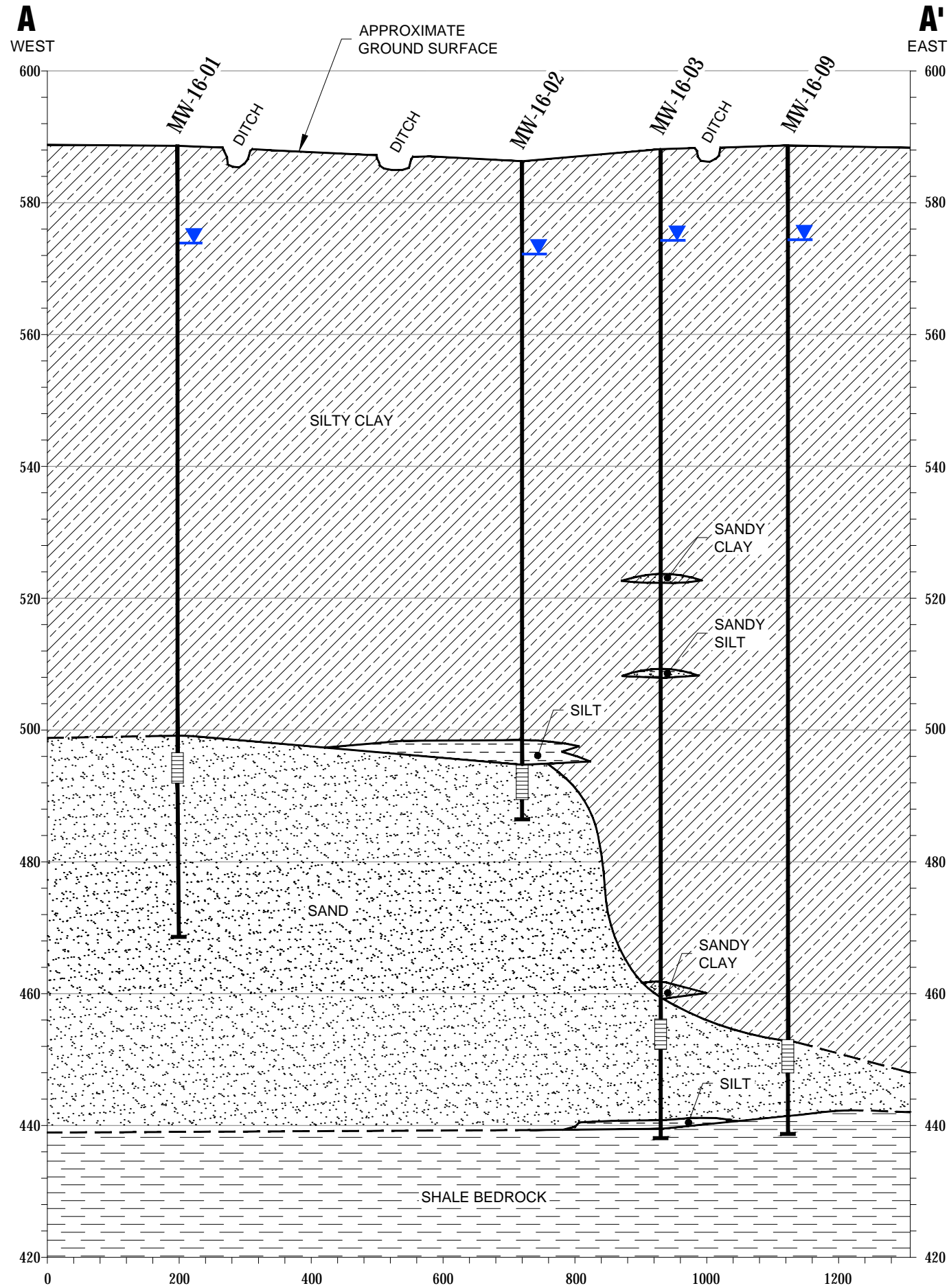
PROJECT:		DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN	
TITLE: CROSS SECTION LOCATOR MAP			
DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	C SCIESZKA	FIGURE B-1	
APPROVED BY:	V BUENING		
DATE:	SEPTEMBER 2017	FILE NO.: 265996-0003-011.mxd	



1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES: DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_1: DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_2: XS aa wells; XS cc wells; XS dd wells; XS DD wells; DRAWING NAME: F:\TRC\DTBelle River PP\265996\0003\01.04.05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG04 XS AA

GENERALIZED GEOLOGIC CROSS-SECTION A-A'

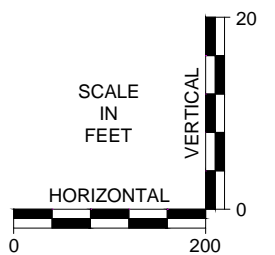


LEGEND

- STRATIGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (COLLECTED 02/27/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

