DTE

November 30, 2020

Sent via email

Mr. Andrew Wheeler, EPA Administrator
United States Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Mail Code 50304-P
Washington DC, 20460

RE: Initial Application for Alternate Liner Demonstration
DTE Electric Company Belle River Power Plant
Bottom Ash Basins Coal Combustion Residuals Unit
4505 King Road, China Township, Michigan

Dear Administrator Wheeler:

The DTE Electric Company (DTE Electric) is submitting this initial application to the US. Environmental Protection Agency (EPA) for approval to submit an Alternate Liner Demonstration pursuant to 40 C.F.R. §257.71(d) for the Bottom Ash Basins located at the Belle River Power Plant located in China Township, Michigan. DTE Electric is requesting the opportunity to complete and submit an Alternate Liner Demonstration Package per 40 CFR §257.71(d)(1)(ii) which would enable the Bottom Ash Basins to continue to receive CCR and non-CCR waste streams after April 11, 2021, until such time that EPA makes a decision on the adequacy of the Belle River Power Plant Bottom Ash Basins alternate liner system.

Enclosed is an Initial Application prepared by TRC that demonstrates how DTE Electric qualifies for and should be granted the opportunity to complete and submit an Alternate Liner Demonstration per 40 CFR §257.71(d)(1)(ii) for approval as continued operation of the BRPP BABs CCR unit would pose no reasonable probability of adverse effects to human health or the environment. As allowed by the agency, electronic files were submitted to Richard Huggins, Mary Jackson, Michelle Long, and Jason Mills via email. If you have any questions regarding this submittal, please contact me at 313.235.0153 or christopher.scieszka@dteenergy.com

Sincerely,

Christopher Scieszka
Project Manager, Environmental Management and Safety, DTE Energy

Enclosure

cc: Richard Huggins, Mary Jackson, Michelle Long, and Jason Mills

Initial Application for an Alternate Liner Demonstration

Belle River Power Plant
Bottom Ash Basins Coal Combustion Residuals Unit

November 2020

Prepared For:

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TRC, on behalf of DTE Electric Company (DTE Electric), has prepared this Initial Application for an Alternate Liner Demonstration pursuant to the *Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments (85 FR 72539 November 12, 2020)* (Part B Rule) for the Belle River Plant Bottom Ash Basins (BRPP BABs) Coal Combustion Residuals (CCR) Unit.

This application and its attachments demonstrate how DTE Electric qualifies for submittal of an Alternate Liner Demonstration per 40 CFR § 257.71(d)(1)(i) for approval as continued operation of the BRPP BABs CCR Unit would pose no reasonable probability of adverse effects to human health or the environment in the future based on the following:

- Compliance with all provisions of the Final Rule: Disposal of CCR from Electric Utilities (CCR Rule); April 15, 2015, 40 CFR part 257 subpart D, including a sufficient groundwater monitoring network under § 257.91;
- The groundwater monitoring program meets the requirements of § 257.93 and § 257.94, and per the groundwater quality data collected as part of the program, the BRPP BABs CCR Unit remains in detection monitoring;
- The presence of a natural geologic barrier (more than 80 feet of native clay-rich soil) that provides the equivalent, or better level of protection from potential migration of contaminants than a composite liner defined in § 257.70(b);
- Sufficient documentation that the unit meets all the location restrictions under § 257.60 through § 257.64, and;
- The BRPP BABs CCR Unit is not located adjacent to a surface water body.

1.0 Site Background and Regulatory Framework

TRC, on behalf of DTE Electric Company (DTE Electric), has prepared this Initial Application for an Alternate Liner Demonstration pursuant to the November 12, 2020 *Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments (40 CFR § 257.71(d))* (Part B Rule) for the Belle River Plant Bottom Ash Basins (BRPP BABs) Coal Combustion Residuals (CCR) Unit.

1.1 Site Background

The BRPP is located in Section 13, Township 4 North, Range 16 East at 4505 King Road, China Township in St. Clair County, Michigan (**Figure 1**). The BRPP, including the BABs, were constructed in the early 1980s.

The property has been used continuously as a coal fired power plant since the Detroit Edison Company (now DTE Electric) began power plant operations at BRPP in 1984. The BABs are designed to manage sluiced bottom ash and have been in operation since the BRPP began operation. The BABs are routinely cleaned out and CCR is either beneficially reused or disposed at DTE Electric's Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP near the Webster Drain **(Figure 2)**. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR Unit. The North and South BABs are located north of the BRPP main building and run roughly east to west approximately 420 feet long by 120 feet wide. The BABs have bottom elevations of approximately 580 feet relative to the North American Vertical Datum (NAVD) 1988, with outflow weir elevations of approximately 590.25 feet relative to the NAVD 1988. The capacity of the North BAB is approximately 2.4 million gallons and the capacity of the South BAB is approximately 2.5 million gallons. The BABs are approximately 0.88 and 0.87 acres, respectively.

1.2 Regulatory Framework

On April 17, 2015, the U.S. EPA issued the Final Rule: Disposal of CCR from Electric Utilities (CCR Rule), 40 CFR 257, Subpart D, to regulate the disposal of CCR materials generated at coal-fired units. The rule is being administered under Subtitle D of the Resource Conservation and Recovery Act (RCRA, 42 U.S.C. § 6901 et seq.). On August 28, 2020 and November 12, 2020, the EPA Administrator issued revisions to the CCR Rule that required all unlined surface impoundments to initiate closure by April 11, 2021, unless an alternative deadline is requested and approved (§ 257.103) or an initial application for an Alternate Liner Demonstration is prepared per § 257.71(d) and submitted by November 30, 2020. This applies to the BRPP BABs CCR Unit.

The April 11, 2021 deadline to cease receipt of waste and initiate closure will be tolled upon submission of a complete application, and until such time that EPA makes a final decision on the application or subsequent demonstration. The initial application for an Alternate Liner Demonstration per § 257.71(d)(1)(i) must include the location of the facility and identify the specific CCR surface impoundment(s) for which the demonstration will be made. The application must also include all the following information:

- **§ 257.71(d)(1)(i)(A)** – A certification signed by the owner or operator that the CCR Unit is in full compliance with this subpart except for § 257.71(a)(1);
- **§ 257.71(d)(1)(i)(B)** – Documentation supporting the certification required under § 257.71(d)(1)(i)(A) which includes the following:
    1. Documentation that the groundwater monitoring network meets the requirements of § 257.91. This must include documentation that the existing network of groundwater monitoring wells is sufficient to ensure detection of any groundwater contamination resulting from the impoundment, based on direction of flow, well location, screening depth and other relevant factors;
    2. Documentation that the CCR surface impoundment remains in detection monitoring pursuant to § 257.94 as a precondition for submitting an application. This includes documentation that the groundwater monitoring program meets the requirements of § 257.93 and § 257.94;
    3. Documentation that the unit meets all the location restrictions under § 257.60 through § 257.64;
    4. Documentation of the most recent structural stability assessment required by § 257.73(d); and
    5. Documentation of the most recent safety factor assessment required by § 257.73(e).
- **§ 257.71(d)(1)(i)(C)** – Documentation of the design specifications for any engineered liner components, as well as all data and analyses the owner or operator of the CCR surface impoundment relied on when determining the materials are suitable for use and that the construction of the liner is of good quality and in-line with proven and accepted engineering practices;
- **§ 257.71(d)(1)(i)(D)** – Facilities with CCR surface impoundments located on properties adjacent to a water body must demonstrate that there is no reasonable probability that a complete and direct transport pathway (*i.e.*, not mediated by groundwater) can exist between the impoundment and any nearby water body; and
- **§ 257.71(d)(1)(i)(E)** – Upon submission of the application, and any supplemental materials submitted in support of the application to the Administrator or the Participating State Director, the owner or operator must place the complete application in the facility's operating record as required by § 257.105(f)(14).

The documentation that must be provided to the EPA per § 257.71(d)(1)(i) to demonstrate that the above criteria have been met for an initial Alternate Liner Demonstration for the BRPP BABs CCR Unit is provided within this report.

2.0 Site Geology and Hydrogeology

Pursuant to the Part B Rule, in order to meet the requirements of § 257.71(d)(1), the owner or operator must demonstrate that, without a composite liner, the continued operation of the unit would pose no reasonable probability of adverse effects to human health or the environment. This is demonstrated when the surface impoundment has not and will not result in groundwater concentrations above the relevant groundwater protection standards (GWPS) at the unit boundary (health based or background, whichever is higher).

The geologic and hydrogeologic conditions at the site support a finding that there is no reasonable probability of adverse effects on human health or the environment due to the continued operation of the BABs CCR Unit. Over 80 feet of low permeability clay-rich deposits are present at the site vertically isolating the BABs from the underlying uppermost aquifer. Regional groundwater present in the uppermost aquifer has the potential to be used for drinking water. However, the groundwater at the site is not currently used for drinking water nor is it likely to be used in the future. The following paragraphs document the existing site conditions, identification of potential receptors, and how potential risks related to identified potential receptors have been addressed.

2.1 Regional Geology and Hydrogeology

The current topography of the St. Clair County area gently undulates consisting of floodplain, stream terrace, and lakeshore deposits. The geology of St. Clair County consists of approximately 101 to 400 feet of glacial deposits, primarily lacustrine deposits, till, and, to a lesser extent, sand and gravel outwash, overlying a variety of bedrock surfaces. The thicker glacial deposits, predominantly low permeability clay-rich deposits, are present toward the central portion of the county, including in the area of the BRPP BABs CCR Unit. These thick low permeability subsurface conditions are present on a regional basis due to continental glaciation. The *Natural Clay Liner Equivalency Evaluation Report, DTE Electric and Consumers Energy Company Six Southeast Michigan Coal Combustion Residual Units* (Natural Clay Liner Equivalency Report), previously submitted to the EPA in December of 2018 also contains additional information on the natural clay liner evaluation including hydraulic head data, cross-sections, site-specific clay hydraulic conductivity values and leakage rate calculations. This report has been attached as **Appendix A**. As part of this study, TRC evaluated Multiple CCR impoundments in southeast Michigan, including the BRPP BABs. Using recognized and generally accepted good engineering practices, TRC concluded that the natural soils below these sites in southeast Michigan perform better than composite liners. In summary:

- TRC calculated leakage rates for six Southeast Michigan CCR units and compared these to the anticipated leakage rates for a single composite liner system. For all six units, the leakage rates were generally within an order of magnitude of the composite liner system. These data show that anticipated leakage rates between the natural soil barriers and the single composite liners are comparable. Data are summarized on Table 1 of the Natural Clay Liner Equivalency Report.
- Data also show that other site-specific factors contribute more significantly to the protectiveness of natural soil barriers when compared to a single composite liner system, including thickness of the natural soil barrier, hydraulic conductivity of the soil barrier, and

the hydraulic gradient between the CCR unit and the underlying aquifer, which can result in significantly greater times of travel to the uppermost aquifer. The results of the time of travel calculations are summarized on Table 1 of the Natural Clay Liner Equivalency Report. As shown, all the six evaluated Southeast Michigan CCR units have natural clay liners that are more protective than a single composite liner system.

- The travel time results from this study show times that exceed the USEPA's vulnerability criterion demonstrating that site-specific evaluations can demonstrate protectiveness. The sites presented in this study and the methods and criteria used to evaluate the competency of the liner systems meet the regulatory standard "does not pose a reasonable probability of adverse effects on health or the environment."

Bedrock in the county includes the Michigan Formation, Marshall Sandstone, Coldwater Shale, Sunbury Shale, Berea Sandstone, Bedford Shale, and Antrim Shale. In the vicinity of the site, the Devonian Bedford and/or Antrim Shale bedrock dips to the northwest and is generally covered by more than 100 feet of unconsolidated clay, silt, sand, and gravel. In this area, generally on the eastern side of the county, the glacial deposits are predominantly silty-clay till and lacustrine deposits with lenses of sand and gravel. Where present, unconsolidated sand and gravel deposits within the till and lacustrine deposits are generally used for water supply throughout the county.

The St. Clair River is the major surface water body in the county and runs along the eastern boundary of the county. Shallow regional groundwater flow would be expected to be to the east towards the St. Clair River.

2.2 Site Geology

The BRPP BABs CCR Unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR Unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet below ground surface (bgs). In general, the BRPP BABs CCR unit is initially underlain by at least 90 to as much as 142 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet and rapidly thins to the south and east of the BABs and pinches out (e.g., is not present) to the southeast in the vicinity of SB-16-01 **(Figure 2).** Consequently, the uppermost aquifer is not laterally contiguous across the entire site, nor is it contiguous across BRPP BABs CCR Unit, and not present beneath the southeastern corner of the BABs.

The variability in the depth to the uppermost aquifer is a consequence of the heterogeneity of the glacial deposits and is driven by the lateral discontinuity of the sand outwash within the encapsulating fine-grained, silty clay till that confines the uppermost aquifer. Data collected by TRC shows that there is a lack of interconnection and/or significant vertical variation between the uppermost aquifer sand unit(s) encountered across the BRPP BABs CCR Unit as demonstrated by the extensive amount of time (months) it took for water levels in monitoring well MW-16-02 to reach equilibrium after well construction and development. Refer to **Figure 7** for a groundwater elevation summary map.

Along the southeastern portion of the BRPP BABs CCR Unit, clay-rich deposits extend to the top of the Bedford Shale and no aquifer is present beneath this portion of the CCR Unit. Refer to the Groundwater Monitoring Systems Summary Report attached as **Appendix B** and **Figures 3 through 6**.

2.3 Site Hydrogeology

A definitive groundwater flow direction is not evident around the BABs based on 15 rounds of groundwater monitoring. Refer to **Figure 7** for a groundwater elevation summary map. This is not unexpected given the horizontally expansive clay across the region, with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR Unit, the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs, where present varying up to 46 feet vertically), the no flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR Unit area, and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas. As such, it is not appropriate to infer horizontal flow direction or gradients across the BRPP BABs CCR Unit.

Hydraulic conductivities measured within the CCR monitoring wells set within the upper portion of the uppermost aquifer across BRPP were evaluated using single well hydraulic conductivity tests (e.g., slug tests) performed in 2016 (attached as **Appendix H**). The calculated hydraulic conductivity of the uppermost aquifer using wells at the BABs CCR Unit area (MW-16-01 and MW-16-04) is approximately 0.5 feet/day. This low hydraulic conductivity further demonstrates the low groundwater yield potential across the conservatively interpreted, potential uppermost aquifer encountered at the site. As discussed above, a definitive horizontal flow direction in the BABs CCR Unit area is not present; therefore, it is not appropriate to estimate the horizontal time of travel.

The water level in the BABs is maintained at an elevation of approximately 590 feet. The hydraulic head in the aquifer below the BABs is approximately 574 feet. The bottom of the BABs is at an elevation of approximately 580 feet and the bottom of the clay underlying the BABs is at an elevation of approximately 498 feet, thus 82 feet of clay separate the bottom of the BABs CCR unit from the underlying aquifer. In addition, the elevation of surface water maintained within the BRPP BABs is approximately 5 feet above the potentiometric surface elevations in the uppermost aquifer at the BABs CCR Unit area. This suggests that if the CCR-affected surface water in the BABs was able to penetrate the silty clay-rich underlying confining unit, the head on that release likely would travel radially away from the BABs within the uppermost aquifer. However, due to the very thick continuous silty clay-rich confining unit with hydraulic conductivity values ranging from 2.1×10^{-8} cm/s to 2.9×10^{-8} cm/s beneath the BRPP, there is no reasonable probability for the uppermost aquifer to have been affected by CCR from BRPP operations that began in the 1980s. Under pre-existing solid waste rules in Michigan, solid waste facilities with similar geology to the BRPP BABs CCR Unit have been granted waivers from groundwater monitoring based on the environmental protectiveness of the native thick clay-rich geology.

Refer to **Appendix C** for the 2019 Annual Groundwater Monitoring Report, **Appendix D** for the 2018 Annual Groundwater Monitoring Report and **Appendix E** for the 2017 Annual Groundwater Monitoring Report for more information on the BRPP BABs CCR unit groundwater flow. Refer to **Figure 7** for a map presenting the potentiometric surface groundwater elevations from 2016 to 2019.

2.4 Vertical Flow Potential to Uppermost Aquifer

As stated previously, the deposits underlying the BRPP predominantly consist of natural silty-clay, and the presence of these deposits has been verified by regional geological studies (Summary of Hydrogeologic Conditions by County for the State of Michigan. U.S. Geological Survey Open-File Report 2007-1236, 78 p, Beth A. Apple and Howard W. Reeves, 2007), and at the site by numerous historical soil borings (refer to **Appendix K**) and confirmed by the twelve soil borings installed as part of the CCR monitoring well installation program at the BABs and DB CCR Units. Therefore, the geology and hydrogeology of the site provides a very high level of environmental protection of the uppermost aquifer. Based on the site geology and hydrogeology, there is no reasonable probability for the impoundments to adversely affect the on-site or off-site uppermost aquifer, human health or the environment given the relatively short duration of continued operation. Groundwater present in the deep confined uppermost aquifer is protected from CCR constituents in the BABs by a clay-rich aquitard with low hydraulic conductivity that is 82 or more feet thick from the bottom of the BABs. Using the hydrogeologic information for the site, the time of travel for water from the base-grade elevation of the BABs down to the uppermost aquifer can be calculated using the following seepage velocity formula:

$$V = Ki/Ne$$

Where:

V = Velocity (feet/day)

K = Hydraulic Conductivity (3 x 10^{-8} cm/s based on high end silty clay-rich data)

i = Downward Vertical Gradient (conservatively assumed to be one foot/foot)

Ne = Effective Porosity (0.5 for clay-rich soil)

From the above formula, the maximum downward flow velocity through the silty-clay confining unit to the uppermost aquifer is 6 x 10^{-8} cm/sec, or 0.063 feet/year. Using conservative assumptions, the time of travel for liquid from the base of the BABs through 82 feet of silty-clay (thinnest potential section of silty-clay confining unit above the uppermost aquifer at the base of the BABs CCR Unit) to the uppermost aquifer is approximately 1,300 years. The calculated travel time presented in the Natural Clay Liner Equivalency Report was performed using the actual hydraulic head of 0.2 vs. the conservative hydraulic head of 1 ft/ft used in the conservative seepage velocity calculation above resulted in a travel time of 5,329 years as detailed in **Appendix A.** Therefore, given that BRPP operations began in 1984, there is no reasonable probability for the uppermost aquifer CCR groundwater monitoring system wells to be affected by the BRPP CCR BABs Unit. In addition, given the fact that DTE Electric has publicly announced that it plans to cease operations at the BRPP by 2030, and close the BABs by CCR removal, there is no reasonable potential for the uppermost aquifer to be affected by the BABs in the future. Refer to the 2019 Integrated Resource Plan (IRP) presented to and approved by the Michigan Public Service Commission attached as **Appendix F**. These data show that the natural clay-rich soil underlying the BABs CCR Unit provides the same, or better level of protection from potential migration of contaminants than the composite liner defined in § 257.70(b).

2.5 Groundwater Use

Groundwater use in the vicinity of the site is very limited. Water supply wells are present within the sand and/or gravel rich aquifer units within the lacustrine unconsolidated sediments at depths of around 100 feet-bgs within between one-half and one mile to the west and southwest of the BRPP. There is no on-site use of groundwater at the BRPP. Surface water bodies present in the area of the BRPP include the Belle River (as approximately 2,000 feet southwest and south of BRPP) and the St. Clair River (approximately one mile to the east of BRPP). Given the distance of the nearest water supply wells and the rivers from the BRPP and the thick natural clay-rich soil liner underlying the BABs CCR Unit, there is no reasonable probability of affected groundwater migrating to water supply wells or the rivers from the CCR Unit.

3.0 Facility Compliance

DTE Electric has a public repository of documents in accordance with § 257.107 which can be found here: DTE CCR Compliance Data and Information. This repository demonstrates that the BRPP facility is in compliance with all record keeping, notification and internet posting requirements as required by 40 CFR 257 Subpart D. DTE Electric retained TRC to audit their records to identify any gaps in compliance and none were noted. As required by § 257.71(d)(1)(i)(A), a certification signed by the owner or operator that the BRPP BABs CCR Unit is in full compliance with this subpart, except for § 257.71(a)(1), has been included as **Appendix G**. A summary of the key compliance metrics for the BRPP BABs is discussed below.

3.1 Groundwater Monitoring System § 257.71(d)(1)(i)(B)(1)

In accordance with § 257.91, a P.E.-certified groundwater monitoring system is established for the BRPP BABs CCR Unit **(Appendix B)**. The monitoring well network for the BABs CCR Unit currently consists of five monitoring wells that are screened in the uppermost aquifer and are sufficient to ensure detection of groundwater contamination resulting from the BABs CCR Unit as discussed further below. The monitoring well locations are shown on **Figure 2** and are adequately placed for detection monitoring at the BABs based on the lack of groundwater flow direction, the small size of the BABs and the limited presence of the aquifer beneath the BABs. The spacing of the wells was designed to cover all sides of the BABs where the aquifer is present.

In February 2016 through June 2016, soil borings were advanced to evaluate the subsurface geology and to allow monitoring well installation using sonic drilling techniques with 4-inch and 6-inch tooling along the perimeter of the BABs area. Soil samples were collected continuously in ten-foot sections from the ground surface to the termination of the soil boring. A TRC geologist was present to log each boring and describe the soil samples in accordance with the Unified Soil Classification System (USCS). The soil borings were advanced to depths ranging from approximately 100 to 150 feet-bgs to within the first encountered saturated sand and/or sand/gravel unit (uppermost aquifer) and/or into the top of the underlying shale bedrock (likely the Bedford Shale) lower confining unit beneath BRPP.

Using the above drilling method, groundwater monitoring wells MW-16-01, MW-16-02, MW-16-04 were installed in the first encountered saturated sand and/or sand/gravel unit (uppermost aquifer) in February and March 2016. A fourth location (later designated as SB-16-01) was attempted along the southeastern portion of the BABs CCR unit. Over 140 feet of continuous silt/clay-rich till was observed to the top of the underlying shale bedrock at SB-16-01 (see soil boring log SB-16-01 in **Appendix B**). The shale bedrock was observed at 142 feet-bgs and did not yield groundwater (i.e., is not an aquifer). Soil boring SB-16-01 was left open-hole across the silt/shale bedrock interface with the sonic casing pulled back overnight and very minimal groundwater (less than 2 inches) entered the soil boring overnight. Therefore, no aquifer was identified to be present in the southeastern portion of the BABs CCR unit in the area of SB-16-01 (**Figure 2**).

After the geology and groundwater flow were evaluated in the newly installed monitoring wells MW-16-01, MW-16-02 and MW-16-04, and the lack of aquifer was noted at the southeastern section of the BABs CCR Unit, TRC mobilized to complete a second round of investigation in the same manner as described above to further document subsurface conditions and enhance the monitoring network by installing additional monitoring wells MW-16-03 and MW-16-09. At the five monitoring well locations (MW-16-01 through MW-16-04 and MW-16-09) a saturated sand-rich upper aquifer unit was encountered at depths ranging from 90 to 136 feet-bgs, generally deeper to the east and southeast.

The perimeter groundwater monitoring well network is appropriate to monitor the BRPP BABs CCR Unit given the wells provide coverage on all sides of the unit where the aquifer is present. The monitoring well system is considered a conservative approach to demonstrating compliance given the relatively small footprint of the BABs, the presence of the substantially thick natural clay liner (as discussed in Section 2.0), where the low permeability of the clay significantly impedes the vertical migration of CCR constituents within groundwater, the lack of an aquifer at the southeast corner of the BABs, the variable depth of the sand-rich aquifer and lack of a consistent horizontal groundwater flow direction observed at the BABs CCR Unit. The monitoring well locations are shown on **Figure 2**. Well Construction and Soil Boring Logs for the monitoring network are attached in **Appendix B**.

Groundwater elevation data collected indicate the lack of an overall groundwater flow direction and/or changing groundwater flow directions over time within the uppermost aquifer. A groundwater potentiometric elevation summary map is shown on **Figure 7**.

3.2 Groundwater Statistical Evaluation Plan § 257.71(d)(1)(i)(B)(2)

The CCR Rule allows a variety of methods for conducting statistical evaluations. The P.E. certified Groundwater Statistical Evaluation Plan for the BRPP BABs CCR Unit including the statistical evaluation of background data is attached as **Appendix I**. This plan was developed using USEPA's *Unified Guidance* and other available guidance (e.g., ASTM). In addition to using applicable guidance documents, commercially available statistical evaluation tools were utilized to establish statistically derived limits so that detection monitoring data could be evaluated. Statistical methods were also selected considering site specific geologic and hydrogeologic conditions.

TRC considered interwell and intrawell methods as part of the selection criteria. These methods are fundamentally different, but both have their advantages and disadvantages. While the interwell analysis compares downgradient compliance wells against a background composed of upgradient well data, it typically relies on uniform hydrogeologic conditions and the presence of consistently upgradient and downgradient hydraulic flow conditions. By contrast, the intrawell analysis compares each compliance well against a background composed of its own historical data such that individual wells serve as both the background and downgradient compliance wells. Intrawell statistical methods for the BRPP BABs CCR Unit were selected due to:

- The relatively small footprint of the BABs;
- The lack of consistent horizontal flow direction and hence velocity;

- The extremely low vertical groundwater flow velocity, the low permeability and diffusive properties of the clay, and potential for radial flow outward from the CCR unit in the unlikely event it were to leak;
- The saturated unit being monitored is isolated by an 80-ft-thick (or more) laterally contiguous silty-clay unit native clay liner, which significantly impedes vertical groundwater flow thus preventing the monitored saturated zone from potentially being affected by CCR constituents from the BABs;
- The uppermost aquifer is not uniformly present;
- The uppermost aquifer is of variable thickness (where present) across the BABs CCR unit; and
- There are no clear upgradient wells.

When an intrawell analysis is used, the base assumption is that the data used as background have not been impacted by the CCR unit. Given the significant clay isolation thickness between the BABs and the uppermost aquifer, the low permeability of the underlying soil, the potential for water quality to be impacted from the BABs CCR Unit is extremely unlikely as described in detail in Section 2.0 of this report, and is further supported by groundwater quality data that are consistent with regional background groundwater quality. On this basis, the intrawell methods are appropriate for detection monitoring at the BABs CCR Unit.

3.3 Detection Monitoring § 257.71(d)(1)(i)(B)(2)

Detection monitoring has been completed since 2017 in accordance with § 257.93 and § 257.94 with compliance as required in § 257.71(d)(1)(i)(B)(2) being documented in the 2017, 2018 and 2019 Annual Reports prepared in accordance with § 257.90 (**Appendix C, D and E**). Statistical evaluation of groundwater data is completed each time samples are collected in accordance with the Groundwater Statistical Evaluation Plan attached as **Appendix I.** The groundwater sampling results have been confirmed to be below background limits for Appendix III indicator parameters since semiannual monitoring events began in 2017 and/or were successfully addressed with an alternative source demonstration (ASD). Therefore, no statistically significant increases (SSIs) have been confirmed for the BRPP BABs CCR unit. See **Appendix C, D and E** for the Annual Groundwater Monitoring Reports that include ASD(s) (when performed) and **Tables 1.1 through 1.5** for a summary of the detection monitoring analytical data and statistical analysis completed for the site from 2017 through 2019.

3.4 Location Standards § 257.71(d)(1)(i)(B)(3)

The BRPP BABs CCR Unit is compliant with the location restrictions of § 257.60-64 as described below.

§ 257.60 – Placement above the Uppermost Aquifer

The federal CCR rule § 257.60 requires that CCR units such as the BRPP BABs 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). The BABs are incised into the clay to an approximate elevation of 580 ft above MSL. The uppermost aquifer is the sand-rich unit. The sand rich unit can be found at an elevation of 453 to 498 ft above MSL. The base of the BABs and the uppermost aquifer are separated by at least 82 feet of native, low permeability clay. Cross-sections showing the approximate pond bottom elevation for each BAB, and the depth to the uppermost aquifer are attached as **Figures 3 through 6.**

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

§ 257.61 – Wetlands

The CCR location standard § 257.61 restrict existing and new CCR surface impoundments from being located in wetlands. Wetlands as defined in § 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 the 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 BABs are located in wetlands.

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 one area located approximately 200 ft north of the BABs as a wetland. NWI also recognizes an area approximately 450 ft west of the BABs as a wetland. These areas are not immediately adjacent to the BABs, and therefore, there is no risk of impact to these areas from the BAB operations.

Based on TRC's review of wetland inventory resources and current site conditions, the BRPP BABs are not located in an area exhibiting wetland characteristics, and any continued operations at the BABs will have no potential to impact any wetlands near the CCR unit. TRC also concludes that, due to their use as NPDES treatment units, these basins are not wetlands, as defined in § 232.2.

§ 257.62 – Fault Areas

The federal CCR rule § 257.62 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 not cause 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), no faults have been mapped near the BRPP BABs.

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

§ 257.63 – Seismic Impact Zones

The federal CCR rule § 257.63 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 BABs are 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) indicates a mapped peak ground acceleration of 0.043 g for the BRPP BABs 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 BABs are not located in a seismic impact zone, and therefore the BABs are in compliance with the requirements of § 257.63.

§2 57.64 – Unstable Areas

The federal CCR rule § 257.64 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 and topography, and evaluating human-made features in the area of the BRPP BABs.

Geotechnical explorations performed at the BRPP BAB area identified clay with lenses of silt and sand. The soils occur above soft to very hard shale bedrock. These observations suggest that there are no unstable soil or unstable underlying bedrock proximal to the BABs.

Geological and geomorphological information was reviewed to determine potential unstable areas at the BRPP BABs. None of the geological or geomorphological information reviewed suggest the presence of unstable areas at or near the BABs. 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, the BRPP BABs are not located in an unstable area. The BABs are in compliance with the requirements of § 257.64.

The location restriction certification report has been attached as **Appendix J**.

3.5 Structural Stability and Safety Factor Assessments § 257.71(d)(1)(i)(B)(4 & 5)

Structural stability assessment and safety factor assessments, as required per § 257.103 (f)(2)(v)(C)(7) and (8), are not required for the BRPP BABs surface impoundments since the CCR Unit is less than 5 feet high, and have therefore not been included with this submittal.

3.6 Documentation of Design Specifications § 257.71(d)(1)(i)(C)

Prior to the construction of BRPP, a significant geotechnical investigation demonstrated extensive clay deposits across the entire BRPP site as documented in a 1976 *Subsurface Investigation and Foundation Report* by Bechtel. According to the report, "The investigation consisted of geologic studies, groundwater measurements, soil/rock borings, and laboratory soil testing, along with an evaluation of previous investigations at the site. The subsurface investigation was directed at confirming the suitability of the site and providing generalized soil parameters and information for design of the various plant facilities". The Bechtel report included an evaluation of the native clay soils that were used in construction of the BRPP BABs CCR Unit surface impoundments, which are incised into the natural clay liner. The soil conditions were evaluated in over 60 soil borings. The evaluation included soil hydraulic conductivity testing showing the native clay soil is greater than 80 feet thick across the property and has a hydraulic conductivity of around 2×10^{-8} cm/s that is similar to the clay hydraulic conductivity that was measured in the 2016 clay-rich soil hydraulic conductivity testing performed at the time the BRPP BABs CCR Unit monitoring well network was installed (See **Section 2.3**). The 1976 Bechtel report is provided in **Appendix K**.

In addition, the December 17, 1981 Technical Specifications for the Construction of Ash Settling Basins, Waste Storage Basins, and Fuel Oil Dike for The Detroit Edison Company Belle River Power Plant Units 1 and 2 demonstrate that the BRPP BABs were constructed with engineered compacted native clay utilizing a quality assurance/quality control (QA/QC) program to ensure proper compaction and construction of the BABs native clay liner. A copy of the 1981 Technical Specifications is included in **Appendix L** along with other design and as built documents for the BAB.

3.7 Facilities with CCR surface impoundments located on properties adjacent to a water body § 257.71(d)(1)(i)(D)

The BRPP BABs CCR Unit is not located adjacent to a surface water body.

3.8 Alternate Liner Application Placed in the Operating Record - § 257.71(d)(1)(i)(E)

This alternate liner demonstration application and supplemental materials submitted in this application have been placed in the facility's operating record as required by § 257.105(f)(14).

4.0 Conclusions

This document demonstrates how the BRPP BAB CCR Unit meets the provisions of the initial application for an alternate liner demonstration by:

- Demonstrating continued compliance with the CCR Rule for all record keeping, notification and internet posting requirements. In addition, detection monitoring is completed at the established groundwater monitoring network as required by § 257.93 and § 257.94 and annual reporting as required by § 257.90 documents compliance with the detection monitoring program;
- Demonstrating the presence of a natural geologic barrier underlying the BRPP BABs CCR Unit, that consists of a substantially thick (> 80 feet), low hydraulic conductivity clay that provides the same, or better level of protection from potential migration of contaminants than the composite liner defined in § 257.70(b);
- Demonstrating that the BRPP BABs CCR Unit is compliant with the location restrictions of § 257.60-64 and that the structural stability and safety factor assessments as required per § 257.103 (f)(2)(v)(C)(7) and (8) are not required;
- Including the BRPP BABs natural clay liner soil assessment performed prior to construction of the surface impoundments;
- Documenting the BRPP BABs are not located adjacent to a surface water body; and
- Placing this alternate liner demonstration application and supplemental materials submitted in this application in the facility's operating record as required by § 257.105(f)(14).

Therefore, it is requested that the EPA approve DTE Electric's initial application to complete an alternate liner demonstration for the BRPP BABs CCR Unit per § 257.71(d)(i).

5.0 References

ASTM. 2012. *Standard Guide for Developing Appropriate Statistical Approaches for Groundwater Detection Monitoring Programs*. D6312-98(2012)e1. West Conshohocken, PA: ASTM International.

Beth A. Apple and Howard W. Reeves, 2007, Summary of Hydrogeologic Conditions by County for the State of Michigan. U.S. Geological Survey Open-File Report 2007-1236, 78 p

Bechtel. August 1976. Subsurface Investigation and Foundation Report – The Detroit Edison Company, Belle River Units 1 & 2.

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DTE Electric Company. 2019. 2019 Integrated Resource Plan Case No: U-20471, Exhibit A-3 submitted to the Michigan Public Service Commission.

The Detroit Edison Company. December 17, 1981. Technical Specifications for Construction of Ash Settling Basins, Waste Storage Basins, and Fuel Oil Dike for The Detroit Edison Belle River Power Plant Units 1 and 2.

TRC Environmental Corporation. January 2020. 2019 Annual Groundwater Monitoring Report - DTE Electric Company Belle River Power Plant Bottom Ash Basins, 4505 King Road, China Township, Michigan 48054

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USEPA. 1989. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance.* Office of Solid Waste.

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Tables

Table 1.1
Comparison of Appendix III Parameter Results to Background Limits – October 2017 and January 2018
Belle River Power Plant BABs – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01			MW-16-02			MW-16-03		MW-16-04		MW-16-09	
Sample Date:		10/2/2017	1/9/2018 (1)	PL	10/2/2017	1/9/2018 (1)	PL	10/2/2017	PL	10/2/2017	PL	10/3/2017	PL
Constituent	Unit	Data			Data			Data		Data		Data	
Appendix III													
Boron	ug/L	950	--	1,300	1,000	--	1,300	1,000	1,300	920	1,100	1,600	1,900
Calcium	ug/L	38,000	--	45,000	53,000	--	59,000	32,000	36,000	44,000	64,000	34,000	41,000
Chloride	mg/L	470	--	530	370	--	400	580	690	510	520	980	1100
Fluoride	mg/L	1.7	--	1.9	1.2	--	1.3	1.8	1.9	1.7	1.9	1.5	1.8
pH, Field	SU	**7.3**	7.6	7.6 - 8.1	**7.3**	7.4	7.4 - 8.0	7.7	7.5 - 8.3	7.8	7.5 - 8.4	8.1	7.7 - 8.7
Sulfate	mg/L	4.2	--	8.1	7.7	--	20	2.5	14	7.9	18	24	40
Total Dissolved Solids	mg/L	930	--	950	760	--	890	1,100	1,100	1,000	1,100	1,700	2,000

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units; pH is a field parameter.
-- = not analyzed.
All metals were analyzed as total unless otherwise specified.
Bold font indicates an exceedance of the Prediction Limit (PL).
RESULT Shading and bold font indicates a confirmed exceedance of the Prediction Limit (PL).
(1) - Results shown for verification sampling performed on 1/9/2018.

Table 1.2
Comparison of Appendix III Parameter Results to Background Limits – March 2018
Belle River Power Plant BABs – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Sample Date:		3/26/2018	PL	3/26/2018	PL	3/26/2018	PL	3/26/2018	PL	3/27/2018	PL
Constituent	Unit	Data		Data		Data		Data		Data	
Appendix III											
Boron	ug/L	1,100	1,300	1,200	1,300	1,200	1,300	1,100	1,100	1,600	1,900
Calcium	ug/L	38,000	45,000	54,000	59,000	33,000	36,000	43,000	64,000	39,000	41,000
Chloride	mg/L	480	530	360	400	610	690	490	520	960	1100
Fluoride	mg/L	1.8	1.9	1.2	1.3	1.8	1.9	1.7	1.9	1.5	1.8
pH, Field	SU	7.6	7.6 - 8.1	7.6	7.4 - 8.0	7.8	7.5 - 8.3	7.8	7.5 - 8.4	7.8	7.7 - 8.7
Sulfate	mg/L	2.1	8.1	4.9	20	1.7	14	13	18	38	40
Total Dissolved Solids	mg/L	950	950	730	890	1,000	1,100	920	1,100	1,700	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

All metals were analyzed as total unless otherwise specified.

Bold font indicates an exceedance of the Prediction Limit (PL).

RESULT Shading and bold font indicates a comfirmed exceedance of the Prediction Limit (PL).

Table 1.3
Comparison of Appendix III Parameter Results to Background Limits – October 2018
Belle River Power Plant BABs – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Sample Date:		10/1/2018	PL	10/1/2018	PL	10/1/2018	PL	10/1/2018	PL	10/4/2018	PL
Constituent	Unit	Data		Data		Data		Data		Data	
Appendix III											
Boron	ug/L	1,000	1,300	1,200	1,300	1,100	1,300	1,100	1,100	1,600	1,900
Calcium	ug/L	41,000	45,000	53,000	59,000	32,000	36,000	44,000	64,000	41,000	41,000
Chloride	mg/L	500	530	390	400	620	690	520	520	980	1100
Fluoride	mg/L	1.7	1.9	1.2	1.3	1.7	1.9	1.7	1.9	1.5	1.8
pH, Field	SU	7.7	7.6 - 8.1	7.8	7.4 - 8.0	8.0	7.5 - 8.3	7.9	7.5 - 8.4	8.4	7.7 - 8.7
Sulfate	mg/L	6.7	8.1	4	20	1.6	14	13	18	5.5	40
Total Dissolved Solids	mg/L	860	950	730	890	980	1,100	920	1,100	1,500	2,000

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units; pH is a field parameter.
-- = not analyzed
All metals were analyzed as total unless otherwise specified.
Bold font indicates an exceedance of the Prediction Limit (PL).
RESULT Shading and bold font indicates a comfirmed exceedance of the Prediction Limit (PL).

Table 1.4

Comparison of Appendix III Parameter Results to Background Limits – March and May 2019

Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program

China Township, Michigan

Sample Location:		**MW-16-01**			**MW-16-02**		**MW-16-03**		**MW-16-04**			**MW-16-09**	
Sample Date:		3/18/2019	5/9/2019 (1)	PL	3/18/2019	PL	3/18/2019	PL	3/18/2019	5/9/2019 (1)	PL	3/20/2019	PL
Constituent	Unit	Data			Data		Data		Data			Data	
Appendix III													
Boron	ug/L	1,200	--	1,300	1,200	1,300	1,200	1,300	1,000	--	1,100	1,600	1,900
Calcium	ug/L	41,000	--	45,000	54,000	59,000	33,000	36,000	42,000	--	64,000	32,000	41,000
Chloride	mg/L	480	--	530	370	400	570	690	500	--	520	960	1,100
Fluoride	mg/L	1.6	--	1.9	1.1	1.3	1.6	1.9	1.6	--	1.9	1.3	1.8
pH, Field	SU	7.6	7.7	7.6 - 8.1	7.6	7.4 - 8.0	7.9	7.5 - 8.3	7.9	7.7	7.5 - 8.4	8.0	7.7 - 8.7
Sulfate	mg/L	5.8	--	8.1	4.8	20	2.4	14	**27**	**24 (2)**	18	18	40
Total Dissolved Solids	mg/L	**960**	**970 (2)**	950	730	890	1,100	1,100	990	**--**	1,100	1,700	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

-- = not analyzed.

All metals were analyzed as total unless otherwise specified.

Bold font indicates an exceedance of the Prediction Limit (PL).

RESULT Shading and bold font indicates a confirmed exceedance of the Prediction Limit (PL).

(1) - Results shown for verification sampling performed on 5/9/2019.

(2) - New successful alternative source demonstration was completed following confirmation of the initial statistically significant exceedance.

Table 1.5

Comparison of Appendix III Parameter Results to Background Limits – September and November 2019

Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program

China Township, Michigan

Sample Location:		MW-16-01		MW-16-02		MW-16-03			MW-16-04		MW-16-09	
Sample Date:		9/16/2019	PL	9/16/2019	PL	9/16/2019	11/11/2019[1]	PL	9/16/2019	PL	9/17/2019	PL
Constituent	Unit	Data		Data		Data			Data		Data	
Appendix III												
Boron	ug/L	1,000	1,300	1,100	1,300	1,100	--	1,300	1,000	1,100	1,500	1,900
Calcium	ug/L	43,000	45,000	58,000	59,000	**38,000**	20,000	36,000	47,000	64,000	37,000	41,000
Chloride	mg/L	460	530	350	400	**1,000**	600	690	480	520	920	1,100
Fluoride	mg/L	1.8	1.9	1.1	1.3	1.8	--	1.9	1.7	1.9	1.4	1.8
pH, Field	SU	7.6	7.6 - 8.1	7.5	7.4 - 8.0	7.6	7.8	7.5 - 8.3	7.8	7.5 - 8.4	8.0	7.7 - 8.7
Sulfate	mg/L	7.5	8.1	5.8	20	1.7	--	14	**20**[2]	18	12	40
Total Dissolved Solids	mg/L	950	950	770	890	1,000	--	1,100	970	1,100	1,800	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

-- = not analyzed.

All metals were analyzed as total unless otherwise specified.

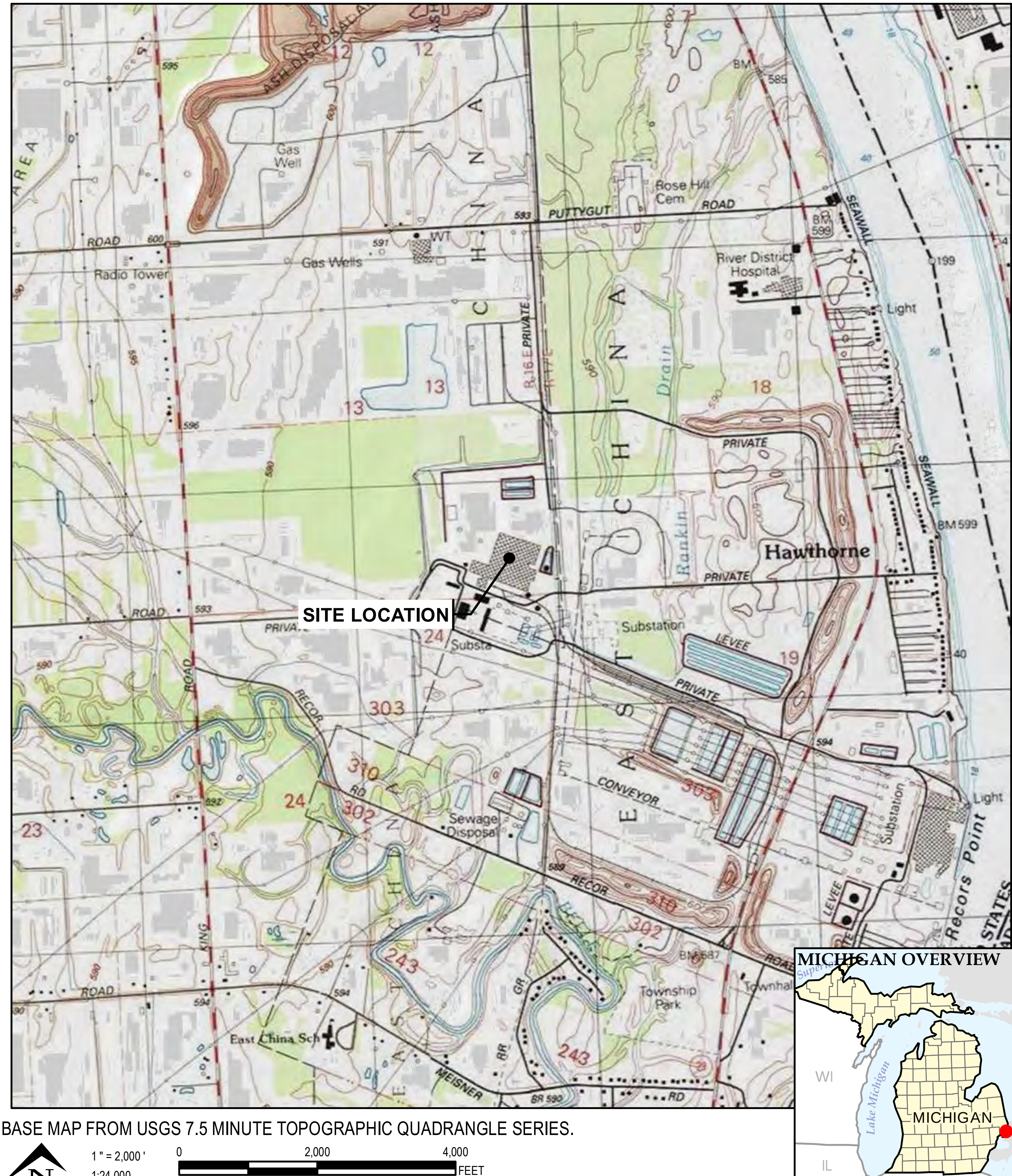
Bold font indicates an exceedance of the Prediction Limit (PL).

RESULT Shading and bold font indicates a confirmed exceedance of the Prediction Limit (PL).

(1) - Results shown for verification sampling performed on 11/11/2019.

(2) - Concentration addressed through first 2019 Semiannual alternative source demonstration.

Figures



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN
TITLE:	SITE LOCATION MAP

DRAWN BY:	S. MAJOR
CHECKED BY:	J. Krenz
APPROVED BY:	V. Buening
DATE:	DECEMBER 2019
PROJ. NO.:	320511.0003
FILE:	320511-0003-001slmMB.mxd

FIGURE 1

E:\DTE\CCR_Sites\2017_265996\320511-0003-001slmMB.mxd -- Saved By: SMAJOR on 12/3/2019, 15:54:02 PM

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO. & PARTNERS, (3/24/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, JUNE 2016, AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND, GRAVEL OR OTHER SATURATED ZONE WAS ENCOUNTERED ABOVE THE SHALE BEDROCK IN THIS LOCATION. THEREFORE, AN AQUIFER WAS NOT ENCOUNTERED AND A MONITORING WELL WAS NOT INSTALLED.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT BOTTOM ASH BASIN
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
SITE PLAN

DRAWN BY:	M. VAPHIADIS	PROJ NO.:	320511.0003.0000 P1 T1
CHECKED BY:	K. CRATSENBURG		**FIGURE 2**
APPROVED BY:	V. BUENING		
DATE:	NOVEMBER 2020		

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FILE NO.: 320511-0003-016.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 11/3/2020, 15:59:42 PM by AADAIR -- LAYOUT: ANSI B(11"x17")
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TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 11/3/2020, 11:46:22 AM by AADAIR -- LAYOUT: ANSI B(11"x17")
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LEGEND

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

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, (3/23/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND, GRAVEL OR OTHER SATURATED ZONE WAS ENCOUNTERED ABOVE THE SHALE BEDROCK IN THIS LOCATION. THEREFORE, AN AQUIFER WAS NOT ENCOUNTERED AND A MONITORING WELL WAS NOT INSTALLED.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT BOTTOM ASH BASIN
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
CROSS SECTION LOCATOR MAP

DRAWN BY:	A. ADAIR	PROJ NO.:	370029.0003
CHECKED BY:	K. CRATSENBURG		**FIGURE 3**
APPROVED BY:	V. BUENING		
DATE:	NOVEMBER 2020		

TRC

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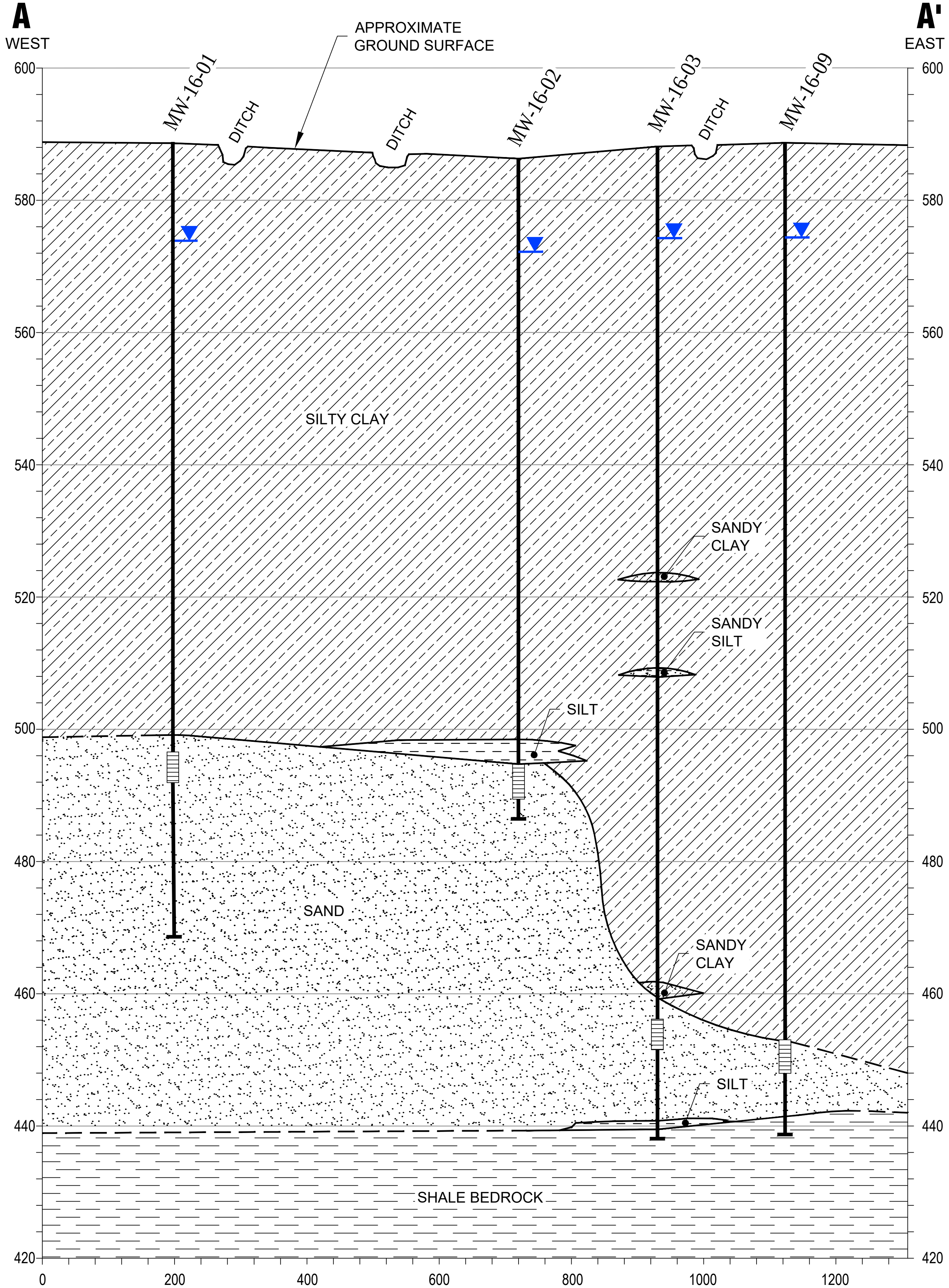
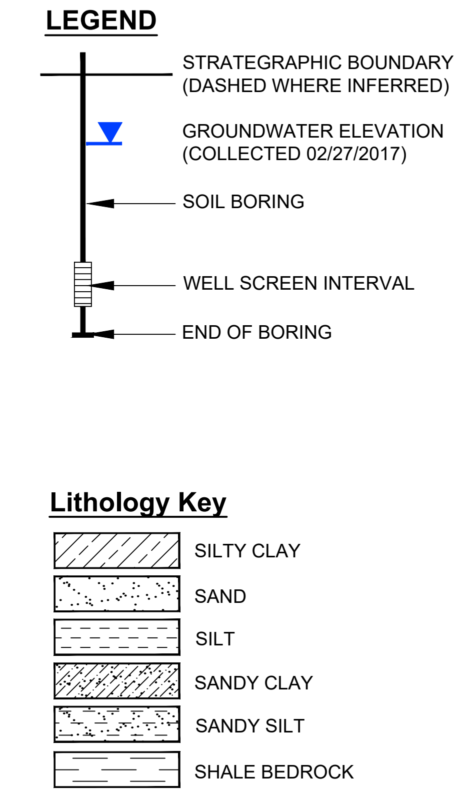
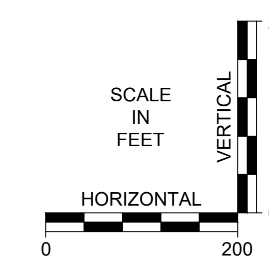
FILE NO.: 370029-0003-003.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'







PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
CHINA TOWNSHIP, MICHIGAN

TITLE:
GENERALIZED
GEOLOGIC CROSS-SECTION A-A'

DRAWN BY:	D.STEHLE	PROJ NO.:	370029.0003.01.01
CHECKED BY:	S.HOLMSTROM	FIGURE 4	
APPROVED BY:	V.BUENING		
DATE:	JULY 2020		

TRC

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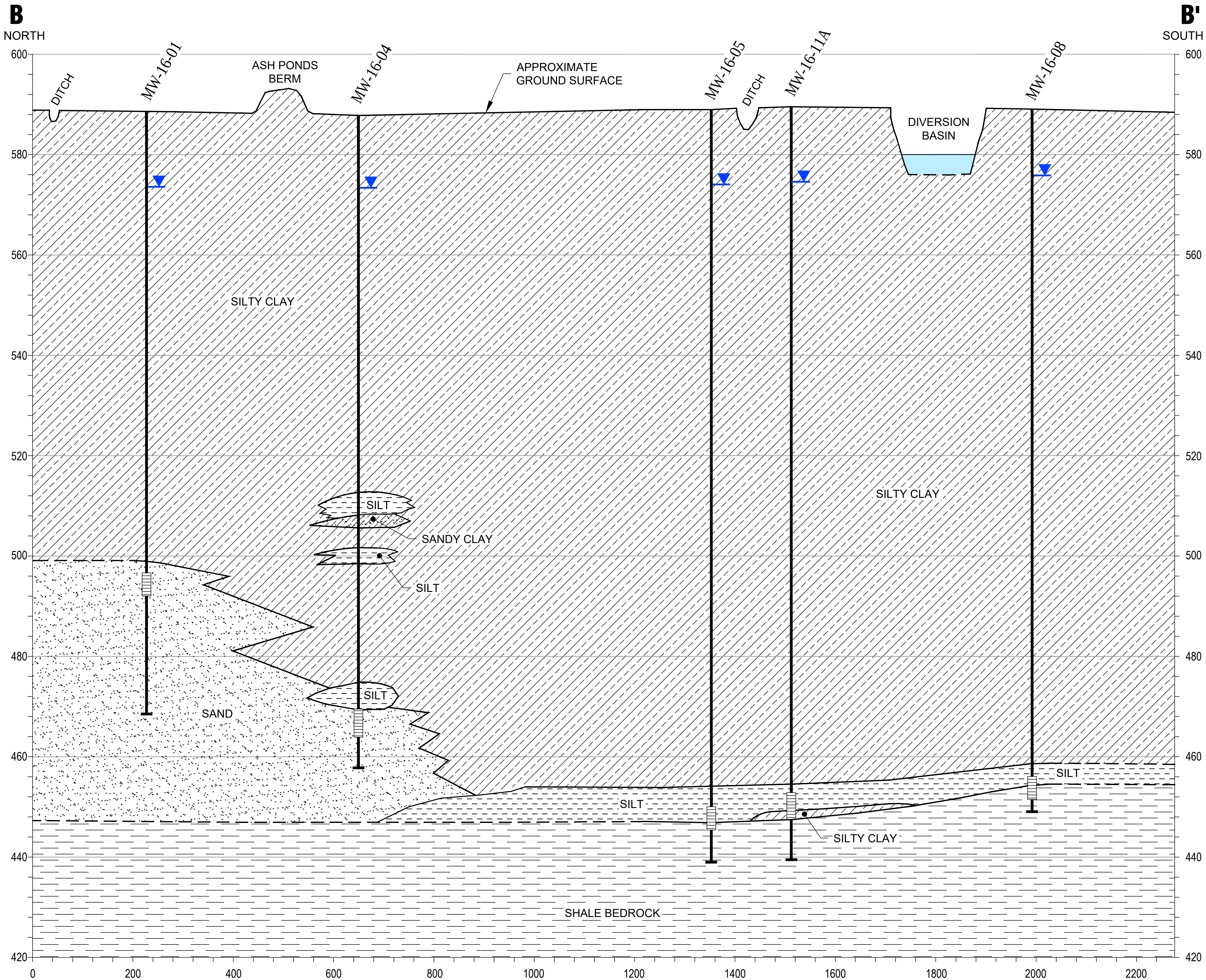
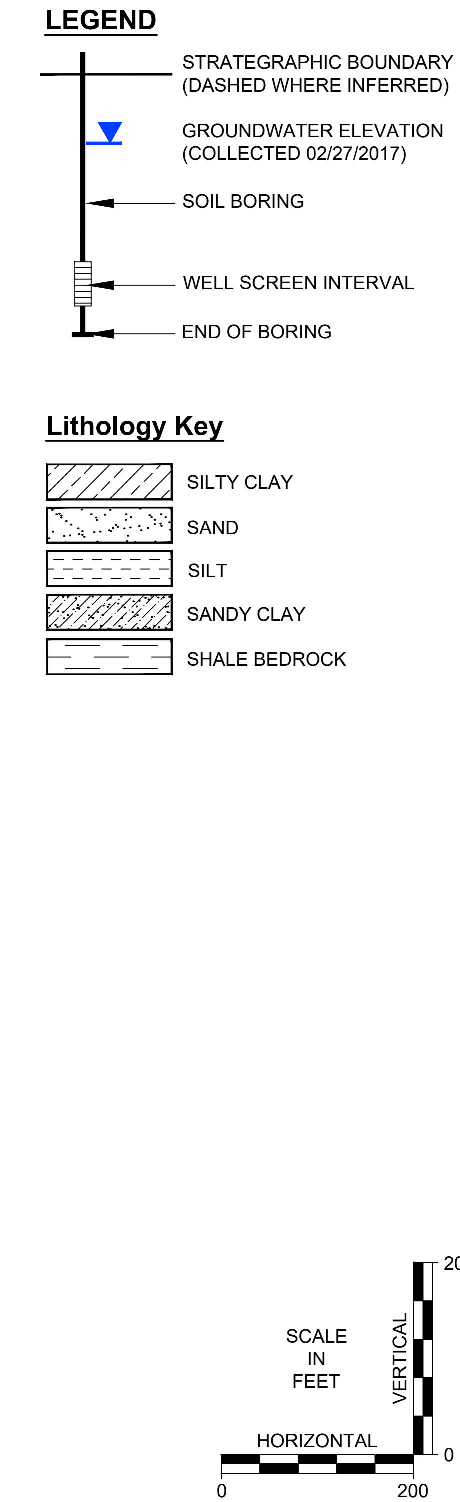
FILE NO.: 370029.0003.01.01.04-05.dwg

11x17 --- ATTACHED XREF'S: --- 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;
DRAWING NAME: J:_TRC\DTE\Belle River PP\370029\0003\01\01_2020 HMP\370029.0003.01.01.04-05.dwg --- PLOT DATE: July 28, 2020 - 6:55AM --- LAYOUT: FIG04 XS AA

GENERALIZED GEOLOGIC CROSS-SECTION B-B'





PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
CHINA TOWNSHIP, MICHIGAN

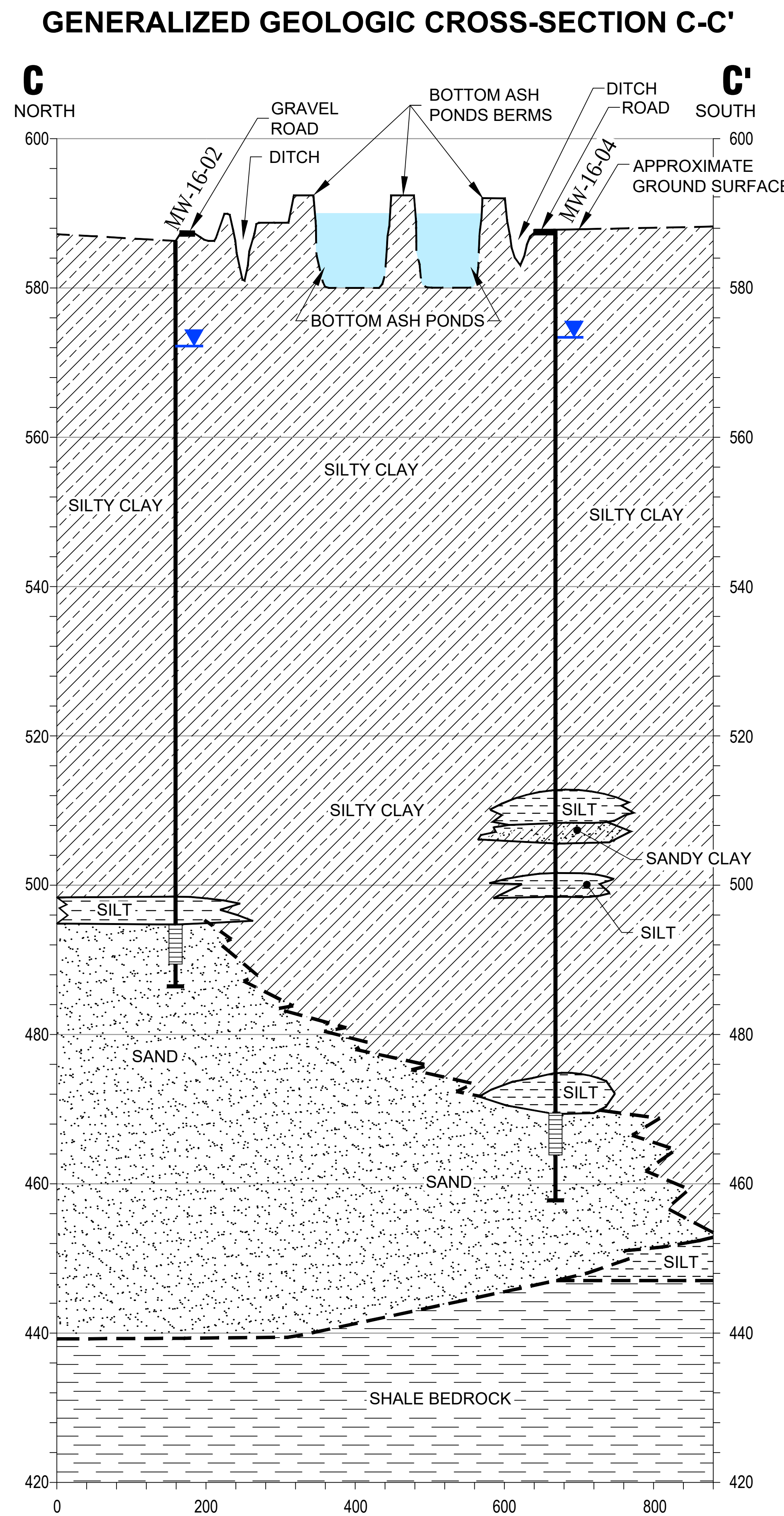
TITLE:
GENERALIZED GEOLOGIC CROSS-SECTION B-B'

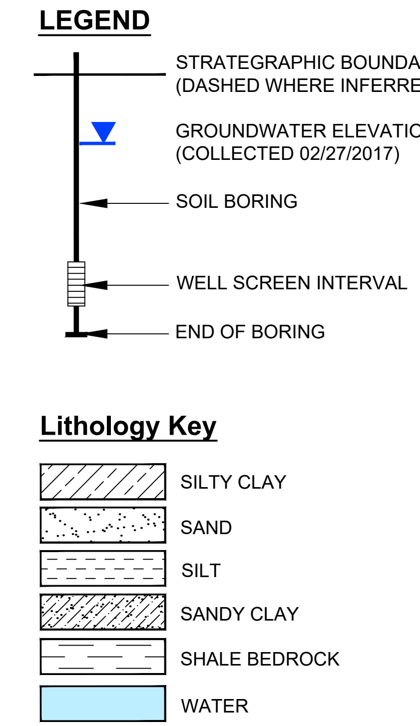
DRAWN BY:	D.STEHLE	PROJ NO.:	370029.0003.01.01
CHECKED BY:	S.HOLMSTROM	FIGURE 5	
APPROVED BY:	V.BUENING		
DATE:	JULY 2020		

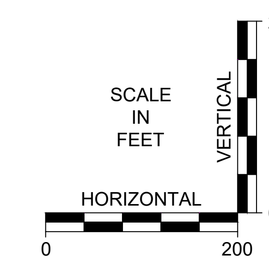
TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trccompanies.com

FILE NO.: 370029.0003.01.01.04-05.dwg

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;
DRAWING NAME: J:_TRC\DTE\Belle River PP\370029\0003\01\01_2020 HMP\370029.0003.01.01.04-05.dwg --- PLOT DATE: July 28, 2020 - 6:55AM --- LAYOUT: FIG05 XS BB







PROJECT:

DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
CHINA TOWNSHIP, MICHIGAN

TITLE:

GENERALIZED GEOLOGIC CROSS-SECTION C-C'

DRAWN BY:	D.STEHLE	PROJ NO.:	370029.0003.01.01
CHECKED BY:	K.CRATSENBURG		**FIGURE 6**
APPROVED BY:	K.CRATSENBURG		
DATE:	NOVEMBER 2020		

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FILE NO.: 370029.0003.01.01.06.dwg

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;
DRAWING NAME: J:_TRC\DTE\Belle River PP\370029\0003\01\01_2020 HMP\370029.0003.01.01.06.dwg --- PLOT DATE: November 10, 2020 - 12:44PM --- LAYOUT: FIG06 XS CC

Monitoring Well Screen Information

Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO. & PARTNERS, (3/24/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY 2016 - 2019

DRAWN BY:	A. ADAIR	PROJ NO.:	386089
CHECKED BY:	K. CRATSENBURG		
APPROVED BY:	K. CRATSENBURG	**FIGURE 7**	
DATE:	NOVEMBER 2020		

TRC

1540 Eisenhower Place
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FILE NO.: 386089-0003-003B.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 11/20/2020, 15:05:36 PM by AADAIR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\386089-0003-003B.mxd

Appendix A
Natural Clay Liner Equivalency Evaluation Report, DTE Electric and Consumers Energy Company Six Southeast Michigan Coal Combustion Residual Units, December 2018

Natural Clay Liner Equivalency Evaluation Report

DTE Electric Company and
Consumers Energy Company
Six Southeast Michigan Coal Combustion Residual Units

December 2018

Natural Clay Liner Equivalency Evaluation Report

DTE Electric Company and Consumers Energy Company Six Southeast Michigan Coal Combustion Residual Units

December 2018

Prepared For
DTE Electric Company and
Consumers Energy Company

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Section 1
Introduction

1.1 Background and Objective

The minimum composite liner specified by federal regulations promulgated on April 17, 2015 (CCR Rule) for coal combustion residual (CCR) disposal units includes a geomembrane directly overlying two feet of compacted clay having a hydraulic conductivity no greater than 1 x 10^{-7} cm/s. For new and existing CCR disposal units, Michigan regulations define a natural soil barrier having a hydraulic conductivity no greater than 1 x 10^{-7} cm/s that may be permitted as a protective liner system in lieu of a constructed composite liner if it can be demonstrated that the natural soil liner meets the performance standards outlined in Rule 299.4307 of PA 451 of the Natural Resources and Environmental Protection Act (NREPA), Part 115 (Solid Waste Management). Michigan's Solid Waste Management Program codified in Part 115 is the state's equivalent Subtitle D permitting program for solid waste management, and is a United States Environmental Protection Agency (EPA) authorized program and consequently there is an inherent acknowledgement that natural soil liners can provide equivalent protection as composite liner systems by Michigan and the EPA.

On August 21, 2018 the United States Court of Appeals District of Columbia Circuit Court (DC Court) ruled on a number of CCR issues, some that have been pending since promulgation of the CCR Rule in 2015. The primary response from the DC Court was to rule on whether EPA's request to stay litigation pending anticipated court-mandated rulemaking from a settlement agreement entered on April 18, 2016 where EPA committed to addressing issues in a Remand Rule by June 2019. The court requested oral argument on all remaining issues of litigation at the time of the request for stay in order to weigh merits of the motion. The DC Court decision ultimately denies the motion and issues an opinion on all of the remaining issues of litigation which included vacatur and remand of:

- 257.101(a), which governed the conditions that would force an unlined surface impoundment to cease receiving CCR and non-CCR if a groundwater protection standard was exceeded unless strict conditions and timelines for alternative closure could be certified by the owner or operator pursuant to 257.103.
- 257.71(a)(1)(i), which defined 2 feet of compacted soil (K value of no more than 1x10^{-7} cm/s) for existing impoundments as meeting the liner standard (i.e., "clay lined" pond considered a lined pond).

By vacating 257.101(a) and 257.71(a)(1)(i), electric power generators who intended to continue using their existing ponds for CCR or non-CCR (assuming they met all of the remaining provisions/standards of 257.101), would potentially have to close or retrofit/reline these ponds.

Multiple CCR impoundments in southeast Michigan are documented to be constructed within thick (> 20 feet thick, in some cases more than 100 feet thick) laterally contiguous glacially compacted natural clay-rich soils with a hydraulic conductivity no greater than 1 x 10^{-7} cm/s prior to implementation of the CCR Rule requiring composite liners (§257.70) or demonstration of equivalent performance to alternative composite liners. As the natural soil underlying these CCR impoundment units consists of thick, low-hydraulic conductivity clay, it is likely that the natural soil is providing the same, or better level of protection from potential migration of contaminants than the composite liner defined in 257.70(b). The purpose of our study is to present existing site data to assess whether the natural soils below six CCR impoundment units at four sites in southeast Michigan are performing equivalently to a composite liner using recognized and generally accepted good engineering practices.

1.2 Description of CCR Units

Natural clay liners were evaluated for six CCR units at four power generation facilities in southeast Michigan:

- Bell River Power Plant (BRPP) Bottom Ash Basins (BAB) CCR Unit
- BRPP Diversion Basin (DB) CCR Unit
- St. Clair Power Plant (SCPP) BAB CCR Unit
- Monroe Power Plant (MONPP) Fly Ash Basin (FAB) CCR Unit
- J.R. Whiting Power Plant (JRWPP) Ponds 1 and 2 CCR Unit
- JRWPP Pond 6 Inactive CCR Unit

Data used for the natural clay liner evaluations were obtained from existing reports and Conceptual Site Models (CSMs) previously developed for each site. A summary of the CSM for each site is provided in the following sections.

1.2.1 BRPP Bottom Ash Basins CCR Unit

The BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the DB CCR unit. The North and South BABs run roughly east to west approximately 420 feet long by 120 feet wide with bottom elevations of approximately 580 feet and outflow weir elevations of approximately 590.25 feet (TRC 2017a).

1.2.2 BRPP Diversion Basin CCR Unit

The DB is an incised CCR surface impoundment located west of the BRPP. Water flows into the DB from the North and South 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. The DB has an approximately 300 foot long entrance channel that connects to the main portion of the basin that runs approximately north-south. The main portion of the DB is approximately 400 feet long by approximately 120 feet wide with a bottom elevation of approximately 576 feet with the water level being maintained at approximately 580 feet (TRC 2017a).

1.2.3 SCPP Bottom Ash Basins CCR Unit

The SCPP BABs are two adjacent sedimentation basins that are incised CCR surface impoundments. The impoundments are sheet piled around the perimeters to approximately 13 feet below ground surface (bgs) into the native clay-rich soil. The BABs are located south of the SCPP and adjacent to the St. Clair River and are used for receiving bottom ash and other process flow water from the power plant, which is first sent to the East BAB then to the West BAB through a connecting concrete canal. Discharge water from the basins flows with other site wastewater into the Overflow Canal in accordance with a NPDES permit (TRC 2017b).

The West and East BABs run roughly north to south with the following approximate dimensions (TRC 2017b):

- The West BAB is approximately 300 feet long by 90 feet wide with a bottom elevation of approximately 572 feet (when fully cleaned out) with an outflow weir elevation of approximately 579.3 feet; and
- The East BAB is approximately 400 feet long by 70 feet wide with a bottom elevation of approximately 572 feet (when fully cleaned out) with an outflow weir elevation of approximately 579.4 feet.

1.2.4 MONPP Fly Ash Basin CCR Unit

The MONPP FAB CCR unit is approximately 410-acres with an original design storage capacity of 18,500 acre-feet at a maximum elevation of 614 feet. The FAB consists of an earthfill clay-rich soil embankment (raised surface impoundment) with a crest perimeter length of approximately 18,200 feet and a general height (from the lowest toe elevation to the top of embankment) of approximately 40 feet, with a maximum height of 44 feet. A road along the top of the crest has an elevation of approximately 614 feet with the typical water operational level being 609 feet. The FAB base is keyed into the existing natural clay-rich soil ground surface at an elevation of 563.4 feet. CCRs are placed into the FAB by use of a "wet" (sluiced) disposal method (TRC 2017c).

1.2.5 JRWPP Ponds 1 and 2 CCR Unit

The JRWPP Ponds 1 and 2 CCR unit is located east of the JRWPP adjacent to Lake Erie. The JRWPP is no longer an active power generating facility and Ponds 1 and 2 are no longer active. The ponds were constructed in the native clay soil and received ash by sluicing. Sluice water was discharged to Pond 2 and then flowed into Pond 1 via a connecting pipe. Discharge water from the basins flowed into the adjacent Forebay in accordance with a NPDES permit (Golder Associates 2017). The Pond 1 outlet had an elevation of 586.3 feet and a perimeter crest of approximately 590 feet (AECOM 2009).

1.2.6 JRWPP Pond 6 CCR Unit

The JRWPP Pond 6 CCR unit is located north of the JRWPP. Pond 6 is no longer in operation and has received a final cap. Pond 6 was constructed in the native clay soil and received ash by sluicing. Discharge water from Pond 6 flowed into the adjacent LaPointe Drain in accordance with a NPDES permit. When in operation, the pool elevation in Pond 6 was maintained between elevations of 592.6 feet and 596.5 feet with a perimeter crest elevation of approximately 600 feet (AECOM 2009).

Section 2
Composite Liner Leakage Literature

2.1 Literature Review

A single composite liner specified by state and federal regulations for new CCR disposal units includes a geomembrane directly overlying two feet (0.61 meters) of compacted clay having a hydraulic conductivity no greater than 1 x 10^{-7} cm/s. These composite liners are intended to prevent advective flow of leachate through the liner. However, studies of installed composite liner systems have identified that composite liners leak through holes in the geomembrane that result from manufacturing defects, damage during installation, or degradation of the membrane over time (Rowe 2012). Holes in the geomembrane allow migration of leachate from the liner cell into the compacted clay portion of the liner. Once in the clay, leachate can migrate through the clay via porous media flow, eventually exiting the clay liner as leakage.

The amount of leakage through a composite liner is controlled in part by the number of holes in the geomembrane, the size of the holes, and the quality of contact between the geomembrane and the underlying clay. Based on a review of available literature, Rowe (2012) reports that the median radius of geomembrane holes is greater than 5 mm (meaning geomembrane holes at a scale of millimeters to centimeters are not uncommon) and the number of holes ranges from 2.5 to 12 holes per hectare of liner. Gaps between the geomembrane and the underlying clay also influence leakage rates by increasing the surface area through which leachate can penetrate the underlying clay (Rowe 2012).

Liner performance can be quantified in terms of the rate of leakage of leachate through the liner into the underlying soils. Researchers have quantified leakage rates for composite liners through the use of leak detection systems (e.g., Bonaparte et al. 2002) and calculations (e.g., Giroud et al. 1998; Rowe 2012). Leakage rates are measured in terms of the volume of liquid (liters or gallons) leaking through the liner each day over the surface area of the liner (hectares or acres) e.g. liters per hectare per day (lphd).

Leakage through the compacted clay portion of a composite liner or through a natural clay liner is controlled by several factors, including the hydraulic conductivity of the clay, the hydraulic head gradient across the liner, and the thickness of the clay. Flow through clay liners can be calculated using physical parameters of the system in question and applying Darcy's Law. The performance of natural clay liners can be assessed by comparing calculated leakage rates for natural clay liners with calculated leakage rates for composite liners.

Section 3
Site Conceptual Models

3.1 Belle River Power Plant

The BRPP CCR units are underlain by more than 130 feet of unconsolidated sediments, consisting mostly of silty clay-rich till. The silty clay-rich till is present from the surface to depths of 86 to 130 feet bgs at the BRPP CCR units. Falling head permeameter tests were completed on four samples of the site clay, producing hydraulic conductivity values ranging from 2.1×10^{-8} cm/s to 2.9×10^{-8} cm/s. Saturated silts and sands underlie the clay and form the shallowest aquifer below the CCR units. The unconsolidated sand and silt aquifer is underlain by the uppermost bedrock consisting of the Bedford Shale, which is generally encountered from 135 to 145 feet bgs (TRC 2017a).

3.1.1 Bottom Ash Basins CCR Unit

As described above, the uppermost aquifer units beneath the BABs CCR unit are hydraulically isolated by at least 80 feet of silty clay-rich till. The first observed sand-rich units that meet the 40 CFR §257.53 definition of uppermost aquifer is encountered at depths ranging from 90 to 136 feet bgs. The sand-rich unit rapidly thins to the south and east of the BABs and pinches out in the southeastern portion of the BABs CCR unit area (TRC 2017a).

The water level in the BABs is maintained at an elevation of approximately 590 feet. The hydraulic head in the aquifer below the BAB is approximately 574 feet (TRC 2018a). The bottom of the BABs is at an elevation of approximately 580 feet and the bottom of the clay underlying the BABs is at an elevation of approximately 500 feet, thus 80 feet of clay separate the bottom of the BABs CCR unit from the underlying aquifer.

3.1.2 Diversion Basin CCR Unit

The potential uppermost aquifer under the DB CCR unit is located at depths ranging from 131 to 145 feet bgs at the silt/shale bedrock interface. The DB CCR unit is isolated from the underlying potential uppermost aquifer by approximately 130 feet of silty clay-rich till. Although the encountered zone of saturation along the interface did not yield significant groundwater, it was conservatively interpreted as the first underlying saturated zone that would presumably become affected with CCR constituents since it was saturated, and although the hydraulic conductivity was low, exhibited a much higher hydraulic conductivity than the clay-rich soils between the bottom of the basin and the monitored zone (TRC 2017a).

The water level in the DB is maintained at an elevation of 580 feet or less. The hydraulic head in the aquifer below the DB is approximately 575 feet (TRC 2018b). The bottom of the DB is at an elevation of approximately 576 feet and the bottom of the clay underlying the DB is at an elevation of approximately 459 feet, thus 117 feet of clay separate the bottom of the DB CCR unit from the underlying aquifer.

3.2 St. Clair Power Plant BABs

The SCPP CCR unit is underlain by glacial silty-clay till, with few isolated sand lenses, and a silt and clay-rich hardpan base directly overlying the shale bedrock (likely the Bedford Shale). The shale bedrock is generally encountered below 130 feet bgs. No significant soil or gravel intervals were encountered at any of the groundwater monitoring system well locations. However, during soil boring advancement for the groundwater monitoring system well locations, some signs of saturation were observed throughout a 5-foot interval along the interface between the overlying till/hardpan and the underlying shale bedrock. The underlying shale does not yield groundwater, rather it is an aquiclude that prevents groundwater flow (i.e., is not an aquifer). Although the encountered zone of saturation along the interface did not yield significant groundwater, it was conservatively interpreted as the uppermost aquifer, because it is saturated and exhibits higher hydraulic conductivity than the clay-rich soils between the bottom of the basin and the monitored zone (TRC 2017b).

The potential uppermost aquifer as defined in 40 CFR §257.53 is encountered at an elevation of approximately 462 feet. The bottom of the BABs is at an elevation of approximately 572 feet, thus 110 feet of vertically contiguous silty clay-rich till separates the BABs CCR unit from the underlying aquifer and serves as a natural confining hydraulic barrier that isolates the underlying uppermost potential aquifer. The overlying silty clay-rich low-permeability soil has a hydraulic conductivity on the order of 2.3 to 3.1 x 10^{-8} centimeters per second (cm/s) as found in soil testing performed during the CCR monitoring well installation in the area of the BABs (TRC 2017b).

The water level in the BABs is maintained at an elevation between 579 feet and 580 feet. The hydraulic head in the aquifer below the BABs is approximately 580 feet (TRC 2018c), thus the little hydraulic head gradient between the BABs CCR unit and the underlying aquifer is very small.

3.3 Monroe Power Plant FAB

The MONPP FAB overlies unconsolidated clay-rich glacial till and/or lacustrine deposits with saturated limestone of the Bass Islands Group bedrock generally encountered from 37 to 53.5 feet below ground surface. The limestone aquifer encountered at the site is generally artesian except in the area of monitoring well MW-16-01. Monitoring well MW-16-01 is located within several hundred feet of several off-site domestic residential water supply wells located to the north along Dunbar Road adjacent to Plum Creek that likely lower the hydraulic head in the area of MW-16-01 (TRC 2017c).

The MONPP FAB CCR unit uppermost aquifer as defined in 40 CFR §257.53 consists of saturated limestone present beneath at least 37 feet and up to 53.5 feet of thick contiguous silty clay-rich soil that serves as a natural confining hydraulic barrier that isolates the underlying uppermost aquifer. At its deepest incised area the MONPP FAB has approximately 23 feet of clay-rich soil separating the bottom of the FAB from the uppermost aquifer. Near the north end of the FAB where the hydraulic gradient is steeper, the clay is at least 30 feet thick. The overlying low permeability silty clay-rich soil has a hydraulic conductivity of 2.7×10^{-8} cm/s calculated as the geometric mean of 33 hydraulic conductivity values obtained from testing of the clay. The water level in the FAB is maintained at an elevation of approximately 609 feet. The hydraulic head in the aquifer below the FAB is ranges from approximately 580 feet to 597 feet (TRC 2018d).

3.4 J.R. Whiting Power Plant

The JRWPP overlies more than 50 feet of unconsolidated clay-rich glacial till and/or lacustrine deposits overlying limestone bedrock. Bedrock is generally encountered from 52 to 64 feet below ground surface (elevations of 524 to 516 feet) (STS Consultants 1993). Permeameter tests completed on eight samples of the site clay produced hydraulic conductivity values ranging from 5.5×10^{-9} cm/s to 2.23×10^{-8} cm/s. The limestone bedrock aquifer underlying clay deposits forms the shallowest aquifer below the CCR units.

3.4.1 JRWPP Ponds 1 and 2 CCR Unit

As described above, the uppermost aquifer unit beneath the Ponds 1 and 2 CCR unit is limestone bedrock that is hydraulically isolated by the overlying clay-rich till. The shallowest bedrock is encountered at an elevation of approximately 520 feet (TRC 2016) and the bottom of the pond is at an elevation of approximately 555 feet (Golder Associates 2016), thus 35 feet of clay separate the bottom of the Ponds 1 and 2 CCR Unit from the underlying aquifer. The water level in Ponds 1 and 2 was maintained at an elevation of approximately 586 feet. The hydraulic head in the aquifer below Ponds 1 and 2 is approximately 575 feet (TRC 2018e).

3.4.2 JRWPP Pond 6 CCR Unit

As with Ponds 1 and 2, the shallowest bedrock is encountered at an elevation of approximately 520 feet below the Pond 6 CCR unit (TRC 2016). The bottom of Pond 6 is at an elevation of approximately 560 feet, thus 40 feet of clay separate the bottom of the Pond 6 CCR unit from the underlying aquifer. During its operational years, the water level in Pond 6 was maintained at elevations between approximately 592 feet to 597 feet. The hydraulic head in the aquifer below Pond 6 is approximately 575 feet.

Section 4
Leakage Rate Calculations

To assess the performance of the natural clay liners underlying the six CCR units at the sites discussed above, leakage rates were calculated for each of the units using site-specific parameters and Darcy's Law:

$$Q = -KA\frac{dh}{dl}$$

where Q is the leakage rate, K is the hydraulic conductivity of the clay, A is the cross-sectional area of flow, dh is the difference between the hydraulic head in the CCR unit and the hydraulic head in the aquifer below the natural clay, and dl is the thickness of the clay. This analysis assumes that flow through the liner is vertical and one-dimensional. Input parameters for K, dh, and dl for each CCR unit are summarized in Table 1. By assuming the cross-sectional area of flow to be one hectare, leakage rates are determined on a per hectare basis, consistent with the liner leakage literature. Calculated leakage rates (in lphd) are also summarized in Table 1. Calculation documentation is provided in Appendix B. Calculated leakage rates for the natural clay liners ranged from 2 lphd (SCPP BABs) to 227 lphd (MONPP FAB).

The calculated leakage rates represent the expected leakage through the natural clays below the CCR units under currently operating conditions, except for the JRWPP CCR units, which are no longer operating. For the JRWPP CCR units, the calculated leakage rates are conservatively based on conditions experienced while they were operating. Now that Pond 6 is capped, it is expected that the hydraulic head within the CCR unit is less than it was during operation, and therefore, the leakage rate under capped conditions is expected to be less than the calculated leakage rate. Ponds 1 and 2 are planned to be capped in the near future, which will also likely reduce the leakage rate associated with that CCR unit.

To compare the performance of the natural clay liners with the expected performance of a single composite liner, potential leakage rates were also calculated for a hypothetical composite liner meeting state and federal regulations. Giroud et al. (1998) provide an equation for calculating the expected leakage through a composite clay liner resulting from a geomembrane defect:

$$Q = 0.976C_{qo}\left[1 + 0.1\left(\frac{h}{T}\right)^{0.95}\right]d^{0.2}h^{0.9}K^{0.74}$$

where Q is the leakage rate (m^3/s), C_{qo} is a dimensionless coefficient that characterizes the quality of contact between the geomembrane and the clay, h is the hydraulic head of the leachate on the liner (m), T is the thickness of the compacted clay (m), d is the diameter of the defect (m), and K is the hydraulic conductivity of the compacted clay (m/s).

The composite liner leakage calculations assume that liner construction consists of two feet (0.61 m) of compacted clay having hydraulic conductivity of 1 x 10^{-7} cm/s (1 x 10^{-9} m/s) underlying a geomembrane. A leachate head of one foot (0.3 m) over the liner and head of zero below the liner is also assumed. As previously discussed, the composite liner leakage calculation also requires assumptions regarding the number of defects, the size of the defects, and the quality of contact between the geomembrane and the clay. To assess the effects of these assumed parameters on the calculated leakage rate, calculations were made using two different values for defect diameter (0.001 m and 0.00564 m), contact coefficient (per Giroud et al. 1998, C_{qo} = 0.21 for good contact, C_{qo} = 1.15 for poor contact), and defect frequency (2.5 defects per hectare and 5 defects per hectare). Using multiple inputs results in a range of potential leakage rates for the hypothetical composite liner in question.

Calculated leakage rates for a composite liner are shown in Table 2. Calculation documentation is provided in Appendix B. The calculated rates range from a low of 0.9 lphd (for 2.5 small defects per hectare and assuming good contact between the geomembrane and underlying clay) to 14 lphd (for 5 large defects per hectare and assuming poor geomembrane-clay contact). Thus a composite liner built in accordance with current regulations could be expected to leak up to 14 lphd.

Rowe (2012) suggests that calculated leakage rates actually underestimate actual leakage. As a result, actual leakage rates from composite liners may be higher than 14 lphd. Nevertheless, two of the investigated CCR units (BRPP DB and SCPP BABs) have leakage rates less than 14 lphd, indicating they are performing at least as well as a single composite liner. Three of the other four CCR units have leakage rates within one order of magnitude of 14 lphd indicating that these natural liners provide a fairly comparable, if not equal, level of protection as a composite liner.

In addition to leakage rate, leachate travel time can also be used to assess liner performance. To determine the amount of time required for leachate to travel through a clay liner the average linear velocity of the leachate must be calculated. Average linear velocity is calculated using a version of Darcy's Law:

$$v = -\frac{K}{n_e}\frac{dh}{dl}$$

where v is the average linear velocity of leachate advection, n_e is the effective porosity of the clay, and K, dh, and dl are as previously defined. Using the values for K, dh, and dl from

Table 1 and assuming an effective porosity for clay of 0.4, average linear velocity was calculated for each of the CCR units. Leachate travel time (t) was then calculated using:

$$t = \frac{dl}{v}$$

Travel times for the six natural clay liners are shown in Table 1. Calculation documentation is provided in Appendix B. Calculations for the MONPP FAB CCR Unit used average hydraulic conductivity due to the amount of historical hydraulic conductivity values. For all other units, calculations used the highest hydraulic conductivity value obtained at the site to produce conservative results. Travel times range from 441 years (MONPP FAB) to 150,800 years (SCPP BABs). All of the computed travel times suggest that the natural clay liners below the six CCR units will be protective of the underlying aquifers well into the future.

For comparison, the calculated time for leachate to travel through 2 feet of compacted clay in a composite liner (assuming leachate head of 1 foot (0.3 meters) above the liner and head of zero below the liner) after having penetrated through a geomembrane defect is only 5 years. Thus even for the natural liners that have higher leakage rates than a composite liner, the thickness of the natural clay results in protection over a much longer timeframe than can be provided by a composite liner.

An additional point of comparison relates to US EPA Statutory Interpretive Guidance – Criteria for Identifying Areas of Vulnerable Hydrogeology Under the Resource Conservation and Recovery Act (July 1986). This document develops criteria and a method for determining groundwater vulnerability at hazardous waste facilities. The method requires calculation of the travel time along a 100-foot flow line originating at the base of the hazardous waste unit. The intent is for the 100-foot flow line to represent a sample of the geologic material at the site representing an area of likelihood of investigation for release. The criterion established by this method relates a travel time along 100-ft of flow line on the order of 100 years is the threshold for vulnerability (US EPA, p. ES-3).

This analog is a very important concept for responding to the DC Court Opinion that found that the record evidence showed that the vast majority of existing impoundments are unlined and that unlined impoundments have a 36.2 to 57 percent chance of leaking at a harmfully contaminating level during their foreseeable use (DC Court, pg. 18). Based on this record, the DC Court found that it isn't reasonable to rely on leak detection followed by closure in order to address reasonable protectiveness of human health and the environment.

The travel time results from this study show travel times that far exceed the vulnerability criterion, demonstrating that site-specific evaluation can demonstrate protectiveness.

Interestingly, the DC Court also found that the self-implementing one-size-fits-all may have been necessary as a national minimum standard, but also acknowledged that more precise risk-based standards are both feasible and enforceable under the individualized permitting programs and direct monitoring provisions authorized by WIIN Act (DC Court, pg. 38). The sites presented in this study and the methods and criterion used to evaluate the competency of the liner systems meet the regulatory standard "does not pose a reasonable probability of adverse effects on health or the environment."

Section 5
Conclusions

Multiple CCR impoundments in southeast Michigan are documented to be constructed within thick (> 20 feet thick, in some cases more than 100 feet thick) laterally contiguous glacially compacted natural clay-rich soils with a hydraulic conductivity no greater than 1×10^{-7} cm/s prior to implementation of the CCR Rule requiring composite liners (§257.70) or demonstration of equivalent performance to alternative composite liners. The natural soil underlying these CCR impoundment units consists of thick, low-hydraulic conductivity clay, that provides the same, or better level of protection from potential migration of contaminants than the composite liner defined in 257.70(b). Using recognized and generally accepted good engineering practices, TRC concludes that the natural soils below six CCR impoundment units at four sites in southeast Michigan perform better than composite liners. In summary:

- TRC calculated leakage rates for six Southeast Michigan CCR units and compared these to the anticipated leakage rates for a single composite liner system. For all six units, the leakage rates were generally within an order of magnitude of the composite liner system. These data show that anticipated leakage rates between the natural soil barriers and the single composite liners are comparable. Data are summarized on Table 1. Data also show that other site specific factors contribute more significantly to the protectiveness of natural soil barriers when compared to single composite liner system, including thickness of the natural soil barrier, hydraulic conductivity of the soil barrier, and the hydraulic gradient between the CCR unit and the underlying aquifer, which can result in significantly greater times of travel to the uppermost aquifer. The results of the time of travel calculations are summarized on Table 1. As shown, all the six evaluated Southeast Michigan CCR units have natural clay liners that are more protective than single composite liner system.

- The travel time results from this study show times that exceed the USEPA's vulnerability criterion demonstrating that site-specific evaluation can demonstrate protectiveness. The sites presented in this study and the methods and criteria used to evaluate the competency of the liner systems meet the regulatory standard "does not pose a reasonable probability of adverse effects on health or the environment."

- Additionally, all of the studied CCR units have been in operation for decades. Although not the focus of this study, groundwater monitoring is currently being performed at all six of the CCR units that are the subject of this study. Based on review of this data, CCR-affected groundwater is not present at these facilities, which further supports the conclusions of this study. Groundwater data supporting this statement are available at:

Consumers Energy

https://www.consumersenergy.com/community/sustainability/environment/waste-management/coal-combustion-residuals

DTE Energy

https://newlook.dteenergy.com/wps/wcm/connect/dte-web/home/community-and-news/common/environment/coal-combustion-residual

Section 6
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TRC. 2017c. Groundwater Monitoring System Summary Report, DTE Electric Company, Monroe Power Plant Fly Ash Basin Coal Combustion Residual Unit. October 2017.

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TRC. 2018b. Annual Groundwater Monitoring Report, DTE Electric Company, Belle River Power Plant Diversion Basin. January 2018.

TRC. 2018c. Annual Groundwater Monitoring Report, DTE Electric Company, St. Clair Power Plant Bottom Ash Basins. January 2018.

TRC. 2018d. Annual Groundwater Monitoring Report, DTE Electric Company, Monroe Power Plant Fly Ash Basin Coal Combustion Residual Unit. January 2018.

TRC. 2018e. Annual Groundwater Monitoring Report, Former JR Whiting Power Plant Ponds 1 and 2 CCR Unit. January 2018.

Tables

Table 1
Summary of Velocity and Travel Time Calculations
Natural Clay Liner Equivalency Evaluation

CCR Units	Basin head (ft amsl)	Aquifer head (ft amsl)	dh	Basin Bottom (ft amsl)	Bottom of Clay (ft amsl)	Clay Thickness (dl, ft)	Vertical Hydraulic Gradient	Max K (cm/s)*	Q (lphd)	Velocity (ft/d)**	Travel time (yrs)
Two feet of clay***	--	--	3	--	--	2	1.5	1.0E-07	--	1.1E-03	5
Belle River PP BABs	590	574	16	580	500	80	0.20	2.9E-08	50	4.1E-05	5,329
Belle River PP DB	580	575	5	576	459	117	0.043	2.9E-08	11	8.8E-06	36,474
St. Clair PP BABs	580	579	1	572	462	110	0.009	3.1E-08	2	2.0E-06	150,800
Monroe PP FAB	609	580	29	563	533	30	0.97	2.7E-08	227	1.9E-04	441
Whiting Ponds 1&2	586	575	11	555	520	35	0.31	2.2E-08	61	5.0E-05	1,929
Whiting Pond 6	597	575	22	560	520	40	0.55	2.2E-08	106	8.7E-05	1,260

Created by: S. Sellwood 11/27/2018
Checked by: C. Olson 12/3/2018

Notes:
ft = feet
ft/d = feet per day
cm/s = centimeters per second
yrs = years
lphd = liters per hectare per day
amsl = above mean sea level
dh = difference between basin head and aquifer head
K = vertical hydraulic conductivity
Q = leakage rate
*The geometric mean of 33 available K values used for Monroe PP FAB, maximum K used for all other CCR units
**Velocity assumes effective porosity of 0.4
***Represents migration of leachate through a composite liner after passing through holes in the geomembrane, assumes 1 foot of head above the liner and head of zero below the liner

Table 2
Calculated Composite Liner Leakage Rates
Natural Clay Liner Equivalency Evaluation

			Size of Liner Defects		Quality of Contact				Q (lphd)		
h (m)	T (m)	K (m/s)	d_{sml} (m)	d_{lrg} (m)	$C_{qo(good)}$	$C_{qo(poor)}$	Q (m^3/s)	Q (L/day)	2.5 defects/hc	5 defects/hc	Assumptions
0.305	0.61	1.00E-09	0.001		0.21		4.07E-09	0.35	0.9	1.8	small defects, liner in good contact with clay
0.305	0.61	1.00E-09		0.00564	0.21		5.75E-09	0.50	1.2	2.5	large defects, liner in good contact with clay
0.305	0.61	1.00E-09	0.001			1.15	2.23E-08	1.92	4.8	9.6	small defects, liner in poor contact with clay
0.305	0.61	1.00E-09		0.00564		1.15	3.15E-08	2.72	6.8	14	large defects, liner in poor contact with clay

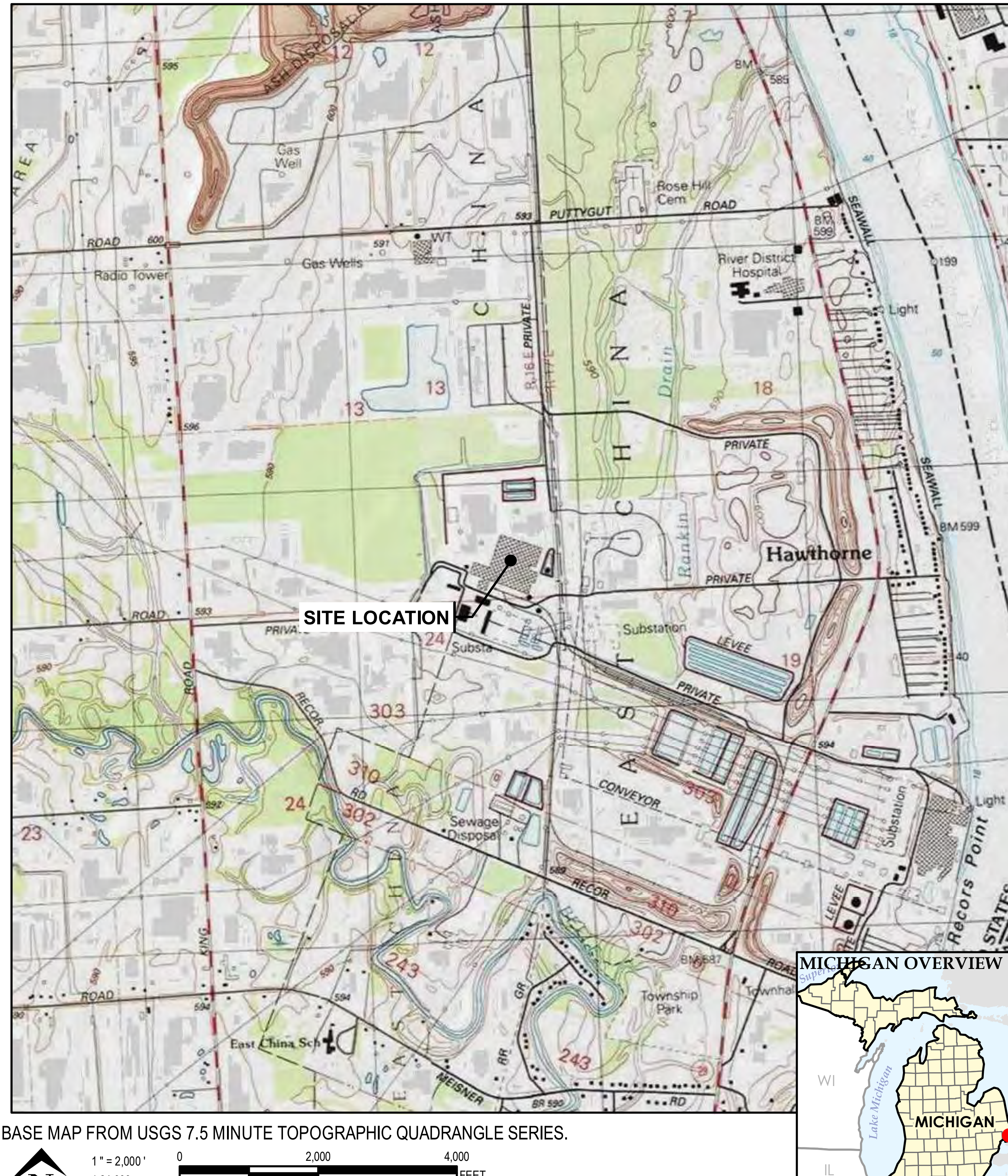
Notes:
h = height of water above the geomembrane
T = thickness of the compacted clay liner
K = hydraulic conductivity of the compacted clay liner
d = diameter of geomembrane defects
C_{qo} = dimensionless coefficient characterizing the quality of the contact between the geomembrane and the underlying compacted clay liner (Giroud et al. 1998)
Q = leakage rate, calculated in accordance with Giroud et al. 1998
m = meter
s = second
L = liter
lphd = liter per hectare per day
hc = hectare

Created by: S. Sellwood 11/27/2018
Checked by: C. Olson 12/3/2018

Appendix A
Site Data (Four Southeast MI CCR Unit Sites)

Table of Contents

BRPP BABs and DB CCR Units Site



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

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TRC - GIS

PROJECT:

DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0003
FILE:	265996-SLMMB.mxd

FIGURE 1

E:\DTE\CCR_Sites\2017_265996\265996-SLMMB.mxd -- Saved By: BDEEGAN on 10/9/2017, 14:49:39 PM

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

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 BY BMJ ENGINEERS & SURVEYORS, INC.