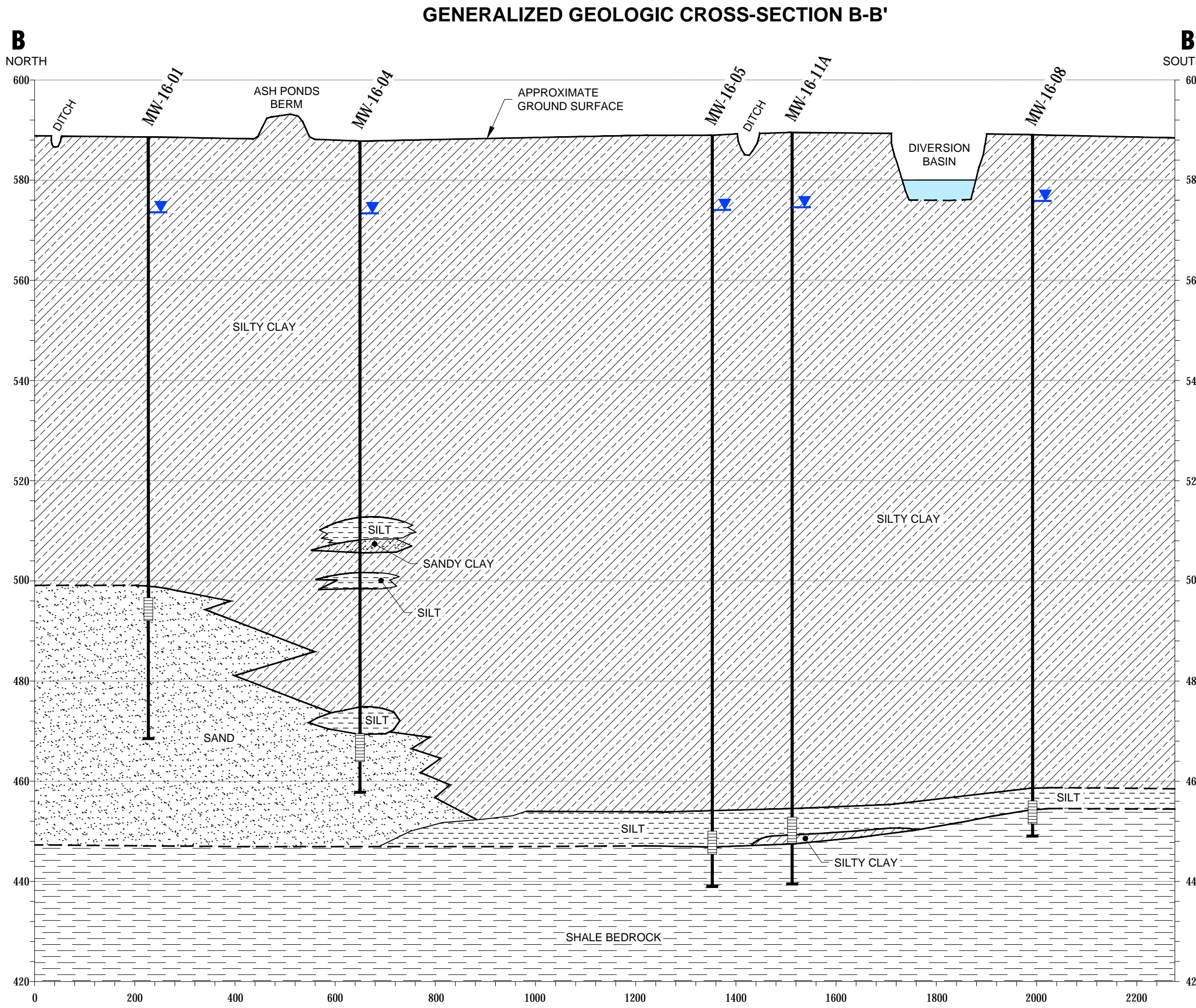
Lithology Key

- SILTY CLAY
- SAND
- SILT
- SANDY CLAY
- SANDY SILT
- SHALE BEDROCK



PROJECT:		DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT CHINA TOWNSHIP, MICHIGAN	
TITLE:		GENERALIZED GEOLOGIC CROSS-SECTION A-A'	
DRAWN BY:	D. STEHLE	PROJ NO.:	265996.0003.01
CHECKED BY:	S. HOLMSTROM	FIGURE B-2	
APPROVED BY:	V. BUENING		
DATE:	SEPTEMBER 2017		
		1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 www.trcsolutions.com	
FILE NO.:		265996.0003.01.04-05.dwg	

11x17 -- ATTACHED XREFS: --- ATTACHED IMAGES: DTE BRPP XSs XXXXXXXXXXXX-02172017092213_Page_1: DTE BRPP XSs XXXXXXXXXXXX-02172017092213_Page_2: XS aa wells; XS cc wells; XS dd wells; XS DD wells; DRAWING NAME: F:\TRC\DTB\Belle River\PP\265996\0003\1.04\05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG05 XS BB