N

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN
TITLE:	SITE PLAN
DRAWN BY: R SUEMNICHT	PROJ NO.: 265996.0003
CHECKED BY: S HOLMSTROM	FIGURE 2
APPROVED BY: V BUENING	
DATE: OCTOBER 2017	

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FILE NO.: 265996-0003-002.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
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Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-002.mxd

Table 1

Groundwater Elevation Summary

Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program

China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Date Installed	3/17/2016		3/15/2016		6/1/2016		3/8/2016		6/2/2016	
TOC Elevation	590.06		588.94		590.66		590.51		590.80	
Geologic Unit of Screened Interval	Sand		Sand		Silty Sand		Sand		Sand	
Screened Interval Elevation	496.3 to 491.3		494.3 to 489.3		456.0 to 451.0		468.5 to 463.5		452.3 to 447.3	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/1/2016	16.21	573.85	15.30	573.64	16.53	574.13	16.89	573.62	16.70	574.10
9/19/2016	16.25	573.81	23.33	565.61	16.54	574.12	16.90	573.61	16.70	574.10
11/7/2016	16.58	573.48	19.91	569.03	16.82	573.84	17.15	573.36	16.95	573.85
1/9/2017	16.39	573.67	17.90	571.04	16.66	574.00	17.02	573.49	16.90	573.90
2/27/2017	16.11	573.95	16.65	572.29	16.43	574.23	16.75	573.76	16.56	574.24
4/17/2017	16.05	574.01	15.71	573.23	16.31	574.35	16.63	573.88	16.45	574.35
5/18/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
6/5/2017	15.67	574.39	14.80	574.14	15.98	574.68	16.31	574.20	16.18	574.62
6/30/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
7/24/2017	15.82	574.24	14.45	574.49	16.12	574.54	16.44	574.07	16.29	574.51

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing

NM - Not Measured

Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet
1 " = 200 '
1:2,400

PROJECT: DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE: BOTTOM ASH BASINS
GROUNDWATER POTENTIOMETRIC
ELEVATION SUMMARY OCTOBER 2017

DRAWN BY:	S. MAJOR	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA	FIGURE 3	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

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FILE NO.: 265996-0003-014.mxd

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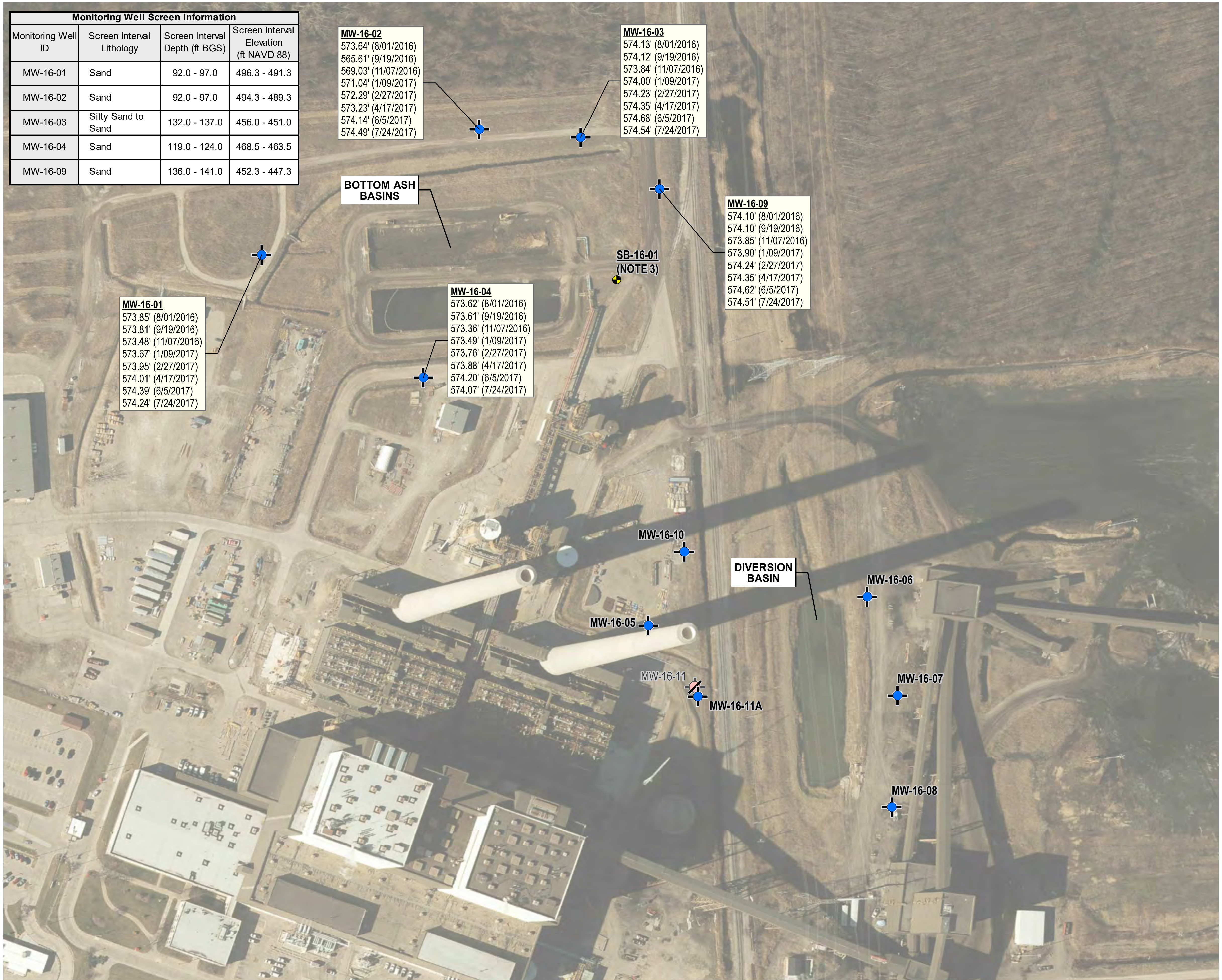
Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT: DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE: BOTTOM ASH BASINS
GROUNDWATER POTENTIOMETRIC
ELEVATION SUMMARY

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA		FIGURE 1
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

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Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
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Table 1

Groundwater Elevation Summary
Belle River Power Plant Diversion Basin – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-05		MW-16-06		MW-16-07		MW-16-08		MW-16-10		MW-16-11 (1)		MW-16-11A	
Date Installed	3/4/2016		3/11/2016		3/9/2016		3/10/2016		6/6/2016		6/7/2016		5/12/2017	
TOC Elevation	590.82		593.21		592.58		591.88		592.26		591.54		591.66	
Geologic Unit of Screened Interval	Clayey Silt/Shale Interface		Silt/Shale Interface		Silt/Shale Interface		Silt/Shale Interface		Gravelly Silt and Silty Clay		Sandy Clay		Silt and Silty Clay	
Screened Interval Elevation	449.3 to 444.3		455.0 to 450.0		456.9 to 451.9		456.3 to 451.3		444.3 to 439.3		452.0 to 447.0		452.5 to 447.5	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/1/2016	16.95	573.87	17.74	575.47	16.84	575.74	15.74	576.14	17.88	574.38	16.86	574.68	Not Installed	
9/19/2016	17.00	573.82	17.85	575.36	17.00	575.58	15.90	575.98	17.98	574.28	16.96	574.58		
11/7/2016	17.13	573.69	17.59	575.62	16.70	575.88	15.70	576.18	18.06	574.20	16.99	574.55		
1/9/2017	17.11	573.71	17.51	575.70	16.60	575.98	15.58	576.30	17.94	574.32	16.87	574.67		
2/27/2017	16.74	574.08	17.36	575.85	16.56	576.02	15.50	576.38	17.72	574.54	NU	NU		
4/17/2017	16.77	574.05	17.71	575.50	16.84	575.74	15.70	576.18	17.81	574.45	NU	NU		
5/18/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	Decommissioned		16.69	574.97
6/5/2017	16.61	574.21	17.66	575.55	16.83	575.75	15.72	576.16	17.73	574.53			16.71	574.95
6/30/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM			16.83	574.83
7/24/2017	16.74	574.08	18.01	575.20	17.13	575.45	15.99	575.89	17.93	574.33			16.91	574.75

Notes:

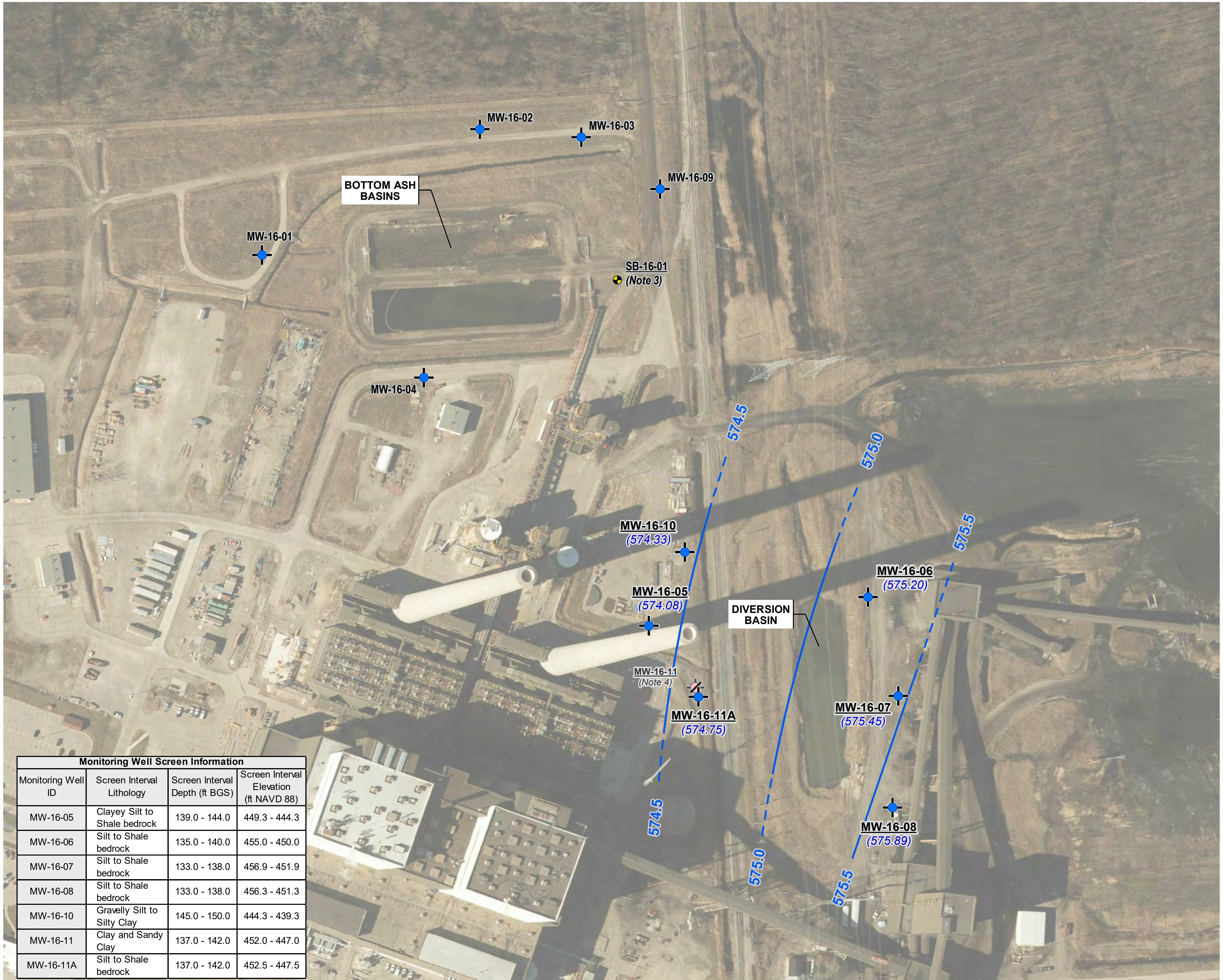
Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing

NU - Not Used; monitoring well was damaged at the time of data collection.

NM - Not Measured

(1) MW-16-11 decomissioned on 5/11/2017 and replaced with MW-16-11A.



Monitoring Well Screen Information

Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-05	Clayey Silt to Shale bedrock	139.0 - 144.0	449.3 - 444.3
MW-16-06	Silt to Shale bedrock	135.0 - 140.0	455.0 - 450.0
MW-16-07	Silt to Shale bedrock	133.0 - 138.0	456.9 - 451.9
MW-16-08	Silt to Shale bedrock	133.0 - 138.0	456.3 - 451.3
MW-16-10	Gravelly Silt to Silty Clay	145.0 - 150.0	444.3 - 439.3
MW-16-11	Clay and Sandy Clay	137.0 - 142.0	452.0 - 447.0
MW-16-11A	Silt to Shale bedrock	137.0 - 142.0	452.5 - 447.5

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING
- *(575.47)* GROUNDWATER ELEVATION (FT NAVD 88)
- GROUNDWATER ELEVATION CONTOUR (0.5-FT INTERVAL, DASHED WHERE INFERRED)

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, AND JUNE 2016 BY BMJ ENGINEERS AND SURVEYORS. INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.
4. MONITORING WELL MW-16-11 WAS DECOMMISSIONED AND REPLACED BY MW-16-11A IN MAY 2017.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO NORTH AMERICAN VERTICAL DATUM OF 1988.

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
DIVERSION BASIN GROUNDWATER POTENTIOMETRIC SURFACE MAP JULY 2017

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA		
APPROVED BY:	V. BUENING	**FIGURE 8**	
DATE:	JANUARY 2018		

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

FILE NO.: 265996-0003-012.mxd

TRC - GIS
Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0
Plot Date: 1/12/2018, 10:17:40 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
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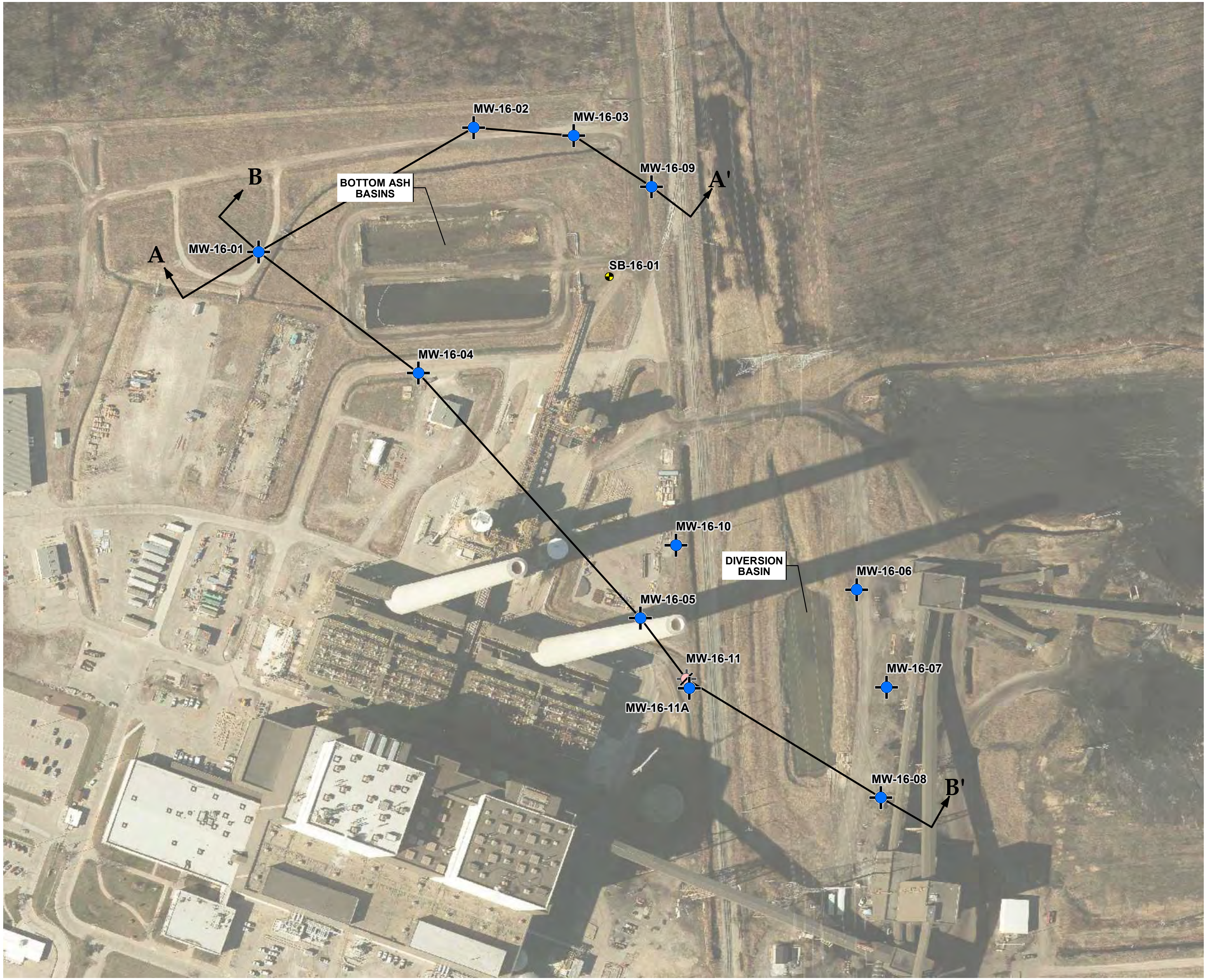


LEGEND

- 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:	S. HOLMSTROM	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

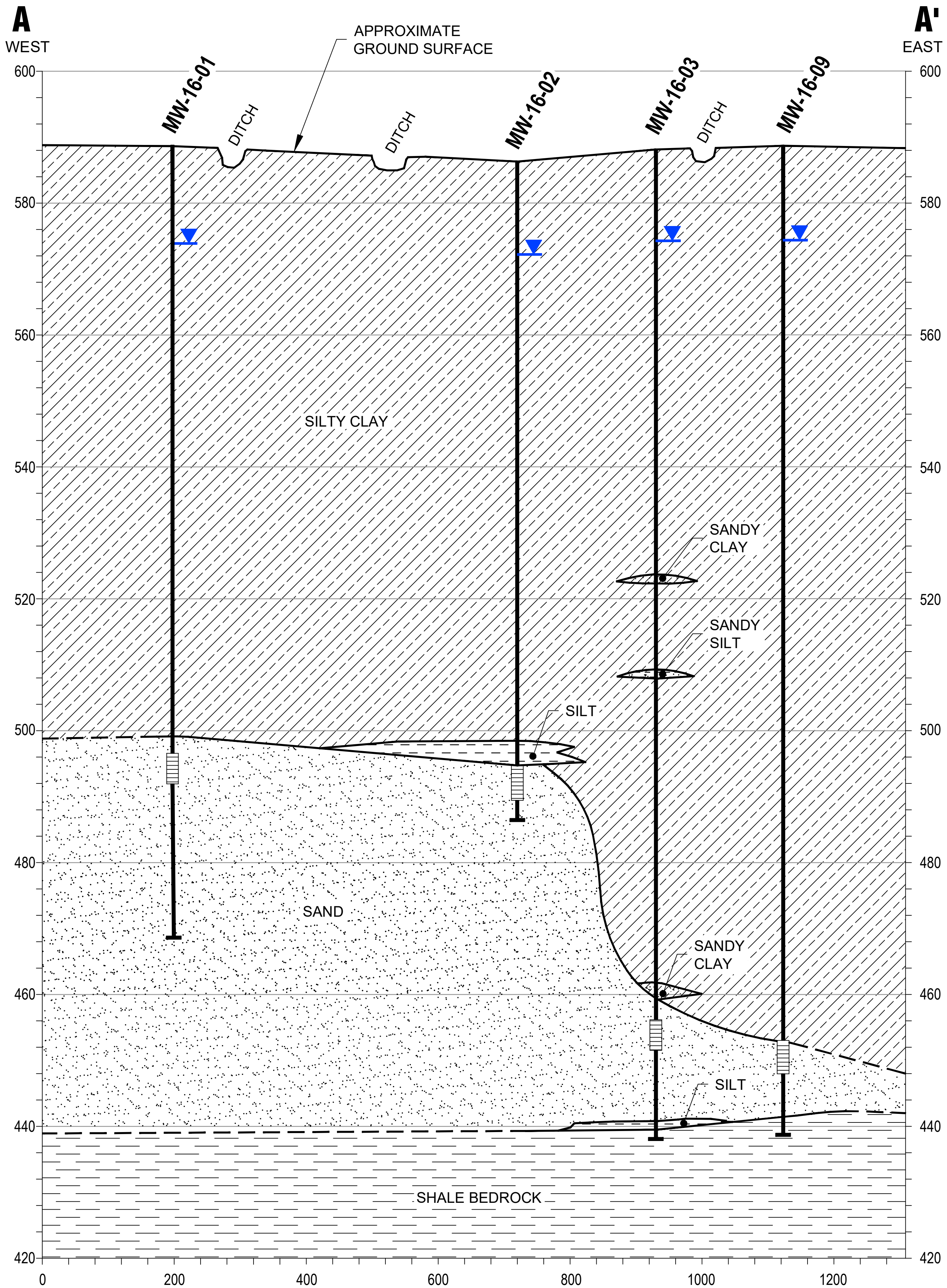
TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0003-011.mxd

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:20:19 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-011.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'



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
- SANDY SILT
- SHALE BEDROCK

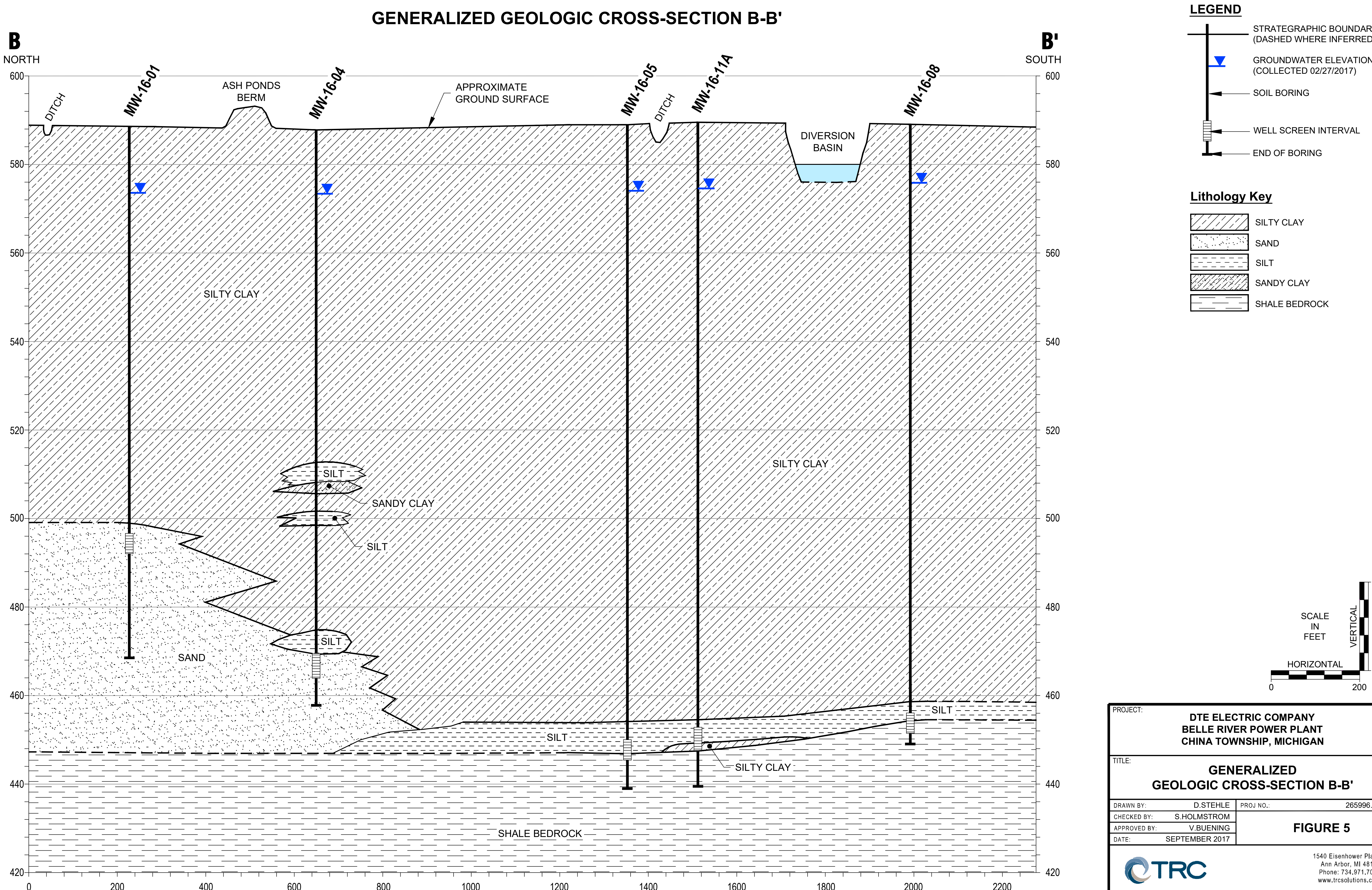
SCALE IN FEET

VERTICAL 0 – 20

HORIZONTAL 0 – 200

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 4
APPROVED BY: V.BUENING	
DATE: SEPTEMBER 2017	
TRC	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 XXXXXXXXXX-02172017092213_Page_1; DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_2; XS aa wells; XS cc wells; XS DD wells;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG04 XS AA



11x17 --- ATTACHED XREF'S: --- 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;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG05 XS BB

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 5
APPROVED BY: V.BUENING	
DATE: SEPTEMBER 2017	
TRC	1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 www.trcsolutions.com
FILE NO.:	265996.0003.01.04-05.dwg

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - BRPP BAB and DB	Cell #:	8
Project #:	231828.0003.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 50-52'	USCS Classification:	N/A
Visual Descript:	Gray lean clay	Average Kv =	2.9E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values		
Sample Dia. (in)	2.87	2.87	Permeant:	Water
Sample Ht. (in)	3.02	3.02	Permeant Specific Gravity:	1.00
Tare & Wet (g)	775.10	649.20	Sample Specific Gravity:	2.70 Est.
Tare & Dry (g)	562.60	471.50	Confining Pressure (psi):	100.0
Tare (g)	88.86	88.64	Burette Diameter (in):	0.250
Sample Wt. (g)	563.65	560.56	Burette Zero (cm):	100.0

Moisture (%)	44.9	46.4	Maximum Gradient:	7.0
Wet Density (pcf)	109.9	109.5	Average Gradient:	6.5
Dry Density (pcf)	75.9	74.8	Max. Effect. Stress (psi):	5.7
Saturation (%)	99.2	100.0	Min. Effect. Stress (psi):	4.3
			Ave. Effect. Stress (psi):	4.8

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	15	8	10.00		0.0	95	95	55.40		3.45		102.60				
2	2016	3	15	11	15.00	11100	23.0	95	95	56.10	0.70	4.05	0.60	101.30	1.30	-36.8	4.7E-08	
3	2016	3	15	14	16.00	10860	23.0	95	95	57.00	0.90	4.75	0.70	100.60	0.70	0.0	3.6E-08	
4	2016	3	15	18	15.00	14340	23.0	95	95	57.75	0.75	5.55	0.80	99.75	0.85	-3.0	3.3E-08	
5	2016	3	16	4	55.00	38400	22.0	95	95	59.30	1.55	7.65	2.10	97.50	2.25	-3.4	3.4E-08	
6	2016	3	16	8	38.00	13380	23.0	95	95	59.80	0.50	8.35	0.70	96.80	0.70	0.0	3.2E-08	
7	2016	3	16	11	56.00	11880	23.0	95	95	60.35	0.55	9.05	0.70	96.30	0.50	16.7	3.1E-08	
8	2016	3	16	15	1.00	11100	23.0	95	95	60.40	0.05	9.60	0.55	95.70	0.60	-4.3	3.2E-08	
9	2016	3	17	5	14.00	51180	22.0	95	95	61.30	0.90	12.10	2.50	93.20	2.50	0.0	3.2E-08	
10	2016	3	17	8	17.00	10980	24.0	95	95	62.05	0.75	12.65	0.55	92.75	0.45	10.0	3.0E-08	
11	2016	3	17	12	19.00	14520	23.0	95	95	62.15	0.10	13.25	0.60	92.05	0.70	-7.7	3.0E-08	
12	2016	3	17	17	49.00	19800	23.0	95	95	62.60	0.45	14.15	0.90	91.30	0.75	9.1	2.9E-08	
13	2016	3	18	5	23.00	41640	22.0	95	95	63.15	0.55	16.00	1.85	89.40	1.90	-1.3	3.3E-08	
14	2016	3	18	8	58.00	12900	24.0	95	95	63.60	0.45	16.55	0.55	88.90	0.50	4.8	3.0E-08	
15	2016	3	18	12	55.00	14220	23.0	95	95	63.80	0.20	17.10	0.55	88.30	0.60	-4.3	3.0E-08	
16	2016	3	18	16	30.00	12900	23.0	95	95	64.10	0.30	17.65	0.55	87.90	0.40	15.8	2.8E-08	
17	2016	3	21	4	58.00	217680	22.0	95	95	67.20	3.10	25.35	7.70	80.20	7.70	0.0	3.1E-08	
18	2016	3	21	8	1.00	10980	24.0	95	95	67.60	0.40	25.70	0.35	79.85	0.35	0.0	3.1E-08	
19	2016	3	21	12	10.00	14940	23.0	95	95	67.60	0.00	26.15	0.45	79.40	0.45	0.0	3.0E-08	
20	2016	3	21	15	12.00	10920	23.0	95	95	67.70	0.10	26.40	0.25	79.15	0.25	0.0	2.3E-08	1
21	2016	3	21	19	36.00	15840	23.0	95	95	68.30	0.60	26.90	0.50	78.70	0.45	5.3	3.1E-08	1
22	2016	3	21	21	31.00	6900	23.0	95	95	68.10	-0.20	27.10	0.20	78.50	0.20	0.0	3.0E-08	1
23	2016	3	22	5	52.00	30060	25.0	95	95	68.90	0.80	28.05	0.95	77.65	0.85	5.6	3.1E-08	1
24	2016	3	22	10	31.00	16740	23.0	95	95	68.85	-0.05	28.45	0.40	77.20	0.45	-5.9	2.8E-08	1
25	2016	3	22	15	59.00	19680	24.0	95	95	69.40	0.55	29.00	0.55	76.70	0.50	4.8	2.9E-08	1
26	2016	3	22	22	32.00	23580	24.0	95	95	69.80	0.40	29.55	0.55	76.10	0.60	-4.3	2.7E-08	1

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.9E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation	QC: JPH
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QA: JPH

Project Name:	DTE - BRPP BAB and DB	Cell #:	9
Project #:	231828.0003.0000	USCS Description:	N/A
Sample Name:	MW-16-05, 50-52'	USCS Classification:	N/A
Visual Descript:	Gray lean clay	Average Kv =	2.7E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values		
Sample Dia. (in)	2.87	2.84	Permeant:	Water
Sample Ht. (in)	3.25	3.20	Permeant Specific Gravity:	1.00
Tare & Wet (g)	536.11	691.40	Sample Specific Gravity:	2.70 Est.
Tare & Dry (g)	403.90	517.10	Confining Pressure (psi):	100.0
Tare (g)	93.83	91.24	Burette Diameter (in):	0.250
Sample Wt. (g)	610.40	600.16	Burette Zero (cm):	100.0

	Initial	Final		
Moisture (%)	42.6	40.9	Maximum Gradient:	7.3
Wet Density (pcf)	110.6	112.8	Average Gradient:	6.9
Dry Density (pcf)	77.5	80.0	Max. Effect. Stress (psi):	6.1
Saturation (%)	98.2	100.0	Min. Effect. Stress (psi):	4.6
			Ave. Effect. Stress (psi):	5.1

	Date Yr.	Mo.	Day	Time Hr.	Min.	Run Time (s)	Temp C°**	Pressure (psi) Bot	Top	Cham (cm)	Cham. Dif.(cm)	Bot (cm)	Bot. Dif.(cm)	Top (cm)	Top Dif.(cm)	Flow Dif.(%)	Kv *** cm/s	Ave.* 0,1
1	2016	3	15	8	11.00		0.0	95	95	25.20		1.95		101.75				
2	2016	3	15	11	15.00		0.0	95	95	27.70		1.80		99.60				
3	2016	3	15	14	17.00	10920	23.0	95	95	29.40	1.70	2.00	0.20	98.65	0.95	-65.2	3.2E-08	
4	2016	3	15	18	16.00	14340	23.0	95	95	30.65	1.25	2.40	0.40	97.60	1.05	-44.8	3.1E-08	
5	2016	3	16	4	56.00	38400	22.0	95	95	32.20	1.55	3.85	1.45	95.40	2.20	-20.5	3.1E-08	
6	2016	3	16	8	39.00	13380	23.0	95	95	32.40	0.20	4.40	0.55	94.85	0.55	0.0	2.6E-08	
7	2016	3	16	11	57.00	11880	23.0	95	95	33.85	1.45	4.95	0.55	94.40	0.45	10.0	2.7E-08	
8	2016	3	16	15	2.00	11100	23.0	95	95	34.00	0.15	5.35	0.40	93.90	0.50	-11.1	2.7E-08	
9	2016	3	17	5	15.00	51180	22.0	95	95	35.20	1.20	7.35	2.00	91.80	2.10	-2.4	2.8E-08	
10	2016	3	17	8	17.00	10920	24.0	95	95	35.80	0.60	7.80	0.45	91.45	0.35	12.5	2.5E-08	
11	2016	3	17	12	20.00	14580	23.0	95	95	35.90	0.10	8.30	0.50	89.85	1.60	-52.4	5.1E-08	
12	2016	3	17	17	50.00	19800	23.0	95	95	36.40	0.50	9.10	0.80	89.25	0.60	14.3	2.6E-08	
13	2016	3	18	5	23.00	41580	22.0	95	95	37.00	0.60	10.65	1.55	88.60	0.65	40.9	2.0E-08	
14	2016	3	18	8	58.00	12900	24.0	95	95	37.50	0.50	11.15	0.50	88.15	0.45	5.3	2.7E-08	
15	2016	3	18	12	55.00	14220	23.0	95	95	37.70	0.20	11.65	0.50	87.60	0.55	-4.8	2.8E-08	
16	2016	3	18	16	31.00	12960	23.0	95	95	38.00	0.30	12.10	0.45	87.20	0.40	5.9	2.5E-08	
17	2016	3	21	4	59.00	217680	22.0	95	95	41.00	3.00	19.25	7.15	79.85	7.35	-1.4	3.0E-08	
18	2016	3	21	8	2.00	10980	24.0	95	95	41.40	0.40	19.55	0.30	79.60	0.25	9.1	2.4E-08	
19	2016	3	21	12	10.00	14880	23.0	95	95	41.40	0.00	19.95	0.40	79.15	0.45	-5.9	2.8E-08	
20	2016	3	21	15	13.00	10980	23.0	95	95	41.60	0.20	20.25	0.30	78.85	0.30	0.0	2.7E-08	1
21	2016	3	21	19	37.00	15840	23.0	95	95	42.00	0.40	20.80	0.55	78.55	0.30	29.4	2.7E-08	1
22	2016	3	21	21	32.00	6900	23.0	95	95	41.80	-0.20	20.90	0.10	78.30	0.25	-42.9	2.6E-08	1
23	2016	3	22	5	53.00	30060	25.0	95	95	42.75	0.95	21.75	0.85	77.55	0.75	6.3	2.6E-08	1
24	2016	3	22	10	32.00	16740	23.0	95	95	42.75	0.00	22.20	0.45	77.10	0.45	0.0	2.8E-08	1
25	2016	3	22	16	0.00	19680	24.0	95	95	43.25	0.50	22.75	0.55	76.65	0.45	10.0	2.7E-08	1
26	2016	3	22	22	33.00	23580	24.0	95	95	43.60	0.35	23.35	0.60	76.10	0.55	4.3	2.6E-08	1

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.7E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QC: JPH QA: JPH

Project Name:	DTE - BRPP BAB and DB	Cell #:	9
Project #:	231828.0003.0000	USCS Description:	N/A
Sample Name:	MW-16-07, 50-52'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.9E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	3.50	3.48	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	512.00	737.80	Sample Specific Gravity:	2.68	Est.
Tare & Dry (g)	387.40	552.10	Confining Pressure (psi):	100.0	
Tare (g)	92.18	89.22	Burette Diameter (in):	0.250	
Sample Wt. (g)	666.40	648.58	Burette Zero (cm):	100.0	

	Initial	Final		
Moisture (%)	42.2	40.1		
Wet Density (pcf)	112.9	112.9		
Dry Density (pcf)	79.4	80.6	Max. Effect. Stress (psi):	6.2
Saturation (%)	102.4	100.0	Min. Effect. Stress (psi):	4.5
			Ave. Effect. Stress (psi):	5.0

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	21	11	16.00		0.0	95	95	16.80		2.50		102.25				
2	2016	4	21	20	32.00	33360	27.0	95	95	27.60	10.80	1.25	-1.25	96.40	5.85	-154.3	4.1E-08	
3	2016	4	22	9	22.00	46200	24.0	95	95	32.50	4.90	2.40	1.15	93.40	3.00	-44.6	3.0E-08	
4	2016	4	22	12	18.00	10560	24.0	95	95	33.50	1.00	2.85	0.45	92.90	0.50	-5.3	3.1E-08	
5	2016	4	22	18	33.00	22500	25.0	95	95	35.05	1.55	3.80	0.95	91.95	0.95	0.0	2.9E-08	
6	2016	4	25	11	30.00	233820	23.0	95	95	44.30	9.25	12.75	8.95	83.10	8.85	0.6	3.1E-08	
7	2016	4	25	17	41.00	22260	24.0	95	95	45.35	1.05	13.50	0.75	82.40	0.70	3.4	2.9E-08	
8	2016	4	25	20	39.00	10680	24.0	95	95	45.30	-0.05	13.80	0.30	82.00	0.40	-14.3	3.0E-08	
9	2016	4	25	23	15.00	9360	24.0	95	95	45.35	0.05	14.10	0.30	81.70	0.30	0.0	3.0E-08	
10	2016	4	26	4	59.00	20640	25.0	95	95	46.00	0.65	14.75	0.65	81.00	0.70	-3.7	3.0E-08	
11	2016	4	26	8	19.00	12000	24.0	95	95	45.95	-0.05	15.10	0.35	80.60	0.40	-6.7	3.0E-08	
12	2016	4	26	13	18.00	17940	24.0	95	95	46.40	0.45	15.70	0.60	80.10	0.50	9.1	3.0E-08	
13	2016	4	27	4	57.00	56340	23.0	95	95	47.60	1.20	17.40	1.70	78.60	1.50	6.2	2.9E-08	
14	2016	4	27	12	47.00	28200	23.0	95	95	47.95	0.35	18.20	0.80	77.90	0.70	6.7	2.8E-08	
15	2016	4	27	15	8.00	8460	23.0	95	95	47.90	-0.05	18.45	0.25	77.65	0.25	0.0	3.2E-08	
16	2016	4	28	5	1.00	49980	22.0	95	95	48.80	0.90	19.80	1.35	76.35	1.30	1.9	3.0E-08	
17	2016	4	28	8	5.00	11040	24.0	95	95	49.40	0.60	20.15	0.35	76.15	0.20	27.3	2.8E-08	
18	2016	4	28	14	56.00	24660	23.0	95	95	49.60	0.20	20.75	0.60	75.55	0.60	0.0	2.8E-08	
19	2016	4	28	20	48.00	21120	23.0	95	95	49.90	0.30	21.30	0.55	75.10	0.45	10.0	2.8E-08	
20	2016	4	29	5	31.00	31380	26.0	95	95	51.05	1.15	22.10	0.80	74.35	0.75	3.2	2.8E-08	
21	2016	4	29	10	27.00	17760	23.0	95	95	50.90	-0.15	22.50	0.40	73.90	0.45	-5.9	3.0E-08	
22	2016	4	29	14	41.00	15240	23.0	95	95	51.25	0.35	22.90	0.40	73.60	0.30	14.3	2.9E-08	
23	2016	4	29	18	0.00	11940	23.0	95	95	51.55	0.30	23.20	0.30	73.40	0.20	20.0	2.7E-08	
24	2016	5	1	16	23.00	166980	22.0	95	95	54.25	2.70	26.95	3.75	70.05	3.35	5.6	3.0E-08	
25	2016	5	2	4	58.00	45300	23.0	95	95	55.05	0.80	27.85	0.90	69.25	0.80	5.9	2.9E-08	
26	2016	5	2	8	4.00	11160	23.0	95	95	55.30	0.25	28.10	0.25	69.05	0.20	11.1	3.1E-08	

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column.

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QC: JPH QA: JPH

Project Name:	DTE - BRPP BAB and DB	Cell #:	9
Project #:	231828.0003.0000	USCS Description:	N/A
Sample Name:	MW-16-07, 50-52'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel		

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	3.50	3.48	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	512.00	737.80	Sample Specific Gravity:	2.68	Est.
Tare & Dry (g)	387.40	552.10	Confining Pressure (psi):	100.0	
Tare (g)	92.18	89.22	Burette Diameter (in):	0.250	
Sample Wt. (g)	666.40	648.58	Burette Zero (cm):	100.0	

Moisture (%)	42.2	40.1	Maximum Gradient:	3.8
Wet Density (pcf)	112.9	112.9	Average Gradient:	3.6
Dry Density (pcf)	79.4	80.6	Max. Effect. Stress (psi):	5.2
Saturation (%)	102.4	100.0	Min. Effect. Stress (psi):	4.6
			Ave. Effect. Stress (psi):	4.9

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	5	2	8	4.00		0.0	95	95	55.30		28.10		69.05				
2	2016	5	2	13	15.00	18660	23.0	95	95	55.65	0.35	28.50	0.40	68.80	0.25	23.1	2.8E-08	
3	2016	5	2	20	45.00	27000	26.0	95	95	56.30	0.65	29.00	0.50	68.35	0.45	5.3	2.6E-08	
4	2016	5	3	4	50.00	29100	23.0	95	95	56.00	-0.30	29.50	0.50	67.75	0.60	-9.1	3.1E-08	
5	2016	5	3	8	0.00	11400	25.0	95	95	56.35	0.35	29.70	0.20	67.60	0.15	14.3	2.5E-08	
6	2016	5	3	11	10.00	11400	23.0	95	95	56.30	-0.05	29.90	0.20	67.35	0.25	-11.1	3.4E-08	
7	2016	5	3	14	12.00	10920	23.0	95	95	56.40	0.10	30.15	0.25	67.25	0.10	42.9	2.8E-08	
8	2016	5	3	19	36.00	19440	24.0	95	95	57.20	0.80	30.55	0.40	67.05	0.20	33.3	2.6E-08	
9	2016	5	4	5	24.00	35280	23.0	95	95	57.60	0.40	31.15	0.60	66.50	0.55	4.3	2.9E-08	
10	2016	5	4	9	48.00	15840	23.0	95	95	57.60	0.00	31.40	0.25	66.25	0.25	0.0	2.9E-08	
11	2016	5	4	14	50.00	18120	23.0	95	95	57.70	0.10	31.70	0.30	66.00	0.25	9.1	2.8E-08	
12	2016	5	4	20	0.00	18600	25.0	95	95	58.25	0.55	32.10	0.40	65.80	0.20	33.3	2.9E-08	
13	2016	5	5	5	24.00	33840	24.0	95	95	58.35	0.10	32.60	0.50	65.30	0.50	0.0	2.8E-08	1
14	2016	5	5	10	25.00	18060	24.0	95	95	58.60	0.25	32.90	0.30	65.10	0.20	20.0	2.7E-08	1
15	2016	5	5	14	42.00	15420	24.0	95	95	58.90	0.30	33.20	0.30	64.85	0.25	9.1	3.5E-08	1
16	2016	5	6	4	52.00	51000	23.0	95	95	59.50	0.60	34.00	0.80	64.25	0.60	14.3	2.8E-08	1
17	2016	5	6	9	32.00	16800	23.0	95	95	59.70	0.20	34.25	0.25	64.05	0.20	11.1	2.9E-08	1
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.9E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - BRPP BAB and DB	Cell #:	10
Project #:	231828.0003.0000	USCS Description:	N/A
Sample Name:	SB-16-01, 50-52'	USCS Classification:	N/A
Visual Descript:	Gray lean clay	Average Kv =	2.1E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values		
Sample Dia. (in)	2.87	2.82	Permeant:	Water
Sample Ht. (in)	2.88	2.86	Permeant Specific Gravity:	1.00
Tare & Wet (g)	534.46	607.60	Sample Specific Gravity:	2.70 Est.
Tare & Dry (g)	400.40	448.80	Confining Pressure (psi):	100.0
Tare (g)	98.45	86.36	Burette Diameter (in):	0.250
Sample Wt. (g)	532.36	521.24	Burette Zero (cm):	100.0

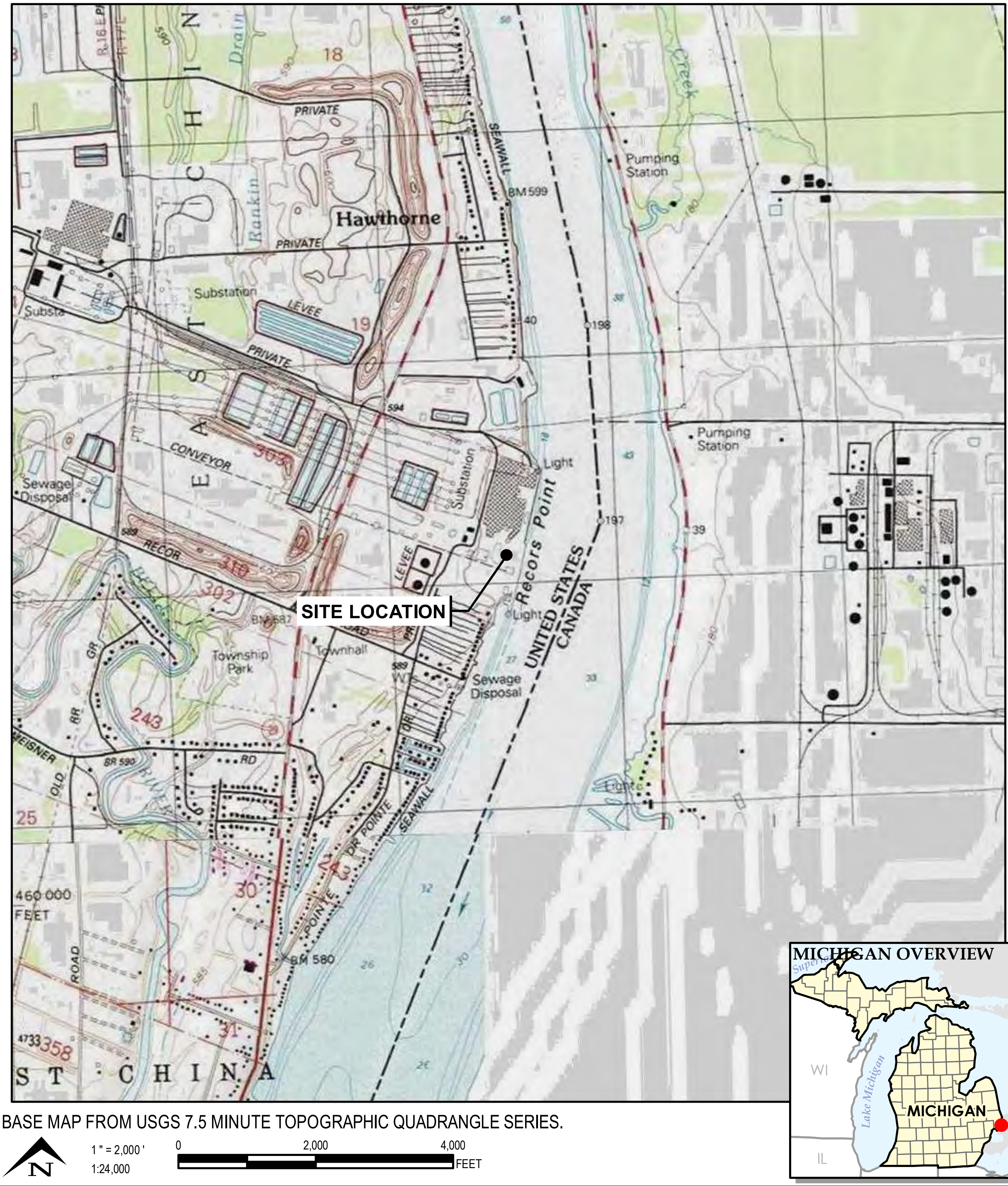
Moisture (%)	44.4	43.8	Maximum Gradient:	8.9
Wet Density (pcf)	109.0	111.0	Average Gradient:	8.4
Dry Density (pcf)	75.5	77.2	Max. Effect. Stress (psi):	6.1
Saturation (%)	97.4	100.0	Min. Effect. Stress (psi):	4.5
			Ave. Effect. Stress (psi):	5.1

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	15	8	11.00		0.0	95	95	24.00		1.65		102.30				
2	2016	3	15	11	16.00		0.0	95	95	27.35		1.15		99.70				
3	2016	3	15	14	17.00		0.0	95	95	29.50		1.15		98.60				
4	2016	3	15	18	17.00	14400	23.0	95	95	30.90	1.40	1.35	0.20	97.50	1.10	-69.2	2.5E-08	
5	2016	3	16	4	56.00	38340	22.0	95	95	34.75	3.85	2.00	0.65	95.00	2.50	-58.7	2.4E-08	
6	2016	3	16	8	39.00	13380	23.0	95	95	35.00	0.25	2.50	0.50	94.55	0.45	5.3	2.0E-08	
7	2016	3	16	11	58.00	11940	23.0	95	95	35.45	0.45	3.00	0.50	94.10	0.45	5.3	2.3E-08	
8	2016	3	16	15	3.00	11100	23.0	95	95	35.80	0.35	3.35	0.35	93.60	0.50	-17.6	2.2E-08	
9	2016	3	17	5	15.00	51120	22.0	95	95	38.75	2.95	4.55	1.20	91.10	2.50	-35.1	2.2E-08	
10	2016	3	17	8	18.00	10980	24.0	95	95	38.25	-0.50	5.25	0.70	90.95	0.15	64.7	2.3E-08	
11	2016	3	17	12	21.00	14580	23.0	95	95	38.60	0.35	5.65	0.40	90.35	0.60	-20.0	2.1E-08	
12	2016	3	17	17	51.00	19800	23.0	95	95	38.50	-0.10	6.45	0.80	89.85	0.50	23.1	2.1E-08	
13	2016	3	18	5	24.00	41580	22.0	95	95	40.80	2.30	7.40	0.95	87.95	1.90	-33.3	2.3E-08	
14	2016	3	18	8	59.00	12900	24.0	95	95	40.40	-0.40	8.05	0.65	87.70	0.25	44.4	2.3E-08	
15	2016	3	18	12	56.00	14220	23.0	95	95	40.70	0.30	8.40	0.35	87.25	0.45	-12.5	1.9E-08	
16	2016	3	18	16	32.00	12960	23.0	95	95	40.70	0.00	8.95	0.55	86.90	0.35	22.2	2.4E-08	
17	2016	3	21	4	59.00	217620	22.0	95	95	45.25	4.55	15.10	6.15	80.30	6.60	-3.5	2.2E-08	
18	2016	3	21	8	2.00	10980	24.0	95	95	45.25	0.00	15.50	0.40	80.10	0.20	33.3	2.2E-08	
19	2016	3	21	12	11.00	14940	23.0	95	95	45.40	0.15	15.90	0.40	79.65	0.45	-5.9	2.4E-08	1
20	2016	3	21	15	13.00	10920	23.0	95	95	45.70	0.30	16.10	0.20	79.35	0.30	-20.0	1.9E-08	1
21	2016	3	21	19	38.00	15900	23.0	95	95	45.70	0.00	16.65	0.55	79.10	0.25	37.5	2.1E-08	1
22	2016	3	21	21	33.00	6900	23.0	95	95	46.10	0.40	16.70	0.05	78.80	0.30	-71.4	2.2E-08	1
23	2016	3	22	5	53.00	30000	25.0	95	95	47.20	1.10	17.35	0.65	78.00	0.80	-10.3	2.0E-08	1
24	2016	3	22	10	32.00	16740	23.0	95	95	47.10	-0.10	17.80	0.45	77.60	0.40	5.9	2.2E-08	1
25	2016	3	22	16	0.00	19680	24.0	95	95	47.40	0.30	18.35	0.55	77.15	0.45	10.0	2.2E-08	1
26	2016	3	22	22	34.00	23640	24.0	95	95	47.10	-0.30	19.10	0.75	76.80	0.35	36.4	2.1E-08	1

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.1E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

MONPP FAB CCR Unit Site



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

TRC

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Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:

DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
4901 POINTE DRIVE
EAST CHINA TOWNSHIP, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0004
FILE:	265996-SLMMB.mxd

FIGURE 1

LEGEND

- MONITORING WELLS
- SURFACE WATER MEASURING POINT
- *(579.85)* GROUNDWATER ELEVATION (FT NAVD88)
- GROUNDWATER ELEVATION CONTOUR (0.5-FT INTERVAL, DASHED WHERE INFERRED)

NOTES

1. BASE MAP IMAGERY FROM ST. CLAIR COUNTY INFORMATION TECHNOLOGY DEPARTMENT WEBMAP, 2015.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN APRIL 2016.
3. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO NORTH AMERICAN VERTICAL DATUM OF 1988.
4. GROUNDWATER ELEVATION DATA FOR MW-16-02 WAS NOT USED. GROUNDWATER LEVEL WAS NOT FULLY RECOVERED AT THE TIME OF DATA COLLECTION.

0 100 200 Feet

1 " = 100 '

1:1,200

PROJECT:

DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
4901 POINTE DRIVE
CHINA TOWNSHIP, MICHIGAN

TITLE:

GROUNDWATER POTENTIOMETRIC SURFACE MAP OCTOBER 2017

DRAWN BY:	S. MAJOR	PROJ NO.:	265996.0004
CHECKED BY:	S. SCIESZKA		FIGURE 3
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

TRC
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Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0004-012.mxd

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/12/2018, 10:19:44 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0004-012.mxd

TRC - GIS

Table 1
Groundwater Elevation Summary
St. Clair Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
East China Township, Michigan

Well ID	MP-01		MW-16-01		MW-16-02		MW-16-03		MW-16-04	
Date Installed	3/23/2016		3/31/2016		3/29/2016		3/25/2016		3/23/2016	
TOC Elevation	580.84(1)		584.74		581.43		581.39		580.95	
Geologic Unit of Screened Interval	NA		Silty Clay Shale Interface		Silty Clay Shale Interface		Silty Clay/Hardpan Shale Interface		Silty Clay/Hardpan Shale Interface	
Screened Interval Elevation	NA		458.1 to 453.1		456.2 to 451.2		455.1 to 450.1		455.0 to 450.0	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/1/2016	NM	NM	3.16	581.58	1.32	580.11	1.39	580.00	1.10	579.85
10/3/2016	4.25	576.58	3.63	581.09	5.25	579.49	1.70	579.69	3.22	578.98
11/11/2016	4.72	576.11	3.25	581.49	1.85	579.58	2.00	579.39	1.43	579.52
1/13/2017	4.95	575.88	3.38	581.36	1.82	579.61	1.85	579.54	1.84	579.11
2/28/2017	5.00	575.83	3.42	581.32	2.10	579.33	3.08	578.31	1.60	579.35
4/21/2017	4.21	576.62	3.44	581.30	2.42	579.01	2.06	579.33	1.24	579.71
6/9/2017	4.12	576.71	3.16	581.58	1.30	580.13	1.40	579.99	1.01	579.94
7/27/2017	4.68	576.15	2.31	582.43	1.41	580.02	1.39	580.00	1.28	579.67

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet below top of casing

NA - not applicable

NM - not measured

1) Elevation represents the point of reference used to collect surface water level measurements.

LEGEND

- MONITORING WELLS
- SURFACE WATER MEASURING POINT

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO & PARTNERS, APRIL 2015.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN APRIL 2016.

N

0 100 200 Feet

1 " = 100 '

1:1,200

PROJECT:

DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
4901 POINTE DRIVE
CHINA TOWNSHIP, MICHIGAN

TITLE:

CROSS SECTION LOCATOR MAP

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0004
CHECKED BY:	S. HOLMSTROM	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

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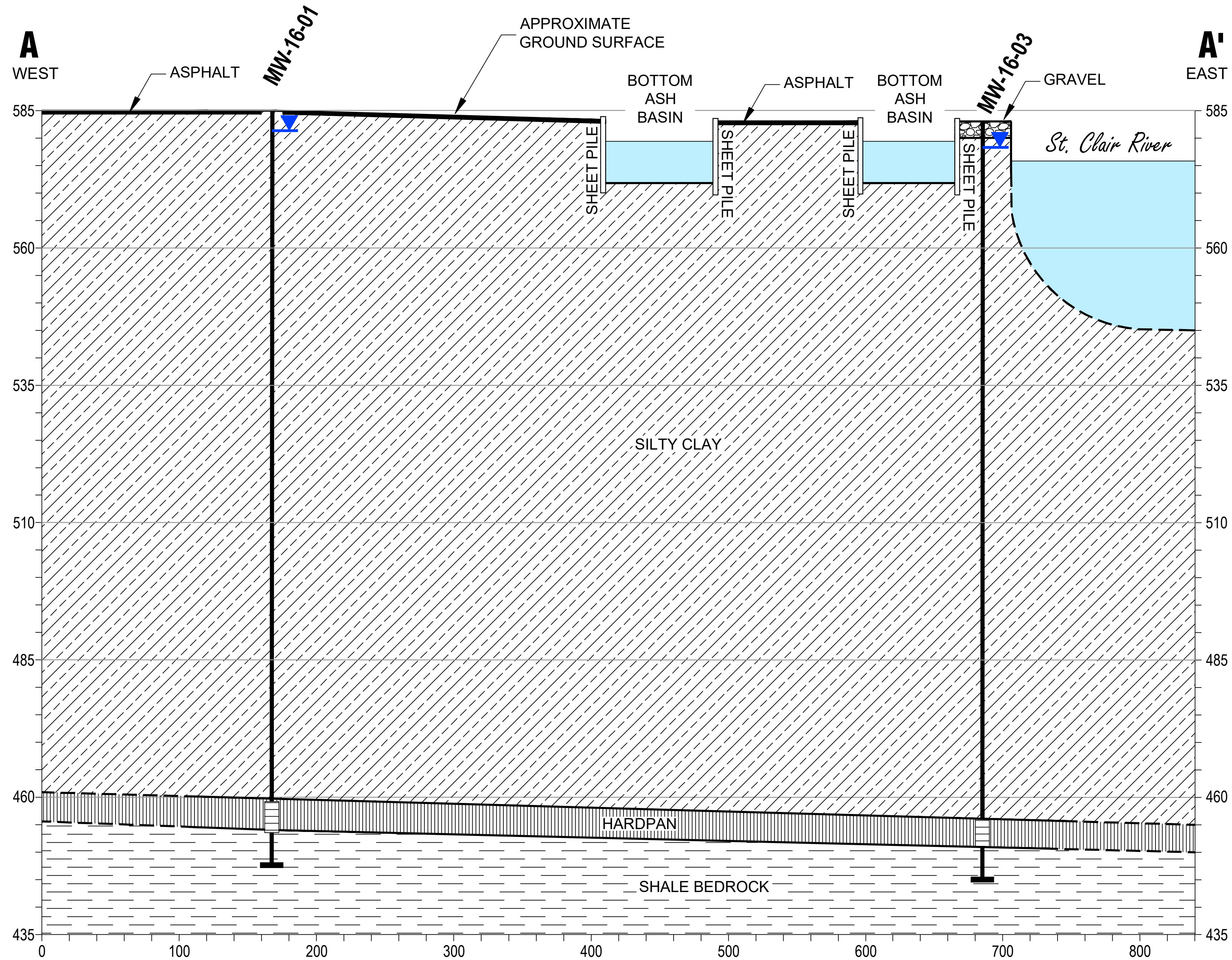
FILE NO.: 265996-0004-010.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:36:52 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0004-010.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'



LEGEND

- STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (COLLECTED 02/28/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

Lithology Key

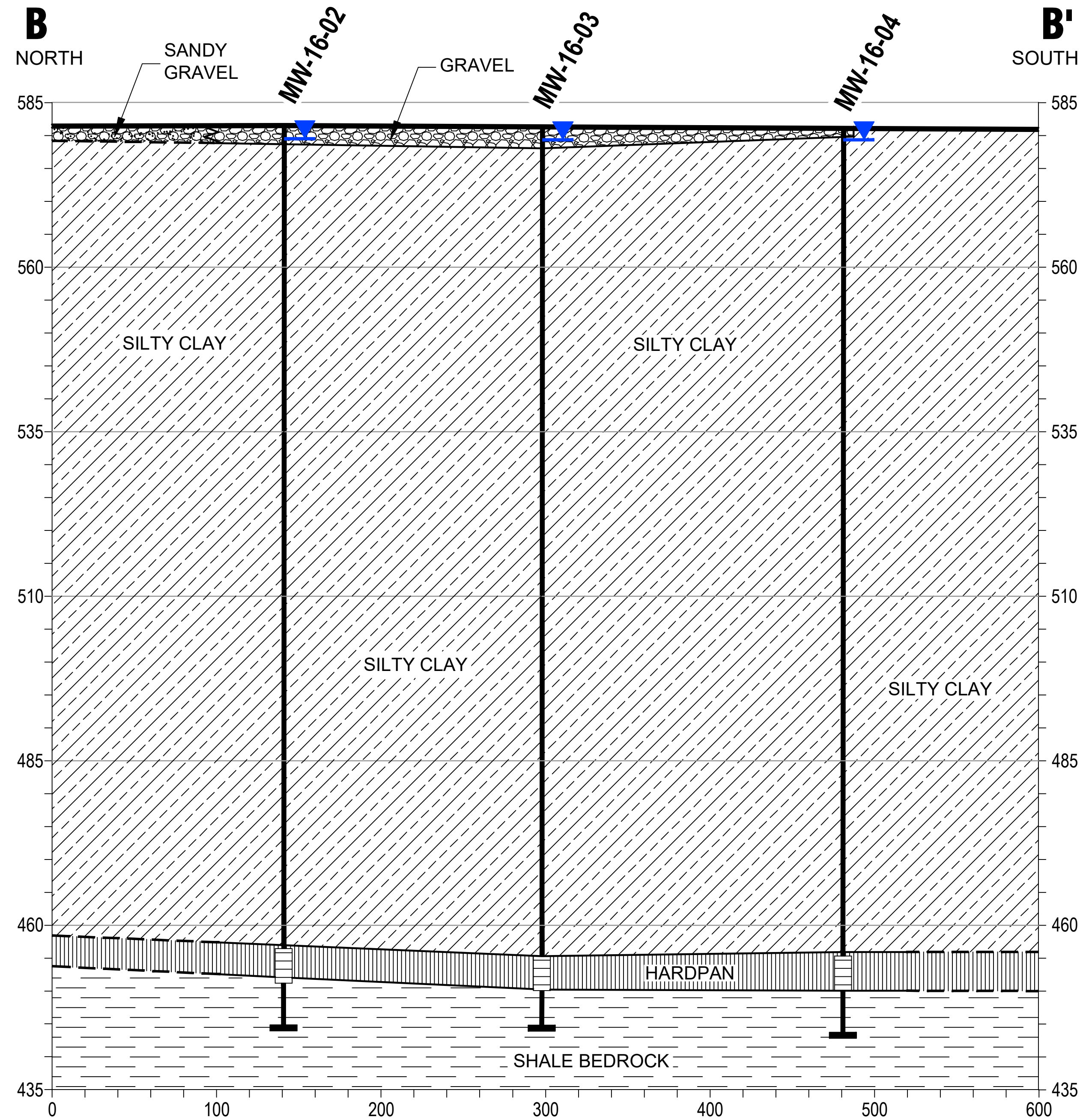
- HARDPAN
- SILTY CLAY
- SHALE BEDROCK

SCALE IN FEET — VERTICAL 0–25; HORIZONTAL 0–100

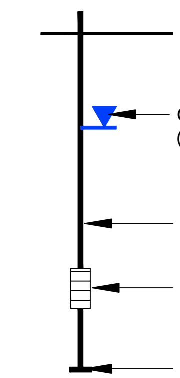
PROJECT:	DTE ELECTRIC COMPANY ST. CLAIR POWER PLANT EAST CHINA TOWNSHIP, MICHIGAN
TITLE:	GENERALIZED GEOLOGIC CROSS-SECTION A-A'
DRAWN BY: D.STEHLE	PROJ NO.: 265996.0004.01.01
CHECKED BY: S.HOLMSTROM	FIGURE 4
APPROVED BY: V.BUENING	
DATE: SEPTEMBER 2017	
TRC	1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 www.trcsolutions.com
FILE NO.:	265996.0004.01.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\St Clair PP\265996\0004\01\ 265996.0004.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 12:02PM --- LAYOUT: FIG04 XS AA

GENERALIZED GEOLOGIC CROSS-SECTION B-B'

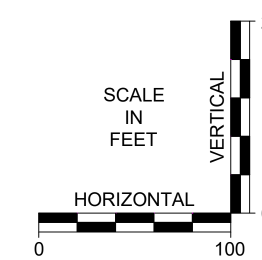


LEGEND



Lithology Key

- HARDPAN
- SILTY CLAY
- SHALE BEDROCK
- GRAVEL
- SANDY GRAVEL



PROJECT:
DTE ELECTRIC COMPANY
ST. CLAIR POWER PLANT
EAST CHINA TOWNSHIP, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS-SECTION B-B'

DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0004.01.01
CHECKED BY:	S.HOLMSTROM		FIGURE 5
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

TRC

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Ann Arbor, MI 48108
Phone: 734.971.7080
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FILE NO.: 265996.0004.01.01.04-05.dwg

11x17 --- ATTACHED XREF'S: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\St Clair PP\265996\0004\01\ 265996.0004.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 12:03PM --- LAYOUT: FIG05 XS BB

TRC Environmental Corporation	QC: JPH
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	10
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.3E-08 cm/s

	Initial Values	Final Values			
Sample Type: Undisturbed					
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	3.62	3.47	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	470.27	763.70	Sample Specific Gravity:	2.60	Est.
Tare & Dry (g)	373.66	604.00	Confining Pressure (psi):	100.0	
Tare (g)	88.45	89.44	Burette Diameter (in):	0.250	
Sample Wt. (g)	703.30	674.26	Burette Zero (cm):	100.0	
Moisture (%)	33.9	31.0			
Wet Density (pcf)	115.2	117.7			
Dry Density (pcf)	86.1	89.8	Max. Effect. Stress (psi):	6.2	
Saturation (%)	99.4	100.0	Min. Effect. Stress (psi):	4.1	
			Ave. Effect. Stress (psi):	4.6	

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	22	9	23.00		0.0	95	95	13.65		2.80		101.50				
2	2016	4	22	18	33.00	33000	25.0	95	95	31.40	17.75	1.00	-1.80	91.35	10.15	-143.1	8.2E-08	
3	2016	4	25	11	31.00	233880	23.0	95	95	54.55	23.15	2.00	1.00	79.25	12.10	-84.7	2.1E-08	
4	2016	4	25	17	43.00	22320	24.0	95	95	55.40	0.85	2.75	0.75	78.55	0.70	3.4	2.7E-08	
5	2016	4	25	20	40.00	10620	24.0	95	95	55.85	0.45	2.95	0.20	78.15	0.40	-33.3	2.3E-08	
6	2016	4	25	23	16.00	9360	24.0	95	95	56.35	0.50	3.20	0.25	77.80	0.35	-16.7	2.7E-08	
7	2016	4	26	5	0.00	20640	25.0	95	95	56.65	0.30	3.85	0.65	77.25	0.55	8.3	2.4E-08	
8	2016	4	26	8	19.00	11940	24.0	95	95	57.55	0.90	4.00	0.15	76.70	0.55	-57.1	2.5E-08	
9	2016	4	26	13	18.00	17940	24.0	95	95	58.40	0.85	4.45	0.45	76.10	0.60	-14.3	2.5E-08	
10	2016	4	27	4	58.00	56400	23.0	95	95	61.65	3.25	5.45	1.00	74.05	2.05	-34.4	2.5E-08	
11	2016	4	27	12	48.00	28200	23.0	95	95	62.00	0.35	6.10	0.65	73.35	0.70	-3.7	2.3E-08	
12	2016	4	27	15	9.00	8460	23.0	95	95	62.00	0.00	6.30	0.20	73.05	0.30	-20.0	2.8E-08	
13	2016	4	28	5	2.00	49980	22.0	95	95	65.10	3.10	6.95	0.65	71.35	1.70	-44.7	2.4E-08	
14	2016	4	28	8	6.00	11040	24.0	95	95	64.75	-0.35	7.40	0.45	71.25	0.10	63.6	2.4E-08	
15	2016	4	28	14	57.00	24660	23.0	95	95	65.30	0.55	7.85	0.45	70.60	0.65	-18.2	2.3E-08	
16	2016	4	28	20	48.00	21060	23.0	95	95	66.25	0.95	8.30	0.45	70.00	0.60	-14.3	2.6E-08	
17	2016	4	29	5	31.00	31380	26.0	95	95	68.05	1.80	8.70	0.40	69.05	0.95	-40.7	2.1E-08	
18	2016	4	29	10	27.00	17760	23.0	95	95	67.10	-0.95	9.25	0.55	68.80	0.25	37.5	2.4E-08	
19	2016	4	29	14	42.00	15300	23.0	95	95	67.70	0.60	9.55	0.30	68.50	0.30	0.0	2.1E-08	
20	2016	4	29	18	0.00	11880	23.0	95	95	67.50	-0.20	9.90	0.35	68.35	0.15	40.0	2.3E-08	
21	2016	5	1	16	24.00	167040	22.0	95	95	72.80	5.30	12.75	2.85	64.50	3.85	-14.9	2.4E-08	
22	2016	5	2	4	59.00	45300	23.0	95	95	74.50	1.70	13.35	0.60	63.50	1.00	-25.0	2.2E-08	
23	2016	5	2	8	5.00	11160	23.0	95	95	74.15	-0.35	13.65	0.30	63.35	0.15	33.3	2.6E-08	
24	2016	5	2	13	16.00	18660	23.0	95	95	74.45	0.30	14.00	0.35	63.10	0.25	16.7	2.1E-08	
25	2016	5	2	20	46.00	27000	26.0	95	95	73.50	-0.95	14.75	0.75	62.90	0.20	57.9	2.2E-08	
26	2016	5	3	4	50.00	29040	23.0	95	95	74.70	1.20	15.05	0.30	62.10	0.80	-45.5	2.5E-08	

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column.

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	10
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel		

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	3.62	3.47	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	470.27	763.70	Sample Specific Gravity:	2.60	Est.
Tare & Dry (g)	373.66	604.00	Confining Pressure (psi):	100.0	
Tare (g)	88.45	89.44	Burette Diameter (in):	0.250	
Sample Wt. (g)	703.30	674.26	Burette Zero (cm):	100.0	

Moisture (%)	33.9	31.0	Maximum Gradient:	4.7
Wet Density (pcf)	115.2	117.7	Average Gradient:	4.5
Dry Density (pcf)	86.1	89.8	Max. Effect. Stress (psi):	4.8
Saturation (%)	99.4	100.0	Min. Effect. Stress (psi):	4.1
			Ave. Effect. Stress (psi):	4.4

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	5	3	4	50.00		0.0	95	95	74.70		15.05		62.10				
2	2016	5	3	8	1.00	11460	25.0	95	95	75.05	0.35	15.25	0.20	61.90	0.20	0.0	2.3E-08	
3	2016	5	3	11	11.00	11400	23.0	95	95	75.60	0.55	15.30	0.05	61.65	0.25	-66.7	1.8E-08	
4	2016	5	3	14	13.00	10920	23.0	95	95	76.00	0.40	15.50	0.20	61.45	0.20	0.0	2.5E-08	
5	2016	5	3	19	37.00	19440	24.0	95	95	76.30	0.30	15.95	0.45	61.25	0.20	38.5	2.3E-08	
6	2016	5	4	5	24.00	35220	23.0	95	95	76.70	0.40	16.45	0.50	60.65	0.60	-9.1	2.2E-08	
7	2016	5	4	9	49.00	15900	23.0	95	95	76.85	0.15	16.75	0.30	60.35	0.30	0.0	2.8E-08	
8	2016	5	4	14	51.00	18120	23.0	95	95	77.40	0.55	16.90	0.15	60.00	0.35	-40.0	2.0E-08	
9	2016	5	4	20	1.00	18600	25.0	95	95	76.85	-0.55	17.40	0.50	59.90	0.10	66.7	2.3E-08	
10	2016	5	5	5	25.00	33840	24.0	95	95	78.30	1.45	17.75	0.35	59.15	0.75	-36.4	2.4E-08	
11	2016	5	5	10	26.00	18060	24.0	95	95	78.30	0.00	18.10	0.35	58.90	0.25	16.7	2.5E-08	1
12	2016	5	5	14	42.00	15360	24.0	95	95	78.60	0.30	18.30	0.20	58.70	0.20	0.0	2.0E-08	1
13	2016	5	6	4	53.00	51060	23.0	95	95	79.30	0.70	19.10	0.80	58.00	0.70	6.7	2.4E-08	1
14	2016	5	6	9	33.00	16800	23.0	95	95	79.90	0.60	19.25	0.15	57.70	0.30	-33.3	2.2E-08	1
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**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.3E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QC: JPH QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	11
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-02, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.7E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.85	2.84	Permeant:	Water	
Sample Ht. (in)	2.69	2.68	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	482.10	587.40	Sample Specific Gravity:	2.68	Est.
Tare & Dry (g)	371.38	440.90	Confining Pressure (psi):	100.0	
Tare (g)	87.03	88.43	Burette Diameter (in):	0.250	
Sample Wt. (g)	507.56	498.97	Burette Zero (cm):	100.0	

Moisture (%)	38.9	41.6	Maximum Gradient:	9.0
Wet Density (pcf)	112.8	112.0	Average Gradient:	8.3
Dry Density (pcf)	81.2	79.1	Max. Effect. Stress (psi):	5.5
Saturation (%)	98.4	100.0	Min. Effect. Stress (psi):	4.0
			Ave. Effect. Stress (psi):	4.6

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	29	5	36.00		0.0	95	95	65.15		2.65		103.70				
2	2016	4	29	10	28.00	17520	23.0	95	95	67.50	2.35	3.50	0.85	102.35	1.35	-22.7	3.1E-08	
3	2016	4	29	14	45.00	15420	23.0	95	95	69.50	2.00	4.40	0.90	102.40	-0.05	111.8	1.4E-08	
4	2016	4	29	17	58.00	11580	23.0	95	95	70.70	1.20	5.05	0.65	102.00	0.40	23.8	2.3E-08	
5	2016	5	1	16	20.00	166920	22.0	95	95	80.70	10.00	13.65	8.60	96.80	5.20	24.6	2.3E-08	
6	2016	5	2	5	0.00	45600	23.0	95	95	82.70	2.00	15.70	2.05	94.70	2.10	-1.2	2.8E-08	
7	2016	5	2	8	7.00	11220	23.0	95	95	83.25	0.55	16.20	0.50	94.25	0.45	5.3	2.6E-08	
8	2016	5	2	13	7.00	18000	23.0	95	95	84.00	0.75	17.05	0.85	93.55	0.70	9.7	2.7E-08	
9	2016	5	2	20	40.00	27180	26.0	95	95	85.60	1.60	18.20	1.15	92.50	1.05	4.5	2.5E-08	
10	2016	5	3	4	51.00	29460	23.0	95	95	85.85	0.25	19.35	1.15	91.10	1.40	-9.8	2.9E-08	
11	2016	5	3	8	3.00	11520	25.0	95	95	86.60	0.75	19.85	0.50	90.65	0.45	5.3	2.7E-08	
12	2016	5	3	11	8.00	11100	23.0	95	95	86.60	0.00	20.30	0.45	90.15	0.50	-5.3	3.0E-08	
13	2016	5	3	14	13.00	11100	23.0	95	95	87.30	0.70	20.75	0.45	89.70	0.45	0.0	2.9E-08	
14	2016	5	3	19	34.00	19260	24.0	95	95	88.25	0.95	21.55	0.80	89.15	0.55	18.5	2.5E-08	
15	2016	5	4	5	25.00	35460	23.0	95	95	89.35	1.10	22.85	1.30	87.75	1.40	-3.7	2.8E-08	
16	2016	5	4	9	50.00	15900	23.0	95	95	89.70	0.35	23.45	0.60	87.20	0.55	4.3	2.8E-08	
17	2016	5	4	14	52.00	18120	23.0	95	95	90.20	0.50	24.10	0.65	86.55	0.65	0.0	2.8E-08	
18	2016	5	4	19	58.00	18360	25.0	95	95	91.10	0.90	24.80	0.70	86.00	0.55	12.0	2.6E-08	
19	2016	5	5	5	26.00	34080	24.0	95	95	91.75	0.65	25.95	1.15	84.75	1.25	-4.2	2.8E-08	1
20	2016	5	5	10	27.00	18060	24.0	95	95	92.40	0.65	26.50	0.55	84.20	0.55	0.0	2.5E-08	1
21	2016	5	5	14	43.00	15360	24.0	95	95	92.80	0.40	27.05	0.55	83.70	0.50	4.8	2.9E-08	1
22	2016	5	6	4	53.00	51000	23.0	95	95	84.30	-8.50	28.70	1.65	82.15	1.55	3.1	2.8E-08	1
23	2016	5	6	9	34.00	16860	23.0	95	95	94.70	10.40	29.20	0.50	81.65	0.50	0.0	2.8E-08	1
24																		
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**A zero in this column starts a series of measurements.   *Average Kv for those rows with a 1 in the Ave. column.   2.7E-08 cm/s

(Termination determined by stable Kv and low flow differential.)   ***Kv adjusted for temperature.

TRC Environmental Corporation Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QC: JPH QA: JPH

Project Name:	DTE - SCPP BAB	Cell #:	2
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-03, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	2.9E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.86	2.83	Permeant:	Water	
Sample Ht. (in)	2.90	2.85	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	474.40	611.40	Sample Specific Gravity:	2.70	Est.
Tare & Dry (g)	351.87	453.40	Confining Pressure (psi):	100.0	
Tare (g)	86.27	88.02	Burette Diameter (in):	0.250	
Sample Wt. (g)	535.23	523.38	Burette Zero (cm):	100.0	
Moisture (%)	46.1	43.2	Maximum Gradient:	7.7	
Wet Density (pcf)	109.4	111.2	Average Gradient:	7.3	
Dry Density (pcf)	74.9	77.6	Max. Effect. Stress (psi):	5.5	
Saturation (%)	99.8	100.0	Min. Effect. Stress (psi):	3.8	
			Ave. Effect. Stress (psi):	4.3	

	Date Yr.	Mo.	Day	Time Hr.	Min.	Run Time (s)	Temp C°**	Pressure (psi) Bot	Top	Cham (cm)	Cham. Dif.(cm)	Bot (cm)	Bot. Dif.(cm)	Top (cm)	Top Dif.(cm)	Flow Dif.(%)	Kv *** cm/s	Ave.* 0,1
1	2016	4	29	5	39.00		0.0	95	95	71.90		3.05		103.70				
2	2016	4	29	10	29.00	17400	23.0	95	95	74.80	2.90	3.25	0.20	100.00	3.70	-89.7	6.0E-08	
3	2016	4	29	14	46.00	15420	23.0	95	95	77.30	2.50	3.70	0.45	98.60	1.40	-51.4	3.3E-08	
4	2016	4	29	17	59.00	11580	23.0	95	95	78.70	1.40	4.15	0.45	97.75	0.85	-30.8	3.1E-08	
5	2016	5	1	16	21.00	166920	22.0	95	95	90.30	11.60	11.25	7.10	89.20	8.55	-9.3	3.0E-08	
6	2016	5	2	5	1.00	45600	23.0	95	95	92.75	2.45	13.05	1.80	87.30	1.90	-2.7	2.8E-08	
7	2016	5	2	8	7.00	11160	23.0	95	95	93.70	0.95	13.40	0.35	86.80	0.50	-17.6	2.7E-08	
8	2016	5	2	13	8.00	18060	23.0	95	95	94.25	0.55	14.20	0.80	86.20	0.60	14.3	2.8E-08	
9	2016	5	2	20	42.00	27240	26.0	95	95	96.15	1.90	15.25	1.05	85.20	1.00	2.6	2.6E-08	
10	2016	5	3	4	52.00	29400	23.0	95	95	95.60	-0.55	16.20	0.95	83.85	1.35	-17.5	3.0E-08	
11	2016	5	3	8	3.00	11460	25.0	95	95	96.60	1.00	16.60	0.40	83.45	0.40	0.0	2.6E-08	
12	2016	5	3	11	9.00	11160	23.0	95	95	96.20	-0.40	17.10	0.50	82.95	0.50	0.0	3.6E-08	
13	2016	5	3	14	14.00	11100	23.0	95	95	97.05	0.85	17.35	0.25	82.55	0.40	-23.1	2.4E-08	
14	2016	5	3	19	34.00	19200	24.0	95	95	98.70	1.65	18.10	0.75	82.00	0.55	15.4	2.7E-08	
15	2016	5	4	5	26.00	35520	23.0	95	95	99.75	1.05	19.25	1.15	80.70	1.30	-6.0	2.9E-08	
16	2016	5	4	9	50.00	15840	23.0	95	95	100.30	0.55	19.80	0.55	80.20	0.50	4.5	2.9E-08	
17	2016	5	4	14	52.00	18120	23.0	95	95	100.60	0.30	20.30	0.50	79.55	0.65	-13.0	2.8E-08	
18	2016	5	4	19	59.00	18420	25.0	95	95	101.75	1.15	21.00	0.70	79.10	0.45	21.7	2.7E-08	
19	2016	5	5	5	26.00	34020	24.0	95	95	102.60	0.85	21.90	0.90	77.85	1.25	-16.3	2.8E-08	
20	2016	5	5	10	27.00	18060	24.0	95	95	103.20	0.60	22.50	0.60	77.35	0.50	9.1	2.8E-08	1
21	2016	5	5	14	43.00	15360	24.0	95	95	103.50	0.30	22.95	0.45	76.85	0.50	-5.3	2.9E-08	1
22	2016	5	6	4	54.00	51060	23.0	95	95	104.00	0.50	24.35	1.40	75.40	1.45	-1.8	2.8E-08	1
23	2016	5	6	9	35.00	16860	23.0	95	95	105.00	1.00	24.80	0.45	74.90	0.50	-5.3	2.9E-08	1
24																		
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 2.9E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	
QC:	JPH
QA:	JPH

Project Name:	DTE - SCPP BAB	Cell #:	3
Project #:	231828.0004.0000	USCS Description:	N/A
Sample Name:	MW-16-04, 40-42'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	3.1E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.85	2.82	Permeant:	Water	
Sample Ht. (in)	2.88	2.84	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	561.80	656.70	Sample Specific Gravity:	2.63	Est.
Tare & Dry (g)	460.60	537.10	Confining Pressure (psi):	100.0	
Tare (g)	95.90	87.80	Burette Diameter (in):	0.250	
Sample Wt. (g)	580.00	568.90	Burette Zero (cm):	100.0	

	Initial	Final		
Moisture (%)	27.7	26.6	Maximum Gradient:	7.7
Wet Density (pcf)	120.5	122.2	Average Gradient:	7.3
Dry Density (pcf)	94.3	96.5	Max. Effect. Stress (psi):	5.5
Saturation (%)	98.7	100.0	Min. Effect. Stress (psi):	4.0
			Ave. Effect. Stress (psi):	4.6

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	29	5	41.00		0.0	95	95	66.60		1.60		104.80				
2	2016	4	29	10	30.00	17340	23.0	95	95	68.30	1.70	2.15	0.55	101.80	3.00	-69.0	5.3E-08	
3	2016	4	29	14	47.00	15420	23.0	95	95	69.60	1.30	2.90	0.75	100.80	1.00	-14.3	3.0E-08	
4	2016	4	29	17	59.00	11520	23.0	95	95	70.60	1.00	3.50	0.60	100.15	0.65	-4.0	2.9E-08	
5	2016	5	1	16	21.00	166920	22.0	95	95	77.85	7.25	11.95	8.45	91.30	8.85	-2.3	3.2E-08	
6	2016	5	2	5	2.00	45660	23.0	95	95	79.40	1.55	13.95	2.00	89.10	2.20	-4.8	3.1E-08	
7	2016	5	2	8	8.00	11160	23.0	95	95	80.15	0.75	14.40	0.45	88.65	0.45	0.0	2.8E-08	
8	2016	5	2	13	9.00	18060	23.0	95	95	80.40	0.25	15.25	0.85	88.00	0.65	13.3	3.0E-08	
9	2016	5	2	20	43.00	27240	26.0	95	95	81.60	1.20	16.40	1.15	86.95	1.05	4.5	2.8E-08	
10	2016	5	3	4	52.00	29340	23.0	95	95	80.60	-1.00	17.50	1.10	85.50	1.45	-13.7	3.3E-08	
11	2016	5	3	8	2.00	11400	25.0	95	95	81.25	0.65	18.00	0.50	85.10	0.40	11.1	2.9E-08	
12	2016	5	3	11	9.00	11220	23.0	95	95	80.75	-0.50	18.40	0.40	84.60	0.50	-11.1	3.2E-08	
13	2016	5	3	14	15.00	11160	23.0	95	95	81.55	0.80	18.85	0.45	84.15	0.45	0.0	3.2E-08	
14	2016	5	3	19	35.00	19200	24.0	95	95	82.95	1.40	19.60	0.75	83.60	0.55	15.4	2.7E-08	
15	2016	5	4	5	26.00	35460	23.0	95	95	83.40	0.45	20.90	1.30	82.20	1.40	-3.7	3.2E-08	
16	2016	5	4	9	50.00	15840	23.0	95	95	83.70	0.30	21.40	0.50	81.60	0.60	-9.1	3.0E-08	
17	2016	5	4	14	53.00	18180	23.0	95	95	83.80	0.10	22.05	0.65	80.95	0.65	0.0	3.2E-08	
18	2016	5	4	19	59.00	18360	25.0	95	95	84.80	1.00	22.80	0.75	80.50	0.45	25.0	2.8E-08	
19	2016	5	5	5	27.00	34080	24.0	95	95	85.10	0.30	23.85	1.05	79.20	1.30	-10.6	3.1E-08	
20	2016	5	5	10	28.00	18060	24.0	95	95	85.60	0.50	24.45	0.60	78.65	0.55	4.3	3.0E-08	1
21	2016	5	5	14	44.00	15360	24.0	95	95	85.80	0.20	25.00	0.55	78.25	0.40	15.8	3.0E-08	1
22	2016	5	6	4	55.00	51060	23.0	95	95	86.70	0.90	26.50	1.50	76.75	1.50	0.0	3.0E-08	1
23	2016	5	6	9	35.00	16800	23.0	95	95	87.20	0.50	27.00	0.50	76.15	0.60	-9.1	3.5E-08	1
24																		
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 3.1E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

SCPP BABs CCR Unit Site

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:

DTE ELECTRIC COMPANY
MONROE POWER PLANT
7955 EAST DUNBAR ROAD
MONROE, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0001
FILE:	265996-SLMMB.mxd

FIGURE 1

E:\DTE\CCR_Sites\2017_265996\265996-SLMMB.mxd -- Saved By: BDEEGAN on 10/9/2017, 14:49:39 PM

LEGEND

MONITORING WELLS

APPROXIMATE BOUNDARY OF FLY ASH BASIN

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN MARCH AND MAY 2016.

N

0 600 1,200 Feet

1 " = 600 '

1:7,200

PROJECT: DTE ELECTRIC COMPANY MONROE POWER PLANT FLY ASH BASIN 7955 EAST DUNBAR ROAD MONROE, MICHIGAN	
TITLE: MONITORING NETWORK AND SITE PLAN	
DRAWN BY: J. PAPEZ	PROJ NO.: 265996.0001
CHECKED BY: S. HOLMSTROM	FIGURE 2
APPROVED BY: V. BUENING	
DATE: JANUARY 2018	
TRC	1540 Eisenhower Place Ann Arbor, MI 48108-3284 Phone: 734.971.7080 www.trcsolutions.com
FILE NO.:	265996-0001-000.mxd

TRC - GIS

Coordinate System: NAD 1983 UTM Zone 17N (Meter)
Map Rotation: 0

Plot Date: 1/29/2018, 09:45:57 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0001-000.mxd

LEGEND

- MONITORING WELL
- APPROXIMATE BOUNDARY OF FLY ASH BASIN
- INFERRED GROUNDWATER FLOW DIRECTION
- POTENTIOMETRIC SURFACE CONTOUR LINE (5-FT INTERVAL,DASHED WHERE INFERRED)
- (582.69) STATIC WATER ELEVATION IN FEET (NAVD, 1988)

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN MARCH AND MAY 2016.
3. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO NORTH AMERICAN VERTICAL DATUM OF 1988

0 600 1,200 Feet

1 " = 600 '

1:7,200

PROJECT:
DTE ELECTRIC COMPANY
MONROE POWER PLANT FLY ASH BASIN
7955 EAST DUNBAR ROAD
MONROE, MICHIGAN

TITLE:
POTENTIOMETRIC SURFACE MAP
SEPTEMBER 2017

DRAWN BY:	S MAJOR	PROJ NO.:	265996.0001
CHECKED BY:	C. SCIESZKA		
APPROVED BY:	V. BUENING	**FIGURE 3**	
DATE:	JANUARY 2018		

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FILE NO.: 265996-0001-011a.mxd

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Coordinate System: NAD 1983 UTM Zone 17N (Meter)
Map Rotation: 0

Plot Date: 1/12/2018, 08:54:41 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0001-011a.mxd

Table 1
Groundwater Elevation Summary
Range Road Landfill – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-05		MW-16-06		MW-16-07	
Date Installed	1/13/2016		1/27/2016		2/1/2016		5/24/2016		5/13/2016		5/10/2016		5/13/2016	
TOC Elevation	595.35		598.44		597.69		596.87		601.97		600.68		589.34	
Geologic Unit of Screened interval	Sand with Silt		Silty Sand with Gravel		Silty Gravel with Sand		Silty Sand		Gravel with Sand		Sand		Sand	
Screened Interval Elevation	390.7 to 385.7		393.8 to 388.8		432.1 to 427.1		414.1 to 409.1		476.6 to 471.6		508.0 to 503.0		494.4 to 489.4	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/11/2016	22.77	572.58	21.10	577.34	20.24	577.45	19.54	577.33	27.73	574.24	23.89	576.79	16.13	573.21
9/22/2016	21.41	573.94	21.04	577.40	20.23	577.46	20.92	575.95	27.74	574.23	23.90	576.78	16.40	572.94
11/10/2016	21.07	574.28	20.96	577.48	20.17	577.52	19.55	577.32	27.72	574.25	23.80	576.88	16.20	573.14
1/11/2017	19.63	575.72	20.87	577.57	20.10	577.59	19.38	577.49	27.53	574.44	23.71	576.97	15.80	573.54
1/3/2017	19.05	576.30	20.30	578.14	19.49	578.20	18.85	578.02	26.91	575.06	23.08	577.60	15.74	573.60
4/19/2017	19.11	576.24	20.75	577.69	19.94	577.75	19.32	577.55	27.41	574.56	23.56	577.12	16.19	573.15
6/7/2017	19.00	576.35	20.79	577.65	20.03	577.66	19.32	577.55	27.50	574.47	23.65	577.03	15.82	573.52
7/26/2017	18.90	576.45	20.45	577.99	20.05	577.64	19.45	577.42	27.60	574.37	23.75	576.93	16.30	573.04

Notes:
Elevations are reported in feet relative to the North American Vertical Datum of 1988.
ft BTOC - feet below top of casing.

LEGEND

- MONITORING WELLS
- APPROXIMATE BOUNDARY OF FLY ASH
- CROSS SECTIONS

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN MARCH AND MAY 2016.