LEGEND

- STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (COLLECTED 02/27/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

Lithology Key

- SILTY CLAY
- SAND
- SILT
- SANDY CLAY
- SHALE BEDROCK

SCALE
IN FEET

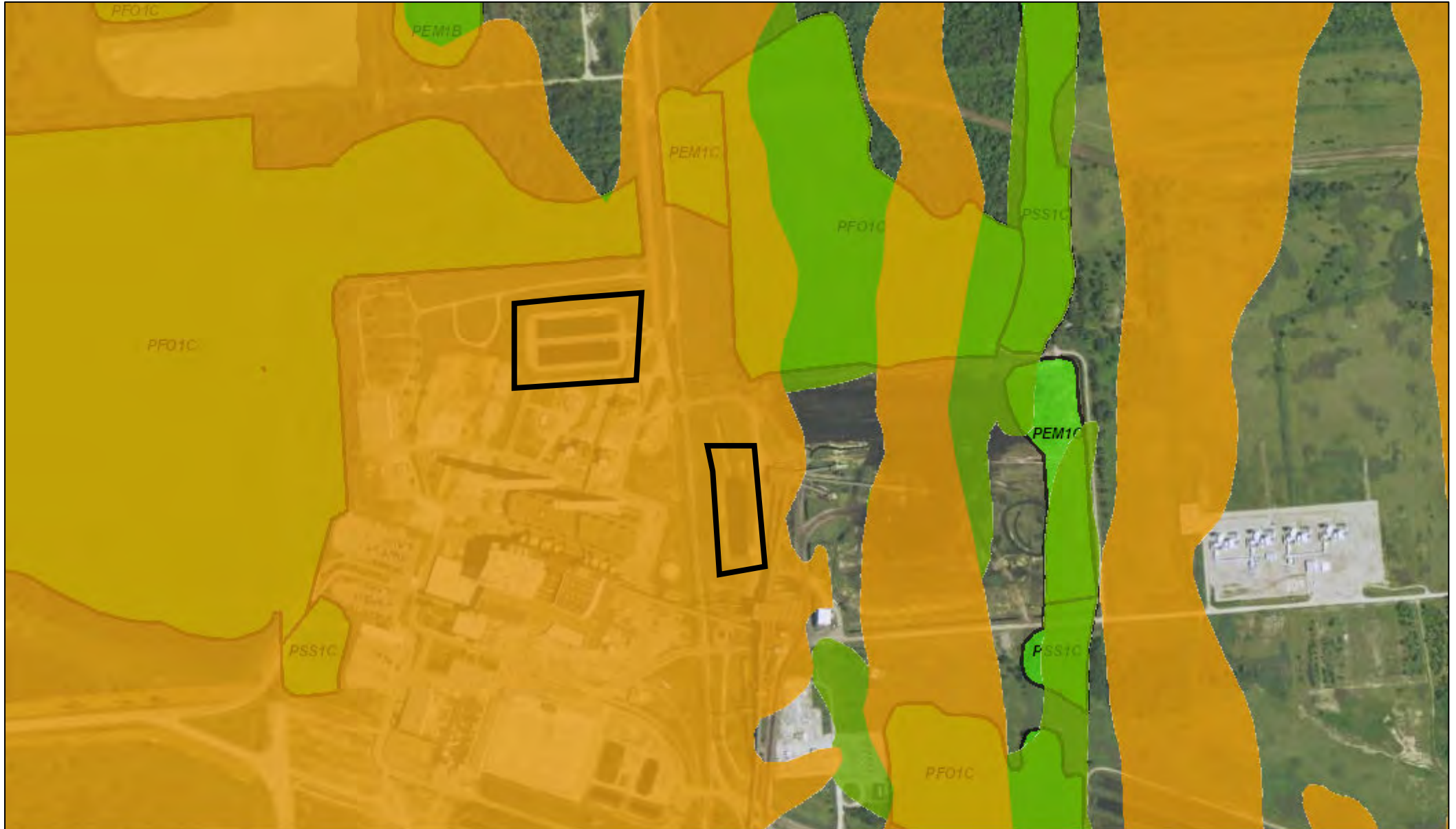
HORIZONTAL: 0 to 200
VERTICAL: 0 to 20

PROJECT: DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT CHINA TOWNSHIP, MICHIGAN	
TITLE: GENERALIZED GEOLOGIC CROSS-SECTION B-B'	
DRAWN BY: D. STEHLE	PROJ NO.: 265996.0003
CHECKED BY: S. HOLMSTROM	FIGURE B-3
APPROVED BY: V. BUENING	
DATE: SEPTEMBER 2017	
 1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 www.trcsolutions.com 	
FILE NO.: 265996.0003.01.04-05.dwg	

Appendix C

National Wetland Inventory Map

Wetlands Map Viewer

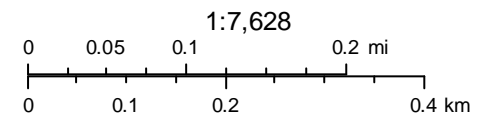


August 17, 2018

Part 303 Final Wetlands Inventory

- Wetlands as identified on NWI and MIRIS maps
- Soil areas which include wetland soils

- Wetlands as identified on NWI and MIRIS maps and soil areas which include wetland soils
- National Wetlands Inventory 2005
- Gage Stations

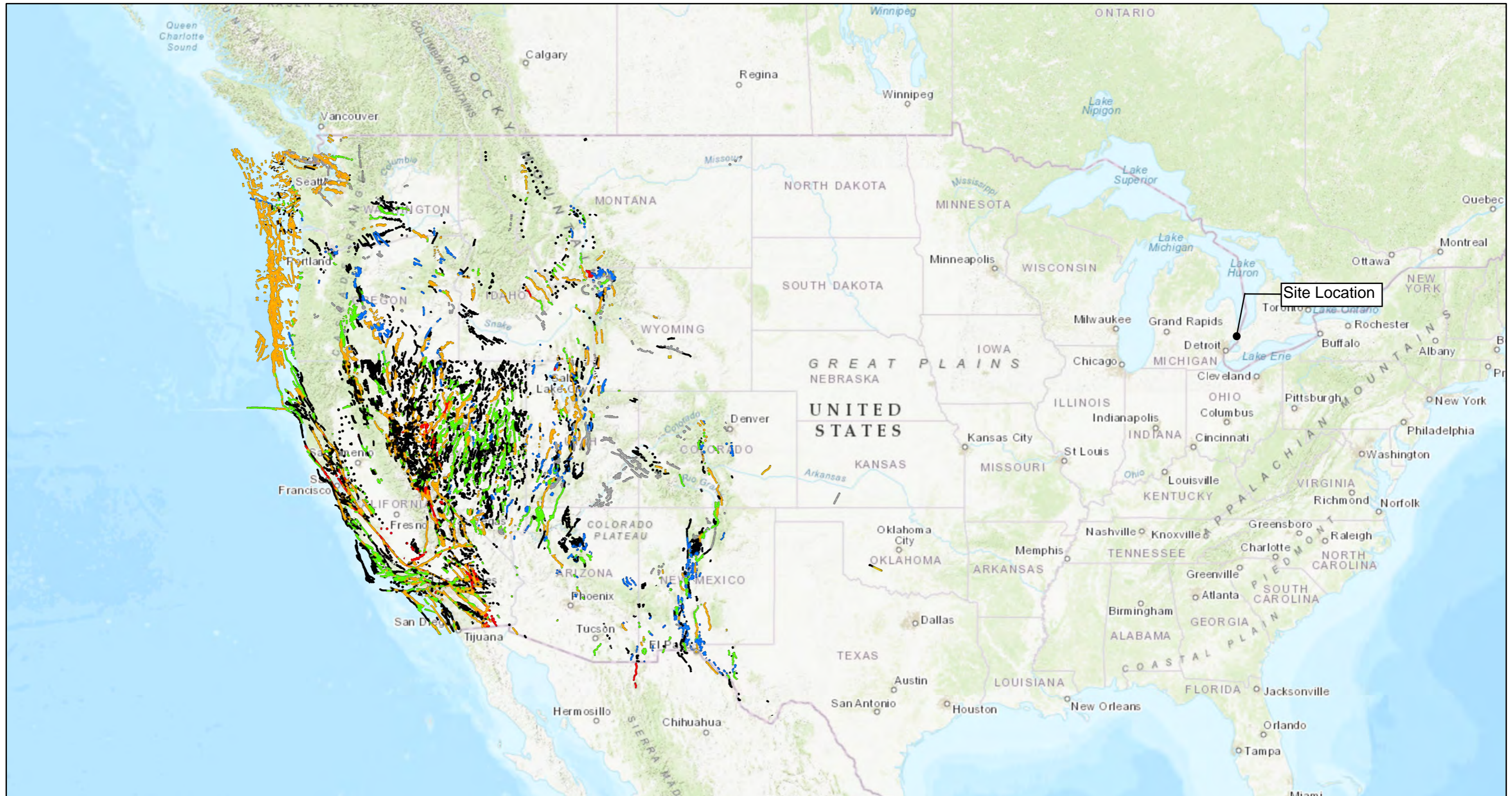


Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Appendix D

U.S. Quaternary Faults and Folds Map

US Quaternary Faults and Folds



9/7/2018 3:20:39 PM

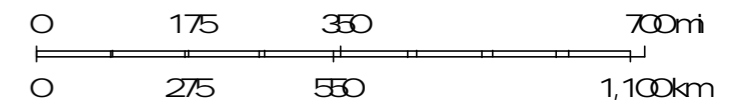
1:18,489,298

Quaternary faults

- unspecified age, well constrained location
- - - unspecified age, moderately constrained location
- .. unspecified age, inferred location
- undifferentiated Quaternary (< 130,000 years), well constrained location
- - - undifferentiated Quaternary (< 130,000 years), moderately constrained location