0 600 1,200 Feet

1 " = 600 '

1:7,200

Coordinate System: NAD 1983 UTM Zone 17N (Meter)
Map Rotation: 0

PROJECT:
DTE ELECTRIC COMPANY
MONROE POWER PLANT FLY ASH BASIN
7955 EAST DUNBAR ROAD
MONROE, MICHIGAN

TITLE:
CROSS SECTION LOCATOR MAP

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0001
CHECKED BY:	S. HOLMSTROM		**FIGURE 3**
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

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FILE NO.: 265996-0001-008.mxd

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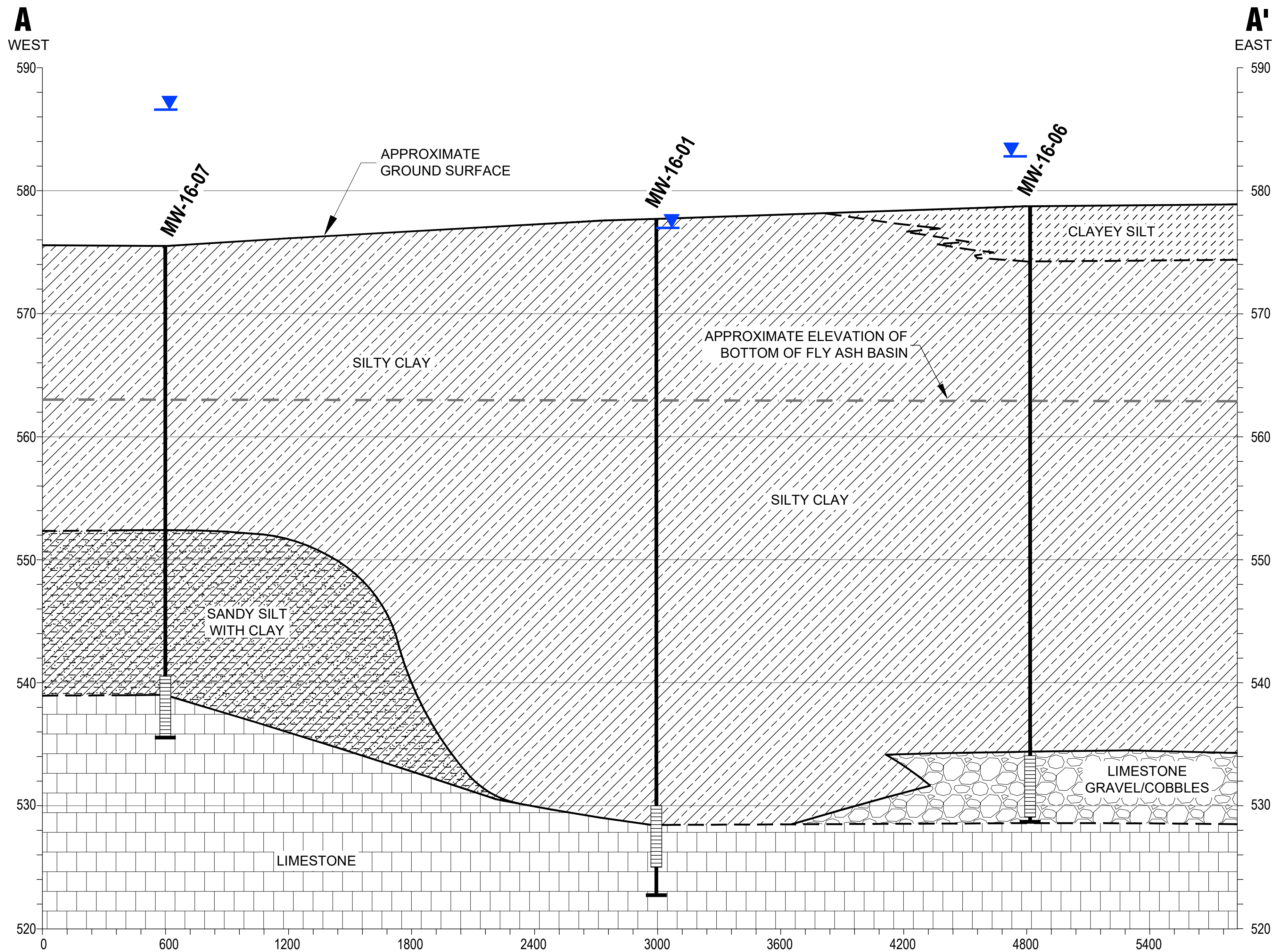
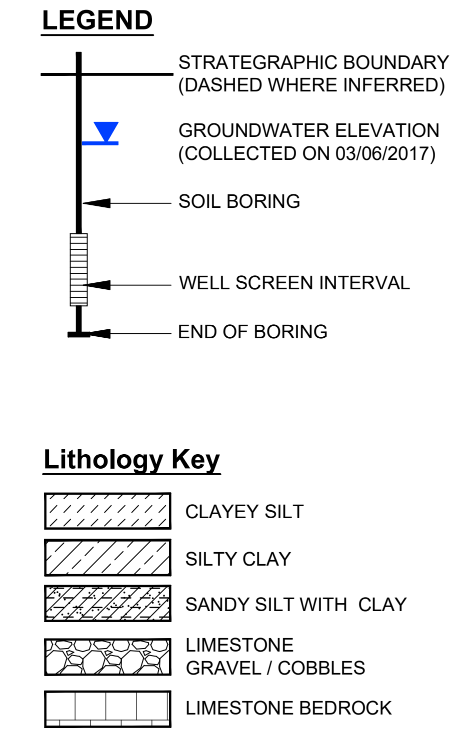
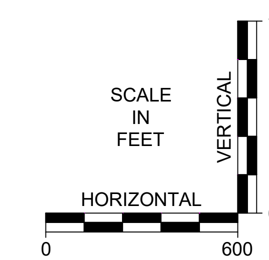
Plot Date: 10/9/2017, 14:56:26 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0001-008.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'







PROJECT:
DTE ELECTRIC COMPANY
MONROE POWER PLANT - FLY ASH BASIN
MONROE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS-SECTION A-A'

DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0001.01
CHECKED BY:	S.HOLMSTROM	**FIGURE 4**	
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

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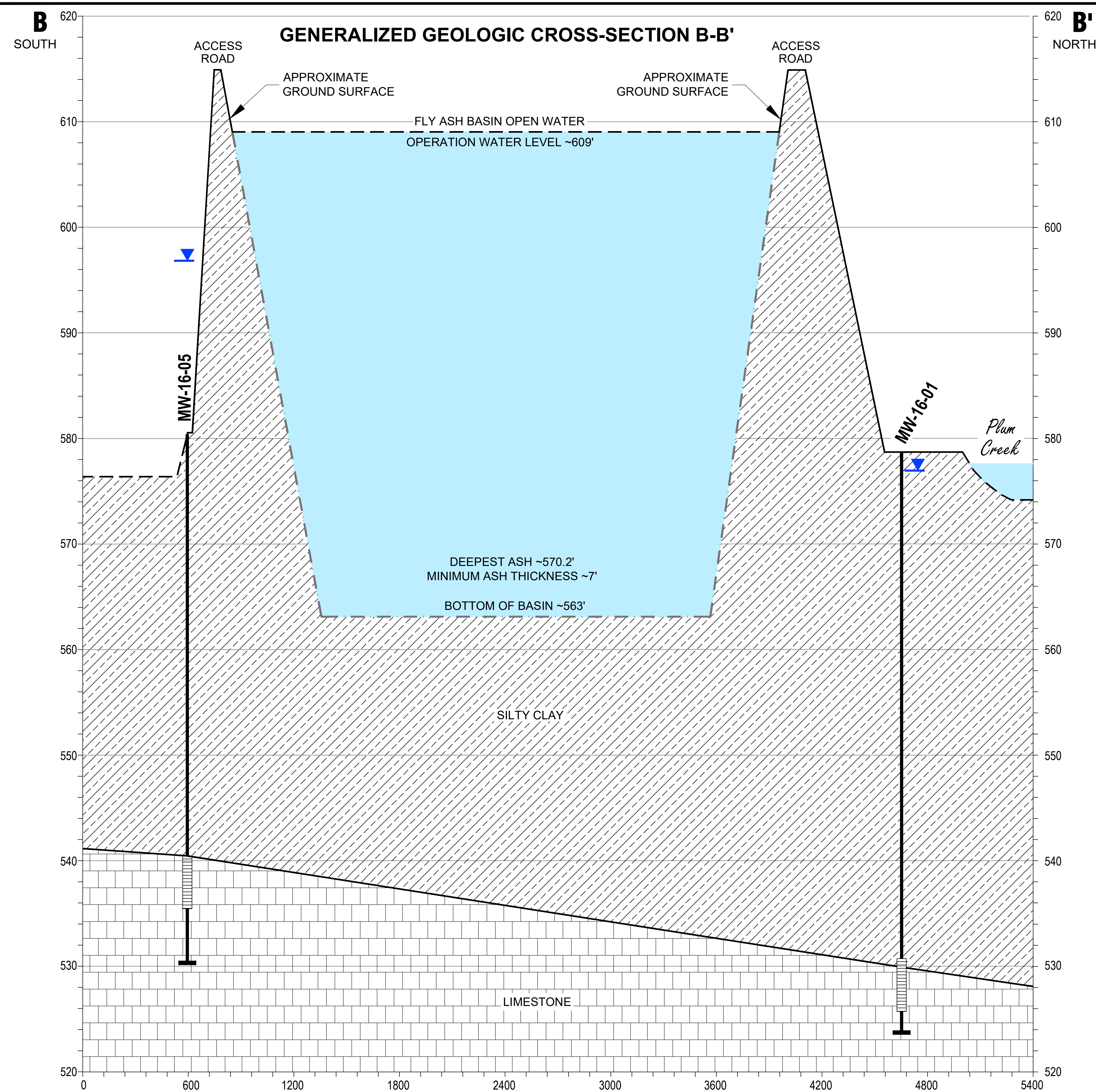
FILE NO.: 265996.0001.01.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\Monroe PP\265996\0001\01\ 265996.0001.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 11:17AM --- LAYOUT: FIG04 XS AA

GENERALIZED GEOLOGIC CROSS-SECTION B-B'



LEGEND

- STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (COLLECTED 03/06/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

Lithology Key

- SILTY CLAY
- LIMESTONE BEDROCK

SCALE IN FEET
VERTICAL 0 – 10
HORIZONTAL 0 – 600

PROJECT:
DTE ELECTRIC COMPANY
MONROE POWER PLANT - FLY ASH BASIN
MONROE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS-SECTION B-B'

DRAWN BY:	D.Stehle	PROJ NO.:	265996.0001.01.01
CHECKED BY:	S.HOLMSTROM		**FIGURE 5**
APPROVED BY:	V.BUENING		
DATE:	MAY 2017		

TRC
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Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0001.01.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\Monroe PP\265996\0001\01\265996.0001.01.01.04-05.dwg --- PLOT DATE: October 12, 2017 - 11:17AM --- LAYOUT: FIG05 XS BB

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	8
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-01, 20-22'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.6E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values		
Sample Dia. (in)	2.87	2.87	Permeant:	Water
Sample Ht. (in)	3.31	3.31	Permeant Specific Gravity:	1.00
Tare & Wet (g)	542.53	912.90	Sample Specific Gravity:	2.81 Est.
Tare & Dry (g)	495.80	821.70	Confining Pressure (psi):	100.0
Tare (g)	90.23	91.36	Burette Diameter (in):	0.250
Sample Wt. (g)	816.00	821.54	Burette Zero (cm):	100.0

	Initial	Final		
Moisture (%)	11.5	12.5	Maximum Gradient:	6.7
Wet Density (pcf)	145.1	146.0	Average Gradient:	6.5
Dry Density (pcf)	130.1	129.8	Max. Effect. Stress (psi):	5.8
Saturation (%)	92.9	100.0	Min. Effect. Stress (psi):	4.4
			Ave. Effect. Stress (psi):	4.9

	Date Yr.	Mo.	Day	Time Hr.	Min.	Run Time (s)	Temp C°**	Pressure (psi) Bot	Top	Cham (cm)	Cham. Dif.(cm)	Bot (cm)	Bot. Dif.(cm)	Top (cm)	Top Dif.(cm)	Flow Dif.(%)	Kv *** cm/s	Ave.* 0,1
1	2016	3	2	5	6.00		0.0	95	95	45.70		2.90		102.20				
2	2016	3	2	9	13.00	14820	24.0	95	95	46.50	0.80	4.15	1.25	100.65	1.55	-10.7	5.6E-08	
3	2016	3	2	12	8.00	10500	22.0	95	95	46.70	0.20	4.95	0.80	99.85	0.80	0.0	4.8E-08	
4	2016	3	2	20	42.00	30840	22.0	95	95	48.30	1.60	7.20	2.25	97.85	2.00	5.9	4.5E-08	
5	2016	3	3	14	8.00	62760	23.0	95	95	50.95	2.65	10.90	3.70	94.55	3.30	5.7	3.8E-08	
6	2016	3	3	18	52.00	17040	24.0	95	95	51.50	0.55	11.80	0.90	93.80	0.75	9.1	3.4E-08	
7	2016	3	4	13	27.00	66900	22.0	95	95	53.20	1.70	14.70	2.90	91.15	2.65	4.5	3.2E-08	
8	2016	3	4	18	53.00	19560	22.0	95	95	53.80	0.60	15.45	0.75	90.45	0.70	3.4	3.0E-08	
9	2016	3	7	5	14.00	210060	22.0	95	95	58.95	5.15	21.05	5.60	85.35	5.10	4.7	2.2E-08	
10	2016	3	7	8	14.00	10800	23.0	95	95	59.30	0.35	21.30	0.25	85.15	0.20	11.1	1.9E-08	
11	2016	3	7	13	26.00	18720	22.0	95	95	59.75	0.45	21.65	0.35	84.80	0.35	0.0	1.8E-08	
12	2016	3	7	18	47.00	19260	21.0	95	95	60.50	0.75	22.05	0.40	84.55	0.25	23.1	1.7E-08	
13	2016	3	8	5	5.00	37080	25.0	95	95	61.50	1.00	22.75	0.70	83.85	0.70	0.0	1.7E-08	
14	2016	3	8	13	23.00	29880	22.0	95	95	62.20	0.70	23.30	0.55	83.30	0.55	0.0	1.8E-08	
15	2016	3	8	19	23.00	21600	22.0	95	95	63.10	0.90	23.70	0.40	83.10	0.20	33.3	1.4E-08	
16	2016	3	9	5	30.00	36420	24.0	95	95	63.80	0.70	24.30	0.60	82.40	0.70	-7.7	1.8E-08	
17	2016	3	9	11	14.00	20640	24.0	95	95	64.30	0.50	24.65	0.35	82.15	0.25	16.7	1.5E-08	
18	2016	3	9	20	22.00	32880	22.0	95	95	64.70	0.40	25.25	0.60	81.70	0.45	14.3	1.7E-08	
19	2016	3	10	4	59.00	31020	23.0	95	95	65.20	0.50	25.70	0.45	81.20	0.50	-5.3	1.6E-08	1
20	2016	3	10	8	24.00	12300	23.0	95	95	65.40	0.20	25.90	0.20	81.00	0.20	0.0	1.7E-08	1
21	2016	3	10	11	23.00	10740	23.0	95	95	65.40	0.00	26.05	0.15	80.85	0.15	0.0	1.5E-08	1
22	2016	3	10	20	45.00	33720	23.0	95	95	66.20	0.80	26.65	0.60	80.45	0.40	20.0	1.6E-08	1
23	2016	3	11	4	53.00	29280	22.0	95	95	66.20	0.00	27.05	0.40	79.95	0.50	-11.1	1.8E-08	1
24	2016	3	11	7	57.00	11040	24.0	95	95	66.60	0.40	27.20	0.15	79.80	0.15	0.0	1.5E-08	1
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 1.6E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation	QC: JPH
Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)	QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	9
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-02, 30-32'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.3E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.87	2.86	Permeant:	Water	
Sample Ht. (in)	3.06	3.03	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	392.27	822.40	Sample Specific Gravity:	2.80	Est.
Tare & Dry (g)	353.20	733.00	Confining Pressure (psi):	100.0	
Tare (g)	89.98	90.41	Burette Diameter (in):	0.250	
Sample Wt. (g)	733.20	731.99	Burette Zero (cm):	100.0	

Moisture (%)	14.8	13.9	Maximum Gradient:	9.2
Wet Density (pcf)	141.0	143.2	Average Gradient:	9.0
Dry Density (pcf)	122.8	125.7	Max. Effect. Stress (psi):	5.7
Saturation (%)	98.2	100.0	Min. Effect. Stress (psi):	4.2
			Ave. Effect. Stress (psi):	4.8

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	2	5	7.00		0.0	95	95	55.10		2.10		101.90				
2	2016	3	2	9	14.00	14820	24.0	95	95	55.90	0.80	2.65	0.55	101.15	0.75	-15.4	2.4E-08	
3	2016	3	2	12	9.00	10500	22.0	95	95	56.20	0.30	2.95	0.30	100.75	0.40	-14.3	1.9E-08	
4	2016	3	2	20	43.00	30840	22.0	95	95	57.75	1.55	4.05	1.10	99.90	0.85	12.8	1.8E-08	
5	2016	3	3	14	9.00	62760	23.0	95	95	60.30	2.55	5.95	1.90	98.50	1.40	15.2	1.5E-08	
6	2016	3	3	18	53.00	17040	24.0	95	95	60.85	0.55	6.50	0.55	98.00	0.50	4.8	1.8E-08	
7	2016	3	4	13	28.00	66900	22.0	95	95	62.50	1.65	8.30	1.80	96.55	1.45	10.8	1.5E-08	
8	2016	3	4	18	54.00	19560	22.0	95	95	63.10	0.60	8.80	0.50	96.15	0.40	11.1	1.5E-08	
9	2016	3	7	5	15.00	210060	22.0	95	95	67.80	4.70	13.70	4.90	92.40	3.75	13.3	1.4E-08	
10	2016	3	7	8	14.00	10740	23.0	95	95	68.30	0.50	13.95	0.25	92.20	0.20	11.1	1.5E-08	
11	2016	3	7	13	26.00	18720	21.0	95	95	68.60	0.30	14.35	0.40	92.00	0.20	33.3	1.2E-08	
12	2016	3	7	18	48.00	19320	21.0	95	95	69.35	0.75	14.80	0.45	91.75	0.25	28.6	1.3E-08	
13	2016	3	8	5	5.00	37020	25.0	95	95	70.40	1.05	15.60	0.80	91.15	0.60	14.3	1.3E-08	
14	2016	3	8	13	48.00	31380	22.0	95	95	70.40	0.00	16.15	0.55	90.70	0.45	10.0	1.2E-08	
15	2016	3	8	19	24.00	20160	22.0	95	95	71.75	1.35	16.60	0.45	90.55	0.15	50.0	1.1E-08	
16	2016	3	9	5	31.00	36420	24.0	95	95	72.40	0.65	17.25	0.65	90.15	0.40	23.8	1.1E-08	
17	2016	3	9	11	15.00	20640	24.0	95	95	72.80	0.40	17.65	0.40	89.85	0.30	14.3	1.3E-08	
18	2016	3	9	20	23.00	32880	22.0	95	95	73.20	0.40	18.35	0.70	89.55	0.30	40.0	1.2E-08	
19	2016	3	10	4	59.00	30960	23.0	95	95	73.60	0.40	18.85	0.50	89.10	0.45	5.3	1.2E-08	1
20	2016	3	10	8	23.00	12240	23.0	95	95	73.80	0.20	19.10	0.25	88.90	0.20	11.1	1.4E-08	1
21	2016	3	10	11	23.00	10800	23.0	95	95	73.80	0.00	19.30	0.20	88.70	0.20	0.0	1.5E-08	1
22	2016	3	10	20	46.00	33780	23.0	95	95	74.50	0.70	20.00	0.70	88.45	0.25	47.4	1.1E-08	1
23	2016	3	11	4	54.00	29280	22.0	95	95	74.40	-0.10	20.45	0.45	87.85	0.60	-14.3	1.5E-08	1
24	2016	3	11	7	58.00	11040	24.0	95	95	74.80	0.40	20.70	0.25	87.75	0.10	42.9	1.3E-08	1
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 1.3E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	10
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-03, 20-22'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.2E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.87	2.87	Permeant:	Water	
Sample Ht. (in)	3.00	3.01	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	563.98	834.70	Sample Specific Gravity:	2.82	Est.
Tare & Dry (g)	512.90	750.80	Confining Pressure (psi):	100.0	
Tare (g)	88.99	90.55	Burette Diameter (in):	0.250	
Sample Wt. (g)	740.10	744.15	Burette Zero (cm):	100.0	

Moisture (%)	12.0	12.7	Maximum Gradient:	9.8
Wet Density (pcf)	145.3	145.8	Average Gradient:	9.4
Dry Density (pcf)	129.7	129.4	Max. Effect. Stress (psi):	5.7
Saturation (%)	95.6	100.0	Min. Effect. Stress (psi):	4.2
			Ave. Effect. Stress (psi):	4.8

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	2	5	8.00		0.0	95	95	50.70		2.00		101.60				
2	2016	3	2	9	14.00	14760	24.0	95	95	50.40	-0.30	2.65	0.65	100.90	0.70	-3.7	2.4E-08	
3	2016	3	2	12	9.00	10500	22.0	95	95	51.00	0.60	2.95	0.30	100.50	0.40	-14.3	1.9E-08	
4	2016	3	2	20	44.00	30900	22.0	95	95	52.65	1.65	3.85	0.90	99.75	0.75	9.1	1.5E-08	
5	2016	3	3	14	10.00	62760	23.0	95	95	55.10	2.45	5.50	1.65	98.30	1.45	6.5	1.4E-08	
6	2016	3	3	18	54.00	17040	24.0	95	95	55.30	0.20	6.00	0.50	97.90	0.40	11.1	1.5E-08	
7	2016	3	4	13	29.00	66900	22.0	95	95	57.20	1.90	7.55	1.55	96.50	1.40	5.1	1.3E-08	
8	2016	3	4	18	55.00	19560	22.0	95	95	57.70	0.50	8.00	0.45	96.00	0.50	-5.3	1.5E-08	
9	2016	3	7	5	15.00	210000	22.0	95	95	63.25	5.55	12.30	4.30	92.10	3.90	4.9	1.3E-08	
10	2016	3	7	8	15.00	10800	23.0	95	95	63.40	0.15	12.60	0.30	91.90	0.20	20.0	1.6E-08	
11	2016	3	7	13	27.00	18720	21.0	95	95	63.80	0.40	12.85	0.25	91.60	0.30	-9.1	1.1E-08	
12	2016	3	7	18	49.00	19320	21.0	95	95	64.65	0.85	13.35	0.50	91.35	0.25	33.3	1.4E-08	
13	2016	3	8	5	6.00	37020	25.0	95	95	65.15	0.50	14.00	0.65	90.75	0.60	4.0	1.1E-08	
14	2016	3	8	13	48.00	31320	22.0	95	95	66.90	1.75	14.40	0.40	90.15	0.60	-20.0	1.2E-08	
15	2016	3	8	19	25.00	20220	22.0	95	95	67.60	0.70	14.80	0.40	89.95	0.20	33.3	1.1E-08	
16	2016	3	9	5	31.00	36360	24.0	95	95	67.70	0.10	15.50	0.70	89.35	0.60	7.7	1.3E-08	1
17	2016	3	9	11	15.00	20640	24.0	95	95	68.40	0.70	15.85	0.35	89.00	0.35	0.0	1.2E-08	1
18	2016	3	9	20	24.00	32940	22.0	95	95	69.10	0.70	16.40	0.55	88.60	0.40	15.8	1.1E-08	1
19	2016	3	10	5	0.00	30960	23.0	95	95	70.20	1.10	16.75	0.35	88.05	0.55	-22.2	1.1E-08	1
20	2016	3	10	8	24.00	12240	23.0	95	95	69.90	-0.30	17.00	0.25	87.80	0.25	0.0	1.6E-08	1
21	2016	3	10	11	24.00	10800	23.0	95	95	70.20	0.30	17.20	0.20	87.70	0.10	33.3	1.1E-08	1
22	2016	3	10	20	47.00	33780	23.0	95	95	70.40	0.20	17.80	0.60	87.40	0.30	33.3	1.0E-08	1
23	2016	3	11	4	54.00	29220	22.0	95	95	71.40	1.00	18.15	0.35	86.75	0.65	-30.0	1.4E-08	1
24	2016	3	11	7	58.00	11040	24.0	95	95	71.25	-0.15	18.35	0.20	86.65	0.10	33.3	1.0E-08	1
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 1.2E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH
QA: JPH

Project Name:	DTE - Monroe FAB	Cell #:	11
Project #:	231828.0001.0000	USCS Description:	N/A
Sample Name:	MW-16-04, 20-22'	USCS Classification:	N/A
Visual Descript:	Gray sandy lean clay, with gravel	Average Kv =	1.2E-08 cm/s

Sample Type: Undisturbed	Initial Values	Final Values			
Sample Dia. (in)	2.87	2.85	Permeant:	Water	
Sample Ht. (in)	3.55	3.51	Permeant Specific Gravity:	1.00	
Tare & Wet (g)	869.30	961.20	Sample Specific Gravity:	2.80	Est.
Tare & Dry (g)	785.95	875.10	Confining Pressure (psi):	100.0	
Tare (g)	0.00	89.15	Burette Diameter (in):	0.250	
Sample Wt. (g)	869.30	872.05	Burette Zero (cm):	100.0	

	Initial	Final		
Moisture (%)	10.6	11.0	Maximum Gradient:	8.4
Wet Density (pcf)	144.2	148.4	Average Gradient:	8.1
Dry Density (pcf)	130.4	133.7	Max. Effect. Stress (psi):	5.7
Saturation (%)	87.3	100.0	Min. Effect. Stress (psi):	4.1
			Ave. Effect. Stress (psi):	4.7

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	2	5	8.00		0.0	95	95	52.10		2.10		102.60				
2	2016	3	2	9	15.00	14820	24.0	95	95	53.45	1.35	2.75	0.65	101.85	0.75	-7.1	3.0E-08	
3	2016	3	2	12	10.00	10500	22.0	95	95	54.20	0.75	3.15	0.40	101.45	0.40	0.0	2.5E-08	
4	2016	3	2	20	40.00	30600	22.0	95	95	56.60	2.40	4.40	1.25	100.50	0.95	13.6	2.4E-08	
5	2016	3	3	14	6.00	62760	23.0	95	95	60.60	4.00	6.50	2.10	98.80	1.70	10.5	2.1E-08	
6	2016	3	3	18	50.00	17040	24.0	95	95	61.60	1.00	7.05	0.55	98.40	0.40	15.8	1.9E-08	
7	2016	3	4	13	25.00	66900	22.0	95	95	64.60	3.00	8.85	1.80	96.75	1.65	4.3	1.9E-08	
8	2016	3	4	18	51.00	19560	22.0	95	95	65.60	1.00	9.35	0.50	96.30	0.45	5.3	1.8E-08	
9	2016	3	7	5	16.00	210300	22.0	95	95	73.80	8.20	13.55	4.20	92.50	3.80	5.0	1.5E-08	
10	2016	3	7	8	15.00	10740	23.0	95	95	74.30	0.50	13.80	0.25	92.30	0.20	11.1	1.7E-08	
11	2016	3	7	13	27.00	18720	21.0	95	95	74.95	0.65	14.10	0.30	92.00	0.30	0.0	1.4E-08	
12	2016	3	7	18	46.00	19140	21.0	95	95	75.95	1.00	14.45	0.35	91.85	0.15	40.0	1.1E-08	
13	2016	3	8	5	6.00	37200	25.0	95	95	77.60	1.65	15.00	0.55	91.35	0.50	4.8	1.1E-08	
14	2016	3	8	13	50.00	31440	22.0	95	95	78.60	1.00	15.45	0.45	90.80	0.55	-10.0	1.4E-08	
15	2016	3	8	19	21.00	19860	22.0	95	95	79.60	1.00	15.80	0.35	90.70	0.10	55.6	9.9E-09	
16	2016	3	9	5	32.00	36660	24.0	95	95	80.80	1.20	16.30	0.50	90.20	0.50	0.0	1.1E-08	1
17	2016	3	9	11	16.00	20640	24.0	95	95	81.60	0.80	16.60	0.30	89.90	0.30	0.0	1.2E-08	1
18	2016	3	9	20	20.00	32640	22.0	95	95	82.25	0.65	17.10	0.50	89.60	0.30	25.0	1.1E-08	1
19	2016	3	10	5	0.00	31200	23.0	95	95	82.90	0.65	17.55	0.45	89.10	0.50	-5.3	1.4E-08	1
20	2016	3	10	8	24.00	12240	23.0	95	95	83.30	0.40	17.70	0.15	89.00	0.10	20.0	9.1E-09	1
21	2016	3	10	11	24.00	10800	23.0	95	95	83.50	0.20	17.85	0.15	88.85	0.15	0.0	1.2E-08	1
22	2016	3	10	20	43.00	33540	23.0	95	95	84.50	1.00	18.35	0.50	88.60	0.25	33.3	1.0E-08	1
23	2016	3	11	4	55.00	29520	22.0	95	95	84.70	0.20	18.65	0.30	88.05	0.55	-29.4	1.3E-08	1
24	2016	3	11	7	59.00	11040	24.0	95	95	85.30	0.60	18.85	0.20	88.00	0.05	60.0	1.0E-08	1
25																		
26																		

**A zero in this column starts a series of measurements. *Average Kv for those rows with a 1 in the Ave. column. 1.2E-08 cm/s

(Termination determined by stable Kv and low flow differential.) ***Kv adjusted for temperature.

LABORATORY TEST RESULTS
VERIFICATION OF NATURAL SOIL BARRIER - MONROE ASH BASIN
SME PROJECT NO. PG-22087

BORING NO.	SAMPLE NO.	DEPTH (feet)	CLASSIFICATION SYMBOL	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO (calculated)	ATTERBERG LIMITS			PARTICLE SIZE DISTRIBUTION (%)						COEFFICIENT OF PERMEABILITY (cm/sec)
								LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	
B2	CS2	6.5	CL	21	108	2.73	0.58	42	17	25	0	0	2	5	36	57	3.3E-08
B2	CS4	11.5	CL	12	126	2.68	0.33	23	15	8	0	0	8	18	39	35	5.8E-08
B2	CS6	16.5	CL	12	126	2.72	0.35	23	14	9	0	0	8	16	40	36	1.3E-08
B2	CS8	21.5	CL	12	127	2.72	0.34	24	13	11	0	0	8	17	38	37	1.5E-08
B2	CS10	26.5	CL	10	131	2.75	0.31	20	11	9	0	0	9	24	34	33	2.0E-08
B2	CS12	31.5	CL	12	122	2.73	0.40	32	15	17	0	0	5	9	39	47	2.0E-08
B4	CS2	6.5	CL	18	111	2.73	0.53	45	19	26	0	0	2	8	37	53	6.6E-08
B4	CS4	11.5	CL	21	109	2.73	0.56	43	17	26	0	0	3	11	36	50	2.1E-08
B4	CS6	16.5	CL	12	126	2.71	0.34	24	13	11	0	0	8	17	41	34	4.7E-08
B4	CS8	21.5	CL	11	136	2.70	0.24	23	13	10	0	0	8	18	37	37	2.1E-08
B4	CS10	26.5	CL	11	130	2.73	0.31	23	14	9	0	0	8	17	38	37	3.0E-08
B4	CS12	31.5	CL	10	128	2.71	0.32	25	14	11	0	0	4	11	44	41	1.8E-08
B4	CS14	36.5	CL	8	118	2.73	0.44	24	13	11	0	0	13	23	44	20	*
B6	CS2	6.5	CL	12	123	2.70	0.37	27	15	12	0	0	8	17	39	36	7.4E-08
B6	CS4	11.5	CL	11	132	2.72	0.29	23	13	10	0	0	8	17	39	36	1.8E-08
B6	CS6	16.5	CL	8	134	2.72	0.27	21	12	9	0	0	7	22	38	33	4.0E-08
B6	CS8	21.5	CL	11	133	2.75	0.29	21	12	9	0	0	7	21	37	35	6.5E-08
B6	CS10	26.5	CL	9	125	2.71	0.35	26	14	12	0	0	5	13	39	43	*
B6	CS12	31.5	CL	10	128	2.74	0.34	26	15	11	0	0	11	17	33	39	*
B8	CS2	6.5	CL	13	118	2.73	0.44	41	15	26	0	0	3	12	35	50	1.5E-08
B8	CS4	11.5	CL	17	112	2.73	0.52	34	17	17	0	0	7	17	38	38	2.2E-08
B8	CS6	16.5	CL	13	127	2.73	0.34	26	15	11	0	0	9	19	38	34	4.8E-08
B8	CS8	21.5	CL	12	129	2.74	0.33	24	14	10	0	0	8	17	40	35	1.6E-08
B8	CS10	26.5	CL	13	130	2.76	0.32	25	14	11	0	0	7	18	36	39	1.7E-08
B8	CS12	31.5	CL	10	134	2.73	0.27	20	11	9	0	0	10	24	41	25	4.7E-08
B8	CS14	36.5	CL	11	135	2.75	0.27	23	12	11	0	0	11	24	31	34	3.8E-08
B8	CS16	41.5	CL	10	127	2.78	0.37	23	13	10	0	0	15	19	46	20	1.9E-07

LABORATORY TEST RESULTS
VERIFICATION OF NATURAL SOIL BARRIER - MONROE ASH BASIN
SME PROJECT NO. PG-22087

BORING NO.	SAMPLE NO.	DEPTH (feet)	CLASSIFICATION SYMBOL	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO (calculated)	ATTERBERG LIMITS			PARTICLE SIZE DISTRIBUTION (%)						COEFFICIENT OF PERMEABILITY (cm/sec)
								LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	
B10	CS2	6.5	CL	20	114	2.72	0.49	40	15	25	0	0	3	13	35	49	3.6E-08
B10	CS4	11.5	CL	18	112	2.75	0.53	35	15	20	0	0	2	9	39	50	1.2E-08
B10	CS6	16.5	CL	22	102	2.74	0.68	36	17	19	0	0	1	2	37	60	5.3E-08
B10	CS8	21.5	CL	13	127	2.71	0.33	25	14	11	0	0	8	17	37	38	3.7E-08
B10	CS10	26.5	CL	10	133	2.74	0.29	23	14	9	0	0	7	17	39	37	1.5E-08

NOTE:

* Sample too small or disturbed to run test.

JRW Ponds 1 & 2 CCR Unit and Pond 6 Inactive CCR Unit Site

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 3,000 '
1:36,000

0 3,000 6,000 FEET

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:

CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S. HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	269767-004
FILE:	269767-004-000SLM.mxd

FIGURE 1

E:\ConsumersEnergy\CCR_GW\2017_269767\269767-004-000SLM.mxd -- Saved By: JPAPEZ on 10/17/2017, 09:07:39 AM

LEGEND

MONITORING WELL (STATIC WATER LEVEL ONLY)

CCR UNIT MONITORING WELL

LABEL FORMAT

MONITORING WELL ID
GROUNDWATER ELEVATION FT MSL (MEASUREMENT DATE)
GROUNDWATER ELEVATION FT MSL (MEASUREMENT DATE)
etc...

NOTES

1. BASE MAP IMAGERY FROM NEARMAP, 4/12/2017.
2. WELL LOCATIONS SURVEYED BY SHERIDAN SURVEYING CO. ON 11/19/2015 AND 11/30/2016.

0 500 1,000 Feet

1 " = 500 '

1:6,000

PROJECT:

CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:

GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY

WORKING COPY

DRAWN BY:	J. PAPEZ	PROJ NO.:	297944-001
CHECKED BY:	J. LI		
APPROVED BY:		**FIGURE 3**	
DATE:	JULY 2018		

TRC

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

FILE NO.: 297944-001-001.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 7/25/2018, 10:23:57 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\297944-001-001.mxd

Table 1

Summary of Groundwater Elevation Data

JR Whiting – RCRA CCR Monitoring Program

Erie, Michigan

Well Location	Ground Surface Elevation (ft)	TOC Elevation (ft)	Geologic Unit of Screen Interval	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)			Round 1				Round 2		Round 3		Round 4	
										November 21, 2016		December 19, 2016		January 24, 2017		March 8, 2017		April 12, 2017	
										Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background																			
JRW-MW-16007	579.47	582.32	Limestone	68.0	to	78.0	511.5	to	501.5	7.58	574.74	8.28	574.04	7.14	575.18	6.78	575.54	6.18	576.14
JRW-MW-16008	579.95	582.84	Limestone	68.0	to	73.0	512.0	to	507.0	7.93	574.91	8.77	574.07	7.70	575.14	7.34	575.50	6.82	576.02
JRW-MW-16009	579.90	582.59	Limestone	69.0	to	79.0	510.9	to	500.9	7.70	574.89	8.53	574.06	7.43	575.16	7.09	575.50	6.54	576.05
Ponds 1 & 2																			
JRW-MW-15001	589.6	590.71	Limestone	78.0	to	88.0	511.6	to	501.6	--	--	16.55	574.16	15.57	575.14	15.22	575.49	14.68	576.03
JRW-MW-15002	590.6	592.31	Limestone	81.0	to	91.0	509.6	to	499.6	--	--	18.13	574.18	17.11	575.20	16.77	575.54	16.25	576.06
JRW-MW-15003	589.6	591.36	Limestone	81.0	to	91.0	508.6	to	498.6	--	--	17.11	574.25	16.18	575.18	16.24	575.12	15.32	576.04
JRW-MW-15004	590.8	592.52	Limestone	86.0	to	96.0	504.8	to	494.8	--	--	18.24	574.28	17.36	575.16	17.07	575.45	16.51	576.01
JRW-MW-15005	592.7	594.25	Limestone	86.0	to	96.0	506.7	to	496.7	--	--	19.96	574.29	19.12	575.13	18.79	575.46	18.22	576.03
JRW-MW-15006	590.3	592.01	Limestone	81.0	to	91.0	509.3	to	499.3	--	--	17.80	574.21	16.91	575.10	16.56	575.45	15.98	576.03

Notes:

Survey conducted by Sheridan Surveying Co., November 2015 (2015 wells), and November 2016 (2016 wells)

Elevation in feet relative to North American Vertical Datum 1988 (NAVD 88).

TOC: Top of well casing.

ft BTOC: Feet below top of well casing.

ft BGS: Feet below ground surface.

Table 1
Summary of Groundwater Elevation Data
JR Whiting – RCRA CCR Monitoring Program
Erie, Michigan

Well Location	Ground Surface Elevation (ft)	TOC Elevation (ft)	Geologic Unit of Screen Interval	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)			Round 5 May 23, 2017		Round 6 June 27, 2017		Round 7 July 31, 2017		Round 8 September 5, 2017		Round 9 October 9, 2017	
										Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background																			
JRW-MW-16007	579.47	582.32	Limestone	68.0	to	78.0	511.5	to	501.5	6.14	576.18	7.33	574.99	6.87	575.45	7.14	575.18	7.93	574.39
JRW-MW-16008	579.95	582.84	Limestone	68.0	to	73.0	512.0	to	507.0	6.66	576.18	7.84	575.00	7.41	575.43	7.63	575.21	8.41	574.43
JRW-MW-16009	579.90	582.59	Limestone	69.0	to	79.0	510.9	to	500.9	6.40	576.19	7.59	575.00	7.15	575.44	7.35	575.24	8.18	574.41
Ponds 1 & 2																			
JRW-MW-15001	589.6	590.71	Limestone	78.0	to	88.0	511.6	to	501.6	14.45	576.26	15.65	575.06	15.27	575.44	15.38	575.33	16.18	574.53
JRW-MW-15002	590.6	592.31	Limestone	81.0	to	91.0	509.6	to	499.6	16.00	576.31	17.18	575.13	16.83	575.48	17.00	575.31	17.80	574.51
JRW-MW-15003	589.6	591.36	Limestone	81.0	to	91.0	508.6	to	498.6	15.02	576.34	16.14	575.22	15.89	575.47	16.00	575.36	16.80	574.56
JRW-MW-15004	590.8	592.52	Limestone	86.0	to	96.0	504.8	to	494.8	16.20	576.32	17.33	575.19	17.05	575.47	17.10	575.42	18.00	574.52
JRW-MW-15005	592.7	594.25	Limestone	86.0	to	96.0	506.7	to	496.7	17.89	576.36	19.04	575.21	18.79	575.46	18.84	575.41	19.70	574.55
JRW-MW-15006	590.3	592.01	Limestone	81.0	to	91.0	509.3	to	499.3	15.71	576.30	16.77	575.24	16.55	575.46	16.68	575.33	17.50	574.51

Notes:
Survey conducted by Sheridan Surveying Co., November 2015 (2015 wells), and November 2016 (2016 wells)
Elevation in feet relative to North American Vertical Datum 1988 (NAVD 88).
TOC: Top of well casing.
ft BTOC: Feet below top of well casing.
ft BGS: Feet below ground surface.

LEGEND

- BACKGROUND MONITORING WELL
- CCR UNIT MONITORING WELL
- CROSS SECTION LOCATION

NOTES

1. BASE MAP IMAGERY FROM NEARMAP, 4/12/2017.
2. WELL LOCATIONS SURVEYED BY SHERIDAN SURVEYING CO. ON 11/19/2015 AND 11/30/2016.

N

0 500 1,000 Feet

1 " = 500 '

1:6,000

PROJECT:

CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:

SITE PLAN WITH MONITORING WELL LOCATIONS

DRAWN BY:	J. PAPEZ	PROJ NO.:	269767-001
CHECKED BY:	S. HOLMSTROM	FIGURE 1	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

TRC

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

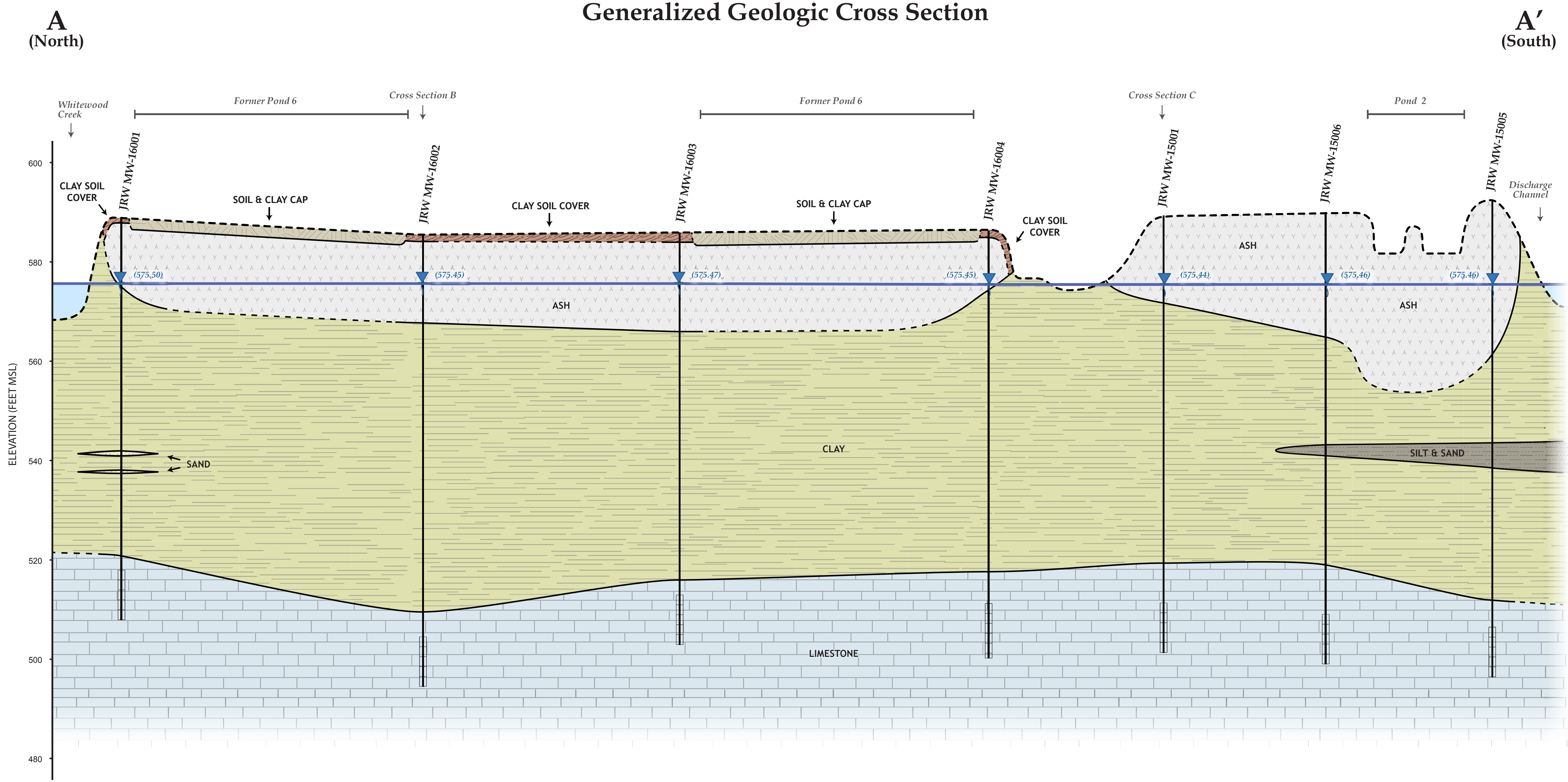
FILE NO.: 269767-004-004.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/17/2017, 09:08:10 AM by JPAPEZ -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\269767-004-004.mxd

Generalized Geologic Cross Section



LEGEND

GROUND SURFACE PROFILE, DASHED WHERE INFERRED

STRATIGRAPHIC BOUNDARY, DASHED WHERE INFERRED

APPROXIMATE CONFINED GROUNDWATER POTENTIOMETRIC ELEVATION (JULY 31, 2017)

SOIL UNIT LITHOLOGY

SOIL & CLAY CAP
CLAY SOIL COVER
ASH
CLAY
LIMESTONE
SILT & SAND
SAND

WELL BOREHOLE
WELL SCREEN

NOTES

1. FEATURE LOCATIONS AND SCALE ARE APPROXIMATE.
2. CROSS SECTION BASED UPON INFORMATION FROM ASH POND MATERIAL CHARACTERIZATION (GOLDER, 2016), SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016), AND 2016 MONITORING WELL DESIGN, INSTALLATION, DEVELOPMENT, AND DECOMISSIONING (TRC, 2016).

20
10
0
0 150 300

Horizontal Scale: 1" = 300'
Vertical Scale: 1" = 20'
15x Vertical Exaggeration
(Scale is Approximate)

PROJECT:
CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS SECTION A-A'

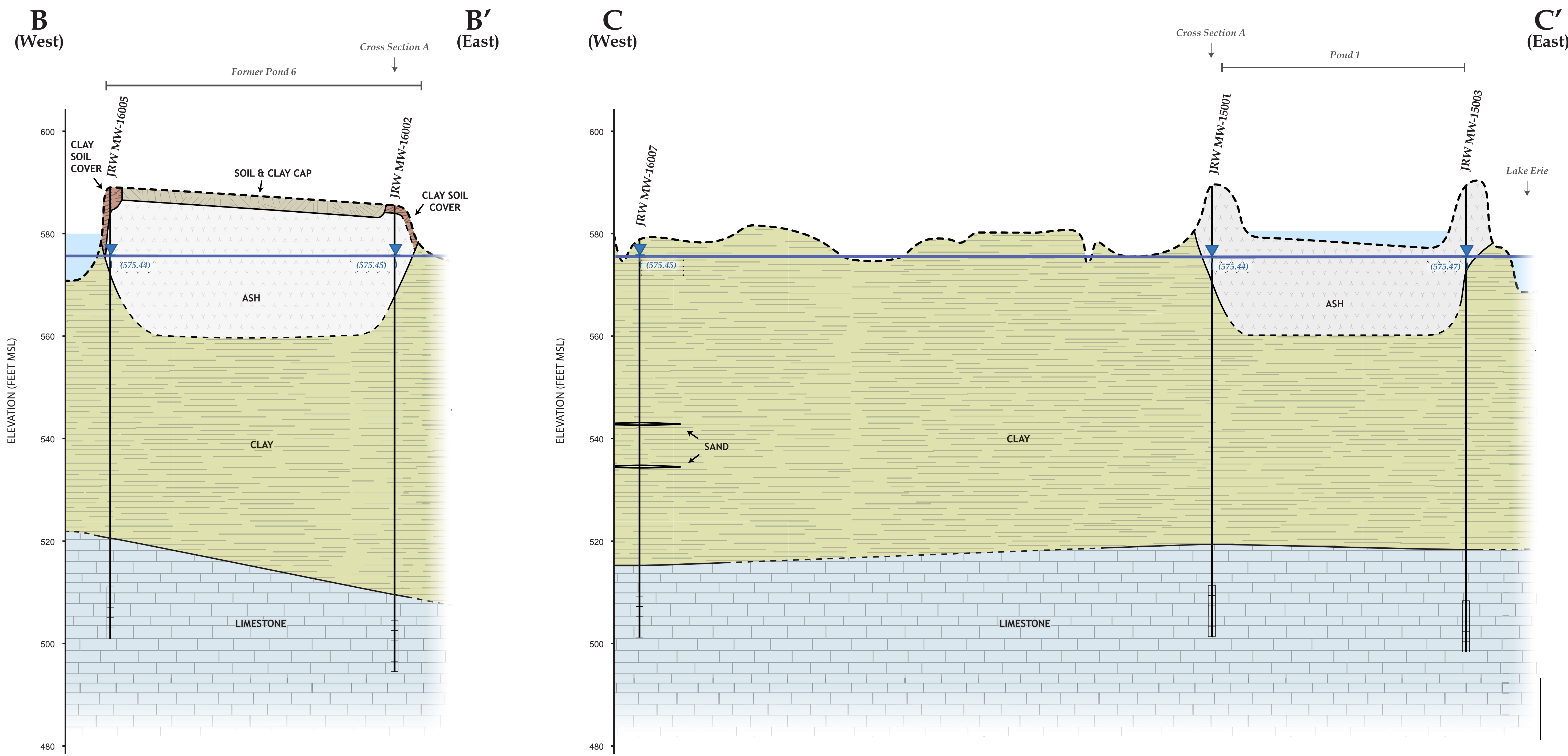
DRAWN BY:	L. AUNER	PROJ NO.:	269767
CHECKED BY:	S. HOLMSTROM		
APPROVED BY:	V. BUENING	FIGURE 2	
DATE:	OCTOBER 2017		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080

FILE NO.: 269767-004-ai01.ai

File Path: E:\WI_DOT\2015_229576\AI\269767-004-ai01.ai

Generalized Geologic Cross Sections



LEGEND

GROUND SURFACE PROFILE, DASHED WHERE INFERRED

STRATIGRAPHIC BOUNDARY, DASHED WHERE INFERRED

APPROXIMATE CONFINED GROUNDWATER POTENTIOMETRIC ELEVATION (JULY 31, 2017)

SOIL UNIT LITHOLOGY

SOIL & CLAY CAP — CLAY

CLAY SOIL COVER — LIMESTONE

ASH — SAND

WELL BOREHOLE

WELL SCREEN

Horizontal Scale: 1" = 300'
Vertical Scale: 1" = 20'
15x Vertical Exaggeration
(Scale is Approximate)

0 150 300 ; 0 10 20

NOTES

1. FEATURE LOCATIONS AND SCALE ARE APPROXIMATE.
2. CROSS SECTION BASED UPON INFORMATION FROM ASH POND MATERIAL CHARACTERIZATION (GOLDER, 2016), SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016), AND 2016 MONITORING WELL DESIGN, INSTALLATION, DEVELOPMENT, AND DECOMISSIONING (TRC, 2016).

PROJECT:
CONSUMERS ENERGY COMPANY
JR WHITING POWER PLANT
ERIE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS SECTIONS B-B' AND C-C'

DRAWN BY:	L. AUNER	PROJ NO.:	269767
CHECKED BY:	S. HOLMSTROM		
APPROVED BY:	V. BUENING	FIGURE 3	
DATE:	OCTOBER 2017		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080

FILE NO.: 269767-004-ai02.ai

File Path: E:\WI_DOT\2015_229576\AI\269767-004-ai02.ai

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
FK Engineering Associates
30425 Stephenson Hwy.
Madison Heights, MI 48071

Enclosed are the laboratory test results for the project shown above.

NUMBER	TEST
8	Permeability

We appreciate the opportunity to be of service to you on this project. If you have any questions, please feel free to contact our office.

Respectfully Submitted,

Malek Smadi, Ph.D., PE
Principal Engineer
GEOTILL, Inc.
Ph: (317) 449-0033 - Ext 101
e-mail: msmadi@geotill.com

GEOTILL ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
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TOTAL PAGES: 9

Mr. Zachary Carr, P.E.
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30425 Stephenson Hwy.
Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084				
TEST CHARACTERISTICS				
Boring No.:	MW-16007	Confining Pressure (psi):	75	
Sample No.:	BS-5	Target Back Pressure Differential (psi):	NA	
Depth (ft):	34.0'-35.0'	Target Bottom Burette Pressure (psi):	70	
		Target Top Burette Pressure (psi):	70	
SAMPLE CHARACTERISTICS				
CHARACTERISTICS	INITIAL		FINAL	
Length (in)	4.14		4.22	
Diameter (in)	4.21		4.14	
Dry Unit Weight (pcf)	**130.1**		131.0	
Moisture Content (%)	**10.5**		10.1	
B Value	96			
SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	947	1027	1124	1740
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	1.21×10^{-8}	1.07×10^{-8}	9.14×10^{-9}	8.03×10^{-9}
Average Hydraulic Conductivity (cm/sec)	**1.00×10^{-8}**		**(Temperature Corrected)**	
COMMENTS: * Constant volume panel was used for the flow measurement			Permeant: tap water	
Deviations from the test method: None				

December 23, 2016

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LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084			
TEST CHARACTERISTICS			
Boring No.:	MW-16006	Confining Pressure (psi):	75
Sample No.:	BS-5	Target Back Pressure Differential (psi):	NA
Depth (ft):	34.5'-35.5	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS		
CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.13	4.20
Diameter (in)	3.99	3.91
Dry Unit Weight (pcf)	**120.2**	123.0
Moisture Content (%)	**15.1**	12.8
B Value	98	

SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1015	1040	1106	1136
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	2.13×10^{-8}	1.90×10^{-8}	1.85×10^{-8}	1.62×10^{-8}
Average Hydraulic Conductivity (cm/sec)	**1.88×10^{-8}**	**(Temperature Corrected)**		

COMMENTS: * Constant volume panel was used for the flow measurement   Permeant: tap water

Deviations from the test method: None

GEOTILL ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
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LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084			
TEST CHARACTERISTICS			
Boring No.:	MW-16005	Confining Pressure (psi):	75
Sample No.:	BS-7	Target Back Pressure Differential (psi):	NA
Depth (ft):	38.0'-39.0'	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS		
CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.18	4.20
Diameter (in)	4.11	4.08
Dry Unit Weight (pcf)	**128.2**	130.4
Moisture Content (%)	**11.9**	9.9
B Value	100	

SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1027	1105	1151	1242
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	1.55×10^{-8}	1.25×10^{-8}	1.13×10^{-8}	1.15×10^{-8}
Average Hydraulic Conductivity (cm/sec)	**1.27×10^{-8}**	**(Temperature Corrected)**		

COMMENTS: * Constant volume panel was used for the flow measurement   Permeant: tap water

Deviations from the test method: None

GEOTILL ENGINEERING, INC.

December 23, 2016

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PROJECT: Laboratory Services
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LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084			
TEST CHARACTERISTICS			
Boring No.:	MW-16001	Confining Pressure (psi):	80
Sample No.:	BS-7	Target Back Pressure Differential (psi):	NA
Depth (ft):	44.0'-45.0'	Target Bottom Burette Pressure (psi):	75
		Target Top Burette Pressure (psi):	75

SAMPLE CHARACTERISTICS		
CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.10	4.10
Diameter (in)	3.67	3.65
Dry Unit Weight (pcf)	**136.4**	137.0
Moisture Content (%)	**9.0**	8.5
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1357	1418	1442	1511
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	1.64×10^{-8}	1.28×10^{-8}	1.20×10^{-8}	1.17×10^{-8}
Average Hydraulic Conductivity (cm/sec)	**1.32×10^{-8}**	**(Temperature Corrected)**		

COMMENTS: * Constant volume panel was used for the flow measurement   Permeant: tap water

Deviations from the test method: None

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
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LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084			
TEST CHARACTERISTICS			
Boring No.:	MW-16002	Confining Pressure (psi):	80
Sample No.:	BS-5	Target Back Pressure Differential (psi):	NA
Depth (ft):	33.0'-34.0'	Target Bottom Burette Pressure (psi):	75
		Target Top Burette Pressure (psi):	75

SAMPLE CHARACTERISTICS		
CHARACTERISTICS	INITIAL	FINAL
Length (in)	3.88	3.89
Diameter (in)	3.37	3.35
Dry Unit Weight (pcf)	**123.4**	123.7
Moisture Content (%)	**13.7**	13.1
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1346	1417	1445	1521
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	1.79×10^{-8}	1.38×10^{-8}	1.46×10^{-8}	1.31×10^{-8}
Average Hydraulic Conductivity (cm/sec)	**1.50×10^{-8}**	**(Temperature Corrected)**		

COMMENTS: * Constant volume panel was used for the flow measurement   Permeant: tap water

Deviations from the test method: None

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
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LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084			
TEST CHARACTERISTICS			
Boring No.:	MW-16003	Confining Pressure (psi):	80
Sample No.:	BS-4C	Target Back Pressure Differential (psi):	NA
Depth (ft):	33.0'-34.0'	Target Bottom Burette Pressure (psi):	75
		Target Top Burette Pressure (psi):	75

SAMPLE CHARACTERISTICS		
CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.11	4.11
Diameter (in)	3.88	3.90
Dry Unit Weight (pcf)	**124.3**	123.3
Moisture Content (%)	**10.5**	10.8
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	1430	1534	1643	1614
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	$6.65x10^{-9}$	$6.05x10^{-9}$	$5.07x10^{-9}$	$4.24x10^{-9}$
Average Hydraulic Conductivity (cm/sec)	**$5.50x10^{-9}$**	**(Temperature Corrected)**		

COMMENTS: * Constant volume panel was used for the flow measurement Permeant: tap water

Deviations from the test method: None

GEOTILL ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

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Madison Heights, MI 48071

LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY
TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084

TEST CHARACTERISTICS			
Boring No.:	MW-16007	Confining Pressure (psi):	75
Sample No.:	BS-10	Target Back Pressure Differential (psi):	NA
Depth (ft):	52.0'-53.0'	Target Bottom Burette Pressure (psi):	70
		Target Top Burette Pressure (psi):	70

SAMPLE CHARACTERISTICS		
CHARACTERISTICS	INITIAL	FINAL
Length (in)	4.17	4.17
Diameter (in)	4.14	4.11
Dry Unit Weight (pcf)	**115.3**	116.1
Moisture Content (%)	**15.6**	15.3
B Value	96	

SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	933	947	1009	1032
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	$3.69x10^{-8}$	$3.15x10^{-8}$	$2.87x10^{-8}$	$2.14x10^{-8}$
Average Hydraulic Conductivity (cm/sec)	**$2.23x10^{-8}$**	**(Temperature Corrected)**		

COMMENTS: * Constant volume panel was used for the flow measurement   Permeant: tap water

Deviations from the test method: None

GEOTILL ENGINEERING, INC.

December 23, 2016

PROJECT: Laboratory Services
Geotill PROJECT NO.: 111610601
Geotill WORK ORDER NO.: 8601
SAMPLE RECEIVED: December 15, 2016
TOTAL PAGES: 9

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30425 Stephenson Hwy.
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LABORATORY HYDRAULIC CONDUCTIVITY TEST SUMMARY TRIAXIAL CELL WITH BACK PRESSURE /ASTM D-5084				
TEST CHARACTERISTICS				
Boring No.:	MW-16004	Confining Pressure (psi):	75	
Sample No.:	BS-4	Target Back Pressure Differential (psi):	NA	
Depth (ft):	31.5'-32.3'	Target Bottom Burette Pressure (psi):	70	
		Target Top Burette Pressure (psi):	70	
SAMPLE CHARACTERISTICS				
CHARACTERISTICS	INITIAL		FINAL	
Length (in)	3.92		3.92	
Diameter (in)	3.91		3.84	
Dry Unit Weight (pcf)	**121.0**		123.5	
Moisture Content (%)	**14.4**		13.3	
B Value	104			
SUMMARY OF FINAL FOUR MEASUREMENTS				
MEASUREMENT	1	2	3	4
Elapsed Time (sec)	951	1010	1030	1058
True Back Pressure Differential (psi)	NA*	NA*	NA*	NA*
Flow Into Sample (cm^3)	NA*	NA*	NA*	NA*
Flow Out of Sample (cm^3)	NA*	NA*	NA*	NA*
Hydraulic Conductivity (cm/sec)	$2.222.8\times10^{-8}$	1.78×10^{-8}	1.72×10^{-8}	1.58×10^{-8}
Average Hydraulic Conductivity (cm/sec)	**1.83×10^{-8}**	**(Temperature Corrected)**		
COMMENTS: * Constant volume panel was used for the flow measurement		Permeant: tap water		
Deviations from the test method:	None			

Appendix B
Calculation Documentation

TRC Results you can rely on

SUBJECT Composite Liner Leakage

Per Giroud et al. 1998, rate of leakage through a composite liner can be calculated by:

$$Q = 0.976\, C_{q0}\left[1 + 0.1\,(h/T)^{0.95}\right] d^{0.2}\, h^{0.9}\, K^{0.74}$$

where Q = leakage rate, m^3/s

C_{q0} = coefficient characterizing contact between geomembrane and underlying clay, dimensionless

C_{q0} - good = 0.21

C_{q0} - poor = 1.15

h = leachate head on top of liner, m

T = thickness of clay liner below geomembrane, m

d = defect diameter, m

K = hydraulic conductivity of clay liner, m/s

Assume:

$h = 0.3$ m $\quad T = 0.61$ m $\quad K = 1 \times 10^{-9}$ m/s

1. Assume:

$d = 0.001$ m $\quad C_{q0} = 0.21$

$$Q = 0.976(0.21)\left[1 + 0.1\left(\frac{0.3}{0.61}\right)^{0.95}\right](0.001)^{0.2}(0.3)^{0.9}(1\times10^{-9})^{0.74}$$

$$Q = 0.976(0.21)(1.05)(0.251)(0.338)(2.19\times10^{-7}) = 4\times10^{-9}\ m^3/s$$

$4\times10^{-9}\ m^3/s \cdot 86400\ s/day \cdot 1000\ L/m^3 = 0.35\ L/day$ per defect

$0.35\ L/day/defect \cdot 2.5\ \frac{defects}{hc} =$ **0.9 lphd**

$0.35\ L/day/defect \cdot 5\ \frac{defects}{hc} =$ **1.8 lphd**

lphd = liters per hectare per day

hc = hectare

2. Assume:

$d = 0.00564$ m $\quad C_{q0} = 0.21$

$$Q = 0.976(0.21)\left[1 + 0.1\left(\frac{0.3}{0.61}\right)^{0.95}\right](0.00564)^{0.2}(0.3)^{0.9}(1\times10^{-9})^{0.74}$$

$$Q = 0.976(0.21)(1.05)(0.355)(0.338)(2.19\times10^{-7}) = 5.7\times10^{-9}\ m^3/s$$

$5.7\times10^{-9}\ m^3/s \cdot 86400\ s/d \cdot 1000\ L/m^3 = 0.5\ L/day$ per defect

$0.5\ L/day \cdot defect\ (2.5\ \frac{defects}{hc}) =$ **1.2 lphd**

$0.5\ L/day \cdot defect\ (5\ \frac{defects}{hc}) =$ **2.5 lphd**

A

3. Assume

$d = 0.001\ m \qquad C_{90} = 1.15$

$Q = 0.976(1.15)[1.05](0.001)^{0.2}(0.338)(2.19 \times 10^{-7}) = 2.2 \times 10^{-8}\ m^3/s$

$2.2 \times 10^{-8}\ m^3/s \cdot 86400 \frac{s}{day} \cdot \frac{1000 L}{m^3} = 1.9 \frac{L}{day}$ per defect

$1.9 \frac{L}{day\text{-}defect} \cdot \frac{2.5\ defects}{hc} = \boxed{4.8\ lphd}$

$1.9 \frac{L}{day \cdot defect} \cdot 5 \frac{defects}{hc} = \boxed{9.6\ lphd}$

4. Assume

$d = 0.00564\ m \qquad C_{90} = 1.15$

$Q = 0.976(1.15)[1.05](0.00564)^{0.2}(0.338)(2.19 \times 10^{-7}) = 3.1 \times 10^{-8}\ m^3/s$

$3.1 \times 10^{-8}\ m^3/s \cdot 86400 \frac{s}{day} \cdot \frac{1000 L}{m^3} = 2.7 \frac{L}{day}$ per defect

$2.7 \frac{L}{day} \cdot \frac{2.5\ defects}{hc} = \boxed{6.7\ lphd}$

$2.7 \frac{L}{day} \cdot \frac{5\ defects}{hc} = \boxed{14\ lphd}$

PROJECT NO. 319742
DATE 11-27-2018
BY S. Sellwood
CHK'D A. Sellwood

TRC Results you can rely on

SUBJECT Natural Clay Leakage

Leakage through a clay-only liner can be calculated using Darcy's Law assuming one-dimensional vertical flow:

$$Q = -KA\frac{dh}{dl}$$

where Q = leakage rate (units depend on inputs)
K = hydraulic conductivity of the clay
A = cross-sectional area of flow
dh = difference in head between the head above the clay and the head in the aquifer underlying the clay
dl = thickness of clay separating hydrogeologic units

CCR Unit	K	dh	dl	A
a. BRPP BABs	2.9×10^{-8} cm/s	16 ft	80 ft	assume 1 hectare (hc)
b. BRPP DB	2.9×10^{-8} cm/s	5 ft	117 ft	"
c. SCPP BABs	3.1×10^{-8} cm/s	1 ft	110 ft	"
d. Monroe PP FAB	6.5×10^{-8} cm/s	12 ft	23 ft	"
e. Whiting Ponds 1+2	2.23×10^{-8} cm/s	11 ft	35 ft	"
f. Whiting Pond 6	2.23×10^{-8} cm/s	22 ft	40 ft	"

a. $Q = -2.9 \times 10^{-8}\ \text{cm/s}\left(-\frac{16\ \text{ft}}{80\ \text{ft}}\right)(1\ \text{hc})(107{,}639\ \text{ft}^2/\text{hc})(28.317\ \text{L}/\text{ft}^3)(2834.6\ \text{ft/d/cm/s}) = 50$ lph

b. $Q = -2.9 \times 10^{-8}\ \text{cm/s}\left(\frac{-5\ \text{ft}}{117\ \text{ft}}\right)(1\ \text{hc})(107{,}639\ \text{ft}^2/\text{hc})(28.317\ \text{L}/\text{ft}^3)(2834.6\ \text{ft/d/cm/s}) = 11$ lphd

c. $Q = -3.1 \times 10^{-8}\ \text{cm/s}(-1\ \text{ft}/110\ \text{ft})(1\ \text{hc})(107{,}639\ \text{ft}^2/\text{hc})(28.317\ \text{L}/\text{ft}^3)(2834.6\ \text{ft/d/cm/s}) = 2$ lphd

d. $Q = -6.5 \times 10^{-8}\ \text{cm/s}(-12\ \text{ft}/23\ \text{ft})(1\ \text{hc})(107{,}639\ \text{ft}^2/\text{hc})(28.317\ \text{L}/\text{ft}^3)(2834.6\ \text{ft/d/cm/s}) = 293$ lp

e. $Q = -2.23 \times 10^{-8}\ \text{cm/s}(-11\ \text{ft}/35\ \text{ft})(1\ \text{hc})(107{,}639\ \text{ft}^2/\text{hc})(28.317\ \text{L}/\text{ft}^3)(2834.6\ \text{ft/d/cm/s}) = 61$ lphd

f. $Q = -2.23 \times 10^{-8}\ \text{cm/s}(-22\ \text{ft}/40\ \text{ft})(1\ \text{hc})(107{,}639\ \text{ft}^2/\text{hc})(28.317\ \text{L}/\text{ft}^3)(2834.6\ \text{ft/d/cm/s}) = 106$ lphd

Velocity: $V = \frac{-K}{n_e}\frac{dh}{dl}$ where n_e = effective clay porosity, assume 0.40 (dimensionless

a. $V = -2.9 \times 10^{-8}\ \text{cm/s}\left(\frac{1}{0.4}\right)(-16\ \text{ft}/80\ \text{ft})(2834.6\ \text{ft/d/cm/s}) = 4.1 \times 10^{-5}$ ft/d

b. $V = -2.9 \times 10^{-8}\ \text{cm/s}\left(\frac{1}{0.4}\right)(-5\ \text{ft}/117\ \text{ft})(2834.6\ \text{ft/d/cm/s}) = 8.8 \times 10^{-6}$ ft/d

c. $V = -3.1 \times 10^{-8}\ \text{cm/s}\left(\frac{1}{0.4}\right)(-1\ \text{ft}/110\ \text{ft})(2834.6\ \text{ft/d/cm/s}) = 2 \times 10^{-6}$ ft/d

d. $V = -6.5 \times 10^{-8}\ \text{cm/s}\left(\frac{1}{0.4}\right)(-12\ \text{ft}/23\ \text{ft})(2834.6\ \text{ft/d/cm/s}) = 2.4 \times 10^{-4}$ ft/d

e. $V = -2.23 \times 10^{-8}\ \text{cm/s}\left(\frac{1}{0.4}\right)(-11\ \text{ft}/35\ \text{ft})(2834.6\ \text{ft/d/cm/s}) = 5 \times 10^{-5}$ ft/d

f. $V = -2.23 \times 10^{-8}\ \text{cm/s}\left(\frac{1}{0.4}\right)(-22\ \text{ft}/40\ \text{ft})(2834.6\ \text{ft/d/cm/s}) = 8.7 \times 10^{-5}$ ft/d

* lphd = liters per hectare per day

A

travel time: $t = \frac{dl}{v}$

a. $t = \frac{80 \text{ ft}}{4.1 \times 10^{-5} \text{ ft/d}} = 1.95 \times 10^{6}$ days

$\frac{1.95 \times 10^{6} \text{ days}}{365.25 \text{ days/yr}} = 5{,}300$ yrs

b. $t = \frac{117 \text{ ft}}{8.8 \times 10^{-6} \text{ ft/d}} = 1.33 \times 10^{7}$ days

$\frac{1.33 \times 10^{7} \text{ days}}{365.25 \text{ days/yr}} = 36{,}400$ yrs

c. $t = \frac{110 \text{ ft}}{2 \times 10^{-6} \text{ ft/d} \, (365.25 \text{ d/yr})} = 151{,}000$ yrs

d. $t = \frac{23 \text{ ft}}{2.4 \times 10^{-4} \text{ ft/d} \, (365.25 \text{ d/yr})} = 260$ yrs

e. $t = \frac{35 \text{ ft}}{5 \times 10^{-5} \text{ ft/d} \, (365.25 \text{ d/yr})} = 1{,}900$ yrs

f. $t = \frac{40 \text{ ft}}{8.7 \times 10^{-5} \text{ ft/d} \, (365.25 \text{ d/yr})} = 1{,}260$ yrs

Monroe PP FAB assuming average K, steeper gradient, and clay thickness associated with the steeper gradient.

$K = 2.7 \times 10^{-8}$ cm/s $\quad dh = 29$ ft $\quad dl = 30$ ft

$Q = -2.7 \times 10^{-8} \text{ cm/s} \left(\frac{-29 \text{ ft}}{30 \text{ ft}}\right)(1 \text{ ha})\left(107{,}639 \frac{\text{ft}^2}{\text{ha}}\right)\left(28.317 \frac{\text{L}}{\text{ft}^3}\right)\left(2834.6 \frac{\text{ft/d}}{\text{cm/s}}\right) = 226$ lphd

$V = -2.7 \times 10^{-8} \text{ cm/s} \left(\frac{1}{0.4}\right)\left(\frac{-29 \text{ ft}}{30 \text{ ft}}\right)\left(2834.6 \frac{\text{ft/d}}{\text{cm/s}}\right) = 1.85 \times 10^{-4}$ ft/d

$t = \frac{30 \text{ ft}}{1.85 \times 10^{-4} \text{ ft/d} \, (365.25 \text{ d/yr})} = 440$ yrs

Appendix B
Groundwater Monitoring Systems Summary Report, October 2017

Groundwater Monitoring Systems Summary Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins and Diversion Basin Coal Combustion Residual Units

4505 King Road
China Township, Michigan

October 2017

Groundwater Monitoring Systems Summary Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins and Diversion Basin Coal Combustion Residual Units

4505 King Road
China Township, Michigan

October 2017

Prepared For
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Section 1
Introduction

1.1 Background and Objective

The United States Environmental Protection Agency (U.S. EPA) established a comprehensive set of requirements for management and disposal of coal combustion residuals (CCR) in landfills and surface impoundments in the Final Rule: Disposal of CCR from Electric Utilities (CCR Rule) on April 17, 2015. The DTE Electric Company (DTE Electric) Belle River Power Plant's (BRPP) two CCR bottom ash basins (BABs) unit and the diversion basin (DB) unit are subject to the CCR Rule.

The objective of this report is to document and certify that the CCR Groundwater Monitoring Systems for the BRPP BABs CCR unit and the DB CCR unit have been designed and constructed to meet the requirements of Title 40 Code of Federal Regulations (CFR) §257.91 (a)(1) and (2) of the CCR Rule. TRC Engineers Michigan, Inc. (TRC) was retained by DTE Electric to provide this report documenting the construction of the CCR groundwater monitoring system for the BRPP BABs and DB.

1.2 Site Location

The BRPP is located in Section 13, Township 4 North, Range 16 East, at 4505 King Road, China Township in St. Clair County, Michigan (**Figure 1**). The BRPP was constructed in the early 1980s with plant operations beginning in 1984.

1.3 Description of BRPP CCR Units

Prior to Detroit Edison Company's operations commencing in the 1980s, 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 (**Figure 2**). The BABs and DB units have been in operation with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

1.3.1 Bottom Ash Basins CCR Unit

The BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP near the Webster Drain (**Figure 2**). These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the DB CCR unit. The North and South BABs are located north of the BRPP main building and run roughly east to west approximately 420 feet long by 120 feet wide with bottom elevations of approximately 580 feet relative to the North American Vertical Datum (NAVD) 1988, with outflow weir elevations of approximately 590.25 feet relative to the NAVD 1988. The capacity of the North BAB is approximately 2.4 million gallons and the capacity of the South BAB is approximately 2.5 million gallons[1].

1.3.2 Diversion Basin CCR Unit

The DB is an incised CCR surface impoundment located west of the BRPP near the Webster Drain. Water flows into the DB from the North and South BABs through a network of pipes and ditches (**Figure 2**). The DB discharges to the St. Clair River with other site wastewater in accordance with a National Pollution Discharge Elimination System (NPDES) permit. The DB has an approximately 300 foot long entrance channel that connects to the main portion of the basin that runs approximately north-south. The main portion of the DB is approximately 400 feet long by approximately 120 feet wide with a bottom elevation of approximately 576 feet with the water level being maintained at approximately 580 feet relative to the NAVD 1988.

[1] NTH Consultants, Ltd., 2016, Inflow Design Flood Control System Plan, Belle River Power Plant, East China, Michigan

Section 2
Hydrogeology

2.1 Regional Hydrogeologic Setting

The geology of St. Clair County consists of approximately 101 to 400 feet of glacial deposits, primarily lacustrine deposits, till, and, to a lesser extent, sand and gravel outwash, overlying a variety of bedrock surfaces[2]. The thicker glacial deposits are present toward the central portion of the county. Bedrock in the county includes the Michigan Formation, Marshall Sandstone, Coldwater Shale, Sunbury Shale, Berea Sandstone, Bedford Shale, and Antrim Shale.

In the vicinity of the site, the Devonian Bedford and/or Antrim Shale bedrock dips to the northwest and is generally covered by more than 100 feet of unconsolidated clay, silt, sand, and gravel. In this area, generally on the eastern side of the county, the glacial deposits are predominantly silty-clay till and lacustrine deposits with lenses of sand and gravel. Where present, unconsolidated sand and gravel deposits within the till and lacustrine deposits are generally used for water supply throughout the county. Approximately 85 percent of the water supply wells in St. Clair County are completed in the glacial deposits compared to approximately 13 percent installed in bedrock[1].

The current topography of the St. Clair area gently undulates reflecting floodplain, stream terrace, and lakeshore deposits. The St. Clair River is the major surface water body in the county and runs along the eastern boundary of the county. Regional groundwater and surface water flow would be expected to be to the east towards the St. Clair River.

2.2 BRPP Hydrogeology

The subsurface geology presented in this report is based on information from historical borings advanced during the initial design of the BRPP in the 1970s in addition to the soil data collected from immediately around the BABs and DB during the groundwater monitoring system installations detailed in Section 3. Soil borings from the groundwater monitoring system are included in Appendix A and generalized geologic cross sections are provided in **Figures 3 through 5**.

This information documents that the BRPP CCR units are underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet-below ground surface (feet-bgs). Unconsolidated, laterally discontinuous

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[2] Beth A. Apple and Howard W. Reeves, 2007, Summary of Hydrogeologic Conditions by County for the State of Michigan. U.S. Geological Survey Open-File Report 2007-1236, 78 p.

saturated sand-rich soil deposits were encountered within the silty clay-rich till deposits in most of the BABs CCR unit soil borings at depths no shallower than 86 feet-bgs (**Figures 3 through 5**). In contrast, no sand-rich deposits were encountered in the DB CCR unit soil borings. At the DB CCR unit, more than 125 feet of contiguous silty clay-rich till is present above the bedrock, with saturation observed along the interface of silt-rich till and the underlying shale bedrock (**Figures 3 and 5**). The underlying shale does not yield groundwater, rather it is an aquiclude that prevents groundwater flow (i.e., is not an aquifer).

Water supply wells are present within the sand and/or gravel rich aquifer units within the lacustrine unconsolidated sediments at depths around 100 feet-bgs within between one-half and one mile to the west and southwest of the BRPP. These uppermost aquifer sand/gravel units are also present on much of the RRLF located one mile north of the BRPP. Surface water bodies present in the area of the BRPP include the Belle River (as close as 2,000 feet southwest and south of BRPP) and the St. Clair River (as close at one mile to the east of BRPP).

2.2.1 Uppermost Aquifer

Definition

The 40 CFR 257.53 definitions of an aquifer and uppermost aquifer are as follows:

- *Aquifer* means a geologic formation, group of formations, or portion of a formation capable of yielding useable quantities of groundwater to wells or springs.
- *Uppermost aquifer* means the geologic formation nearest the natural ground surface that is an aquifer, as well as the lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary. Upper limit is measured at a point nearest to the natural ground surface to which the aquifer rises during the wet season.

Site Uppermost Aquifer

The entire BRPP site is underlain by 86 feet to as much as 135 feet of contiguous low permeability clay-rich till that has a hydraulic conductivity on the order of 2 to 3 x 10^{-8} centimeters per second (cm/s) as found in historical soil testing and further verified during recent soil permeability testing performed on soil samples collected during the CCR monitoring well installation at the BABs and DB CCR units. The silty clay-rich till is a natural hydraulic barrier that confines the uppermost aquifer(s) (where present) and isolates them from the BABs and DB CCR units.

Monitoring wells were established at first signs of groundwater yield to monitor groundwater quality in accordance with the CCR Rule.

Bottom Ash Basins CCR Unit Area

As described above, the uppermost aquifer units beneath the BABs CCR unit are hydraulically isolated by at least 90 feet of silty clay-rich till (see **Figures 3 through 5**). The first observed sand-rich units that meet the 40 CFR §257.53 definition of uppermost aquifer is encountered at depths ranging from 90 to 136 feet bgs. The sand-rich unit rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) in the southeastern portion of the BABs CCR unit area in the vicinity of SB-16-01. Consequently, the uppermost aquifer is not laterally contiguous across the site, and not present in the southeastern corner of the BABs in the area of SB-16-01. Because the uppermost aquifer was not present in this area, no monitoring wells were installed along the southeastern portion of the BABs CCR unit area (**Figure 2**). At locations where wells were installed (e.g., MW-16-01 through MW-16-04 and MW-16-09), wells were installed within the upper portion of the aquifer, which generally ranges between 12 to 40 feet in thickness in the area of the BABs. More details are provided in Sections 3.1.1 and 3.1.2 (see **Figures 3 through 5**, Appendix A and Table 1).

As shown on the geologic cross sections, the top of the uppermost aquifer encountered at each of the CCR monitoring well and soil boring locations are at significantly different elevations across the BABs CCR unit, where present, from 90 to 136 feet-bgs. The variability in boring/well depths is a consequence of the heterogeneity of the glacial deposits and is driven by the lateral discontinuity of the coarse-grained sand and gravel outwash within the encapsulating fine-grained, silty clay till that confines the uppermost aquifer (see cross-sections in **Figures 3 through 5**). Based on the data collected during investigations performed by TRC, there is an apparent lack of interconnection and/or significant vertical variation between the uppermost aquifer sand unit(s) encountered across the BABs CCR unit, as demonstrated by the extensive amount of time (months) it took for water levels in monitoring well MW-16-02 to reach equilibrium after well construction and development.

Diversion Basin CCR Unit Area

The potential uppermost aquifer under the DB CCR unit is located at depths ranging from 131 to 145 feet-bgs at the silt/shale bedrock interface. The DB CCR unit is isolated from the underlying potential uppermost aquifer by approximately 130 feet of silty clay-rich till (see **Figures 3 and 5**). Although the encountered zone of saturation along the interface did not yield significant groundwater, it was conservatively interpreted as the first underlying saturated zone that would presumably become affected with CCR constituents since it was saturated, and although the hydraulic conductivity was low, exhibited a much higher conductivity than the clay-rich soils between the bottom of the basin and the monitored zone.

As described in Sections 3.1.1 and 3.1.2, CCR groundwater monitoring wells MW-16-05 through MW-16-08, MW-16-10 and MW-16-11 were installed at the silt/shale bedrock potential uppermost aquifer that is approximately 5 feet thick in the area of the DB CCR unit (see **Figures 3 and 5**, Appendix A and Table 1).

2.2.2 Groundwater Flow

Groundwater Flow Direction

Seven rounds of confined static water level measurements (i.e., potentiometric surface elevations) collected from these groundwater monitoring events are displayed on **Figure 6** for the BABs CCR unit, with an eighth round of static water level measurements completed before October 17, 2017; a representative potentiometric groundwater surface map is provided as **Figure 7** for the DB CCR unit.

<u>Bottom Ash Basins CCR Unit Area</u>

As can be seen on **Figure 6**, a definitive groundwater flow direction is not evident around the BABs in seven rounds of groundwater monitoring, which is likely due to:

- The fact that the screened intervals of these monitoring wells and the top of the uppermost aquifer elevation encountered within each of the BABs CCR unit monitoring wells varies up to 46 feet vertically; and
- That the degree of interconnection is likely limited in some areas (specifically in the area of MW-16-02).

Therefore, given the horizontally expansive clay with substantial vertical thickness, the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs, where present varying up to 46 feet vertically), the no-flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area, and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the BABs CCR unit.

Diversion Basin CCR Unit Area

Based on data collected by TRC during 2016 and 2017 in monitoring wells near the DB CCR unit, there is an overall flow potential to the north-northwest with a mean gradient of 0.003 foot/foot from CCR monitoring wells MW-16-06 through MW-16-08 (up gradient) on the east side of the BABs CCR unit towards monitoring wells MW-16-05, MW-16-10 and MW-16-11/11A (down gradient). **Figure 7** illustrates a representative groundwater potentiometric surface map from September 2016 depicting the groundwater flow direction in the vicinity of the DB CCR unit.

In addition, the elevation of CCR-affected water maintained within the BRPP BABs and DB is approximately 5 to 15 feet above the potentiometric surface elevations in the uppermost aquifer at the BABs and DB CCR unit areas. This suggests that if the CCR affected surface water in the BABs and DB were able to penetrate the silty clay-rich underlying confining unit that the head on that release likely would travel radially away from the BABs and/or DB within the uppermost aquifer. However, with the very thick continuous silty clay-rich confining unit beneath the BRPP it is not possible for the uppermost aquifer to have been affected by CCR from BRPP operations that began in the 1980s (see vertical travel time of travel discussion below). In addition, under Michigan Part 115, the Range Road Landfill, which is located within one mile to the north of the BRPP, is not required to monitor units beneath the clay-rich confining unit due to its thickness, continuity and low hydraulic conductivity.

Uppermost Aquifer Hydraulic Conductivity

Hydraulic conductivities measured within the CCR monitoring wells set within the upper portion of the uppermost aquifer across BRPP were evaluated using single well hydraulic conductivity tests (e.g., slug tests) performed in 2016 and range between 0.2 feet/day in the DB CCR unit area to approximately 0.5 feet/day in the BABs CCR unit area.

Horizontal Time of Travel

As previously discussed in Section 2.2.2, a definitive horizontal flow direction in the BABs CCR unit area is not present; therefore, it is not appropriate to estimate the horizontal time of travel. Because there is no clear flow direction, inter-well statistical tests are inappropriate for detection monitoring of this basin.

For the DB CCR unit, assuming an average porosity of 0.4 for the silt in the uppermost aquifer in this area, the mean hydraulic conductivity of 0.2 feet/day and a hydraulic gradient of 0.003 foot/foot for the upper aquifer, the potential horizontal groundwater flow rate to approximately the north-northwest is approximately 0.0015 feet/day or 0.55 feet/year. Given low flow velocity of this zone, inter-well (upgradient to downgradient) statistical tests are inappropriate for detection monitoring of this basin.

Vertical Time of Travel

The BRPP is a natural silty-clay site, and the presence of the natural hydraulic barrier has been verified by numerous historical soil borings and confirmed by the twelve soil borings installed as part of the CCR monitoring well installation program at the BABs and DB CCR units. Therefore, the geology and hydrogeology of the site provides a very high level of environmental protection of the uppermost aquifer. Based on the site geology and hydrogeology, there is extremely low potential for the impoundments to affect the off-site uppermost aquifer groundwater in the future. Groundwater occurring in the deep confined uppermost aquifer is protected from CCR constituents in the BABs and DB by a clay-rich aquitard with low hydraulic conductivity that is 82 or more feet thick. Using the hydrogeologic information for the site, the time of travel for water from the base-grade elevation of the BABs and DB down to the uppermost aquifer can be calculated using the following formula:

$$V = Ki/N_e$$

Where:

V = Velocity (feet/day)

K = Hydraulic Conductivity (3×10^{-8} cm/s based on high end silty clay-rich soil geotechnical measurements)

i = Downward Vertical Gradient (conservatively assumed to be one foot/foot)

N_e = Effective Porosity (0.5 for clay-rich soil)

From the above formula, the maximum downward flow velocity through the silty-clay confining unit to the uppermost aquifer is 6×10^{-8} cm/sec, or 0.063 feet/year. Therefore, the time of travel for liquid from the base of the BABs and DB through 82 feet of silty-clay (thinnest potential section of silty-clay confining unit found on BRPP above the uppermost aquifer at the base of the BABs and DB CCR units) to the uppermost aquifer is approximately 1,300 years. Therefore, given that BRPP operations began in the 1984, approximately 33-years ago, there is no potential for the uppermost aquifer CCR groundwater monitoring systems wells to be affected from the BRPP CCR BABs and DB units.

Section 3
Groundwater Monitoring Systems

3.1 Groundwater Monitoring Systems Installation

During 2016, TRC, on behalf of DTE Electric, oversaw the installation and development of the groundwater monitoring system in accordance with 40 CFR §257.91. Five monitoring wells in the BABs CCR unit area (MW-16-01 through MW-16-04, and MW-09) and six monitoring wells (MW-16-05 through MW-16-08, MW-10, and MW-11/11A) in the DB CCR unit area were installed by a Michigan-licensed well driller in order to establish the groundwater monitoring systems in accordance with the 40 CFR §257.91 as described below:

3.1.1 Soil Boring Advancement

In February to June 2016, twelve soil borings were advanced to evaluate the subsurface geology and to allow monitoring well installation using sonic drilling techniques with 4-inch and 6-inch tooling along the perimeter of the BABs and DB CCR unit areas. Soil samples were collected continuously in ten-foot sections from the ground surface to the termination of the soil boring. A TRC geologist was present to log each boring and describe the soil samples in accordance with the Unified Soil Classification System (USCS). The soil borings were advanced to depths ranging from approximately 100 to 150 feet-bgs to within the first encountered saturated sand and/or sand/gravel unit (uppermost aquifer) and/or into the top of the underlying shale bedrock (likely the Bedford Shale) lower confining unit beneath BRPP.

Bottom Ash Basins CCR Unit Area

Along the southeastern portion of the BABs CCR unit, over 90 feet of continuous silt/clay-rich till is present to the top of the underlying shale bedrock (see soil boring log SB-16-01 in Appendix A). The shale bedrock is encountered at 142 feet-bgs and does not yield groundwater (i.e., is not an aquifer). Soil boring SB-16-01 was left open-hole across the silt/shale bedrock interface with the sonic casing in place overnight and minimal groundwater entered the soil boring overnight. Therefore, no aquifer was identified to be present in the southeastern portion of the BABs CCR unit in the area of SB-16-01 (**Figure 2**). At the remaining five soil boring locations (now logged as monitoring wells MW-16-01 through MW-16-04 and MW-16-09) in the BABs CCR unit a saturated sand-rich upper aquifer unit was encountered at depths ranging from 90 to 136 feet-bgs, generally deeper to the east and southeast. The five monitoring wells were installed as described in Section 3.1.2.

Diversion Basin CCR Unit Area

At the DB CCR unit area in six locations along the east and west side of the DB soil borings (now logged as monitoring wells MW-16-05 through MW-16-08 and MW-16-10 and MW-16-11/11A) were advanced to the shale bedrock. At each of those locations a contiguous silty-clay till unit was present to depths ranging from 131 to 145 feet-bgs, with 2 to 7 feet of unconsolidated silt at the base, between the till and the shale bedrock (**Figures 3 and 5** and Appendix A). Several of these soil borings were left open hole across the silt and/or silt/shale bedrock interface interval with the sonic casing in above and left overnight. Recoverable amounts of groundwater entered the soil borings overnight, supporting that this interval is potentially the uppermost aquifer beneath the DB CCR unit. On May 12, 2017, monitoring well MW-16-11A was installed as a replacement well after monitoring well MW-16-11 was found to be damaged subsequent to collection of several groundwater samples. The six monitoring wells (plus the replacement MW-16-11A) were set within these borings as described in Section 3.1.2 below.

3.1.2 Monitoring Well Installation

CCR monitoring wells MW-16-01 through MW-16-04, and MW-09 were screened within the uppermost portion of the uppermost aquifer in the western, northern, northeastern and southwestern perimeter of the BABs CCR unit with screened intervals ranging from 92 to 97 feet-bgs to 136 to 141 feet-bgs in five locations (**Figure 2**). As previously noted, an aquifer was not present in the southeastern portion of the BABs CCR unit at soil boring SB-16-01 (see **Figure 2**) and no monitoring wells were installed along the southeastern perimeter of the BAB CCR unit. Given the presence of the natural clay-rich till hydraulic barrier and the relatively small foot-print of the BABs, the horizontal spacing of the wells is appropriate to detect constituents from the CCR unit.

As described above in Section 3.1.1, after ensuring that sufficient saturation was present along the silt/bedrock interface, monitoring wells MW-16-05 through MW-16-08, MW-16-10 and MW-16-11 were initially installed to the northwest, west and east of the DB. Wells were screened at the silt/shale bedrock interface potential aquifer in order to have at least one up gradient (MW-16-06 through MW-16-08) and three down gradient monitoring wells (MW-16-05, MW-16-10 and MW-16-11) in the DB CCR unit area. As noted in Section 3.1.1, monitoring well MW-11A was installed as a replacement for MW-16-11 after that well was found to be damaged and MW-16-11 was properly decommissioned. The DB monitoring wells were screened at intervals ranging from 133 to 138 feet-bgs to 145-150 feet-bgs. Given the presence of the natural clay-rich till hydraulic barrier and the relatively small foot-print of the DB, the horizontal spacing of the wells is appropriate to detect constituents from the CCR unit.

Monitoring wells were constructed within each borehole where a potential aquifer was encountered using 2-inch-diameter, Schedule 40, PVC casing and 5-foot long screens with 0.010-inch factory cut slots. Monitoring well construction diagrams from the installed monitoring wells accompany the soil boring logs in Appendix A. Following well installation, the grout and bentonite seal materials were allowed to stabilize for more than 24-hours before monitoring well development began.

3.1.3 Monitoring Well Development and Surveying

Following installation, each CCR monitoring well was developed by air lifting methods. In addition, a Michigan-licensed surveyor horizontally located each monitoring well utilizing the Michigan State Plane South Zone-2113, North American Datum 1983, International feet. Vertical elevations of the ground surface at each soil boring and monitoring well location and the top of casing for each monitoring well were also surveyed in feet relative to the North American Vertical Datum of 1988 (NAVD 88). Monitoring well and soil boring coordinates, elevations, screened intervals, and monitoring well development details are included in Table 1.

3.1.4 Detection Monitoring

As stated earlier, it would take approximately 1,300 years for a release from either basin to reach the upper most aquifer and there is no potential for the uppermost aquifer CCR groundwater monitoring systems wells to be affected from the BRPP CCR BABs and DB units. However, detection monitoring will be performed as required by the Rule as specified below.

<u>BRPP Bottom Ash Basins</u>

The BABs CCR unit groundwater monitoring system shown on **Figure 2** will serve as the detection monitoring locations pursuant to Title 40 CFR §257.93 and §257.94 of the CCR Rule. Due to the relatively small footprint of the BABs, the low vertical and horizontal groundwater flow velocity, and the fact that the saturated unit being monitored is isolated by a laterally contiguous silty-clay unit which significantly impedes vertical groundwater flow thus preventing the monitored saturated zone from potentially being affected by CCR, monitoring of the BABs CCR unit using intra well statistical methods is appropriate. In addition, because the uppermost aquifer is not uniformly present across the BABs CCR unit, there are no clear upgradient wells. As such, intra-well statistical approaches will be evaluated for use during detection monitoring. Using the data collected from the monitoring well system, a statistical evaluation plan is being developed to evaluate compliance with the CCR Rule.

BRPP Diversion Basin

The BRPP DB CCR unit groundwater monitoring system shown on **Figure 2** will serve as the detection monitoring locations pursuant to Title 40 CFR §257.93 and §257.94 of the CCR Rule. Due to the relatively small footprint of the DB, the low vertical and horizontal groundwater flow velocity and radial flow potential outward from the CCR unit, and the fact that the uppermost saturated unit being monitored potential uppermost aquifer is isolated by a laterally contiguous silty-clay unit which significantly impedes vertical groundwater flow thus preventing the monitored saturated zone (identified as the potential uppermost aquifer) from potentially being affected by CCR, monitoring of the DB CCR unit using intra-well statistical methods is appropriate. As such, intra-well statistical approaches will be evaluated for use during detection monitoring. Using the data collected from the monitoring well system, a statistical evaluation plan is being developed to evaluate compliance with the CCR Rule.

Section 4
Groundwater Monitoring Systems Certification

Groundwater Monitoring Systems Certification per 40 CFR §257.91(f)
Belle River Power Plant Bottom Ash Basins and Diversion Basin
China Township, Michigan

The U.S. EPA's Disposal of Coal Combustion Residuals from Electric Utilities Final Rule Title 40 CFR Part 257 §257.91 requires that the owner or operator of an existing CCR unit install a groundwater monitoring system. The owner or operator must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system has been designed and constructed to meet the requirements of Title 40 CFR §257.91.

CERTIFICATION

I hereby certify that the groundwater monitoring systems presented within this document for the BRPP BABs and DB CCR units have been designed and constructed to meet the requirements of Title 40 CFR §257.91 of the CCR Rule. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.91.

Name	Expiration Date	
David B. McKenzie, P.E.	October 31, 2017	STATE OF MICHIGAN DAVID B. McKENZIE ENGINEER No. 42332 LICENSED PROFESSIONAL ENGINEER
Company	**Date**	
TRC Engineers Michigan, Inc.	October 13, 2017	Stamp

Tables

Table 1
Monitoring Well Information Summary
DTE Electric Company – Belle River Power Plant
China Township, Michigan

Well Location	Date Installed	Northing	Easting	Ground Surface Elevation (ft AMSL)	TOC Elevation (ft AMSL)	Geologic Unit of Screen Interval	Well Construction	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft AMSL)	Borehole Terminus Depth (ft BGS)	Borehole Terminus Elevation (ft AMSL)
Belle River Power Plant											
MW-16-01	3/17/2016	471155.70	13625546.02	588.26	590.06	Sand	2" PVC	92.0 to 97.0	496.3 to 491.3	100.0	488.3
MW-16-02	3/15/2016	471409.06	13625991.78	586.27	588.94	Sand	2" PVC	92.0 to 97.0	494.3 to 489.3	100.0	486.3
MW-16-03	6/1/2016	471391.78	13626202.49	588.03	590.66	Silty Sand at 132-133.5 ft BGS, and Sand at 133.5-137 ft BGS	2" PVC	132.0 to 137.0	456.0 to 451.0	150.0	438.0
MW-16-04	3/8/2016	470893.74	13625876.34	587.50	590.51	Sand	2" PVC	119.0 to 124.0	468.5 to 463.5	130.0	457.5
MW-16-05	3/4/2016	470378.15	13626342.79	588.32	590.82	Clayey Silt at 139-142 ft BGS, and Shale bedrock at 142-144 ft BGS	2" PVC	139.0 to 144.0	449.3 to 444.3	150.0	438.3
MW-16-06	3/11/2016	470439.03	13626796.04	589.98	593.21	Silt at 135-138 ft BGS, and Shale bedrock at 138-140 ft BGS	2" PVC	135.0 to 140.0	455.0 to 450.0	140.0	450.0
MW-16-07	3/9/2016	470233.47	13626858.79	589.89	592.58	Silt at 133-134 ft BGS, and Shale bedrock at 134-138 ft BGS	2" PVC	133.0 to 138.0	456.9 to 451.9	140.0	449.9
MW-16-08	3/10/2016	470002.90	13626846.85	589.31	591.88	Silt at 133-135 ft BGS, and Shale bedrock 135-138 ft BGS	2" PVC	133.0 to 138.0	456.3 to 451.3	140.0	449.3
MW-16-09	6/2/2016	471284.45	13626365.84	588.28	590.80	Sand	2" PVC	136.0 to 141.0	452.3 to 447.3	150.0	438.3
MW-16-10	6/6/2016	470532.54	13626417.00	589.25	592.26	Gravelly Silt at 145-147.5 ft BGS, and Silty Clay at 147.5-150 ft BGS	2" PVC	145.0 to 150.0	444.3 to 439.3	150.0	439.3
MW-16-11A	5/12/2017	470232.10	13626444.98	589.52	591.66	Silt at 137-140 ft BGS, and Silty Clay at 140-142 ft BGS	2" PVC	137.0 to 142.0	452.5 to 447.5	142.0	447.5
MW-16-11	6/7/2016	470251.34	13626438.92	589.03	591.54	Clay at 137-138.5, Sandy Clay at 138.5-140 ft BGS, and Clay at 140-142 ft BGS	2" PVC	137.0 to 142.0	452.0 to 447.0	150.0	439.0

Notes:
Coordinates are Michigan State Plane South Zone-2113, International Feet
Elevation in feet above NAVD88.
TOC: Top of well casing.
ft AMSL: Feet above mean sea level.
ft BGS: Feet below ground surface.
GRAY text represents decommissioned monitoring well.

Figures

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

TRC
1540 Eisenhower Place
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Phone: 734.971.7080
TRC - GIS

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0003
FILE:	265996-SLMMB.mxd

FIGURE 1

E:\DTE\CCR_Sites\2017_265996\265996-SLMMB.mxd -- Saved By: BDEEGAN on 10/9/2017, 14:49:39 PM

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

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 BY BMJ ENGINEERS & SURVEYORS, INC.

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN
TITLE:	SITE PLAN
DRAWN BY: R SUEMNICHT	PROJ NO.: 265996.0003
CHECKED BY: S HOLMSTROM	FIGURE 2
APPROVED BY: V BUENING	
DATE: OCTOBER 2017	

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FILE NO.: 265996-0003-002.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:18:14 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
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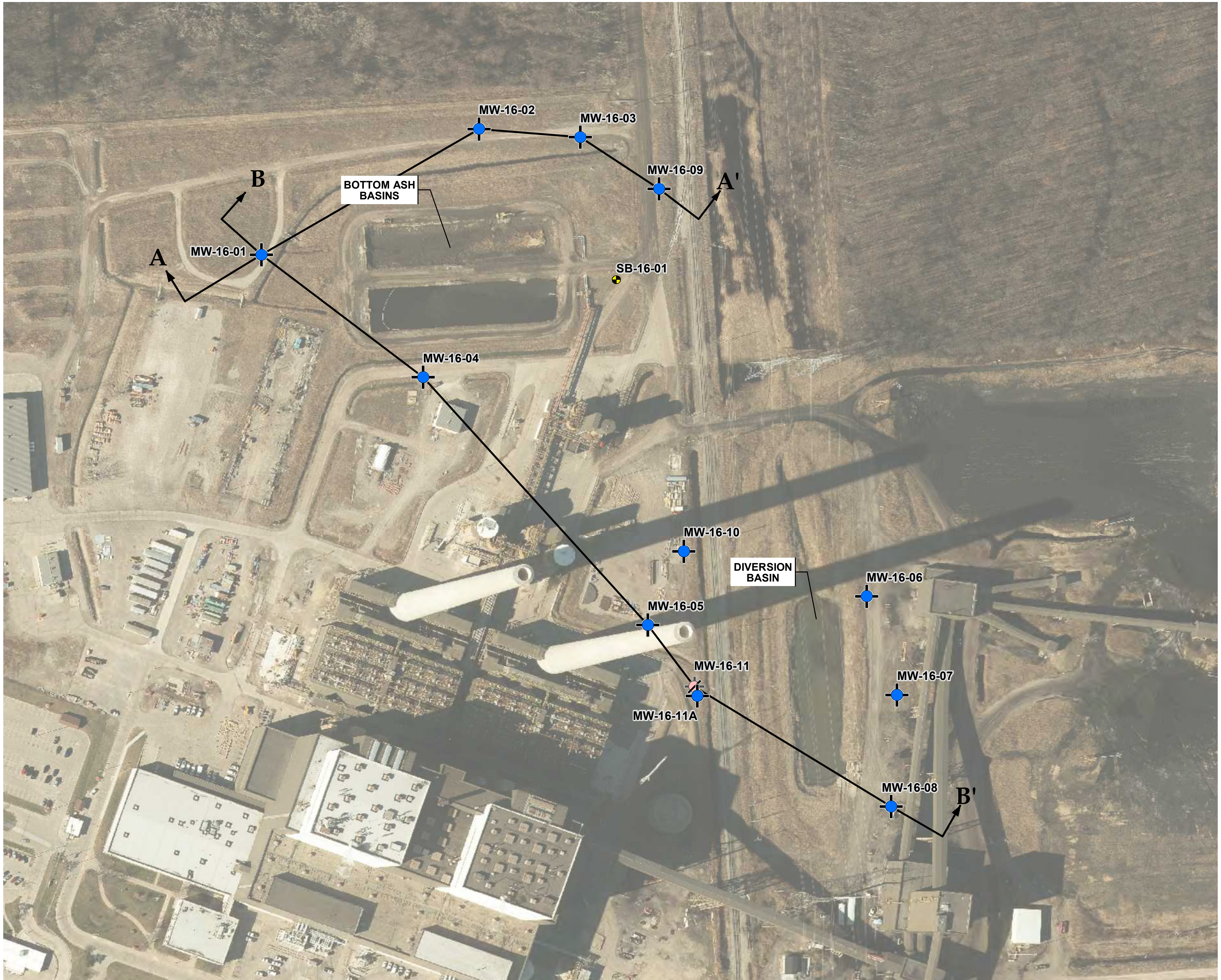

LEGEND

- 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.