- .. undifferentiated Quaternary (< 130,000 years), inferred location
- middle and late Quaternary (< 1.6 million years), well constrained location
- - - middle and late Quaternary (< 1.6 million years), moderately constrained location
- .. middle and late Quaternary (< 1.6 million years), inferred location
- latest Quaternary (< 15,000 years), well constrained location
- - - latest Quaternary (< 15,000 years), moderately constrained location

- .. latest Quaternary (< 15,000 years), inferred location
- late Quaternary (< 130,000 years), well constrained location



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community, USGS

Appendix E

U.S. Seismic Design Maps

U.S. Geological Survey - Earthquake Hazards Program



Due to insufficient resources and the recent development of similar web tools by third parties, this spring the USGS will be streamlining the two U.S. Seismic Design Maps web applications, including the one below. Whereas the current applications each interact with users through a graphical user interface (GUI), the new web services will receive the inputs (e.g. latitude and longitude) in the form of a web address and return the outputs (e.g. S_{DS} and S_{D1}) in text form, without supplementary graphics. Though designed primarily to be read by the aforementioned third-party web GUIs, the text outputs are also human-readable. To preview the new web services, [please click here](#). Step-by-step instructions for using one of these web services, namely that for the recently published 2016 ASCE 7 Standard, [are posted here](#).

BRPP DB - Seismic Impact Zone

Latitude = 42.772°N, Longitude = 82.512°W

Location



Reference Document

2015 NEHRP Provisions

Site Class

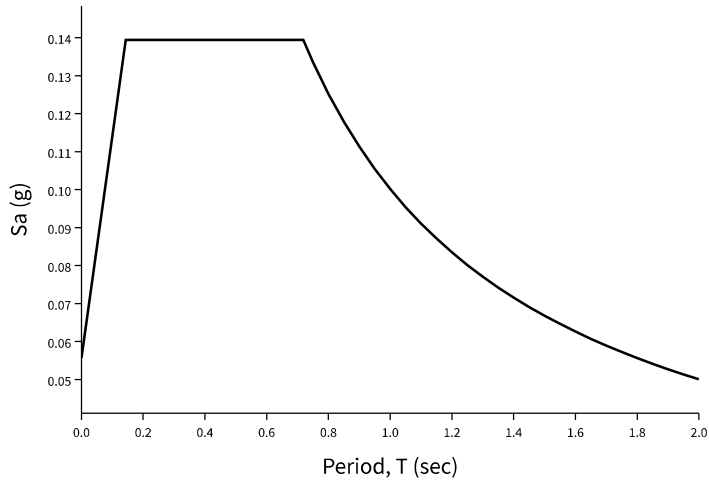
D (default): Stiff Soil

Risk Category

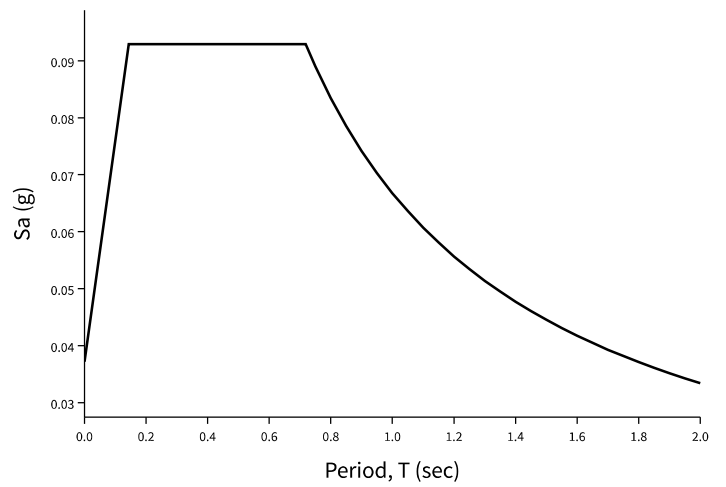
I or II or III

$S_S =$	0.087 g	$S_{MS} =$	0.139 g	$S_{DS} =$	0.093 g
$S_1 =$	0.042 g	$S_{M1} =$	0.100 g	$S_{D1} =$	0.067 g

MCE_R Spectrum



Design Response Spectrum



Mapped Acceleration Parameters, Long-Period Transition Periods, and Risk Coefficients

Note: The S_S and S_1 ground motion maps provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) 1.3 (to obtain S_1).