0 200 400 Feet
1 " = 200 '
1:2,400

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:	S. HOLMSTROM	**FIGURE 3**	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

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FILE NO.: 265996-0003-011.mxd

TRC - GIS
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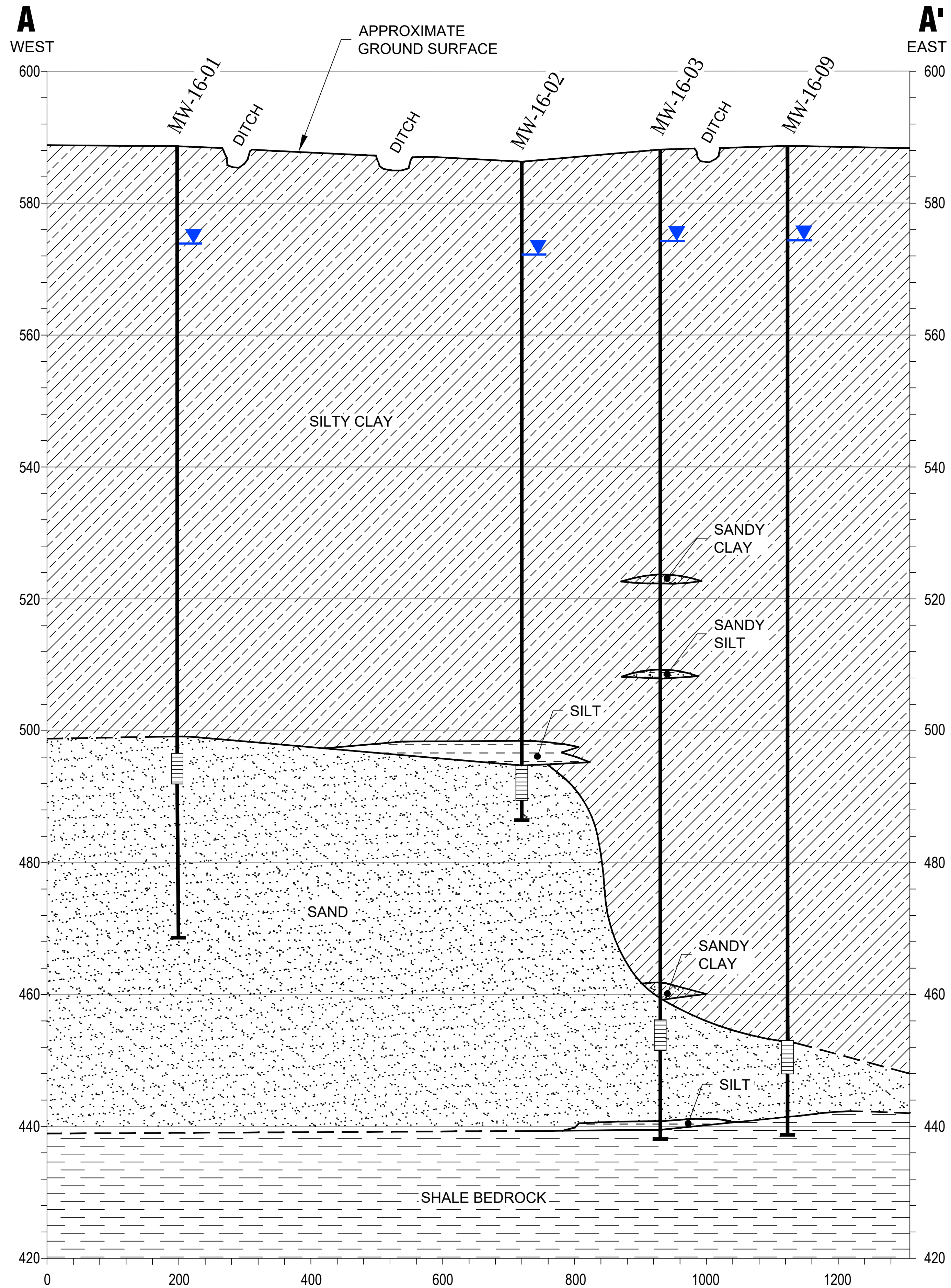
GENERALIZED GEOLOGIC CROSS-SECTION A-A'

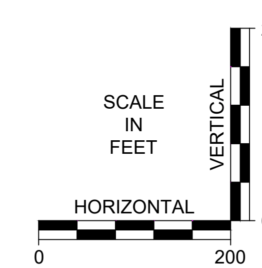


LEGEND

- 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
- 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 4	
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

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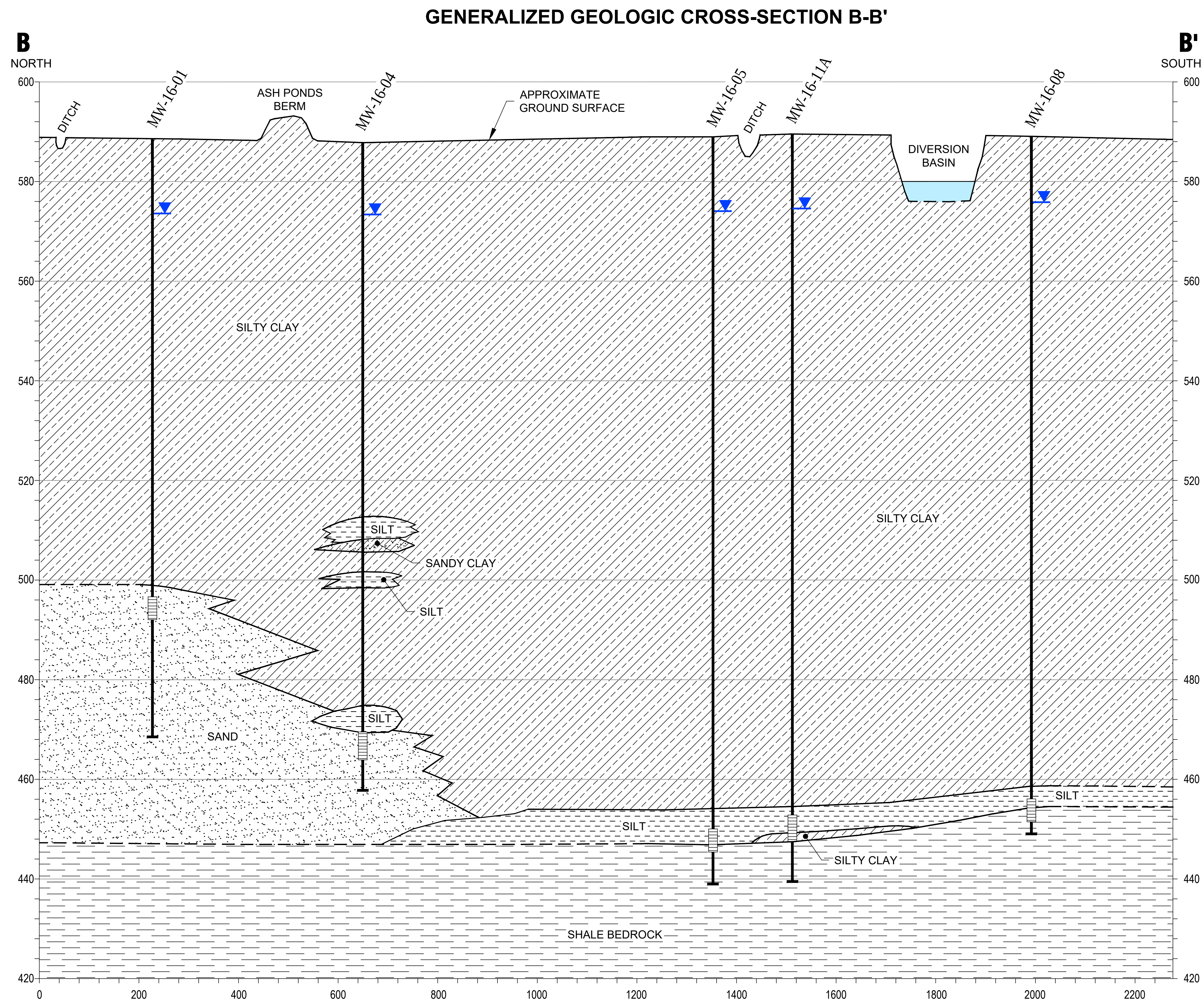
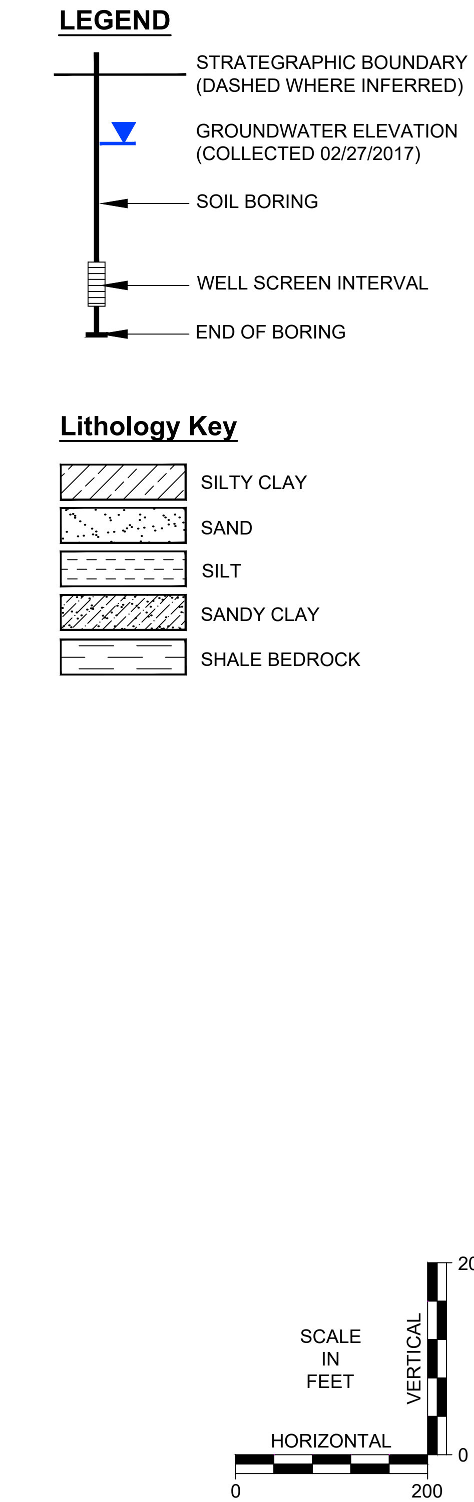
FILE NO.: 265996.0003.01.04-05.dwg

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;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG04 XS AA

11x17 --- ATTACHED XREF'S: --- 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;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG05 XS BB





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 5	
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

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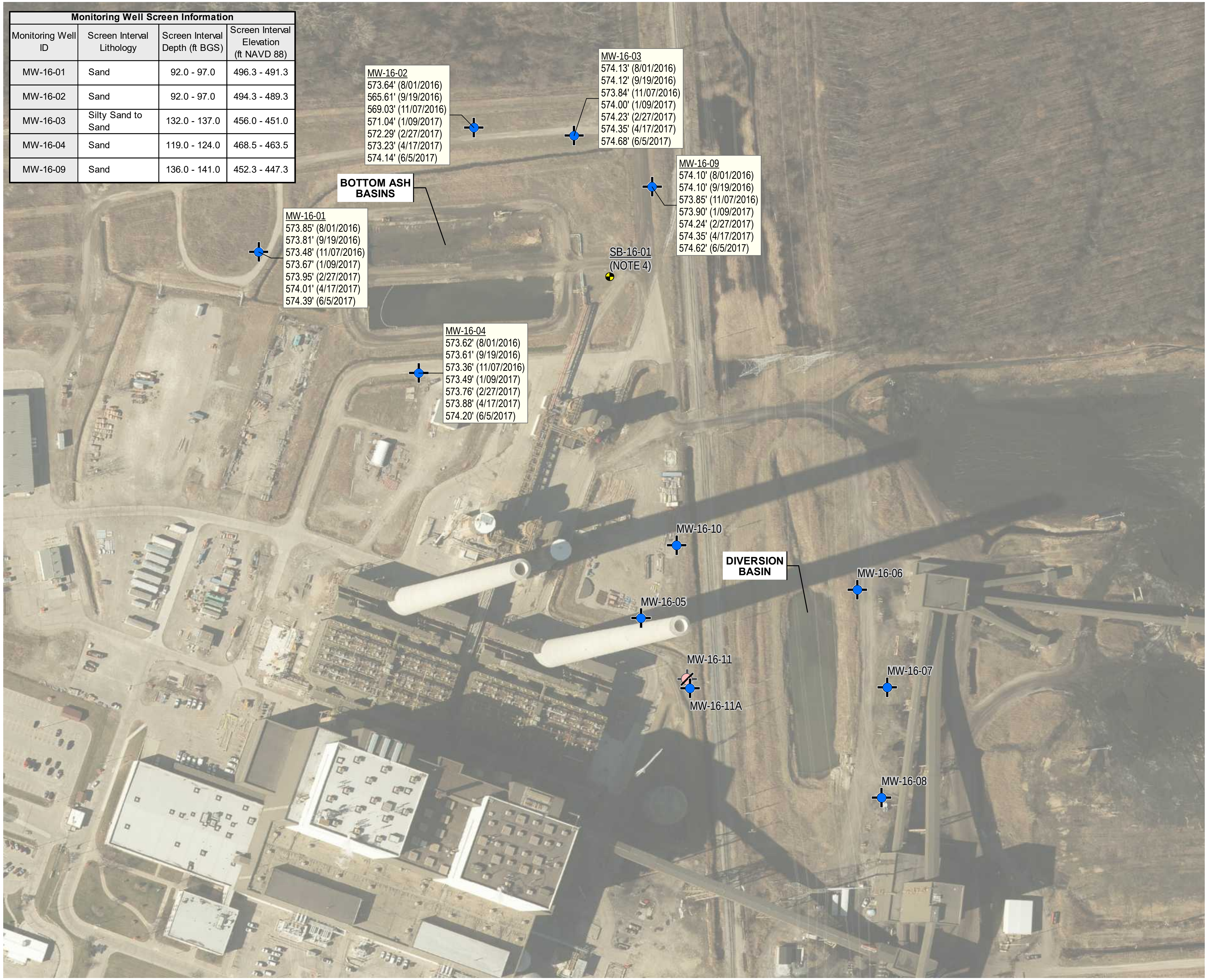
FILE NO.: 265996.0003.01.04-05.dwg

Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. GROUNDWATER ELEVATIONS DISPLAYED IN FEET ABOVE MEAN SEA LEVEL.
4. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

0 200 400 Feet
1 " = 200 '
1:2,400

PROJECT: DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE: BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	S. HOLMSTROM	FIGURE 6	
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

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FILE NO.: 265996-0003-003.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:30:02 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-003.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/13/2017, 07:54:31 AM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
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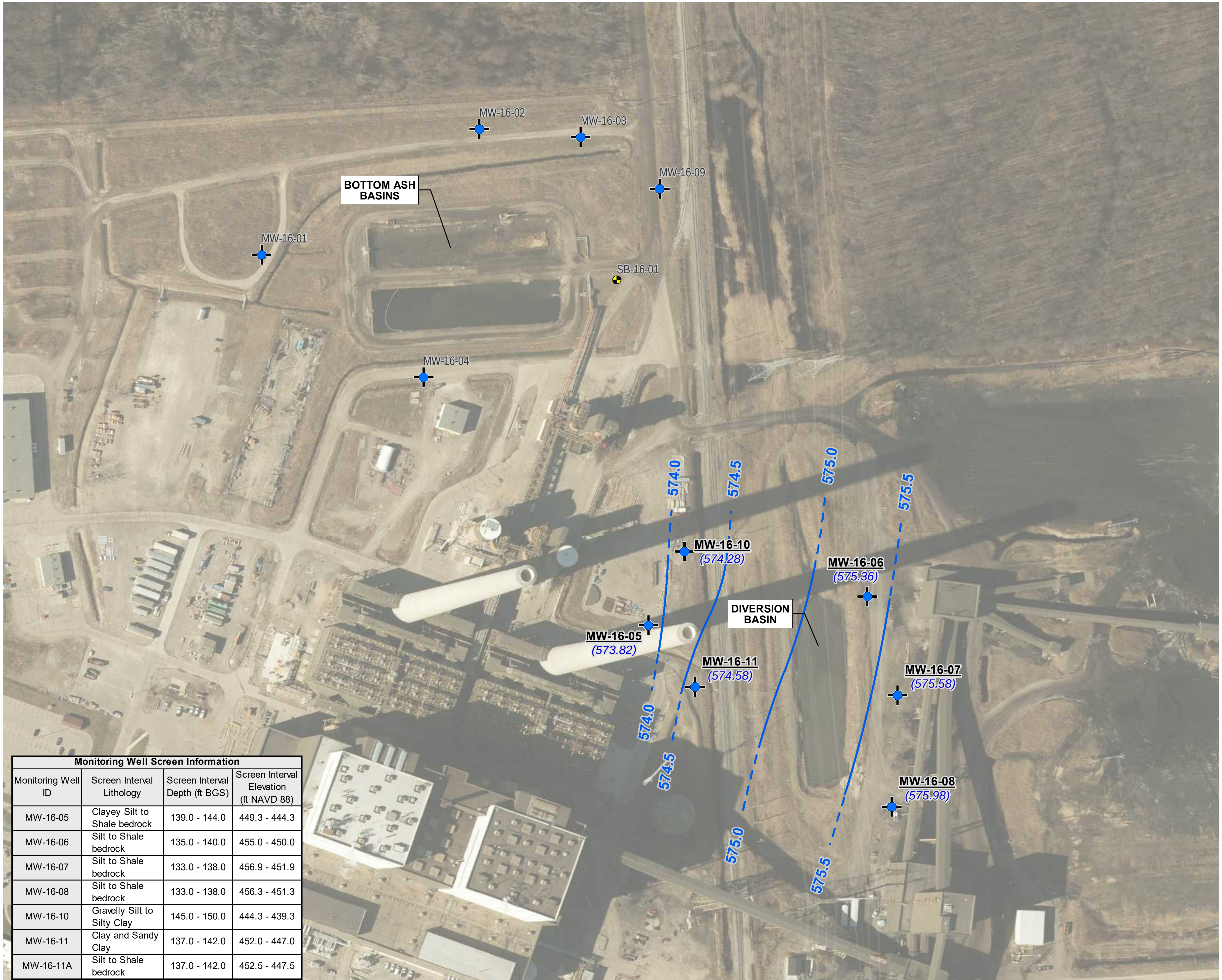

Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-05	Clayey Silt to Shale bedrock	139.0 - 144.0	449.3 - 444.3
MW-16-06	Silt to Shale bedrock	135.0 - 140.0	455.0 - 450.0
MW-16-07	Silt to Shale bedrock	133.0 - 138.0	456.9 - 451.9
MW-16-08	Silt to Shale bedrock	133.0 - 138.0	456.3 - 451.3
MW-16-10	Gravelly Silt to Silty Clay	145.0 - 150.0	444.3 - 439.3
MW-16-11	Clay and Sandy Clay	137.0 - 142.0	452.0 - 447.0
MW-16-11A	Silt to Shale bedrock	137.0 - 142.0	452.5 - 447.5

LEGEND

- SOIL BORING
- MONITORING WELL
- (575.47) GROUNDWATER ELEVATION (FT MSL)
- GROUNDWATER ELEVATION CONTOUR (0.5-FT INTERVAL, DASHED WHERE INFERRED)

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, “WORLD IMAGERY”, WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 BY BMJ ENGINEERS & SURVEYORS, INC.
3. GROUNDWATER ELEVATIONS DISPLAYED IN FEET ABOVE MEAN SEA LEVEL.

N

0 200 400 Feet
1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
DIVERSION BASIN GROUNDWATER POTENTIOMETRIC SURFACE MAP SEPTEMBER 2016

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	S. HOLMSTROM		**FIGURE 7**
APPROVED BY:	V. BUENING		
DATE:	OCTOBER 2017		

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FILE NO.: 265996-0003-005.mxd

Appendix A
Soil Boring and Monitoring Well Installation Logs

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-01

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	Borehole Dia. (in) 6/4
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 ___ Depth (ft bgs) ___; 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
			0	**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.	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. Original boring abandoned due to compromised screen. Redrilled and installed at survey location noted above within 10 feet of original location.
1 CS	60		5	**CLAY** mostly clay, trace fine to coarse gravel, high plasticity, brown (10YR 5/3), moist, stiff. Change to dark gray (10YR 4/1), very stiff at 5.0 feet. Change to soft at 8.0 feet.	CL			
2 CS	50		10–15	Change to no gravel, dark gray (10YR 4/1) mottled with brown (10YR 5/3), very soft at 10.0 feet. ▼ (14.52)	CL			
3 CS	100		20–25	Change to dark gray (10YR 4/1) at 20.0 feet.	CL			
4 CS	100		30–35		CL			
			40					

Signature: [signature]

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

Checked By: C. Scieszka

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-01

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, soft.				
6 ST	100		50					
7 CS	100		55					
			60					
8 CS	80		65		CL			
			70					
9 CS	100		75					
			80					
10 CS	100		85					
			90	**SAND** mostly fine sand, dark gray (10YR 4/1), saturated.				
11 CS	100		95		SP			
			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

TRC

WELL NO. MW-16-02

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/14/16	3/15/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	586.27	588.94	100.0	6/4

Boring Location:	Personnel	Drilling Equipment:
325 feet W of haul road, 5 feet N of road, N of bottom ash basins. N: 471409.06 E: 13625991.78	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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
				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.
1 CS	80		5					
				Change to no gravel at 7.0 feet.				
			10	Change to high plasticity, dark gray (10YR 4/1), moist, very soft at 10.0 feet.				
2 CS	80		15	▼				
			20		CL			
3 CS	100		25					
			30					
4 CS	90		35					
			40					

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

Signature: [signature]

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

Checked By: C. Scieszka

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-03

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	5/25/16	5/31/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.03	590.66	150.0	6/4

Boring Location:	Personnel	Drilling Equipment:
Approximately 100 feet W of haul road, N of bottom ash basins. N: 471391.78 E: 13626202.49	Logged By - J. Reed Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	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
				TOPSOIL				
1 CS	100		5	**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.
			10	Change to gray (10YR 5/1) at 10.5 feet.				
2 CS	100		15	▼ **CLAY** mostly clay, few silt, trace to few fine to medium sand, medium plasticity, gray (10YR 5/1), moist, soft to medium stiff.	CL			
			20					
3 CS	100		25	Change to trace to few fine to coarse sand at 25.0 feet.				
			30					
4 CS	100		35					
			40	Change to trace fine to coarse sand at 41.5 feet.				

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Checked By: M. Powers

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-03

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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.				
			50					
6 CS	90		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			
				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			
			70					
8 CS	90		75	1-inch thick interval of silty fine to coarse sand at 75.0 feet.				
				SANDY SILT mostly silt, little to some fine to medium sand, gray (10YR 5/1), moist, medium dense.	ML			
			80	**CLAY** mostly clay, few silt, few fine to coarse sand, low to medium plasticity, gray (10YR 5/1), moist, stiff.	CL			
9 CS	100		85					
			90	Change to medium soft at 90.0 feet.				
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					

Sample Number and Type	Sample Recovery (%)	Blow Counts	Depth in Feet	Lithologic Description	USCS	Comments
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.	CL	
			110	Change to low plasticity, soft to medium stiff at 111.0 feet.		
12 CS	100		115			
			120			
13 CS	100		125			
				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.	CL	
			130	**SILTY SAND** mostly fine to medium sand, little silt, gray (10YR 5/1), moist, loose.	SM	
14 CS	90		135	**SAND** mostly fine to medium sand, trace silt, gray (10YR 5/1), moist, loose.	SP	
				SILTY SAND mostly fine to medium sand, little silt, few clay, gray (10YR 5/1), moist, loose.	SM	
			140	**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		145			
				SILT mostly silt, few clay, trace coarse sand to fine gravel, gray (10YR 5/1), dry to moist, dense to very dense.	ML	
			150	**SHALE** weathered shale bedrock, dark gray.		
				End of boring at 150 feet below ground surface.		
			155			

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-04

Facility/Project Name:		Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant		3/7/16	3/8/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	587.50	590.51	130.0	6/4

Boring Location:	Personnel	Drilling Equipment:
200 feet from W corner of road, S of bottom ash basins. N: 470893.74 E: 13625876.34	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 4/13/16 09:31 ▼ Depth (ft bgs) 13.91

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
			0	**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.	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.
1 CS	80		5					
			10	Change to stiff at 10.5 feet.				
				Change to dark gray (10YR 4/1), very soft at 12.0 feet.				
			▼					
2 CS	100		15					
			20					
3 CS	100		25					
			30					
4 CS	100		35					
			40					

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

Signature: [signature]

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Checked By: C. Scieszka

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), very soft.	CL			
			50					
6 CS	100		55					
			60	Change to few coarse gravel at 60.0 feet.				
7 CS	100		65					
			70					
8 CS	100			**SILTY CLAY** mostly clay, little to some silt, trace fine sand, medium plasticity, dark gray (10YR 4/1), very stiff.	CL-ML			
			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			
				SANDY CLAY mostly clay, some fine sand, high plasticity, dark gray (10YR 4/1), moist.	CL			
9 CS	100		85	**SILTY CLAY** mostly clay, some silt, high plasticity, dark gray (10YR 4/1), stiff.	CL-ML			
				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.	CL-ML			
10 CS	100		95					
			100	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), very soft.	CL			

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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.				

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-05

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/3/16	3/4/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.32	590.82	150.0	6

Boring Location:	Personnel	Drilling Equipment:
S end of haul road, W of diversion basin. N: 470378.15 E: 13626342.79	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 4/13/16 09:55 ▼ Depth (ft bgs) 14.37

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				CLAY WITH GRAVEL mostly clay, few to some coarse gravel, high plasticity, dark grayish brown (10YR 4/2), 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.
1 CS	80		5	**CLAY** mostly clay, few fine to coarse gravel, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, hard. Change to no gravel, very stiff at 4.0 feet.				
			10	Change to dark gray (10YR 4/1), very soft at 10.0 feet.				
2 CS	100		15	▼				
			20					
3 CS	100		25	Change to medium stiff at 26.0 feet. Change to very soft at 28.0 feet.	CL			
			30					
4 CS	100		35					
			40					

Signature: [signature]

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WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-05

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

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-05

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				CLAY mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, soft.	CL			
12 CS	100		105					
			110					
13 CS	100		115					
			120					
14 CS	100		125					
			130					
15 CS	100		135	**CLAYEY SILT** mostly silt, some clay, medium plasticity, dark gray (10YR 4/1), wet, medium stiff.	ML-CL			
			140	**SHALE** dark gray (10YR 4/1), dry.				
16 CS	90		145					
			150	End of boring at 150.0 feet below ground surface.				
			155					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-06

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/10/16	3/11/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.98	593.21	140.0	6

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:	County:	State:
China Township	St. Clair	MI

Water Level Observations:
While Drilling: Date/Time Depth (ft bgs)
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
			0	**GRAVEL WITH SAND** mostly gravel, some fine to coarse sand, brown (10YR 5/3), moist, dense.				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.
				CLAY mostly clay, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, very stiff.				
1 CS	50		5					
			10	Change to few coarse gravel at 10.0 feet.				
				Change to dark gray (10YR 4/1), stiff at 12.0 feet.				
				Change to very soft at 13.0 feet.				
			▼					
2 CS	100		15					
			20		CL			
3 CS	100		25					
			30					
4 CS	100		35					
			40					

Signature: [signature]
Checked By: C. Scieszka

Firm: TRC Environmental Corporation
1540 Eisenhower Place Ann Arbor, Michigan
734.971.7080
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WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-06

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
			50					
6 CS	100		55					
			60					
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.	CL-ML			
			80					
9 CS	80		85					
			90	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
10 CS	70		95					
			100					

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

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WELL CONSTRUCTION LOG

WELL NO. MW-16-06

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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		120 / 125	**SILTY CLAY** mostly clay, some silt, medium plasticity, dark gray (10YR 4/1), moist, medium stiff.	CL-ML			
14 CS	100		130 / 135	**SILT** mostly silt, dark gray (10YR 4/1), saturated, very soft.	ML			
				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

TRC

WELL NO. MW-16-07

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/8/16	3/9/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.89	592.58	140.0	6

Boring Location:	Personnel	Drilling Equipment:
326 feet S of road connecting to haul road, E of diversion basin. N: 470233.47 E: 13626858.79	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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
			0	**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.
1 CS	60		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.				
				▼ Change to moist, very soft at 13.0 feet.				
2 CS	100		15					
			20		CL			
3 CS	100		25					
			30					
4 CS	100		35					
			40					

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

Checked By: C. Scieszka

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-07

SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	COMMENTS
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	
			60			
8 CS	100			**CLAYEY SILT** mostly silt, little to some clay, few fine to coarse sand, low plasticity, dark gray (10YR 4/1), moist.	ML-CL	
			65	**SAND** mostly fine to coarse sand, dark gray (10YR 4/1), moist, loose.	SW	
				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.	CL-ML	
9 CS	100		75			
			80			
10 CS	100		85			
			90			
11 CS	100		95			
			100			

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-07

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				SILTY CLAY mostly clay, little silt, high plasticity, dark gray (10YR 4/1), moist, soft.	CL-ML			
12 CS	100		105					
			110					
13 CS	80		115					
			120					
14 CS	100		125					
			130					
				SILT mostly silt, no plasticity, dark gray (10YR 4/1), saturated, loose.	ML			
				SHALE dark gray (10YR 4/1), brittle, hard.				
15 CS	100		135					
			140	End of boring at 140.0 feet below ground surface.				
			145					
			150					
			155					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-08

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/9/16	3/10/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.31	591.88	140.0	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:	County:	State:
China Township	St. Clair	MI

Water Level Observations:
While Drilling: Date/Time Depth (ft bgs)
After Drilling: Date/Time 4/13/16 12:00 ▼ Depth (ft bgs) 13.19

Sample Number and Type	Recovery (%)	Blow Counts	Depth in Feet	Lithologic Description	USCS	Comments
			0–5	**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.
1 CS	50		5	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, very stiff.		
			10	Change to dark gray (10YR 4/1), very soft at 10.0 feet.		
			▼ (13.19)			
2 CS	100		15			
			20			
3 CS	100		25		CL	
			30			
4 CS	100		35			
			40			

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

Signature: [signature]

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

Checked By: C. Scieszka

WELL CONSTRUCTION LOG

WELL NO. MW-16-08

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
			50					
6 CS	100		55					
			60					
7 CS	80		65					
			70	**SILTY CLAY** mostly clay, some silt, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, soft.	CL-ML			
8 CS	100		75					
			80					
9 CS	100		85					
			90					
10 CS	60		95					
			100					

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-08

SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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.				
			115					
13 CS	100		120					
			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					

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-09

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	6/1/16	6/1/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.28	590.80	150.0	6

Boring Location: E of bottom ash basins, E of haul road.	Personnel	Drilling Equipment:
N: 471284.45 E: 13626365.84	Logged By - J. Reed Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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
				TOPSOIL				
1 CS	75			**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.	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.
			5	**CLAY** mostly clay, few silt, trace to few fine to coarse sand, medium plasticity, gray (10YR 5/1), moist, soft.				
			10					
2 CS	85		15	▼				
			20					
3 CS	100		25		CL			
			30	Change to trace to few fine gravel at 30.0 feet.				
4 CS	100		35					
			40					

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

Signature: [signature]

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

Checked By: M. Powers

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
			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.				
5 CS	100		50	Change to soft to medium stiff at 50.0 feet.				
			55					
			60					
			65					
6 CS	100		70	Change to soft at 70.0 feet.	CL			
			75					
			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					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-09

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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.	CL			
9 CS	80		110–115					
10 CS	100		120–135					
			135–141	**SAND** mostly fine sand, trace silt, dark gray (10YR 4/1), moist, loose.	SP			
11 CS	80		141–147	**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			
			147–150	**SHALE** weathered, gray (10YR 5/1), brittle.				
			150	End of boring at 150.0 feet below ground surface.				
			155					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-10

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	6/2/16	6/3/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.25	592.26	150.0	6

Boring Location:	Personnel	Drilling Equipment:
S end of haul road, W/NW of diversion basin. N: 470532.54 E: 13626417.00	Logged By - J. Reed Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 6/9/16 07:45 ▼ Depth (ft bgs) 15.30

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
			0	**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.
1 CS	50		5					
			10	Change to gray (10YR 5/1) at 11.0 feet. Change to soft to medium stiff at 12.0 feet.				
2 CS	90		15	▼				
			20		CL			
3 CS	95		25	Change to soft at 25.0 feet.				
			30	Change to few fine to coarse sand, medium stiff at 30.0 feet. Change to dark gray (10YR 4/1) at 32.0 feet.				
4 CS	100		35	Change to soft at 35.0 feet.				
			40					

Signature: [signature]

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

Checked By: M. Powers

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, few silt, trace to few fine to coarse sand, dark gray (10YR 4/1), moist, soft.	CL			
			50					
6 CS	100		55					
			60					
7 CS	100		65					
8 CS	100		70	**CLAY WITH SAND** mostly clay, little fine to coarse sand, few silt, trace gravel, dark gray (10YR 4/1), moist, very stiff.	CL			
			75	Change to few to little medium to coarse sand, low to medium plasticity, stiff at 75.0 feet.				
9 CS	100		80	**CLAYEY SAND** mostly fine to coarse sand, some clay, dark grayish brown (10YR 4/2), moist, medium dense.	SC			
				SAND mostly fine to medium sand, dark grayish brown (10YR 4/2), moist, loose.	SP			
			85					
10 CS	100		90	**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			
			95					
			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			

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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			**SAND** mostly medium to coarse sand, dark gray (10YR 4/1), moist, loose.	SP			
			115	**CLAY** mostly clay, little sand, few to little silt, dark gray (10YR 4/1), moist, stiff.	CL			
			120					
13 CS	95		125					
			130					
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			
				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

TRC

WELL NO. MW-16-11

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	6/3/16	6/6/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.03	591.54	150.0	6

Boring Location:	Personnel	Drilling Equipment:
S of haul road, W of diversion basin. N: 470251.34 E: 13626438.92	Logged By - J. Reed; Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs); After Drilling: Date/Time 6/21/16 07:45 ▼ Depth (ft bgs) 14.47

SAMPLE Number and Type	Recovery (%)	Blow Counts	Depth in Feet	Lithologic Description	USCS	Graphic Log	Well Diagram	Comments
				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.
1 CS	50		5					
				Change to trace gravel at 8.0 feet.				
			10					
				Change to gray (10YR 5/1) at 12.0 feet.				
				Change to no gravel at 13.0 feet.				
			▼					
2 CS	70		15					
			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 231828.0003.0000.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: M. Powers

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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					

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-11

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				CLAY mostly clay, few silt, trace to few sand, trace gravel, low to medium plasticity, gray (10YR 5/1), moist, medium stiff to stiff.				
11 CS	85		105					
			110	Change to medium stiff at 110.0 feet.				
12 CS	80		115					
			120		CL			
13 CS	85		125					
			130					
14 CS	90		135					
				SANDY CLAY mostly clay, some fine sand, few silt, dark gray (10YR 4/1), moist.	CL			
			140	**CLAY** mostly clay, few silt, trace to few sand, trace gravel, low to medium plasticity, gray (10YR 5/1), moist, medium stiff.	CL			
				SHALE dark gray.				
15 CS	90		145					
			150	End of boring 150.0 feet below ground surface.				
			155					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-11A

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	5/11/17	5/12/17	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.5	591.66	142.0	6

Boring Location:	Personnel	Drilling Equipment:
North of fuel oil tank number 2, between berm and fence.	Logged By - J. Krenz Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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.	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					
2 CS	60			▼				
			20	Change to high plasticity, gray (10YR 5/1), soft at 19.0 feet.				
3 CS	70							
			30					
4 CS	70							
			40					
5 CS	100							
			50					
6 CS	100							
			60					
7								

Signature: [signature] Firm: TRC Environmental

Fax

Checked By: C. Scieszka

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

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

SOIL BORING LOG

TRC

BORING NO. SB-16-01

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/1/16	3/1/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.69	---	150.0	6

Boring Location:	Personnel	Drilling Equipment:
Corner of E connecting road off haul road, E of bottom ash basins. N: 471096.38 E: 13626276.67	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time Depth (ft bgs)

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
			0	**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.	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.
				CLAY mostly clay, trace fine sand, high plasticity, dark gray (10YR 4/1), mottled with brown (10YR 5/3), moist, very stiff.			
1 CS	50		5				
			10	Change to stiff at 10.0 feet.			
				Change to no sand, dark gray (10YR 4/1), very soft at 13.0 feet.			
2 CS	100		15				
			20				
					CL		
3 CS	100		25				
			30				
4 CS	100		35				
			40				

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

Checked By: M. Powers

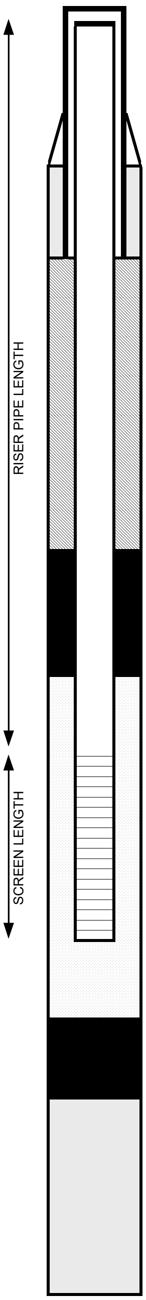
SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
5 CS	100		45	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
6 ST	100		50				
7 CS	100		55				
				CLAY WITH SAND mostly clay, little fine to coarse sand, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
8 CS	100		60	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
			65	**SANDY SILT** mostly silt, little to some fine to coarse sand, few clay, low plasticity, dark gray (10YR 4/1), moist, stiff.	ML		
9 CS	100		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.	CL		
			75				
10 CS	100		80	Change to few coarse gravel at 80.0 feet.			
			85				
11 CS	100		90				
			95				
			100				

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
12 CS	100		105	**CLAY** mostly clay, few coarse gravel, dark gray (10YR 4/1), moist, soft.	CL		
13 CS	100		110–115				
14 CS	100		120–125				
15 CS	100		130–135	**SILT** mostly silt, few fine sand, non plastic, dark gray (10YR 4/1), moist.	ML		
16 CS	100		140–145	**SHALE** dark gray (10YR 4/1), dry.			
			150	End of boring at 150.0 feet below ground surface.			
			155				

WELL CONSTRUCTION DIAGRAM

PROJ. NAME:	DTE Electric Company Belle River Power Plant	WELL ID:	**MW-16-01**
PROJ. NO: 231828.0003	DATE INSTALLED: 3/17/2016	INSTALLED BY: A. Knutson	CHECKED BY: C. Scieszka

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
590.06	1.8 TOP OF CASING
588.26	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
	GROUT/BACKFILL METHOD: TREMIE
93.8 (RISER PIPE LENGTH)	
	84.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	89.0 BENTONITE SEAL
496.3	92.0 TOP OF SCREEN
5.00 (SCREEN LENGTH)	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
491.3	97.0 BOTTOM OF SCREEN
	97.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: NATURAL COLLAPSE
488.3	100.0 HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 97 FT.; 4 IN. FROM 97 TO 100 FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.; ____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 120 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: BROWN /GREY

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	98.20	T/PVC	3/21/2016	--
DTB AFTER DEVELOPING:	100.32	T/PVC	4/13/2016	845
SWL BEFORE DEVELOPING:	12.92	T/PVC	3/21/2016	--
SWL AFTER DEVELOPING:	16.32	T/PVC	4/13/2016	845
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

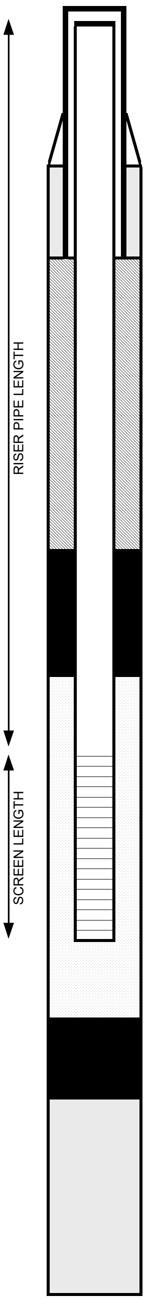
PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

LOCK KEY NUMBER: 3120

WELL CONSTRUCTION DIAGRAM

PROJ. NAME: DTE Electric Company Belle River Power Plant		WELL ID:	**MW-16-02**
PROJ. NO: 231828.0003	DATE INSTALLED: 3/15/2016	INSTALLED BY: A. Knutson	CHECKED BY: C. Scieszka



ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)	
588.94	2.7	TOP OF CASING
586.27	0.0	GROUND SURFACE
	1.0	CEMENT SURFACE PLUG
		GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
		GROUT/BACKFILL METHOD: TREMIE
94.7 (RISER PIPE LENGTH)		
	84.0	GROUT
		BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	89.0	BENTONITE SEAL
494.2	92.0	TOP OF SCREEN
		FILTER PACK MATERIAL: MEDIUM, WASHED SAND
5.00 (SCREEN LENGTH)		
489.2	97.0	BOTTOM OF SCREEN
	97.0	BOTTOM OF FILTER PACK
	NA	BENTONITE PLUG
		BACKFILL MATERIAL: NATURAL COLLAPSE
486.2	100.0	HOLE BOTTOM

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 97 FT.; 4 IN. FROM 97 TO 100 FT.

SURF. CASING DIAMETER: ___ IN. FROM ___ TO ___ FT.; ___ IN. FROM ___ TO ___ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 460 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: BROWN /GREY

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	97.07	T/PVC	3/15/2016	--
DTB AFTER DEVELOPING:	100.20	T/PVC	4/13/2016	9:24
SWL BEFORE DEVELOPING:	14.56	T/PVC	3/15/2016	--
SWL AFTER DEVELOPING:	28.28	T/PVC	3/18/2016	--
OTHER SWL:	18.77	T/PVC	4/13/2016	9:24
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

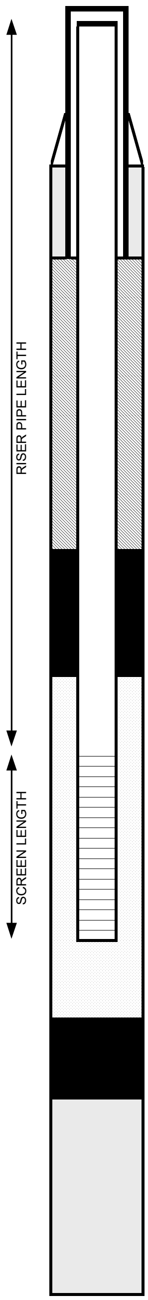
LOCK KEY NUMBER: 3120

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME:	DTE Electric Company Belle River Power Plant	WELL ID:	MW-16-03
PROJ. NO: 231828.0003	DATE INSTALLED: 6/1/2016 INSTALLED BY: J. Reed		CHECKED BY: M. Powers

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
590.66	2.6 TOP OF CASING
588.03	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
134.5	GROUT/BACKFILL METHOD: TREMIE
	126.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	129.0 BENTONITE SEAL
456.2	132.0 TOP OF SCREEN
5.00	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
451.2	137.0 BOTTOM OF SCREEN
	137.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: NATURAL COLLAPSE
438.2	150.0 HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 140 FT.
4 IN. FROM 140 TO 150 FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 60 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: TURBID

COLOR BEFORE: LIGHT GRAY

CLARITY AFTER: SLIGHTLY TURBID

COLOR AFTER: VERY LIGHT GRAY

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	140.00	T/PVC	6/8/2016	7:20
DTB AFTER DEVELOPING:	140.00	T/PVC	6/8/2016	14:30
SWL BEFORE DEVELOPING:	16.06	T/PVC	6/8/2016	7:20
SWL AFTER DEVELOPING:	15.32	T/PVC	6/8/2016	14:30
OTHER DTB:	140.41	T/PVC	6/9/2016	10:00
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

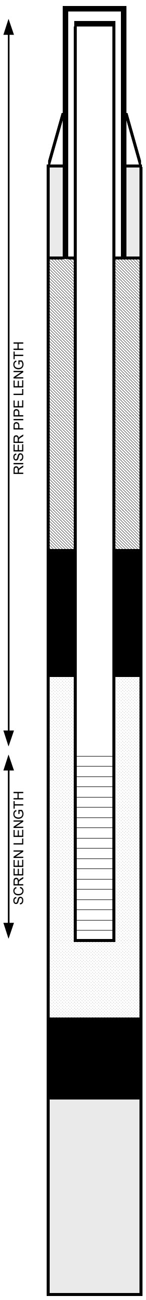
LOCK KEY NUMBER: 3120

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME: DTE Electric Company Belle River Power Plant		WELL ID:	**MW-16-04**
PROJ. NO: 231828.0003	DATE INSTALLED: 3/8/2016 INSTALLED BY: A. Knutson		CHECKED BY: C. Scieszka

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
590.51	3.0 TOP OF CASING
587.50	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
122.0	GROUT/BACKFILL METHOD: TREMIE
	111.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	116.0 BENTONITE SEAL
468.5	119.0 TOP OF SCREEN
5.00	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
463.5	124.0 BOTTOM OF SCREEN
	124.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: NATURAL COLLAPSE
457.5	130.0 HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 124 FT.
4 IN. FROM 124 TO 130 FT.

SURF. CASING DIAMETER: ___ IN. FROM ___ TO ___ FT.
___ IN. FROM ___ TO ___ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 288 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: BROWN /GREY

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	123.97	T/PVC	3/8/2016	--
DTB AFTER DEVELOPING:	126.45	T/PVC	4/13/2016	9:31
SWL BEFORE DEVELOPING:	13.98	T/PVC	3/15/2016	14:30
SWL AFTER DEVELOPING:	13.46	T/PVC	3/18/2016	7:30
OTHER SWL:	16.91	T/PVC	4/13/2016	9:31
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

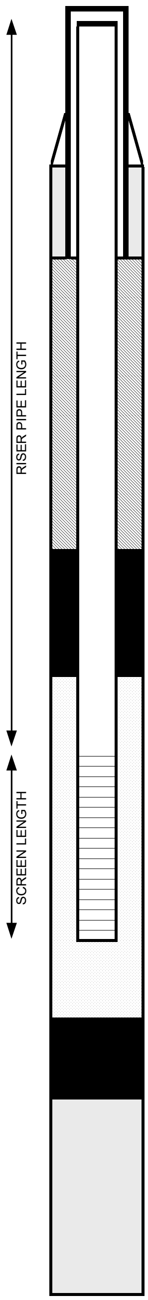
PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

LOCK KEY NUMBER: 3120

WELL CONSTRUCTION DIAGRAM

PROJ. NAME:	DTE Electric Company Belle River Power Plant	WELL ID:	**MW-16-05**
PROJ. NO: 231828.0003	DATE INSTALLED: 3/4/2016 INSTALLED BY: A. Knutson		CHECKED BY: C. Scieszka

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)	
590.82	2.5	TOP OF CASING
588.32	0.0	GROUND SURFACE
	1.0	CEMENT SURFACE PLUG
		GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
141.5		GROUT/BACKFILL METHOD: TREMIE
	128.0	GROUT
		BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	133.0	BENTONITE SEAL
449.3	139.0	TOP OF SCREEN
5.00		FILTER PACK MATERIAL: MEDIUM, WASHED SAND
444.3	144.0	BOTTOM OF SCREEN
	150.0	BOTTOM OF FILTER PACK
	NA	BENTONITE PLUG
		BACKFILL MATERIAL: WASHED SAND
444.3	150.0	HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 150 FT.
____ IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 300 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: GREY

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	144.03	T/PVC	3/4/2016	--
DTB AFTER DEVELOPING:	147.16	T/PVC	4/13/2016	9:55
SWL BEFORE DEVELOPING:	13.71	T/PVC	3/15/2016	--
SWL AFTER DEVELOPING:	14.13	T/PVC	3/18/2016	--
OTHER SWL:	16.87	T/PVC	4/13/2016	9:55
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

LOCK KEY NUMBER: 3120

REVISED 11/2013

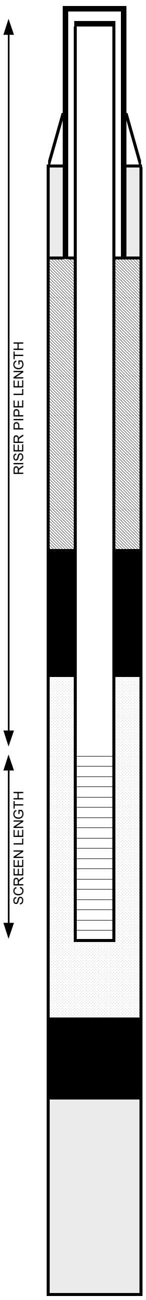
WELL CONSTRUCTION DIAGRAM

PROJ. NAME:	DTE Electric Company Belle River Power Plant	WELL ID:	**MW-16-06**
PROJ. NO: 231828.0003	DATE INSTALLED: 3/11/2016	INSTALLED BY: A. Knutson	CHECKED BY: C. Scieszka

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
593.21	3.2 TOP OF CASING
589.98	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
	GROUT/BACKFILL METHOD: TREMIE
	127.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	132.0 BENTONITE SEAL
455.0	135.0 TOP OF SCREEN
	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
450.0	140.0 BOTTOM OF SCREEN
	140.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: NA
450.0	140.0 HOLE BOTTOM

RISER PIPE LENGTH: 138.2

SCREEN LENGTH: 5.00



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 140 FT.
___ IN. FROM ___ TO ___ FT.

SURF. CASING DIAMETER: ___ IN. FROM ___ TO ___ FT.
___ IN. FROM ___ TO ___ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 50 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: BROWN /GREY

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NOT MEASURED

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	135.07	T/PVC	3/8/2016	--
DTB AFTER DEVELOPING:	142.85	T/PVC	4/13/2016	10:01
SWL BEFORE DEVELOPING:	19.62	T/PVC	3/15/2016	14:30
SWL AFTER DEVELOPING:	14.90	T/PVC	3/18/2016	7:30
OTHER SWL:	17.65	T/PVC	4/13/2016	10:01
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

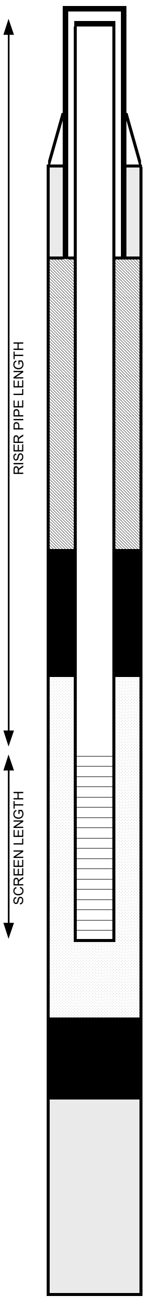
LOCK KEY NUMBER: 3120

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME: DTE Electric Company Belle River Power Plant		WELL ID:	**MW-16-07**
PROJ. NO: 231828.0003	DATE INSTALLED: 3/9/2016	INSTALLED BY: A. Knutson	CHECKED BY: C. Scieszka

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
592.58	2.7 TOP OF CASING
589.89	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
	GROUT/BACKFILL METHOD: TREMIE
135.7 (RISER PIPE LENGTH)	
	125.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	130.0 BENTONITE SEAL
456.9	133.0 TOP OF SCREEN
5.00 (SCREEN LENGTH)	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
451.9	138.0 BOTTOM OF SCREEN
	140.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: WASHED SAND
449.89	140.0 HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 140 FT.
___ IN. FROM ___ TO ___ FT.

SURF. CASING DIAMETER: ___ IN. FROM ___ TO ___ FT.
___ IN. FROM ___ TO ___ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 120 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: BROWN /GREY

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	138.02	T/PVC	3/9/2016	--
DTB AFTER DEVELOPING:	141.19	T/PVC	4/13/2016	11:56
SWL BEFORE DEVELOPING:	14.66	T/PVC	3/15/2016	--
SWL AFTER DEVELOPING:	14.25	T/PVC	3/18/2016	--
OTHER SWL:	16.83	T/PVC	4/13/2016	11:56
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

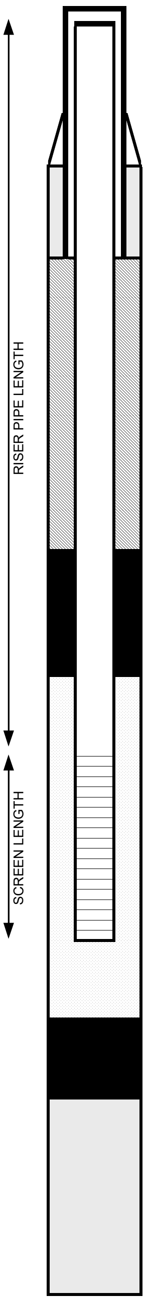
LOCK KEY NUMBER: 3120

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME:	DTE Electric Company Belle River Power Plant	WELL ID:	**MW-16-08**
PROJ. NO: 231828.0003	DATE INSTALLED: 3/10/2016	INSTALLED BY: A. Knutson	CHECKED BY: C. Scieszka

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)	
591.88	2.6	TOP OF CASING
589.31	0.0	GROUND SURFACE
	1.0	CEMENT SURFACE PLUG
		GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
		GROUT/BACKFILL METHOD: TREMIE
135.6 (RISER PIPE LENGTH)		
	125.0	GROUT
		BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	130.0	BENTONITE SEAL
456.3	133.0	TOP OF SCREEN
5.00 (SCREEN LENGTH)		FILTER PACK MATERIAL: MEDIUM, WASHED SAND
451.3	138.0	BOTTOM OF SCREEN
	140.0	BOTTOM OF FILTER PACK
	NA	BENTONITE PLUG
		BACKFILL MATERIAL: WASHED SAND
449.3	140.0	HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 140 FT.
___ IN. FROM ___ TO ___ FT.

SURF. CASING DIAMETER: ___ IN. FROM ___ TO ___ FT.
___ IN. FROM ___ TO ___ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4 HOURS

WATER REMOVED: 125 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: BROWN /GREY

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	137.94	T/PVC	3/11/2016	--
DTB AFTER DEVELOPING:	140.80	T/PVC	4/13/2016	12:00
SWL BEFORE DEVELOPING:	14.23	T/PVC	3/15/2016	14:30
SWL AFTER DEVELOPING:	14.23	T/PVC	3/18/2016	7:30
OTHER SWL:	15.79	T/PVC	4/13/2016	12:00
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

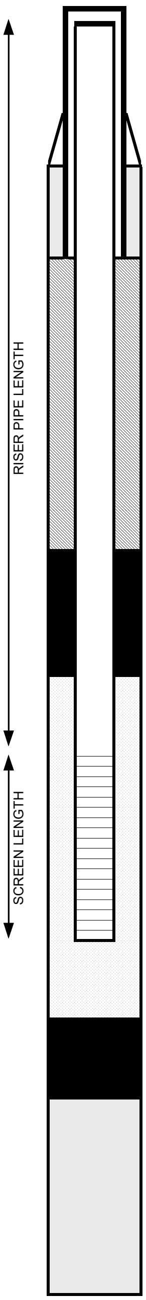
LOCK KEY NUMBER: 3120

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME: DTE Electric Company Belle River Power Plant		WELL ID:	**MW-16-09**
PROJ. NO: 231828.0003	DATE INSTALLED: 6/2/2016 INSTALLED BY: J. Reed	CHECKED BY: M. Powers	

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
590.80	2.5 TOP OF CASING
588.28	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
138.4	GROUT/BACKFILL METHOD: TREMIE
	130.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	133.0 BENTONITE SEAL
452.4	136.0 TOP OF SCREEN
5.00	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
447.4	141.0 BOTTOM OF SCREEN
	141.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: NATURAL COLLAPSE
438.4	150.0 HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 150 FT.
IN. FROM TO FT.

SURF. CASING DIAMETER: IN. FROM TO FT.
IN. FROM TO FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 7 HOURS

WATER REMOVED: 30 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: TURBID

COLOR BEFORE: GRAY

CLARITY AFTER: VERY TURBID

COLOR AFTER: GRAY

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	140.00	T/PVC	6/7/2016	12:00
DTB AFTER DEVELOPING:	140.00	T/PVC	6/8/2016	10:25
SWL BEFORE DEVELOPING:	7.00	T/PVC	6/7/2016	12:00
SWL AFTER DEVELOPING:	117.42	T/PVC	6/8/2016	10:25
OTHER SWL:	16.76	T/PVC	6/9/2016	15:13
OTHER DTB:	144.30	T/PVC	6/9/2016	15:13

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

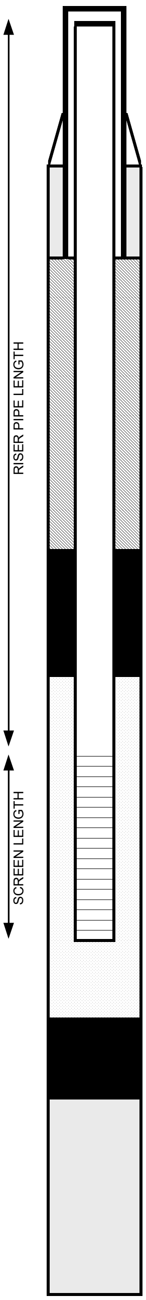
LOCK KEY NUMBER: 3120

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME: DTE Electric Company Belle River Power Plant		WELL ID:	**MW-16-10**
PROJ. NO: 231828.0003	DATE INSTALLED: 6/6/2016 INSTALLED BY: J. Reed	CHECKED BY: M. Powers	

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
592.26	3.0 TOP OF CASING
589.25	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
148.0	GROUT/BACKFILL METHOD: TREMIE
	137.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	142.0 BENTONITE SEAL
444.3	145.0 TOP OF SCREEN
5.00	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
439.3	150.0 BOTTOM OF SCREEN
	150.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: NA
439.3	150.0 HOLE BOTTOM



CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 150 FT.
IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 4.5 HOURS

WATER REMOVED: 85 GALLONS

WATER ADDED: 60 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: DARK GRAY

CLARITY AFTER: VERY TURBID

COLOR AFTER: DARK GRAY

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	151.30	T/PVC	6/9/2016	7:45
DTB AFTER DEVELOPING:	152.28	T/PVC	6/9/2016	16:50
SWL BEFORE DEVELOPING:	17.80	T/PVC	6/9/2016	7:45
SWL AFTER DEVELOPING:	59.44	T/PVC	6/9/2016	16:50
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

LOCK KEY NUMBER: 3120

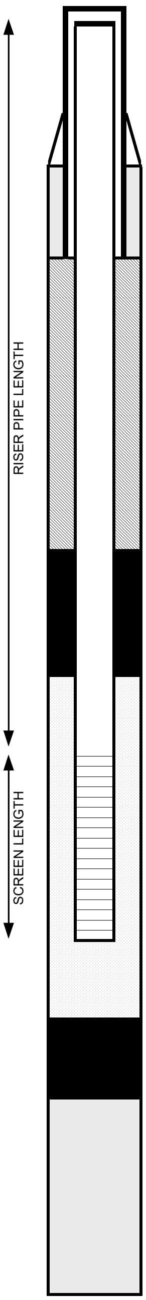
NOTES:

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME:	DTE Electric Company Belle River Power Plant	WELL ID:	**MW-16-11**
PROJ. NO: 231828.0003	DATE INSTALLED: 6/7/2016 INSTALLED BY: J. Reed		CHECKED BY: M. Powers

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
591.54	2.5 TOP OF CASING
589.03	0.0 GROUND SURFACE
	1.0 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
139.5	GROUT/BACKFILL METHOD: TREMIE
	130.0 GROUT
	BENTONITE SEAL MATERIAL: TIME RELEASE PELLETS
	135.0 BENTONITE SEAL
452.0	137.0 TOP OF SCREEN
5.00	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
447.0	142.0 BOTTOM OF SCREEN
	150.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: WASHED SAND
447.0	150.0 HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 150 FT.
___ IN. FROM ___ TO ___ FT.

SURF. CASING DIAMETER: ___ IN. FROM ___ TO ___ FT.
___ IN. FROM ___ TO ___ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 3 HOURS

WATER REMOVED: 84 GALLONS

WATER ADDED: 60 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: DARK GRAY

CLARITY AFTER: VERY TURBID

COLOR AFTER: GRAY

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	141.36	T/PVC	6/9/2016	12:35
DTB AFTER DEVELOPING:	142.00	T/PVC	6/9/2016	15:45
SWL BEFORE DEVELOPING:	9.65	T/PVC	6/9/2016	12:35
SWL AFTER DEVELOPING:	116.00	T/PVC	6/9/2016	15:45
OTHER SWL:	16.67	T/PVC	6/21/2016	7:45
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

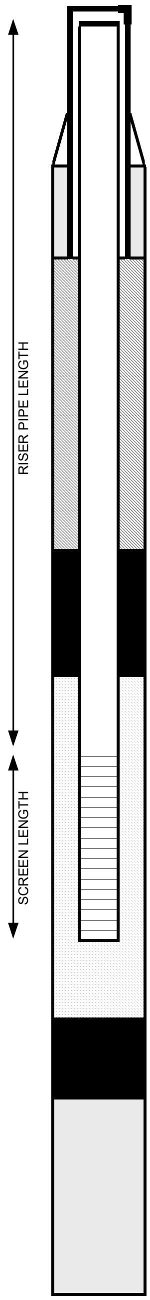
LOCK KEY NUMBER: 3120

REVISED 11/2013

WELL CONSTRUCTION DIAGRAM

PROJ. NAME: DTE Electric Company Belle River Power Plant		WELL ID:	**MW-16-11A**
PROJ. NO: 265996.0003	DATE INSTALLED: 5/12/2017 INSTALLED BY: Jake Krenz		CHECKED BY: C. Scieszka

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)
591.66	2.1 TOP OF CASING
589.52	0.0 GROUND SURFACE
	1.5 CEMENT SURFACE PLUG
	GROUT/BACKFILL MATERIAL: BENTONITE SLURRY
139.1	GROUT/BACKFILL METHOD: TREMIE
	131.5 GROUT
	BENTONITE SEAL MATERIAL: PELLETS
	134.0 BENTONITE SEAL
452.5	137.0 TOP OF SCREEN
5'	FILTER PACK MATERIAL: MEDIUM, WASHED SAND
447.5	142.0 BOTTOM OF SCREEN
	142.0 BOTTOM OF FILTER PACK
	NA BENTONITE PLUG
	BACKFILL MATERIAL: NA
447.52	142.0 HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SOLVENT USED? NO

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 6 IN. FROM 0 TO 142 FT.; NA IN. FROM NA TO NA FT.

SURF. CASING DIAMETER: NA IN. FROM NA TO NA FT.; NA IN. FROM NA TO NA FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: AIR LIFT

TIME DEVELOPING: 3 HOURS

WATER REMOVED: 110 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: Very Turbid

COLOR BEFORE: Dark Gray

CLARITY AFTER: Very Turbid

COLOR AFTER: Light Gray

ODOR (IF PRESENT): None

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	141.98	T/PVC	5/15/2017	0838
DTB AFTER DEVELOPING:	145.45	T/PVC	5/15/2017	1612
SWE BEFORE DEVELOPING:	17.79	T/PVC	5/15/2017	0838
SWE AFTER DEVELOPING:	90.12	T/PVC	5/15/2017	1612
OTHER SWE:		T/PVC		
OTHER SWE:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

LOCK KEY NUMBER: 3120

REVISED 06/2011

Appendix C
2019 Annual Groundwater Monitoring Report

2019 Annual Groundwater Monitoring Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins

4505 King Road
China Township, Michigan

January 2020

2019 Annual Groundwater Monitoring Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins

4505 King Road
China Township, Michigan

January 2020

Prepared For
DTE Electric Company

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

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

TRC | DTE Electric Company
Final
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Executive Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule), as amended July 30, 2018. The CCR Rule, which became effective on October 19, 2015 (amendment effective August 29, 2018), applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs) CCR unit. Pursuant to the CCR Rule, no later than January 31, 2018, and annually thereafter, the owner or operator of a CCR unit must prepare an annual groundwater monitoring and corrective action report for the CCR unit documenting the status of groundwater monitoring and corrective action for the preceding year in accordance with §257.90(e). On behalf of DTE Electric, TRC Engineers Michigan, Inc., the engineering entity of TRC Environmental Corporation (TRC), has prepared this Annual Groundwater Monitoring Report for calendar year 2019 activities at the BRPP BABs CCR unit.

The groundwater sampling results were below prediction limits for Appendix III indicator parameters during both the March and October 2018 semiannual monitoring events; therefore, no statistically significant increases (SSIs) were reported for the Belle River Power Plant Bottom Ash Basins (BRPP BABs) CCR unit. As such, DTE Electric continued detection monitoring at the BRPP BABs CCR Unit in 2019 pursuant to §257.94 of the CCR Rule.

The semiannual detection monitoring events for 2019 were completed in March and September 2019 and included sampling and analyzing groundwater within the groundwater monitoring system for the indicator parameters listed in Appendix III to the CCR Rule. As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify SSIs in detection monitoring parameters to determine if concentrations in detection monitoring well samples exceed prediction limits. Detection monitoring data that have been collected and evaluated in 2019 are presented in this report.

Potential SSIs over prediction limits were noted for a few Appendix III constituents in one or more downgradient wells during the March and September 2019 monitoring events. These potential SSIs were either not statistically significant (i.e. verification resampling did not confirm the exceedance) or were evaluated and determined to be a result of natural variability in groundwater quality as documented in an alternative source demonstration (ASD) and not attributable to the BRPP BABs CCR unit. With the very thick continuous silty clay-rich confining unit beneath the BRPP BABs CCR unit, it is not possible for the uppermost aquifer to have been affected by CCR from BRPP operations that began in the 1980s. Therefore, detection monitoring will be continued at the BRPP BABs CCR unit in accordance with §257.94 of the CCR Rule.

Section 1
Introduction

1.1 Program Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule), as amended July 30, 2018. The CCR Rule, which became effective on October 19, 2015 (amendment effective August 29, 2018), applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs). Pursuant to the CCR Rule, no later than January 31, 2018, and annually thereafter, the owner or operator of a CCR unit must prepare an annual groundwater monitoring and corrective action report for the CCR unit documenting the status of groundwater monitoring and corrective action for the preceding year in accordance with §257.90(e). On behalf of DTE Electric, TRC Engineers Michigan, Inc., the engineering entity of TRC Environmental Corporation (TRC), has prepared this Annual Groundwater Monitoring Report for calendar year 2019 activities at the BRPP BABs CCR unit (2019 Annual Report).

The groundwater sampling results were below background limits for Appendix III indicator parameters during both the March and October 2018 semiannual monitoring events; therefore, no statistically significant increases (SSIs) were reported for the Belle River Power Plant Bottom Ash Basins (BRPP BABs) CCR unit. As such, DTE Electric continued detection monitoring at the BRPP BABs CCR Unit in 2019 pursuant to §257.94 of the CCR Rule. This 2019 Annual Report presents the monitoring results and the statistical evaluation of the detection monitoring parameters (Appendix III to Part 257 of the CCR Rule) for the March and September 2019 semiannual groundwater monitoring events for the BRPP BABs CCR unit. Detection monitoring for these events continued to be performed in accordance with the *CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin* (QAPP) (TRC, July 2016; revised August 2017) and statistically evaluated per the Stats Plan (TRC, October 2017). As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify SSIs of detection monitoring parameters compared to background levels.

1.2 Site Overview

The BRPP is located in Section 13, Township 4 North, Range 16 East, at 4505 King Road, China Township in St. Clair County, Michigan. The BRPP was constructed in the early 1980s with plant operations beginning in 1984. Prior to Detroit Edison Company's operations commencing in the 1980s, 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 BABs have been in use with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR unit, which is monitored as a separate CCR unit in accordance with the CCR Rule and addressed in a separate 2019 Annual Report.

The DB is an incised CCR surface impoundment located east of the BRPP. Water flows into the DB from the North and South 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.

1.3 Geology/Hydrogeology

The BRPP BABs CCR unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet below ground surface (bgs). In general, the BRPP BABs CCR unit is initially underlain by at least 90 to as much as 136 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet within the monitoring well network and rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) to the southeast in the vicinity of SB-16-01 (Figure 1). Consequently, the uppermost aquifer is not laterally contiguous across the entire BRPP BABs CCR unit, and not present beneath the southeastern corner of the BABs.

The variability in the depth to the uppermost aquifer is a consequence of the heterogeneity of the glacial deposits and is driven by the lateral discontinuity of the sand outwash within the encapsulating fine-grained, silty clay till that confines the uppermost aquifer. There is an apparent lack of interconnection and/or significant vertical variation between the uppermost aquifer sand unit(s) encountered across the BRPP BABs CCR unit as demonstrated by the extensive amount of time (months) it took for water levels in monitoring well MW-16-02 to reach equilibrium after well construction and development (TRC, 2017).

Given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit, the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs, where present varying up to 46 feet vertically), the no flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area, and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the BRPP BABs CCR unit.

In addition, the elevation of CCR-affected water maintained within the BRPP BABs is approximately 5 feet above the potentiometric surface elevations in the uppermost aquifer at the BABs CCR unit area. This suggests that if the CCR affected surface water in the BABs were able to penetrate the silty clay-rich underlying confining unit that the head on that release likely would travel radially away from the BABs within the uppermost aquifer. However, with the very thick continuous silty clay-rich confining unit beneath the BRPP it is not possible for the uppermost aquifer to have been affected by CCR from BRPP operations that began in the 1980s.

Due to the relatively small footprint of the BABs, the low vertical and horizontal groundwater flow velocity, the potential for radial flow, and the fact that the saturated unit being monitored is isolated by a laterally contiguous silty-clay unit, which significantly impedes vertical groundwater flow thus preventing the monitored saturated zone from potentially being affected by CCR, monitoring of the BRPP BABs CCR unit using intrawell statistical methods is appropriate. In addition, because the uppermost aquifer is not uniformly present across the BABs CCR unit, there are no clear upgradient wells. As such, intrawell statistical approaches are being used during detection monitoring as discussed in the Stats Plan.

Section 2
Groundwater Monitoring

2.1 Monitoring Well Network

A groundwater monitoring system has been established for the BRPP BABs 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 BABs CCR unit currently consists of five monitoring wells that are screened in the uppermost aquifer. The monitoring well locations are shown on Figure 2.

As discussed in the Stats Plan, intrawell statistical methods for the BABs CCR unit were selected based on the geology and hydrogeology at the Site (primarily the presence of clay/hydraulic barrier, the variability in the presence of the uppermost aquifer across the site, and presence of no flow boundary on the southeast side of the aquifer), in addition to other supporting lines of evidence that the aquifer is unaffected by the CCR unit (such as the consistency in concentrations of water quality data). An intrawell statistical approach requires that each of the downgradient wells doubles as a background and compliance well, where data from each individual well during a detection monitoring event is compared to a statistical limit developed using the background dataset from that same well. Monitoring wells MW-16-01 through MW-16-04 and MW-16-09 are located around the north, east and south perimeter of the BABs and provide data on both background and downgradient groundwater quality that has not been affected by the CCR unit (total of five background/downgradient monitoring wells).

2.2 Semiannual Groundwater Monitoring

The semiannual monitoring parameters for the detection groundwater monitoring program were selected per the CCR Rule's Appendix III to Part 257 – Constituents for Detection Monitoring. The Appendix III indicator parameters consist of boron, calcium, chloride, fluoride, pH (field reading), sulfate, and total dissolved solids (TDS) and were analyzed in accordance with the sampling and analysis plan included within the QAPP. In addition to pH, the collected field parameters included dissolved oxygen, oxidation reduction potential, specific conductivity, temperature, and turbidity.

2.2.1 Data Summary

The first semiannual groundwater detection monitoring event for 2019 was performed during March 18 to 20, 2019 by TRC personnel and samples were analyzed by TestAmerica in accordance with the QAPP. Static water elevation data were collected at all five monitoring well locations. Groundwater samples were collected from the five detection monitoring wells for the Appendix III indicator parameters and field parameters. A summary of the groundwater data collected during the March 2019 event is provided on Table 1 (static groundwater elevation data), Table 2 (field data), and Table 3 (analytical results).

The second semiannual groundwater detection monitoring event for 2019 was performed during September 16 to 17, 2019 by TRC personnel and samples were analyzed by TestAmerica in accordance with the QAPP. Static water elevation data were collected at all five monitoring well locations. Groundwater samples were collected from the five detection monitoring wells for the Appendix III indicator parameters and field parameters. A summary of the groundwater data collected during the October 2018 event is provided on Table 1 (static groundwater elevation data), Table 2 (field data), and Table 4 (analytical results).

2.2.2 Data Quality Review

Data from each round were evaluated for completeness, overall quality and usability, method-specified sample holding times, precision and accuracy, and potential sample contamination. The data were found to be complete and usable for the purposes of the CCR monitoring program. Data quality reviews are summarized in Appendix B.

2.2.3 Groundwater Flow Rate and Direction

As presented in the GWMS Report, and mentioned above, given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit; the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs; where present, varying up to 46 feet vertically); the no flow boundary where no sand or gravel is present in the southeastern portion of the BRPP BABs CCR unit area; and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the site. Groundwater elevations measured across the Site during the March 2019 sampling event are provided on Table 1 and are summarized in plan view on Figure 3. Groundwater elevations measured across the Site during the September 2019 sampling event are provided on Table 1 and are summarized in plan view on Figure 4.

Groundwater elevation data collected during the 2019 sampling events show that groundwater conditions within the uppermost aquifer are consistent with previous monitoring events and continue to demonstrate that the downgradient wells are appropriately positioned to detect the presence of Appendix III parameters that could potentially migrate from the BRPP BABs CCR unit.

Section 3
Statistical Evaluation

3.1 Establishing Background Limits

Per the Stats Plan, background limits were established for the Appendix III indicator parameters following the collection of at least eight background monitoring events using data collected from each of the five established detection monitoring wells (MW-16-01 through MW-16-04 and MW-16-09). The statistical evaluation of the background data is presented in the 2017 Annual Report. The Appendix III background limits for each monitoring well will be used throughout the detection monitoring period to determine whether groundwater has been impacted from the BRPP BABs CCR unit by comparing concentrations in the detection monitoring wells to their respective background limits for each Appendix III indicator parameter.

3.2 Data Comparison to Background Limits – First Semiannual Event (March 2019)

The concentrations of the indicator parameters in each of the detection monitoring wells (MW-16-01 through MW-16-04 and MW-16-09) were compared to their respective statistical background limits calculated from the background data collected from each individual well (i.e., monitoring data from MW-16-01 is compared to the background limit developed using the background dataset from MW-16-01, and so forth).

The comparisons of the March 2019 monitoring event data to background limits are presented on Table 3. The statistical evaluation of the March 2019 Appendix III indicator parameters showed potential initial SSIs over background for:

- Total dissolved solids (TDS) at MW-16-01; and
- Sulfate at MW-16-04.

3.3 Verification Resampling for the First Semiannual Event

Verification resampling is recommended per the Stats Plan and the *USEPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (Unified Guidance, USEPA, 2009) to achieve performance standards as specified by §257.93(g) in the CCR Rule. Per the Stats Plan, if there is an exceedance of a prediction limit for one or more of the parameters, the well(s) of concern will be resampled within 30 days of the completion of the initial statistical analysis. Only constituents that initially exceed their statistical limit (i.e., have no previously recorded SSIs) will be analyzed for verification purposes.

Verification resampling for the March 2019 event was conducted on May 9, 2019 by TRC personnel. Groundwater samples were collected for total dissolved solids at MW-16-01 and sulfate at MW-16-04, In accordance with the QAPP. A summary of the analytical results collected during the May 2019 resampling event is provided on Table 3. The associated data quality review is included in Appendix A.

The verification results for TDS (MW-16-01) and sulfate (MW-16-04) are above the prediction limits, consequently the initial potential SSIs from the March 2019 event are confirmed at these locations.

According to §257.94(e), in the event that the facility determines, pursuant to §257.93(h), that there is a SSI over background levels for one or more of the Appendix III constituents, the facility will, within 90 days of detecting a SSI, demonstrate that a source other than the CCR unit caused the SSI, or the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. If an alternate source demonstration (ASD) is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under §257.95. If an ASD is completed, a certification from a qualified professional engineer is required, and the CCR unit may continue with detection monitoring. The facility must also include the ASD in the annual groundwater monitoring and corrective action report required by §257.90(e), in addition to the certification by a qualified professional engineer.

DTE Electric prepared an ASD dated August 8, 2019, *Alternate Source Demonstration: 2019 First Semi Annual Detection Monitoring Sampling Event Bell River Power Plant Coal Combustion Residual Bottom Ash Basins* (April 2019 ASD). This ASD demonstrates that the SSIs confirmed above are from natural variability in groundwater quality and not from a release of the BRPP BABs CCR unit and is provided in Appendix A. As such, detection monitoring continued at the BRPP BABs CCR unit in 2019.

3.4 Data Comparison to Background Limits – Second Semiannual Event (September 2019)

The concentrations of the indicator parameters in each of the detection monitoring wells (MW-16-01 through MW-16-04 and MW-16-09) were compared to their respective statistical background limits calculated from the background data collected from each individual well (i.e., monitoring data from MW-16-01 is compared to the background limit developed using the background dataset from MW-16-01, and so forth).The comparisons of the September 2019 monitoring event are presented on Table 4. The statistical evaluation of the September 2019 Appendix III indicator parameters showed potential initial SSIs over background for:

- Calcium at MW-16-03;

- Chloride at MW-16-03; and
- Sulfate at MW-16-04

The sulfate concentration at MW-16-04 is a continued exceedance of the prediction limit that has been demonstrated to be from natural variability and is not from a release from the CCR unit as presented in the August 2019 ASD (Appendix A).

3.5 Verification Resampling for the Second Semiannual Event

Verification resampling for the September 2019 event was conducted on November 11, 2019 by TRC personnel. Groundwater samples were collected for calcium and chloride at MW-16-03, in accordance with the QAPP. A summary of the analytical results collected during the November 2019 resampling event is provided on Table 4. The associated data quality review is included in Appendix B.

The calcium and chloride verification results are below the prediction limits, consequently the initial potential SSIs from the September 2019 event are not confirmed. Therefore, in accordance with the Stats Plan and the Unified Guidance, the initial exceedances are not statistically significant, and no SSIs will be recorded for the September 2019 monitoring event.

Section 4
Conclusions and Recommendations

Potential SSIs over background limits were noted for a few Appendix III constituents in one or more downgradient wells during the March and September 2019 monitoring events. These potential SSIs were either not statistically significant (i.e. verification sampling did not confirm the exceedance) or were evaluated and determined to be a result of natural variability in groundwater quality as documented in an ASD (Appendix A) and not attributable to the BRPP BABs CCR unit. As discussed above and in the GWMS Report, with the presence of the vertically and horizontally extensive clay-rich confining till beneath the BRPP BABs CCR unit, it is not possible for the uppermost aquifer to have been affected by CCR from operations. In addition, due to limitations on CCR Rule implementation timelines, the background data sets are of relatively short duration for capturing the occurrence of natural temporal changes in the aquifer. Therefore, detection monitoring will be continued at the BRPP BABs CCR unit in accordance with §257.94. No corrective actions were performed in 2019. The next semiannual monitoring event is scheduled for the second calendar quarter of 2020.

Section 5
Groundwater Monitoring Report Certification

The U.S. EPA's Disposal of Coal Combustion Residuals from Electric Utilities Final Rule Title 40 CFR Part 257 §257.90(e) requires that the owner or operator of an existing CCR unit prepare an annual groundwater monitoring and corrective action report.

Annual Groundwater Monitoring Report Certification
Belle River Power Plant Bottom Ash Basins
China Township, Michigan

CERTIFICATION

I hereby certify that the annual groundwater and corrective action report presented within this document for the BRPP BABs CCR unit has been prepared to meet the requirements of Title 40 CFR §257.90(e) of the Federal CCR Rule. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.90(e).

Name: David B. McKenzie, P.E.	Expiration Date: October 31, 2021	State of Michigan David B. McKenzie Engineer No. 42332 Licensed Professional Engineer
Company: TRC Engineers Michigan, Inc.	Date: January 30, 2020	Stamp

Section 6
References

TRC Environmental Corporation. July 2016; Revised March and August 2017. CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. October 2017. Groundwater Monitoring System Summary Report – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin Coal Combustion Residual Units, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. October 2017. Groundwater Statistical Evaluation Plan – DTE Electric Company Belle River Power Plant Coal Combustion Residual Bottom Ash Basins, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. January 2018. Annual Groundwater Monitoring Report – DTE Electric Company Belle River Power Plant Bottom Ash Basins, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. April 12, 2018. Alternate Source Demonstration: 2017 Initial Detection Monitoring Sampling Event Belle River Power Plant Coal Combustion Residual Bottom Ash Basins. Prepared for DTE Electric Company.

TRC Environmental Corporation. August 8, 2019. Alternate Source Demonstration: 2019 First Semi Annual Detection Monitoring Sampling Event Belle River Power Plant Coal Combustion Residual Bottom Ash Basins. Prepared For DTE Electric Company.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA facilities, Unified Guidance. Office of Conservation and Recovery. EPA 530/R-09-007.

USEPA. April 2015. 40 CFR Parts 257 and 261. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. 80 Federal Register 74 (April 17, 2015), pp. 21301-21501 (80 FR 21301).

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(Venable LLP). Re: Coal Combustion Residuals Rule Groundwater Monitoring Requirements. April 30, 2018. United States Environmental Protection Agency, Washington, D.C. 20460. Office of Solid Waste and Emergency Response, now the Office of Land and Emergency Management.

Tables

Table 1
Summary of Groundwater Elevation Data – March and September 2019
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Date Installed	3/17/2016		3/15/2016		6/1/2016		3/8/2016		6/2/2016	
TOC Elevation	590.06		588.94		590.66		590.51		590.80	
Geologic Unit of Screened Interval	Sand		Sand		Silty Sand		Sand		Sand	
Screened Interval Elevation	496.3 to 491.3		494.3 to 489.3		456.0 to 451.0		468.5 to 463.5		452.3 to 447.3	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
3/18/2019	15.88	574.18	13.40	575.54	16.27	574.39	16.64	573.87	16.46	574.34
9/16/2019	15.88	574.18	13.38	575.56	16.16	574.50	16.53	573.98	16.35	574.45

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing.

Table 2
Summary of Field Data – March and September 2019
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (SU)	Specific Conductivity (umhos/cm)	Temperature (deg C)	Turbidity (NTU)
MW-16-01	3/18/2019	0.17	-134.9	7.6	1,822	10.30	2.42
	9/16/2019	0.16	-172.1	7.6	1,614	13.44	2.06
MW-16-02	3/18/2019	1.34	-116.3	7.6	1,428	10.90	2.13
	9/16/2019	0.33	-167.1	7.5	1,267	15.49	1.57
MW-16-03	3/18/2019	1.14	-163.4	7.9	2,088	10.50	1.13
	9/16/2019	0.16	-194.2	7.6	1,840	14.89	0.96
MW-16-04	3/18/2019	1.34	-168.7	7.9	1,899	10.00	45.3
	9/16/2019	0.14	-211.2	7.8	1,676	16.06	50.2
MW-16-09	3/20/2019	1.17	-237.8	8.0	2,933	10.80	68.7
	9/17/2019	0.14	21.1	8.0	2,994	14.34	120

Notes:
mg/L - milligrams per liter.
mV - milliVolt.
SU - standard unit.
umhos/cm - micro-mhos per centimeter.
deg C - degrees Celcius.
NTU - nephelometric turbidity units.

Table 3
Comparison of Appendix III Parameter Results to Background Limits – March and May 2019
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01			MW-16-02		MW-16-03		MW-16-04			MW-16-09	
Sample Date:		3/18/2019	5/9/2019(1)	PL	3/18/2019	PL	3/18/2019	PL	3/18/2019	5/9/2019(1)	PL	3/20/2019	PL
Constituent	Unit	Data			Data		Data		Data			Data	
Appendix III													
Boron	ug/L	1,200	--	1,300	1,200	1,300	1,200	1,300	1,000	--	1,100	1,600	1,900
Calcium	ug/L	41,000	--	45,000	54,000	59,000	33,000	36,000	42,000	--	64,000	32,000	41,000
Chloride	mg/L	480	--	530	370	400	570	690	500	--	520	960	1,100
Fluoride	mg/L	1.6	--	1.9	1.1	1.3	1.6	1.9	1.6	--	1.9	1.3	1.8
pH, Field	SU	7.6	7.7	7.6 - 8.1	7.6	7.4 - 8.0	7.9	7.5 - 8.3	7.9	7.7	7.5 - 8.4	8.0	7.7 - 8.7
Sulfate	mg/L	5.8	--	8.1	4.8	20	2.4	14	**27**	**24(2)**	18	18	40
Total Dissolved Solids	mg/L	**960**	**970(2)**	950	730	890	1,100	1,100	990	**--**	1,100	1,700	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

All metals were analyzed as total unless otherwise specified.

Bold font indicates an exceedance of the Prediction Limit (PL).

RESULT Shading and bold font indicates a confirmed exceedance of the Prediction Limit (PL).

(1) - Results shown for verification sampling performed on 5/9/2019.

(2) - New successful alternative source demonstration was completed following confirmation of the initial statistically significant exceedance.

Table 4
Comparison of Appendix III Parameter Results to Background Limits – September and November 2019
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01		MW-16-02		MW-16-03			MW-16-04		MW-16-09	
Sample Date:		9/16/2019	PL	9/16/2019	PL	9/16/2019	11/11/2019(1)	PL	9/16/2019	PL	9/17/2019	PL
Constituent	Unit	Data		Data		Data			Data		Data	
Appendix III												
Boron	ug/L	1,000	1,300	1,100	1,300	1,100	--	1,300	1,000	1,100	1,500	1,900
Calcium	ug/L	43,000	45,000	58,000	59,000	**38,000**	20,000	36,000	47,000	64,000	37,000	41,000
Chloride	mg/L	460	530	350	400	**1,000**	600	690	480	520	920	1,100
Fluoride	mg/L	1.8	1.9	1.1	1.3	1.8	--	1.9	1.7	1.9	1.4	1.8
pH, Field	SU	7.6	7.6 - 8.1	7.5	7.4 - 8.0	7.6	7.8	7.5 - 8.3	7.8	7.5 - 8.4	8.0	7.7 - 8.7
Sulfate	mg/L	7.5	8.1	5.8	20	1.7	--	14	**20**(2)	18	12	40
Total Dissolved Solids	mg/L	950	950	770	890	1,000	--	1,100	970	1,100	1,800	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

-- = not analyzed.

All metals were analyzed as total unless otherwise specified.

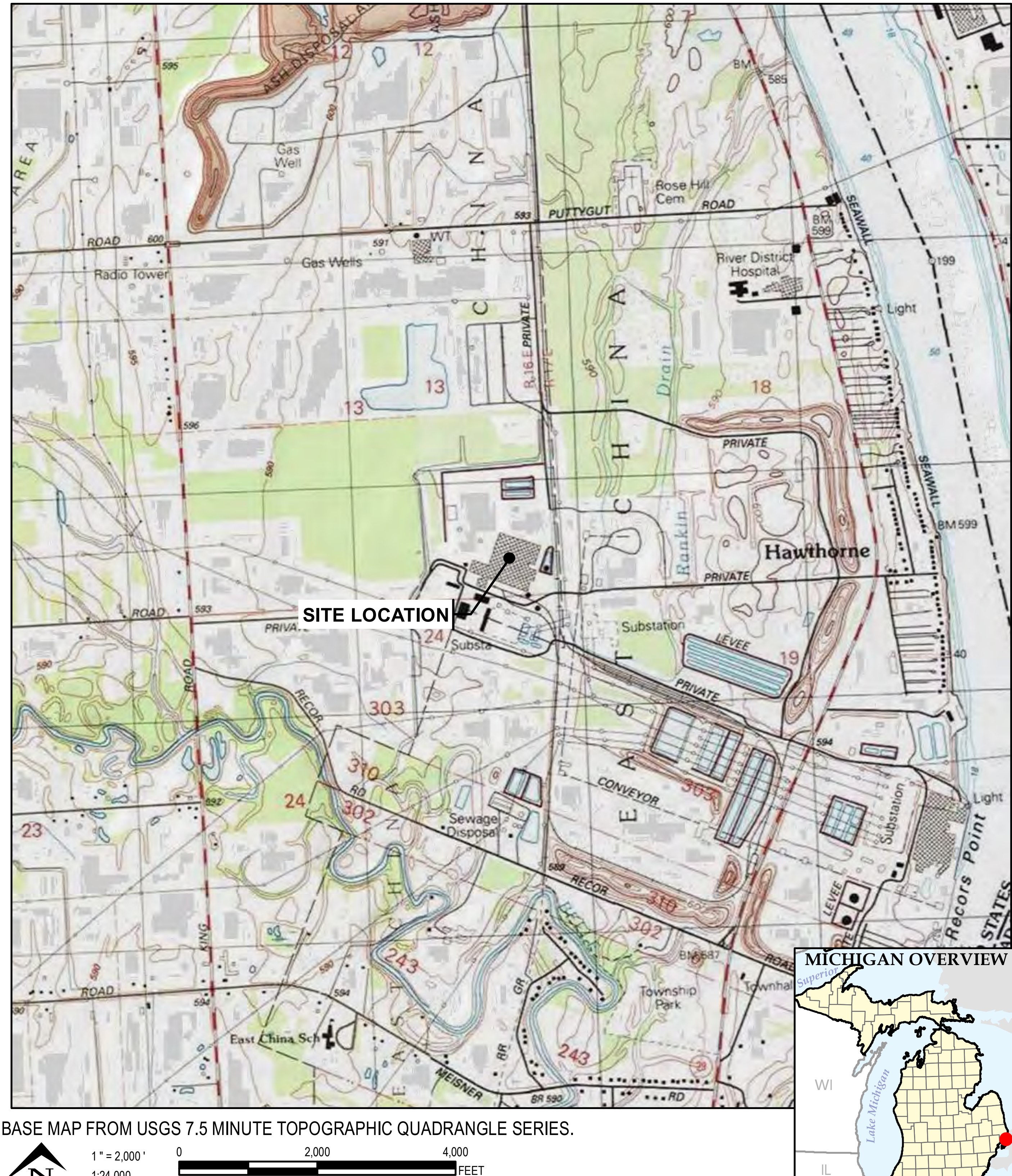
Bold font indicates an exceedance of the Prediction Limit (PL).

RESULT Shading and bold font indicates a confirmed exceedance of the Prediction Limit (PL).

(1) - Results shown for verification sampling performed on 11/11/2019.

(2) - Concentration addressed through first 2019 Semiannual alternative source demonstration.

Figures



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '

1:24,000

0 2,000 4,000 FEET

TRC

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

TRC - GIS

PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN
TITLE:	SITE LOCATION MAP

DRAWN BY:	S. MAJOR
CHECKED BY:	J. KRENZ
APPROVED BY:	V. BUENING
DATE:	JANUARY 2020
PROJ. NO.:	320511.0003
FILE:	320511-0003-003slmMB.mxd

FIGURE 1

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/28/2020, 08:56:04 AM by MVAPHIADIS -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\320511-0003-022.mxd

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO. & PARTNERS, (3/24/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, JUNE 2016, AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT BOTTOM ASH BASIN 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN		
TITLE:	SITE PLAN		
DRAWN BY:	M. VAPHIADIS	PROJ NO.:	320511.0003.0000 P1 T1
CHECKED BY:	J. KRENZ	FIGURE 2	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2020		

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FILE NO.: 320511-0003-022.mxd

Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3

LEGEND

SOIL BORING

MONITORING WELL

DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, (3/23/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT BOTTOM ASH BASIN
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY MARCH 2019

DRAWN BY:	M. VAPHIADIS	PROJ NO.:	320511.0003
CHECKED BY:	J. KRENZ		
APPROVED BY:	V. BUENING	FIGURE 3	
DATE:	JANUARY 2020		

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Phone: 734.971.7080
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FILE NO.: 320511-0003-023.mxd

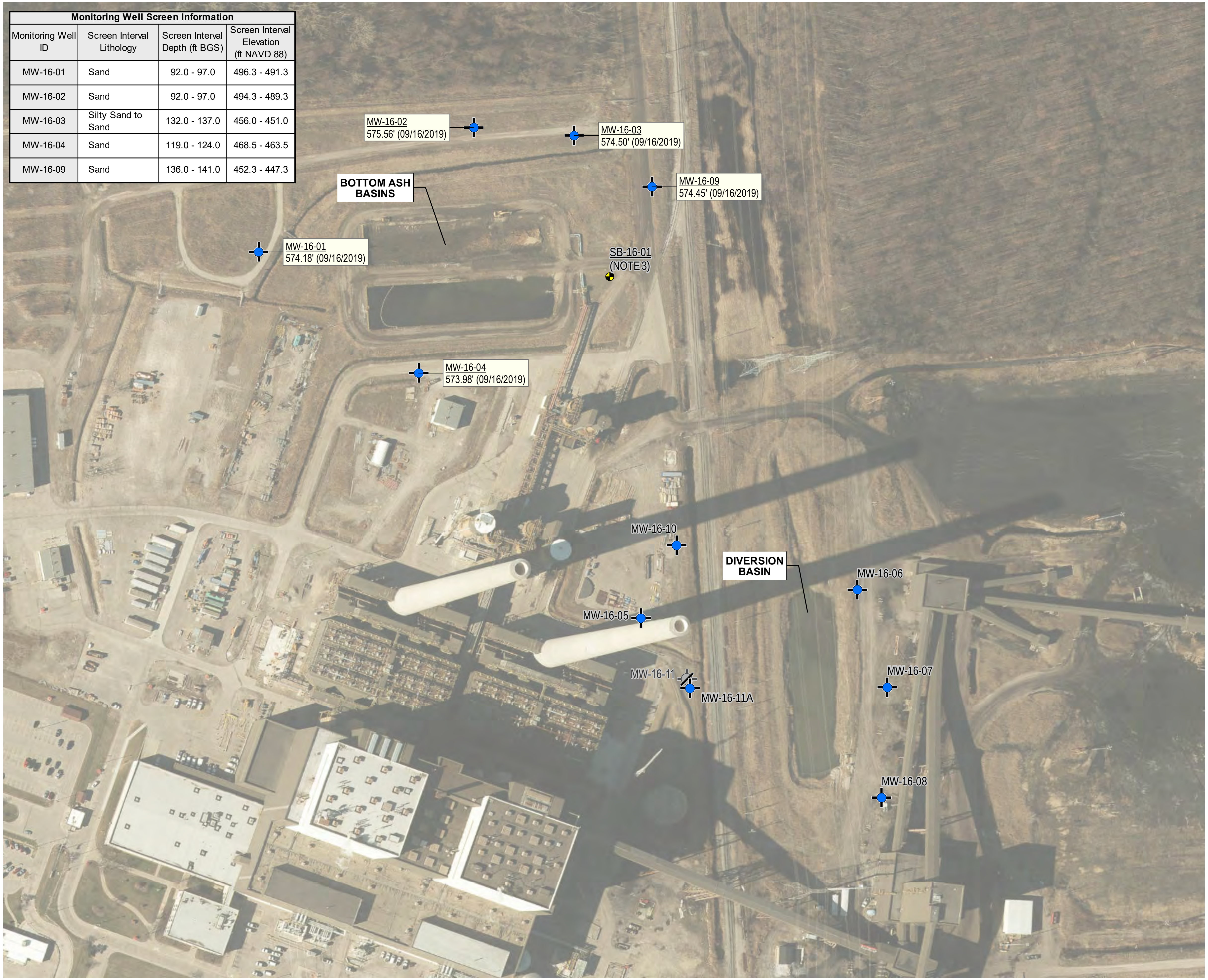
TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/28/2020, 09:00:10 AM by MVAPHIADIS -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\320511-0003-023.mxd

Monitoring Well Screen Information

Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

- SOIL BORING
- MONITORING
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, (3/23/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT BOTTOM ASH BASIN
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY SEPTEMBER 2019

DRAWN BY:	M. VAPHIADIS	PROJ NO.:	320511.0003
CHECKED BY:	J. KRENZ		
APPROVED BY:	V. BUENING		**FIGURE 4**
DATE:	JANUARY 2020		

TRC
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Phone: 734.971.7080
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FILE NO.: 320511-0003-024.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/28/2020, 09:03:29 AM by MVAPHIADIS -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\320511-0003-024.mxd

Appendix A
Alternative Source Demonstration: First 2019 Semiannual Detection Monitoring Sampling Event

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Technical Memorandum

Date: August 8, 2019

To: Christopher P. Scieszka
DTE Electric Company

From: Graham Crockford, TRC
David McKenzie, TRC

Project No.: 320511.0003.0000 Phase 001, Task 001

Subject: Alternate Source Demonstration: 2019 First Semi Annual Detection Monitoring Sampling Event Belle River Power Plant Coal Combustion Residual Bottom Ash Basins

Introduction

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule). The CCR Rule, which became effective on October 19, 2015, applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs) CCR unit.

TRC Engineers Michigan, Inc. (TRC) conducted the first semiannual 2019 detection monitoring event for the BRPP BABs CCR unit on behalf of DTE Electric on March 18 through March 20, 2019 in accordance with the *CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin* (QAPP) (TRC, July 2016; revised March and August 2017). The semiannual groundwater monitoring event included the statistical evaluation of the detection monitoring parameters (Appendix III to Part 257 of the CCR Rule) for the BRPP BABs CCR unit. This event is the fourth detection monitoring event performed to comply with §257.94. As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify statistically significant increases (SSIs) in detection monitoring parameters to determine if concentrations in detection monitoring well samples exceed background levels. The statistical analysis was performed pursuant to §257.93(f) and (g), and in accordance with the Groundwater Statistical Evaluation Plan (Stats Plan) (TRC, 2017).

The statistical evaluation of the March 2019 Appendix III indicator parameters showed potential SSIs over background for:

- Total Dissolved Solids (TDS) at MW-16-01; and
- Sulfate at MW-16-04

All other Appendix III constituents were within the statistical background limits.

In accordance with §257.94(3)(2), DTE Electric may demonstrate that a source other than the CCR unit caused the SSI or that the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. This Alternate Source Demonstration (ASD) has been prepared to evaluate the potential SSIs identified in the March 2019 detection monitoring event.

Background

The BRPP is located in China Township in St. Clair County, Michigan. The site location is shown in Figure 1. The BRPP was constructed in the early 1980s with plant operations beginning in 1984. 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 BABs have been in use with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB gravity flows over an outlet weir to a conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR unit, which is monitored as a separate CCR unit in accordance with the CCR Rule.

The BRPP BABs CCR unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet below ground surface (bgs). In general, the BRPP BABs CCR unit is initially underlain by at least 90 to as much as 136 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet within the monitoring well network and rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) to the southeast. Consequently, the uppermost aquifer is not laterally contiguous across the entire BRPP BABs CCR unit, and not present in the southeastern corner of the BABs.

The detection monitoring well network for the BABs CCR unit currently consists of five monitoring wells that are screened in the uppermost aquifer. As discussed in the Stats Plan, intrawell statistical methods for the BABs CCR unit were selected based on the geology and hydrogeology at the Site (primarily the presence of clay/hydraulic barrier, the variability in the presence of the uppermost aquifer across the site, and presence of no flow boundary on the southeast side of the aquifer), in addition to other supporting lines of evidence that the aquifer is unaffected by the CCR unit (such as the consistency in concentrations of water quality data). Monitoring wells MW-16-01 through MW-16-04 and MW-16-09 are located around the north, east and south perimeter of the BABs and provide data on both background and downgradient groundwater quality that has not been affected by the CCR unit (total of five background/downgradient monitoring wells). The monitoring well locations are shown in Figure 2. 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) details the groundwater monitoring system (TRC, October 2017).

Alternate Source Demonstration

Verification resampling was performed as recommended per the Stats Plan and the USEPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance (Unified Guidance, USEPA, 2009) to achieve performance standards as specified by §257.93(g) in the CCR rules. Per the Stats Plan, if there is an exceedance of a prediction limit for one or more of the parameters, the well(s) of concern will be resampled within 30 days of the completion of the initial statistical analysis. Only constituents that initially exceed their statistical limit (i.e., have no previously recorded SSIs) will be analyzed for verification purposes. As such, verification resampling was conducted on May 9, 2019, by TRC personnel. Groundwater samples were collected for TDS at monitoring well MW-16-01 and sulfate at monitoring well MW-16-04 in accordance with the Quality Assurance Project Plan (TRC, July 2016, revised in March and August 2017). A summary of the groundwater data collected during the verification resampling event is provided on Table 1. The associated data quality review is included in Attachment A.

The verification resampling confirmed the TDS exceedance at MW-16-01 and the sulfate exceedance at MW-16-04 during the May 2019 verification sampling event. The following discussion presents the ASD for the confirmed prediction limit exceedances.

TDS at MW-16-01: The TDS concentrations at MW-16-01, shown graphically as data points greater than the prediction limit in Figure 3, are likely the result of natural spatial variability in groundwater quality at the site and a statistical false positive, and not the result of a release from the BRPP BABs CCR unit. Multiple lines of evidence are provided in support of this conclusion and are as follows:

- **Spatial variability in groundwater quality** – After 8 background sampling events, the prediction limits calculated for each of the 5 monitoring wells range from 890 mg/L to 2,000 mg/L. This variability in groundwater quality across the site, shows that the TDS concentrations vary spatially throughout the uppermost aquifer and suggests the confirmed TDS SSI at MW-16-01 could be attributed to spatial variability rather than the CCR unit.
- **Insufficient background sampling timeline to account for long-term trends** – Variability in TDS concentrations observed in the groundwater at BRPP BABs CCR unit during the background sampling events provides evidence of the heterogeneity of this constituent in groundwater. The short duration of the background sampling events limits the ability of the statistical analysis to capture the natural temporal trends in the groundwater quality at the BRPP BABs CCR unit. This is a limitation of the CCR Rule implementation timeline.

- **Lack of similar increase in other indicator parameters** – The lack of SSIs for any other parameters within the same monitoring well, and across the other wells within the monitoring well network, also suggests a source other than CCR leachate for the observed TDS SSI at this location.
- **Time of travel analysis** – The clay formation immediately beneath the BRPP BABs CCR unit provides a natural geologic barrier to migration of CCR constituents to the underlying aquifer. The vertical extent of the clay layer beneath the CCR unit is shown in Figures 6 and 7 as cross-sections. Figure 5 shows the cross-section locations in plan view. Conservatively calculating a time of travel for liquid from the base of the BRPP BABs CCR unit through a minimum of 82 feet of clay, to the underlying upper aquifer, yields approximately 1,300 years of travel time (TRC, October 2017). The BRPP BABs CCR unit began accepting coal ash in approximately 1984, so, based on this analysis, there is no potential for indicator parameters to have migrated to the upper aquifer.

Sulfate at MW-16-04: The sulfate concentrations at MW-16-04, shown graphically as data points greater than the prediction limit in Figure 4, are likely the result of natural spatial variability in groundwater quality at the site and a statistical false positive, and not the result of a release from the BRPP BABs CCR unit. Multiple lines of evidence are provided in support of this conclusion and are as follows:

- **Spatial variability in groundwater quality** – After 8 background sampling events, the prediction limits calculated for each of the 5 monitoring wells range from 8.1 mg/L to 40 mg/L. This variability in groundwater quality across the site, shows that the sulfate concentrations vary spatially throughout the uppermost aquifer and suggests the confirmed sulfate SSI at MW-16-04 could be attributed to spatial variability rather than the CCR unit.
- **Insufficient background sampling timeline to account for long-term trends** – Variability in sulfate concentrations observed in the groundwater at BRPP during the background sampling events provides evidence of the heterogeneity of this constituent in groundwater. The short duration of the background sampling events limits the ability of the statistical analysis to capture the natural temporal trends in the groundwater quality at the BRPP. This is a limitation of the CCR Rule implementation timeline.
- **Lack of similar increase in other indicator parameters** – The lack of SSIs for any other parameters within the same monitoring well, and across the other wells within the monitoring well network, also suggests a source other than CCR leachate for the observed sulfate SSI at this location.
- **Time of travel analysis** – The clay formation immediately beneath the BRPP BABs CCR unit provides a natural geologic barrier to migration of CCR constituents to the underlying aquifer. The vertical extent of the clay layer beneath the CCR unit is shown in Figures 6 and 7 as cross-sections. Figure 5 shows the cross-section locations in plan view. Conservatively calculating a time of travel for liquid from the base of the BRPP BABs CCR unit through a minimum of 82 feet of clay, to the underlying upper aquifer, yields approximately 1,300 years of travel time (TRC, October 2017). The BRPP BABs CCR unit began accepting coal ash in approximately 1984, so,

based on this analysis, there is no potential for indicator parameters to have migrated to the upper aquifer.