- [FIGURE 22-1 \$S_S\$ Risk-Targeted Maximum Considered Earthquake \(\$MCE_R\$ \) Ground Motion Parameter for the Conterminous United States for 0.2 s Spectral Response Acceleration \(5% of Critical Damping\), Site Class B](#)
- [FIGURE 22-2 \$S_1\$ Risk-Targeted Maximum Considered Earthquake \(\$MCE_R\$ \) Ground Motion Parameter for the Conterminous United States for 1.0 s Spectral Response Acceleration \(5% of Critical Damping\), Site Class B](#)
- [FIGURE 22-9 Maximum Considered Earthquake Geometric Mean \(\$MCE_G\$ \) PGA, %g, Site Class B for the Conterminous United States](#)
- [FIGURE 22-14 Mapped Long-Period Transition Period, \$T_L\$ \(s\), for the Conterminous United States](#)
- [FIGURE 22-18 Mapped Risk Coefficient at 0.2 s Spectral Response Period, \$C_{RS}\$](#)
- [FIGURE 22-19 Mapped Risk Coefficient at 1.0 s Spectral Response Period, \$C_{R1}\$](#)

Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site class as Site Class , based on the site soil properties in accordance with Chapter 20.

Table 20.3-1 Site Classification

Site Class	\bar{v}_s	\bar{N} or \bar{N}_{ch}	\bar{s}_u
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: <ul style="list-style-type: none"> • Plasticity index $PI > 20$ • Moisture content $w \geq 40\%$, and • Undrained shear strength $\bar{s}_u < 500$ psf 		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		
For SI: 1ft/s = 0.3048 m/s 1lb/ft ² = 0.0479 kN/m ²			

Site Coefficients and Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Risk-targeted Ground Motion (0.2 s)

$$C_{RS}S_{SUH} = 0.935 \times 0.093 = 0.087 \text{ g}$$

Deterministic Ground Motion (0.2 s)

$$S_{SD} = 1.500 \text{ g}$$

$$S_S \equiv \text{“Lesser of } C_{RS}S_{SUH} \text{ and } S_{SD}\text{”} = 0.087 \text{ g}$$

Risk-targeted Ground Motion (1.0 s)

$$C_{R1}S_{1UH} = 0.910 \times 0.046 = 0.042 \text{ g}$$

Deterministic Ground Motion (1.0 s)

$$S_{1D} = 0.600 \text{ g}$$

$$S_1 \equiv \text{“Lesser of } C_{R1}S_{1UH} \text{ and } S_{1D}\text{”} = 0.042 \text{ g}$$

Table 11.4-1: Site Coefficient F_a

Site Class	Spectral Reponse Acceleration Parameter at Short Period					
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S = 1.25$	$S_S \geq 1.50$
A	0.8	0.8	0.8	0.8	0.8	0.8
B (measured)	0.9	0.9	0.9	0.9	0.9	0.9
B (unmeasured)	1.0	1.0	1.0	1.0	1.0	1.0
C	1.3	1.3	1.2	1.2	1.2	1.2
D (determined)	1.6	1.4	1.2	1.1	1.0	1.0
D (default)	1.6	1.4	1.2	1.2	1.2	1.2
E	2.4	1.7	1.3	1.2 [*]	1.2 [*]	1.2 [*]
F	See Section 11.4.7					

* For Site Class E and $S_S \geq 1.0$ g, see the requirements for site-specific ground motions in Section 11.4.7 of the 2015 NEHRP Provisions. Here the exception to those requirements allowing F_a to be taken as equal to that of Site Class C has been invoked.

Note: Use straight-line interpolation for intermediate values of S_S .

Note: Where Site Class B is selected, but site-specific velocity measurements are not made, the value of F_a shall be taken as 1.0 per Section 11.4.2.

Note: Where Site Class D is selected as the default site class per Section 11.4.2, the value of F_a shall not be less than 1.2 per Section 11.4.3.

For Site Class = D (default) and $S_S = 0.087$ g, $F_a = 1.600$

Table 11.4-2: Site Coefficient F_v

Site Class	Spectral Response Acceleration Parameter at 1-Second Period					
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 = 0.50$	$S_1 \geq 0.60$
A	0.8	0.8	0.8	0.8	0.8	0.8
B (measured)	0.8	0.8	0.8	0.8	0.8	0.8
B (unmeasured)	1.0	1.0	1.0	1.0	1.0	1.0
C	1.5	1.5	1.5	1.5	1.5	1.4
D (determined)	2.4	2.2 ¹	2.0 ¹	1.9 ¹	1.8 ¹	1.7 ¹
D (default)	2.4	2.2 ¹	2.0 ¹	1.9 ¹	1.8 ¹	1.7 ¹
E	4.2	3.3 ¹	2.8 ¹	2.4 ¹	2.2 ¹	2.0 ¹
F	See Section 11.4.7					

¹ For Site Class D or E and $S_1 \geq 0.2$ g, site-specific ground motions might be required. See Section 11.4.7 of the 2015 NEHRP Provisions.

Note: Use straight-line interpolation for intermediate values of S_1 .

Note: Where Site Class B is selected, but site-specific velocity measurements are not made, the value of F_v shall be taken as 1.0 per Section 11.4.2.