Conclusions and Recommendations

The information provided in this report serves as the ASD for the DTE Electric BRPP BABs CCR unit, was prepared in accordance with 40 CFR 257.94(e)(2) of the CCR Rule, and demonstrates that the TDS SSI and sulfate SSI determined based on the first semiannual detection monitoring event performed in 2019 are not due to a release of CCR leachate into the groundwater. Therefore, based on the information provided in this ASD, DTE Electric will continue detection monitoring as per 40 CFR 257.94 at the BRPP BABs CCR unit.

Certification Statement

I hereby certify that the alternative source demonstration presented within this document for the BRPP BAB CCR unit has been prepared to meet the requirements of Title 40 CFR §257.94(e) 2 of the Federal CCR Rule. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.94(e) 2.

Name: David B. McKenzie, P.E.	Expiration Date: October 31, 2019	State of Michigan David B. McKenzie Engineer No. 42332 Licensed Professional Engineer
Company: TRC Engineers Michigan, Inc.	Date: 8/8/19	Stamp

References

TRC Environmental Corporation. July 2016; Revised March and August 2017. CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. October 2017. Groundwater Monitoring System Summary Report – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin Coal Combustion Residual Units, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. October 2017. Groundwater Statistical Evaluation Plan – DTE Electric Company Belle River Power Plant Coal Combustion Residual Bottom Ash Basins, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA facilities, Unified Guidance. Office of Conservation and Recovery. EPA 530/R-09-007.

Attachments

Table 1. Comparison of Verification Sampling Results to Background Limits

Figure 1. Site Location Map
Figure 2. Monitoring Network and Site Plan
Figure 3. MW-16-01 TDS Time Series Plot
Figure 4. MW-16-04 Sulfate Time Series Plot
Figure 5. Cross Section Locator Map
Figure 6. Generalized Geologic Cross-Section A-A′
Figure 7. Generalized Geologic Cross-Section B-B′

Attachment A. Data Quality Review

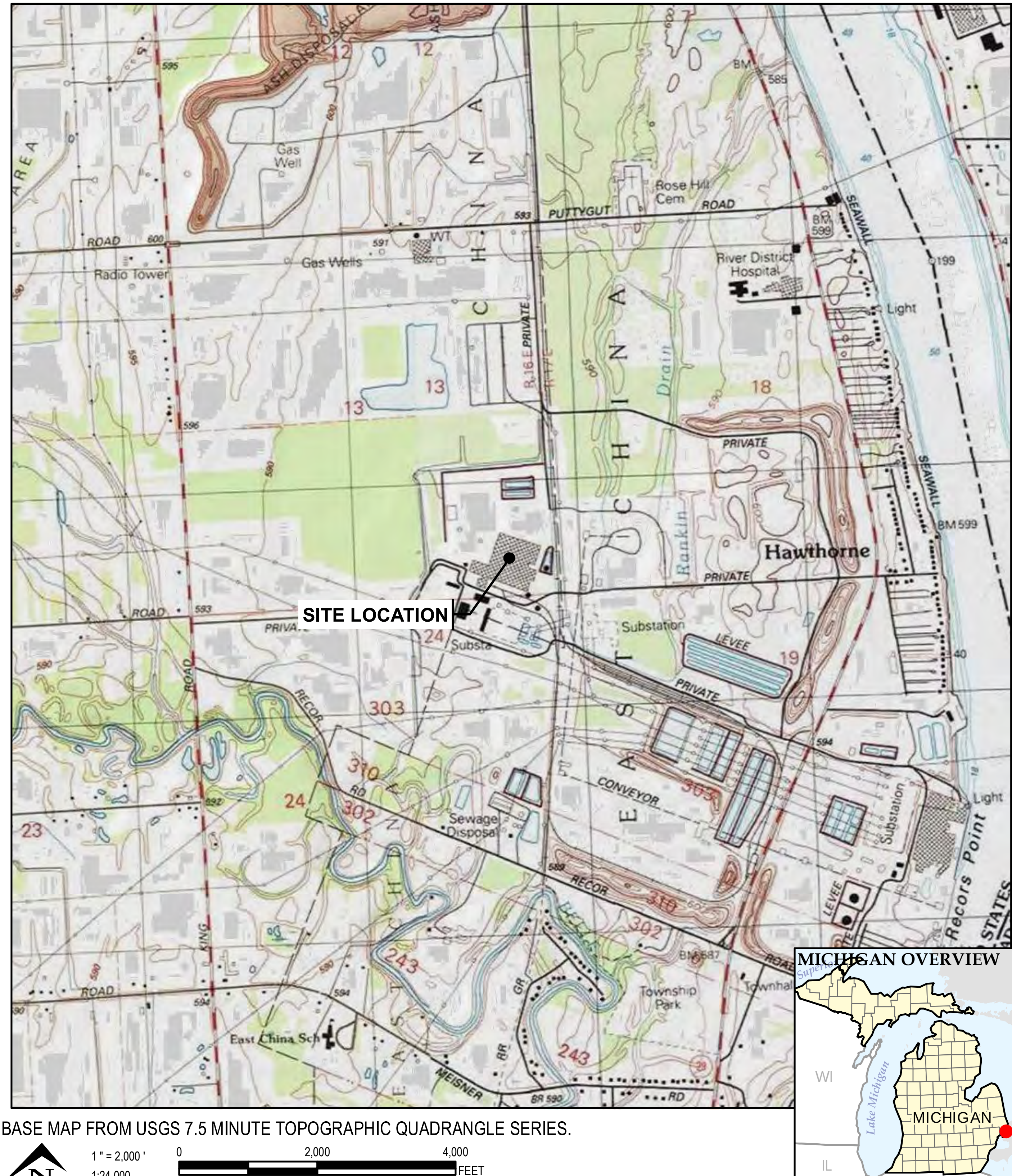
Table 1

Table 1
Comparison of Verification Sampling Results to Background Limits
Belle River Power Plant BABs - RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		**MW-16-01**		**MW-16-04**	
Sample Date:		5/9/2019		5/9/2019	
Constituent	Unit	Data	PL	Data	PL
Appendix III					
Sulfate	mg/L	--	8.1	**24**	18
Total Dissolved Solids	mg/L	**970**	950	--	1,100

Notes:
mg/L - milligrams per liter.
RESULT Shading and bold font indicates a confirmed exceedance of the Prediction Limit (PL).

Figures



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

TRC 1540 Eisenhower Place Ann Arbor, MI 48108-3284 Phone: 734.971.7080	PROJECT: **DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN**	DRAWN BY:	J PAPEZ
		CHECKED BY:	S HOLMSTROM
		APPROVED BY:	V BUENING
		DATE:	AUGUST 2019
	TITLE: **SITE LOCATION MAP**	PROJ. NO.:	320511.0003.0000 P1 T1
		FILE:	320511-0003-001slmMB.mxd
TRC - GIS		**FIGURE 1**	

E:\DTE\CCR_Sites\2017_265996\320511-0003-001slmMB.mxd -- Saved By: AADAIR on 8/6/2019, 12:28:21 PM

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO. & PARTNERS, (3/24/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, JUNE 2016, AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.

N

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT:	**DTE ELECTRIC COMPANY** **BELLE RIVER POWER PLANT** **4505 KING ROAD** **CHINA TOWNSHIP, MICHIGAN**
TITLE:	**SITE PLAN**
DRAWN BY: R SUEMNICHT	PROJ NO.: 320511.0003.0000 P1 T1
CHECKED BY: S HOLMSTROM	**FIGURE 2**
APPROVED BY: V BUENING	
DATE: AUGUST 2019	

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Phone: 734.971.7080
www.trccompanies.com

FILE NO.: 320511-0003-004.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 8/6/2019, 12:43:33 PM by AADAIR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\320511-0003-004.mxd

Figure 3
MW-16-01 TDS Time Series Plot
Belle River Power Plant Bottom Ash Basins - RCRA CCR Monitoring Program

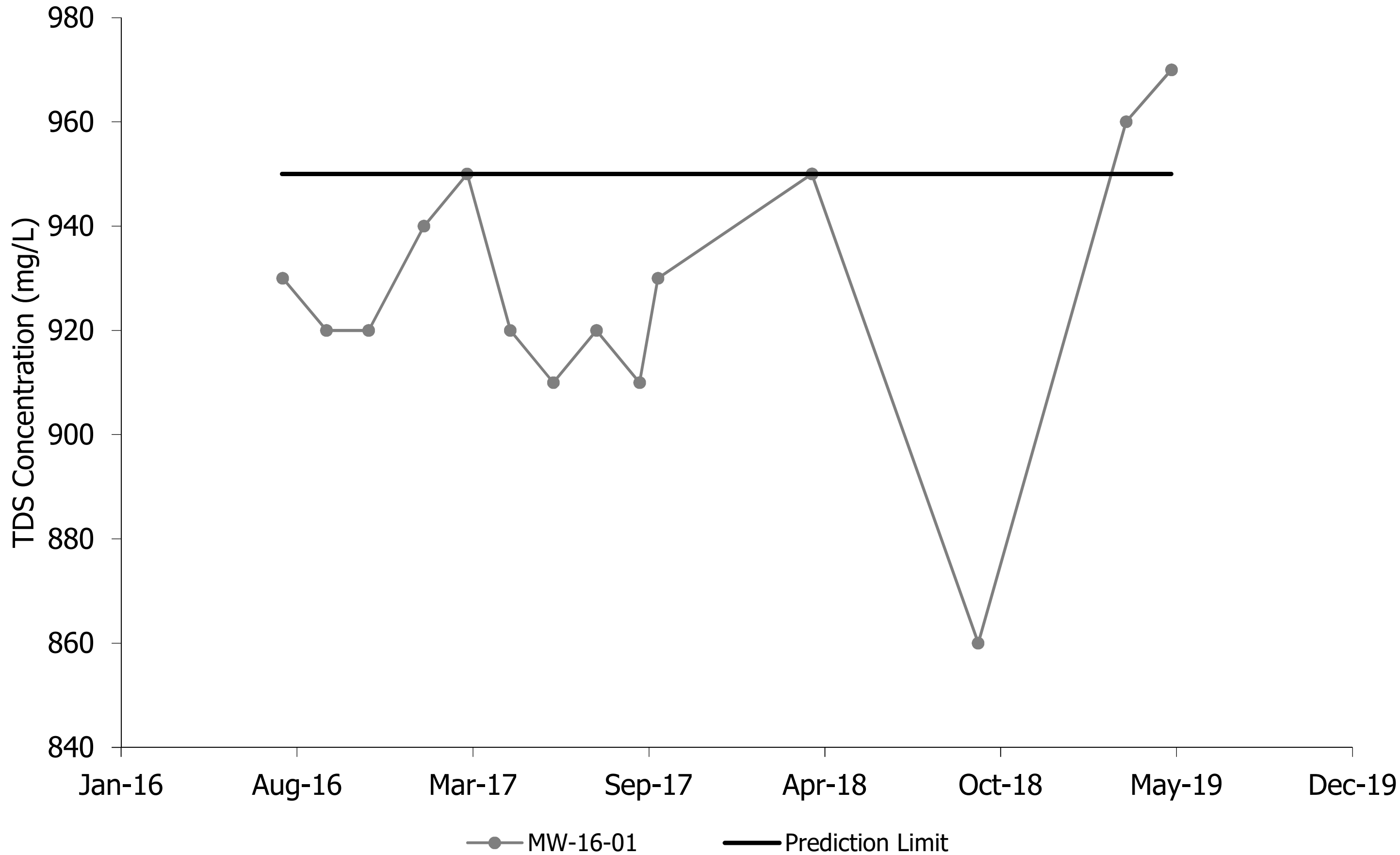
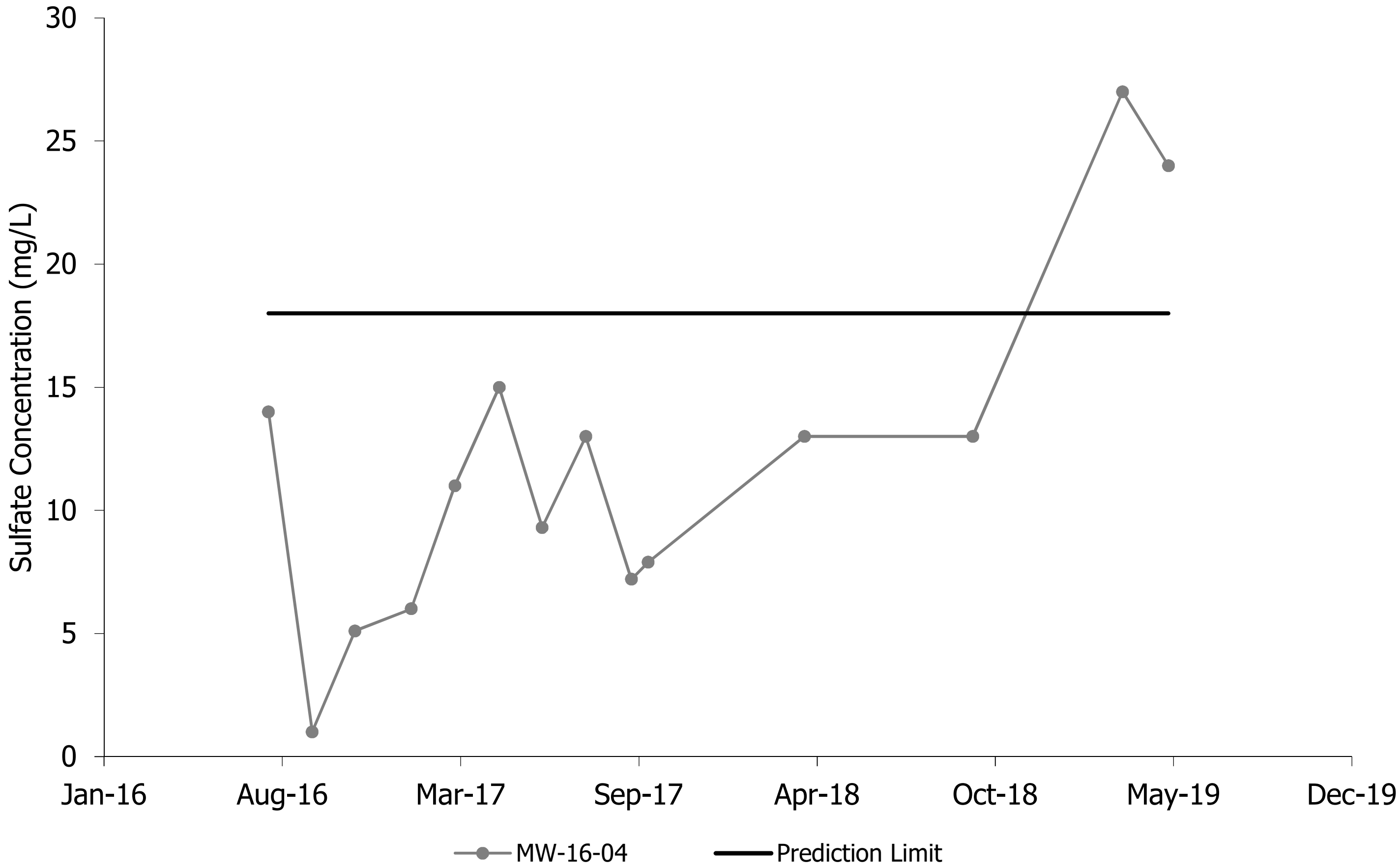


Figure 4
MW-16-04 Sulfate Time Series Plot
Belle River Power Plant Bottom Ash Basins - RCRA CCR Monitoring Program



LEGEND

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

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO. & PARTNERS, (3/24/2019).
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL, JUNE 2016, AND JUNE 2017.

0 200 400 Feet
1 " = 200 '
1:2,400

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.:	320511.0003.0000 P1 T1
CHECKED BY:	S. HOLMSTROM	FIGURE 5	
APPROVED BY:	V. BUENING		
DATE:	AUGUST 2019		

TRC
1540 Eisenhower Place
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FILE NO.: 320511-0003-011.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 8/7/2019, 08:32:15 AM by AADAIR -- LAYOUT: ANSI B(11"x17")
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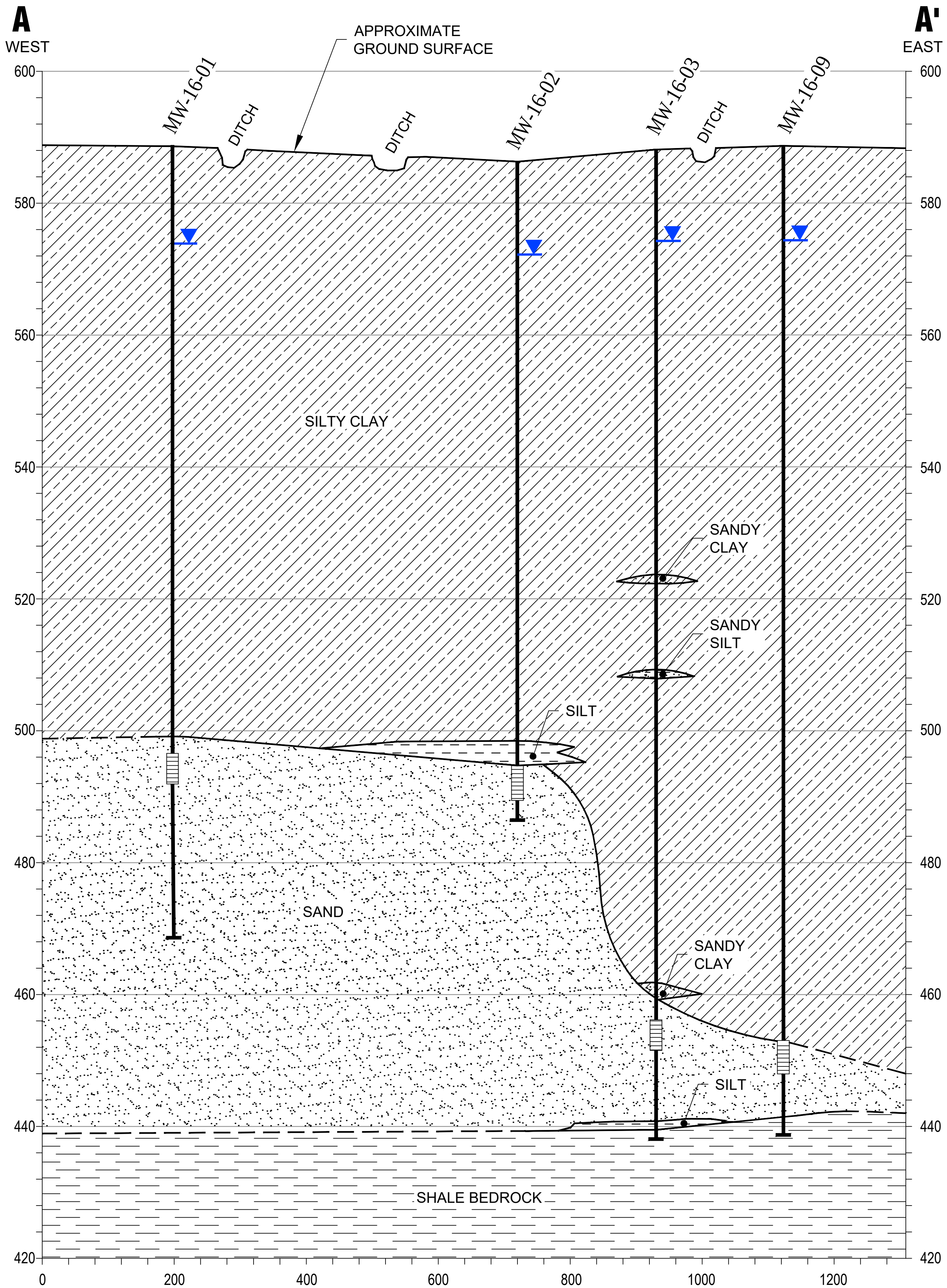
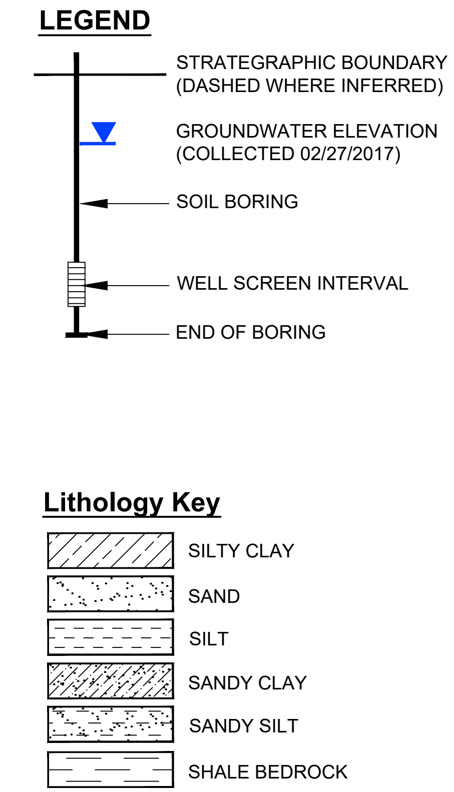
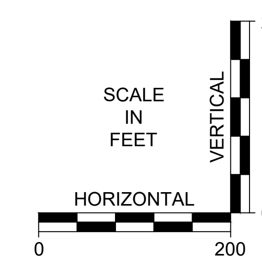
GENERALIZED GEOLOGIC CROSS-SECTION A-A'







PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT CHINA TOWNSHIP, MICHIGAN
TITLE:	GENERALIZED GEOLOGIC CROSS-SECTION A-A'

DRAWN BY:	D.STEHLE	PROJ NO.:	320511.0003.01.01
CHECKED BY:	S.HOLMSTROM	FIGURE 6	
APPROVED BY:	V.BUENING		
DATE:	AUGUST 2019		

TRC
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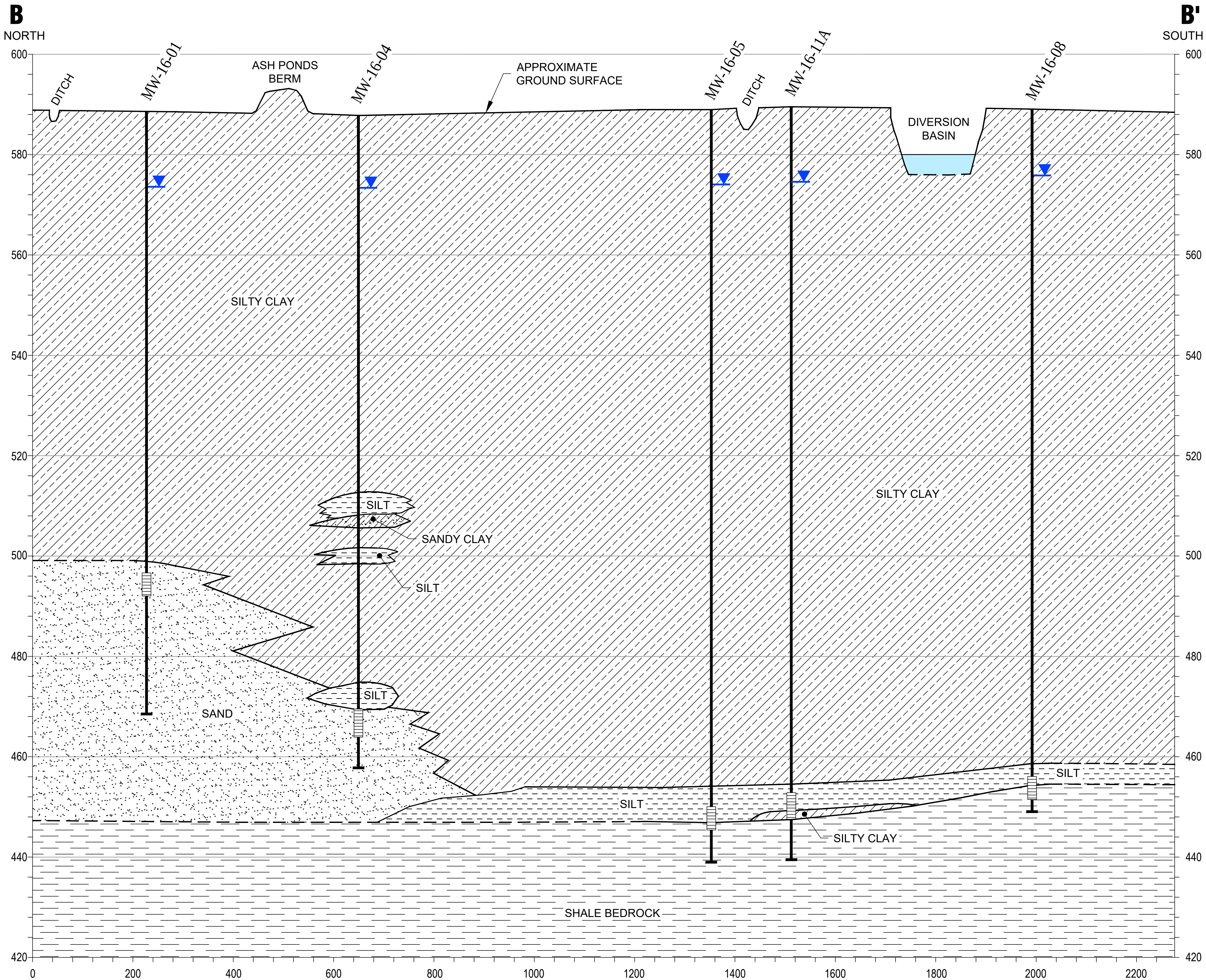
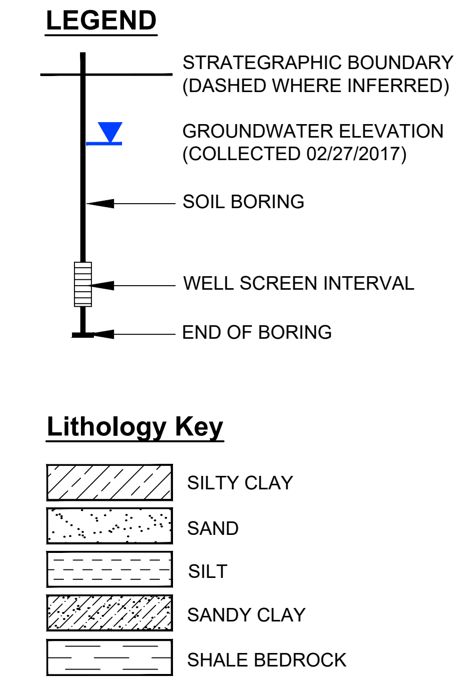
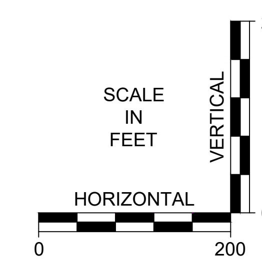
FILE NO.: 320511.0003.01.01.06-07.dwg

GENERALIZED GEOLOGIC CROSS-SECTION B-B'







PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
CHINA TOWNSHIP, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS-SECTION B-B'

DRAWN BY:	D.STEHLE	PROJ NO.:	320511.0003.01.01
CHECKED BY:	S.HOLMSTROM	FIGURE 7	
APPROVED BY:	V.BUENING		
DATE:	AUGUST 2019		

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FILE NO.: 320511.0003.01.01.06-07.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
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Attachment A
Data Quality Review

Laboratory Data Quality Review
Groundwater Monitoring Event May 2019 (Verification Resampling)
DTE Electric Company Belle River Power Plant (DTE BRPP)

On May 9, 2019, TRC Environmental Corporation (TRC) collected groundwater samples at MW-16-01 and MW-16-04 to verify analytical results that were outside of the prediction limits during the March 2019 detection monitoring event. Samples were analyzed by Test America Laboratories, Inc. (Test America), located in Canton, Ohio for anions (SW846 6020/9056A) and total dissolved solids (TDS) (SM 2540C). The laboratory analytical results are reported in laboratory report J112501-1.

TRC reviewed the laboratory data to assess data usability. The following sections summarize the data review procedure and the results of the review.

Data Quality Review Procedure

The analytical data were reviewed using the USEPA National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). The following items were included in the evaluation of the data:

- Sample receipt, as noted in the cover page or case narrative;
- Technical holding times for analyses;
- Data for method blanks. Method blanks are used to assess potential contamination arising from laboratory sample preparation and/or analytical procedures;
- Reporting limits (RLs) compared to project-required RLs;
- Data for blind field duplicates. Field duplicate samples are used to assess variability introduced by the sampling and analytical processes;
- Data for laboratory control samples (LCSs). The LCSs are used to assess the accuracy of the analytical method using a clean matrix;
- Data for laboratory duplicates. The laboratory duplicates are replicate analyses of one sample and are used to assess the precision of the analytical method; and
- Overall usability of the data.

This data usability report addresses the following items:

- Usability of the data if quality control (QC) results suggest potential problems with all or some of the data;
- Actions regarding specific QC criteria exceedances.

Review Summary

The data quality objectives and laboratory completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

QA/QC Sample Summary:

- Target analytes were not detected in associated method blanks.
- LCS recoveries were within laboratory control limits.
- Dup-01 corresponds with MW-16-01 and Dup-02 corresponds with MW-16-04; relative percent differences (RPDs) between the parent and duplicate sample were within the QC limits.
- Data are usable for purposes of verification sampling.

Appendix B
Data Quality Reviews

Laboratory Data Quality Review
Groundwater Monitoring Event March 2019 (Detection Monitoring)
DTE Electric Company Belle River Power Plant (DTE BRPP)

Groundwater samples were collected by TRC for the March 2019 sampling event for the Diversion Basin at the DTE BRPP. Samples were analyzed for anions, boron, calcium, and total dissolved solids by Test America Laboratories, Inc., (Test America) located in North Canton, Ohio. The laboratory analytical results are reported in laboratory report 240-109798-1.

During the March 2019 sampling event, a groundwater sample was collected from the following wells:

- MW-16-01
- MW-16-02
- MW-16-03
- MW-16-04
- MW-16-05
- MW-16-06
- MW-16-07
- MW-16-08
- MW-16-09
- MW-16-10
- MW-16-11A

Each sample was analyzed for the following constituents:

Analyte Group	Method
Anions (Chloride, Fluoride, Sulfate)	SW846 9056A
Total Boron	SW846 3005A/6010B
Total Calcium	SW846 3005A/6020
Total Dissolved Solids	SM 2540C

TRC reviewed the laboratory data to assess data usability. The following sections summarize the data review procedure and the results of the review.

Data Quality Review Procedure

The analytical data were reviewed using the USEPA National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). The following items were included in the evaluation of the data:

- Sample receipt, as noted in the cover page or case narrative;
- Technical holding times for analyses;
- Reporting limits (RLs) compared to project-required RLs;
- Data for method blanks and equipment blanks. Method blanks are used to assess potential contamination arising from laboratory sample preparation and/or analytical procedures. Equipment blanks are used to assess potential contamination arising from field procedures;

- Data for laboratory control samples (LCSs). The LCSs are used to assess the accuracy of the analytical method using a clean matrix;
- Data for matrix spike and matrix spike duplicate samples (MS.MSDs), if applicable. The MS/MSDs are used to assess the accuracy and precision of the analytical method using a sample from the dataset;
- Data for laboratory duplicates, if applicable. The laboratory duplicates are used to assess the precision of the analytical method using a sample from the dataset;
- Data for blind field duplicates. Field duplicate samples are used to assess variability introduced by the sampling and analytical processes; and
- Overall usability of the data.

This data usability report addresses the following items:

- Usability of the data if quality control (QC) results suggest potential problems with all or some of the data;
- Actions regarding specific QC criteria exceedances.

Review Summary

The data quality objectives and laboratory completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

- The reviewed constituents will be utilized for the purposes of a detection monitoring program.
- Data are usable for the purposes of the detection monitoring program.

QA/QC Sample Summary:

- The holding time for TDS for samples MW-16-01, MW-16-02, MW-16-03, MW-16-04, MW-16-05, DUP-01, and EB-01 exceeded the 7-day holding time criteria by approximately 5-10 hours. These results are estimated and may be biased low.
- Target analytes were not detected in the equipment blank (EB-01_20190318).
- Target analytes were not detected in the method blanks.
- LCS recoveries for all target analytes were within laboratory control limits.
- Sample DUP-01 corresponds with sample MW-16-01. The relative percent differences (RPDs) between the parent and duplicate sample were within the acceptance limits.
- Laboratory duplicate analyses were performed on sample MW-16-01 for TDS; the RPD was within the acceptance limits.

- MS/MSD analyses were performed on the following samples:
  - Sample MW-16-01 for boron; the percent recoveries (%Rs) and RPDs were within the acceptance limits.
  - Samples MW-16-02 and DUP-01 for fluoride and sulfate; the %Rs and RPDs were within the acceptance limits.
  - Sample MW-16-02 for calcium; the MS/MSD %Rs (68%/63%) were below the lower QC limit of 75%, but no action was required since the sample result in the parent sample was > 4x the spike added.
- For TDS, the constant weight was not achieved after three drying cycles for sample MW-16-02; there was no impact on data usability.

Laboratory Data Quality Review
Groundwater Monitoring Event September 2019 (Detection Monitoring)
DTE Electric Company Belle River Power Plant (DTE BRPP)

Groundwater samples were collected by TRC for the September 2019 sampling event for the Bottom Ash Basins and Diversion Basin at the DTE BRPP. Samples were analyzed for anions, total boron, total calcium, and total dissolved solids by Eurofins-Test America Laboratories, Inc. (Eurofins-TA), located in North Canton, Ohio. The laboratory analytical results are reported in laboratory report 240-119135-1.

During the September 2019 sampling event, a groundwater sample was collected from each of the following wells:

Bottom Ash Basins:

- MW-16-01
- MW-16-02
- MW-16-03
- MW-16-04
- MW-16-09

Diversion Basin:

- MW-16-05
- MW-16-06
- MW-16-07
- MW-16-08
- MW-16-10
- MW-16-11A

Each sample was analyzed for the following constituents:

Analyte Group	Method
Anions (Chloride, Fluoride, Sulfate)	SW846 9056A
Total Boron	SW846 3005A/6010B
Total Calcium	SW846 3005A/6020
Total Dissolved Solids	SM 2540C

TRC reviewed the laboratory data to assess data usability. The following sections summarize the data review procedure and the results of the review.

The analytical data were reviewed using the USEPA National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). The following items were included in the evaluation of the data:

- Sample receipt, as noted in the cover page or case narrative;
- Technical holding times for analyses;
- Reporting limits (RLs) compared to project-required RLs;

- Data for method blanks and equipment blanks, where applicable. Method blanks are used to assess potential contamination arising from laboratory sample preparation and/or analytical procedures. Equipment blanks are used to assess potential contamination arising from field procedures;
- Data for laboratory control samples (LCSs). The LCSs are used to assess the accuracy of the analytical method using a clean matrix;
- Data for matrix spike and matrix spike duplicate samples (MS/MSDs), where applicable. The MS/MSDs are used to assess the accuracy and precision of the analytical method using a sample from the dataset;
- Data for laboratory duplicates, where applicable. The laboratory duplicates are used to assess the precision of the analytical method using a sample from the dataset;
- Data for blind field duplicates. Field duplicate samples are used to assess variability introduced by the sampling and analytical processes; and
- Overall usability of the data.

This data usability report addresses the following items:

- Usability of the data if quality control (QC) results suggest potential problems with all or some of the data;
- Actions regarding specific QC criteria exceedances.

Review Summary

The data quality objectives and laboratory completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

- Appendix III constituents will be utilized for the purposes of a detection monitoring program.
- Data are usable for the purposes of the detection monitoring program.

QA/QC Sample Summary:

- There was one equipment blank submitted with this dataset (EB-01) which was associated with the low hydraulic conductivity wells (MW-16-08, MW 16-10, and MW-16-11A). Chloride was detected at 1.8 mg/L and TDS was detected at 12 mg/L in this equipment blank. However, these analytes were detected at concentrations greater than five times the blank concentrations in the associated wells; thus, there was no impact on data usability.

- Target analytes were not detected in the method blanks.

- LCS recoveries for all target analytes were within laboratory control limits.

- MS/MSD analyses were performed on samples MW-16-01 for boron, MW-16-03 for fluoride and sulfate, and MW-16-02 for calcium; the percent recoveries (%Rs) and relative percent differences (RPDs) were acceptable.
  - MS/MSD analyses were not performed for chloride; per the project QAPP, MS/MSD analyses are required for chloride at a frequency of 1 per 20 samples. It is likely that an MS/MSD was performed on sample MW-16-03 for chloride but not reported by the laboratory since the sample was re-analyzed at a dilution for chloride.

- Laboratory duplicate analyses were not performed for TDS. Per the project QAPP, laboratory duplicate analyses are required for TDS at a frequency of 1 per 20 samples.

- Dup-01 corresponds with MW-16-01; RPDs between the parent and duplicate sample were within the QC limits.

- The nondetect reporting limits (5.0 mg/L) for sulfate in samples MW-16-06, MW-16-08, and MW-16-11A were above the QAPP-specified RL (1.0 mg/L) due to a 5-fold dilution which was likely the result of elevated chloride concentrations.

Laboratory Data Quality Review
Groundwater Monitoring Event
November Verification (Detection Monitoring)
DTE Electric Company Belle River Power Plant (DTE BRPP)

One groundwater sample was collected by TRC for the November 2019 sampling event for the Bottom Ash Basin at the DTE BRPP. The sample was analyzed for calcium and chloride by Test America Laboratories, Inc. (Test America), located in North Canton, Ohio. The laboratory analytical results are reported in laboratory report 240-122291-1

During the November 2019 sampling event, a groundwater sample was collected from the following well:

Bottom Ash Basin:

- MW-16-03

The sample was analyzed for the following constituents:

Analyte Group	Method
Chloride	SW846 9056A
Total Recoverable Calcium	SW846 3005A/6020

TRC reviewed the laboratory data to assess data usability. The following sections summarize the data review procedure and the results of the review.

The analytical data were reviewed using the USEPA National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). The following items were included in the evaluation of the data:

- Sample receipt, as noted in the cover page or case narrative;
- Technical holding times for analyses;
- Reporting limits (RLs) compared to project-required RLs;
- Data for method blanks and equipment blanks. Method blanks are used to assess potential contamination arising from laboratory sample preparation and/or analytical procedures. Equipment blanks are used to assess potential contamination arising from field procedures;
- Data for laboratory control samples (LCSs). The LCSs are used to assess the accuracy of the analytical method using a clean matrix;
- Data for matrix spike and matrix spike duplicate samples (MS/MSDs). The MS/MSDs are used to assess the accuracy and precision of the analytical method using a sample from the dataset;

- Data for laboratory duplicates. The laboratory duplicates are used to assess the precision of the analytical method using a sample from the dataset;
- Data for blind field duplicates. Field duplicate samples are used to assess variability introduced by the sampling and analytical processes; and
- Overall usability of the data.

This data usability report addresses the following items:

- Usability of the data if quality control (QC) results suggest potential problems with all or some of the data;
- Actions regarding specific QC criteria exceedances.

Review Summary

The data quality objectives and laboratory completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

- Appendix III constituents will be utilized for the purposes of a detection monitoring program.
- Data are usable for the purposes of the detection monitoring program.

QA/QC Sample Summary:

- Target analytes were not detected in the method blanks.

- LCS recoveries for all target analytes were within laboratory control limits.

- MS/MSD analyses were not performed on the sample in this data set.

- DUP-01_20191111 corresponds with MW-16-03_20191111; the RPD between the parent and duplicate sample were within the QC limits for chloride; the RPD of 51.9% exceeded the QC limits for calcium and potential uncertainty exists for calcium in all groundwater samples, as summarized in the attached table, Appendix B.

Appendix D
2018 Annual Groundwater Monitoring Report

2018 Annual Groundwater Monitoring Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins

4505 King Road
China Township, Michigan

January 2019

2018 Annual Groundwater Monitoring Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins

4505 King Road
China Township, Michigan

January 2019

Prepared For
DTE Electric Company

Graham Crockford, C.P.G
Senior Project Geologist

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

TRC | DTE Electric Company
Final
X:\WPAAM\PJT2\265996\03 BRPP\CCR\BABS\2018\R265996-BRPP BABS FINAL.DOCX

1540 Eisenhower Place, Ann Arbor, MI 48108 ● 734.971.7080 Phone ● 734.971.9022 Fax
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Executive Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule), as amended July 30, 2018. The CCR Rule, which became effective on October 19, 2015 (amendment effective August 29, 2018), applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs) CCR unit. Pursuant to the CCR Rule, no later than January 31, 2018, and annually thereafter, the owner or operator of a CCR unit must prepare an annual groundwater monitoring and corrective action report for the CCR unit documenting the status of groundwater monitoring and corrective action for the preceding year in accordance with §257.90(e). On behalf of DTE Electric, TRC Engineers Michigan, Inc., the engineering entity of TRC Environmental Corporation (TRC), has prepared this Annual Groundwater Monitoring Report for calendar year 2018 activities at the BRPP BABs CCR unit.

In the January 31, 2018 *Annual Groundwater Monitoring Report for the Belle River Power Plant Bottom Ash Basins,* covering calendar year 2017 activities, DTE Electric reported that the pH observed within groundwater at one or more downgradient wells was outside background limits. Resampling was performed in January 2018 in accordance with the TRC October 2017 *Groundwater Statistical Evaluation Plan – Belle River Power Plant Coal Combustion Residual Fly Ash Basin* (Stats Plan). Based on the results of the resampling, the pH was within the prediction limits and no statistically significant exceedance (SSI) or decrease exists for pH in accordance with the Stats Plan. As such, DTE Electric continued detection monitoring at the BRPP BABs CCR unit pursuant to §257.94 of the CCR Rule.

The semiannual detection monitoring events for 2018 were completed in March and October 2018 and included sampling and analyzing groundwater within the groundwater monitoring system for the indicator parameters listed in Appendix III to the CCR Rule. As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify SSIs in detection monitoring parameters to determine if concentrations in detection monitoring well samples exceed background levels. Detection monitoring data that have been collected and evaluated in 2018 are presented in this report.

The groundwater sampling results were below background limits for all Appendix III indicator parameters during both the March and October 2018 semiannual monitoring events; therefore, no SSIs were reported for the BRPP BABs CCR unit. As such, detection monitoring will be continued at the BRPP BABs CCR unit in accordance with §257.94 of the CCR Rule.

Section 1
Introduction

1.1 Program Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule), as amended July 30, 2018. The CCR Rule, which became effective on October 19, 2015 (amendment effective August 29, 2018), applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs). Pursuant to the CCR Rule, no later than January 31, 2018, and annually thereafter, the owner or operator of a CCR unit must prepare an annual groundwater monitoring and corrective action report for the CCR unit documenting the status of groundwater monitoring and corrective action for the preceding year in accordance with §257.90(e). On behalf of DTE Electric, TRC Engineers Michigan, Inc., the engineering entity of TRC Environmental Corporation (TRC), has prepared this Annual Groundwater Monitoring Report for calendar year 2018 activities at the BRPP BABs CCR unit (2018 Annual Report).

In the January 31, 2018 *Annual Groundwater Monitoring Report for the Belle River Power Plant Bottom Ash Basins,* covering calendar year 2017 activities (2017 Annual Report), DTE Electric reported that the pH observed within groundwater at one or more downgradient wells was outside background limits. Resampling was performed in January 2018 in accordance with the TRC October 2017 *Groundwater Statistical Evaluation Plan – Belle River Power Plant Coal Combustion Residual Fly Ash Basin* (Stats Plan). Based on the results of the resampling, the pH was within the prediction limits and no statistically significant increase (SSI) or decrease exists for pH in accordance with the Stats Plan. As such, DTE Electric continued detection monitoring at the BRPP BABs CCR unit pursuant to §257.94 of the CCR Rule. The verification sampling and results are summarized in the *Alternate Source Demonstration: 2017 Initial Detection Monitoring Sampling Event Belle River Power Plant Coal Combustion Residual Bottom Ash Basins*, dated April 12, 2018, (April 2018 ASD) included in Appendix A.

This 2018 Annual Report presents the monitoring results and the statistical evaluation of the detection monitoring parameters (Appendix III to Part 257 of the CCR Rule) for the March and October 2018 semiannual groundwater monitoring events for the BRPP BABs CCR unit. Detection monitoring for these events continued to be performed in accordance with the *CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin* (QAPP) (TRC, July 2016; revised August 2017) and statistically evaluated per the Stats Plan (TRC, October 2017). As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify SSIs of detection monitoring parameters compared to background levels.

1.2 Site Overview

The BRPP is located in Section 13, Township 4 North, Range 16 East, at 4505 King Road, China Township in St. Clair County, Michigan. The BRPP was constructed in the early 1980s with plant operations beginning in 1984. Prior to Detroit Edison Company's operations commencing in the 1980s, 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 BABs have been in use with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR unit, which is monitored as a separate CCR unit in accordance with the CCR Rule.

The DB is an incised CCR surface impoundment located west of the BRPP near the Webster Drain. Water flows into the DB from the North and South 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.

1.3 Geology/Hydrogeology

The BRPP BABs CCR unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet below ground surface (bgs). In general, the BRPP BABs CCR unit is initially underlain by at least 90 to as much as 136 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet within the monitoring well network and rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) to the southeast in the vicinity of SB-16-01 (Figure 1). Consequently, the uppermost aquifer is not laterally contiguous across the entire BRPP BABs CCR unit, and not present beneath the southeastern corner of the BABs.

The variability in the depth to the uppermost aquifer is a consequence of the heterogeneity of the glacial deposits and is driven by the lateral discontinuity of the sand outwash within the encapsulating fine-grained, silty clay till that confines the uppermost aquifer. There is an apparent lack of interconnection and/or significant vertical variation between the uppermost aquifer sand unit(s) encountered across the BRPP BABs CCR unit as demonstrated by the extensive amount of time (months) it took for water levels in monitoring well MW-16-02 to reach equilibrium after well construction and development (TRC, 2017).

Given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit, the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs, where present varying up to 46 feet vertically), the no flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area, and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the BRPP BABs CCR unit.

In addition, the elevation of CCR-affected water maintained within the BRPP BABs is approximately 5 feet above the potentiometric surface elevations in the uppermost aquifer at the BABs CCR unit area. This suggests that if the CCR affected surface water in the BABs were able to penetrate the silty clay-rich underlying confining unit that the head on that release likely would travel radially away from the BABs within the uppermost aquifer. However, with the very thick continuous silty clay-rich confining unit beneath the BRPP it is not possible for the uppermost aquifer to have been affected by CCR from BRPP operations that began in the 1980s.

Due to the relatively small footprint of the BABs, the low vertical and horizontal groundwater flow velocity, the potential for radial flow, and the fact that the saturated unit being monitored is isolated by a laterally contiguous silty-clay unit, which significantly impedes vertical groundwater flow thus preventing the monitored saturated zone from potentially being affected by CCR, monitoring of the BRPP BABs CCR unit using intrawell statistical methods is appropriate. In addition, because the uppermost aquifer is not uniformly present across the BABs CCR unit, there are no clear upgradient wells. As such, intrawell statistical approaches are being used during detection monitoring as discussed in the Stats Plan.

Section 2
Groundwater Monitoring

2.1 Monitoring Well Network

A groundwater monitoring system has been established for the BRPP BABs 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 BABs CCR unit currently consists of five monitoring wells that are screened in the uppermost aquifer. The monitoring well locations are shown on Figure 2.

As discussed in the Stats Plan, intrawell statistical methods for the BABs CCR unit were selected based on the geology and hydrogeology at the Site (primarily the presence of clay/hydraulic barrier, the variability in the presence of the uppermost aquifer across the site, and presence of no flow boundary on the southeast side of the aquifer), in addition to other supporting lines of evidence that the aquifer is unaffected by the CCR unit (such as the consistency in concentrations of water quality data). An intrawell statistical approach requires that each of the downgradient wells doubles as a background and compliance well, where data from each individual well during a detection monitoring event is compared to a statistical limit developed using the background dataset from that same well. Monitoring wells MW-16-01 through MW-16-04 and MW-16-09 are located around the north, east and south perimeter of the BABs and provide data on both background and downgradient groundwater quality that has not been affected by the CCR unit (total of five background/downgradient monitoring wells).

2.2 Semiannual Groundwater Monitoring

The semiannual monitoring parameters for the detection groundwater monitoring program were selected per the CCR Rule's Appendix III to Part 257 – Constituents for Detection Monitoring. The Appendix III indicator parameters consist of boron, calcium, chloride, fluoride, pH (field reading), sulfate, and total dissolved solids (TDS) and were analyzed in accordance with the sampling and analysis plan included within the QAPP. In addition to pH, the collected field parameters included dissolved oxygen, oxidation reduction potential, specific conductivity, temperature, and turbidity.

2.2.1 Data Summary

The first semiannual groundwater detection monitoring event for 2018 was performed during March 26 to 28, 2018 by TRC personnel and samples were analyzed by TestAmerica in accordance with the QAPP. Static water elevation data were collected at all five monitoring well locations. Groundwater samples were collected from the five detection monitoring wells for the Appendix III indicator parameters and field parameters. A summary of the groundwater data collected during the March 2018 event is provided on Table 1 (static groundwater elevation data), Table 2 (field data), and Table 3 (analytical results).

The second semiannual groundwater detection monitoring event for 2018 was performed during October 1 to 4, 2018 by TRC personnel and samples were analyzed by TestAmerica in accordance with the QAPP. Static water elevation data were collected at all five monitoring well locations. Groundwater samples were collected from the five detection monitoring wells for the Appendix III indicator parameters and field parameters. A summary of the groundwater data collected during the October 2018 event is provided on Table 1 (static groundwater elevation data), Table 2 (field data), and Table 4 (analytical results).

2.2.2 Data Quality Review

Data from each round were evaluated for completeness, overall quality and usability, method-specified sample holding times, precision and accuracy, and potential sample contamination. The data were found to be complete and usable for the purposes of the CCR monitoring program. Data quality reviews are summarized in Appendix B.

2.2.3 Groundwater Flow Rate and Direction

As presented in the GWMS Report, and mentioned above, given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit; the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs; where present, varying up to 46 feet vertically); the no flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area; and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the site. Groundwater elevations measured across the Site during the March 2018 sampling event are provided on Table 1 and are summarized in plan view on Figure 3. Groundwater elevations measured across the Site during the October 2018 sampling event are provided on Table 1 and are summarized in plan view on Figure 4.

Groundwater elevation data collected during the 2018 sampling events show that groundwater conditions within the uppermost aquifer are consistent with previous monitoring events and continue to demonstrate that the downgradient wells are appropriately positioned to detect the presence of Appendix III parameters that could potentially migrate from the BRPP BABs CCR unit.

Section 3
Statistical Evaluation

3.1 Establishing Background Limits

Per the Stats Plan, background limits were established for the Appendix III indicator parameters following the collection of at least eight background monitoring events using data collected from each of the five established detection monitoring wells (MW-16-01 through MW-16-04 and MW-16-09). The statistical evaluation of the background data is presented in the 2017 Annual Report. The Appendix III background limits for each monitoring well will be used throughout the detection monitoring period to determine whether groundwater has been impacted from the BRPP BABs CCR unit by comparing concentrations in the detection monitoring wells to their respective background limits for each Appendix III indicator parameter.

3.2 Data Comparison to Background Limits

The concentrations of the indicator parameters in each of the detection monitoring wells (MW-16-01 through MW-16-04 and MW-16-09) were compared to their respective statistical background limits calculated from the background data collected from each individual well (i.e., monitoring data from MW-16-01 is compared to the background limit developed using the background dataset from MW-16-01, and so forth). The comparisons of the March 2018 and October 2018 data to background limits are presented on Tables 3 and 4, respectively.

The statistical evaluation of both the March 2018 and October 2018 Appendix III indicator parameters shows that all results are below their respective background limits and no SSIs exist for any Appendix III parameter during the March and October 2018 events.

Section 4
Conclusions and Recommendations

The groundwater sampling results were below background limits for all Appendix III indicator parameters during both the March and October 2018 semiannual monitoring events; therefore, there were no SSIs over background limits at the BRPP BABs CCR unit. As such, detection monitoring will be continued at the BRPP BABs CCR unit in accordance with §257.94.

No corrective actions were performed in 2018. The next semiannual monitoring event is scheduled for the second calendar quarter of 2019.

Section 5
Groundwater Monitoring Report Certification

The U.S. EPA's Disposal of Coal Combustion Residuals from Electric Utilities Final Rule Title 40 CFR Part 257 §257.90(e) requires that the owner or operator of an existing CCR unit prepare an annual groundwater monitoring and corrective action report.

Annual Groundwater Monitoring Report Certification
Belle River Power Plant Bottom Ash Basins
China Township, Michigan

CERTIFICATION

I hereby certify that the annual groundwater and corrective action report presented within this document for the BRPP BABs CCR unit has been prepared to meet the requirements of Title 40 CFR §257.90(e) of the Federal CCR Rule. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.90(e).

Name: David B. McKenzie, P.E.	Expiration Date: October 31, 2019	State of Michigan · David B. McKenzie · Engineer · No. 42332 · Licensed Professional Engineer
Company: TRC Engineers Michigan, Inc.	Date: January 31, 2019	Stamp

Section 6
References

TRC Environmental Corporation. July 2016; Revised March and August 2017. CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

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USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA facilities, Unified Guidance. Office of Conservation and Recovery. EPA 530/R-09-007.

USEPA. April 2015. 40 CFR Parts 257 and 261. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. 80 Federal Register 74 (April 17, 2015), pp. 21301-21501 (80 FR 21301).

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USEPA. April 2018. Barnes Johnson (Office of Resource Conservation and Recovery) to James Roewer (c/o Edison Electric Institute) and Douglas Green, Margaret Fawal (Venable LLP). Re: Coal Combustion Residuals Rule Groundwater Monitoring Requirements. April 30, 2018. United States Environmental Protection Agency, Washington, D.C. 20460. Office of Solid Waste and Emergency Response, now the Office of Land and Emergency Management.

Tables

Table 1
Summary of Groundwater Elevation Data – March & October 2018
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Date Installed	3/17/2016		3/15/2016		6/1/2016		3/8/2016		6/2/2016	
TOC Elevation	590.06		588.94		590.66		590.51		590.80	
Geologic Unit of Screened Interval	Sand		Sand		Silty Sand		Sand		Sand	
Screened Interval Elevation	496.3 to 491.3		494.3 to 489.3		456.0 to 451.0		468.5 to 463.5		452.3 to 447.3	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
3/26/2018	16.21	573.85	14.08	574.86	17.60	573.06	17.00	573.51	16.83	573.97
10/01/2018	16.07	573.99	13.85	575.09	16.05	574.61	16.87	573.64	16.72	574.08

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing.

Table 2
Summary of Field Data – March & October 2018
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (SU)	Specific Conductivity (umhos/cm)	Temperature (deg C)	Turbidity (NTU)
MW-16-01	3/26/2018	0.21	-147.0	7.6	1,772	11.97	4.08
	10/1/2018	0.29	-131.3	7.7	1,605	11.96	1.93
MW-16-02	3/26/2018	0.23	-128.1	7.6	1,401	12.19	1.64
	10/1/2018	0.36	-131.6	7.8	1,282	12.22	1.68
MW-16-03	3/26/2018	0.13	-153.1	7.8	2,035	12.28	1.50
	10/1/2018	0.12	-156.3	8.0	1,903	12.07	1.84
MW-16-04	3/26/2018	0.27	-186.6	7.8	1,842	11.72	43.2
	10/1/2018	0.60	-161.4	7.9	1,670	13.08	39.1
MW-16-09	3/27/2018	0.37	-230.9	7.8	3,305	10.76	34.6
	10/4/2018	0.17	-126.5	8.4	3,100	12.60	114

Notes:

mg/L - milligrams per liter.

mV - milliVolt.

SU - standard unit.

umhos/cm - micro-mhos per centimeter.

deg C - degrees celcius.

NTU - nephelometric turbidity units.

Table 3
Comparison of Appendix III Parameter Results to Background Limits – March 2018
Belle River Power Plant BABs – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Sample Date:		3/26/2018	PL	3/26/2018	PL	3/26/2018	PL	3/26/2018	PL	3/27/2018	PL
Constituent	Unit	Data		Data		Data		Data		Data	
Appendix III											
Boron	ug/L	1,100	1,300	1,200	1,300	1,200	1,300	1,100	1,100	1,600	1,900
Calcium	ug/L	38,000	45,000	54,000	59,000	33,000	36,000	43,000	64,000	39,000	41,000
Chloride	mg/L	480	530	360	400	610	690	490	520	960	1100
Fluoride	mg/L	1.8	1.9	1.2	1.3	1.8	1.9	1.7	1.9	1.5	1.8
pH, Field	SU	7.6	7.6 - 8.1	7.6	7.4 - 8.0	7.8	7.5 - 8.3	7.8	7.5 - 8.4	7.8	7.7 - 8.7
Sulfate	mg/L	2.1	8.1	4.9	20	1.7	14	13	18	38	40
Total Dissolved Solids	mg/L	950	950	730	890	1,000	1,100	920	1,100	1,700	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

All metals were analyzed as total unless otherwise specified.

Bold font indicates an exceedance of the Prediction Limit (PL).

RESULT Shading and bold font indicates a comfirmed exceedance of the Prediction Limit (PL).

Table 4
Comparison of Appendix III Parameter Results to Background Limits – October 2018
Belle River Power Plant BABs – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Sample Date:		10/1/2018	PL	10/1/2018	PL	10/1/2018	PL	10/1/2018	PL	10/4/2018	PL
Constituent	Unit	Data		Data		Data		Data		Data	
Appendix III											
Boron	ug/L	1,000	1,300	1,200	1,300	1,100	1,300	1,100	1,100	1,600	1,900
Calcium	ug/L	41,000	45,000	53,000	59,000	32,000	36,000	44,000	64,000	41,000	41,000
Chloride	mg/L	500	530	390	400	620	690	520	520	980	1100
Fluoride	mg/L	1.7	1.9	1.2	1.3	1.7	1.9	1.7	1.9	1.5	1.8
pH, Field	SU	7.7	7.6 - 8.1	7.8	7.4 - 8.0	8.0	7.5 - 8.3	7.9	7.5 - 8.4	8.4	7.7 - 8.7
Sulfate	mg/L	6.7	8.1	4	20	1.6	14	13	18	5.5	40
Total Dissolved Solids	mg/L	860	950	730	890	980	1,100	920	1,100	1,500	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

-- = not analyzed

All metals were analyzed as total unless otherwise specified.

Bold font indicates an exceedance of the Prediction Limit (PL).

RESULT Shading and bold font indicates a comfirmed exceedance of the Prediction Limit (PL).

Figures

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '

1:24,000

0 2,000 4,000 FEET

TRC 1540 Eisenhower Place Ann Arbor, MI 48108-3284 Phone: 734.971.7080 TRC - GIS	PROJECT: **DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN**	DRAWN BY:	J. PAPEZ
		CHECKED BY:	S HOLMSTROM
		APPROVED BY:	V. BUENING
		DATE:	OCTOBER 2017
	TITLE: **SITE LOCATION MAP**	PROJ. NO.:	265996.0003
		FILE:	265996-SLMMB.mxd
		FIGURE 1	

E:\DTE\CCR_Sites\2017_265996\265996-SLMMB.mxd -- Saved By: BDEEGAN on 10/9/2017, 14:49:39 PM

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING

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 BY BMJ ENGINEERS & SURVEYORS, INC.

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT: **DTE ELECTRIC COMPANY**
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE: **SITE PLAN**

DRAWN BY:	S. MAJOR	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA		
APPROVED BY:	V. BUENING		**FIGURE 2**
DATE:	JANUARY 2019		

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

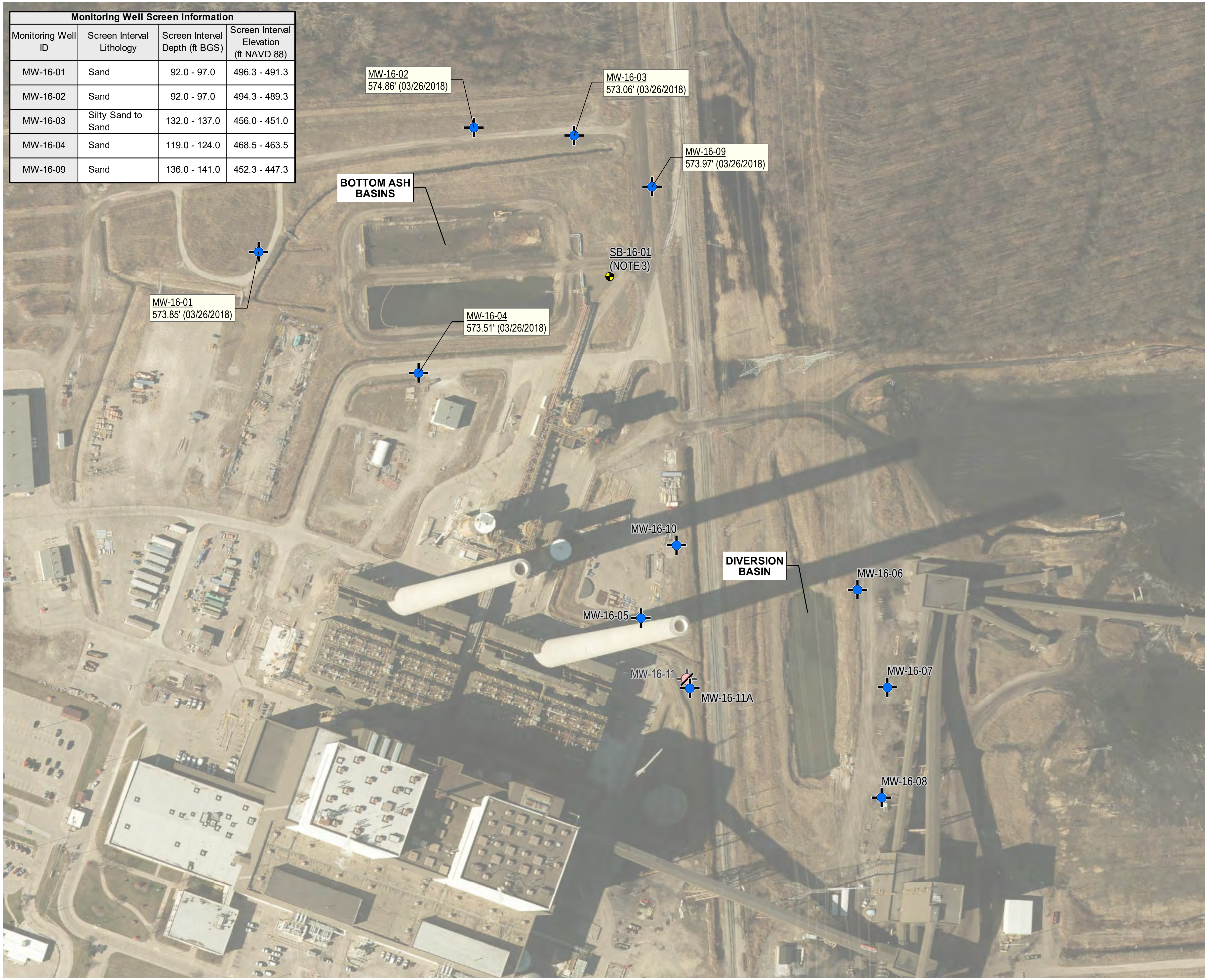
FILE NO.: 265996-0003-023.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/14/2019, 10:00:59 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-023.mxd

Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY MARCH 2018

DRAWN BY:	S. MAJOR	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA		
APPROVED BY:	V. BUENING		**FIGURE 3**
DATE:	JANUARY 2019		

TRC

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

FILE NO.: 265996-0003-024.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/2/2019, 09:37:29 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-024.mxd

Monitoring Well Screen Information

Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS
GROUNDWATER POTENTIOMETRIC
ELEVATION SUMMARY OCTOBER 2018

DRAWN BY:	S. MAJOR	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA		**FIGURE 4**
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2019		

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

FILE NO.: 265996-0003-026.mxd

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/29/2019, 12:41:10 PM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-026.mxd

Appendix A
Alternative Source Demonstration

Technical Memorandum

Date: April 12, 2018

To: Robert J. Lee
DTE Electric Company

From: Graham Crockford, TRC
David McKenzie, TRC

Project No.: 265996.0003.0000 Phase 003, Task 001

Subject: Alternate Source Demonstration: 2017 Initial Detection Monitoring Sampling Event
Belle River Power Plant Coal Combustion Residual Bottom Ash Basins

Introduction

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule). The CCR Rule, which became effective on October 19, 2015, applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs) CCR unit.

TRC Engineers Michigan, Inc. (TRC) prepared the 2017 Annual Groundwater Monitoring Report (Annual Report) for the BRPP BABs CCR unit on behalf of DTE Electric in accordance with the requirements of §257.90(e) (TRC, 2018). The Annual Report included the results of the October 2017 semiannual groundwater monitoring event for the BRPP BABs CCR unit and the statistical evaluation of the detection monitoring parameters (Appendix III to Part 257 of the CCR Rule) for the BRPP BABs CCR unit. This event is the initial detection monitoring event performed to comply with §257.94. As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify statistically significant increases (SSIs) in detection monitoring parameters to determine if concentrations in detection monitoring well samples exceed background levels. The statistical analysis was performed pursuant to §257.93(f) and (g), and in accordance with the Groundwater Statistical Evaluation Plan (Stats Plan) (TRC, 2017).

The statistical evaluation of the October 2017 Appendix III indicator parameters showed potential SSIs over background for:

- pH at MW-16-01 and MW-16-02

All other Appendix III constituents were within the statistical background limits.

In accordance with §257.94(3)(2), DTE Electric may demonstrate that a source other than the CCR unit caused the SSI or that the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. This Alternate Source Demonstration (ASD) has been prepared to address the potential SSIs identified in the October 2017 detection monitoring event.

Background

The BRPP is located in China Township in St. Clair County, Michigan. The BRPP was constructed in the early 1980s with plant operations beginning in 1984. 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 BABs have been in use with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB gravity flows over an outlet weir to a conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR unit, which is monitored as a separate CCR unit in accordance with the CCR Rule.

The BRPP BABs CCR unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet below ground surface (bgs). In general, the BRPP BABs CCR unit is initially underlain by at least 90 to as much as 136 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet within the monitoring well network and rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) to the southeast. Consequently, the uppermost aquifer is not laterally contiguous across the entire BRPP BABs CCR unit, and not present in the southeastern corner of the BABs.

The detection monitoring well network for the BABs CCR unit currently consists of five monitoring wells that are screened in the uppermost aquifer. As discussed in the Stats Plan, intrawell statistical methods for the BABs CCR unit were selected based on the geology and hydrogeology at the Site (primarily the presence of clay/hydraulic barrier, the variability in the presence of the uppermost aquifer across the site, and presence of no flow boundary on the southeast side of the aquifer), in addition to other supporting lines of evidence that the aquifer is unaffected by the CCR unit (such as the consistency in concentrations of water quality data). Monitoring wells MW-16-01 through MW-16-04 and MW-16-09 are located around the north, east and south perimeter of the BABs and provide data on both background and downgradient groundwater quality that has not been affected by the CCR unit (total of five background/downgradient monitoring wells).

Alternate Source Demonstration

Verification resampling was performed as recommended per the Stats Plan and the USEPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance (Unified Guidance, USEPA, 2009) to achieve performance standards as specified by §257.93(g) in the CCR rules. Per the Stats Plan, if there is an exceedance of a prediction limit for one or more of the parameters, the well(s) of concern will be resampled within 30 days of the completion of the initial statistical analysis. Only constituents that initially exceed their statistical limit (i.e., have no previously recorded SSIs) will be analyzed for verification purposes. As such, verification resampling was conducted on January 9, 2018, by TRC personnel. Groundwater samples were collected for pH (field reading) at monitoring wells MW-16-01 and MW-16-02 in accordance with the Quality Assurance Project Plan (TRC, July 2016, revised in March and August 2017). A summary of the groundwater data collected during the verification resampling event is provided on Table 1. The associated data quality review is included in Attachment A.

All of the pH verification results are within the prediction limits; consequently, the initial SSIs from the October 2017 event are not confirmed. Therefore, in accordance with the Stats Plan and the Unified Guidance, the initial exceedances are not statistically significant and no SSIs will be recorded for the October 2017 monitoring event.

Conclusions and Recommendations

Based on the results of the verification resampling, the initial exceedances for pH at monitoring wells MW-16-01 and MW-16-02 are not statistically significant; therefore, no SSIs are recorded for the initial detection monitoring event. In addition, as discussed in the Annual Report, with the presence of the vertically and horizontally extensive clay-rich confining till beneath the BRPP BABs CCR unit, it is not possible for the uppermost aquifer to have been affected by CCR from operations. Due to limitations on CCR Rule implementation timelines, the background data sets are of relatively short duration for capturing the occurrence of natural temporal changes in the aquifer.

Since no confirmed SSIs over background limits were identified for any of the Appendix III parameters during the October 2017 monitoring event, DTE Electric will continue with the detection monitoring program at BRPP BABs CCR unit. The next semiannual monitoring event is scheduled for the second calendar quarter of 2018.

Certification Statement

I hereby certify that the alternative source demonstration presented within this document for the BRPP BAB CCR unit has been prepared to meet the requirements of Title 40 CFR §257.94(e) 2 of the Federal CCR Rule. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.94(e) 2.

Name: David B. McKenzie, P.E.	Expiration Date: October 31, 2019	State of Michigan David B. McKenzie Engineer No. 42332 Licensed Professional Engineer
Company: TRC Engineers Michigan, Inc.	Date: April 12, 2018	Stamp

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TRC Environmental Corporation. July 2016; Revised March and August 2017. CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

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Attachments

Table 1. Comparison of Verification Sampling Results to Background Limits

Attachment A. Data Quality Review

Table 1

Table 1
Comparison of Verification Sampling Results to Background Limits
Belle River Power Plant BABs – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		**MW-16-01**		**MW-16-02**	
Sample Date:		1/9/2018		1/9/2018	
Constituent	Unit	Data	PL	Data	PL
Appendix III					
pH, Field	SU	7.6	7.6 - 8.1	7.4	7.4 - 8.0

Notes:

SU - standard units; pH is a field parameter.

RESULT Shading and bold font indicates a confirmed exceedance of the Prediction Limit (PL).

Attachment A
Data Quality Review

Field Parameter Data Quality Review
Groundwater Monitoring Event January 2018 (Verification Resampling)
DTE Electric Company Belle River Power Plant (DTE BRPP)

On January 9, 2018, TRC Environmental Corporation (TRC) collected groundwater samples at MW-16-01 and MW-16-02 to verify initial pH (field measured) results that were outside of the prediction limits during the October 2017 detection monitoring event. Prior to sample collection, groundwater was purged and stabilized using the low flow sampling methods followed during the October 2017 monitoring event in accordance with the *CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin* (QAPP) (TRC, July 2016; revised August 2017).

TRC reviewed the field data to assess data usability. The following sections summarize the data review procedure and the results of the review.

Data Quality Review Procedure

The following items were included in the evaluation of the data:

- Review of sonde calibration data;
- Confirm field parameter stabilization criteria were met;
- Compare field parameters to historical data; and
- Overall usability of the data based on these items.

Review Summary

The data quality objectives and completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

QA/QC Sample Summary:

- Sonde calibration readings were within calibration range for all field parameters.
- Field parameters met stabilization criteria for 3 successive readings.
- Field parameters readings were comparable to historical data.
- Data are usable for purposes of verification resampling.

Appendix B
Data Quality Reviews

Laboratory Data Quality Review
Groundwater Monitoring Event March 2018 (Detection Monitoring)
DTE Electric Company Belle River Power Plant (DTE BRPP)

Groundwater samples were collected by TRC for the April 2018 sampling event for the Bottom Ash Basins and Diversion Basin at the DTE BRPP. Samples were analyzed for anions, total metals, and total dissolved solids by Test America Laboratories, Inc. (Test America), located in Canton, Ohio. The laboratory analytical results are reported in laboratory report J93478-1.

During the April 2018 sampling event, a groundwater sample was collected from each of the following wells:

Bottom Ash Basins:

- MW-16-01
- MW-16-02
- MW-16-03
- MW-16-04
- MW-16-09

Diversion Basin:

- MW-16-05
- MW-16-06
- MW-16-07
- MW-16-08
- MW-16-10
- MW-16-11A

Each sample was analyzed for the following constituents:

Analyte Group	Method
Anions (Chloride, Fluoride, Sulfate)	EPA 9056A
Total Metals	EPA 6010B
Total Dissolved Solids	SM 2540C

TRC reviewed the laboratory data to assess data usability. The following sections summarize the data review procedure and the results of the review.

Data Quality Review Procedure

The analytical data were reviewed using the USEPA National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). The following items were included in the evaluation of the data:

- Sample receipt, as noted in the cover page or case narrative;
- Technical holding times for analyses;
- Data for method blanks and equipment blanks. Method blanks are used to assess potential contamination arising from laboratory sample preparation and/or analytical procedures. Equipment blanks are used to assess potential contamination arising from field procedures;

- Percent recoveries for matrix spike (MS) and matrix spike duplicates (MSD). Percent recoveries are calculated for each analyte spiked and used to assess bias due to sample matrix effects;
- Reporting limits (RLs) compared to project-required RLs;
- Data for blind field duplicates. Field duplicate samples are used to assess variability introduced by the sampling and analytical processes;
- Data for laboratory control samples (LCSs). The LCSs are used to assess the accuracy of the analytical method using a clean matrix;
- Data for laboratory duplicates. The laboratory duplicates are replicate analyses of one sample and are used to assess the precision of the analytical method; and
- Overall usability of the data.

This data usability report addresses the following items:

- Usability of the data if quality control (QC) results suggest potential problems with all or some of the data;
- Actions regarding specific QC criteria exceedances.

Review Summary

The data quality objectives and laboratory completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

- Appendix III constituents will be utilized for the purposes of a detection monitoring program.
- Data are usable for the purposes of the detection monitoring program.

QA/QC Sample Summary:

- Target analytes were not detected in the method blank.
- LCS recoveries were within laboratory control limits.
- Dup-01 corresponds with MW-16-06; relative percent differences (RPDs) between the parent and duplicate sample were within the QC limits.
- Laboratory duplicates were performed on sample Dup-01 for total dissolved solids; RPDs between the parent and duplicate sample were within the QC limits.
- MS/MSD analyses were performed on sample MW-16-04, MW-16-07, and EB_20180327 for anions (fluoride and sulfate). Percent recoveries and RPDs were within laboratory control limits.

Laboratory Data Quality Review
Groundwater Monitoring Event October 2018 (Detection Monitoring)
DTE Electric Company Belle River Power Plant (DTE BRPP)

Groundwater samples were collected by TRC for the October 2018 sampling event for the Bottom Ash Basins and Diversion Basin at the DTE BRPP. Samples were analyzed for anions, total metals, and total dissolved solids by Test America Laboratories, Inc. (Test America), located in North Canton, Ohio. The laboratory analytical results are reported in laboratory reports 240-102395-1 and 240-102609-1-1.

During the October 2018 sampling event, a groundwater sample was collected from each of the following wells:

Bottom Ash Basins:

- MW-16-01
- MW-16-02
- MW-16-03
- MW-16-04
- MW-16-09

Diversion Basin:

- MW-16-05
- MW-16-06
- MW-16-07
- MW-16-08
- MW-16-10
- MW-16-11A

Each sample was analyzed for the following constituents:

Analyte Group	Method
Anions (Chloride, Fluoride, Sulfate)	SW846 9056A
Total Boron	SW846 3005A/6010B
Total Calcium	SW846 3005A/6020
Total Dissolved Solids	SM 2540C

TRC reviewed the laboratory data to assess data usability. The following sections summarize the data review procedure and the results of the review.

The analytical data were reviewed using the USEPA National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). The following items were included in the evaluation of the data:

- Sample receipt, as noted in the cover page or case narrative;
- Technical holding times for analyses;
- Reporting limits (RLs) compared to project-required RLs;

- Data for method blanks and equipment blanks. Method blanks are used to assess potential contamination arising from laboratory sample preparation and/or analytical procedures. Equipment blanks are used to assess potential contamination arising from field procedures;
- Data for laboratory control samples (LCSs). The LCSs are used to assess the accuracy of the analytical method using a clean matrix;
- Data for matrix spike and matrix spike duplicate samples (MS/MSDs). The MS/MSDs are used to assess the accuracy and precision of the analytical method using a sample from the dataset;
- Data for laboratory duplicates. The laboratory duplicates are used to assess the precision of the analytical method using a sample from the dataset;
- Data for blind field duplicates. Field duplicate samples are used to assess variability introduced by the sampling and analytical processes; and
- Overall usability of the data.

This data usability report addresses the following items:

- Usability of the data if quality control (QC) results suggest potential problems with all or some of the data;
- Actions regarding specific QC criteria exceedances.

Review Summary

The data quality objectives and laboratory completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

- Appendix III constituents will be utilized for the purposes of a detection monitoring program.
- Data are usable for the purposes of the detection monitoring program.

QA/QC Sample Summary:

- There was one equipment blank submitted with this dataset (EB-01_20181003). Chloride at 1.2 mg/L and TDS at 11 mg/L were detected in this equipment blank. However, the sample results for these analytes were detected at concentrations greater than five times the blank concentrations; thus, there was no impact on data usability.

- Target analytes were not detected in the method blanks.

- LCS recoveries for all target analytes were within laboratory control limits.

- MS/MSD analyses were performed on sample MW-16-02 for the anions; the percent recoveries (%Rs) and relative percent differences (RPDs) were acceptable.

- Dup-01 corresponds with MW-16-03; RPDs between the parent and duplicate sample were within the QC limits.

- The reporting limit (2.0 mg/L) for the nondetect sulfate results in samples MW-16-08 and MW-16-11A was above the QAPP-specified RL (1.0 mg/L) due to a 2-fold dilution as a result of a difficult matrix.

Appendix E
2017 Annual Groundwater Monitoring Report

Annual Groundwater Monitoring Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins

4505 King Road
China Township, Michigan

January 2018

Annual Groundwater Monitoring Report

DTE Electric Company
Belle River Power Plant Bottom Ash Basins

4505 King Road
China Township, Michigan

January 2018

Prepared For
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Final
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Executive Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule). The CCR Rule, which became effective on October 19, 2015, applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs) CCR unit. Pursuant to the CCR Rule, no later than January 31, 2018, and annually thereafter, the owner or operator of a CCR unit must prepare an annual groundwater monitoring and corrective action report for the CCR unit documenting the status of groundwater monitoring and corrective action for the preceding year in accordance with §257.90(e).

TRC Engineers Michigan, Inc., the engineering entity of TRC Environmental Corporation (TRC), prepared this Annual Groundwater Monitoring Report (Annual Report) for the BRPP BABs CCR unit on behalf of DTE Electric. This Annual Report was prepared in accordance with the requirements of §257.90(e) and presents the monitoring results and the statistical evaluation of the detection monitoring parameters (Appendix III to Part 257 of the CCR Rule) for the October 2017 semiannual groundwater monitoring event for the BRPP BABs CCR unit. This event is the initial detection monitoring event performed to comply with §257.94. As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify statistically significant increases (SSIs) in detection monitoring parameters to determine if concentrations in detection monitoring well samples exceed background levels.

Potential SSIs over background limits were noted for pH in one or more downgradient wells for the October 2017 monitoring event. This is the initial detection monitoring event; therefore, it is the initial identification of a SSI over background levels. Based on the hydrogeology at the Site, with the presence of the vertically and horizontally extensive clay-rich confining till beneath the BRPP BABs CCR unit, it is not possible for the uppermost aquifer to have been affected by CCR from operations. Due to limitations on CCR Rule implementation timelines, the background data sets are of relatively short duration for capturing the occurrence of natural temporal changes in the aquifer.

According to §257.94(e), if the facility determines, pursuant to §257.93(h), that there is a SSI over background levels for one or more of the Appendix III constituents, the facility will, within 90 days of detecting a SSI, establish an assessment monitoring program **<or>** demonstrate that:

- A source other than the CCR unit caused the SSI, or
- The SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

In response to the potential pH SSIs over background limits noted during the October 2017 monitoring event, DTE Electric plans to collect a resample for each of the potential SSIs and prepare an Alternative Source Demonstration (ASD) to evaluate the SSIs and demonstrate that natural variation within the uppermost aquifer is the cause of the SSIs.

Section 1
Introduction

1.1 Program Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule). The CCR Rule, which became effective on October 19, 2015, applies to the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs). Pursuant to the CCR Rule, no later than January 31, 2018, and annually thereafter, the owner or operator of a CCR unit must prepare an annual groundwater monitoring and corrective action report for the CCR unit documenting the status of groundwater monitoring and corrective action for the preceding year in accordance with §257.90(e).

TRC Engineers Michigan, Inc., the engineering entity of TRC Environmental Corporation (TRC), prepared this Annual Groundwater Monitoring Report (Annual Report) for the BRPP BABs CCR unit on behalf of DTE Electric. This Annual Report was prepared in accordance with the requirements of §257.90(e) and presents the monitoring results and the statistical evaluation of the detection monitoring parameters (Appendix III to Part 257 of the CCR Rule) for the October 2017 semiannual groundwater monitoring event for the BRPP BABs CCR unit. This event is the initial detection monitoring event performed to comply with §257.94. The monitoring was performed in accordance with the *CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin* (QAPP) (TRC, July 2016; revised August 2017) and statistically evaluated per the *Groundwater Statistical Evaluation Plan – Belle River Power Plant Coal Combustion Residual Bottom Ash Basins* (Stats Plan) (TRC, October 2017). As part of the statistical evaluation, the data collected during detection monitoring events are evaluated to identify statistically significant increases (SSIs) of detection monitoring parameters compared to background levels.

1.2 Site Overview

The BRPP is located in Section 13, Township 4 North, Range 16 East, at 4505 King Road, China Township in St. Clair County, Michigan. The BRPP was constructed in the early 1980s with plant operations beginning in 1984. Prior to Detroit Edison Company's operations commencing in the 1980s, 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 BABs have been in use with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR unit, which is monitored as a separate CCR unit in accordance with the CCR Rule.

The DB is an incised CCR surface impoundment located west of the BRPP near the Webster Drain. Water flows into the DB from the North and South 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.

1.3 Geology/Hydrogeology

The BRPP BABs CCR unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet below ground surface (bgs). In general, the BRPP BABs CCR unit is initially underlain by at least 90 to as much as 136 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet within the monitoring well network and rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) to the southeast in the vicinity of SB-16-01 (Figure 1). Consequently, the uppermost aquifer is not laterally contiguous across the entire BRPP BABs CCR unit, and not present in the southeastern corner of the BABs.

The variability in the depth to the uppermost aquifer is a consequence of the heterogeneity of the glacial deposits and is driven by the lateral discontinuity of the sand outwash within the encapsulating fine-grained, silty clay till that confines the uppermost aquifer. There is an apparent lack of interconnection and/or significant vertical variation between the uppermost aquifer sand unit(s) encountered across the BRPP BABs CCR unit as demonstrated by the extensive amount of time (months) it took for water levels in monitoring well MW-16-02 to reach equilibrium after well construction and development (TRC, 2017).

Given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit, the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs, where present varying up to 46 feet vertically), the no flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area, and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the BRPP BABs CCR unit.

In addition, the elevation of CCR-affected water maintained within the BRPP BABs is approximately 5 feet above the potentiometric surface elevations in the uppermost aquifer at the BABs CCR unit area. This suggests that if the CCR affected surface water in the BABs were able to penetrate the silty clay-rich underlying confining unit that the head on that release likely would travel radially away from the BABs within the uppermost aquifer. However, with the very thick continuous silty clay-rich confining unit beneath the BRPP it is not possible for the uppermost aquifer to have been affected by CCR from BRPP operations that began in the 1980s.

Due to the relatively small footprint of the BABs, the low vertical and horizontal groundwater flow velocity, the potential for radial flow, and the fact that the saturated unit being monitored is isolated by a laterally contiguous silty-clay unit, which significantly impedes vertical groundwater flow thus preventing the monitored saturated zone from potentially being affected by CCR, monitoring of the BRPP BABs CCR unit using intrawell statistical methods is appropriate. In addition, because the uppermost aquifer is not uniformly present across the BABs CCR unit, there are no clear upgradient wells. As such, intrawell statistical approaches are being used during detection monitoring as discussed in the Stats Plan.

Section 2
Groundwater Monitoring

2.1 Monitoring Well Network

A groundwater monitoring system has been established for the BRPP BABs 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 BABs CCR unit currently consists of five monitoring wells that are screened in the uppermost aquifer. The monitoring well locations are shown on Figure 2.

As discussed in the Stats Plan, intrawell statistical methods for the BABs CCR unit were selected based on the geology and hydrogeology at the Site (primarily the presence of clay/hydraulic barrier, the variability in the presence of the uppermost aquifer across the site, and presence of no flow boundary on the southeast side of the aquifer), in addition to other supporting lines of evidence that the aquifer is unaffected by the CCR unit (such as the consistency in concentrations of water quality data). An intrawell statistical approach requires that each of the downgradient wells doubles as the background and compliance well, where data from each individual well during a detection monitoring event is compared to a statistical limit developed using the background dataset from that same well. Monitoring wells MW-16-01 through MW-16-04 and MW-16-09 are located around the north, east and south perimeter of the BABs and provide data on both background and downgradient groundwater quality that has not been affected by the CCR unit (total of five background/downgradient monitoring wells).

2.2 Background Sampling

Background groundwater monitoring was conducted at the BRPP BABs CCR unit from August 2016 through September 2017 in accordance with the QAPP. Data collection included eight background data collection events of static water elevation measurements, analysis for parameters required in the CCR Rule's Appendix III and Appendix IV to Part 257, and field parameters (dissolved oxygen, oxidation reduction potential, pH, specific conductivity, temperature, and turbidity) from all five monitoring wells installed for the BABs CCR unit, in addition to supplemental sampling events at select locations. The supplemental background sampling events were conducted for a subset of monitoring wells in September 2017 to expand the background data set and confirm analytical results; one additional background sampling event was performed for monitoring wells MW-16-01, MW-16-02, MW-16-04, and MW-16-09. The groundwater samples were analyzed by TestAmerica Laboratories, Inc. (TestAmerica).

Background data are included in Appendix A Tables 1 through 3, where: Table 1 is a summary of static water elevation data; Table 2 is a summary of groundwater analytical data compared to potentially relevant criteria; and Table 3 is a summary of field data. In addition to the data tables, groundwater potentiometric elevation data are summarized for each background monitoring event in Appendix A Figure 1.

2.3 Semiannual Groundwater Monitoring

The semiannual monitoring parameters for the detection groundwater monitoring program were selected per the CCR Rule's Appendix III to Part 257 – Constituents for Detection Monitoring. The Appendix III indicator parameters consist of boron, calcium, chloride, fluoride, pH (field reading), sulfate, and total dissolved solids (TDS) and were analyzed in accordance with the sampling and analysis plan included within the QAPP. In addition to pH, the collected field parameters included dissolved oxygen, oxidation reduction potential, specific conductivity, temperature, and turbidity.

2.3.1 Data Summary

The initial semiannual groundwater detection monitoring event for 2017 was performed during October 2 and 3, 2017, by TRC personnel and samples were analyzed by TestAmerica in accordance with the QAPP. Static water elevation data were collected at all five monitoring well locations. Groundwater samples were collected from the five detection monitoring wells for the Appendix III indicator parameters and field parameters. A summary of the groundwater data collected during the October 2017 event is provided on Table 1 (static groundwater elevation data), Table 2 (analytical results), and Table 3 (field data).

2.3.2 Data Quality Review

Data from each round were evaluated for completeness, overall quality and usability, method-specified sample holding times, precision and accuracy, and potential sample contamination. The data were found to be complete and usable for the purposes of the CCR monitoring program. Particular data non-conformances are summarized in Appendix B.

2.3.3 Groundwater Flow Rate and Direction

As presented in the GWMS Report, and mentioned above, given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit; the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs; where present, varying up to 46 feet vertically); the no flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area; and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the site. Groundwater elevations measured across the Site during the October 2017 sampling event are provided on Table 1 and are summarized in plan view on Figure 3.

Groundwater elevation data collected during the most recent sampling event show that groundwater conditions within the uppermost aquifer are consistent with previous monitoring events, and continue to demonstrate that the downgradient wells are appropriately positioned to detect the presence of Appendix III parameters that could potentially migrate from the BRPP BABs CCR unit.

Section 3
Statistical Evaluation

3.1 Establishing Background Limits

Per the Stats Plan, background limits were established for the Appendix III indicator parameters following the collection of at least eight background monitoring events using data collected from each of the five established detection monitoring wells (MW-16-01 through MW-16-04 and MW-16-09). The statistical evaluation of the background data is presented in detail in Appendix C. The Appendix III background limits for each monitoring well will be used throughout the detection monitoring period to determine whether groundwater has been impacted from the BRPP BABs CCR unit by comparing concentrations in the detection monitoring wells to their respective background limits for each Appendix III indicator parameter.

3.2 Data Comparison to Background Limits

The concentrations of the indicator parameters in each of the detection monitoring wells (MW-16-01 through MW-16-04 and MW-16-09) were compared to their respective statistical background limits calculated from the background data collected from each individual well (i.e., monitoring data from MW-16-01 is compared to the background limit developed using the background dataset from MW-16-01, and so forth). The comparisons are presented on Table 4.

The statistical evaluation of the October 2017 Appendix III indicator parameters shows potential SSIs outside of background for:

- pH at MW-16-01 and MW-16-02.

There were no SSIs compared to background for boron, calcium, chloride, fluoride, sulfate or TDS.

Section 4
Conclusions and Recommendations

Potential SSIs over background limits were noted for pH in one or more downgradient wells during the October 2017 monitoring event. This is the initial detection monitoring event; therefore, it is the initial identification of a potential SSI over background levels. As discussed above, and in the GWMS Report, with the presence of the vertically and horizontally extensive clay-rich confining till beneath the BRPP BABs CCR unit, it is not possible for the uppermost aquifer to have been affected by CCR from operations. Due to limitations on CCR Rule implementation timelines, the background data sets are of relatively short duration for capturing the occurrence of natural temporal changes in the aquifer. In addition, although the statistical limits based on the initial background dataset were exceeded for pH, the calculated prediction limits and results respective to each of these potential SSIs are within the USEPA's maximum contaminant level (MCL) pH range of 6.5 to 8.5 standard units (SU) for drinking water (USEPA, 2012).

According to §257.94(e), in the event that the facility determines, pursuant to §257.93(h), that there is a SSI over background levels for one or more of the Appendix III constituents, the facility will, within 90 days of detecting a SSI, establish an assessment monitoring program **<or>** demonstrate that:

- A source other than the CCR unit caused the SSI, or
- The SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

The owner or operator must complete a written demonstration (i.e., Alternative Source Demonstration, ASD), of the above within 90 days of confirming the SSI. Based on the outcome of the ASD the following steps will be taken:

- If a successful ASD is completed, a certification from a qualified professional engineer is required, and the CCR unit may continue with detection monitoring.
- If a successful ASD is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under §257.95. The facility must also include the ASD in the annual groundwater monitoring and corrective action report required by §257.90(e), in addition to the certification by a qualified professional engineer.

In response to the potential pH SSIs over background limits noted for the October 2017 monitoring event, DTE Electric plans to collect a resample for each of the potential SSIs and prepare an ASD within 90-days to evaluate the SSIs. The SSI is likely the result of temporal variability that was not captured in the background data set, given the short duration of time that the background data set was collected, but this will be further evaluated during the ASD process.

No corrective actions were performed in 2017. The next semiannual monitoring event at the BRPP BABs CCR unit is scheduled for the second calendar quarter of 2018.

Section 5
Groundwater Monitoring Report Certification

The U.S. EPA's Disposal of Coal Combustion Residuals from Electric Utilities Final Rule Title 40 CFR Part 257 §257.90(e) requires that the owner or operator of an existing CCR unit prepare an annual groundwater monitoring and corrective action report.

Annual Groundwater Monitoring Report Certification
Belle River Power Plant Bottom Ash Basins
China Township, Michigan

CERTIFICATION

I hereby certify that the annual groundwater and corrective action report presented within this document for the BRPP BABs CCR unit has been prepared to meet the requirements of Title 40 CFR §257.90(e) of the Federal CCR Rule. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.90(e).

Name: David B. McKenzie, P.E.	Expiration Date: October 31, 2019	State of Michigan David B. McKenzie Engineer No. 42332 Licensed Professional Engineer
Company: TRC Engineers Michigan, Inc.	Date: 1/30/18	Stamp

Section 6
References

TRC Environmental Corporation. July 2016; Revised March and August 2017. CCR Groundwater Monitoring and Quality Assurance Project Plan – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. October 2017. Groundwater Monitoring System Summary Report – DTE Electric Company Belle River Power Plant Bottom Ash Basins and Diversion Basin Coal Combustion Residual Units, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

TRC Environmental Corporation. October 2017. Groundwater Statistical Evaluation Plan – DTE Electric Company Belle River Power Plant Coal Combustion Residual Bottom Ash Basins, 4505 King Road, China Township, Michigan. Prepared for DTE Electric Company.

U.S. Environmental Protection Agency. April 2012. 2012 Edition of the Drinking Water Standards and Health Advisories. EPA 822-S-12-001. Office of Water, U.S. Environmental Protection Agency, Washington, DC. Spring 2012; Date of update: April, 2012.

Tables

Table 1
Summary of Groundwater Elevation Data – October 2017
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Date Installed	3/17/2016		3/15/2016		6/1/2016		3/8/2016		6/2/2016	
TOC Elevation	590.06		588.94		590.66		590.51		590.80	
Geologic Unit of Screened Interval	Sand		Sand		Silty Sand		Sand		Sand	
Screened Interval Elevation	496.3 to 491.3		494.3 to 489.3		456.0 to 451.0		468.5 to 463.5		452.3 to 447.3	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
10/2/2017	16.33	573.73	14.71	574.23	16.62	574.04	16.98	573.53	16.81	573.99

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing

Table 2
Summary of Groundwater Analytical Data – October 2017
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		**MW-16-01**	**MW-16-02**	**MW-16-03**	**MW-16-04**	**MW-16-09**
Sample Date:		10/2/2017	10/2/2017	10/2/2017	10/2/2017	10/3/2017
Constituent	Unit					
Appendix III						
Boron	ug/L	950	1,000	1,000	920	1,600
Calcium	ug/L	38,000	53,000	32,000	44,000	34,000
Chloride	mg/L	470	370	580	510	980
Fluoride	mg/L	1.7	1.2	1.8	1.7	1.5
pH, Field	SU	7.3	7.3	7.7	7.8	8.1
Sulfate	mg/L	4.2	7.7	2.5	7.9	24
Total Dissolved Solids	mg/L	930	760	1,100	1,000	1,700

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

All metals were analyzed as total unless otherwise specified.

Table 3
Summary of Field Data – October 2017
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (SU)	Specific Conductivity (umhos/cm)	Temperature (deg C)	Turbidity (NTU)
MW-16-01	10/2/2017	0.54	-113.6	7.3	1,764	13.35	2.91
MW-16-02	10/2/2017	0.45	-102.8	7.3	1,391	15.02	0.54
MW-16-03	10/2/2017	0.24	-142.2	7.7	2,021	14.38	0.77
MW-16-04	10/2/2017	0.27	-132.9	7.8	1,807	15.92	82.2
MW-16-09	10/3/2017	0.21	-180.5	8.1	3,272	14.15	57.0

Notes:

mg/L - milligrams per liter.

mV - milliVolt.

SU - standard unit.

umhos/cm - micro-mhos per centimeter.

deg C - degrees celcius.

NTU - nephelometric turbidity units.

Table 4
Comparison of Appendix III Parameter Results to Background Limits – October 2017
Belle River Power Plant BABs – RCRA CCR Monitoring Program
China Township, Michigan

	Sample Location:	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
	Sample Date:	10/2/2017		10/2/2017		10/2/2017		10/2/2017		10/3/2017	
Constituent	Unit	Data	PL	Data	PL	Data	PL	Data	PL	Data	PL
Appendix III											
Boron	ug/L	950	1,300	1,000	1,300	1,000	1,300	920	1,100	1,600	1,900
Calcium	ug/L	38,000	45,000	53,000	59,000	32,000	36,000	44,000	64,000	34,000	41,000
Chloride	mg/L	470	530	370	400	580	690	510	520	980	1100
Fluoride	mg/L	1.7	1.9	1.2	1.3	1.8	1.9	1.7	1.9	1.5	1.8
pH, Field	SU	**7.3**	7.6 - 8.1	**7.3**	7.4 - 8.0	7.7	7.5 - 8.3	7.8	7.5 - 8.4	8.1	7.7 - 8.7
Sulfate	mg/L	4.2	8.1	7.7	20	2.5	14	7.9	18	24	40
Total Dissolved Solids	mg/L	930	950	760	890	1,100	1,100	1,000	1,100	1,700	2,000

Notes:

ug/L - micrograms per liter.

mg/L - milligrams per liter.

SU - standard units; pH is a field parameter.

All metals were analyzed as total unless otherwise specified.

RESULT Shading and bold font indicates an exceedance of the Prediction Limit (PL).

Figures

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 2,000 '
1:24,000

0 2,000 4,000 FEET

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN
TITLE:	SITE LOCATION MAP

DRAWN BY:	J. PAPEZ
CHECKED BY:	S HOLMSTROM
APPROVED BY:	V. BUENING
DATE:	OCTOBER 2017
PROJ. NO.:	265996.0003
FILE:	265996-SLMMB.mxd

FIGURE 1

E:\DTE\CCR_Sites\2017_265996\265996-SLMMB.mxd -- Saved By: BDEEGAN on 10/9/2017, 14:49:39 PM

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

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 BY BMJ ENGINEERS & SURVEYORS, INC.