For Site Class = D (default) and $S_1 = 0.042$ g, $F_v = 2.400$

Site-adjusted MCE_R (0.2 s)

$$S_{MS} = F_a S_S = 1.600 \times 0.087 = 0.139 \text{ g}$$

Site-adjusted MCE_R (1.0 s)

$$S_{M1} = F_v S_1 = 2.400 \times 0.042 = 0.100 \text{ g}$$

Design Spectral Acceleration Parameters

Design Ground Motion (0.2 s)

$$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.139 = 0.093 \text{ g}$$

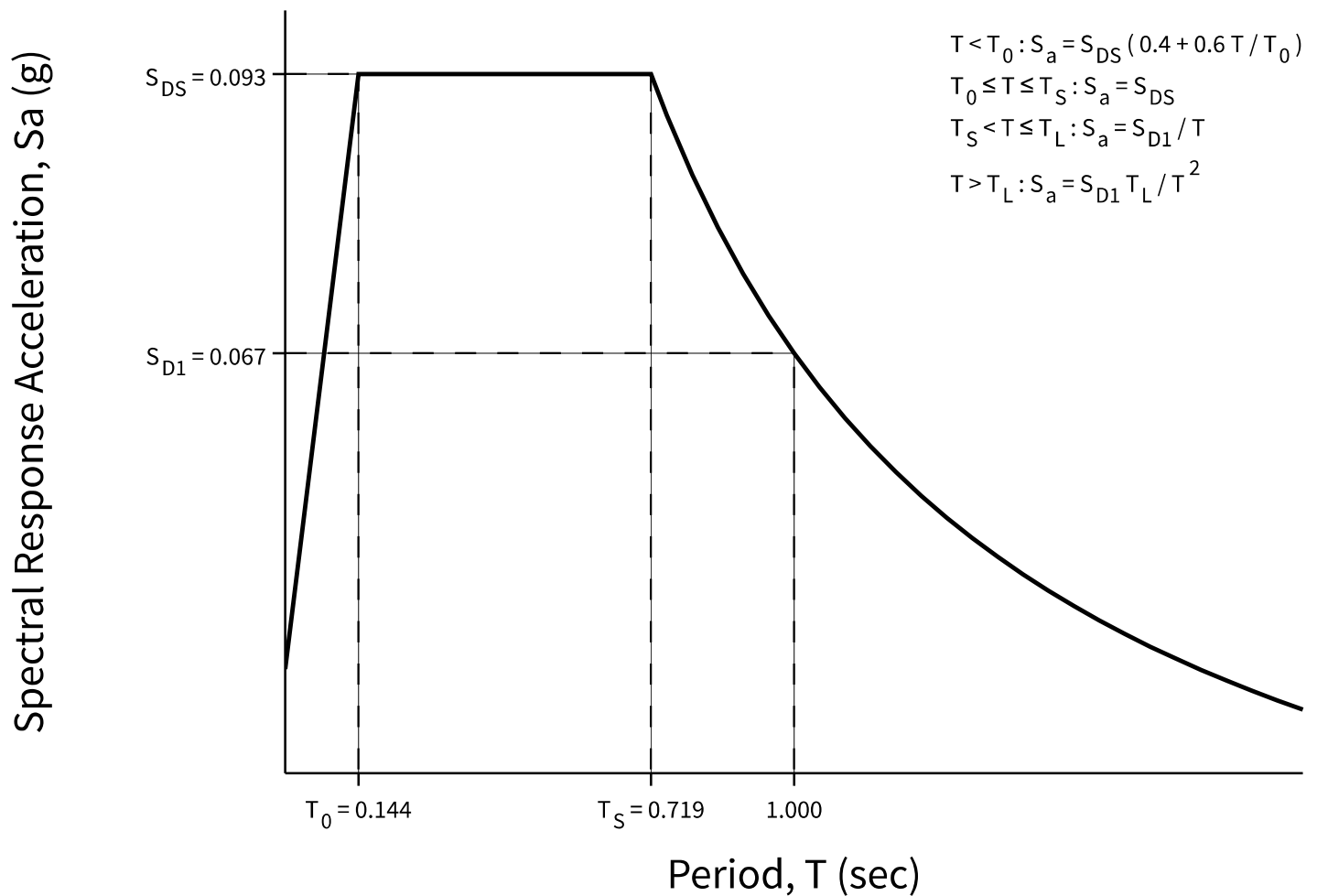
Design Ground Motion (1.0 s)

$$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0.100 = 0.067 \text{ g}$$

Design Response Spectrum

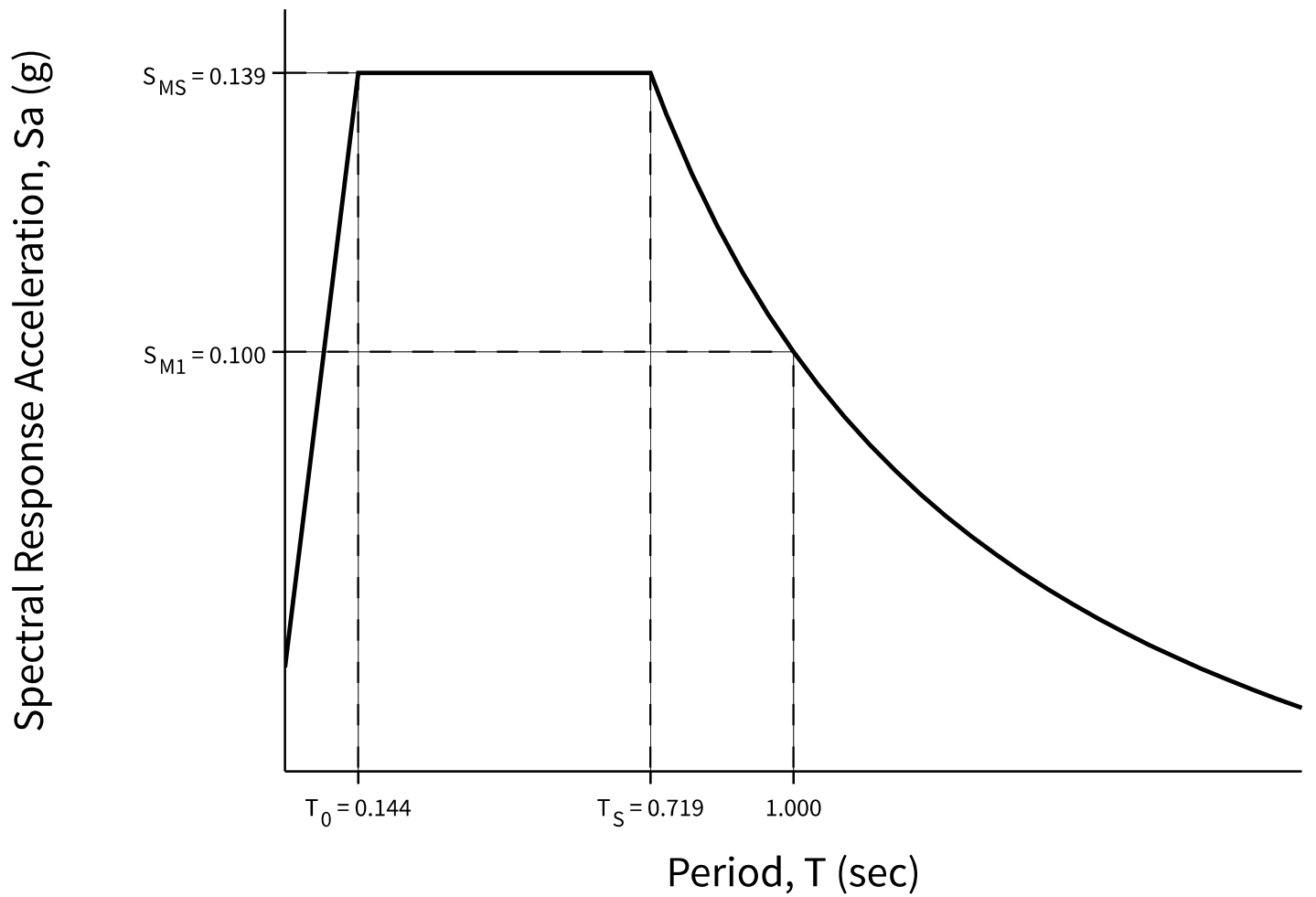
Long-Period Transition Period = $T_L = 12$ s

Figure 11.4-1: Design Response Spectrum



MCE_R Response Spectrum

The MCE_R response spectrum is determined by multiplying the design response spectrum above by 1.5.



Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

Table 11.8-1: Site Coefficient for F_{PGA}

Site Class	Mapped MCE Geometric Mean (MCE_G) Peak Ground Acceleration					
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA = 0.50	PGA ≥ 0.60
A	0.8	0.8	0.8	0.8	0.8	0.8
B (measured)	0.9	0.9	0.9	0.9	0.9	0.9
B (unmeasured)	1.0	1.0	1.0	1.0	1.0	1.0
C	1.3	1.2	1.2	1.2	1.2	1.2
D (determined)	1.6	1.4	1.3	1.2	1.1	1.1
D (default)	1.6	1.4	1.3	1.2	1.2	1.2
E	2.4	1.9	1.6	1.4	1.2	1.1
F	See Section 11.4.7					

Note: Use straight-line interpolation for intermediate values of PGA

Note: Where Site Class D is selected as the default site class per Section 11.4.2, the value of F_{pga} shall not be less than 1.2.

For Site Class = D (default) and PGA = 0.043 g, $F_{PGA} = 1.600$

Mapped MCE_G

PGA = 0.043 g

Site-adjusted MCE_G

$$PGA_M = F_{PGA} PGA = 1.600 \times 0.043 = 0.068 \text{ g}$$