N

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT:

DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:

SITE PLAN

DRAWN BY:	R SUEMNICHT	PROJ NO.:	265996.0003
CHECKED BY:	S HOLMSTROM		**FIGURE 2**
APPROVED BY:	V BUENING		
DATE:	OCTOBER 2017		

TRC

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

FILE NO.: 265996-0003-002.mxd

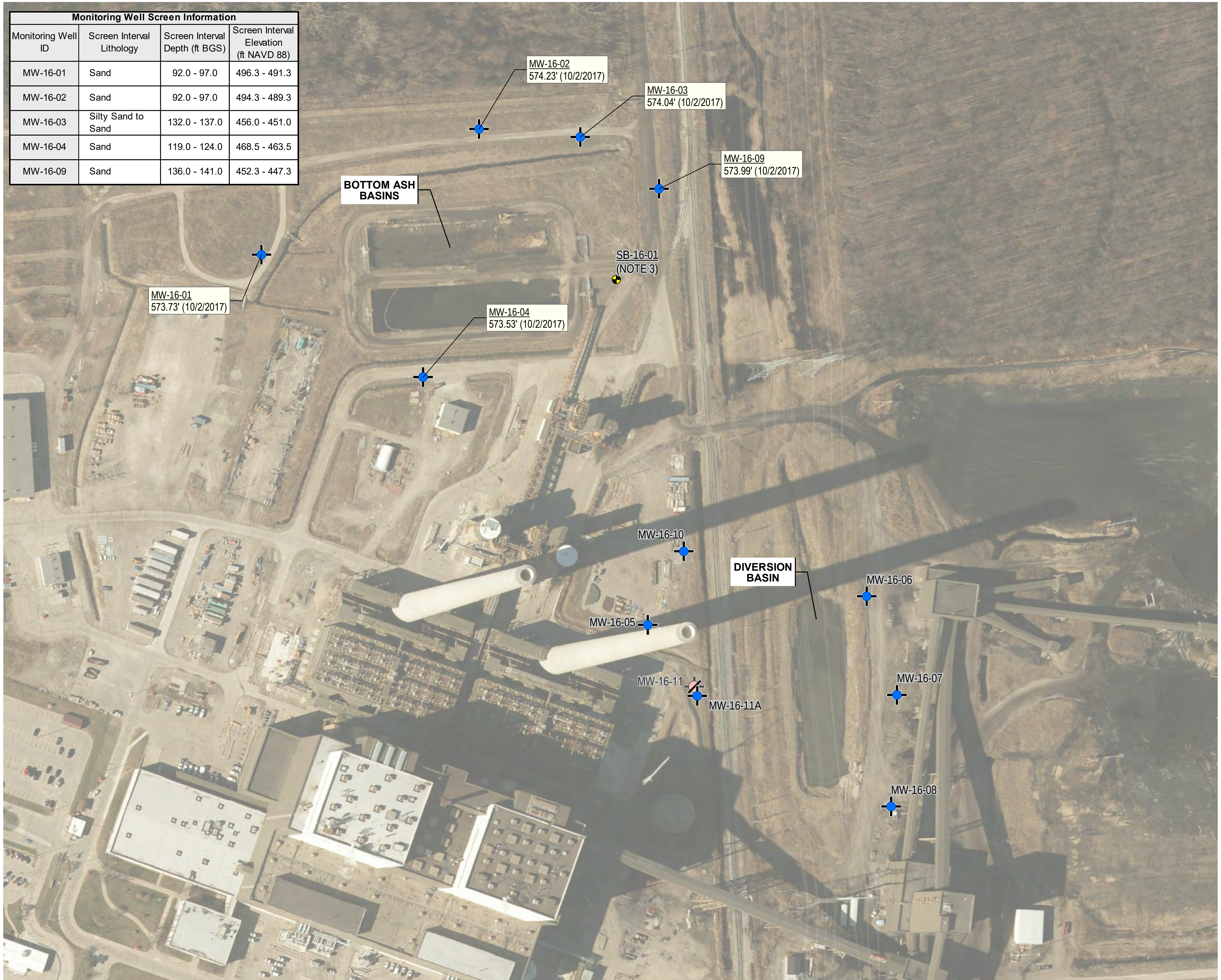
TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 10/9/2017, 15:18:14 PM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-002.mxd

Monitoring Well Screen Information

Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY OCTOBER 2017

DRAWN BY:	S. MAJOR	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA		
APPROVED BY:	V. BUENING	**FIGURE 3**	
DATE:	JANUARY 2018		

TRC

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

FILE NO.: 265996-0003-014.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/12/2018, 09:54:28 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-014.mxd

Appendix A
Background Data

Table 1
Groundwater Elevation Summary
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Well ID	MW-16-01		MW-16-02		MW-16-03		MW-16-04		MW-16-09	
Date Installed	3/17/2016		3/15/2016		6/1/2016		3/8/2016		6/2/2016	
TOC Elevation	590.06		588.94		590.66		590.51		590.80	
Geologic Unit of Screened Interval	Sand		Sand		Silty Sand		Sand		Sand	
Screened Interval Elevation	496.3 to 491.3		494.3 to 489.3		456.0 to 451.0		468.5 to 463.5		452.3 to 447.3	
Unit	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft	ft BTOC	ft
Measurement Date	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation	Depth to Water	GW Elevation
8/1/2016	16.21	573.85	15.30	573.64	16.53	574.13	16.89	573.62	16.70	574.10
9/19/2016	16.25	573.81	23.33	565.61	16.54	574.12	16.90	573.61	16.70	574.10
11/7/2016	16.58	573.48	19.91	569.03	16.82	573.84	17.15	573.36	16.95	573.85
1/9/2017	16.39	573.67	17.90	571.04	16.66	574.00	17.02	573.49	16.90	573.90
2/27/2017	16.11	573.95	16.65	572.29	16.43	574.23	16.75	573.76	16.56	574.24
4/17/2017	16.05	574.01	15.71	573.23	16.31	574.35	16.63	573.88	16.45	574.35
5/18/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
6/5/2017	15.67	574.39	14.80	574.14	15.98	574.68	16.31	574.20	16.18	574.62
6/30/2017	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
7/24/2017	15.82	574.24	14.45	574.49	16.12	574.54	16.44	574.07	16.29	574.51

Notes:

Elevations are reported in feet relative to the North American Vertical Datum of 1988.

ft BTOC - feet Below top of casing

NM - Not Measured

Table 2
Summary of Groundwater Analytical Results
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-01								
	Sample Date:	8/1/2016	9/20/2016	11/7/2016	1/9/2017	2/27/2017	4/17/2017	6/5/2017	7/24/2017	9/11/2017
Constituent	Unit									
Appendix III										
Boron	ug/L	1,000	980	1,100	1,100	1,100	1,100	1,300	1,200	1,100
Calcium	ug/L	45,000	38,000	37,000	42,000	39,000	38,000	38,000	42,000	41,000
Chloride	mg/L	490	480	520	490	450	440	500	470	460
Fluoride	mg/L	1.7	1.5	1.6	1.4	1.7	1.6	1.7	1.7	1.8
pH	SU	7.95	7.9	7.9	7.9	7.9	7.9	7.7	7.8	7.5
Sulfate	mg/L	1.5	1.5	< 5.0	1.9	< 5.0	< 5.0	4.6	4.8	7.2
Total Dissolved Solids	mg/L	930	920	920	940	950	920	910	920	910
Appendix IV										
Antimony	ug/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Arsenic	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	300	260	240	250	240	240	240	250	240
Beryllium	ug/L	< 1.0	2.8	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chromium	ug/L	13	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Cobalt	ug/L	3.6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Fluoride	mg/L	1.7	1.5	1.6	1.4	1.7	1.6	1.7	1.7	1.8
Lead	ug/L	3.5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lithium	ug/L	23	13	12	9.5	9.6	11	10	12	< 8.0
Mercury	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	89	82	76	70	79	76	73	83	73
Radium-226	pCi/L	1.22	0.599	1.08	0.589	0.576	0.482	0.659	0.500	0.475
Radium-226/228	pCi/L	1.84	1.07	1.46	1.08	0.656	0.619	1.32	0.942	0.536
Radium-228	pCi/L	< 0.991	0.468	< 0.460	< 0.643	< 0.412	< 0.434	0.657	0.442	< 0.335
Selenium	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Thallium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units.
pCi/L - picocuries per liter.
All metals were analyzed as total, unless
otherwise specified.

Table 2
Summary of Groundwater Analytical Results
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-02									
Sample Date:		8/2/2016	9/19/2016	11/7/2016	11/7/2016	1/9/2017	2/27/2017	4/17/2017	6/5/2017	7/24/2017	9/12/2017
Constituent	Unit				Field Dup						
Appendix III											
Boron	ug/L	980	1,000	1,200	1,200	1,100	1,200	1,100	1,200	1,100	1,100
Calcium	ug/L	55,000	57,000	56,000	55,000	58,000	55,000	52,000	53,000	54,000	54,000
Chloride	mg/L	360	370	390	390	390	370	340	360	370	360
Fluoride	mg/L	1.1	1.0	1.1	1.1	0.97	1.2	1.1	1.2	1.2	1.3
pH	SU	7.80	7.8	7.9	7.9	7.8	7.8	7.9	7.7	7.7	7.8
Sulfate	mg/L	18	< 1.0	< 5.0	< 5.0	2.0	12	11	11	8.3	7.6
Total Dissolved Solids	mg/L	760	710	720	740	780	760	910	810	760	770
Appendix IV											
Antimony	ug/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Arsenic	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	330	320	270	270	290	280	270	280	270	280
Beryllium	ug/L	< 1.0	2.8	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chromium	ug/L	19	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Cobalt	ug/L	3.9	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Fluoride	mg/L	1.1	1.0	1.1	1.1	0.97	1.2	1.1	1.2	1.2	1.3
Lead	ug/L	2.9	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lithium	ug/L	19	15	13	12	12	13	13	13	13	12
Mercury	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	65	39	35	34	34	38	36	36	38	36
Radium-226	pCi/L	2.46	1.31	1.63	1.62	1.46	1.02	1.13	0.839	1.09	1.08
Radium-226/228	pCi/L	2.65	1.46	1.80	2.12	1.73	1.10	1.18	1.10	1.35	1.55
Radium-228	pCi/L	< 0.919	< 0.402	< 0.405	0.501	< 0.719	< 0.384	< 0.381	< 0.314	< 0.340	0.477
Selenium	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Thallium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units.
pCi/L - picocuries per liter.
All metals were analyzed as total, unless
otherwise specified.

Table 2
Summary of Groundwater Analytical Results
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-03												
Sample Date:		8/2/2016	9/19/2016	9/19/2016	11/7/2016	1/9/2017	1/9/2017	2/27/2017	2/27/2017	4/17/2017	4/17/2017	6/5/2017	7/24/2017	7/24/2017
Constituent	Unit			Field Dup			Field Dup		Field Dup		Field Dup			Field Dup
Appendix III														
Boron	ug/L	1,000	980	960	1,200	1,100	1,100	1,100	1,200	1,100	1,100	1,200	1,100	1,100
Calcium	ug/L	34,000	33,000	32,000	31,000	35,000	37,000	32,000	34,000	31,000	31,000	31,000	33,000	32,000
Chloride	mg/L	580	570	570	680	600	610	550	550	530	520	650	580	570
Fluoride	mg/L	1.6	1.5	1.5	1.7	1.5	1.5	1.7	1.7	1.6	1.6	1.8	1.8	1.8
pH	SU	7.91	7.9	7.9	8.0	7.9	7.9	8.0	8.0	8.0	7.9	7.9	7.9	7.8
Sulfate	mg/L	6.9	3.3	3.4	< 10	4.4	4.1	< 10	< 10	< 5.0	< 5.0	2.7	2.8	2.6
Total Dissolved Solids	mg/L	1,100	1,100	530	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100
Appendix IV														
Antimony	ug/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Arsenic	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	300	300	280	270	300	310	290	310	300	300	310	310	290
Beryllium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chromium	ug/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Cobalt	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Fluoride	mg/L	1.6	1.5	1.5	1.7	1.5	1.5	1.7	1.7	1.6	1.6	1.8	1.8	1.8
Lead	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lithium	ug/L	11	13	13	13	14	15	16	16	18	18	18	19	18
Mercury	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	100	100	97	94	89	89	98	99	98	98	93	98	94
Radium-226	pCi/L	1.08	0.601	0.694	1.52	0.809	0.788	0.777	2.18	0.790	0.631	0.901	0.720	0.748
Radium-226/228	pCi/L	1.43	0.816	1.20	1.98	1.70	1.62	0.963	5.31	1.19	0.958	1.36	1.24	1.28
Radium-228	pCi/L	< 0.428	< 0.442	0.505	0.455	0.888	0.835	< 0.427	3.13	0.403	0.328	0.458	0.522	0.530
Selenium	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Thallium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units.
pCi/L - picocuries per liter.
All metals were analyzed as total, unless
otherwise specified.

Table 2
Summary of Groundwater Analytical Results
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-04								
	Sample Date:	8/2/2016	9/20/2016	11/7/2016	1/9/2017	2/27/2017	4/18/2017	6/5/2017	7/24/2017	9/13/2017
Constituent	Unit									
Appendix III										
Boron	ug/L	990	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100
Calcium	ug/L	57,000	63,000	51,000	57,000	47,000	45,000	46,000	47,000	49,000
Chloride	mg/L	500	500	490	510	470	460	490	500	490
Fluoride	mg/L	1.6	1.5	1.5	1.4	1.7	1.6	1.7	1.7	1.8
pH	SU	8.05	7.9	8.0	7.9	8.0	7.9	7.9	7.9	7.9
Sulfate	mg/L	14	< 1.0	5.1	6.0	11	15	9.3	13	7.2
Total Dissolved Solids	mg/L	940	960	960	1,100	970	980	1,000	1,000	950
Appendix IV										
Antimony	ug/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Arsenic	ug/L	6.0	7.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	390	440	340	360	330	330	330	340	340
Beryllium	ug/L	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chromium	ug/L	27	26	13	13	9.8	8.7	9.5	9.4	10
Cobalt	ug/L	6.4	7.4	3.8	4.1	2.6	2.4	3.2	2.4	3.0
Fluoride	mg/L	1.6	1.5	1.5	1.4	1.7	1.6	1.7	1.7	1.8
Lead	ug/L	6.1	7.1	3.6	4.1	2.8	2.5	3.3	2.2	3.0
Lithium	ug/L	30	37	26	25	24	26	26	27	24
Mercury	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	96	110	94	81	87	91	87	94	93
Radium-226	pCi/L	1.37	0.934	1.54	1.19	0.880	0.761	0.912	0.849	0.687
Radium-226/228	pCi/L	1.69	2.70	2.16	< 1.65	1.43	1.09	1.97	1.47	0.802
Radium-228	pCi/L	< 1.07	1.76	< 1.23	< 1.65	< 0.587	< 0.483	1.06	0.619	< 0.471
Selenium	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Thallium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units.
pCi/L - picocuries per liter.
All metals were analyzed as total, unless
otherwise specified.

Table 2
Summary of Groundwater Analytical Results
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location:		MW-16-09								
Sample Date:		8/2/2016	9/20/2016	11/9/2016	1/10/2017	2/28/2017	4/17/2017	6/5/2017	7/25/2017	9/14/2017
Constituent	Unit									
Appendix III										
Boron	ug/L	1,500	1,600	1,800	1,600	1,700	1,700	1,800	1,800	1,700
Calcium	ug/L	29,000	35,000	28,000	32,000	32,000	34,000	34,000	37,000	40,000
Chloride	mg/L	1,000	990	1,100	1,000	970	890	980	1,000	990
Fluoride	mg/L	1.3	1.2	1.5	1.1	1.5	1.4	1.6	1.6	1.6
pH	SU	8.23	8.3	8.3	7.9	8.1	8.0	8.1	8.2	8.0
Sulfate	mg/L	8.4	3.3	12	19	27	27	27	< 10	32
Total Dissolved Solids	mg/L	1,700	1,800	1,800	1,900	1,900	1,900	1,900	1,800	1,700
Appendix IV										
Antimony	ug/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Arsenic	ug/L	7.2	6.9	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	280	280	250	270	290	290	310	290	290
Beryllium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chromium	ug/L	15	17	9.8	7.6	11	13	16	18	8.0
Cobalt	ug/L	4.1	5.6	2.9	2.7	2.8	3.7	4.3	5.9	2.5
Fluoride	mg/L	1.3	1.2	1.5	1.1	1.5	1.4	1.6	1.6	1.6
Lead	ug/L	4.3	5.4	2.5	2.6	2.6	3.2	3.4	5.1	2.8
Lithium	ug/L	39	50	39	37	40	49	46	55	32
Mercury	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	65	62	59	53	59	60	59	60	56
Radium-226	pCi/L	1.37	1.79	1.72	0.996	0.864	1.04	1.18	0.839	0.703
Radium-226/228	pCi/L	2.07	3.20	2.83	2.51	1.10	1.67	1.75	1.90	2.49
Radium-228	pCi/L	< 0.917	< 2.09	1.11	1.51	< 0.685	0.627	0.566	1.06	1.79
Selenium	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Thallium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units.
pCi/L - picocuries per liter.
All metals were analyzed as total, unless
otherwise specified.

Table 3
Summary of Field Parameters
Belle River Power Plant Bottom Ash Basins – RCRA CCR Monitoring Program
China Township, Michigan

Sample Location	Sample Date	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (mV)	pH (SU)	Specific Conductivity (umhos/cm)	Temperature (deg C)	Turbidity (NTU)
MW-16-01	8/1/2016	0.34	-174.4	8.08	1,318	13.38	150
	9/20/2016	0.97	-13.9	7.92	1,575	12.80	11.4
	11/7/2016	0.58	-8.8	7.91	1,321	11.43	6.64
	1/9/2017	1.02	2.9	7.62	1,237	8.39	4.42
	2/27/2017	1.10	4.4	7.76	1,189	9.39	2.32
	4/17/2017	0.23	-91.7	7.88	1,647	12.20	4.83
	6/5/2017	0.44	-125.0	7.84	1,764	12.21	3.85
	7/24/2017	0.39	-99.3	7.63	1,738	13.43	3.52
	9/11/2017	0.28	13.0	7.00	1,795	14.12	1.24
MW-16-02	8/2/2016	0.45	45.8	7.79	1,185	16.02	267
	9/19/2016	0.70	-14.7	7.93	1,420	17.56	4.07
	11/7/2016	0.95	16.1	7.80	1,070	12.67	3.21
	1/9/2017	0.54	-46.8	7.62	955	7.81	8.38
	2/27/2017	1.73	40.5	7.64	978	10.60	1.78
	4/17/2017	0.55	-72.0	7.78	1,315	12.30	0.99
	6/5/2017	0.68	-96.9	7.71	1,388	15.92	3.60
	7/24/2017	0.41	-92.3	7.64	1,386	14.62	1.11
	9/12/2017	0.37	-125.5	7.47	1,357	15.19	0.91
MW-16-03	8/2/2016	0.58	10.3	7.97	1,805	17.55	3.48
	9/19/2016	1.03	29.2	8.16	2,051	16.75	2.80
	11/7/2016	0.40	-25.2	7.95	1,607	13.56	2.05
	1/9/2017	1.40	-16.4	7.60	1,396	7.43	1.20
	2/27/2017	1.25	69.0	7.83	1,440	11.41	1.25
	4/17/2017	0.29	-111.1	8.01	1,939	12.11	0.46
	6/5/2017	0.17	-147.0	8.01	2,023	12.85	0.34
	7/24/2017	0.25	-122.8	7.89	2,027	14.03	0.57
MW-16-04	8/2/2016	0.28	-121.7	8.02	1,647	15.78	726
	9/20/2016	0.39	-73.8	8.28	1,744	15.98	367
	11/7/2016	0.25	-53.8	7.99	1,477	14.85	136
	1/9/2017	0.13	-138.5	7.86	1,283	8.64	92.0
	2/27/2017	1.12	5.9	7.91	1,296	11.59	82.8
	4/18/2017	0.73	-89.9	7.81	1,816	8.94	63.1
	6/5/2017	0.38	-167.3	7.95	1,795	14.57	83.2
	7/24/2017	0.38	-154.4	7.85	1,793	16.50	56.5
	9/13/2017	0.31	-147.5	7.60	1,750	18.64	63.2
MW-16-09	8/2/2016	0.29	9.4	8.41	3,726	15.05	126
	9/20/2016	0.37	48.3	8.51	3,168	15.75	339
	11/9/2016	0.63	54.9	8.26	2,487	10.82	211
	1/10/2017	0.92	8.8	7.91	2,560	9.05	82.3
	2/28/2017	0.68	63.3	8.22	2,190	10.90	85.3
	4/17/2017	0.50	-102.7	8.15	3,120	12.34	100.7
	6/5/2017	0.34	-141.9	8.16	3,292	14.25	101
	7/25/2017	0.18	-188.8	8.20	3,239	14.50	128
	9/14/2017	0.16	-270.3	7.83	3,410	14.80	65.9

Notes:

mg/L - milligrams per liter.

mV - milliVolt.

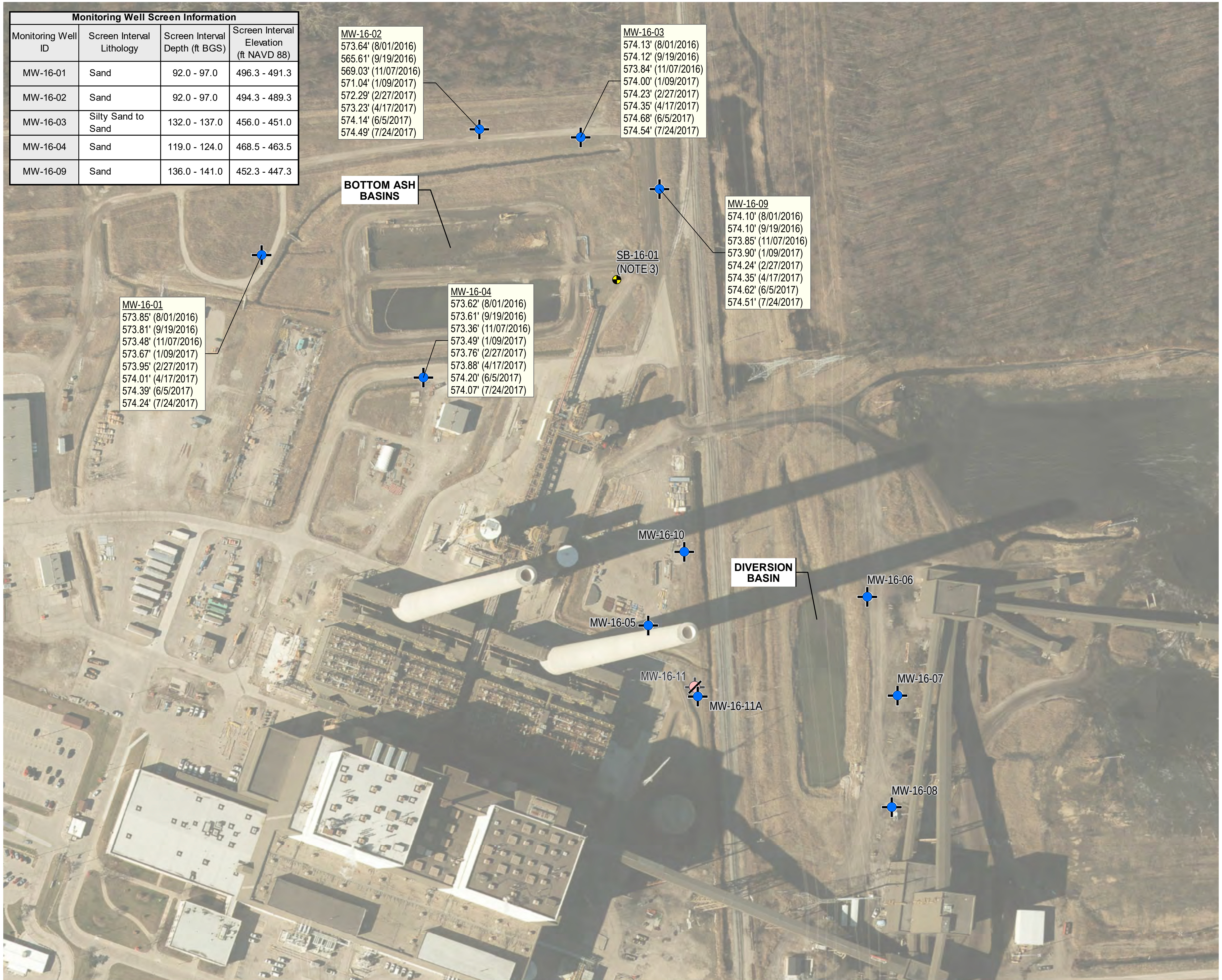
SU - standard unit.

umhos/cm - micro-mhos per centimeter.

deg C - degrees celcius.

NTU - nephelometric turbidity units.

Monitoring Well Screen Information			
Monitoring Well ID	Screen Interval Lithology	Screen Interval Depth (ft BGS)	Screen Interval Elevation (ft NAVD 88)
MW-16-01	Sand	92.0 - 97.0	496.3 - 491.3
MW-16-02	Sand	92.0 - 97.0	494.3 - 489.3
MW-16-03	Silty Sand to Sand	132.0 - 137.0	456.0 - 451.0
MW-16-04	Sand	119.0 - 124.0	468.5 - 463.5
MW-16-09	Sand	136.0 - 141.0	452.3 - 447.3



LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

MW ID
GROUNDWATER ELEVATION (DATE)
GROUNDWATER ELEVATION (DATE)
etc...

FT BGS
FEET BELOW GROUND SURFACE
FT NAVD 88
ELEVATION RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED IN MARCH, APRIL AND JUNE 2016 AND JUNE 2017 BY BMJ ENGINEERS & SURVEYORS, INC.
3. NO SAND OR GRAVEL UNIT PRESENT ABOVE BEDROCK IN THIS LOCATION.

N

0 200 400 Feet

1 " = 200 '
1:2,400

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 1/15/2018, 10:06:08 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-003A.mxd

PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE:
BOTTOM ASH BASINS GROUNDWATER POTENTIOMETRIC ELEVATION SUMMARY

DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	C. SCIESZKA	FIGURE 1	
APPROVED BY:	V. BUENING		
DATE:	JANUARY 2018		

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

FILE NO.: 265996-0003-003A.mxd

Appendix B
Data Quality Review

Laboratory Data Quality Review
Groundwater Monitoring Event October 2017
DTE Electric Company Belle River Power Plant (DTE BRPP)

Groundwater samples were collected by TRC for the October 2017 sampling event for the Bottom Ash Basins and Diversion Basin at the DTE BRPP. Samples were analyzed for anions, pH, total metals, and total dissolved solids by Test America Laboratories, Inc. (Test America), located in Canton, Ohio. The laboratory analytical results are reported in laboratory report J86174-1.

During the October 2017 sampling event, a groundwater sample was collected from each of the following wells:

Bottom Ash Basins:

- MW-16-01
- MW-16-02
- MW-16-03
- MW-16-04
- MW-16-09

Diversion Basin:

- MW-16-05
- MW-16-06
- MW-16-07
- MW-16-08
- MW-16-10
- MW-16-11A

Each sample was analyzed for the following constituents:

Analyte Group	Method
Anions (Chloride, Fluoride, Sulfate)	EPA 9056A
pH	EPA 9040C
Total Metals	EPA 6010B
Total Dissolved Solids	SM 2540C

TRC reviewed the laboratory data to assess data usability. The following sections summarize the data review procedure and the results of the review.

Data Quality Review Procedure

The analytical data were reviewed using the USEPA National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). The following items were included in the evaluation of the data:

- Sample receipt, as noted in the cover page or case narrative;
- Technical holding times for analyses;

- Data for method blanks. Method blanks are used to assess potential contamination arising from laboratory sample preparation and/or analytical procedures;
- Percent recoveries for matrix spike (MS) and matrix spike duplicates (MSD). Percent recoveries are calculated for each analyte spiked and used to assess bias due to sample matrix effects;
- Reporting limits (RLs) compared to project-required RLs;
- Data for blind field duplicates. Field duplicate samples are used to assess variability introduced by the sampling and analytical processes;
- Data for laboratory control samples (LCSs). The LCSs are used to assess the accuracy of the analytical method using a clean matrix;
- Data for laboratory duplicates. The laboratory duplicates are replicate analyses of one sample and are used to assess the precision of the analytical method; and
- Overall usability of the data.

This data usability report addresses the following items:

- Usability of the data if quality control (QC) results suggest potential problems with all or some of the data;
- Actions regarding specific QC criteria exceedances.

Review Summary

The data quality objectives and laboratory completeness goals for the project were met, and the data are usable for their intended purpose. A summary of the data quality review, including non-conformances and issues identified in this evaluation are noted below.

- Appendix III constituents will be utilized for the purposes of a detection monitoring program.
- Data are usable for the purposes of the detection monitoring program.
- When the data are evaluated through a detection monitoring statistical program, findings below may be used to support the removal of outliers.

QA/QC Sample Summary:

- Target analytes were not detected in the method blank.
- Dup-01 corresponds with MW-16-01; relative percent differences (RPDs) between the parent and duplicate sample were within the QC limits.
- Laboratory duplicates were performed on sample MW-16-01 and MW-16-10 for pH and sample MW-16-02 for total dissolved solids; RPDs between the parent and duplicate sample were within the QC limits.

- MS/MSD analyses were performed on sample MW-16-01 for calcium and boron, and samples MW-16-02 and MW-16-09 for anions (chloride, fluoride, and sulfate). The boron recovery in the MSD were above the upper laboratory control limits. The boron concentration in the parent sample was >4x the spike concentration; therefore, the laboratory control limits are not applicable. Data usability is not affected.

Appendix C
Statistical Background Limits

Technical Memorandum

Date: January 15, 2018

To: DTE Electric Company

From: Darby Litz, TRC
Sarah Holmstrom, TRC
Jane Li, TRC

Project No.: 265996.0003.0000 Phase 001, Task 001

Subject: Background Statistical Evaluation – DTE Electric Company, Belle River Power Plant Coal Combustion Residual Bottom Ash Basins

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Pursuant to the United States Environmental Protection Agency's (U.S. EPA's) Resource Conservation and Recovery Act (RCRA) Federal Final Rule for Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities (herein after "the CCR Rule") promulgated on April 17, 2015, the owner or operator of a CCR unit must collect a minimum of eight rounds of background groundwater data to initiate a detection monitoring program and evaluate statistically significant increases above background (40 CFR §257.94). This memorandum presents the background statistical limits derived for the DTE Electric Company (DTE Electric) Belle River Power Plant (BRPP) Coal Combustion Residual Bottom Ash Basins (BABs) CCR unit.

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 BABs have been in use with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR unit, which is monitored as a separate CCR unit in accordance with the CCR Rule.

The DB is an incised CCR surface impoundment located west of the BRPP near the Webster Drain. Water flows into the DB from the North and South 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.

A groundwater monitoring system has been established for BRPP BAB CCR unit (TRC, October 2017), which established the following locations for detection monitoring.

MW-16-01	MW-16-02	MW-16-03
MW-16-04	MW-16-09	

Following the baseline data collection period (August 2016 through September 2017), the background data for the Site were evaluated in accordance with the *Groundwater Statistical Evaluation Plan* (Stats Plan) (TRC, October 2017). Background data were evaluated utilizing ChemStat™ statistical software. ChemStat™ is a software tool that is commercially available for performing statistical evaluation consistent with procedures outlined in U.S. EPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (Unified Guidance; UG). Within the ChemStat™ statistical program (and the UG), prediction limits (PLs) were selected to perform the statistical calculation for background limits. Use of PLs is recommended by the UG to provide high statistical power and is an acceptable approach for intrawell detection monitoring under the CCR rule. PLs were calculated for each of the CCR Appendix III parameters. The following narrative describes the methods employed and the results obtained and the ChemStat™ output files are included as an attachment.

The set of five background wells utilized for the BABs CCR Unit includes MW-16-01 through MW-16-04 and MW-16-09. An intrawell statistical approach requires that each of the monitoring system wells doubles as the background and compliance well, where data from each individual well during a detection monitoring event is compared to a statistical limit developed using the background/baseline dataset from that same well. The background evaluation included the following steps:

- Review of data quality checklists for the baseline/background data sets for CCR Appendix III constituents;
- Graphical representation of the baseline data as time versus concentration (T v. C) by well/constituent pair;
- Outlier testing of individual data points that appear from the graphical representations as potential outliers;
- Evaluation of percentage of nondetects for each baseline/background well-constituent (w/c) pair;
- Distribution of the data; and
- Calculation of the upper PLs for each cumulative baseline/background data set (upper and lower PLs were calculated for field pH).

The results of these evaluations are presented and discussed below.

Data Quality

Data from each sampling round were evaluated for completeness, overall quality and usability, method-specified sample holding times, precision and accuracy, and potential sample contamination. The review was completed using the following quality control (QC) information which at a minimum included chain-of-custody forms, investigative sample results including blind field duplicates, and, as provided by the laboratory, method blanks, laboratory control spikes, laboratory duplicates. The data were found to be complete and usable for the purposes of the CCR monitoring program.

Time versus Concentration Graphs

The time versus concentration (T v. C) graphs (Attachment A) do not show potential or suspect outliers for any of the Appendix III parameters.

While variations in results are present, the graphs show consistent baseline data and do not suggest that data sets, as a whole, likely have overall trending or seasonality. However, due to limitations on CCR Rule implementation timelines, the data sets are of relatively short duration for making such observations regarding overall trending or seasonality.

Outlier Testing

No outliers were identified in the T v. C graphs. Therefore, outlier testing was not applicable.

Distribution of the Data Sets

ChemStat™ was utilized to evaluate each data set for normality. If the skewness coefficient was calculated to be between negative one and one, then the data were assumed to be approximately normally distributed. If the skewness coefficient was calculated as greater than one (or less than negative one) then the calculation was performed on the natural log (Ln) of the data. If the Ln of the data still determined that the data appeared to be skewed, then the Shapiro-Wilk test of normality (Shapiro-Wilk) was performed. The Shapiro-Wilk statistic was calculated on both non-transformed data, and the Ln-transformed data. If the Shapiro-Wilk statistic indicated that normal distributional assumptions were not valid, then the parameter was considered a candidate for non-parametric statistical evaluation. The data distributions are summarized in Table 1.

Prediction Limits

Table 1 presents the calculated PLs for the background/baseline data sets. For normal and lognormal distributions, PLs are calculated for 95 percent confidence using parametric methods. For nonnormal background datasets, a nonparametric PL is utilized, resulting in the highest value from the background dataset as the PL. The achieved confidence levels for nonparametric prediction limits depend entirely on the number of background data points, which are shown in the ChemStat™ outputs. Verification resampling (1 of 2) is recommended per the Stats Plan and UG to achieve performance standards specified in the CCR rules.

Attachments

Table 1 – Summary of Descriptive Statistics and Prediction Limit Calculations
Attachment A – Background Concentration Time-Series Charts
Attachment B – ChemStat™ Prediction Limit Outputs

Tables

Table 1
Summary of Descriptive Statistics and Prediction Limit Calculations
Background Statistical Evaluation
DTE Electric Company – Belle River Power Plant Bottom Ash Basins

Monitoring Well	Skewness Test		Shapiro-Wilks Test (5% Critical Value)		Outliers Removed	Prediction Limit Test	Prediction Limit
	Un-Transformed Data	Natural Log Transformed Data	Un-Transformed Data	Natural Log Transformed Data			
Appendix III							
Boron (ug/L)							
MW-16-01	-1 < 0.644988 < 1	--	--	--	N	Parametric	1,300
MW-16-02	-1 < -0.281192 < 1	--	--	--	N	Parametric	1,300
MW-16-03	-1 < -0.119695 < 1	--	--	--	N	Parametric	1,300
MW-16-04	-2.47487 < -1	-2.47487 < -1	0.829 > 0.390021	0.829 > 0.390021	N	Non-Parametric	1,100
MW-16-09	-1 < -0.455599 < 1	--	--	--	N	Parametric	1,900
Calcium (ug/L)							
MW-16-01	-1 < 0.64429 < 1	--	--	--	N	Parametric	45,000
MW-16-02	-1 <0.16697 < 1	--	--	--	N	Parametric	59,000
MW-16-03	-1 < 0.397748 < 1	--	--	--	N	Parametric	36,000
MW-16-04	-1 < 0.746142 < 1	--	--	--	N	Parametric	64,000
MW-16-09	-1 < 0.190727 < 1	--	--	--	N	Parametric	41,000
Chloride (mg/L)							
MW-16-01	-1 < 0.0686352 < 1	--	--	--	N	Parametric	530
MW-16-02	-1 < -0.0299798 < 1	--	--	--	N	Parametric	400
MW-16-03	-1 < 0.637775 < 1	--	--	--	N	Parametric	690
MW-16-04	-1 < -0.804984 < 1	--	--	--	N	Parametric	520
MW-16-09	-1 < 0.215449 < 1	--	--	--	N	Parametric	1,100
Fluoride (mg/L)							
MW-16-01	-1 < -0.673575 < 1	--	--	--	N	Parametric	1.9
MW-16-02	-1 < -0.0489763 < 1	--	--	--	N	Parametric	1.3
MW-16-03	-1 < -3.02559e-015 < 1	--	--	--	N	Parametric	1.9
MW-16-04	-1 < -0.21451 < 1	--	--	--	N	Parametric	1.9
MW-16-09	-1 < -0.590448 < 1	--	--	--	N	Parametric	1.8

Notes:

2.14275 > 1   -1 < 0.537721 < 1   ← Skewness Coefficient

0.818 > 0.781314   ← Shapiro-Wilks 5% Critical Value (0.781314); Shapiro-Wilks 'W' Statistic (0.818)

ug/L = micrograms per liter
mg/L = milligrams per liter
SU = standard units
(1) Variance = 0; as such, parametric methods were used for calculating the prediction limit.

Table 1
Summary of Descriptive Statistics and Prediction Limit Calculations
Background Statistical Evaluation
DTE Electric Company – Belle River Power Plant Bottom Ash Basins

Monitoring Well	Skewness Test		Shapiro-Wilks Test (5% Critical Value)		Outliers Removed	Prediction Limit Test	Prediction Limit
	Un-Transformed Data	Natural Log Transformed Data	Un-Transformed Data	Natural Log Transformed Data			
pH, Field (SU)							
MW-16-01	-1.51827 < -1	-1.59328 < -1	0.829 > 0.819337	0.829 > 0.8032	N	Non-Parametric	7.6 - 8.1
MW-16-02	-1 < -0.139898 < 1	--	--	--	N	Parametric	7.4 - 8.0
MW-16-03	-1 < -0.773774 < 1	--	--	--	N	Parametric	7.5 - 8.3
MW-16-04	-1 < 0.307547 < 1	--	--	--	N	Parametric	7.5 - 8.4
MW-16-09	-1 < -0.237318 < 1	--	--	--	N	Parametric	7.7 - 8.7
Sulfate (mg/L)							
MW-16-01	-1 < 0.376341 < 1	--	--	--	N	Parametric	8.1
MW-16-02	-1 < 0.416234 < 1	--	--	--	N	Parametric	20
MW-16-03	-1 < -0.220202 < 1	--	--	--	N	Parametric	14
MW-16-04	-1 < -0.369347 < 1	--	--	--	N	Parametric	18
MW-16-09	-1 < -0.11514 < 1	--	--	--	N	Parametric	40
Total Dissolved Solids (mg/L)							
MW-16-01	-1 < 0.796876 < 1	--	--	--	N	Parametric	950
MW-16-02	1.32553 > 1	1.16468 > 1	0.829 < 0.840922	--	N	Parametric	890
MW-16-03	Variance = 0 (1)	--	--	--	N	Parametric	1,100
MW-16-04	1.66722 > 1	1.59092 > 1	0.829 > 0.784612	0.829 > 0.802563	N	Non-Parametric	1,100
MW-16-09	-1 < -0.41295 < 1	--	--	--	N	Parametric	2,000

Notes:

2.14275 > 1 -1 < 0.537721 < 1 — Skewness Coefficient

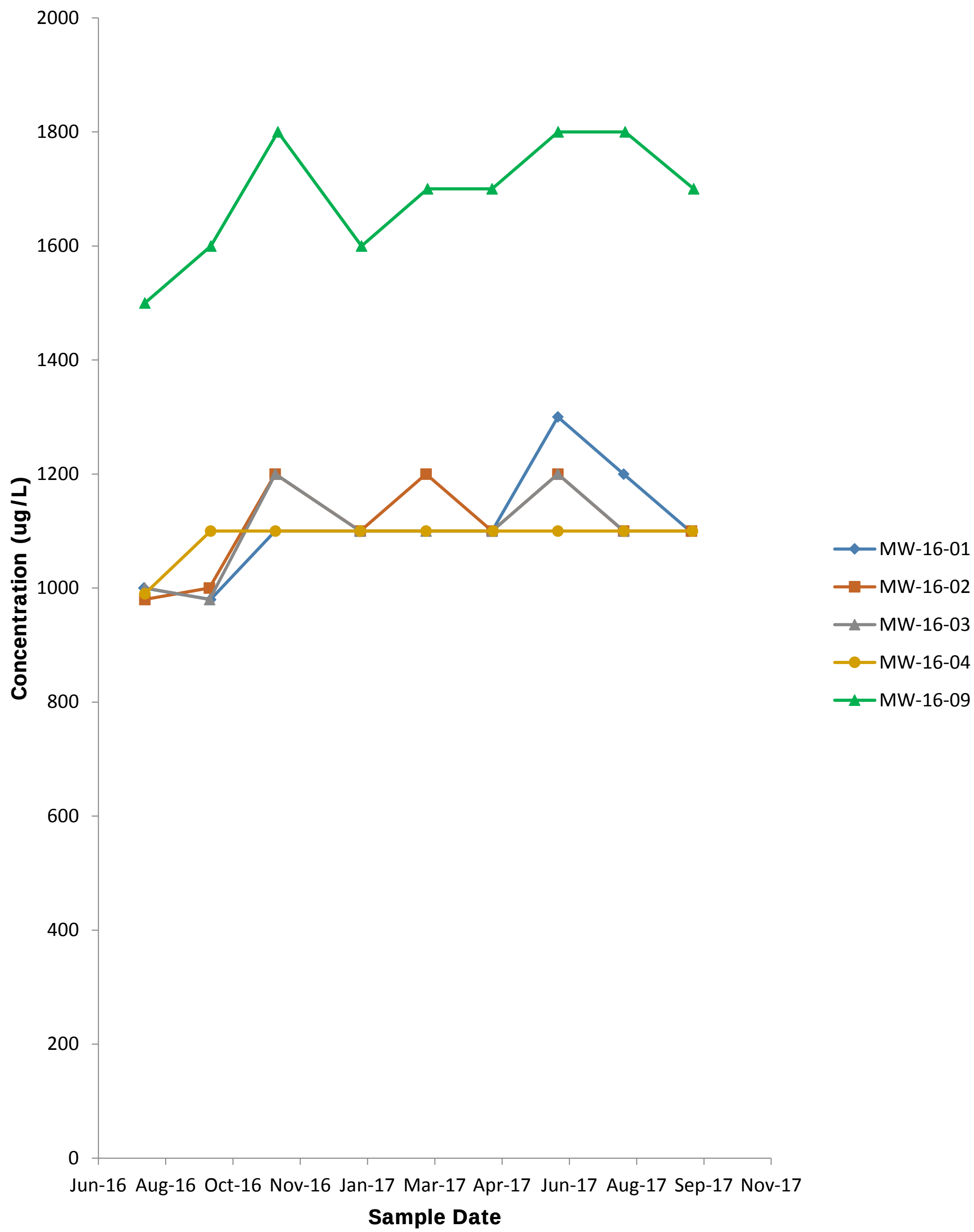
0.818 > 0.781314 — Shapiro-Wilks 5% Critical Value; Shapiro-Wilks 'W' Statistic

ug/L = micrograms per liter
mg/L = milligrams per liter
SU = standard units
(1) Variance = 0; as such, parametric methods were used for calculating the prediction limit.

Attachment A

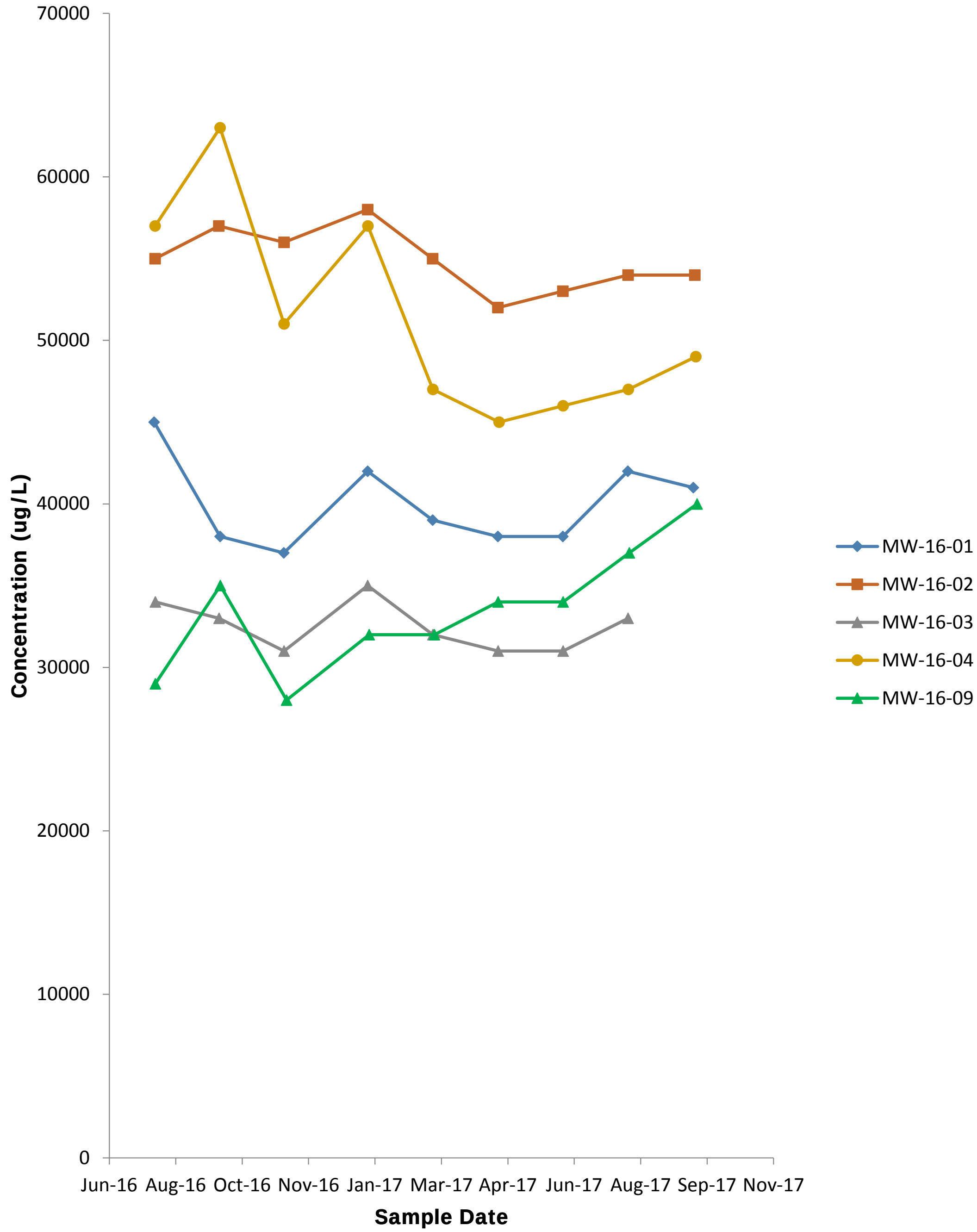
Background Concentration Time-Series Charts

Time-Series Plots
DTE Electric Company - Belle River Power Plant Bottom Ash Basins
China Township, Michigan
Boron



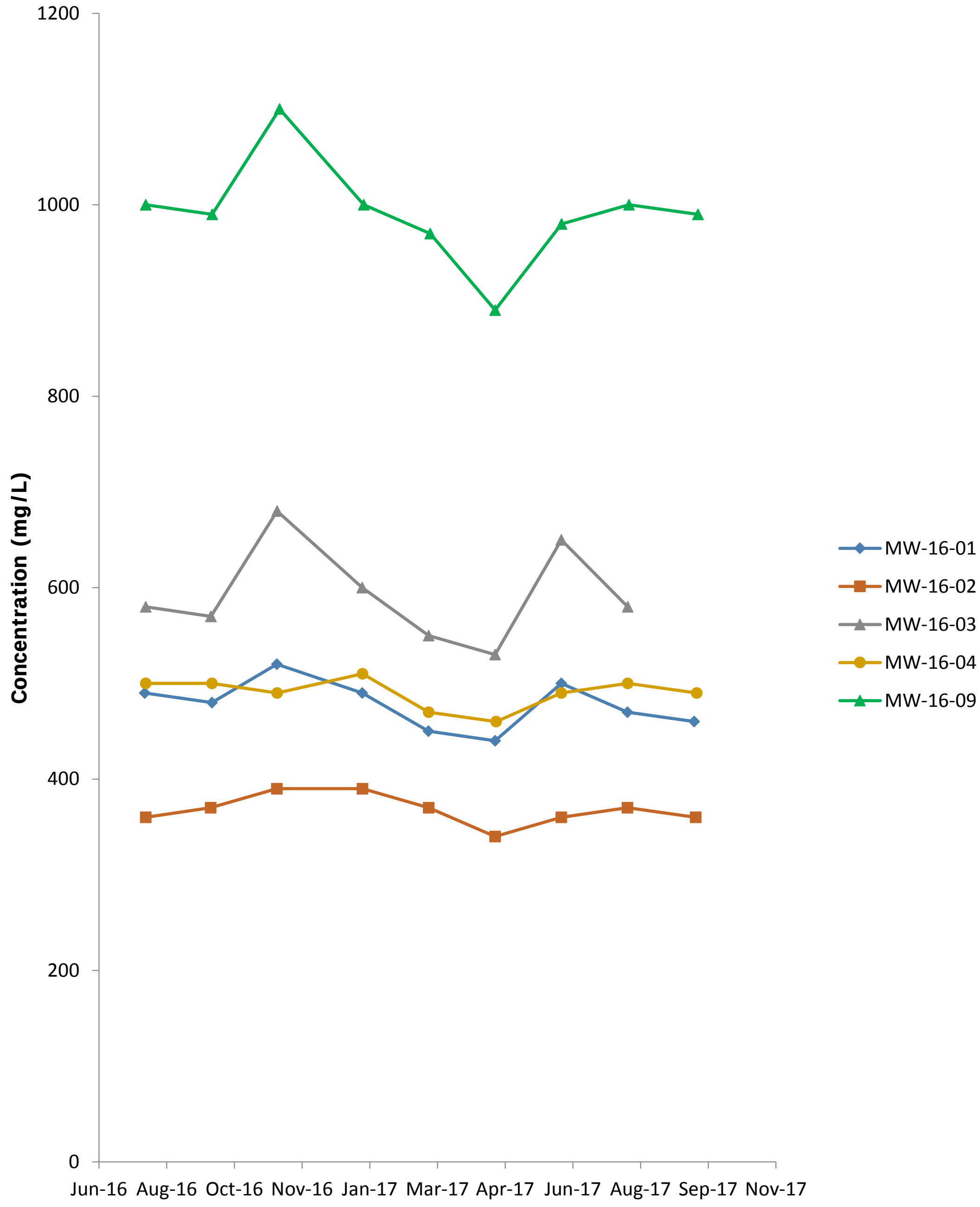
Open symbols denote non-detect concentrations.

Time-Series Plots
DTE Electric Company - Belle River Power Plant Bottom Ash Basins
China Township, Michigan
Calcium



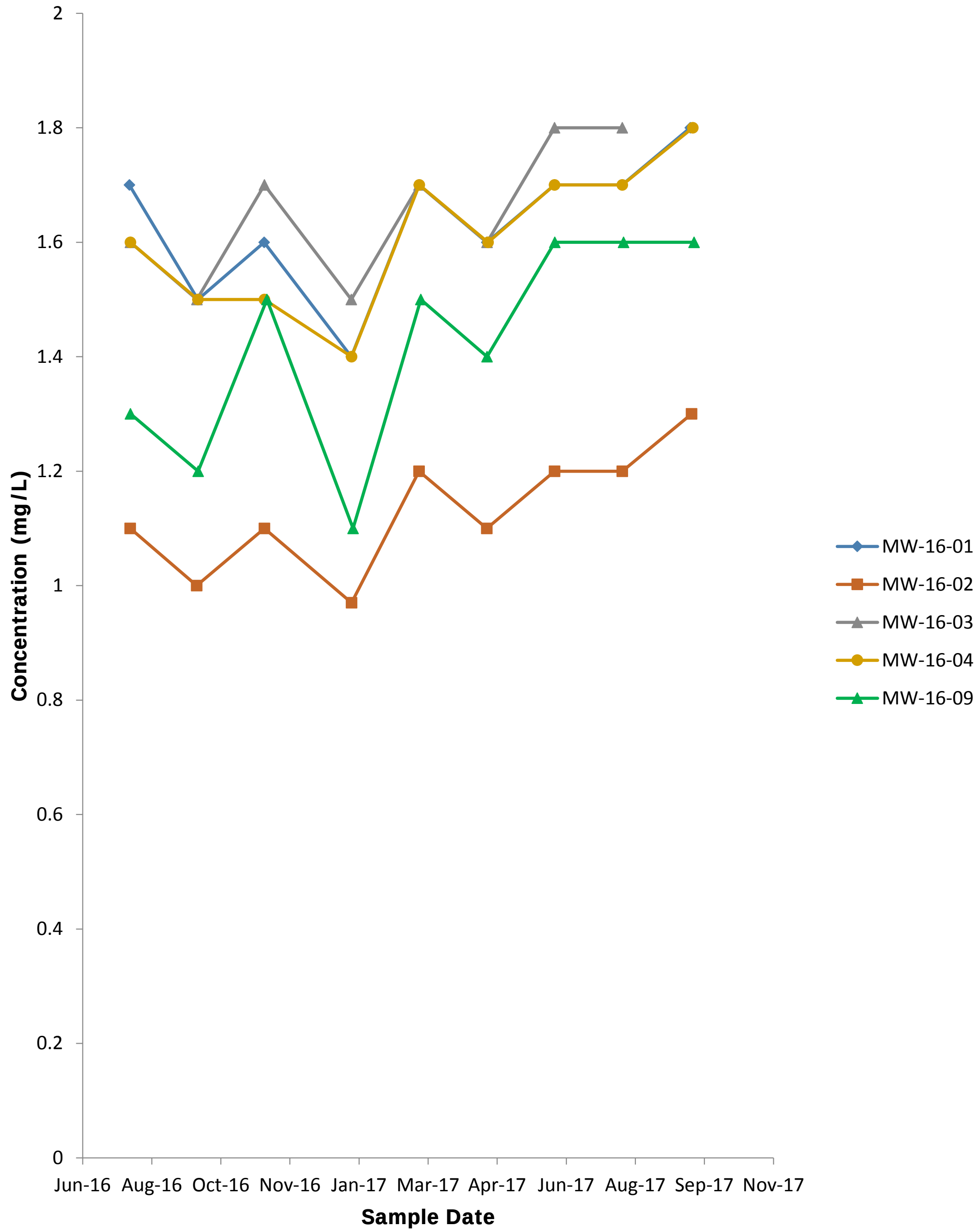
Open symbols denote non-detect concentrations.

Time-Series Plots
DTE Electric Company - Belle River Power Plant Bottom Ash Basins
China Township, Michigan
Chloride



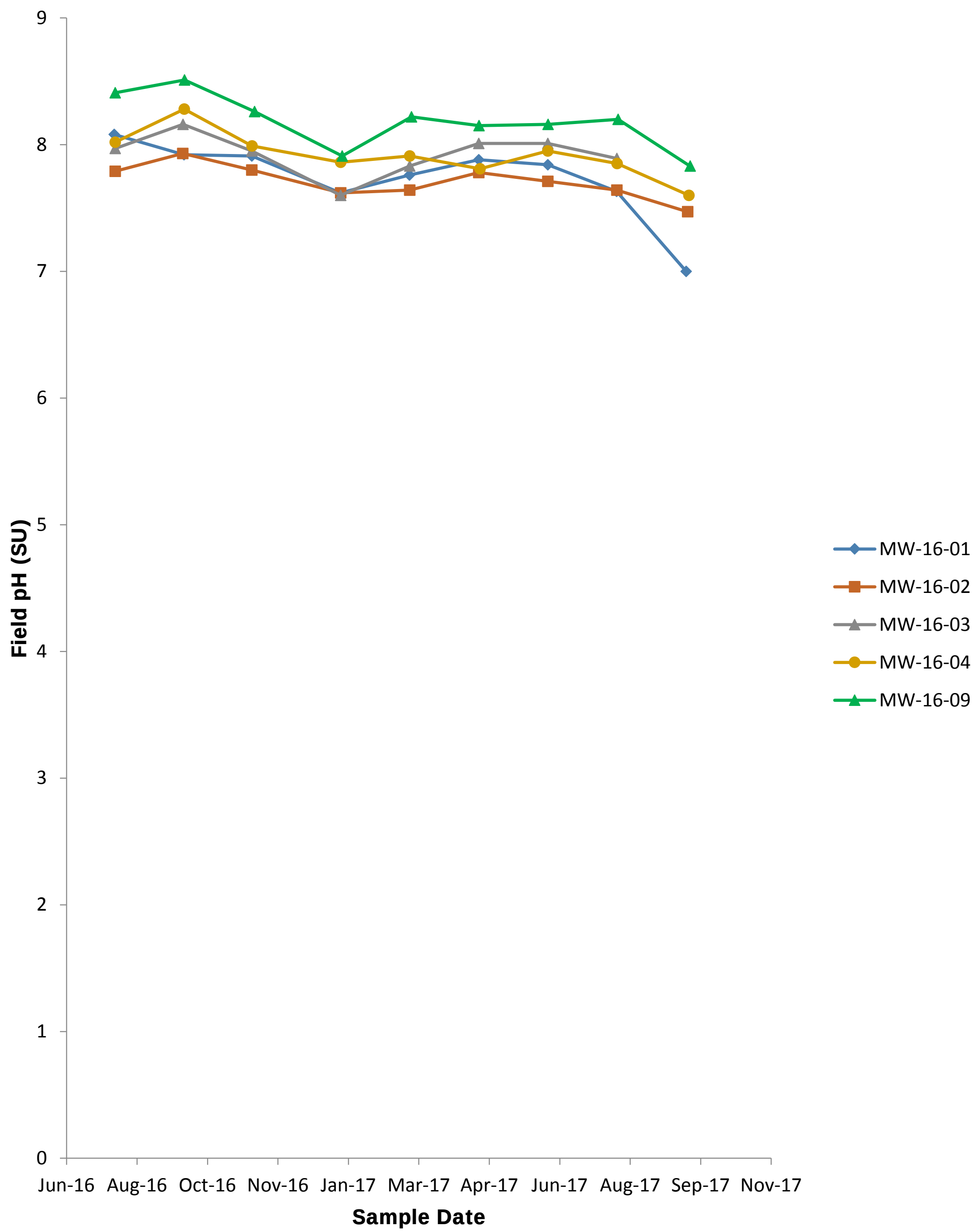
Open symbols denote non-detect concentrations.

Time-Series Plots
DTE Electric Company - Belle River Power Plant Bottom Ash Basins
China Township, Michigan
Fluoride

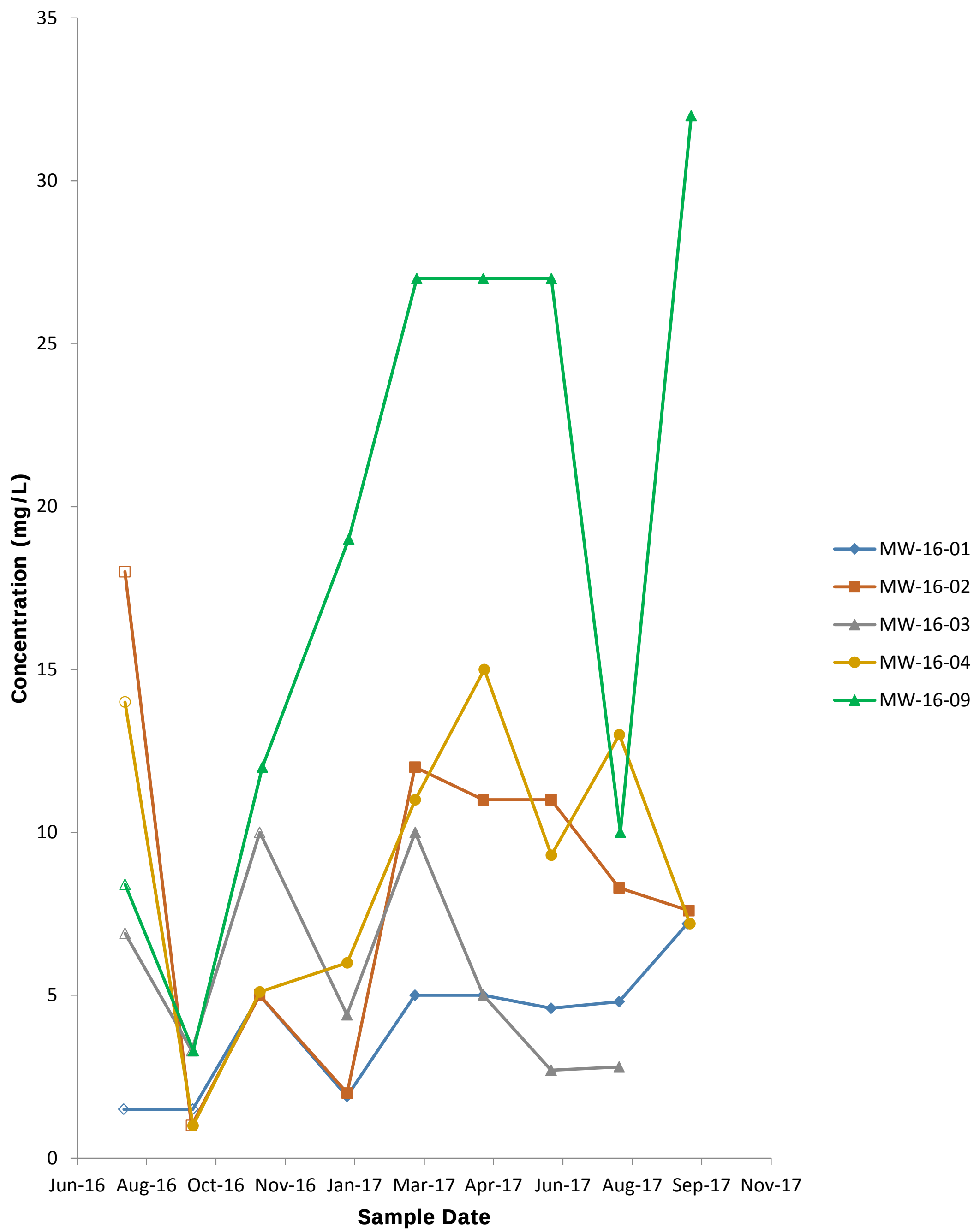


Open symbols denote non-detect concentrations.

Time-Series Plots
DTE Electric Company - Belle River Power Plant Bottom Ash Basins
China Township, Michigan
pH, Field

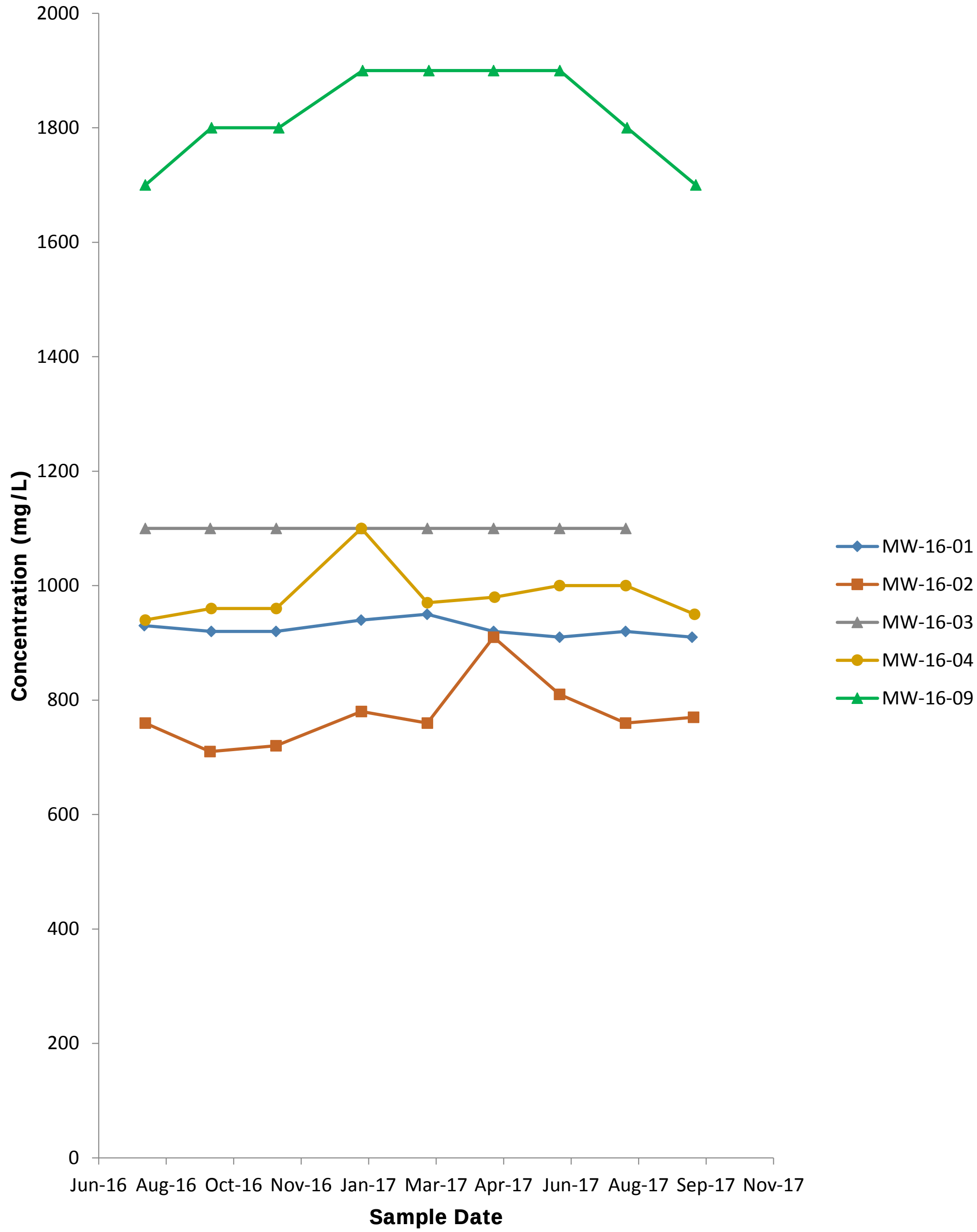


Time-Series Plots
DTE Electric Company - Belle River Power Plant Bottom Ash Basins
China Township, Michigan
Sulfate



Open symbols denote non-detect concentrations.

Time-Series Plots
DTE Electric Company - Belle River Power Plant Bottom Ash Basins
China Township, Michigan
Total Dissolved Solids



Open symbols denote non-detect concentrations.

Attachment B

ChemStat™ Prediction Limit Outputs

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-01
Parameter: Boron
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/1/2016	1000
	9/20/2016	980
	11/7/2016	1100
	1/9/2017	1100 B
	2/27/2017	1100
	4/17/2017	1100
	6/5/2017	1300 B
	7/24/2017	1200
	9/11/2017	1100

From 9 baseline samples
Baseline mean = 1108.89
Baseline std Dev = 95.9745

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	950	[0, 1297.01]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-02
Parameter: Boron
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	980
	9/19/2016	1000
	11/7/2016	1200
	1/9/2017	1100 B
	2/27/2017	1200
	4/17/2017	1100
	6/5/2017	1200 B
	7/24/2017	1100
	9/12/2017	1100

From 9 baseline samples
Baseline mean = 1108.89
Baseline std Dev = 81.9214

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	1000	[0, 1269.47]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-03
Parameter: Boron
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1000
	9/19/2016	980
	11/7/2016	1200
	1/9/2017	1100 B
	2/27/2017	1100
	4/17/2017	1100
	6/5/2017	1200 B
	7/24/2017	1100

From 8 baseline samples
Baseline mean = 1097.5
Baseline std Dev = 79.5972

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 8 (background observations) - 1
t(0.95, 8) = 1.89458

Date	Samples	Mean	Interval	Significant
10/2/2017	1	1000	[0, 1257.45]	FALSE

Non-Parametric Prediction Interval

Intra-Well Comparison for MW-16-04
Parameter: Boron
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Total Percent Non-Detects = 0%
Future Samples (k) = 1
Recent Dates = 1
Baseline Measurements (n) = 8
Maximum Baseline Concentration = 1100
Confidence Level = 88.9%
False Positive Rate = 11.1%

Baseline Measurements	Date	Value
	8/2/2016	990
	9/20/2016	1100
	11/7/2016	1100
	1/9/2017	1100 B
	2/27/2017	1100
	4/18/2017	1100
	6/5/2017	1100 B
	7/24/2017	1100

Date	Count	Mean	Significant
10/2/2017	1	920	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-09
Parameter: Boron
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1500
	9/20/2016	1600
	11/9/2016	1800
	1/10/2017	1600 B
	2/28/2017	1700
	4/17/2017	1700
	6/5/2017	1800 B
	7/25/2017	1800
	9/14/2017	1700

From 9 baseline samples
Baseline mean = 1688.89
Baseline std Dev = 105.409

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/3/2017	1	1600	[0, 1895.51]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-01
Parameter: Calcium
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/1/2016	45000
	9/20/2016	38000
	11/7/2016	37000
	1/9/2017	42000
	2/27/2017	39000
	4/17/2017	38000
	6/5/2017	38000
	7/24/2017	42000
	9/11/2017	41000

From 9 baseline samples
Baseline mean = 40000
Baseline std Dev = 2645.75

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	38000	[0, 45186]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-02
Parameter: Calcium
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	55000
	9/19/2016	57000
	11/7/2016	56000
	1/9/2017	58000
	2/27/2017	55000
	4/17/2017	52000
	6/5/2017	53000
	7/24/2017	54000
	9/12/2017	54000

From 9 baseline samples
Baseline mean = 54888.9
Baseline std Dev = 1900.29

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	53000	[0, 58613.7]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-03
Parameter: Calcium
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	34000
	9/19/2016	33000
	11/7/2016	31000
	1/9/2017	35000
	2/27/2017	32000
	4/17/2017	31000
	6/5/2017	31000
	7/24/2017	33000

From 8 baseline samples
Baseline mean = 32500
Baseline std Dev = 1511.86

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 8 (background observations) - 1
t(0.95, 8) = 1.89458

Date	Samples	Mean	Interval	Significant
10/2/2017	1	32000	[0, 35538.1]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-04
Parameter: Calcium
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	57000
	9/20/2016	63000
	11/7/2016	51000
	1/9/2017	57000
	2/27/2017	47000
	4/18/2017	45000
	6/5/2017	46000
	7/24/2017	47000
	9/13/2017	49000

From 9 baseline samples
Baseline mean = 51333.3
Baseline std Dev = 6245

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	44000	[0, 63574.4]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-09
Parameter: Calcium
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	29000
	9/20/2016	35000
	11/9/2016	28000
	1/10/2017	32000
	2/28/2017	32000
	4/17/2017	34000
	6/5/2017	34000
	7/25/2017	37000
	9/14/2017	40000

From 9 baseline samples
Baseline mean = 33444.4
Baseline std Dev = 3745.37

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/3/2017	1	34000	[0, 40785.9]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-01
Parameter: Chloride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/1/2016	490
	9/20/2016	480
	11/7/2016	520
	1/9/2017	490
	2/27/2017	450
	4/17/2017	440
	6/5/2017	500
	7/24/2017	470
	9/11/2017	460

From 9 baseline samples
Baseline mean = 477.778
Baseline std Dev = 25.3859

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	470	[0, 527.538]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-02
Parameter: Chloride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	360
	9/19/2016	370
	11/7/2016	390
	1/9/2017	390
	2/27/2017	370
	4/17/2017	340
	6/5/2017	360
	7/24/2017	370
	9/12/2017	360

From 9 baseline samples
Baseline mean = 367.778
Baseline std Dev = 15.6347

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	370	[0, 398.424]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-03
Parameter: Chloride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	580
	9/19/2016	570
	11/7/2016	680
	1/9/2017	600
	2/27/2017	550
	4/17/2017	530
	6/5/2017	650
	7/24/2017	580

From 8 baseline samples
Baseline mean = 592.5
Baseline std Dev = 50.0714

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 8 (background observations) - 1
t(0.95, 8) = 1.89458

Date	Samples	Mean	Interval	Significant
10/2/2017	1	580	[0, 693.119]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-04
Parameter: Chloride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	500
	9/20/2016	500
	11/7/2016	490
	1/9/2017	510
	2/27/2017	470
	4/18/2017	460
	6/5/2017	490
	7/24/2017	500
	9/13/2017	490

From 9 baseline samples
Baseline mean = 490
Baseline std Dev = 15.8114

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	510	[0, 520.992]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-09
Parameter: Chloride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1000
	9/20/2016	990
	11/9/2016	1100
	1/10/2017	1000
	2/28/2017	970
	4/17/2017	890
	6/5/2017	980
	7/25/2017	1000
	9/14/2017	990

From 9 baseline samples
Baseline mean = 991.111
Baseline std Dev = 53.4894

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/3/2017	1	980	[0, 1095.96]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-01
Parameter: Fluoride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/1/2016	1.7
	9/20/2016	1.5
	11/7/2016	1.6
	1/9/2017	1.4
	2/27/2017	1.7
	4/17/2017	1.6
	6/5/2017	1.7
	7/24/2017	1.7
	9/11/2017	1.8

From 9 baseline samples
Baseline mean = 1.63333
Baseline std Dev = 0.122474

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	1.7	[0, 1.8734]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-02
Parameter: Fluoride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1.1
	9/19/2016	1
	11/7/2016	1.1
	1/9/2017	0.97
	2/27/2017	1.2
	4/17/2017	1.1
	6/5/2017	1.2
	7/24/2017	1.2
	9/12/2017	1.3

From 9 baseline samples
Baseline mean = 1.13
Baseline std Dev = 0.105357

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	1.2	[0, 1.33651]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-03
Parameter: Fluoride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1.6
	9/19/2016	1.5
	11/7/2016	1.7
	1/9/2017	1.5
	2/27/2017	1.7
	4/17/2017	1.6
	6/5/2017	1.8
	7/24/2017	1.8

From 8 baseline samples
Baseline mean = 1.65
Baseline std Dev = 0.119523

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 8 (background observations) - 1
t(0.95, 8) = 1.89458

Date	Samples	Mean	Interval	Significant
10/2/2017	1	1.8	[0, 1.89018]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-04
Parameter: Fluoride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1.6
	9/20/2016	1.5
	11/7/2016	1.5
	1/9/2017	1.4
	2/27/2017	1.7
	4/18/2017	1.6
	6/5/2017	1.7
	7/24/2017	1.7
	9/13/2017	1.8

From 9 baseline samples
Baseline mean = 1.61111
Baseline std Dev = 0.12693

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	1.7	[0, 1.85991]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-09
Parameter: Fluoride
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1.3
	9/20/2016	1.2
	11/9/2016	1.5
	1/10/2017	1.1
	2/28/2017	1.5
	4/17/2017	1.4
	6/5/2017	1.6
	7/25/2017	1.6
	9/14/2017	1.6

From 9 baseline samples
Baseline mean = 1.42222
Baseline std Dev = 0.185592

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/3/2017	1	1.5	[0, 1.78601]	FALSE

Non-Parametric Prediction Interval

Intra-Well Comparison for MW-16-01
Parameter: pH, Field
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Total Percent Non-Detects = 0%
Future Samples (k) = 1
Recent Dates = 1
Baseline Measurements (n) = 8
Maximum Baseline Concentration = 8.08 **Minimum Baseline Concentration = 7.62**
Confidence Level = 88.9%
False Positive Rate = 11.1%

Baseline Measurements	Date	Value
	8/1/2016	8.08
	9/20/2016	7.92
	11/7/2016	7.91
	1/9/2017	7.62
	2/27/2017	7.76
	4/17/2017	7.88
	6/5/2017	7.84
	7/24/2017	7.63

Date	Count	Mean	Significant
10/2/2017	1	7.25	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-02
Parameter: pH, Field
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% Two-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	7.79
	9/19/2016	7.93
	11/7/2016	7.8
	1/9/2017	7.62
	2/27/2017	7.64
	4/17/2017	7.78
	6/5/2017	7.71
	7/24/2017	7.64
	9/12/2017	7.47

From 9 baseline samples
Baseline mean = 7.70889
Baseline std Dev = 0.133832

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1)/2 = 97.5 %
t is Percentile of Student's T-Test (0.95/1/2) = 0.975
Degrees of Freedom = 9 (background observations) - 1
t(0.975, 9) = 2.30601

Date	Samples	Mean	Interval	Significant
10/2/2017	1	7.27	[7.38, 8.03]	TRUE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-03
Parameter: pH, Field
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% Two-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	7.97
	9/19/2016	8.16
	11/7/2016	7.95
	1/9/2017	7.6
	2/27/2017	7.83
	4/17/2017	8.01
	6/5/2017	8.01
	7/24/2017	7.89

From 8 baseline samples
Baseline mean = 7.9275
Baseline std Dev = 0.163947

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1)/2 = 97.5 %
t is Percentile of Student's T-Test (0.95/1/2) = 0.975
Degrees of Freedom = 8 (background observations) - 1
t(0.975, 8) = 2.36462

Date	Samples	Mean	Interval	Significant
10/2/2017	1	7.66	[7.52, 8.34]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-04
Parameter: pH, Field
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% Two-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	8.02
	9/20/2016	8.28
	11/7/2016	7.99
	1/9/2017	7.86
	2/27/2017	7.91
	4/18/2017	7.81
	6/5/2017	7.95
	7/24/2017	7.85
	9/13/2017	7.6

From 9 baseline samples
Baseline mean = 7.91889
Baseline std Dev = 0.183197

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1)/2 = 97.5 %
t is Percentile of Student's T-Test (0.95/1/2) = 0.975
Degrees of Freedom = 9 (background observations) - 1
t(0.975, 9) = 2.30601

Date	Samples	Mean	Interval	Significant
10/2/2017	1	7.78	[7.47, 8.36]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-09
Parameter: pH, Field
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% Two-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	8.41
	9/20/2016	8.51
	11/9/2016	8.26
	1/10/2017	7.91
	2/28/2017	8.22
	4/17/2017	8.15
	6/5/2017	8.16
	7/26/2017	8.2
	9/14/2017	7.83

From 9 baseline samples
Baseline mean = 8.18333
Baseline std Dev = 0.214126

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1)/2 = 97.5 %
t is Percentile of Student's T-Test (0.95/1/2) = 0.975
Degrees of Freedom = 9 (background observations) - 1
t(0.975, 9) = 2.30601

Date	Samples	Mean	Interval	Significant
10/3/2017	1	8.08	[7.66, 8.7]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-01
Parameter: Sulfate
Original Data (Not Transformed)
Cohen's Adjustment

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/1/2016	1.5
	9/20/2016	1.5
	11/7/2016	ND<5 U
	1/9/2017	1.9 F1
	2/27/2017	ND<5 U
	4/17/2017	ND<5 U
	6/5/2017	4.6
	7/24/2017	4.8
	9/11/2017	7.2

From 9 baseline samples
Baseline mean = 3.58333
Baseline std Dev = 2.32845

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	4.2	[0, 8.14741]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-02
Parameter: Sulfate
Original Data (Not Transformed)
Cohen's Adjustment

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	18
	9/19/2016	ND<1 U
	11/7/2016	ND<5 U
	1/9/2017	2
	2/27/2017	12
	4/17/2017	11
	6/5/2017	11
	7/24/2017	8.3
	9/12/2017	7.6

From 9 baseline samples
Baseline mean = 7.6019
Baseline std Dev = 6.35826

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	7.7	[0, 20.0649]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-03
Parameter: Sulfate
Original Data (Not Transformed)
Cohen's Adjustment

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	6.9
	9/19/2016	3.3
	11/7/2016	ND<10 U
	1/9/2017	4.4
	2/27/2017	ND<10 U
	4/17/2017	ND<5 U
	6/5/2017	2.7
	7/24/2017	2.8

From 8 baseline samples
Baseline mean = 6.54763
Baseline std Dev = 3.73491

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 8 (background observations) - 1
t(0.95, 8) = 1.89458

Date	Samples	Mean	Interval	Significant
10/2/2017	1	2.5	[0, 14.0529]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-04
Parameter: Sulfate
Original Data (Not Transformed)
Non-Detects Replaced with 1/2 DL

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	14
	9/20/2016	ND<0.5 U
	11/7/2016	5.1
	1/9/2017	6
	2/27/2017	11
	4/18/2017	15
	6/5/2017	9.3
	7/24/2017	13
	9/13/2017	7.2

From 9 baseline samples
Baseline mean = 9.01111
Baseline std Dev = 4.7538

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	7.9	[0, 18.3292]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-09
Parameter: Sulfate
Original Data (Not Transformed)
Non-Detects Replaced with 1/2 DL

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	8.4
	9/20/2016	3.3
	11/9/2016	12
	1/10/2017	19
	2/28/2017	27
	4/17/2017	27
	6/5/2017	27
	7/25/2017	ND<5 U
	9/14/2017	32

From 9 baseline samples
Baseline mean = 17.8556
Baseline std Dev = 10.9148

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/3/2017	1	24	[0, 39.25]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-01
Parameter: Total Dissolved Solids
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/1/2016	930
	9/20/2016	920
	11/7/2016	920
	1/9/2017	940
	2/27/2017	950
	4/17/2017	920
	6/5/2017	910
	7/24/2017	920
	9/11/2017	910

From 9 baseline samples
Baseline mean = 924.444
Baseline std Dev = 13.3333

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	930	[0, 950.58]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-02
Parameter: Total Dissolved Solids
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	760
	9/19/2016	710
	11/7/2016	720
	1/9/2017	780
	2/27/2017	760
	4/17/2017	910
	6/5/2017	810
	7/24/2017	760
	9/12/2017	770

From 9 baseline samples
Baseline mean = 775.556
Baseline std Dev = 58.5472

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

Date	Samples	Mean	Interval	Significant
10/2/2017	1	760	[0, 890.316]	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-03
Parameter: Total Dissolved Solids
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1100
	9/19/2016	1100
	11/7/2016	1100
	1/9/2017	1100
	2/27/2017	1100
	4/17/2017	1100
	6/5/2017	1100
	7/24/2017	1100

From 8 baseline samples
Baseline mean = 1100
Baseline std Dev = 0

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 8 (background observations) - 1
t(0.95, 8) = 1.89458

Date	Samples	Mean	Interval	Significant
10/2/2017	1	1100	[0, 1100]	FALSE

Non-Parametric Prediction Interval

Intra-Well Comparison for MW-16-04
Parameter: Total Dissolved Solids
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Total Percent Non-Detects = 0%
Future Samples (k) = 1
Recent Dates = 1
Baseline Measurements (n) = 8
Maximum Baseline Concentration = 1100
Confidence Level = 88.9%
False Positive Rate = 11.1%

Baseline Measurements	Date	Value
	8/2/2016	940
	9/20/2016	960
	11/7/2016	960
	1/9/2017	1100
	2/27/2017	970
	4/18/2017	980
	6/5/2017	1000
	7/24/2017	1000

Date	Count	Mean	Significant
10/2/2017	1	1000	FALSE

Parametric Prediction Interval Analysis

Intra-Well Comparison for MW-16-09
Parameter: Total Dissolved Solids
Original Data (Not Transformed)
Non-Detects Replaced with Detection Limit

Intra-Well Unified Guid. Formula 95% One-Sided Comparison

Baseline Samples	Date	Result
	8/2/2016	1700
	9/20/2016	1800
	11/9/2016	1800
	1/10/2017	1900
	2/28/2017	1900
	4/17/2017	1900
	6/5/2017	1900
	7/25/2017	1800
	9/14/2017	1700

From 9 baseline samples
Baseline mean = 1822.22
Baseline std Dev = 83.3333

For 1 recent sampling event(s)
Actual confidence level is 1.0 - (0.05/1) = 95 %
t is Percentile of Student's T-Test (0.95/1) = 0.95
Degrees of Freedom = 9 (background observations) - 1
t(0.95, 9) = 1.85955

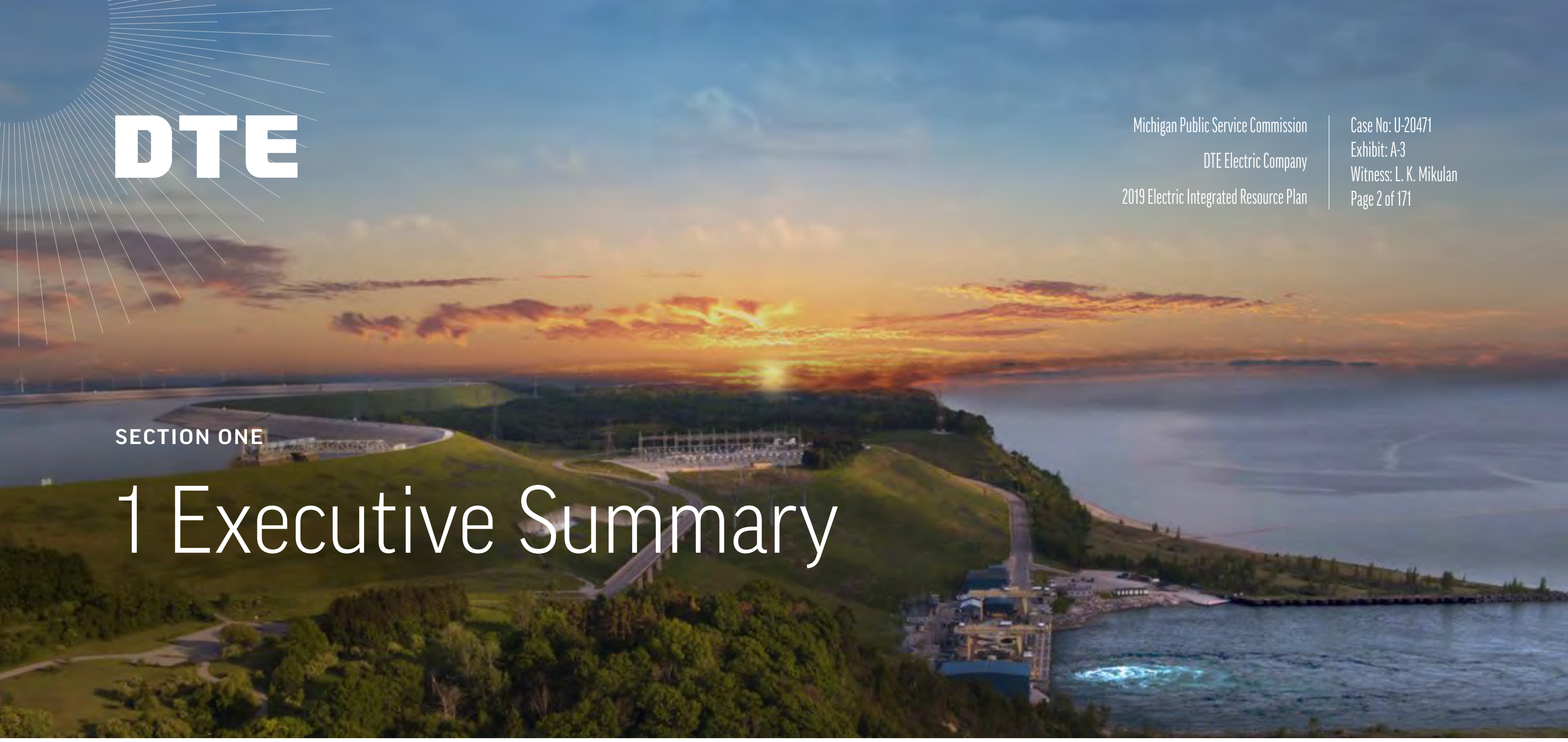
Date	Samples	Mean	Interval	Significant
10/3/2017	1	1700	[0, 1985.57]	FALSE

Appendix F
2019 Integrated Resource Plan

DTE

2019 INTEGRATED RESOURCE PLAN

Clean, Reliable Solutions to Power Michigan's Future



SECTION ONE

1 Executive Summary

Introduction

Michigan is in the midst of an energy transformation. We are reimagining and restructuring how we power our homes, our businesses and our vehicles.

The drivers of that transformation – a desire for safe, clean, affordable and reliable power; an aging power infrastructure; and the need to minimize our impact on the environment – each require thoughtful consideration and balance. DTE has 11,770 megawatt system capacity, and uses coal, nuclear fuel, natural gas, hydroelectric pumped storage, wind, and solar to generate its electrical output. The Company also holds a variety of power purchase agreements with independent power producers throughout Michigan.

At DTE Energy – a Michigan-based company serving 2.2 million electric customers and 1.3 million gas customers – we have been at the forefront of successfully striking that balance. In 2017, DTE announced plans to reduce our carbon emissions by more than 80 percent by 2050, making it one of the most aggressive plans in the country. And last year, we committed to producing 50 percent of our energy from clean sources by 2030. This clean energy commitment includes a minimum of 25 percent renewables and at least a 1.5 percent improvement in energy efficiency each year.

With this integrated resource plan, we're going even further – a lot further. **We're moving up our carbon-emissions goal by a full decade, pledging to reduce emissions by 80 percent by 2040. And in the near term, we have committed to a 50 percent carbon emissions reduction by 2030[1].** And we're doing so in a way that ensures our energy sources remain reliable and the power they produce affordable.

In order to achieve our bold new goal, we're expanding our energy-efficiency programs to reduce even more consumption and help our customers - especially our low-income customers - save energy and money. And we've expanded our voluntary renewables program, MIGreenPower, to our large business and industrial customers, which will accelerate our state's transition to renewable energy and empower companies to meet their sustainability goals through voluntary investments.

We're also moving our previously announced closures of the Trenton Channel Power Plant and the final generation unit at St. Clair Power Plant up one year, to 2022.

We're committed to our communities – to creating jobs for the people who live in them and to providing a balanced mix of safe, clean, reliable and affordable energy. In fact, reducing carbon is the greatest opportunity we have as an energy company. And we're already doing it – by building the clean energy sources that our customers are asking us to build.

This integrated resource plan (IRP), submitted to the Michigan Public Service Commission, lays out our vision for ensuring Michigan continues to lead in creating clean, reliable, affordable, home-grown energy that its residents and businesses can depend on. It provides both a high-level and detail-rich strategy for powering Michigan's homes and businesses over the next five years, as well as a flexible long-term plan that can evolve as our technological options and the needs of our state evolve.

More Clean Energy, Less Coal

Climate change is one of the defining public policy issues of our time. At DTE, we are passionate about being central to the solution. That's why we have set ambitious new goals of reducing carbon emissions by 80 percent by 2040 and 50 percent by 2030. Those goals align with the target scientists have identified as necessary to help address climate change, and we will achieve them through aggressive investment in energy efficiency, renewables, the Blue Water Energy Center and our voluntary renewables programs, as well as through earlier coal retirements.

Coal Plant Retirements

In 2016, DTE announced the retirements by 2023 of three aging power plants – River Rouge, St. Clair and Trenton Channel– that account for nearly 20 percent of our total generation. Those retirements follow the closure of two other plants – Marysville and Harbor Beach – between 2011 and 2013, and generation units at our St. Clair, Trenton Channel and River Rouge plants between 2011 and 2017.

"Not only is our 80% carbon reduction goal achievable – it is achievable in a way that keeps Michigan's power affordable and reliable. There doesn't have to be a choice between the health of our environment or the health of our economy; we can achieve both."

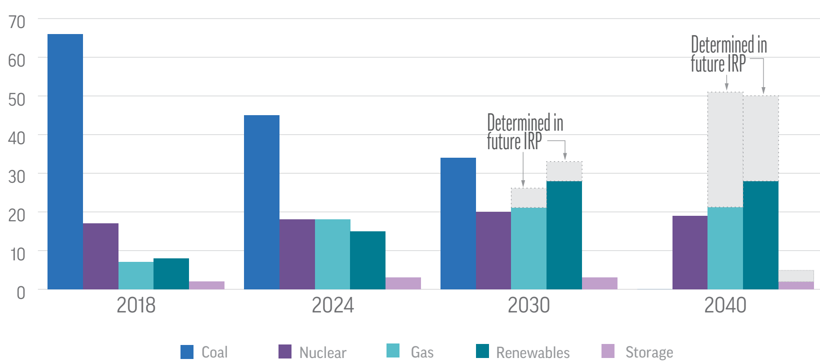
Gerry Anderson, chairman and CEO, DTE Energy

1 Compared to 2005 baseline; CO2 emissions associated with energy generated for DTE Electric customers.

We're now planning to close our Trenton Channel Power Plant and St. Clair Power Plant in 2022 – one year earlier than we originally intended.[2] We want to move forward as quickly as possible to achieve our carbon-reduction goal, and need to do it in a way that balances the reliability of the energy grid while also working closely with the impacted communities and employees during this transition.

We're now planning to close our coal-burning Trenton Channel Power Plant and the last operating unit at St. Clair Power Plant in 2022 – one year earlier than we originally intended. The Midcontinent Independent System Operator (MISO), the regional grid operator, must complete a reliability assessment before these dates are finalized. We want to move forward as quickly as possible to achieve our carbon reduction goal, and need to do it in a way that balances the reliability of the energy grid while also working closely with the impacted communities and employees during this transition.

FIGURE 1.1 2018-2040 Generation Mix



*Based on current projections. Final percentages to be determined in future IRPs.

Our coal plants have served our communities and employees well for nearly 75 years. We're proud of that legacy of service and will continue to build upon it for generations to come. We are working closely with municipal leaders in River Rouge, Trenton and St. Clair County to find meaningful ways to turn the coal plant properties into viable economic contributors after our facilities close. We are collaborating with union leadership on developing retraining programs and an employee transition strategy that is committed to no layoffs while maintaining affordable and reliable 24/7 power for our customers.

4,000

Michigan jobs created

2040

Our renewable energy will quadruple by 2040

2 contingent on resolution of grid reliability concerns

Building Renewables

DTE is Michigan's largest renewable-energy provider. By 2024, we will more than double our renewable energy, generating enough clean energy to power 800,000 Michigan homes. By the time we remove all coal from our generation fleet in 2040, our renewable-energy portfolio will have quadrupled.

Since 2009, we've driven investments of $2.8 billion in renewable energy – a figure that will increase to $4.8 billion by 2024. The vast majority of that investment is supporting Michigan communities and creating Michigan jobs.

DTE's Renewables Mix Today

Solar

DTE currently operates more than 30 solar parks in Michigan, with plans to increase solar capacity by 25 percent over the next five years. In 2017, DTE commissioned the O'Shea Solar Park in Detroit, repurposing 10 acres of previously vacant land, and the Lapeer Solar Park, the largest universal solar park in the state. The Lapeer site includes 200,000 solar panels, making it one of the largest solar parks east of the Mississippi, and its arrays produce enough clean energy to power 11,000 homes.

30
30 solar parks in Michigan

200K
200,000 solar panels in Lapeer

11K
11,000 homes can be powered by the Lapeer Solar Park

Wind

Wind is currently our lowest-cost and most abundant renewable resource, which is why we've already invested in the building of 14 wind parks. In early 2019, DTE commissioned Pine River, its largest operating wind park to date. Its 65 turbines generate enough energy to power more than 54,000 homes. Pine River will offset nearly 300,000 metric tons of CO_2 annually – the greenhouse-gas equivalent of taking more than 63,000 cars off the road. In early 2020, we'll commission an additional wind park that will be even larger than Pine River.

14
We've invested in 14 wind parks

300K
Pine River will offset nearly 300,000 metric tons of CO_2

2020
In 2020 we'll commission an additional wind park

Partnering with Michigan residents, business and industry

We're proud of our investment in renewables, of DTE's leadership in this critically important area and of the fact that we align with scientific consensus about the steps needed to protect our planet. And we're determined to go further.

Combating climate change must be a cross-industry effort, so we've expanded our MIGreenPower program to our large business and industrial customers. Introduced in 2017, MIGreenPower is a voluntary renewable energy program that provides DTE's residential and business customers with an easy and affordable way to reduce their carbon footprint by increasing the percentage of their energy use attributable to local wind and solar energy sources, up to 100 percent. Participating customers – who now number more than 5,000 – see a slight increase in their monthly bill while knowing they're helping to support Michigan's clean energy future.

We're expanding this voluntary initiative to meet the needs of our largest business and industrial customers who are working to meet their own sustainability goals, enabling them to invest in renewable energy, which will help drive our state toward an even cleaner future. The program is designed to grow and represents a progressive approach to fill market demand. In fact, we've already partnered with Ford and GM to provide renewable energy to support their sustainability goals.

Ford has committed to procuring 500,000 MW hours annually of wind energy to power several of its Michigan facilities, including the plant that makes its popular F-150 truck. GM has partnered with DTE to procure 300,000 MW hours annually of wind energy to power its technical center in Warren, Mich., and its headquarters in Detroit.

DTE also is exploring opportunities to expand its residential offerings to those interested in more local, community renewable energy.

Improving Energy Efficiency

Energy efficiency works hand-in-hand with renewable energy sources to ensure we meet our clean energy goals. In short, when

homes and businesses reduce their energy use, we can generate less electricity, benefiting both customers' pocketbooks and the environment.

DTE previously committed to increasing energy efficiency at a level equivalent to 1.5 percent of sales annually. Our efforts already have resulted in nearly 700 MW annually of reduced energy demand since 2009, equivalent to the energy produced by one large power plant. Improving energy efficiency also results in lower bills for customers; for every dollar invested in energy efficiency, customers save $5.

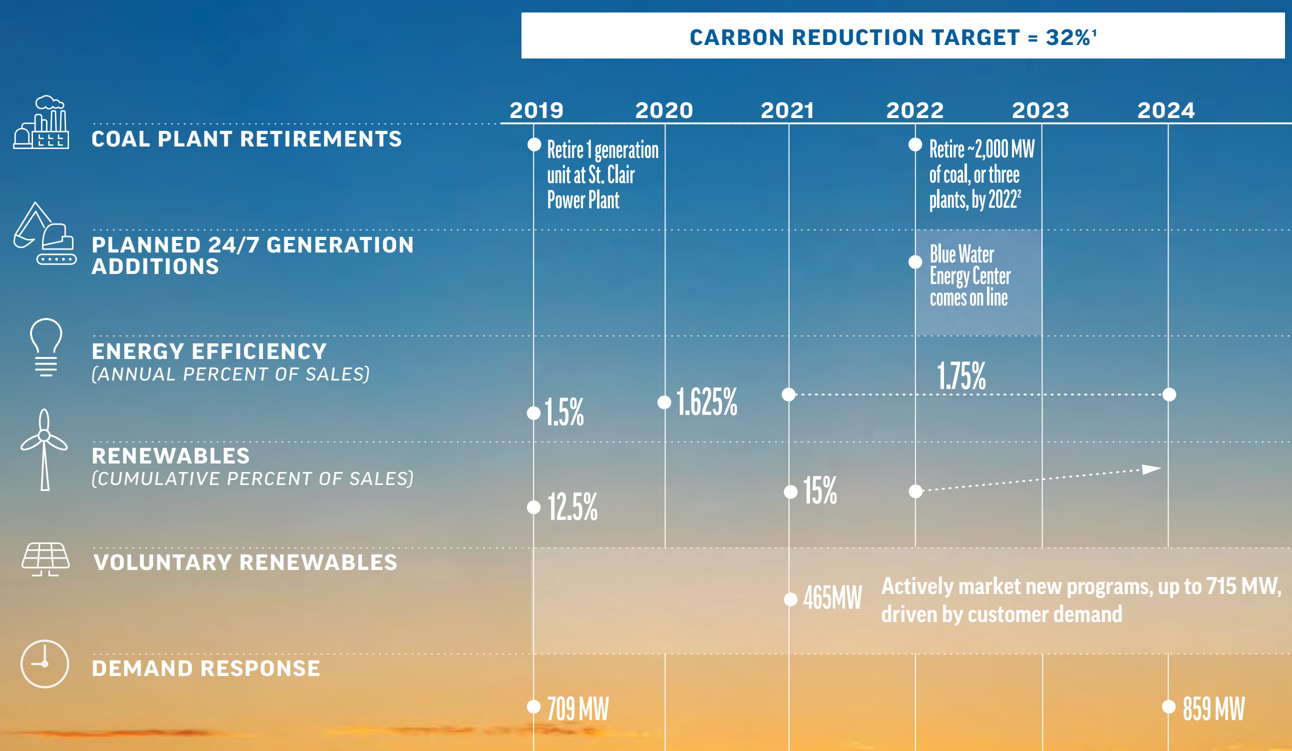
With this plan, we're building on the success of these efforts by committing to a 1.75 percent annual improvement in energy efficiency - 75 percent more than the level required by law. Improving energy efficiency will reduce our carbon emissions even further – meaning we need to generate even less energy. The expansion of those programs also will mean more jobs and business for the Michigan firms that support them.

DTE also is a leader in demand response, rewarding residential and business customers who reduce or shift electricity usage during peak periods. We offer our customers the opportunity to reduce their energy use and lower their bills through multiple programs. Our demand-response program is in the top 25 percent nationwide and is the largest in Michigan, with more than 700 MW of program capacity.

Powering Michigan's Future

The plan we are submitting focuses on the next five years and considers the most affordable and reliable mix of generation sources that are available today. However, these technologies are improving rapidly, so we also have created a flexible long-term plan that allows us to review technological advancements as they become feasible and affordable. We've developed four alternate long-term options, modeling different costs and technology assumptions for each. We will continue to revisit and refine our plan as technology develops, customer desires and trends become more clear, and costs decline. For more information on demand-side rates and resources, see Section 8: Demand-Side Resources

The Defined Short Term: 2019-2024



1. Compared to 2005 baseline; CO2 emissions associated with energy generated for DTE Electric customers

2. Retirements of St. Clair, River Rouge and Trenton Channel plants are contingent on the successful start up of Blue Water Energy Center and resolution of grid reliability concerns

The Flexible Future: 2025-2030

CARBON REDUCTION TARGET = 50%[1]

- Retire Belle River Power Plant by 2030
- Increase renewables to at least 25%
- Continue 1.75% energy efficiency and review biannually
- Maintain or increase demand response
- Continue to market and add voluntary renewables based on customer demand

Possible pathways that could meet future generation needs:

A Achieve 1,390 MW of voluntary renewables Increase demand response Maintain 1.75% energy efficiency	**B** Achieve 1,390 MW of voluntary renewables Construct new natural gas-fueled power plant Maintain 1.75% energy efficiency
C Achieve 465 MW of voluntary renewables Increase demand response Increase energy efficiency to 2.00% in 2026	**D** Achieve 465 MW of voluntary renewables Construct new natural gas-fueled power plant Maintain 1.75% energy efficiency

The Flexible Future: 2031-2040

CARBON REDUCTION TARGET = 80%[1]

- Retire Monroe Power Plant by 2040
- Increase renewables, energy efficiency and demand response consistent with carbon reduction goals

There are multiple pathways to meet carbon goals and generation needs in 2030 and beyond; we will remain flexible and present potential future options in our next IRP.

Balanced, Reliable, Customer-Focused

As we embrace renewable energy, our IRP provides a clear and balanced path for meeting our carbon-reduction goals while ensuring energy remains affordable and reliable.

Michigan's unique peninsular geography and the physical limitations of the transmission system mean that 95 percent of Michigan's power generation must be physically located in the Lower Peninsula to meet regional capacity reliability standards. So while some power can be imported from out of state, the vast majority must be locally produced in order to maintain a reliable energy grid.

Even as three coal plants are going away, the demand for around-the-clock electricity is not. And since the weather and the economy are both prone to change, we need a flexible, nimble mix of energy sources that can meet our customers' changing needs, 24 hours a day, seven days a week. Because renewable energy is variable, the need to carefully plan for and balance local supply for every hour of the year is absolutely critical. We cannot rely on purchasing energy on the market when demand is high – if every energy company in our region did that, reliability would be undermined. That's why we're pushing hard to both meet our ambitious clean-energy goals and to ensure our regional energy grid remains reliable.

Key to balancing these commitments are the Blue Water Energy Center and the Ludington Pumped Storage Power Plant.

850K

In 2022 BWEC will provide enough energy to power 850,000 homes

Blue Water Energy Center

Natural gas will help us make the transition to renewables in a way that provides the reliability Michigan residents need, while significantly reducing our carbon footprint. Natural gas plants are a highly efficient, low-emission energy source that provide reliable, on-demand, 24/7 electricity.

The Blue Water Energy Center (BWEC), approved by the Michigan Public Service Commission in 2018, will be a state-of-the-art, natural gas combined-cycle plant and one of the most efficient plants in the United States. It will replace three retiring coal plants, allowing Michigan to have both a sharp reduction in carbon emissions and an always-available energy source, helping us create a cleaner energy future. It will be capable of ramping up quickly to accommodate changes in demand and fluctuations in renewables and other energy sources, ensuring our state's homes and businesses have a reliable power source and giving them peace of mind.

This plant will provide enough 24/7, affordable and reliable energy to power 850,000 homes beginning in 2022. BWEC will reduce CO_2 emissions by 70 percent compared with the three coal plants it is replacing. It also will reduce sulfur dioxide (SO_2), and nitrous oxide (NO_x) emissions by more than 95 percent compared with the coal plants slated for retirement, while supporting Michigan's manufacturing operations and residential customers. The plant represents a nearly $1 billion investment in Michigan. Construction jobs will peak at about 520 full-time positions during construction and will provide about 35 full-time positions once the plant is in operation.

Ludington Pumped Storage Power Plant

The Ludington Pumped Storage Power Plant, which DTE co-owns with Consumers Energy, is located on a 1,000-acre site on Lake Michigan in Mason County. The plant generates hydroelectric power and supports our renewables generation because it acts like a giant battery that can be tapped when renewable output drops.

The Ludington plant consists of a man-made reservoir located above six 300-ton turbines. The reversible turbines work as pumps when energy is plentiful and low-cost, such as when the sun is shining and the wind is blowing, and as power generators when demand is higher and renewable sources less abundant. The plant pumps water from Lake Michigan uphill to the 27 billion-gallon reservoir at low-demand times, and releases the stored water downhill through the turbines to generate electricity when energy demand is higher.

Ludington can ramp up to peak output in just 30 minutes. It provides a sustainable, clean, reliable energy source that quickly responds to the daily, weekly and seasonal highs and lows of Michigan's energy demand. It also helps keep energy bills lower because it allows DTE to avoid having to buy expensive out-of-state electricity when demand peaks.

An $800 million upgrade project to replace each of the six turbines is on schedule to be completed in 2020. Ludington, the second-largest pumped storage facility in the United States, will then support power for 175,000 DTE households.

$800M

An $800 million upgrade project to replace each of the six turbines is on schedule to be completed in 2020.

DTE has listened carefully to that input. We are confident this IRP incorporates the needs and concerns of Michigan residents and businesses and provides a safe, affordable, reliable and effective course of action.

We appreciate the participation and feedback that was provided and engagement from our technical and public stakeholders. We will continue to communicate with our stakeholders as part of our commitment to engagement..

A Collaborative Vision: Stakeholder Input

We must work together collaboratively to secure Michigan's energy future. DTE spent months seeking input on this IRP from members of the public, consumer and environmental advocates, and other stakeholders at numerous forums and open houses across the state.

We believe everyone benefits from the exchange of information and open dialogue, and so we worked to implement a comprehensive, transparent and participatory stakeholder engagement process. Outreach was designed to create awareness of the IRP process, encourage honest communication, and obtain and incorporate feedback. We hosted four technical workshops and three public open houses, and created a DTE IRP email account for electronic comment submission and response.

Registration for the open houses was not required, and we publicized them through social media, the DTE newsroom, emails to stakeholders and through our blog, EmpoweringMichigan.com. We also included open house content on the site for easy access.

At each technical meeting and open house, we worked to understand and respond to stakeholder suggestions and concerns. Here's what we heard at those meetings:

- Michiganders want their power sources to be safe, affordable and reliable.
- They care about climate issues and want to make sure we're doing everything we can to transition to cleaner energy, including renewable energy, energy efficiency and demand response.
- They want more information on how to engage with DTE on everything from energy-efficiency audits to tree trimming..

SECTION TWO

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SECTION THREE

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SECTION FOUR

4 Introduction

4.1 Company Overview

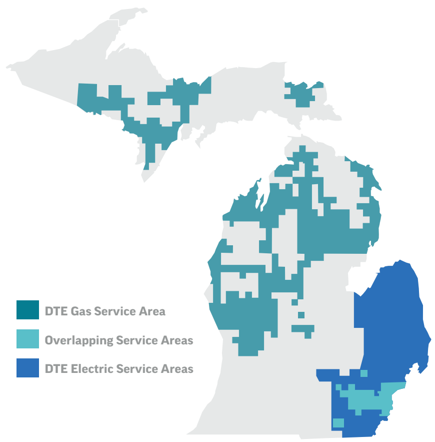
DTE (NYSE: DTE) is a Detroit-based diversified energy company involved in the development and management of energy-related businesses and services nationwide. Its operating units include an electric utility serving 2.2 million customers in Southeastern Michigan and a natural gas utility serving 1.3 million customers in Michigan. The DTE portfolio includes non-utility energy businesses focused on power and industrial projects, natural gas pipelines, gathering and storage, and energy marketing and trading.

At DTE, we are reimagining and restructuring how we power our customers' homes, businesses, and vehicles. The drivers of that transformation – a desire for safe, clean, affordable and reliable power, an aging power infrastructure, and the need to minimize our impact on the environment – each require thoughtful consideration and balance. DTE announced plans in 2017 to reduce our carbon emissions by more than 80 percent by 2050, making it one of the most aggressive plans in the country. With this integrated resource plan, we are going even further. We are moving up our carbon-emissions -eduction goal by a full decade, pledging to reduce emissions by 80 percent by 2040.

DTE is also committed to being a force for good in the communities where it serves through volunteerism, education and employment initiatives, philanthropy, and economic progress. Information about DTE is available at dteenergy.com, empoweringmichigan.com, twitter.com/dte_energy and facebook.com.

DTE has more than 10,000 employees in utility and non-utility subsidiaries involved in a wide range of energy-related businesses. Founded in 1903, DTE Electric (DTEE or Company) is the largest electric utility in Michigan and one of the largest in the nation. With an 11,770 megawatt (MW) system capacity, the Company uses coal, nuclear fuel, natural gas, hydroelectric pumped storage, wind, and solar to generate its electrical output.

FIGURE 4.1.1: DTE Service Areas



Just as the generation fleet is diverse, so too is the customer base we serve each hour of the day. DTEE's customer mix spans three primary classes: residential, commercial, and industrial. Several business sectors comprise the commercial class, while the industrial class consists of three primary sub-classes: automotive, steel, and other manufacturing. The figures to the right highlight the 2019 forecasted service area sales and allocation of peak load by customer class. Further details regarding the Company's load forecast methodology and customer classes are provided in Section 10.

FIGURE 4.1.2: Forecasted 2019 Service Area Sales

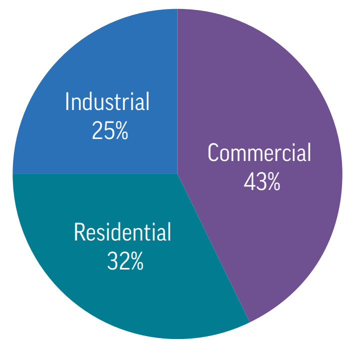
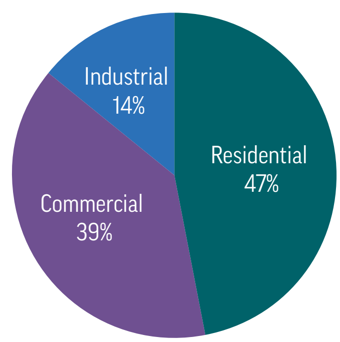


FIGURE 4.1.3: Forecasted 2019 Service Area Peak



4.2 Existing Resource Portfolio

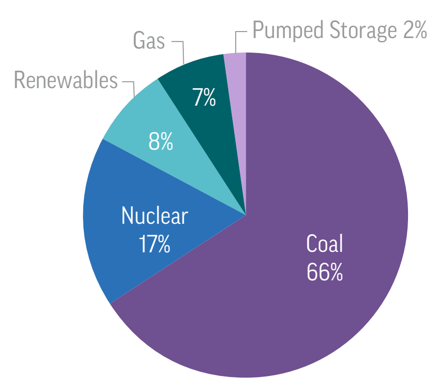
DTEE's generation assets include a diverse mix of owned and contracted sources of energy. The Company owns and operates a collection of generating units including coal, natural gas, oil, nuclear, wind, solar, and hydroelectric energy-storage facilities. The Company also holds a variety of power purchase agreements (PPAs) with independent power producers throughout Michigan. These PPAs are primarily for renewable energy resources, including wind, hydro, biomass, landfill gas, and waste recovery (Section 7 provides a breakdown of the Company's existing supply-side resource fleet). In addition to supply-side resources to meet customer energy needs, the Company offers a wide range of demand-side resources. These resources, described in Section 8, include demand response programs and energy waste reduction programs.

DTEE-owned generation, based on summer capacity ratings, is 11,772 MW, as shown in Table 4.2.1 below. The 2018 generation mix is shown in Figure 4.2.2.

TABLE 4.2.1: 2018 Current Owned Generation Resources

Summer Capacity Rating (MW)[1]	
Fossil Steam	6,868 MW
Peaking Plant	2,033 MW
Pumped Storage	1,054 MW
Total Fossil/Hydraulic System	9,955 MW
Nuclear	1,141 MW
Renewables[2]	676 MW (612 MW wind, 64 MW solar)
Total Owned Generation	11,772 MW

FIGURE 4.2.2: 2018 Fleet Generation Mix

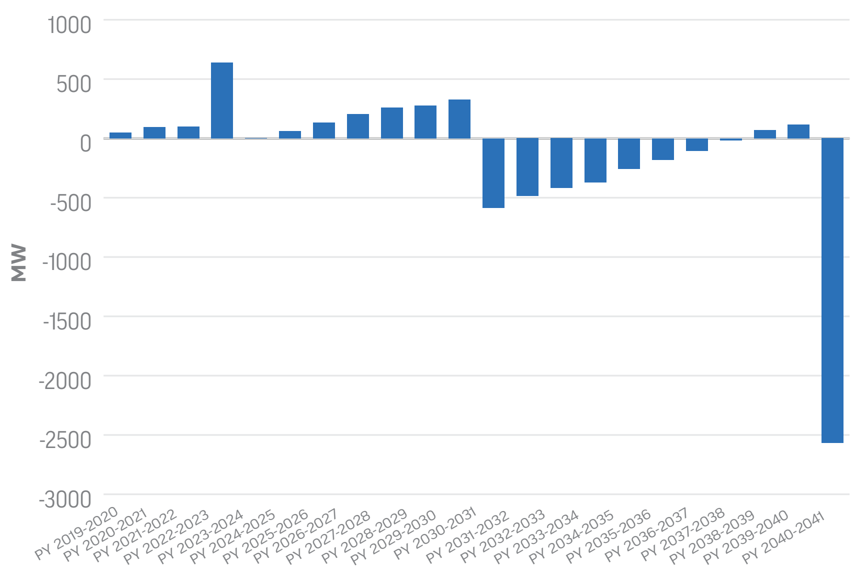


1 Renewables based on MWac installed
2 Revenue requirement of existing generation and power purchase agreements can be found in the IRP Appendix R (Exhbit A-4)

4.3 Capacity Outlook

Developing the Company's capacity outlook projection was integral to the IRP process. When the IRP modeling began, in June 2018, an assessment of the current state of the Company's capacity position was completed as the optimization modeling's starting point. This included evaluating the balance between load requirements (including reserve margins) and the assumed demand-side and supply-side resources (including planned retirements and planned additions) throughout the study period to determine if, and when, there was a need for additional resources. Figure 4.3.1 below illustrates the Company's starting point capacity position throughout the IRP study period of 2019 through 2040.

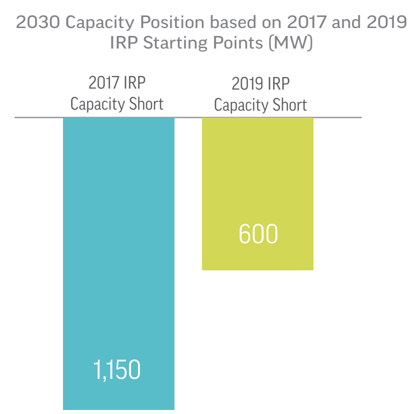
Figure 4.3.1: Starting Point Capacity Position



Starting capacity position notes: In April 2018, the Michigan Public Service Commission (MPSC) issued an Order approving the Company's request for Certificates of Necessity (CON) to construct the Blue Water Energy Center (BWEC), an 1,150 MW natural gas combined-cycle plant, to replace in part the loss of capacity associated with planned retirement of Tier 2 coal units between 2020 and 2023, specifically: River Rouge Unit 3, St. Clair Units 1-3, 6 and 7, and Trenton Channel Unit 9. With the addition of BWEC and the Tier 2 retirements:

- the Company did not project a capacity need for the 10-year period of 2019 to 2028;
- a starting point capacity need was forecasted in 2029 and 2030 as a result of the assumed retirement of Belle River Units 1 and 2, respectively;
- the capacity need forecasted in 2030 was 550 MW less when compared to the need identified in the 2017 IRP filed in support of the CON, primarily due to an updated load forecast, planned renewables to meet 2030 clean-energy goals, and the expansion of existing demand response programs. See Figure 4.3.2 below.

Figure 4.3.2 - 2030 Forecasted Capacity Need (MW) – Walk from 2017 IRP to 2019 IRP



Reductions in capacity short was driven by:
- Reduced load forecast
- Additional renewables
- PURPA
- Increased demand response

4.4 Assumptions Across Scenarios & Sensitivities

The Michigan Integrated Resource Planning Parameters, developed pursuant to section 6(t) of 2016 PA 341, provided three required scenarios: Business as Usual (BAU), Emerging Technologies (ET) and Environmental Policy (EP). In addition to the required scenarios, DTEE created an additional scenario, Reference (REF), that incorporates DTEE's viewpoint of the future.

Each scenario assumed that certain market conditions would evolve over time, resulting in differing futures. For example, compared to the BAU scenario, the ET scenario assumes a 35 percent capital-cost reduction for solar, battery storage, energy waste reduction, demand response, and other emerging technologies. The future state assumed by the REF scenario aligns most closely to the required BAU scenario. However, inputs related to the natural-gas fuel price and carbon-emission costs in the REF scenario differ from the required scenarios. Although currently there are no taxes or cost on CO_2 emissions, there is the possibility that in the future there will be a new version of the Clean Power Plan that will include a cost applied to CO_2.

Figure 4.4.1 and Figure 4.4.2 highlight the natural-gas and CO_2-emission cost forecasts for each scenario throughout the study period. Also shown are the forecasts used for the high gas price (200 percent of 2018 EIA) and CO_2 sensitivities. The consultant company PACE Global

FIGURE 4.4.1: Annual Natural-Gas Price – MichCon Gas Hub

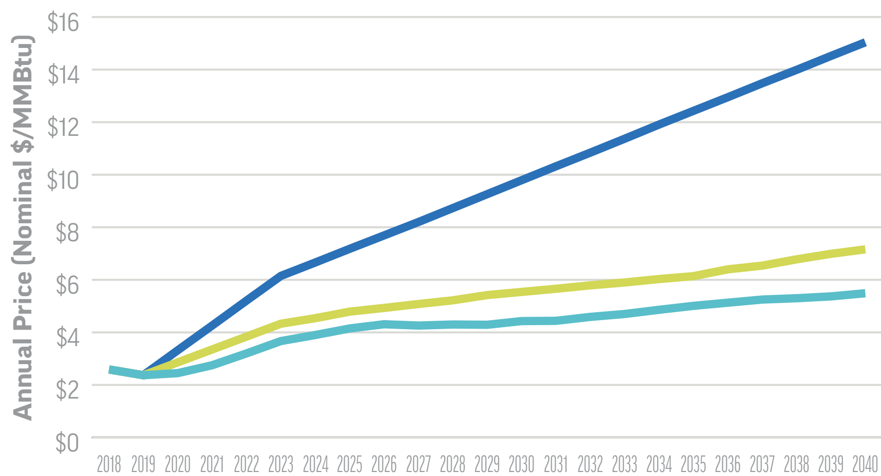
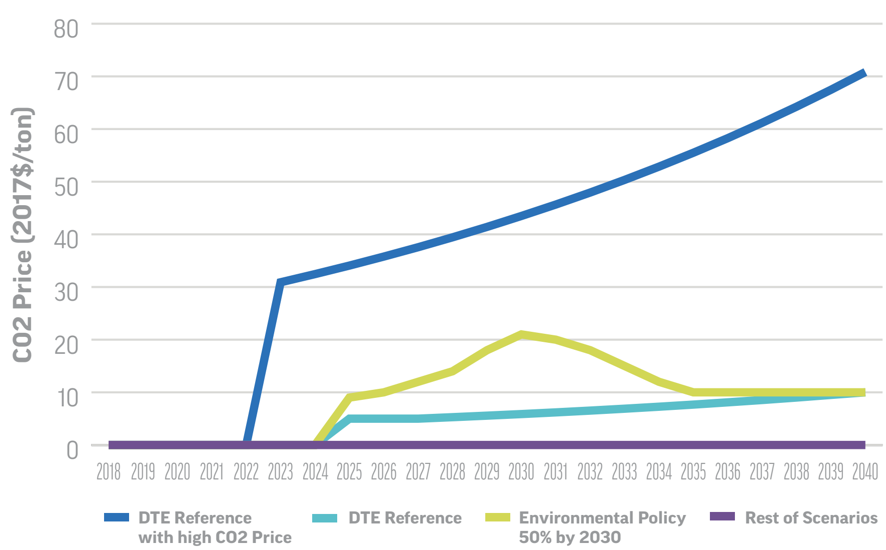


FIGURE 4.4.2: CO2 Price Forecasts

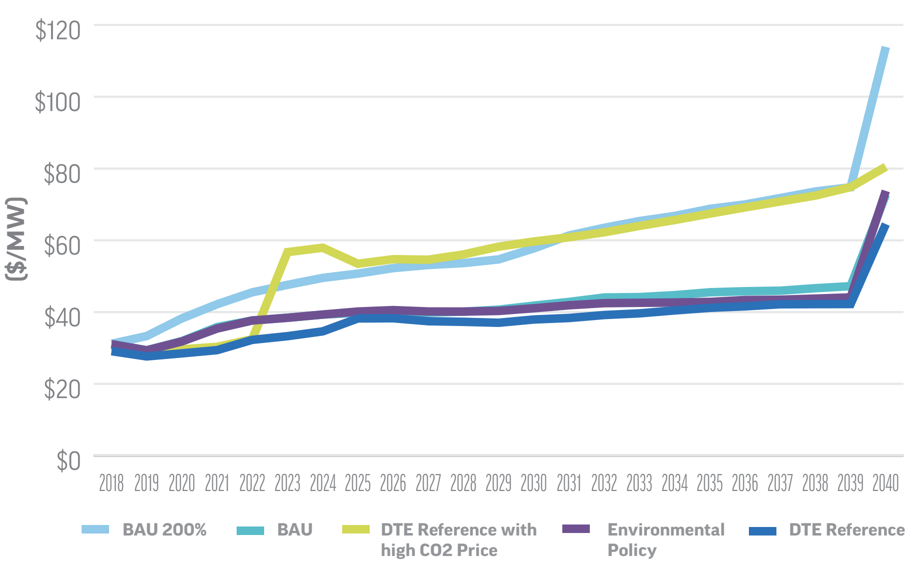


developed the long-term gas price forecast in the RER scenario. The other three scenarios used the publicly available 2018 EIA long-term gas-price forecast. The methodology utilized to develop the natural-gas fuel forecast is described in Section 13 and further explanation of the CO2 cost is included in Section 6.

Because each scenario, and certain sensitivities, had different market assumptions, the resulting forecasts for energy prices varied as well. DTEE utilized PACE Global to develop energy-price forecasts across the scenarios and specific sensitivities. PACE Global modeled the entire U.S. footprint to determine markets and interrelationships between energy markets, environmental rules, gas markets, build plans, and reserve margin/capacity price forecasts. Figure 4.4.3 illustrates the resulting energy forecast prices for the Midcontinent Independent System Operator (MISO) Michigan hub. The projected increase in modeled energy prices from 2039 to 2040 was caused by the planned retirement of a significant amount of 24/7 baseload coal resources by both DTEE and Consumers Energy.

The projected increase in modeled energy prices from 2039 to 2040 is caused by the planned retirement of a significant amount of baseload coal resources by both DTEE and Consumers Energy.

Figure 4.4.3: MISO Michigan Hub Power Prices



4.5 Regulatory Environment & Market Dynamics

Michigan set course in late 2016, with the passage of Public Act 341, to revamp the guidelines and requirements forIRPs to be filed with the MPSC. Throughout 2017, DTEE participated in several IRP stakeholder collaborative groups led by the MPSC staff. The collaborative groups called for the consideration of a broad range of perspectives as the MPSC staff developed recommendations for IRP modeling parameters and filing requirements. The MPSC issued two orders governing IRPs to be filed under the new legislation:

1. Michigan Integrated Resource Planning Parameters, Pursuant to Public Act 341 of 2016, Section 6t (Case No. U-18418; issued on Nov. 21, 2017)
2. Integrated Resource Plan Filing Requirements, Pursuant to Public Act 341 of 2016, Section 6t (Case No. U-18461; issued on Dec. 20, 2017)

The Company relied upon these orders, in combination with Section 6t of Public Act 341, to ensure the filed IRP is compliant with the current regulatory construct.

DTEE's commitment to customers is to continue providing reliable, affordable energy while reducing carbon emissions that affect climate change.

Potential Changes in the MISO Market

As a load serving entity in MISO Local Resource Zone 7 (LRZ 7), DTEE participates in ongoing stakeholder discussions concerning the capacity market's current and future state. Various MISO initiatives are underway in stakeholder forums that may affect future capacity requirements and/or resource accreditation. These initiatives include the Renewable Integration Impact Assessment and Resource Availability and Need, which are described in greater detail below:

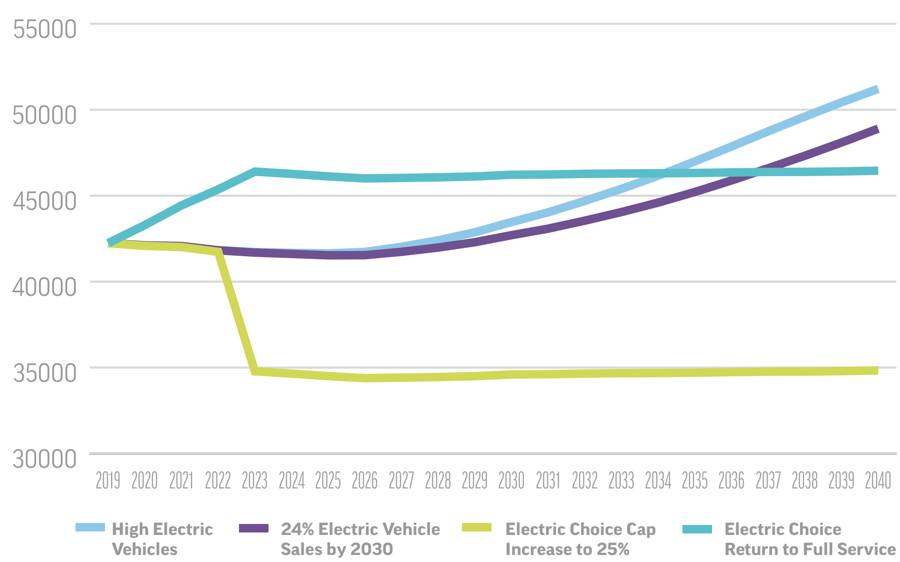
Renewable Integration Impact Assessment (RIIA) – Designed to facilitate a broader conversation around renewable-energy-driven impacts on future system reliability, the RIIA is focused on identifying potential integration issues and mitigating solutions. The assessment's primary outputs will include resource adequacy considerations, including potential impacts to the effective load carrying capability (ELCC) assigned to renewable energy resources. The RIIA is being performed in phases, with findings being shared on a variable intermittent basis. To date the assessment has considered renewable penetration levels up to 40 percent. In this IRP, DTEE has assumed a declining ELCC for future solar installations consistent with assumptions in MISO's Transmission Expansion Plan (MTEP) 19 Futures process. The ELCC for future solar installations is assumed to be 50 percent through 2023 and then to decline at 2 percent per year until 2033.

Resource Availability and Need (RAN) – The RAN initiative is focused on developing market-based solutions for the efficient conversion of capacity to energy and was initiated in response to various observed trends that have resulted in an increased likelihood of capacity emergencies throughout the planning year. Potential outcomes include changes to load modifying resource registration requirements, alteration in outage coordination practices, and the implementation of a seasonal resource adequacy construct (as opposed to the current one-year prompt market). Although this IRP doesn't include considerations of this initiative, DTEE will continue to monitor and evaluate potential changes to resource planning in the future.

Electric Customer Choice

The current regulatory construct in Michigan allows 10 percent of retail load to be served by alternative energy suppliers. Changes to the existing Electric Customer Choice construct would have an impact on the Company's potential long-term resource pathways, as load is a critical component to resource planning. In the majority of the scenarios and sensitivities analyzed, the IRP assumes the current 10 percent retail-load cap remains intact. However, the IRP does consider sensitivities in which the Electric Choice cap is expanded or returns to zero. The figure below highlights a sample of load sensitivities modeled in the IRP, including varying levels of Electric Choice. Descriptions of the Company's load-forecast methodology and sensitivities evaluated are included in Section 10.

FIGURE 4.5.1: Load Sensitivity Bundled Sales (GWh)



Environmental

DTEE's commitment to customers is to continue providing reliable, affordable energy while minimizing our impact on the environment, including reducing carbon emissions that affect climate change. In May 2017, DTEE was one of the first electric companies to announce a long-term carbon reduction target to reduce CO2 emissions by more than 80 percent by 2050, positioning the Company as an industry leader in reducing greenhouse gases. A plan for reducing DTEE's CO2 emissions makes business sense, ensures safe, reliable, affordable, and cleaner energy for its customers, and allows the Company to implement a long-term generation-transformation strategy in which more than half of the energy is generated from zero-emitting resources. With the plans laid out in this IRP, the Company is able to take the next step on our clean-energy journey, and is announcing that we are accelerating our carbon reduction goals to 50 percent by 2030, and more than 80 percent by 2040, a full decade ahead of the previous 2050 goal.

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released a special report on global warming. The report focused on movements away from fossil fuel generation and supplementing it with wind and solar energy. DTE'Es plan to reduce carbon emissions by 80 percent is consistent with the range of what the report says is necessary to combat climate change. DTEE reviewed what could be done within our system to minimize our contribution to climate change and established a plan to transition our generation fleet to low- and zero-emitting sources in a manner and timeframe that also continues to assure reliability and minimizes cost impact on our customers.

Currently in the United States no federal regulation requires reductions in CO2 emissions from electric generating units. Although the U.S. Supreme Court stayed the Clean Power Plan, there is a proposed EPA regulation called the Affordable Clean Energy (ACE) rule, which would direct states to develop plans establishing plant-specific standards of performance for CO2 based on applicable heat-rate-improvement technologies. Some states have established CO2 cap-and-trade programs to reduce greenhouse gas emissions from the electric sector, most notably the Regional Greenhouse Gas Initiative and the California cap-and-trade system. These state-wide systems require robust CO2 accounting methods to verify emissions, and stakeholders are driving the development of improved methods of accounting for the CO2 emissions associated with energy purchases and sales. In Michigan and in MISO, there is currently no accounting required for the CO2 associated with the purchase and sales of energy. However, this is under consideration in other jurisdictions, subject to emissions trading programs. This type of CO2 accounting would credit the seller of energy for a calculated average CO2 mass attributable to the CO2 intensity of the energy produced at the time of the sale, and similarly the purchaser would incur the CO2 associated with the purchase. While simple in concept, the calculations are complicated and would require coordination and data sharing across MISO, the sellers and purchasers, and other stakeholders. In this IRP, we have calculated the CO2 emissions both with and without an estimate of the carbon impact of energy purchases and sales. It is expected that the role of CO2 accounting in IRPs will evolve in future filings.

Our proposed course of action (PCA) is based on the low- and zero-emission technologies that are available and economic today and where we are confident in the trends going forward. Our PCA also focuses on demand-side resources, and reducing energy demand through reducing energy waste and expanding peak demand response technologies. As we developed this plan, we considered how the technologies' feasibility and economics could facilitate this generation transition to improve faster. In future IRPs, we will continue to develop and implement plans to transition our generation fleet in a manner and timeframe that also continues to assure reliability and minimizes financial impact on our customers.

Renewable Portfolio Standards

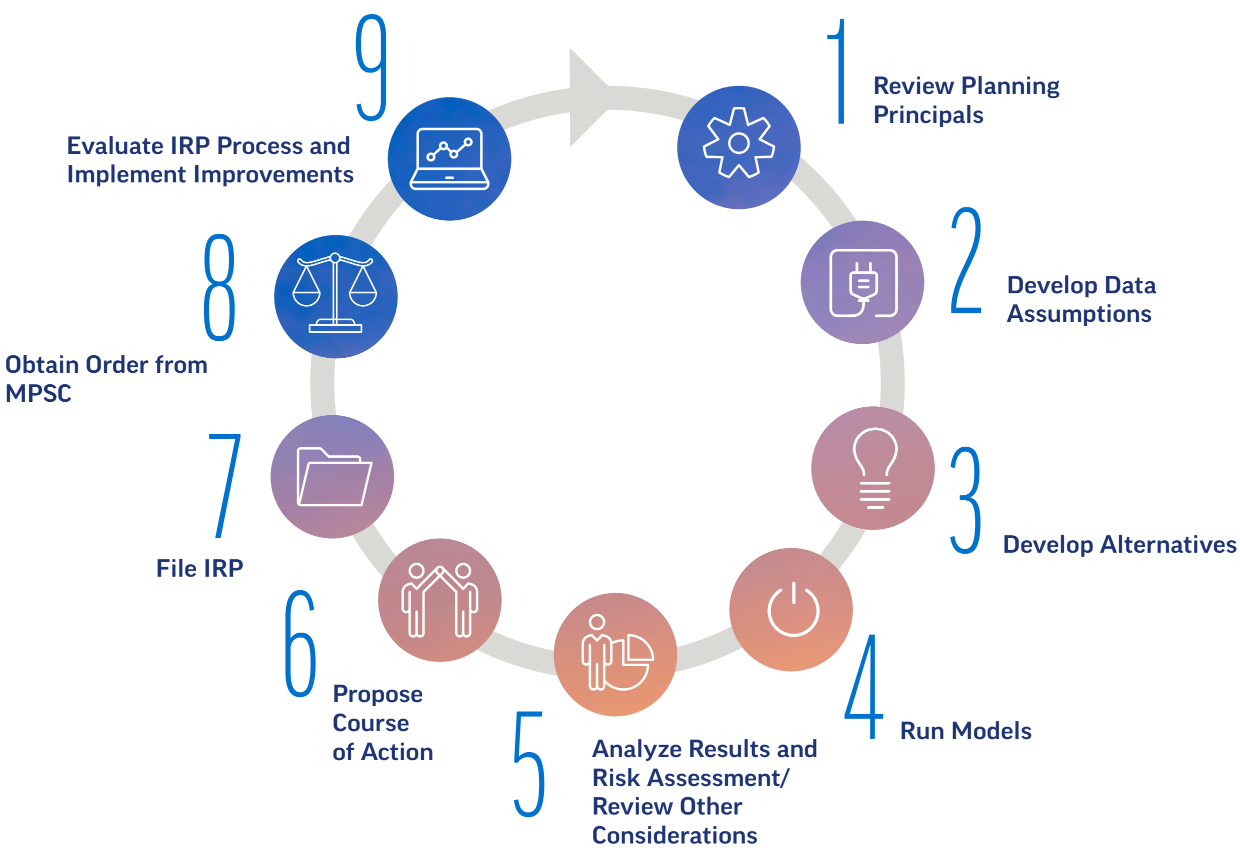
Public Act 342 of 2016 amended Public Act 295 of 2008 by increasing Michigan's Renewable Portfolio Standard from 10 percent by 2015 to 12.5 percent by 2019 and 15 percent by 2021. Public Act 342 required electric providers to file amended plans to meet the new standards within one year of its effective date; the Company filed its amended plan (Case No.: U-18232) in March 2018, demonstrating compliance with the new standards. In support of our carbon and clean energy goals, the renewable energy plans outlined in this 2019 IRP take DTEEI to renewable levels beyond those requirements.

4.6 IRP Planning Process

IRP Process

The Company's IRP process contains nine steps designed to ensure the completion of a comprehensive plan, as shown in Figure 4.6.1. Because assumptions and environmental and regulatory factors change, the integrated resource planning process must be continuous over time. Prior to filing the IRP with the MPSC, DTEE hosted four technical stakeholder workshops to share information regarding the IRP assumptions and preliminary modeling results. These workshops also provided stakeholders the opportunity to provide input into the IRP process, ask questions, and submit comments. Further details regarding stakeholder collaboration are included in Section 4.7.

FIGURE 4.6.1: IRP Planning Process



Review Planning Principles

The IRP planning principles, Figure 4.6.2, are based on the factors the Company has historically used in making resource decisions and were formally documented when the Company was developing the 2017 IRP.

As shown in the first step, before any modeling or analysis was undertaken, the Company reviewed the seven planning principles that would be used to ensure the IRP was appropriately balanced.

FIGURE 4.6.2: Planning Principles

Reliability	Each plan analyzed is required to meet the reliability planning requirements established by MISO and to encompass our desire to maintain a reliable fleet in the face of aging coal units.
Affordability	Affordability is measured by the yearly impacts to the revenue requirement.
Clean	Environmental sustainability, low carbon aspirations, and clean-energy goals are major factors in the determination of the recommended resource portfolio.
Flexible and Balanced	The resource plan needs to be flexible, having the ability to adapt to unforeseen changes int he market. Additionally, it must have a well balanced mix of resources so that it is not heavily reliant on the market or one source of generation.
Compliant	All resource plans are modeled to be compliant with the IRP filing requirements as well as with environmental regulations.
Reasonable Risk	The Company desires a portfolio that minimizes risks related to commodity and market pricing, fuel availability, grid reliability, capacity constraints, operations and evolving regulations.
Community Impact	The Company considers the aspects of employment, tax base, and other community impacts.

Develop Data Assumptions

After reviewing the planning principles, a broad set of scenarios and sensitivities were developed. Scenarios were made up of driving forces that shape and define different paths to the future. They contain key uncertainties that are critical components to help construct and differentiate among the scenarios. These are generally broad market assumptions that affect the entire country, such as commodity prices, technology costs, national load growth, and environmental regulations. As described previously, the MPSC developed the market assumptions for the three required scenarios (Business as Usual, Emerging Technology, and Environmental Policy) and the Company utilized some of its own assumptions in the Reference scenario.

Sensitivities, considered smaller changes from a modeling perspective, are specific variables that affect only the DTEE service territory and/or Michigan. Examples of sensitivities are changes in load, energy waste reduction, and fuel costs.

Develop Alternatives

To develop a reasonable and prudent plan, it was important to consider all feasible resource options to meet customer demand. The IRP process evaluated a multitude of alternative technologies including natural-gas units, coal units, nuclear units, renewable generation, and demand-side management resources.

FIGURE 4.6.3: Resource Screen Methodology

Preliminary Economic Analysis

- Resources screened on technical feasibility, practicality, and geographic limitations
- Options were narrowed based on economics
- Similar technologies were compared on a levelized cost of energy basis

Market Valuation

- An additional level of economic analysis was conducted that evaluated the benefit/cost ratio for each option against the market

Modeling

- Strategist® was then used to optimize the technologies and develop a series of build plans containing a combination of least-cost alternative
- Strategist® computed a revenue requirement for each build plan
- Modeling results were analyzed for each scenario and sensitivity

PCA

- Components from least-cost build plans from each scenario and sensitivity were considered for inclusion in the PCA
- Planning principles were applied
- Risk analyses were completed

Run Models / Analyze Results / Develop Proposed Course of Action

DTEE used various modeling methodologies as the IRP process progressed to refine the demand-side and supply-side technologies considered as options in the PCA. The evaluations ranged from simplistic economic screenings to increasingly complex analyses. The methods for screening and evaluating technology options are shown in Figure 4.6.3. Upon completing the layers of analysis, reviewing the modeling outputs, risk analysis, and planning principles, DTEE developed a proposed course of action.

File IRP / Regulatory Case Proceeding

The Company then filed an application and supporting testimony requesting MPSC approval of its IRP. Per Section 6t of Public Act 341, the MPSC will conduct a contested case proceeding in which an order shall be issued within 300 days (at most 360 days) of the date of filing.

Evaluate Process and Implement Improvements

DTEE strives to continuously improve all aspects of its work. After filing the IRP and receiving an order from the MPSC, we will spend time reviewing our processes to identify opportunities for improvement. Those improvement opportunities will then be implemented into the process for future IRPs.

4.7 Stakeholder Involvement in the IRP

Overview

Key to the IRP process was gaining input from our stakeholders and incorporating their feedback. DTEE reached out to individuals and organizations who have had involvement in our regulatory cases in the past, had expressed interest in having input into our process, or who might be impacted by the Company's plan, in order to create awareness of the IRP process and to encourage honest communication. The intent was to implement a comprehensive, transparent, and participatory stakeholder-engagement process.

Key to the IRP process was gaining input from our stakeholders and incorporating their feedback.

DTEE hosted four technical workshops for stakeholders expected to be involved in the IRP's technical aspects and regulatory processes, and three public open houses to serve customers and the general public. DTEE provided stakeholders with various opportunities to share their ideas on how to meet Michigan's future energy and capacity needs, including reviewing and commenting on IRP inputs, sensitivities and technology options. In addition, DTEE created a dedicated IRP email account for electronic comment submissions.

All public meetings were held in DTEE's service territory, with notice, including publishing full details on the Empowering Michigan website. The public meetings were held after normal business hours to ensure accessibility for members of the public. Invitees included the public in our service territory and other stakeholders including expected intervenors and MPSC staff.

Technical Workshops

DTEE hosted four technical workshops in various locations, as shown in Table 4.7.1, for technical stakeholders, who regularly participate in our regulatory filings. The technical presentations included:

- The IRP process's steps and timeline
- The assumptions, scenarios and sensitivities that would be analyzed to develop our plan
- Review of IRP models and how to interpret results
- The sharing of modeling results across a broad range of futures

TABLE 4.7.1: Technical Workshop Time and Location Details

Meeting	Date	Location	Time
Technical Workshop #1	June 11, 2018	Bad Axe, MI	1:00-4:00 pm
Technical Workshop #2	September 27, 2018	Detroit, MI	1:00-4:00 pm
Technical Workshop #3	November 12, 2018	Conference Call	1:00-2:00 pm
Technical Workshop #4	January 31, 2019	Conference Call/ Detroit, MI	1:00-3:30 pm

A total of 125 stakeholders attended the four technical workshops.

The Company invited participants to these workshops based on the parties that were granted intervention in the Company's last electric rate case and certificate of necessity case. A total of 125 stakeholders attended the four technical workshops. Participants included staff from MPSC and the Michigan Department of Environmental Quality, environmental organizations, ITC, special interest groups and DTEE employees.

DTEE notified technical stakeholders in advance of the workshops via email and sent participants the workshop presentation ahead of the meeting. Stakeholders were provided the opportunity to ask questions, and DTEE subject-matter experts were present to answer the questions. Comments were collected and questions and answers were documented and sent to stakeholders following the meeting.

DTEE encouraged stakeholders to submit technology options for consideration and invited each organization to submit a sensitivity. Four sensitivities were provided to the Company for modeling. The sensitivities were analyzed, and selected results were provided to stakeholders at the January technical workshop. Full results are provided in Section 15.

The workshop format allowed participants to hear questions from others and obtain answers from DTEE subject matter experts at the same time, which created consistency in sharing information, open dialogue and exchange of ideas.

Public Open Houses

DTEE hosted three public open houses for customers, the community, and other stakeholders to discuss the company's IRP process, as well as other DTEE topics of community interest. The open houses provided the public and DTEE an opportunity to have open dialogue, ask questions and obtain feedback. Registration was not required and the events were open to all interested parties. Each open house included eight booths where the public could learn about the various areas within the Company. A bilingual booth was available at the third open house based upon feedback from the previous open houses. An IRP landing page on our blog site was created to provide open house documents.

TABLE 4.7.3: Public Open House Times and Locations

Meeting	Date	Location	Time
Open House #1	July 26, 2018	Wayne County Community College Downriver Campus, Taylor MI	4:00 -7:00 pm
Open House #2	August 16, 2018	Schoolcraft Community College, Livonia, MI	4:00 -7:00 pm
Open House #3	October 23, 2018	Wayne County Community Downtown District, Detroit MI	4:00 -7:00 pm
Blue Water Energy Center Community Open House	September 25, 2018	Marine City High School, Marine City MI	4:00 - 8:00 pm

The open houses were publicized through:

- Social media
- DTEE newsroom postings
- DTEE internal news
- Emailing stakeholders in advance of the events

A total of 132 registered stakeholders attended the three public open houses. Participants included customers, community members, staff from the MPSC and the Michigan Department of Environmental Quality, environmental organizations, and special interest groups. Attendees could talk to subject-matter experts one-on-one. DTEE staff worked to understand stakeholders' concerns for the environment and assure them that we are focused on providing safe, clean, reliable energy to our customers as we work through this time of transitioning our generation fleet.

Stakeholders left feedback on comment cards. In addition to the three IRP public open houses, a Blue Water Energy Center open house was held near the site of the project for the local community to learn about the project. The stakeholder comments and questions from both the technical workshops and the public open houses were reviewed, and informed the Company's analysis and determination of components in the PCA, including higher levels of renewables and energy waste reduction.

Additional Stakeholder Communications

In addition to the IRP technical workshops and public open houses, DTEE conducted several meetings with the MPSC staff to review IRP sensitivities, modeling process and considerations, transmission considerations, updates from the energy waste reduction potential study, and long-term forecasting assumptions.

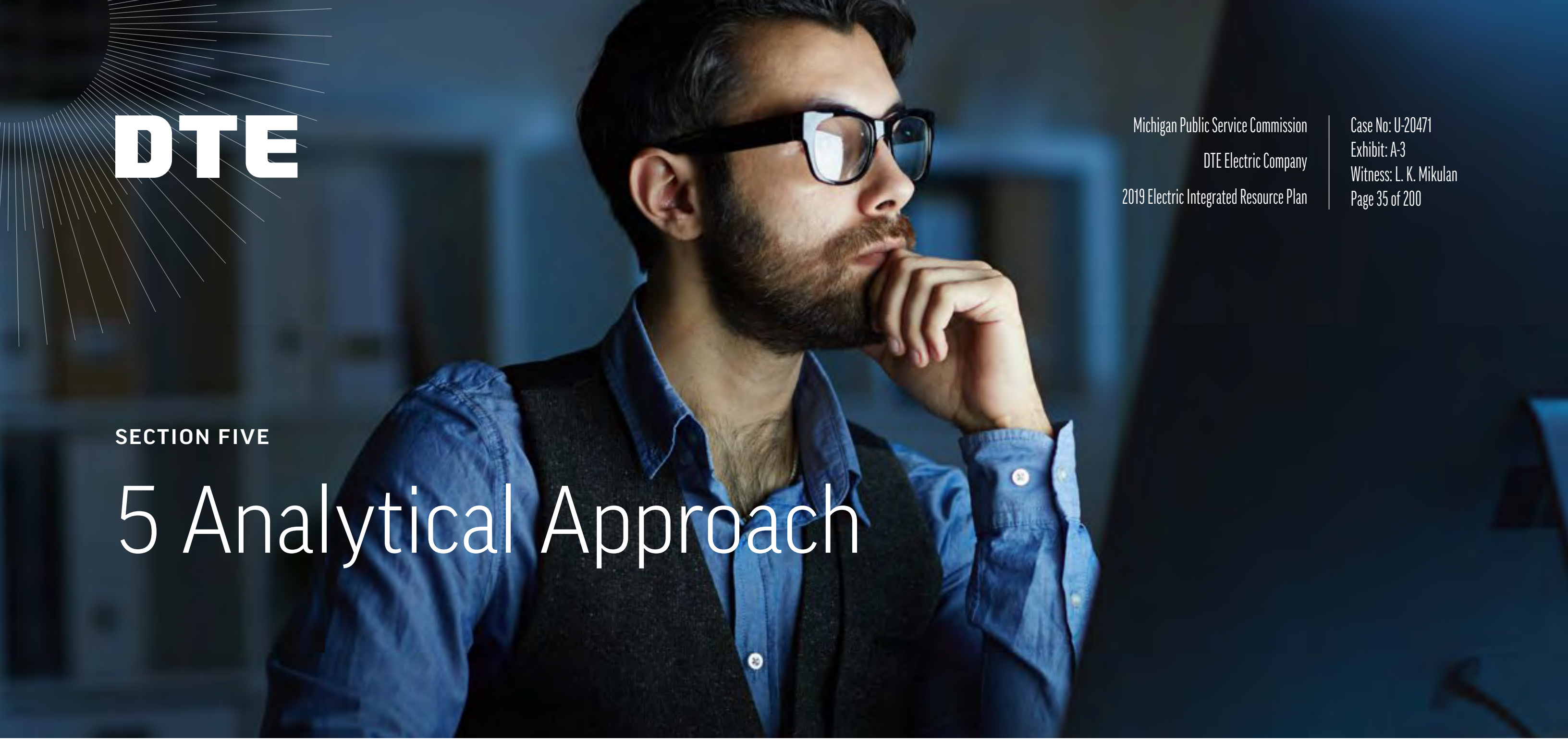
The Company also met with ITC to review IRP filing requirements, review ITC's transmission study scope and assumptions, and discuss modelling results of various scenarios under the study scope. DTEE also engaged MISO to review technical workshop presentations and communicated to MISO regarding our collaboration with ITC on this IRP filing.

DTEE has communicated about key aspects of the IRP with communities, employees, stakeholder organizations, investors, and local, state and federal leaders.

Conclusion

DTEE spent a great deal of time on the IRP outreach process in order to be transparent, obtain participation, gain feedback, and have open dialogue with our stakeholders. We appreciate the participation and feedback that was provided and the engagement from our technical and public stakeholders. It was beneficial to hear stakeholder inputs and concerns about Michigan's energy future as we developed our IRP and the PCA.

DTEE has communicated about key aspects of the IRP with communities, employees, stakeholder organizations, investors, and local, state and federal leaders.



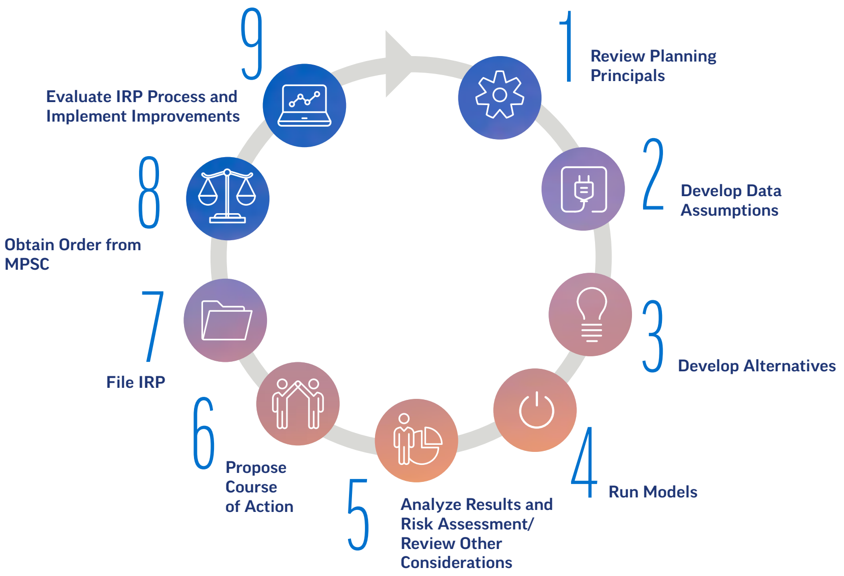
SECTION FIVE

5 Analytical Approach

5.1 Overview

Developing the IRP was a detailed, multi-step process that involved many subject matter experts both internal and external to DTEE. The IRP continuous process wheel, Figure 5.1.1, shows the analytical approach to developing, running, and analyzing the models. Steps two through five provide the modeling steps that were utilized to obtain the proposed course of action.

FIGURE 5.1.1: IRP Continuous Process Wheel



5.2 Modeling process

The modeling process started with determining the data assumptions and developing alternative technologies, which are steps two and three on the IRP continuous process wheel. The data assumptions were gathered utilizing several of the Company's subject matter experts (SMEs) as well as PACE Global, a consulting company. In addition, as discussed in Section 4.7, the Company shared data assumptions with and offered opportunities to IRP stakeholders to provide input. DTEE SMEs provided a range of data assumptions including load forecast, near-term fuel forecast, renewables plan, energy waste reduction level and cost sensitivities, demand response, and goals.

To satisfy the modeling requirements put forward in MPSC Case No. U-18418, the SMEs drew upon public data when available, and used industry expertise to develop assumptions that were unique to DTEE. PACE provided data assumptions that included long-term fuel prices[1], market prices, capacity prices, and emission prices. PACE determined these data assumptions by modeling a national footprint. The data assumptions changed depending on the scenario. Four scenarios were run, including three required by the Michigan Integrated Resource Planning Parameters, section 6t of 2016 PA 341, and one scenario developed by DTEE, as well as several sensitivities.

In step three of the IRP process, alternative technologies were developed which could potentially fill the Company's energy or capacity needs and meet customer demand.. The IRP process evaluated a multitude of technologies, including natural-gas units, coal units, nuclear units, renewable generation, and demand-side management resources. These were called "alternatives." Each alternative's costs and operating parameters were inputs to the analysis. The Company used technology-cost and operating data from publicly available data from a variety of sources (see Exhibit A-4, Appendix B). The alternatives were then sent through a screening process to limit the number of possible choices in the modeling programs. (Too many alternatives can significantly slow the modeling program down or even make the optimization unsolvable.) Once the data assumptions and alternative technologies were determined, they were then built into the modeling programs.

Step four in the IRP process was running the model. The IRP optimization modeling utilized the Strategist® program, an energy-market simulation that calculates the net present value revenue requirement for multiple plans that meet customers' forecasted energy and capacity demand. In this IRP, modeling runs start in 2018 and run through 2040. All scenarios and sensitivities, except for retirement of Tier 2 assets, were run through Strategist® to develop the least-cost build plans.

In the Tier 2 retirement analysis, short-term capacity purchases were assumed to replace the retired coal unit's energy and capacity. The analyses were run in both the PROMOD® and internal revenue requirement models because only one year of energy and capacity purchases is needed to replace the generation, prior to the start-up of its long-term

2 Develop Data Assumptions

3 Develop Alternatives

4 Run Models

5 Analyze Results and Risk Assessment/ Review Other Considerations

1 With respect to the gas price forecasts, PACE developed the long-term gas price forecast in the Reference scenario. The other three scenarios used the publicly available 2018 EIA long term gas price forecast.

replacement, the Blue Water Energy Center. PROMOD® is an hourly dispatch model that simulates the energy market. The revenue requirement model was used to represent the Company's financial structure and treatment of capital investments. The output of PROMOD® was put into the revenue requirement model.

Step five of the IRP process analyzed results of the completed Strategist® optimization model runs. Once the least-cost plans were generated for each scenario and sensitivity combination, they were reviewed with respect to the planning principles. A proposed course of action (PCA) was developed in step six of the IRP process by synthesizing the results of each least-cost plan output in conjunction with the Company's planning principles. (Development of the PCA is discussed in more detail in Section 16.) After the PCA was determined, the PROMOD® model was used to model the PCA across the four scenarios and operating characteristics, including capacity factors, fuel prices, rate impacts, and emissions.

In addition to scenario and sensitivity analysis DTEE employed multiple risk assessment methodologies

5.3 Risk Assessment Methodology

Two types of risk need to be evaluated in an IRP: the quantifiable financial risks that could be computed using various analytical methods, and the non-financial aspects of the PCA that may not be easily quantifiable. When the DTEE planning principles were considered as part of risk assessment, affordability fell under financial risk, while the other six principles of reliability, flexible and balanced, clean, reasonable risk, compliant, and community impact fell into the non-financial evaluation of risk. Some of these risks could potentially be mitigated by a solution that has a cost, such as building a new transmission line to reduce reliability risk. However, most of the risks identified were more abstract, making it difficult to assign a financial impact. Therefore, the Company employed both quantitative analysis of the financial risks in the form of stochastic analysis and scenario and sensitivity analyses, and evaluation of the non-financial aspects of risk using change analysis and evaluation of relevant plans' planning principles. The evaluation of IRP inputs that may have changed since initial adoption in the IRP process addresses both categories. Each of the risk assessment methodologies are described below, while results from the risk assessment methodologies are included in Section 15.

Risk Analysis Method 1: Stochastic Risk Assessment

A stochastic analysis is an advanced modeling technique that uses probability distributions of key assumptions to evaluate portfolios. Pace Global utilized the Aurora model to generate 200 different draws from the key drivers' probability distributions. The portfolio's average present value was determined. The economic risk, which represented the risk of having a high-cost portfolio, was calculated by taking the average cost of the highest 10 percent of the draws for each resource plan. The stochastic analysis's goal was to minimize both the average portfolio cost and the economic risk. The key drivers were characterized as probability distribution functions using a combination of historical measures of volatility, market correlations, and expected future relationships between the assumptions. In our stochastic modeling, load growth; natural gas and coal prices; the price of carbon used for analytic purposes; and the cost of generating technologies all were evaluated with probability distributions. More details are shown in Section 15.8.

Risk Analysis Method 2: Change Analysis

Many factors will change between the filing of this IRP in 2019 and 2030, when the first year of capacity need is expected. The change analysis examined the factors that could change between now and the next IRP filing, currently expected in 2025. The change analysis specifically addressed the flexible aspect of the 2019 IRP PCA from 2025 through 2030, ensuring that the PCA was robust across a range of potential futures. The change analysis looked at a list of outcomes, or "situations," that could arise from different drivers, or "causations." Each situation presents a likely adaptation of the PCA. The PCA has the flexibility to adapt to and accommodate the constant development of situations. The change analysis covered situations from multiple categories such as fuel, environmental, load, future technology development and evolution, and transmission. The change analysis's results are shown in Section 15.9.

Risk Analysis Method 3: Application of Planning Principles

The application of planning principles is a comparative qualitative analysis method that was used to rank plans by individual planning principles. In our analysis, 12 plans were analyzed and assigned rankings for five of the seven planning principles: reliability, clean, flexible and balanced, reasonable risk, and community impact. The plans were not ranked based on affordability, as each plan was identified as a "least-cost" plan, and the plans were not ranked on compliance, as each plan was compliant with current regulations.

Risk Analysis Method 4: Evaluation of key IRP Inputs

The IRP inputs (e.g. capital costs, market prices, fuel price forecasts, etc.) were adopted in May through August of 2018 before the optimization models were built. Before the filing, in February 2019, most of the inputs were considered again to see if they had changed materially since the initial adoption. If the inputs had materially changed, then a decision was made whether to update the modeling with the latest values. This process is described in detail in section 15.5.11.

Risk Analysis Method 5: Scenario and Sensitivity Analysis

Scenario and sensitivity analysis is a method of risk assessment. This is covered at length in section 6, with results provided in Section 15.1 through 15.5.

SECTION SIX

6 IRP Scenario & Sensitivities

6.1 Scenarios

Scenarios are made up of driving forces that shape and define different paths to the future. They contain key uncertainties that are critical to help construct and differentiate among them. These are generally broad market assumptions that affect the entire country, such as commodity prices, technology costs, national load growth, and environmental regulations. While scenarios help us to frame a particular future, the true future still remains uncertain and difficult to predict. The Michigan Integrated Resource Planning Parameters, section 6(t) of 2016 PA 341, provided three required scenarios, all of which utilize the 2018 EIA gas-price forecast: Business as Usual (BAU), Emerging Technologies (ET) and Environmental Policy (EP). DTEE developed an additional scenario, Reference, that incorporates DTEE's viewpoint of the future based on research and forecasts. Exploring these four scenarios, incorporated with numerous sensitivities, ensures that the resulting DTEE 2019 IRP provides the optimal solutions to DTEE's future demands for electricity in a range of potential futures.

All alternative technology costs for the scenarios were taken from publicly available sources. In each scenario, specific new units were modeled with their associated expected operating parameters (rather than using public sources) if already under construction or if the specific unit had received regulatory approval consistent with guidelines established in the Michigan Integrated Resource Planning Parameters, section 6(t) of 2016 PA 341. In terms of unit-retirement assumptions, the starting point for each scenario used DTEE's announced Tier 2 coal-retirement plan as of summer 2018 when the IRP modeling began. The starting point for renewable energy builds, energy waste reduction, and demand response levels across all scenarios is described in sections 8 and 9. Finally, in each scenario the starting point assumed renewal of all existing Public Utility Regulatory Policies Act of 1978 (PURPA) contracts.

Reference: This scenario most closely matches our internal planning assumptions, forecasts and goals/aspirations. It utilized DTEE's gas forecast and incorporated DTEE's CO_2 and clean-energy goals as a starting point. It includes a CO_2 price starting at approximately $5 per ton in 2025 continuing up to $15 per ton in 2040.

Business as Usual: Thermal and nuclear generation retirements in the modeling footprint were driven by a maximum-age assumption, public announcements, or economics. Demand and energy remained at low growth rates. The BAU gas forecast was based on the 2018 Annual Energy Outlook from the U. S. Energy Information Administration, "Natural Gas: Henry Hub Spot Price: Reference Case." (2018 EIA gas forecast). No CO_2 price was applied.

Emerging Technology: This scenario assumed that technological advancements and economies of scale result in a 35 percent reduction in capital costs for demand response, energy waste reduction, storage, and solar, plus an assumed 17.5 percent reduction in capital costs for wind. Retirements of all coal units except the most efficient were considered. The 2018 EIA gas forecast was used for this scenario. No CO_2 price was applied.

Environmental Policy: This scenario assumed tighter carbon regulation by targeting a 30 percent CO_2 reduction by 2030. Coal units were retired based first on carbon emissions, then economics. The wind and solar capital costs were assumed to decline by 35 percent. All other technologies costs were unchanged from the BAU scenario. The 2018 EIA gas forecast was used, as well as no CO_2 price, to achieve the specified 30 percent CO_2 reduction.

All alternative technology costs for the scenarios were taken from publicly available sources.

TABLE 6.1.1 - Scenarios and Sensitivities

Scenarios	Reference (REF)	Business as Usual (BAU)	Emerging Technology (ET)	Environmental Policy (EP)
Description	Utilizes DTEE's forecast on fuel costs. Assumes current retirement schedule and Company's environmental goals.	Utilizes 2018 EIA as gas forecast and no CO_2 price. Existing fleet is largely unchanged.	Same as BAU but utilizes optimistic views on capital costs of wind decreasing by 17.5 percent and solar and storage decreasing by 35 percent.	Same as BAU, but utilizes optimistic views on capital costs of wind and solar decreasing by 35 percent.
CO_2 Assumption	CO_2 price based on DTEE CO_2 goals. $5/ton starting in 2025.	No CO_2 price applied	No CO_2 price applied	No CO_2 price applied
Gas Prices	Utilizes DTEE fuel forecast and transitions to PACE forecast.	Utilizes DTEE fuel forecast and transitions to 2018 EIA gas-price forecast	Same as BAU	Same as BAU
Capital Costs	Public sources	Public sources	Public sources, but decrease wind by 17.5 percent and solar, storage, EWR, and DR by 35 percent	Public sources, but decrease renewables by 35 percent.
EWR Cost Assumptions	Tiered costs	Flat high; consistent with Potential Study	Flat low; capital costs are dropped by 35 percent from the Potential Study	Flat high; consistent with Potential Study
Renewables	50 percent clean energy goal (renewable and EWR)	35 percent clean energy goal (renewable and EWR)	35 percent clean energy goal (renewable and EWR)	35 percent clean energy goal (renewable and EWR)

Because each scenario has different market assumptions, the resulting forecast for energy and capacity prices varies. Described below is the methodology utilized to determine the energy and capacity-price forecasts associated with each scenario.

TABLE 6.1.2: Annual Energy Price Forecasts ($/MWH)

Year	Source of Forecast	REF	BAU (ET and EP similar)	High Gas BAU (high gas ET and EP similar)
2018	Forwards	29.68	29.68	29.68
2019	Forwards	29.46	29.46	29.46
2020	Transition	29.30	29.86	30.89
2021	Transition	31.28	34.04	37.41
2022	Transition	35.73	39.94	47.13
2023	PACE	38.99	44.19	54.68
2024	PACE	40.97	46.17	58.17
2025	PACE	46.29	47.79	60.88
2026	PACE	47.46	48.63	64.02
2027	PACE	47.23	49.84	66.44
2028	PACE	48.07	51.19	68.42
2029	PACE	48.56	52.98	71.18
2030	PACE	50.86	55.55	76.73
2031	PACE	52.61	58.09	83.20
2032	PACE	54.93	60.97	87.81
2033	PACE	56.77	62.43	92.31
2034	PACE	58.98	64.50	96.28
2035	PACE	61.26	67.02	101.14
2036	PACE	63.06	68.72	105.02
2037	PACE	65.25	70.45	109.98
2038	PACE	66.55	72.98	115.11
2039	PACE	68.09	75.39	119.32
2040[1]	PACE	104.69	118.41	185.44

1 The projected increase in modeled energy prices in 2040 is caused by the planned retirement of a significant amount of baseload coal resources by both DTEE and Consumers Energy.

Energy Price

Energy prices were determined by using energy price forwards for 2018 and 2019, and long-term fundamental data derived from PACE for 2023 and beyond, with a transition period in 2020-2022. The forwards are a short-range outlook that represents what is happening in markets today and for two to three years into the future. Energy price fundamental forecasts typically take a longer-term view and are more representative of what is forecasted to happen in the mid-to-long term (2023-2040). PACE bases the long-range fundamental forecast market prices on projected gas prices and changes in the generation fleet in various regions, based on economics and forecasted regulations for each scenario.

The forwards are the same for each scenario, but each has a separate set of long-term fundamental data. In all scenarios, years 2018 and 2019 utilize the market forwards. To shift smoothly from the 2019 forwards to the 2023 PACE long term data, a three-year transition is used for years 2020-2022. That 36-month period was adjusted each month by performing a 36-increment interpolation between the forwards for each month and the PACE long-term 2023 monthly forecast. On-peak, off-peak, and around-the-clock monthly locational marginal prices were determined using the 36-increment method. The resulting prices on an annual basis are shown in Table 6.1.2.

TABLE 6.1.3: Capacity-Price Forecasts ($/kW)

Year	REF	BAU	BAU High Gas	ET	ET High Gas	EP	EP High Gas	REF High CO2
2018	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
2019	50.6	52.2	52.6	52.7	52.9	50.6	52.9	45.1
2020	52.7	55.1	56.3	55.7	55.2	54.3	55.2	46.6
2021	51.0	53.5	53.3	54.0	1.7	1.7	1.7	1.4
2022	56.3	58.3	58.1	59.1	58.9	59.0	58.7	48.9
2023	58.0	59.4	59.1	60.3	60.0	60.1	59.8	49.6
2024	1.8	1.8	1.8	2.9	1.8	15.8	1.8	1.6
2025	1.8	1.8	1.8	7.8	1.9	20.7	1.9	13.8
2026	14.8	2.5	1.8	8.5	1.9	18.8	1.9	23.8
2027	17.1	2.9	1.9	4.8	1.9	11.4	1.9	33.4
2028	19.2	6.9	1.9	1.9	1.9	5.7	1.9	34.3
2029	25.3	12.2	1.9	7.4	2.0	8.5	1.9	36.9
2030	35.4	19.8	1.9	15.3	2.0	9.5	2.0	41.4
2031	43.2	30.3	1.9	21.0	2.0	6.4	2.0	50.2
2032	43.5	29.7	2.0	12.7	2.0	2.0	2.0	49.6
2033	48.8	27.7	2.0	12.2	2.1	2.0	2.0	48.1
2034	52.8	37.8	2.0	16.5	2.1	2.1	2.1	54.3
2035	58.0	47.9	2.0	27.1	2.1	2.1	2.1	57.3
2036	60.0	49.3	2.0	19.1	2.2	2.1	2.1	55.7
2037	62.3	53.3	2.1	21.0	2.2	2.1	2.1	55.8
2038	64.1	55.9	2.1	18.9	2.2	2.1	2.2	59.6
2039	68.2	61.9	2.1	24.7	2.2	2.2	2.2	60.8
2040	72.5	73.3	70.7	74.9	75.7	73.0	74.1	70.8

Capacity Prices

PACE calculated the capacity-price forecast as part of the fundamental modeling for each scenario, or high-gas and high-CO2 market sensitivity. In the IRP optimization modeling, no credit was given when excess capacity was available to theoretically sell into the market. For more details, please see Appendix F, Exhibit A-4. Table 6.1.3 represents nominal $/kW capacity prices.

6.2 Sensitivities

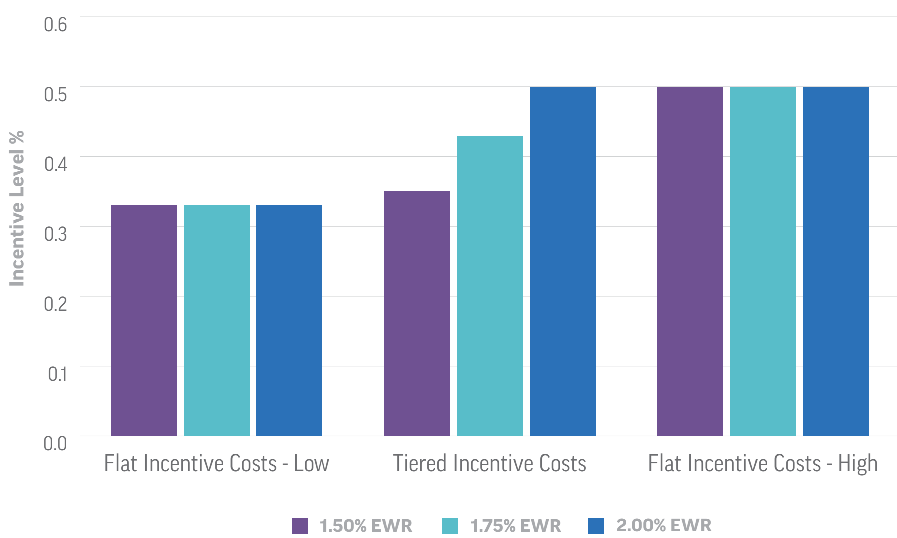
Sensitivities, as compared to scenarios, are generally designed to test one specific uncertainty. The Michigan Integrated Resource Planning Parameters, section 6t of 2016 PA 341, provided several required sensitivities. Each scenario has a starting point with no sensitivities applied. Then, each sensitivity was applied to the appropriate scenarios. A sensitivity typically changes one variable from the starting point. The sensitivities are described below.

Load: The starting point was the DTEE forecasted load. The load sensitivities included high-growth, 50 percent Electric Choice return by 2023, 100 percent Electric Choice return by 2023, and high electrical vehicle penetration assumption. The high-growth sensitivity assumed a 1.5 percent increase in the annual growth rate for energy and demand. The 50 and 100 percent choice return sensitivities assumed customers returned to DTEE, effectively increasing our load. The high electric vehicle penetrations assumed a large number of electric vehicles in our territory, which would increase our load.

Energy Waste Reduction: Several levels of energy waste reduction were tested as sensitivities. The starting point assumption was 1.5 percent EWR, with sensitivities increasing to 1.75 percent, 2.0 percent, 2.25 percent and 2.5 percent.

EWR Cost Levels: In the REF scenario, EWR costs were assumed to be tiered such that the 1.5 percent EWR sensitivity used historical costs that reflected incentives equal to 35 percent of the cost of the EWR measure. The 2 percent EWR sensitivity assumed incentives of 50 percent, consistent with the state-wide potential study. The 1.75 percent sensitivity assumed incentives of 42.5 percent, which is mid-way between the 1.5 percent and 2.0 percent sensitivities. These, collectively, are the tiered EWR incentive costs. The EP and the BAU scenarios assumed that incentives were offered at 50 percent of the measure cost, consistent with the Potential Study and regardless of what level of EWR was targeted. These are the flat-high EWR incentive costs. Finally, the ET scenario assumed a 35 percent reduction in EWR incentive levels from the Potential Study, regardless of what level of EWR is targeted. These are the flat-low EWR incentive costs. As sensitivities, the REF scenario's tiered pricing assumptions were applied to the BAU and EP scenarios, and the Potential Study's flat-high costs were likewise run on the Reference scenario.

FIGURE 6.2.1: Comparison of EWR Cost Sensitivities



Until higher levels (>1.5%) of EWR are achieved and sustained, there is uncertainty around the incentive costs required by the market to achieve the higher levels

Gas Prices: The BAU, ET, and EP scenarios all used the 2018 EIA forecast as their starting point. A sensitivity for each of these scenarios was to increase the EIA forecast by 200 percent to determine the impact of gas prices. The Reference scenario used the DTEE forecast as its starting point, with no additional sensitivity on gas prices.

Retirement: All scenarios used the announced DTEE retirement plan as their starting point. The Tier 2 retirement analysis was performed as a sensitivity in the ET scenarios. (Results of these sensitivities are covered in Section 15.)

Demand Response: The starting point for the REF scenario assumed DTEE's current demand response plan. A demand response sensitivity was run on all scenarios that allowed for only demand response programs to fill the capacity need before 2040.

Lithium-Ion Battery: A sensitivity was performed on the ET scenario that coupled a lithium-ion battery with a solar project. It was assumed that the solar project would charge the battery locally to take advantage of the investment tax credit, even though the Strategist model follows market price signals. Additionally, both projects were assumed to be behind-the-meter generators, which would result in additional benefits above resources located in the distribution system. Those benefits included scaling up the resources to account for distribution losses and an increase in firm capacity credit realized by behind-the-meter generation (Planning Reserve Margin adjustment).

Carbon Price: The REF scenario's starting point has a $5/ton price for carbon in 2025, which reaches $14/ton in 2040 (real $). The BAU, ET and EP scenarios' starting points have a constant $0/ton carbon price across all years. There was a carbon-price sensitivity on the EP scenario to achieve 50 percent carbon reduction by 2030. This sensitivity applied a $20/ton carbon price in 2030.

Available Replacement: The BAU scenario included a sensitivity where only combustion turbines were allowed as the replacement resource.

Additional Sensitivities: Additional sensitivities were run on relevant scenarios, including the impact of market purchases, transmission and distribution, and higher or lower utility discount rates, and an all-solar sensitivity. The details and the results of all these runs are in section 15.

A diverse set of sensitivities were considered in the IRP process, spanning 12 variable categories

TABLE 6.2.2: Summary of Sensitivities Modeled

Sensitivity	REF	BAU	ET	EP
Load	High Growth High EV Penetration Electric Choice Return	High Growth Electric Choice Return	High Growth	High Growth
EWR	4 levels	4 levels	4 levels	4 levels
EWR Incentive Cost	Flat High	Tiered	Flat Low	Tiered
Gas Price		200 percent of 2018 EIA forecast	200 percent of 2018 EIA forecast	200 percent of 2018 EIA forecast
Retirement			Adjust Tier 2 early	
Demand Response	Only DR programs before 2040	Only DR programs before 2040	Only DR programs before 2040	Only DR programs before 2040
Carbon Price				$20/ton in 2030 to achieve 50 percent CO2 reduction by 2030
Available Replacement		CT only		
T&D	$7/KW avoided T&D benefit	$7/KW avoided T&D benefit	$7/KW avoided T&D benefit	$7/KW avoided T&D benefit

Sensitivity	REF	BAU	ET	EP
No Gas	First plan without a gas unit	First plan without a gas unit	First plan without a gas unit	First plan without a gas unit
All Solar	Plan with solar as only resource	Plan with solar as only resource	Plan with solar as only resource	Plan with solar as only resource
Utility Discount Rate	5% utility discount rate		9% utility discount rate	
Market Purchase	Purchase capacity from market	Purchase capacity from market	Purchase capacity from market	Purchase capacity from market
Wind Congestion			Impact of market congestion on wind economics	

6.3 Sensitivities Submitted by Stakeholders

During its first technical conference, DTEE asked its stakeholders for input on sensitivities to run. Each stakeholder group could submit one sensitivity. Six stakeholders submitted a total of four sensitivities incorporating a range of variables.

The first sensitivity, submitted by three stakeholders, included an increased CO2 price and was applied to the REF scenario. The CO2 price starts at $30/ton in 2023 and escalates in the out years.

The second sensitivity was to retire Belle River sooner than the announced dates of 2029 and 2030. Specifically, Belle River Unit 1 would be retired on Dec. 31, 2025, and Unit 2 would be retired on Dec. 31, 2026. This sensitivity was requested to be run on the REF scenario.

The third sensitivity, referred to as sensitivity N, incorporated several changes in variables as opposed to a sensitivity that changes only one variable. This sensitivity was run on the REF scenario. The inputs specified for this sensitivity are shown in Table 6.3.1.

TABLE 6.3.1: Sensitivity N Inputs

Sensitivity N	
1. Load Growth	DTEE forecast plus 24% EV sales by 2030 (Bloomberg)
2. EWR	2.0% annually through all years unless more is required to meet no. 9
3. Capital Cost	DTE CCGT cost
4. Renewable	50% clean energy goal and 35% renewables by 2030 -additional 1,300 MW of renewables
5. Gas Price	Reference
6. Retirement	DTEE plan (starting point)
7. Demand Response	Full amount from 2017 State of MI Potential Study (high case) (974 MW DR by 2030)
8. Distributed Renewables	450 MW incremental solar
9. Available Replacement	Defer second CCGT with EWR, DR, and renewables
10. Conservation Voltage Reduction	150 MW by 2028

The fourth sensitivity asked for the Electric Choice current cap to increase from 10 percent to 25 percent. This sensitivity was asked to be run on the BAU scenario.

SECTION SEVEN

7 Existing Supply-Side Resources

7.1 Overview

DTEE has a diverse fleet of generation consisting of 24/7 baseload coal and nuclear power plants, natural-gas and oil-fired peaking units, pumped storage, and wind and solar parks. In addition, DTEE has entered into several power purchase agreements, most sourced with renewable generation. The following sections provide detail on the Company's existing supply-side resources.

7.2 Fossil-Fueled Generating Units

TABLE 7.2.1: Coal-Fired Units

Generation Unit Name	Commercial Operation Date	Age (Years)	Starting Point Planned Retirement Year	Planned Remaining Life (Years)	NCF (%) 2014 - 2018	Summer Capacity Rating (MW)
Belle River Power Plant - Unit 1	1984	35	2029	10	65.3	517
Belle River Power Plant - Unit 2	1985	34	2030	11	64.4	517
Monroe Power Plant - Unit 1	1971	48	2040	21	56.3	758
Monroe Power Plant - Unit 2	1973	46	2040	21	49.4	773
Monroe Power Plant - Unit 3	1973	46	2040	21	62.1	773
Monroe Power Plant - Unit 4	1974	45	2040	21	61.6	762
River Rouge Power Plant - Unit 3	1958	61	2020	1	42.8	272
St. Clair Power Plant - Unit 1	1953	66	2022	3	48.2	151
St. Clair Power Plant - Unit 2	1953	66	2022	3	43.1	154
St. Clair Power Plant - Unit 3	1954	65	2022	3	41.3	160
St. Clair Power Plant - Unit 6	1961	58	2022	3	35.2	311
St. Clair Power Plant - Unit 7	1969	50	2023	4	32.2	440
Trenton Channel Power Plant - Unit 9	1968	51	2023	4	40.3	495

Belle River Power Plant sits near the St. Clair River in both East China Township and China Township, Mich.. DTEE co-owns the plant with the Michigan Public Power Authority (MPPA), a consortium of 18 municipalities that aggregate together to provide for the electrical needs of their customers. Belle River is a two-unit plant; Unit 1 was placed into service in 1984 and Unit 2 began commercial operations in 1985. MPPA has an ownership position equal to 18.61 percent of the plant and so is entitled to 18.61 percent of the total plant electrical capacity and energy output and pays 18.61 percent of all costs. Each unit has a DTEE-owned net demonstrated capacity rating of 517 MW. The 2014-2018 average capacity factor for Unit 1 was 65 percent and for Unit 2 was 64 percent. Both units are coal-fired and utilize low-sulfur western (LSW) coal as their primary fuel source. Fuel oil is also utilized for unit startup and can be utilized as a supplemental fuel source during peak load conditions. The units are equipped with multiple emission-control technologies, including low NOX burners, over-fire air (OFA) systems, electrostatic precipitators (ESPs), dry sorbent injection (DSI), and activated carbon injection (ACI).

Monroe Power Plant is in the city of Monroe, Mich., along Lake Erie. It is a four-unit, supercritical coal-fired steam plant whose units were sequentially placed into service between 1971 and 1974. Unit net demonstrated capacity ratings for Units 1-4 are 758 MW, 773 MW, 773 MW, and 762 MW, respectively. The 2014-2018 average capacity factor for Unit 1 was 56 percent, for Unit 2 was 49 percent, for Unit 3 was 62 percent, and for Unit 4 was 62 percent. The units utilize coal as their primary fuel source, while also utilizing fuel oil for unit startup and as a supplemental fuel source during peak load conditions. Monroe blends various coal types based on electrical and fuel-market pricing dynamics. The units are equipped with multiple emission-control technologies, including low NOx burners, OFA systems, ESPs, flue gas desulphurization (FGD) scrubbers, and selective catalytic reduction.

River Rouge Power Plant is in the city of River Rouge, Mich., along the Detroit River. River Rouge Unit 2 was retired in 2016. River Rouge Unit 3, commissioned in 1958, has a net demonstrated capacity rating of 272 MW, utilizing coal as its primary fuel source and low-cost blast furnace gas and coke oven gas as additional fuel sources to the limit of their availability. Natural gas is also utilized as a fuel source for unit startup and as a supplemental fuel source during peak load conditions. River Rouge uses primarily LSW but also blends other coal types based on electricity and fuel market pricing dynamics. The unit is equipped with multiple emission-control technologies, including low NOx burners, OFA, ESPs, DSI, and ACI systems.

St. Clair Power Plant is in East China Township, Mich., along the St. Clair River. It is a five-unit, coal-fired steam plant. St. Clair Units 1-3 began service in 1953–1954, Unit

6 began commercial service in 1961, and Unit 7 began commercial service in 1969. The net demonstrated capacity ratings for Units 1-3, 6, and 7 are 151 MW, 154 MW, 160 MW, 311 MW, and 440 MW, respectively. St. Clair Unit 4 was retired in 2017 and St Clair Unit 5 was retired in 1979. The 2014-2018 average capacity factor for Unit 1 was 48 percent, for Unit 2 was 43 percent, for Unit 3 was 41 percent, for Unit 6 was 35 percent, and for Unit 7 was 32 percent. St. Clair utilizes coal as its primary fuel source. Fuel oil or natural gas is also utilized as fuel sources for unit startup and as supplemental fuel sources during peak load conditions on specific units. St. Clair uses primarily LSW but also blends other coal types based on electricity and fuel market pricing dynamics. The units are equipped with multiple emission-control technologies, including low NOX burners, OFA, ESPs, DSI, and ACI systems.

Trenton Channel Power Plant is in the city of Trenton, Mich., along the Detroit River. Trenton Channel Unit 9, which remains in service, was commissioned in 1968. The unit's net demonstrated capacity rating is 495 MW, and its 2014-2018 average capacity factor was 40 percent. Trenton Channel Unit 9 utilizes coal as its primary fuel source. Fuel oil is also utilized as a fuel source for unit startup and as a supplemental fuel source during peak load conditions. Trenton Channel uses primarily LSW but also blends other coal types based on electricity and fuel market pricing dynamics. The unit is equipped with multiple emission-control technologies, including low NOX burners, OFA, ESPs, DSI, and ACI systems.

DTEE owns both oil- and gas-fired peaking plants, which are shown in Tables 7.2.2 and 7.2.3 below.

TABLE 7.2.2: Oil Fired Peaking Units

Generation Unit Name	Fuel	Commercial Operation Date	Age (Years)	Number of Units	Summer Capacity Rating (MW)
Belle River Power Plant Peaker 11-1 / 11-5	Oil	1981	38	5	14
Colfax Peaker 11-1 / 11-5	Oil	1969	50	5	14
Enrico Fermi Power Plant - Peaker 11-1	Oil	1966	53	1	13
Enrico Fermi Power Plant - Peaker 11-2	Oil	1966	53	1	13
Enrico Fermi Power Plant - Peaker 11-3	Oil	1966	53	1	13
Enrico Fermi Power Plant - Peaker 11-4	Oil	1966	53	1	12
Monroe Power Plant - Peaker 11-1 / 11-5	Oil	1969	50	5	14
Northeast Peaker 13-1	Oil	1971	48	1	19
Northeast Peaker 13-2	Oil	1971	48	1	20
Oliver Peaker 11-1 / 11-5	Oil	1970	49	5	14
Placid Peaker 11-1 / 11-5	Oil	1970	49	5	14
River Rouge Power Plant Peaker 11-1 / 11-4	Oil	1967	52	4	11
Slocum Peaker 11-1 / 11-5	Oil	1968	51	5	14
St. Clair Power Plant - Peaker 12-1 / 12-2	Oil	1970	49	2	5
Superior Peaker 11-1	Oil	1966	53	1	13
Superior Peaker 11-2	Oil	1966	53	1	13
Superior Peaker 11-3	Oil	1966	52	1	12
Superior Peaker 11-4	Oil	1966	52	1	14
Wilmot Peaker 11-1 / 11-5	Oil	1968	50	5	14

Table 7.2.3: Gas-Fired Peaking Units

Generation Unit Name	Fuel	Commercial Operation Date	Age (Years)	Number of Units	Summer Capacity Rating (MW)
Belle River Power Plant Peaker 12-1	Gas	1999	20	1	75
Belle River Power Plant Peaker 12-2	Gas	1999	20	1	75
Belle River Power Plant Peaker 13	Gas	1999	20	1	74
Dean Peaker 11-1	Gas	2002	17	1	78
Dean Peaker 11-2	Gas	2002	17	1	78
Dean Peaker 12-1	Gas	2002	17	1	78
Dean Peaker 12-2	Gas	2002	17	1	78
Delray Peaker 11-1	Gas	2000	19	1	64
Delray Peaker 12-1	Gas	2000	19	1	63
Greenwood Energy Center - Peaker 11-1	Gas	1999	20	1	75
Greenwood Energy Center - Peaker 11-2	Gas	1999	20	1	75
Greenwood Energy Center - Peaker 12	Gas	1999	20	1	74
Greenwood Energy Center - Unit 1	Gas	1979	40	1	785
Hancock Peaker 11-1	Gas	1967	52	1	11
Hancock Peaker 11-2	Gas	1967	52	1	18
Hancock Peaker 11-3	Gas	1967	52	1	17
Hancock Peaker 11-4	Gas	1969	50	1	17
Hancock Peaker 12-1	Gas	1970	49	1	32
Hancock Peaker 12-2	Gas	1966	53	1	33
Northeast Peaker 11-1	Gas	1966	53	1	15
Northeast Peaker 11-2	Gas	1966	53	1	15
Northeast Peaker 11-3	Gas	1966	53	1	14
Northeast Peaker 11-4	Gas	1966	53	1	15
Northeast Peaker 12-1	Gas	1971	48	1	18
Renaissance 1	Gas	2002	17	1	163
Renaissance 2	Gas	2002	17	1	163
Renaissance 3	Gas	2002	17	1	163
Renaissance 4	Gas	2002	17	1	163
St. Clair Power Plant - Peaker 11-1	Gas	1968	51	1	19

The 2014–2018 average capacity factor for the peaking units was approximately five percent. All peaking units were assumed to remain operational throughout the study period (2019–2040).

7.3 Nuclear Generating Units

DTEE owns and operates the Enrico Fermi 2 Power Plant in Frenchtown Township, Mich. It is a boiling water reactor with a net demonstrated capacity rating of 1,141 MW. The plant was commissioned in 1988 and received a 20-year license renewal in 2016, allowing the unit to continue operating through at least 2045. During 2014-2018 the plant operated at an 80 percent average capacity factor.

7.4 Hydroelectric Generating Units

DTEE owns 49 percent of the Ludington Pumped Storage facility, which is discussed in more detail in Section 7.6. The Company also has contracts in place to purchase power from four small hydroelectric facilities within the state. Information regarding these facilities and the respective contracts are included in Section 7.7.

The Company also has contracts in place to purchase power from four small hydroelectric facilities within the state

7.5 Renewable Generating Units

As of 2019, DTEE's portfolio of owned and contracted renewable generating assets exceeds 1,150 MW, including assets to meet the renewable portfolio standard (RPS) and serve Voluntary Green Pricing (VGP) programs. Renewable energy resources owned by the Company are described in this section and those under contract are described in later sections. All company-owned renewable assets were assumed to remain in operation throughout the study period (2019–2040).

DTEE owns eight Michigan wind parks, with a combined capacity of 612 MW, which includes the assets for the RPS and those serving VGP programs. All of the parks are located in the state's Lower Peninsula, with six parks in the Thumb region and two in central Michigan. The parks' nameplate capacities range from 14 MW to 161 MW, and the fleet consists of 342 wind-turbine generators. An additional park, Polaris, is scheduled to be completed in 2020 in central Michigan, with an installed capacity of 168 MW and 68 installed wind turbines. Table 7.5.1 provides detailed information about DTEE-owned wind parks.

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TABLE 7.5.1: DTEE-Owned Wind Parks

Park Name	Location	Commercial Operation Date	Wind Turbines	Turbine Size	Capacity Factor (%)[1]	Installed Capacity (MW)
Gratiot Wind Park	Central, MI	2011	64	1.6	29.1	102.4
Minden	Thumb, MI	2013	20	1.6	41.5	32.0
McKinley	Thumb, MI	2013	9	1.6	41.5	14.4
Sigel	Thumb, MI	2013	40	1.6	41.5	64.0
ECHO	Thumb, MI	2014	70	1.6	39.8	112.0
Brookfield	Thumb, MI	2014	44	1.7	40.2	74.8
Pinnebog	Thumb, MI	2016	30	1.7	38.0	51.0
Pine River	Central, MI	2019	65	2.3 / 2.5	30 (est)	161.3
Polaris	Central, MI	2020	68	2.3 / 2.5	34 (est)	168.0

[1]Based on historical performance

DTEE owns eight Michigan wind parks, with a combined capacity of 612 MW

DTEE also has entered into six wind Power Purchase Agreements (PPAs) with renewable projects, with a combined capacity of 458 MW (the agreements are highlighted in Section 7.7). DTEE receives the renewable energy credits produced by these parks for use in complying with Michigan's renewable portfolio standard.

In addition to the wind portfolio, DTEE owns and operates a diverse set of solar assets across Michigan totaling 64 MWAC. Since 2010, DTEE has experimented with various technologies and approaches to building solar, and has worked with its partners at the arrays' host sites to help educate the community about solar energy. The sites in the Company's portfolio range in size from less than 100 kWAC to almost 28 MWAC. The sites' designs vary and include ground-mount, roof-mount, and carport panels. DTEE's owned solar parks are shown in Table 7.5.2.

TABLE 7.5.2: DTEE-Owned Solar Parks

Park Name	Location (County)	Commercial Operation Date	Capacity Factor (%)[1]	Capacity (MWAC)
SCIO Solar Array	Washtenaw	2010	14.3	0.056
Blue Cross Blue Shield	Wayne	2011	13.5	0.200
Monroe County Community	Monroe	2011	14.0	0.500
Ford Solar Array	Wayne	2011	11.7	0.500
Training and Development Center	Wayne	2011	13.4	0.380
General Motors Solar Array	Wayne	2011	12.7	0.500
DTE Headquarters (DECo Project #3)	Wayne	2012	10.7	0.081
Mercy High School	Oakland	2012	13.3	0.375
Warren Consolidated Schools	Macomb	2012	10.5	0.189
General Motors Orion Assembly	Oakland	2012	14.6	0.300
Huron Clinton Indian Springs Metro	Oakland	2012	13.5	0.495
Wil-Le Farms	Huron	2012	13.8	0.484
Immaculate House of Mary	Monroe	2012	14.4	0.500
University of Michigan - North Campus Center	Washtenaw	2012	13.5	0.430
University of Michigan - Institute of Science	Washtenaw	2013	14.3	0.241

The sites in the Company's portfolio range in size from less than 100 kWAC to almost 28 MWAC.

Park Name	Location (County)	Commercial Operation Date	Capacity Factor (%)[1]	Capacity (MWAC)
Riopelle Farms	Huron	2013	14.3	0.503
St. Clair RESA	St. Clair	2013	14.8	0.503
Leipprandt Orchards	Huron	2013	14.6	0.503
Hartland Schools	Livingston	2013	13.8	0.444
McPhail	Oakland	2014	14.4	0.750
Domino Farms	Washtenaw	2015	15.6	1.000
Thumb Electric Cooperative	Tuscola	2015	14.8	0.603
Ford World Headquarters	Wayne	2015	13.1	0.750
Ashley / Romulus	Wayne	2015	13.9	0.684
Brownstown	Wayne	2016	14.4	0.500
Greenwood Energy Center	St. Clair	2016	17.9	1.392
Ypsilanti	Washtenaw	2016	16.5	0.672
General Motors Transmission Plant	Macomb	2016	16.5	0.744
Demille Rd	Lapeer	2017	16.0	28.00
Turrill Rd	Lapeer	2017	15.5	20.00
O'Shea	Wayne	2017	16.4	2.00

[1]Based on 2017-2018 site performance; Demille, Turrill, and O'Shea based on 2018

7.6 Energy Storage Facilities

The Ludington Pumped Storage facility is in Ludington, Mich., alongside Lake Michigan. It is a six-unit hydroelectric power plant. The plant is co-owned by DTEE and Consumers Energy (CE); DTEE owns 49 percent and CE owns 51 percent. CE, as the majority owner, is also the operating authority. The units were commissioned in 1973 and their 2014-2018 average capacity factors were 13 percent, 10 percent, 13 percent, 12 percent, eight percent, and 11 percent, respectively. The current net demonstrated capacity of the plant portion owned by DTEE is 1,054 MW. Sthe units began going through a maintenance overhaul upgrade in 2015, one unit at a time. Four of the unit upgrades have been completed, the fifth will be completed in May 2019, and the last unit is expected to be completed in May 2020. These upgrades are providing 34 MW of increased generation (DTEE ownership) for each unit, for a total of 204 MW. When the upgrades are completed in 2020, DTEE-owned capacity in Ludington will be 1,122 MW.

Ludington can act as a 1,000 MW storage system, and provides a great opportunity to support the announced renewable energy resources that will grow in Michigan's bulk electric system. Ludington operates by pumping water up from Lake Michigan into a reservoir when power prices are low, and then generates energy by releasing the water through turbines back into Lake Michigan when customer demand increases or generation from intermittent resources decreases and electricity prices increase. When weather conditions disrupt renewables generation, Ludington can ramp up to provide generation quickly, thus smoothing the impact of renewable resources.

Ludington can act as a 1,000 MW storage system, and provides a great opportunity to support the announced renewable energy resources that will grow in Michigan's bulk electric system.

7.7 Power Purchase Agreements

In addition to owned resources, DTEE has entered into various PPAs that have been approved by the MPSC under PA 2/PURPA and PA 295/342:

- The Public Utility Regulatory Policies Act of 1978 (PURPA) requires electric utilities to purchase power from qualifying facilities (QFs) at the utilities' avoided cost, provide back-up power to QFs, interconnect with QFs, and operate with QFs under reasonable terms and conditions.
- PA 2 of 1989, enacted by Michigan, requires utilities with greater than 500,000 customers to enter into PPAs for both energy and capacity from certain landfill gas and solid waste QFs.
- PA 295 of 2008, enacted by Michigan, required utilities to meet certain renewable energy standards by 2015, and requires 50 percent of renewable energy credits used for compliance to be sourced from third parties.
- PA 342 of 2016, enacted by Michigan, increases the renewable energy standards from 10 percent by 2015 to 15 percent by 2021.

The Company currently has 11 PA 2/PURPA contracts and nine PA 295/342 contracts for both energy and capacity. The Company also receives capacity credit for customer-owned generation in the amount of 3.3 MW. The Company has capacity rights from both PURPA/PA 2 and 2008 PA 295/342 renewable-energy contracts, which are distinct from DTEE-owned renewable-energy systems. The Company will receive a total of 178 zonal resource credits in the 2019-20 planning year associated with PPAs (including customer-owned generation). If an existing contract term was set to mature prior to the end of the IRP study period (2040), for modeling purposes, it was assumed to be renewed and continues through 2040, at the respective contract price. The contracts are listed in Tables 7.7-1 and 7.7-2 with their corresponding expiration dates and UCAP values.

TABLE 7.7.1: PA 2 and PURPA Contracts

P.A. 2/ PURPA Facility	Expiration Date	Generation Type	UCAP (MW)
Ann Arbor - Barton Dam	4/1/2036	Hydro	0.2
Ann Arbor – Superior	5/1/2036	Hydro	0.0
STS French Landing	1/30/2039	Hydro	0.2
Charter Township Ypsilanti	1/1/2028	Hydro	0.4
Michigan Waste Energy	6/30/2024	Waste	42.8
Riverview Energy Systems	8/13/2027	Landfill Gas	4.8
Sumpter Energy Associates (Station #1)	7/13/2033	Landfill Gas	19.1
Lyon Electric Generating	9/21/2030	Landfill Gas	Combined with Arbor Hills
Turbine Power Limited Partnership - Arbor Hills	6/12/2031	Landfill Gas	14.4
Ann Arbor Landfill	4/29/2033	Landfill Gas	0.6

TABLE 7.7.2: P.A. 295 Agreements

P.A. 295 Agreement	Expiration Date	Generation Type	UCAP (MW)
Heritage Stoney Corners Wind Farm I, LLC	1/1/2030	Wind	3.2
Heritage's Garden Wind	1/1/2030	Wind	1.2
L'Anse Warden Electric Company, LLC	1/1/2032	Biomass	14.7
WM Renewable Energy, LLC	1/1/2032	Landfill Gas	2.8
Gratiot County Wind, LLC	1/1/2033	Wind	15.2
Blue Water Renewables, Inc.	1/1/2032	Biomass	2.8
Tuscola Bay Wind, LLC	1/1/2033	Wind	17.6
Tuscola Wind II, LLC	1/1/2034	Wind	16.8
Pheasant Run Wind, LLC	1/1/2034	Wind	13.4
Big Turtle Wind Farm, LLC	1/1/2035	Wind	3.0

7.8 Regional Transmission Operator; Unit Capacity Credits

In addition to energy, a key benefit of DTEE's generating units and PPAs is the provision of capacity. MISO, a Regional Transmission Operator (RTO), grants the Company's generating units and PPAs with capacity credits, also known as zonal resource credits (ZRCs). A summary of the current capacity credit for the Company's owned generating units is provided in the following table:

TABLE 7.8.1: RTO Capacity Credits, Company-Owned

Resource	2019/2020 Planning Year RTO Capacity Credit (ZRCs)
Fossil (Coal)	5,060
Fossil (Gas & Oil Peakers)	2,476
Nuclear	1,068
Pumped Storage	992
Owned Renewables	129

7.9 Spot market purchases and off-system sales

DTEE operates within the MISO energy market. As part of its function as a load-serving entity within MISO Local Resource Zone 7, the Company purchases wholesale energy from the MISO energy market, as required. The Company also sells energy to the MISO energy market when generating in excess of its customer demand.

SECTION EIGHT

8 Demand-Side Resources

8.1 Overview

Demand response (DR) programs are designed to help reduce enrolled customers' energy use during peak hours. DTEE's demand response programs have been part of its resource portfolio since the late 1960s. DTEE has developed a portfolio of demand response products, which include dispatchable programs, such as direct load control programs and interruptible tariffs, and non-dispatchable programs, such as time-varying rates. In 2017, DTEE ranked number one in the State of Michigan for potential peak-demand (MW) savings through utility demand response programs, number 11 (out of 411 utilities) nationally and number two (out of 126 utilities) in the Midcontinent Independent Service Operator (MISO) territory. [1] Currently, DTEE has more than 700 MW of enrolled capacity, which accounted for over six percent of the Company's 2018 peak load.

DR programs provide many benefits to DTEE, which ultimately flow through to its customer base. Those benefits include cost savings from potentially avoiding or deferring new generation needed to meet capacity requirements[2], reduced capacity purchases at costly times, risk reduction and energy security.

1 See 2017 data at https://www.eia.gov/electricity/data/eia861

2 Avoided electric energy and capacity costs are based upon the costs an electric utility would incur to either construct or operate new electric power plants or other IRP alternatives, or to operate existing power plants. The energy component includes the costs associated with the production of electricity, while the capacity component includes costs associated with the capability to deliver electric energy during peak load periods.

The table below, Table 8.1.1, summarizes the Company's current demand response programs available as options for customers and the associated MWs each program claimed in the MISO 2019/2020 planning year as load modifying resources (LMRs) and in the IRP as the existing demand response levels.. Each program is described in more detail in sections 8.2 thru 8.4.

TABLE 8.1.1: Summary of Current Demand Response Programs

Demand Response Program	MW (UCAP)
R10 – Interruptible Supply Rider	336
D1.1 – Interruptible Space Conditioning	158
D8 – Interruptible Supply Base	98
R1.2 – Electric Process Heat	81
D3.3 – Interruptible General Service	23
R1.1 – Alternative Metal Melting	7
D5 – Interruptible Water Heating	6
R12 – Capacity Release	0
Total	**709**

Dispatchable programs provide the Company with zonal resource credits that can help it meet its Planning Reserve Margin Requirement (PRMR) for MISO planning purposes.

8.2 Dispatchable Programs

A dispatchable program is where an action is taken in response to requests or "calls" from a utility. The dispatch may be communicated directly to connected devices, such as a control switch or to designated energy managers, who modify their operations. Customers who wish to participate in direct load control programs permit the Company to install a device that allows the Company to cycle an appliance on and off during a time when electricity consumption is the highest. Typically, these programs do not offer an override option.

Dispatchable programs provide the Company with zonal resource credits that can help it meet its Planning Reserve Margin Requirement (PRMR) for MISO planning purposes. The PRMR is the amount of capacity above the weather-normalized peak demand needed to reliably serve load, while meeting events such as extreme weather and unplanned capacity outages.

Interruptible Space-Conditioning Rate (D1.1): This program consists of a separately metered service connected to the customer's central air conditioner (A/C) or heat pump and is available to residential and commercial customers. DTEE will cycle the A/C condenser by remote control on selected days for intervals of no more than 30 minutes in any hour and no more than eight hours in any day. Causes of interruptions may include, but are not limited to, maintaining system integrity, making an emergency purchase, economic reasons, or available system generation being insufficient to meet anticipated system load. Approximately 275,000 residential customers and 900 commercial customers take service under rate D1.1, providing a zonal resource credit of 158 MW for the 2019 planning year.

Interruptible General Service Rate (D3.3): Commercial secondary customers can elect to have separately metered service that is subject to interruption. This rate is not available to customers whose loads are primarily off-peak. 122 customers take service under this rate, providing the Company with 23 MW of zonal resource credits for the 2019 planning year.

Water Heating Service Rate (D5): This program is available to customers using hot water for sanitary purposes or other uses subject to the approval of the Company. A timer or other monitoring device controls the daily use of all controlled water heating service. Control of service shall not exceed four hours per day. Approximately 50,000 residential customers and 800 commercial customers take service under rate D5, providing the Company with six zonal resource credits for the 2019 planning year.

Interruptible Supply Base Service Rate (D8): Primary voltage customers who desire separately metered service for a specified quantity of demonstrated interruptible load of not less than 50 kW at a single location can take service under this rate. Participation in this rate is limited to 300 MW. For the 2019 planning year, D8 provides 98 MW of zonal resource credits.

Alternative Electric Metal Melting (Rider 1.1): Customers who operate electric furnaces for the reduction of metallic ores or metal melting can have that load separately metered, making it subject to interruption. Seventeen customers take service under this rate, providing the Company with seven zonal resource credits for 2019.

Electric Process Heat (Rider 1.2): Customers who use electric heat as an integral part of a manufacturing process, or electricity as an integral part of anodizing, plating or a coating process, who are willing to be subject to interruption, can take service under this rate through a separate meter. The 196 customers who take service under Rider 1.2 provide the Company with 81 zonal resource credits for 2019.

Interruptible Supply Rider (Rider 10): Rider 10 allows customers to elect the amount of interruption they are willing to take under a separate meter, up to 650 MW of enrolled load. Rider 10 is designed for customers of greater than 50 MW at a single location, but at DTEE's discretion and with available capacity, the minimum site requirements can be waived. 61 customers are enrolled in Rider 10, providing the Company with 336 zonal resource credits for 2019.

Capacity Release (Rider 12): Customers can be provided a voluntary capacity-release payment by subscribing at least 50 percent of their facility load to voluntary interruption during peak events. The capacity-release payment is a mutually negotiated rate between the customer and DTE. Zonal resource credits can be claimed under Rider 12, but currently no customers are taking service under this rate.

All dispatchable demand response resources are currently registered with MISO as load modifying resources. Load modifying resources are MISO registered resources that are used in the MISO Capacity Auction to help meet capacity requirements for the peak period. Most of the programs maintained by the Company may only be utilized to maintain system integrity (which would include MISO capacity shortages), thus preventing them from economic dispatch in the energy market. Two programs (D1.1 and D3.3) in the Company's demand response portfolio can also be deployed when interruption is economically preferable to purchasing energy.

8.3 Non-dispatchable Programs

A non-dispatchable program is where voluntary actions are taken by the customer to reduce or shift demand form peak to non-peak periods. Similar to how MISO treats non-dispatchable programs, these programs are treated as an offset to peak-load in the IRP.

Time-of-Use (TOU) Programs

DTEE's time-of-use programs shift load in time. Time-of-use programs play an increasingly integral part in the resource portfolio. DTEE has four residential time-of-use rates to encourage customers to shift their load to off-peak periods. While time-of-use programs provide value to customers and the Company, they do not qualify for any zonal resource credits in MISO. To qualify for zonal resource credits, a resource must be available to reduce demand with no more than 12 hours' advance notice from MISO, and a demand response program must have the capability to reduce demand to a targeted level or firm service level at the MISO coincident peak.

Residential Time-of-Day (D1.2): Residential customers can pay a lower energy charge for kWh during off-peak hours (7 P.M. to 11 A.M.) than on-peak hours (11 A.M. to 7 P.M.), Monday through Friday. While not a callable program, the time-of-day rate encourages customers to shift their energy usage patterns, which lowers overall system demand. There are approximately 9,000 residential customers taking service under this rate.

Geothermal Time-of-Day (D1.7): This rate is available, on an optional basis, to residential customers who desire separately metered service for approved geothermal space conditioning and/or water heating. The off-peak and on-peak schedule is the same as the residential time-of-day rate. Approximately 8,000 customers take service under this rate.

Dynamic Peak Pricing (D1.8): Residential and commercial customers can elect to have a tiered time-of-use rate with a critical-peak-event overlay. The rate is designed to allow customers to manage their electricity costs by reducing or shifting load during high-cost periods. The three-tiered rate has an off-peak period (weekdays between 11 P.M. to 7 A.M., Company recognized holidays and weekends), a mid-peak period (non-holiday weekdays from 7 A.M. to 3 P.M. and 7 P.M. to 11 P.M) and an on-peak period (non-holiday weekdays from 3 P.M. to 7 P.M.). During a critical peak event, the cost per kWh increases during the on-peak period. The Company is permitted to call up to 20 events per year. Though the events are callable, the dynamic peak pricing doesn't provide any zonal resource credits due to the amount of time required to notify a customer of an event. More than 5,000 residential customers and one commercial customer are enrolled on rate D1.8.

Electric Vehicle Time-of-Day (D1.9): Customers with electric vehicles have the option to take separately metered service to charge their vehicle. Rate D1.9 is a time-of-use rate designed to shift the time customers charge their vehicles to the off-peak period. The on-peak period is Monday through Friday from 9 A.M. to 11 P.M. while the off-peak period comprises the remaining hours. Nearly 2,000 customers take service under this rate.

Beginning in 2021, the Company expects to fully implement the mandatory time-of-use rate for all residential customers as order by the Commission in the Company's last ordered rate case, U-18255. The Company's proposed rate design includes a one cent differential between off and on-peak. The Company did not forecast any load shift resulting from the mandated TOU rate because of the small price differential between the off-peak and on-peak time periods. This resulted in the Company not adjusting the IRP peak load forecasts to reflect any impacts of the mandatory TOU rate.

Non-dispatchable programs are treated as an offset to peak-load in the IRP.

8.4 Demand Response Pilot Programs

DTE Electric is conducting additional demand side management pilots encompassing residential, commercial and industrial customers. Based on the results of these pilots and of utility benchmarking efforts, the Company expects to identify other alternative DR programs that may become economic and technically viable alternatives to generation capacity, have an appropriate level of customer adoption potential, and are cost effective for customers. While the Company intends to learn as much as possible through benchmarking of other pilots and programs and leverage the knowledge of vendors who have experience in implementing demand response programs, it is considered best practice to conduct actual internal pilots before launching a new full-scale program. These pilots seek to identify how our unique customer base will react to specific marketing tactics, program design features, and other characteristics that are dependent on DTE Electric's unique combination of systems, equipment, tariffs, programs and processes.

Residential Pilots

Bring Your Own Device (BYOD): In the BYOD program, the Company enrolls residential customers and who have a Wi-Fi-enabled smart thermostat already installed. Customers who are already enrolled in the Interruptible Air Conditioning or the Programmable Communicating Thermostat program are excluded from the BYOD pilot. In 2018, customers were offered a chance to win one of ten $500 gift cards as an incentive to enroll in the program. Customers' thermostats were then configured to allow the Company to send a control signal during BYOD events, which only occur on weekdays between 3 P.M. and 7 P.M. and are limited to 10 events per year. During such an event, the Company sends a pricing signal to a customer's thermostat to raise the set-point by four degrees. Customers can override the event if they choose. This program is considered a non-dispatchable program although the Company is assessing customer engagement levels and may recommend program modifications that would eventually allow the BYOD program to qualify as an LMR.

Programmable Communicating Thermostat (PCT): The PCT Pilot, also known as SmartCurrents™, requires customers to enroll or be enrolled on the Dynamic Peak Pricing (D1.8) tariff. Upon enrollment, customers are sent a free Wi-Fi enabled thermostat. Once the thermostat is installed, the Company sends a pricing signal to the thermostat during a critical peak event that raises the thermostat setpoint by four degrees. The customer has the option to override the temperature setpoint but by doing so could drive the customer's bill higher with increased energy usage during the peak period.

DTE Electric is conducting additional demand side management pilots encompassing residential, commercial and industrial customers

Commercial & Industrial Pilots

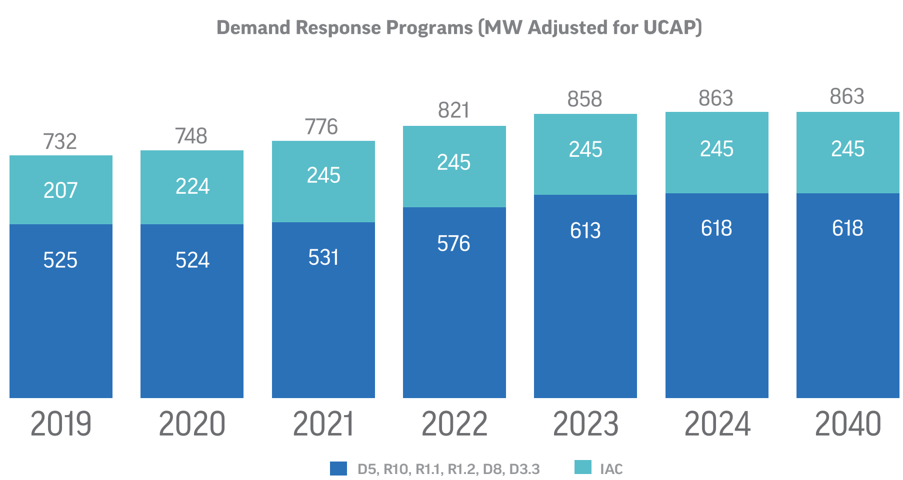
Building Automation Pilot: The Company partnered with NextEnergy (a facility space that incorporates an auditorium, meeting spaces, laboratories, microgrid and other areas) and Enbala (a cloud-based platform provider) to implement a cost-effective pilot encompassing multiple system assets at NextEnergy's commercial customer facility. The goal of the pilot was to specifically assess the performance of the Enbala's Symphony technology and the communication tool and platform during DR events. The Company was able to use the platform to select and manage specific customer assets for load controlling without a full facility shut-off or interruption. The pilot included various customer assets including chilled and chiller water pumps, air handler units (AHU), load bank (microgrid), a generator, and an electric vehicle charger that were all interconnected through Enbala's Virtual Power Plant software. The Company finalized the pilot in 2018 and expects to use the key insights to investigate future potential pilots or programs of similar nature in other individual commercial and industrial customers in 2019 and 2020.

Plug in Electric Vehicle (EV) Platform: The Company is conducting a pilot that involves a partnership with the Electric Power Research Institute (EPRI)'s Transportation Program. The pilot program will leverage EPRI's Plug-in Electric Vehicle (PEV) platform to develop a proof-of-concept to streamline the management of PEV charging. The Company is partnering with specific PEV automotive manufacturers in its territory in pilots so that the Company can assess the effectiveness of the open-standard-based platform concept to integrate PEV charging with grid objectives through demand response. The Company and the manufacturers hope to learn the responsiveness of the PEV owners and their willingness to participate in DR events specifically targeted at vehicle charging and the amount of demand that is curtailed through events. The planning stage of this pilot has concluded, and the first event was called on February 26, 2019.

Rider 12 Tariff – Capacity Release: The Rider 12 tariff (described above) is not new to the Company, but currently no customers take service under it. However, in the Demand Response Market Assessment Study that the Michigan Public Service Commission commissioned in 2017, commercial and industrial customers expressed interest in a capacity release-like program. As a result of that feedback, the Company plans to begin marketing this program and enroll large commercial and industrial customers in the second quarter 2019.

Battery Storage Pilots: The Company is evaluating various battery storage pilots and their applicability to demand response. These pilots are still in the exploratory phase but the Company considers it prudent to study the technology for future implications.

FIGURE 8.5.1 - Starting point demand response in IRP from 2019 to 2040



8.5 IRP Starting Point: Demand Response

The existing demand response programs included in the starting point consisted of both dispatchable and non-dispatchable programs. The starting point for demand response was 732 MWs and grew to 863 MWs by 2040. This was based on 2017 data and was consistent with the Company's capacity demonstration (case U-18197) that was filed on December 1, 2017, see Figure 8.5.1.

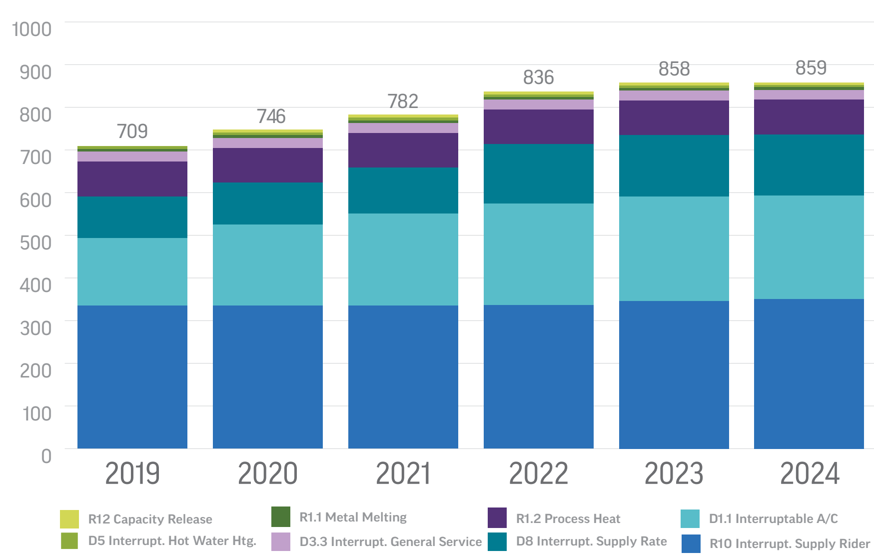
8.6 Proposed Course of Action: Demand Response

IRP Defined PCA: Demand Response

Since IRP modeling began in the summer of 2018, the demand response forecast has changed slightly and has been updated to reflect the Company's most recent capacity demonstration. Based on updated program data, the Company forecasts 709 MWs of demand response in 2019 with existing programs growing to 859 MWs in 2024, see Figure 8.6.1. This is consistent with the Company's latest capacity demonstration (Case U-20154) that was filed on December 3, 2018 and is based on the most current data. Beyond 2024, it was assumed that existing programs remain flat through 2040.

Based on updated program data, the Company forecasts 709 MWs of demand response in 2019 with existing programs growing to 859 MWs in 2024

FIGURE 8.6.1: Existing demand response capacity in IRP from 2019 to 2024



Flexible PCA: Demand Response

In regards to the flexible portion of the proposed course of action the Flexible PCA identifies four pathways (A, B, C, and D) with varying levels of demand response. Pathways A, B and D do not increase the levels of demand response from the Defined PCA. Pathway C increases the levels of demand response by an incremental 100 MWs. The makeup of the 100 MWs of incremental demand response in pathway C has not been decided although it is believed to come from the successful implementation of on-going and future pilot programs.

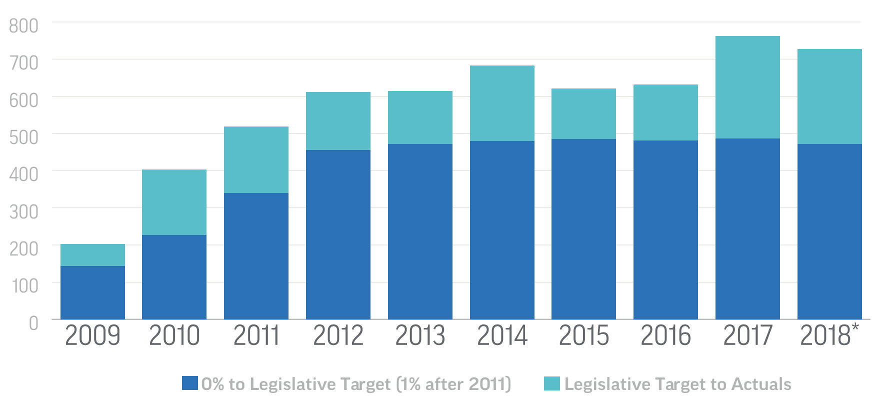
8.7 Energy Waste Reduction

DTEE's Energy Waste Reduction (EWR) program launched in June 2009 as a result of the Clean, Renewable, and Efficient Energy Act, also known as 2008 Public Act (PA) 295. In 2016, PA 342 was signed into law, amending PA 295. The EWR standards in PA 342 maintain the minimum energy savings standards developed in PA 295 of 1.0% of total annual retail electric sales per year through 2021.

DTEE's EWR programs are designed to help customers reduce their energy usage by increasing customer awareness and adoption of energy-saving technologies. This is accomplished by providing products and services such as rebates, tips, tools, strategies and energy-efficiency education to help customers make informed energy-saving decisions. DTEE has continued to build on its momentum from the 2009 launch by expanding the scope of existing programs and adding new program options to the portfolio. DTEE's EWR program has consistently exceeded savings targets and is expected to continue that trend through the future, as shown in Figure 8.7.1

DTEE's EWR programs are designed to help customers reduce their energy usage by increasing customer awareness and adoption of energy-saving technologies.

FIGURE 8.7.1: Summary of Annual EWR Savings (GWh)



*2018 savings are based on projections from the DTEE 2018/2019 EWR Plan Filing, Case No. U-18262

DTEE's ability to run the EWR programs effectively has continued to improve through further maturity of systems and back-office processes. DTEE is currently engaged in evaluating new programs, delivery, and results as it continues to evolve the EWR portfolio.

8.8 General Benefits of EWR

EWR programs have multiple benefits, including savings from the avoided cost of new generation capacity, non-electric benefits such as water savings, environmental benefits, economic stimulus, job creation, risk reduction and energy security. EWR programs help reduce the Company's reliance on fossil-fueled generation from existing plants, mitigate the need to build new generation resources in the future, help reduce reliance on power purchases from other suppliers, and ease utility bill pressures by providing benefits to consumers and the DTEE system.

At the consumer level, energy-efficient products often cost more than their standard counterparts, but the higher up-front cost is balanced by lower energy consumption, resulting in lower energy bills. Over time, the money saved on electric bills as a result of energy-efficient products may pay consumers back for their initial investment. Although some energy-efficient technologies are complex and expensive, such as installing high-efficiency windows or a high-efficiency boiler, many are simple and inexpensive. Installing light-emitting diode (LED) lighting or low-flow water devices, for example, can be done by most individuals.

DTEE's EWR programs include residential programs, commercial and industrial programs, pilot programs, and general education and awareness programs.

8.9 EWR Program Offerings

DTEE's EWR programs include residential programs, commercial and industrial programs, pilot programs, and general education and awareness programs. In addition, the Evaluation, Measurement and Verification requirement verifies net energy savings reported by the EWR programs. The programs are managed by DTEE program managers and operated by expert implementation contractors, primarily utilizing local labor and products.

Each program offers a combination of EWR products, customer incentives or rebates, and education. Following is an overview of each program category:

Residential Programs offer customers products, services and rebates encompassing appliance recycling; lighting; heating, ventilating and air conditioning (HVAC); weatherization; home energy assessments; low-income programs; energy education; behavioral programs; school programs; an online marketplace; and direct install programs.

Commercial and Industrial Programs offer businesses products, services, and prescriptive rebates for specific equipment replacement such as lighting, boilers, pumps, and compressors; custom programs providing rebates per kilowatt hour (kWh) of electricity savings for a comprehensive system or industrial process improvement; business energy consultation programs; operational programs; and

energy education.

Pilot Programs focus on new and emerging experimental programs to fit longer-term portfolio needs, test the cost-effectiveness of new technologies, assess customer adoption of new technologies and market acceptance of existing technologies using new approaches.

Education and Awareness Programs are designed to raise customer EWR awareness to help save energy and to reduce energy costs. A secondary objective is to raise awareness of the DTEE website and social media, which provide channels for customers to engage in specific EWR programs.

EWR programs require independent verification of the utility claimed energy savings. An independent **Evaluation, Measurement and Verification** contractor performs this work to industry standards and guidelines developed by the MPSC EWR Collaborative's Evaluation Workgroup.

Refer to Figure 8.9.1 for a list of current programs offered. A complete description for each program may be found in the Company's 2017 Energy Waste Reduction Annual Report [3].

FIGURE 8.9.1: Current Energy Efficiency Program Offerings

Residential Programs	C&I Programs	Education & Awareness Programs	Pilot Programs
DTE INSIGHT & ENERGY BRIDGE	PRESCRIPTIVE	RESIDENTIAL	RESIDENTIAL
APPLIANCE RECYCLING	NON-PRESCRIPTIVE	COMMERCIAL & INDUSTRIAL	COMMERCIAL & INDUSTRIAL
MULTI FAMILY	SELF-DIRECT	EMPLOYEES	ENERGY MANAGEMENT TOOLS
ENERGY EFFICIENT ASSISTANCE			
HVAC & WATER HEATING	RETROCOMISSIONING		
ENERGY STAR	MID-STREAM LIGHTING		
AUDIT & WEATHERIZATION			
ON-LINE ENERGY AUDIT			
HOME ENERGY CONSULTATION			
SCHOOLS			
HOME ENERGY REPORTS			

3 https://newlook.dteenergy.com/wps/wcm/connect/e20de3d0-11df-41e5-bfbc-b41927e5a77c/2015-EO-Annual-Report.pdf?MOD=AJPERES

8.10 Historical EWR Performance

Since their inception in 2009, DTEE's EWR programs have resulted in the first-year energy savings, first-year capacity savings, and spend detailed in Table 8.10.1

TABLE 8.10.1: Annual Energy Savings, Capacity Savings and Spend (2009-2018)

Year	Incremental Annual Energy Savings (MWh)	Annual % Energy Savings	Incremental Annual Capacity Savings (MW)	Spend ($MM)[5]
2009	202,718[2]	0.42%	19[2]	$23
2010	402,995[2]	0.89%	46[1]	$47
2011	519,263[3]	1.15%	69[1]	$65
2012	610,655	1.34%	80[1]	$80
2013	613,528	1.30%	84[3]	$86
2014	681,638	1.42%	96[3]	$98
2015	620,850	1.28%	81[3]	$100
2016	630,920	1.31%	106	$102
2017	761,630	1.57%	116	$111
2018[4]	727,360	1.54%	95	$126

[1]Utility Reported Gross Savings [2]Audited Gross Savings [3]Verified Gross Savings

[4]Projected savings and spend [5] Includes financial performance incentive

In 2018 EWR programs resulted in energy savings of more than 700,000 MWh.

From 2009 through 2018, DTEE customers saved approximately 5,772 gigawatt hours (GWh) and four billion dollars in avoided-cost savings. The savings achieved so far will continue into future years.

8.11 IRP Starting Point: EWR

Since the portfolio's inception in 2009, the Company has provided robust EWR programs to help customers reduce energy waste. However, it took time to develop and implement programs that deliver the high levels of energy savings the Company has recently achieved. In 2018, the Company increased its energy savings target to 1.5% as part of its commitment to reduce customer energy waste. The 1.5% EWR level was used as the starting point assumption in this IRP.

Since the portfolio's inception in 2009, the Company has provided robust EWR programs to help customers reduce energy waste.

8.12 Proposed Course of Action: EWR

IRP Defined PCA: EWR

PA 342 as passed in December 2016 establishes a minimum energy savings requirement of 1 percent of total annual retail sales through 2021. DTEE's Defined PCA increases the level of EWR to 1.75%, starting with an increase to 1.625% in 2020 and full implementation of 1.75% in 2021 through 2024, thus exceeding the minimum energy savings requirement. The annual energy and capacity savings for DTEE's 2019-2024 EWR programs includes the forecasted amounts shown in Table 8.12.1.

TABLE 8.12.1: Forecasted Annual MWh Savings, Capacity Savings and Spend (2019-2024)

Year	Forecasted Incremental Annual Energy Savings (MWh)	Forecasted Spend ($MM)
2019	702,851	$136
2020	759,276	$154
2021	818,016	$186
2022	817,273	$193
2023	814,027	$184
2024	811,246	$177

Flexible PCA: EWR

The Flexible PCA identifies four pathways (A, B, C, and D) with various levels of EWR. Pathways A, B, and D continue the 1.75% EWR level from 2025 through 2040. Pathway C increases the level of EWR to 2.00%, starting with an increase to 1.875% in 2025 and full implementation of 2.00% in 2026 through 2040.

Cumulative EWR Energy Savings: MWh

Figure 8.10.2 displays the forecasted cumulative MWh savings for both the Defined PCA and Flexible PCA pathways. Cumulative energy savings represent both the overall savings occurring in each year from new participants and that continuing to result from past participation with EWR measures that are still in place. Cumulative annual does not always equal the sum of all prior year incremental values as EWR measures have finite lives and, as a result, their savings decline over time.

When EWR levels are increased to 1.75% and maintained at that level (Flexible PCA A, B, and D), the cumulative energy savings is forecasted to be more than 7.2 million MWhs from 2019 through 2040 at a cost of $4.0 billion to DTEE's customers. When EWR levels are further increased to 2.0% by 2026 and maintained at that level (Flexible PCA C), the cumulative energy savings is forecasted to be more than 8.1 million MWhs from 2019 through 2040 at a cost of $4.8 billion to DTEE's customers.

TABLE 8.12.2: Flexible PCA (A, B, C, & D) Annual MWh Savings, Capacity Savings and Spend (2025-2040)

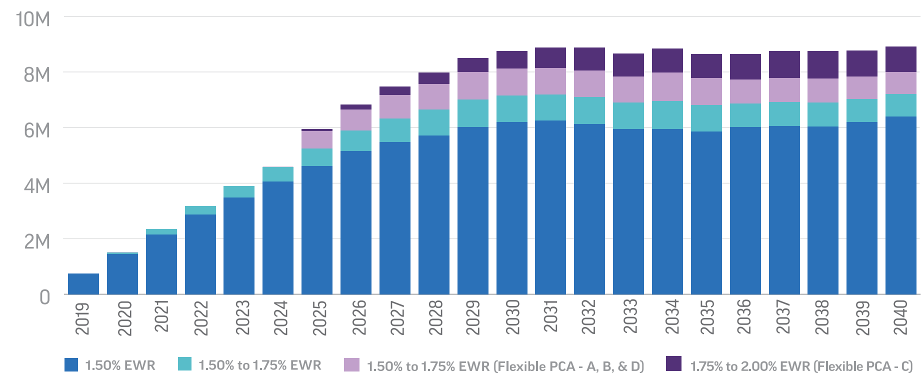
	Flexible PCA (A, B, & D): 1.75%		Flexible PCA (C): 2.00%	
Year	Forecasted Incremental Annual Energy Savings (MWh)	Forecasted Spend ($MM)	Forecasted Incremental Annual Energy Savings (MWh)	Forecasted Spend ($MM)
2025	808,399	$179	866,142	$207
2026	806,390	$178	921,589	$234
2027	804,684	$173	917,335	$224
2028	803,107	$181	913,363	$232
2029	802,147	$178	910,134	$231
2030	801,392	$178	907,325	$234
2031	800,659	$188	905,091	$237
2032	800,234	$192	903,600	$241
2033	799,603	$193	901,900	$246
2034	799,760	$192	901,041	$239
2035	799,607	$192	900,298	$237
2036	799,413	$188	899,150	$234
2037	799,455	$196	898,749	$240
2038	798,973	$194	897,315	$242
2039	798,634	$195	896,524	$243
2040	798,631	$197	896,317	$245

Cumulative Energy Savings: MWH

Figure 8.12.3 displays the forecasted cumulative MWh savings for both the Defined PCA and Flexible PCA pathways. Cumulative energy savings represent both the overall savings occurring in each year from new participants and that continuing to result from past participation with EWR measures that are still in place. Cumulative annual does not always equal the sum of all prior year incremental values as EWR measures have finite lives and, as a result, their savings decline over time.

When EWR levels are increased to 1.75% and maintained at that level (Flexible PCA - A, B, and D), the cumulative energy savings is forecasted to be more than 7.2 million MWhs from 2019 through 2040 at a cost of $4.0 billion to DTEE's customers. When EWR levels are further increased to 2.0% by 2026 and maintained at that level (Flexible PCA - C), the cumulative energy savings is forecasted to be more than 8.1 million MWhs from 2019 through 2040 at a cost of $4.8 billion to DTEE's customers.

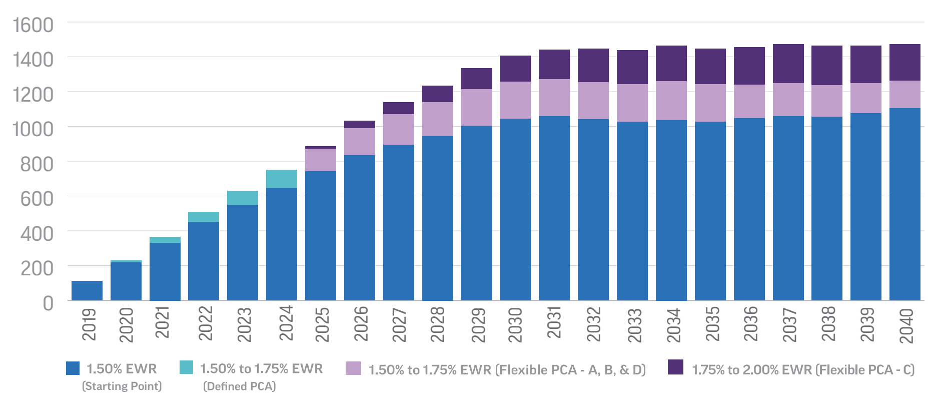
FIGURE 8.12.3: Forecasted Cumulative MWh Savings (2019-2040)



Cumulative Capacity Savings: MW

Although peak demand reductions are not the EWR programs' primary focus, when EWR levels are increased to 1.75% (Defined PCA) and maintained at that level (Flexible PCA - A, B, and D), the cumulative capacity savings is forecasted to be 1,264 MWs by the end of 2040. When EWR levels are further increased to 2.0% by 2026 and maintained at that level (Flexible PCA - C), the cumulative capacity savings is forecasted to be 1,474 MWs by the end

FIGURE 8.12.4: Forecasted Cumulative MW Savings (2019-2040)



of 2040. Figure 8.11.4 shows that the DTEE's EWR programs are projected to achieve significant cumulative MW savings from 2019 through 2040.

DTEE performed an analysis ensuring that the proposed course of action for EWR is cost-effective. Cost-effectiveness is measured by the results of the Utility Cost Test (UCT) as established in PA 342. Specifically, if the savings can be delivered at a UCT benefit-cost ratio greater than 1.0, then the EWR plan is considered cost-effective. When EWR levels are increased to 1.75% (Defined PCA) and maintained at that level (Flexible PCA - A, B, and D) through 2040, the resulting UCT benefit-cost ratio is 2.53. When EWR levels are further increased to 2.0% by 2026 and maintained at that level (Flexible PCA - C) through 2040, the resulting UCT benefit-cost ratio is 2.38.

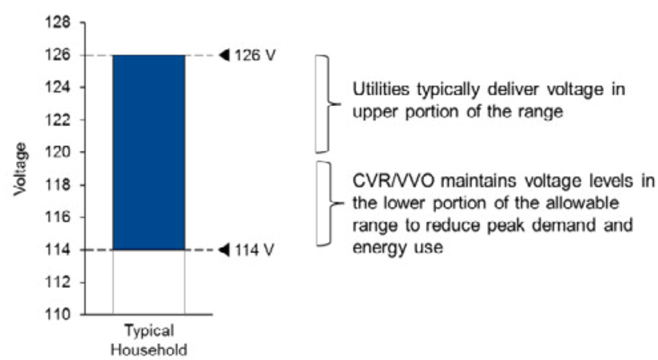
In summary, DTEE is well-positioned to continue to provide value to its customers and other stakeholders through a robust and well-run EWR program. Based on DTEE's experience implementing EWR programs since 2009 and the results of its electric energy-efficiency potential study, DTEE believes the EWR assumptions included in the proposed course of action are likely to deliver the projected energy savings.

8.13 Volt-Var Optimization (VVO) and Conservative Voltage Reduction (CVR)

Volt Var Optimization (VVO) manages system-wide voltage levels and reactive power flow to achieve one or more specific operating objectives. The objectives can include reducing losses, managing voltage volatility due to intermittent renewable generation, optimizing operating parameters and/or optimizing power factors, etc. Conservation Voltage Reduction (CVR), as one of the VVO options, is designed to maintain customer voltage levels in the lower portion of the allowable voltage ranges, thus reducing system losses, peak demand, or energy consumption.

CVR is achieved by utilizing various electrical equipment including transformer load tap changers (LTC), overhead line regulators, and capacitor banks. In addition, supervisory control and data acquisition (SCADA) monitoring devices and line sensors are used to ensure customer voltage levels are maintained in allowable voltage ranges; advanced telecommunication and optimization tool can also be used to achieve optimal savings in the system.

FIGURE 8.13.1 Allowable Voltage Range for a Typical Household



The American National Standards Institute (ANSI) Standard C84.1 provides allowable voltage ranges for electrical power systems and equipment. As illustrated in Figure 8.13.1, the allowable voltage range is 114 V – 126 V for a typical household. Utilities typically deliver voltage in the upper portion of the allowable voltage range, whereas CVR/VVO is to maintain customer voltages in the lower portion of the allowable range to reduce peak demand and energy consumption.

To understand the CVR/VVO potential in the DTEE system, a detailed study was performed on 12 sample circuits that belong to five circuit groups. The circuit groups were formed based on characteristics that could significantly affect how circuits react to CVR/VVO implementation, including 4.8 kV vs. 13.2 kV operating voltage, overhead vs. underground construction, load density, and mix of commercial vs. residential customers (See Table 8.13.2).

TABLE 8.13.2 - Circuit Group

Group ID	Group Definition
Group 1	13.2 kV underground, primarily in newer suburban areas
Group 2	13.2 kV residential and commercial, mixed overhead and underground
Group 3	13.2 kV with areas where the voltage was stepped down to 4.8 KV to serve customers at legacy voltage
Group 4	4.8 kV ringed circuits
Group 5	4.8 KV long circuits

The study indicates CVR/VVO is potentially economically feasible for Group 1 and Group 2, with cost estimates to implement CVR/VVO peaking at $500 per KW, whereas it is not economically feasible for the other three groups, with costs that are hundred to thousand times higher. Table 8.13.3 summarized the average benefits and costs for each of the circuit groups from the study.

TABLE 8.13.3 CVR/VVO Benefit Cost Analysis

Group ID	Average Circuit kW Reduction	Average Circuit Annual MWh Reduction	Average cost Per kW for CVR/ VVO ($)	Upgrades Required
Group 1	45-55	15-75	$300-500	Installation of sensors and communications, settings changes, and minor equipment reconfiguration
Group 2	70-90	40-200	$300-500	Installation of sensors and communications, settings changes, and minor equipment reconfiguration
Group 3	0-65	0-260	$64,000 – 90,000	25% of the circuits need voltage upgrades, otherwise regulator and capacitor bank additions
Group 4	15-35	30-65	$400,000-600,000	All circuits need to be upgraded to 13.2 kV (cost range does not include costs for substation upgrades)
Group 5	20-80	20-150	$500,000-650,000	All circuits need to be upgraded to 13.2 kV (cost range does not include costs for substation upgrades)

The two economically feasible groups (Groups 1 and 2) are composed of complete 13.2 kV circuits, where at least seasonal CVR/VVO is potentially feasible with the current configuration of the circuits. The other three groups (Groups 3-5) all involve circuits that are completely 4.8 kV or have areas of 4.8 kV. Without significant upgrades, these circuits do not have the ability to support CVR/VVO while operating according to ANSI standards. In most cases, the voltages for circuits in Groups 3-5 are too low at some locations to support further voltage reduction without converting to 13.2 kV circuit design.

After extrapolating results from the 12 sample circuits to the entire system, the total peak demand reduction and energy reduction were estimated in ranges for each circuit group, as shown in Table 8.13.4. The study suggests the circuits in Groups 1 and 2 can potentially produce a total peak demand reduction of approximately 40-60 MW and an annual energy reduction of approximately 55,000-75,000 MWh. The total capital cost to upgrade these circuits is estimated at $18-24 million based on an average cost per circuit of $30,000-40,000 and a total of 591 circuits in Groups 1 and 2.

TABLE 8.13.4 CVR/VVO Summary Benefits

Group ID	# of Circuits	Peak Demand Reduction (kW)	Energy Reduction (MWH)	Capital Cost Estimates ($ million)
Group 1	242	10,500 – 27,000	5,500 – 13,000	$7 - $10
Group 2	349	28,500 – 35,500	50,000 – 63,500	$11 - $14
Group 3	430	0 – 25,500	24,000 – 27,500	$815 - $1,150
Group 4	1,375	12,500 – 25,000	69,000 - 291,000	$7,500 - $ 11,250
Group 5	238	4,500 - 12,500	31,500 - 60,000	$4,250 - $5,525

The technology upgrades needed to implement CVR/VVO on Circuit Groups 1 and 2 include two major components. One is to enhance remote monitoring and control capability at substations and circuits. The technology upgrades could take the form of:

- Installing Remote Terminal Units (RTU) and SCADA at substations to enable remote voltage and current monitoring, and to enable remote control of transformer load tap changers when needed
- Installing advanced line sensors on circuits to enable remote monitoring of circuit voltage

The other technology enhancement is to install or upgrade line capacitor banks to improve voltage conditions, particularly at the tail ends of the circuits. The technology upgrades could take the form of:

- Installing remote controllable capacitor banks to improve circuit voltage profile during peak hours
- Upgrading existing capacitor banks to improve circuit voltage profile during peak hours

The exact technology installed at substations and on the circuits, could vary depending on detailed engineering and technology analysis prior to CVR/VVO implementation on individual circuits. The cost estimates, discussed above, average $30,000 - $40,000 per circuit for Groups 1 and 2. The cost estimates assume minimal upgrades are required to enable circuit CVR/VVO, and consider various upgrade situations including circuits that are ready for CVR/VVO without any upgrades and circuits that may need multiple technology upgrades to implement CVR/VVO.

The number of circuits for CVR/VVO implementation and their potential peak demand and energy reductions represent the best estimates based on the study results. With that said, due to the limited sample size, not all circuits within a Group will react to the CVR/VVO implementation in a similar manner as the sampled circuits. A result of the real-world heterogeneity, some targeted circuits may require more modifications, the cost of which may make the implementation of CVR/VVO uneconomic or otherwise infeasible.

In addition, the CVR/VVO potential was modeled assuming customers require constant currents, rather than constant energy. As voltage drops, a constant current load will consume less power, generating demand and energy reductions. In contrast, a constant energy load will increase current to compensate for the lower voltage, producing little to no demand and energy reductions.

To compensate for the study limitations, a range of savings was developed. This range will narrow as individual circuits are studied in detail prior to field implementation.

8.14 Proposed Course of Action: CVR/VVO

IRP Defined PCA: CVR/VVO

DTE Electric plans to execute a CVR/VVO pilot in 2019-2020 as part of the defined PCA. The pilot is expected to complete CVR/VVO implementation on 20 distribution circuits that are categorized as Groups 1 or 2.

Circuits will be randomly selected for the pilot, capturing a diverse portfolio of characteristics such as load density, mix of residential versus commercial, underground versus overhead construction, and remote control capability. The goal of the pilot is to verify the CVR/VVO implementation on a diverse portfolio of circuits to better understand program costs and benefits as well as any field execution constraints.

Flexible PCA: CVR/VVO

The flexible PCA identifies four pathways (A, B, C, and D) with different levels of CVR/VVO. Pathways A and C both have CVR/VVO beginning in 2026 and ramping up to 50 MW by 2030. Pathways B and D do not include any CVR/VVO in the flexible PCA.

SECTION NINE

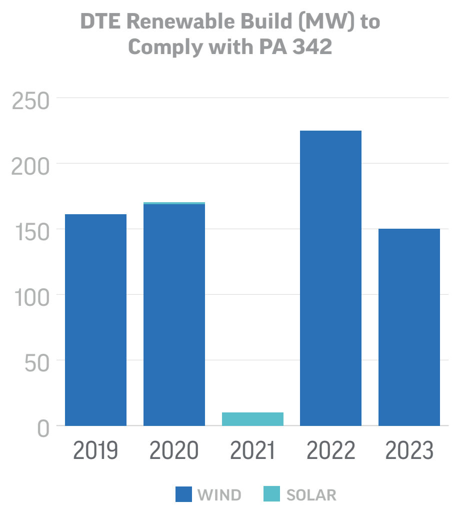
9 Future Renewable Planning

DTEE believes that renewables are a critical part of our plan to achieve our generation and carbon reduction goals. As the Company transitions its fleet to meet its commitment to reduce carbon by 80%, the future of renewables will certainly play a large role. Not only is DTEE embracing renewables, but the Company wants to support our customers, many of whom also have unique clean energy goals. That's why the Company has launched new customer-facing Voluntary Green Pricing (VGP) programs where customers can manage their own carbon footprints. The future of renewables is unfolding at a rapid pace and the Company stands ready to lead the change.

9.1 Existing Renewable Energy Standards

Pursuant to Public Act 342, the Company's 2018 amended Renewable Energy Plan (REP), included a renewable energy portfolio to meet the updated renewable energy targets. Those targets are 12.5 percent in 2019 and 2020, and 15 percent by 2021 through August 2029, the end of the REP's timeframe. The previous 12-month period of weather-normalized retail sales will be used to calculate the number of megawatt hours of electricity in the renewable energy credit portfolio. The Company's ability to comply with the renewable portfolio standard through the end of the REP is highly dependent upon the actual performance of the renewable assets closely matching the capacity factor projections among other assumptions. The total incremental cost of compliance forecasted in the Company's last filed amended REP for 2017 through August of 2029 is approximately $95.5 million. The 2018 REP filing includes a summary of the planned renewable energy credit portfolio, including incentive RECs, as well as the forecasted expected compliance levels by year to meet the renewable portfolio targets. The existing renewable energy fleet and the build plan shown in Figure 9.1.1 are forecasted to meet and sustain the updated renewable energy RPS targets, and are forecasted to have approximately two million RECs remaining at the end of the plan.

FIGURE 9.1.1: DTE Renewable Build

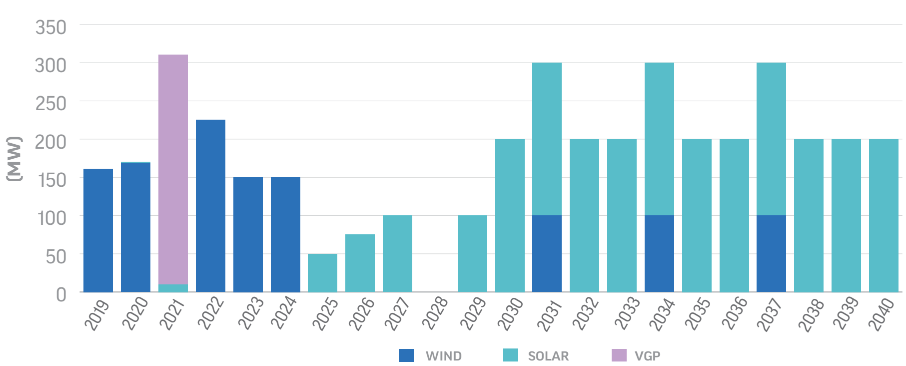


Public Act 342 also includes a Clean Energy Goal, encompassing a renewable energy and energy waste reduction goal of 35 percent in 2025. DTE's energy waste reduction team anticipates achieving at least a 35% reduction by 2025, with renewable energy contributing at least 15 percentage points of this goal.

9.2 IRP Starting Point: Renewable Energy

TThe IRP starting point, with respect to renewable energy, encompasses more than the Renewable Portfolio Standard mandated by PA 342 and the Michigan Energy Legislation 35% Clean Energy Goal. In addition, the IRP starting point included our commitment, announced in 2017, to an 80 percent carbon-reduction goal by 2050 reflecting our commitment to doing our part to mitigate the impact of climate change. The Company's plan to reduce carbon emissions by more than 80 percent was one of the first to be announced and among the most aggressive in the energy industry. Also, announced in 2018, we committed to a 50 percent clean energy goal, exceeding the Michigan RPS with aspirations to have at least 25 percent renewable energy and 25 percent energy waste reduction achieved by 2030. The starting point build plan below encompasses the additional amount of renewable energy needed to meet and sustain these commitments through the IRP study period of 2040.

FIGURE 9.2.1: Starting Point: Renewable Energy Build Plan



The Company's plan to reduce carbon emissions by more than 80 percent is among the most aggressive and was among the first to be announced in the energy industry.

9.3 Voluntary Green Pricing (VGP) Programs

In addition to the RPS and clean energy goals, the Company is growing its VGP programs. These programs will enable our customers who are pursuing their own carbon reduction efforts. The Company plans to actively market these programs and accommodate customer demand without setting program participation caps.

Residential and Small Commercial Customers

DTEE offers MIGreenPower, a VGP program, open to all 2.2 million full-service business and residential electric customers. Launched in April 2017, MIGreenPower provides interested customers with an easy and affordable way to reduce their carbon footprint by increasing the percentage of their energy usage that is attributed to specific renewable projects. Customers who subscribe to MIGreenPower can elect to increase the amount of renewable energy they use in five percent increments, up to 100 percent. Participating customers will see a slight increase to their monthly bill depending on the level of renewable energy they select while knowing they are helping to support Michigan's clean energy future.

Large Commercial and Industrial Customers

In an effort to expand DTEE's voluntary offerings, the Company received MPSC approval in January 2019 for a Large Customer VGP program. Enrollment in the program is voluntary and allows full-service large commercial and industrial customers to increase the portion of their electric usage attributable to renewable resources in five percent increments at a level beyond the renewable energy all customers receive from the Company's generation fleet, up to 100 percent, allowing customers to choose a participation level that aligns with their specific preferences and objectives. The Company will provide at least 15 percent renewable

Local

Joining the MIGreenPower program enables you to support renewable energy production in Michigan. The growth of renewable resources in our state creates local jobs in the clean energy industry and reduces your overall carbon footprint.

Flexible

Program participation is structured in five percent increments, giving you the power to choose the level of impact that works best for you. You can attribute anywhere from 17.5 to 100 percent of your energy use to renewable energy.

Affordable

Both residential and commercial customers can use an environmental impact calculator to find a participation level and financial contribution that works best for them energy under current PA 342 legislation by 2021 to all customers; therefore, the minimum participation match is 20 percent of monthly energy use, up to 100 percent.

The program and associated tariff are designed to grow with customer demand in phases. New assets will be added to ensure the program grows with our customers' needs. Initial program assets will be approved though the existing REP contract-approval process, ensuring fairness and cost competitiveness. Understanding that it would not be prudent to bring on excess resources without adequate demand, DTEE aims to manage both forecasted demand and renewable energy construction timelines to ensure that there is no extended gap in program availability to new subscribers. The build plan is designed to be flexible and accommodate growing demand over time for DTEE's VGP programs.

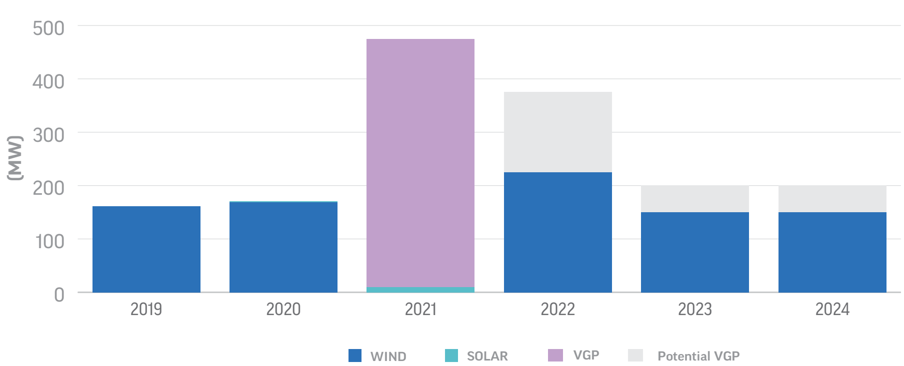
9.4 Proposed Course of Action: Renewable Energy

Defined PCA – Renewable Energy

With respect to renewables, the PCA is definitive in the near term to meet PA 342's RPS compliance and shared goal with EWR along with the Company's Clean Energy and Carbon Reduction commitments. In addition, the Company plans to install 465 MW of renewable energy sourced by wind to support the Large Customer VGP Program. Renewable energy sourced by solar or wind could be added from 2022 to 2024 to support future VGP programs. See Figure 9.4.1 below.

In addition, the Company plans to install 465 MW of renewable energy sourced by wind to support the Large Customer Voluntary Green Pricing Program.

FIGURE 9.4.1 – Defined PCA: Renewable Energy Build Plan

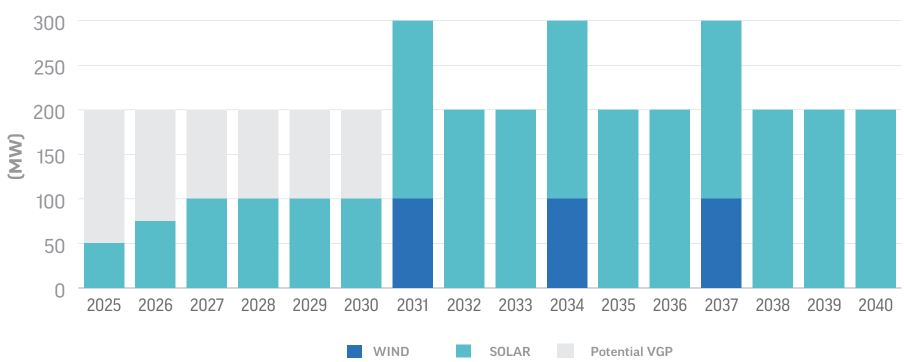


Flexible PCA – Renewable Energy

The flexible PCA contains the renewable resources between 2025 and 2040 to meet the company's Clean Energy and Carbon Reduction commitments. What remains less clear at the time of this IRP is how much demand for the VGP program will emerge in future years. Thus, the flexible component of the PCA identifies four pathways (A, B, C, and D) with two different levels of VGP program renewables. Pathways C and D maintain the VGP programs at 465 MW from 2025 through 2040. Pathway A and B increase the level of VGP programs to 1,390 MW, starting at a 2024 base of 715 MW and full implementation of 1,390 MW by 2030, maintained through 2040. This reflects an incremental 925 MW of VGP programs that could be sourced from wind or solar energy through 2030. As described above, more assets will be added as demand warrants. See Figure 9.4.2 below.

The flexible component of renewable energy PCA reflects an incremental 925 MW of VGP that could be sourced from wind or solar energy through 2030.

FIGURE 9.4.2 – Flexible PCA: Incremental Voluntary Renewables (2022 – 2030)



SECTION TEN

10 Peak Demand & Energy Forecasts

10.1 Overview

An accurate load forecast for the planning period was a key input into the Integrated Resource Plan. DTEE developed its load forecast by analyzing historical data to identify the statistically significant factors in energy sales for each customer class. The resulting models included economic variables and projected increases in energy waste reduction to forecast annual DTEE service-area sales, bundled sales and peak demand.

The methodology to develop the annual DTEE service-area and bundled peak-demand forecast utilizes the hourly electric load model. DTEE also used this model to determine monthly peak demands in the forecast period. The Electric Power Research Institute (EPRI) developed the hourly electric load model, which aggregates hourly demand profiles from various sales categories or end-uses into a system annual load shape. The annual sales and hourly demand profiles for each end-use are inputs to this model.

Normal temperature on the day of the annual peak is assumed to be 83.0 F, which is the mean temperature from Detroit Metropolitan Airport. The value is based upon an average peak-day mean temperature for a 30-year period (1981 through 2010). The mean temperature is calculated as the average of the high and low temperatures for the day. The peak day is assumed to occur on a weekday in July or August. In addition, normal weather conditions were utilized for the projection of weather-sensitive sales.

The energy forecast was developed from the bottom up, utilizing a model for each customer class. The models' results were added together to obtain the total service-area sales forecast. The Electric Choice sales forecast was subtracted from the service-area sales forecast to obtain the bundled sales forecast. The residential class accounts for approximately 32 percent, commercial class 42 percent and industrial class 25 percent of the service area forecast sales. Service area forecast peak sales are comprised of approximately 47 percent residential class, 39 percent commercial class and 14 percent industrial class. The allocation of customer classes for both sales and peak demand is shown in the figures below.

10.2 Customer Classes

For most of the forecast's sectors, electricity sales levels are related to various economic, technological, regulatory and demographic factors that have affected them in the past. The process began with the gathering of historical data related to the forecast's various sectors. This data was examined, and the factors that were statistically significant in explaining electric sales were identified using regression techniques. Forecast models were developed employing the appropriate regression equations. Forecasts of economic variables or explanatory factors, such as motor vehicle production, steel production, employment and other economic indicators were entered in the forecast models to calculate projected future sales levels.

Residential

Electricity sales in the residential class were forecast by an end-use method including 39 different appliances or appliance groups. For each forecast year, three separate items were forecast: saturation of major appliances; number of residential customers; and average electricity use per appliance. For each appliance, the product of these three forecast values yielded the annual electricity sales.

The Company conducts a residential appliance saturation survey, the most recent survey used in this forecast was conducted in late 2016. The survey was sent to a representative sample of DTEE's residential customers. Some of the questions asked whether the customer had certain appliances and whether the appliances were last replaced. The responses helped the Company to understand the penetration of appliances in the DTEE's service area. These insights were then applied to the residential forecast model. The total for all appliances is the total annual residential-class electricity sales.

The federal government has enacted energy-efficiency standards for many appliances. The end-use approach incorporates projected increases in energy efficiency of the various appliances into the residential-class electricity sales. The Company uses federal energy-efficiency standards to determine the decrease in use per appliance. As most customers do not buy a new appliance just because a more energy-efficient one becomes available, the Company phases in the decrease in energy usage, which over time drives down residential customer electricity usage.

The number of residential customers was forecast using the annual percentage change in households. This percentage change was applied to the prior year's customer count to obtain the forecast of customers for that year.

FIGURE 10.1.1: Forecasted 2019 Service Area Sales

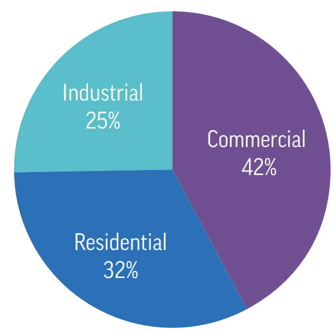


FIGURE 10.1.2: Forecasted 2019 Service Area Peak by Customer Class

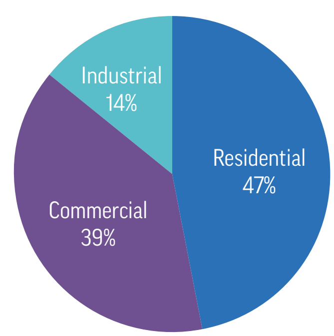
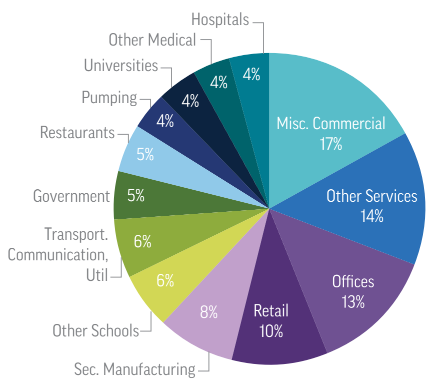


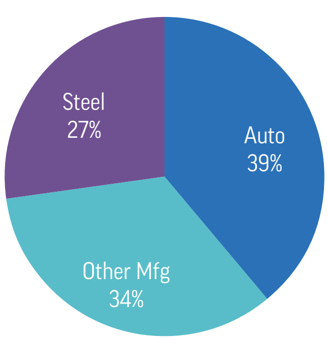
FIGURE 10.2.1: Forecasted 2019 Commercial Sales



Commercial

Sales for most commercial class sectors were forecast using regression models. Explanatory variables included population, employment and local automotive production. Other markets, such as agricultural supply, farming and apartments, were forecast with time trend models and were combined with the previous regression models to obtain total commercial-class electricity sales. The figure below shows the commercial class sectors and their respective percentage of the total commercial sales volumes in 2019.

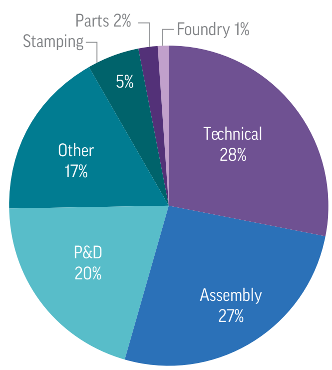
FIGURE 10.2.2: Forecasted 2019 Industrial Sales



Industrial

Industrial class sales consist of three large sub-classes: automotive, primary metals (steel) and other manufacturing sales. The sub-classes' relative sizes are shown in the figure below.

FIGURE 10.2.3: Forecasted 2019 Automotive Sales



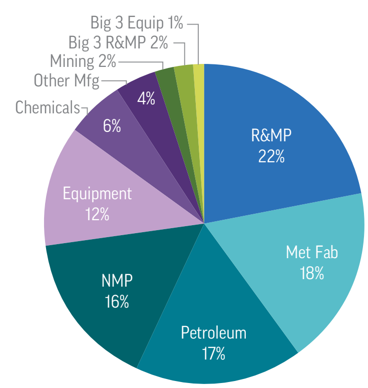
Auto

The automotive sector was disaggregated into seven groups of automotive facilities, as shown in the figure below: assembly plants, stamping plants, powertrain/drivetrain plants (P&D), research and administrative facilities (technical), other parts plants, part suppliers, foundries and other automotive plants. The automotive sector's electricity sales were forecast using regression-based models, with automotive production as the primary explanatory variable. Additional sales impacts from announced plant closings and expansions and/or plant-specific information also were factored into these models.

Steel

Three large producers account for almost 60 percent of steel sales. Because of the market's high concentration and volatility, forecasting steel sales can be challenging. Global market conditions can have a significant effect on local steel production.

FIGURE 10.2.4: Forecasted 2019 Other Manufacturing



Other Manufacturing

The other manufacturing sector of the industrial class was disaggregated into 10 markets and sub-markets: chemicals, petroleum, rubber and plastics (R&MP), mining, non-metal processing (NMP), metal fabrication, manufacturing equipment, other manufacturing, Big Three R&MP, and Big Three manufacturing equipment. Electricity sales for most of these markets were also forecast using regression-based models with automotive production, manufacturing employment and other economic indicators as variables. The markets' relative sizes are shown in the figure below.

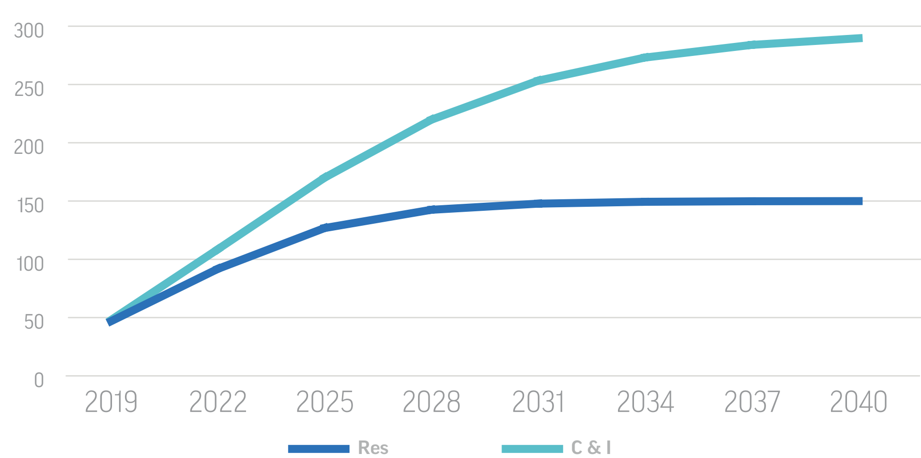
10.3 Demand Side Management & Emerging Technologies

Future demand side management and emerging technologies, including EWR, distributed generation and electric vehicles, were incorporated into the long-term load forecast as exogenous variables. Demand Response programs were not explicitly included in the forecast peak. However, demand response programs were included in determining the Company's required amount of unforced capacity need to meet the MISO Adequacy requirements for the forecast MISO coincident peak demand for the DTEE bundled load.

EWR

The base, or starting point, forecast assumes a 1.5 percent EWR savings level and was modeled in the three customer class models. Since the residential class's forecast was derived from an end-use method, the EWR savings were a direct input from the 1.5 percent EWR program for residential customers. The EWR in the residential model was divided into seven distinct categories: lighting, refrigeration, water heating, appliances, heating, cooling and miscellaneous. The historical sales in the regression models captured the impact of the Company's previous EWR programs and the incremental energy savings were applied to the commercial and industrial models.

FIGURE 10.3.1: Distributed Generation Forecast (GWh)

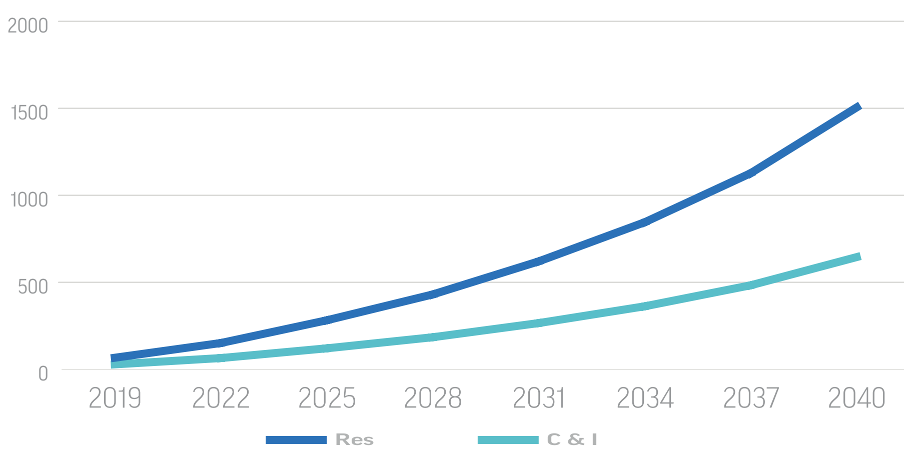


Distributed Generation

The long-term load forecast included an outlook of future distributed generation in the residential, commercial and industrial models. Photovoltaic systems were a large portion of the distributed generation forecast, which was based on the Company's existing interconnections. Utilizing the historical data, an S-shaped market adoption curve was applied to generate the distributed generation outlook. The growth rates between the three customer classes range from five to seven percent, which are aligned with PACE Consulting and EIA1 growth assumptions for distributed generation. The figure below displays each customer class's distributed generation projection.

Additionally, in the university sector, co-generation facilities have been developed which will reduce sales by approximately 250 GWh annually by 2020. The annual sales reduction was based on discussions with the customers and the Company's account managers. This information was then utilized to estimate the sales impact and subtracted from the universities market within the commercial model to account for the reduction in sales.

FIGURE 10.3.2: Electric Vehicle Forecast (GWh)



Electric vehicles represent about 1.5 percent of light-duty vehicle sales.

Electric Vehicles

Electric vehicles represent about 1.5 percent of light-duty vehicle sales. In early 2018, electric vehicle sales in Michigan reached 15,300 and total light-duty vehicle sales were approximately 600,000 units. Future electric-vehicle adoption, including both all-battery and plug-in hybrid light vehicles, were incorporated into the long-term forecast using this historical data. According to GTM Research, approximately 70 percent of electric vehicle charging is done at personal residences, while the other approximately 30 percent is done at a non-residential location[1] . Therefore, 70 percent of the electric vehicle sales forecast was applied to the residential model as an additional end use. The remaining 30 percent was applied to the commercial and industrial models. The outlook for electric-vehicle charging's impact to annual sales is displayed in the figure above.

1 "The Impact of Electric Vehicles on the Grid Customer Adoption, Grid Load and Outlook" GTM Research. GTM Research is the market analysis and advisory arm of Greentech Media.

10.4 Prior Year Load Forecasts

The compounded annual growth rate for 2014-2018 is -0.4 percent. The table below includes the previous five-year service-area load forecasts and actual weather-normalized sales

TABLE 10.4.1: Historical Growth in Electric Sales[1]

	Service Area Forecast	Service Area Actual TN Sales	Year Over Year CAGR
2014	48,535	47,737	
2015	48,103	46,962	-1.6%
2016	47,373	47,551	1.3%
2017	47,102	47,206	-0.7%
2018	46,759	47,072	-0.3%
		2014-2018 CAGR	-0.4%

1 Actual sales are weather normalized

10.5 IRP Starting Point: Sales & Demand Forecast

The starting points for service-area sales and peak demand, over the forecast period 2019 through 2040, are expected to decline annually an average of 0.1 percent and 0.3 percent respectively. The growth rate for bundled sales was the same as the service area due to a steady Electric Choice sales forecast. The figures below show the starting point forecast sales and peak demand. The Electric Choice sales forecast was based on weather-normalized sales through May 2018 and forecasted sales for June through December 2018 which were expected to be 4,840 GWh. The forecast for Electric Choice sales were kept flat at that level. Market clearing prices are not expected to increase significantly from current levels, therefore, no other changes in Electric Choice sales were forecasted.

FIGURE 10.5.1: Annual Sales (GWh)

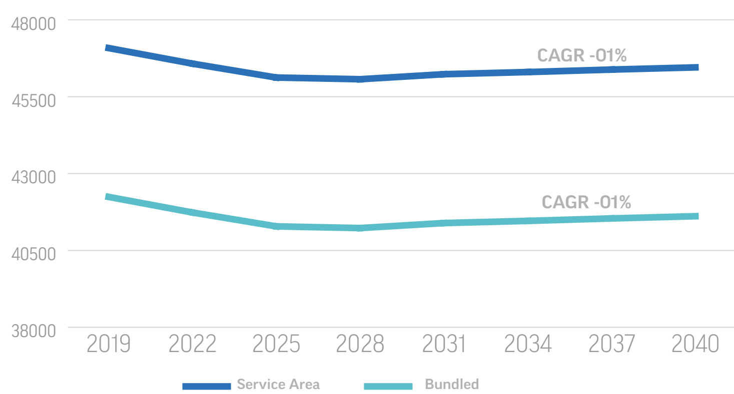


FIGURE 10.5.2: Annual Peak Sales (MW)

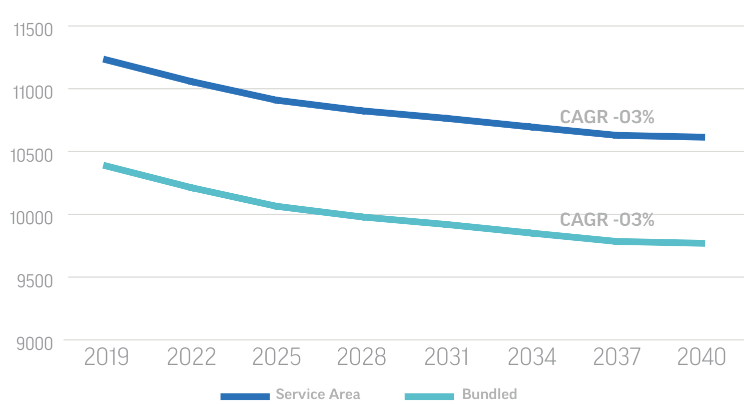


Table 10.5.3: IRP STARTING POINT - Service Area Electric Sales and Demand

	Sales		Losses	System Output		Load	Peak	
Year	(GWh)	% Change	(GWh)	(GWh)	% Change	Factor	(MW)	% Change
2010	50,706		3,541	54,248		53.0	11,687	
2011	51,006	0.6%	3,404	54,410	0.3%	49.5	12,547	7.4%
2012	48,643	-4.6%	3,640	52,282	-3.9%	48.9	12,201	-2.8%
2013	48,379	-0.5%	3,513	51,892	-0.7%	50.8	11,669	-4.4%
2014	47,480	-1.9%	3,579	51,059	-1.6%	53.1	10,970	-6.0%
2015	47,072	-0.9%	3,836	50,908	-0.3%	54.5	10,660	-2.8%
2016	48,601	3.2%	3,394	51,995	2.1%	51.8	11,422	7.2%
2017	47,142	-3.0%	3,203	50,345	-3.2%	54.5	10,554	-7.6%
2018	48,527	2.9%	3,644	52,172	3.6%	52.2	11,418	8.2%
2019	47,081	-3.0%	3,352	50,433	-3.3%	51.3	11,230	-1.6%
2020	46,920	-0.3%	3,344	50,264	-0.3%	51.3	11,188	-0.4%
2021	46,853	-0.1%	3,340	50,193	-0.1%	51.4	11,143	-0.4%
2022	46,574	-0.6%	3,326	49,900	-0.6%	51.5	11,057	-0.8%
2023	46,400	-0.4%	3,317	49,717	-0.4%	51.6	11,006	-0.5%
2024	46,268	-0.3%	3,311	49,579	-0.3%	51.6	10,959	-0.4%
2025	46,123	-0.3%	3,303	49,426	-0.3%	51.7	10,909	-0.5%
2026	46,003	-0.3%	3,297	49,300	-0.3%	51.8	10,865	-0.4%
2027	46,033	0.1%	3,300	49,333	0.1%	51.9	10,847	-0.2%
2028	46,068	0.1%	3,303	49,371	0.1%	52.1	10,824	-0.2%
2029	46,117	0.1%	3,307	49,424	0.1%	52.2	10,803	-0.2%
2030	46,218	0.2%	3,314	49,532	0.2%	52.4	10,796	-0.1%
2031	46,231	0.0%	3,315	49,546	0.0%	52.5	10,764	-0.3%
2032	46,271	0.1%	3,318	49,590	0.1%	52.7	10,743	-0.2%
2033	46,292	0.0%	3,320	49,612	0.0%	52.8	10,721	-0.2%
2034	46,301	0.0%	3,321	49,622	0.0%	53.0	10,695	-0.2%
2035	46,322	0.0%	3,323	49,645	0.0%	53.1	10,674	-0.2%
2036	46,352	0.1%	3,325	49,677	0.1%	53.2	10,652	-0.2%
2037	46,381	0.1%	3,327	49,708	0.1%	53.4	10,629	-0.2%
2038	46,386	0.0%	3,328	49,714	0.0%	53.5	10,601	-0.3%
2039	46,411	0.1%	3,330	49,741	0.1%	53.5	10,607	0.1%
2040	46,453	0.1%	3,332	49,785	0.1%	53.5	10,615	0.1%
Compound Annual Growth Rate 2019-2040								
	-0.06%			-0.05%			0.02%	

The table to the left shows DTEE's service-area sales, net system output, load factor and peak demand for the starting point. Data for 2010-2018 is actual, not weather-normalized. The forecast for 2019-2040 assumes normal weather, see Table 10.5.3.

Table 10.5.4: Service Area Weather-Normalized Electric Sales by Class (GWh)

Year	Residential	C & I	Other	Total	% Change
2010	14,980	31,401	3,210	49,591	
2011	15,213	31,544	3,136	49,894	0.6%
2012	15,062	31,483	958	47,503	-4.8%
2013	15,249	32,189	942	48,379	1.8%
2014	15,115	32,106	517	47,737	-1.3%
2015	15,055	31,617	291	46,962	-1.6%
2016	15,182	32,105	264	47,551	1.3%
2017	14,982	31,966	258	47,206	-0.7%
2018	14,955	31,893	224	47,072	-0.3%
2019	14,910	31,948	223	47,081	0.0%
2020	14,898	31,804	218	46,920	-0.3%
2021	14,851	31,787	215	46,853	-0.1%
2022	14,794	31,567	213	46,574	-0.6%
2023	14,764	31,421	214	46,400	-0.4%
2024	14,750	31,304	214	46,268	-0.3%
2025	14,735	31,173	215	46,123	-0.3%
2026	14,728	31,060	215	46,003	-0.3%
2027	14,717	31,100	216	46,033	0.1%
2028	14,703	31,149	216	46,068	0.1%
2029	14,690	31,211	216	46,117	0.1%
2030	14,683	31,319	216	46,218	0.2%
2031	14,667	31,348	216	46,231	0.0%
2032	14,657	31,398	216	46,271	0.1%
2033	14,646	31,429	216	46,292	0.0%
2034	14,636	31,448	216	46,301	0.0%
2035	14,628	31,478	216	46,322	0.0%
2036	14,620	31,516	216	46,352	0.1%
2037	14,612	31,554	216	46,381	0.1%
2038	14,604	31,566	216	46,386	0.0%
2039	14,597	31,598	216	46,411	0.1%
2040	14,589	31,648	216	46,453	0.1%
Compound Annual Growth Rate 2019-2040					
	-0.10%	-0.04%	-0.15%	-0.06%	

Table 10.5.4 shows DTEE's weather-normalized service-area sales by customer class for the starting point. Other historical class sales include wholesale for resale sales as various contracts expired through mid-2014. The total growth rate for 2019-2040 is -0.06 percent.

10.6 Forecast Sensitivities

To manage future uncertainties, sensitivities were developed exploring a range of higher and lower sales and peak demand levels. The alternative sensitivities, excluding the sensitivities completed in accordance with the Commission's final order in Case No. U-18418, include High Electric Vehicles, 24 percent Electric Vehicle Sales by 2030, Electric Choice Cap Increase to 25 percent, and Electric Choice Return to Full Service. The various sensitivities are displayed in the figures below.

High Electric Vehicles

The High Electric Vehicle sensitivity was based on the Bloomberg New Energy Finance (BNEF)3 2017 long term EV outlook. BNEF's outlook assumes high electric vehicle adoption rates resulting from assumed declining prices, enhanced autonomy technology and mobility. Battery electric vehicles are expected to dominate the market by 2025 due to an assumed production phase-out of plug-in hybrid electric vehicles due to the engineering complexity and dual powertrains. BNEF estimated the global annual electric-vehicle percentage of new sales for 2020 at 3.5 percent, for 2025 at 11 percent and for 2030 at 35 percent. The sensitivity's projected annual sales percentages between the identified years and after 2030 were developed using linear growth.

24 Percent Electric Vehicles Sales by 2030

This sensitivity was submitted through the stakeholder collaboration process and was defined as 24 percent of the new car fleet in the DTEE service area to be electric vehicles by 2030. The High Electric Vehicle sensitivity was used as a starting point and adjusted downward to get the market penetration in 2030 from 35 percent to 24 percent.

Electric Choice Cap Increases to 25 Percent

This sensitivity was also submitted through the stakeholder collaboration process to assess the impact of increasing the retail open access from 10 percent to 25 percent by 2023. A linear phase out of full-service customer load was assumed, beginning in 2020 until full 25 percent transfer to Electric Choice in 2023.

FIGURE 10.6.1: Load Sensitivity Bundled Sales (GWh)

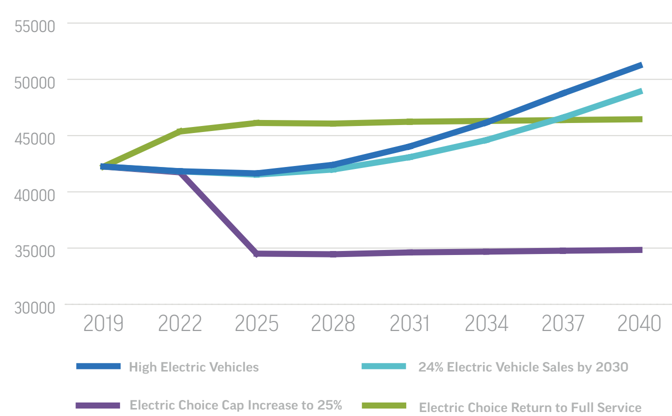
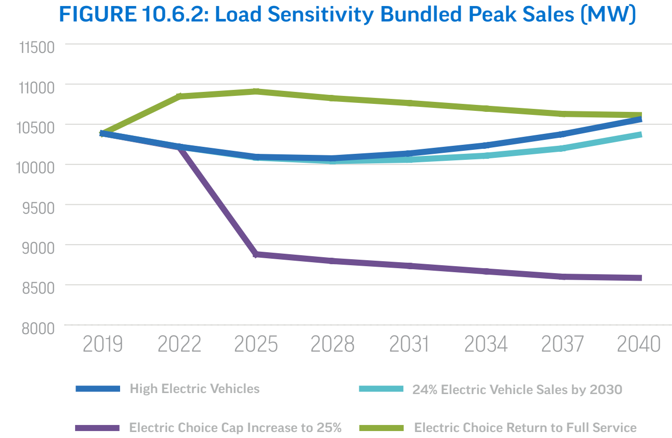


FIGURE 10.6.2: Load Sensitivity Bundled Peak Sales (MW)



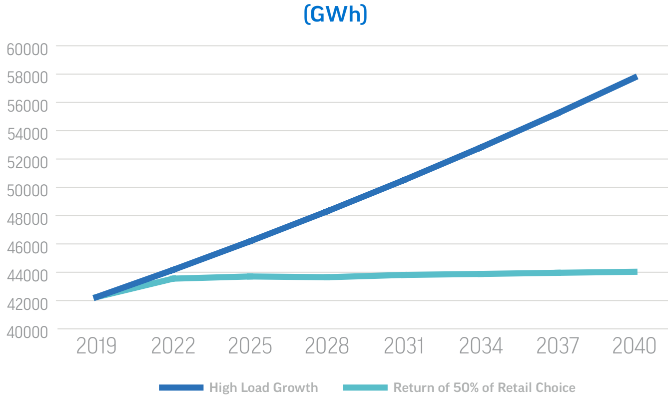
Electric Retail-Choice Return to Full Service

The Electric Choice Return to Full Service sensitivity assumes that all retail open access customers return as DTEE full service customers by 2023. A linear phase in was assumed, beginning in 2020 until all customers were full service in 2023.

High Load Growth and 50 Percent Electric Retail-Choice Return

The Commission's final Order, Case No. U-18418, specified the IRP modeling parameters and requirements. It also specified sensitivities within the parameters regarding the load projection. Under the business-as-usual scenario, two sensitivities were required: *(a) High load growth: Increase the energy and demand growth rates by at least a factor of two above the business-as-usual energy and demand growth rates. In the event that doubling the energy and demand growth rates results in less than a 1.5 percent spread between the business-as-usual load projection and the high-load sensitivity projection, assume a 1.5 percent increase in the annual growth rate for energy and demand for this sensitivity. (b) If the utility has retail-choice load in its service territory, model the return of 50 percent of its retail-choice load to the utility's capacity service by 2023*[2]. For the emerging technologies and environmental scenarios, the high load growth sensitivity was required as well. The alternative forecast sensitivities, in accordance with Case No. U-18418, are displayed in the figure below.

FIGURE 10.6.3: U-18418 Alternative Forecast Sensitivity Sales (GWh)



2 Exhibit A, Order issued 11/21/2017 in MPSC Case No. U-18418, page 16.

A comparison of the growth rates for all the sensitivities is shown in the table below.

From 2019-2040	Service Area Sales	Bundled Sales	Service Area Peak	Bundled Peak
Starting Point	-0.1%	-0.1%	-0.3%	-0.3%
High Electric Vehicles	0.8%	0.9%	0.1%	0.1%
24% Electric Vehicle Sales by 2030	0.6%	0.7%	0.0%	0.0%
Electric Choice Cap Increase to 25%	-0.1%	-0.9%	-0.3%	-0.9%
Electric Choice Return to Full Service	-0.1%	0.5%	-0.3%	0.1%
High Load Growth	1.5%	1.5%	1.5%	1.5%
Return of 50% of Retail Choice	-0.1%	0.2%	-0.3%	-0.1%

DTE

SECTION ELEVEN

11 Capacity & Reliability Requirements

11.1 Markets

Midcontinent Independent System Operator

DTEE is a market participant in the Midcontinent Independent System Operator (MISO), which is a Regional Transmission Organization (RTO) that was established to ensure reliability and grid stability across 15 U.S. states and Manitoba.

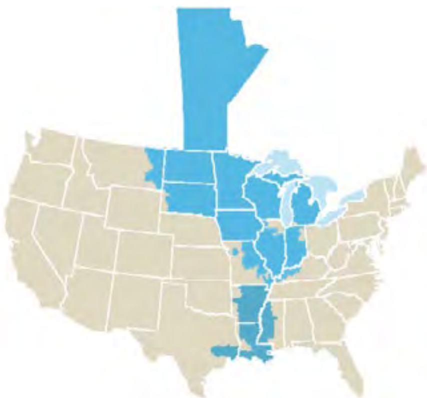
MISO Energy Market

MISO administers day-ahead and real-time markets for operating reserves where each of the three operating reserve products – regulating, spinning and supplemental – are bought and sold. Regulating reserve is the ability to generate resources to raise or lower output to follow the moment-to-moment changes in demand and frequency. Spinning reserve is synchronized unloaded resource capacity set aside to be available to immediately offset deficiencies in energy supply that result from a resource contingency or other abnormal event. Supplemental reserve is unloaded (possibly off-line) resource capacity set aside to be fully available within the contingency reserve deployment period (typically 10 minutes) to offset deficiencies in energy supply that result from a resource contingency or other abnormal event.

Reactive supply and voltage control is supplied by facilities that can be operated to produce or absorb reactive power to control voltage on the system. MISO/ITC administers this service, ensuring it is sold by qualified generators and purchased by transmission customers.

These products' current value in the MISO market is relatively small. However, their value may increase in the future as renewable generation penetration increases..

FIGURE 11.1.1 - MISO Service Territory



MISO Ancillary Service Market

MISO administers day-ahead and real-time markets for operating reserves where each of the three operating reserve products – regulating, spinning and supplemental – are bought and sold. Regulating reserve is the ability to generate resources to raise or lower output to follow the moment-to-moment changes in demand and frequency. Spinning reserve is synchronized unloaded resource capacity set aside to be available to immediately offset deficiencies in energy supply that result from a resource contingency or other abnormal event. Supplemental reserve is unloaded (possibly off-line) resource capacity set aside to be fully available within the contingency reserve deployment period (typically 10 minutes) to offset deficiencies in energy supply that result from a resource contingency or other abnormal event.

Reactive supply and voltage control is supplied by facilities that can be operated to produce or absorb reactive power to control voltage on the system. MISO/ITC administers this service, ensuring it is sold by qualified generators and purchased by transmission customers.

These products' current value in the MISO market is relatively small. However, their value may increase in the future as renewable generation penetration increases.

DTEE sells generation and purchases energy from the wholesale power market in both the day-ahead and real-time energy markets, and participates in the MISO Resource Adequacy process.

MISO Capacity Market

MISO has a hybrid voluntary annual capacity construct that requires all available generation in the MISO region to participate in an annual planning resource auction and be available for all 8,760 hours of the following MISO planning year. Load-serving entities can either participate in the auction (bid their load into annual auction) or pay a capacity deficiency charge. The MISO Planning Year (PY) runs from June 1 to May 31. The forward capacity market is designed to ensure sufficient resources are in place to reliably serve load on a forward-looking basis. Load-serving entities can meet their Planning Reserve Margin Requirement (PRMR) by offering capacity resources and demand to the auction through one, or both, of the following methods:

- Offering or self-scheduling capacity resources and bidding load demand into the auction
- Opting out of the auction by submitting a Fixed Resource Adequacy Plan, which offsets capacity resources and load demand

11.2 Resource Adequacy Construct

Planning Reserve Margin Requirement (PRMR)

Under the MISO Resource Adequacy construct, MISO sets an annual capacity requirement for the following planning year – the PRMR – for load-serving entities based on their peak demand forecast coincident with the MISO peak, plus a planning reserve margin. The planning reserve margin is established to confirm there is sufficient generation resource capacity to ensure that interruption of firm customer demand – known as "loss of load expectation" – occurs no more frequently than one day in 10 years. MISO requires all market participants to secure resources to meet the PRMR and thus achieve the loss of load expectation.

In simpler terms, demand (load) must be balanced with supply (resources). If the two are unbalanced, there is either an excess of capacity and supply is greater than demand, or there is a capacity shortfall and demand is greater than supply. A market participant with a capacity shortfall to its PRMR is required to purchase sufficient zonal resource credits for the entirety of the MISO planning year to avoid paying a capacity deficiency charge. In addition, MCL 460.6w (PA 341) requires the Company to demonstrate, annually, that it will have sufficient resources to meet its projected planning reserve margin on a four-year forward basis. This Michigan requirement is intended to ensure proper

longer-term planning for resource adequacy, which is different from MISO's annual planning cycle which focuses on one-year

FIGURE 11.2.1: MISO Local Resource Zones (LRZs)

Local Resource Zone	Local Balancing Authorities
1	DPC, GRE, MDU, MP, NSP, OTP, SMP
2	ALTE, MGE, MIUP, UPPC, WEC, WPS
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, CIN, HE, IPL, NIPSCO, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	EMBA, SME

MISO has divided its region into 10 sub-regions known as local resource zones – DTEE's load demand rests entirely within Zone 7

MISO has divided its region into 10 sub-regions known as local resource zones to support regional transmission and system constraints. DTEE's load demand rests entirely within Zone 7; all company-owned and contracted generation-capacity resources, with the exception of L'Anse Warden PPA (Zone 2), are also in Zone 7. Zone 7 PRMR for the 2019-20 MISO planning year is 21,976 MW using MISO preliminary PRA data published 3/22/19.

Local Reliability Requirement

The MISO local reliability requirement is the minimum amount of unforced capacity (the amount of installed capacity available at any time, after accounting for unit forced outage rate) that must be physically located in a local resource zone to maintain a loss of load expectation of one day in 10 years, without consideration of the benefit of imports from other zones by use of the electric transmission system. The MISO Loss of Load Expectation Working Group (LOLEWG) analysis determines the minimum local reliability requirement by either adding or removing planning resources (electric generation) until the loss of load expectation reaches the target of interruption of firm demand no more frequently than one day in 10 years.

Capacity Import Limit and Capacity Export Limit

The LOLEWG determines the capacity import limit and capacity export limit to and from each MISO local resource zone. The limits are effectively the electric transmission import and export capability that can be reliably depended upon to transport power between zones. The LOLEWG updates the limits annually in order to capture changes in these capabilities as a result of modifications to the electric system.

MISO has determined a Zone 7 capacity import limit of 3,211 MW and export limit of 1,358 MW for the 2019/20 PY.

Local Clearing Requirement

To ensure adequate supply and reliability, each zone has a local clearing requirement, or the minimum amount of resources that must be physically located within the zone taking electric transmission import capability into consideration. The local clearing requirement is equal to the local reliability requirement less the capacity import limit for the zone and less non-pseudo tied exports for the zone. The PRMR for the zone less the local clearing requirement equals the effective capacity import limit (ECIL) for that zone. Non-pseudo tied exports are those exports in which MISO maintains dispatch control of the generating resource.

DTEE Capacity Meets PRMR

For the 12-month period beginning June 1, 2019 (MISO PY 2019/20), MISO determined an unforced capacity planning reserve margin (PRMUCAP) of 7.9 percent. Applied to DTEE's adjusted peak demand (plus transmission losses) of 9,960 MW, this results in a DTEE PRM of 787 MW. As discussed in Section 7, DTEE's generation assets include a diverse mix of owned and contracted sources of energy to ensure reliable and economical capacity adequacy for its customers. The Company is meeting its 787 zonal resource credits (ZRCs) of PRM using a combination of baseload, cycling, peaking, intermittent, demand-side and storage resources.

To ensure adequate supply and reliability, each zone has a local clearing requirement, or the minimum amount of resources that must be physically located within the zone taking electric transmission import capability into consideration.

SECTION TWELVE

12 Transmission Analysis

12.1 Transmission Overview

In 2003, DTEE sold its transmission system to ITC Holdings Corp ("ITC"), which became responsible for the ownership, operation, maintenance, and planning of the transmission system in DTEE's service territory. ITC subsequently joined MISO and thereby became bound by its tariff provisions and business practice manuals, which define processes through which the transmission system is operated and planned. Thereafter, MISO became responsible for providing transmission service to the Company.

MISO is a Regional Transmission Organization (RTO) that manages the electric power system in several American states and one Canadian province and is regulated by the Federal Energy Regulatory Commission (FERC). This management includes transmission system planning. The MISO Transmission Expansion Plan (MTEP) process evaluates the need for upgrades to the transmission system for reliability, economic, or policy-driven purposes and establishes a framework for MISO stakeholder input. Although transmission owners are obligated to propose solutions to identified reliability issues on the transmission system, MISO will consider other stakeholder input in its determination of the final project implemented. After stakeholder review, MISO's board of directors approves justified projects to MTEP appendix A, at which point the appropriate transmission owner must make a good-faith effort to construct the project.

12.2 Collaboration with ITC

As part of a joint planning approach, the Company met with ITC to examine the transmission system implications of DTEE's IRP. DTEE met with ITC on six occasions to establish and discuss the studies' scope, the specific scenarios likely most relevant to the IRP, and the studies' results and significance. ITC performed two main analyses: an analysis of the transmission upgrade costs needed to accommodate the Company's IRP and an analysis of the capacity import limit (CIL) under conditions similar to those contemplated in the Company's IRP.

TABLE 12.2.1: ITC Studied Scenarios[1]

Scenario	Case	Imports from Ontario	Ludington Status	Renewables (Incremental in LRZ 7)	New Generation	Retirements
2023 Base	70% Peak Load	1,800 MW	Pumping	2,000 MW Wind; 500 MW Utility Scale Solar; No new DG	1,175 MW at BWEC	TC9, RR3, SC1-3,6,7
	100% Peak Load	-200 MW	Generating			
2023 Base	70% Peak Load	1,800 MW	Pumping	2,000 MW Wind; 500 MW Utility Scale Solar; No new DG	1,175 MW at BWEC	TC9, RR3, SC1-3,6,7
	100% Peak Load	-200 MW	Generating			
2028 Base	70% Peak Load	1,800 MW	Pumping	2,200 MW Wind; 1,500 MW Utility Scale Solar; No new DG	1,175 MW & 500 MW at BWEC	TC9, RR3, SC1-3,6,7, BLRPP 1&2
	100% Peak Load	-200 MW	Generating			
2028 Medium Renewables	70% Peak Load	1,800 MW	Pumping	2,200 MW Wind; 3,500 MW Utility Scale Solar; No new DG	1,175 MW at BWEC	TC9, RR3, SC1-3,6,7, BLRPP 1&2
	100% Peak Load	-200 MW	Generating			
2028 High Renewables	70% Peak Load	1,800 MW	Pumping	2,200 MW Wind; 6,000 MW Utility Scale Solar; 0 MW DG	1,175 MW at BWEC	TC9, RR3, SC1-3,6,7, BLRPP 1&2
	100% Peak Load	-200 MW	Generating			
2028 High Renewables/ D.G.	70% Peak Load	1,800 MW	Pumping	2,200 MW Wind; 4,500 MW Utility Scale Solar; 1500 MW DG	1,175 MW at BWEC	TC9, RR3, SC1-3,6,7, BLRPP 1&2
	100% Peak Load	-200 MW	Generating			
2028 Base + South CT	70% Peak Load	1,800 MW	Pumping	2,200 MW Wind; 1,500 MW Utility Scale Solar; No new DG	1,175 MW & 500 MW at BWEC + 320 MW at Trenton	TC9, RR3, SC1-3,6,7, BLRPP 1&2
	100% Peak Load	-200 MW	Generating			

1 Abbreviations used in Table 12.2.1: CT = Combustion Turbine, DG = Distributed Generation, BWEC = Blue Water Energy Center, TC9 = Trenton Channel Unit 9, RR3 = River Rouge Unit 3, SC = Saint Clair, BLRPP = Belle River Power Plant

In order to identify likely transmission system challenges and opportunities related to its IRP, DTEE requested that ITC study scenarios with varying assumptions about new generation, renewables, and distributed generation. Ultimately, ITC and DTEE agreed upon the seven scenarios documented in Table 12.2.1.

All scenarios assumed 1,175 MW of new generation at the Blue Water Energy Center and the retirements of all existing units at Trenton Channel, River Rouge, and Saint Clair. The 2028 scenarios assumed the retirement of Belle River units 1 and 2.

TABLE 12.2.2: ITC Estimated Scenario Costs

Scenario	Retirements	Additions	Estimated Cost (in Millions)
2023 Base	Trenton Channel 9 River Rouge 3 St. Clair 1-3,6,7	1175 MW at Blue Water Energy Center, 2000 MW Wind, 500 MW Utility Scale Solar, No new DG	$20-$25
2023 Base + South CT	Trenton Channel 9 River Rouge 3 St. Clair 1-3,6,7	1175 MW at Blue Water Energy Center, 2000 MW Wind, 500 MW Utility Scale Solar, No new DG, 220 MW CT at Trenton Channel	$20-$25
2028 Base	Trenton Channel 9 River Rouge 3 St. Clair 1-3,6,7 Belle River 1 & 2	500 MW & 1175 MW at Blue Water Energy Center, 2200 MW Wind, 1500 MW Utility Scale Solar, No new DG	$25-$30
2028 Medium Renewable	Trenton Channel 9 River Rouge 3 St. Clair 1-3,6,7 Belle River 1 & 2	1175 MW at Blue Water Energy Center, 2200 MW Wind, 3500 MW Utility Scale Solar, No new DG	$25-$30
2028 High Renewables	Trenton Channel 9 River Rouge 3 St. Clair 1-3,6,7 Belle River 1 & 2	1175 MW at Blue Water Energy Center, 2200 MW Wind, 6000 MW Utility Scale Solar, No new DG	$25-$30
2028 High Renewables/ DG	Trenton Channel 9 River Rouge 3 St. Clair 1-3,6,7 Belle River 1 & 2	1175 MW at Blue Water Energy Center, 2200 MW Wind, 4500 MW Utility Scale Solar, 1500 MW DG	$25-$30
2028 Base + South CT	Trenton Channel 9 River Rouge 3 St. Clair 1-3,6,7 Belle River 1 & 2	500 MW & 1175 MW at Blue Water Energy Center, 2200 MW Wind, 1500 MW Utility Scale Solar, No new Purpa or DG, 320 MW CT at Trenton Channel	$20-$25

12.3 ITC's Transmission Evaluation

After evaluating all relevant single point of failure outages for each scenario, ITC estimated that the minimum level of incremental transmission investment needed to accommodate the studied scenarios was between $20 million and $30 million, as shown in Table 12.2.2. This amount was considered immaterial by DTEE for purposes of comparing economic alternatives and was not specifically included in the net present value of revenue requirements modeled in the IRP. ITC's cost estimate does not include the potential cost of upgrades outside of ITC's service territory. Also, ITC did not perform transient stability analysis or consider multiple point of failure outages due to the high level of complexity required.

Import capacity is a measure of the transmission system's ability to transfer power from another zone. In MISO's resource adequacy construct, the Capacity Import Limit (CIL) and Capacity Export Limit (CEL) represent the amount of power that can be transferred between zones during the system coincident peak load. The Company's assumptions about the CIL and CEL were based upon public reports from MISO. Specifically, the Company used the 2019/2020 values of 3,211 MW for the CIL and 1,358 MW for the CEL contained in MISO's Loss of Load Expectation (LOLE) Study Report for Planning Year 2019 – 2020.

The Company requested that ITC perform an analysis of capacity imports into Michigan to understand the effects that generation additions and retirements contemplated in the Company's IRP may have on future CIL values. ITC performed this analysis using a methodology consistent with MISO's annual LOLE analysis for six scenario/sensitivity combinations. In order to understand the effects of integrating solar into the state's generation portfolio, ITC evaluated three scenarios of incremental instate solar generation - no solar (0 MW), mid solar (3,500 MW), and high solar (6,000 MW) - comparable to the amount of incremental solar contemplated in the 2028 Base, 2028 Medium Renewable, and 2028 High Renewable scenarios identified in Table 12.2.2. These three scenarios cover the range of solar studied by ITC to determine the amount of incremental transmission investment needed, shown in Table 12.2.2. To understand the effect of alleviating a voltage constraint at the Fermi 345 kV switchyard that was identified in a MISO study of the suspension of Trenton Channel Unit 9, ITC evaluated two sensitivities for each scenario, one using the current voltage criteria and the other that relaxes the criteria at this switchyard to ITC's system-wide criteria under emergency conditions, or 92 percent of the nominal voltage.

Results from ITC's analysis are provided in Table12.2.3 .

TABLE 12.2.3: ITC Capacity Imports Analysis

Scenario	Fermi	DG Solar Installation (CE/DTE load MW)	Utility Wind (MW)	Utility Solar Installation (MW)	Total CIL (MW)
No Solar	0.92 per unit	0	2,200	0	4,283
Mid Solar		750/750	2,200	2,000	4,975
High Solar		1,500/1,500	2,200	3,000	5,437
No Solar	Current Voltage Criteria	0	2,200	0	N/A
Mid Solar		750/750	2,200	2,000	2,494
High Solar		1,500/1,500	2,200	3,000	2,985

As can be seen from this analysis, the Company's plan to integrate solar energy in its IRP would not adversely affect the system's ability to import power from neighboring regions. ITC's analysis also demonstrates the importance of resolving known voltage issues identified at the Fermi 345 kV switchyard. Allowing these issues to remain unmitigated would reduce the CIL to at most 2,985 MW in the scenario with 6,000 MW of additional solar output in the state. In the unmitigated scenario with no additional solar output, the state would have insufficient access to resources to serve load, via instate resources or imports, indicated by "N/A" in the Total CIL column.

Through the MISO stakeholder process, ITC and DTEE have proposed multiple potential solutions to mitigate the voltage issues at Fermi. ITC proposed a Static VAR Compensator (SVC), and DTEE proposed non-transmission alternatives that would leverage Company assets. ITC has indicated that their proposed SVC solution would have a total capital cost of $62 million. The costs associated with the Company's proposed solutions are still under development. ITC and DTEE will continue working through the MISO stakeholder process to find the best solution for the Company's customers.

SECTION THIRTEEN

13 Fuel

13.1 Overview

DTEE has several existing fossil-fuel-generating facilities. The largest portion of DTEE's current capacity mix is coal generators, including those at Monroe, Belle River, St. Clair, River Rouge, and Trenton Channel power plants. DTEE also has gas-fired generating capability at Greenwood, Renaissance, Dean, Belle River Peakers, Delray, Hancock and Northeast, St. Clair, and River Rouge. Furthermore, the Company has oil-fueled over-fire capabilities at its Monroe, Trenton Channel, Belle River, and St. Clair power plants, along with a number of oil-fueled peaking units.

13.2 Natural Gas

Natural gas overview

DTEE currently uses natural gas as the primary fuel at Greenwood, Renaissance, the Belle River Peakers, and Dean sites as well as at other smaller peaking units. Natural gas is also used as a supplemental fuel at the River Rouge and St. Clair coal plants. The Company's Blue Water Energy Center (BWEC), which is expected to be operational in 2022, is a natural-gas-fired 24/7 baseload combined-cycle gas turbine. Depending on the location, natural gas and natural-gas transportation are procured from supply and transportation providers, via third-party marketers, or from local distribution companies.

The Company expects that natural gas will become a more critical fuel for baseload electricity generation for MISO in the future. As this occurs, DTEE will enter into firm gas-supply and gas-transportation contracts, as needed, to ensure fuel-supply reliability. To this end, DTEE entered into an agreement with NEXUS Gas Transmission to provide firm natural-gas transportation from the Utica and Marcellus shale region starting in November 2018. Similar to DTEE's approach to coal and coal-transportation procurement, future gas-supply and firm transportation contracts will be secured to ensure reliability.

Delivered natural-gas prices to existing and planned utility-owned generating plants

Forecast methodology

When forecasting natural-gas prices, the commodity costs are added to the applicable transportation costs to determine the delivered cost of natural gas to each generation facility.

Forecasted natural gas prices

The forecast methodology was based on the forecasted prices at the applicable natural-gas hub locations in or around Michigan, including MichCon CityGate and Dawn. For 2018 and 2019, these prices were determined by using the Chicago Mercantile Exchange (CME) Group/New York Mercantile Exchange (NYMEX) near-term futures prices. A transition period that, starts in 2020 and continues through 2022, draws on a combination of near-term futures prices and the long-term gas-price forecasts from PACE Global. During this transition period, there was a ratable adjustment between the two forecast methodologies; the PACE Global forecast is used exclusively starting in 2023. The transition period is described in further detail in the natural-gas price forecasts under the various scenarios section.

Forecasted transportation prices

Next, forecasted transportation costs were added to the forecasted natural gas prices, as applicable, to represent the costs associated with transporting the gas from the relevant hub to the power plant. Depending on the plant and location, transportation costs may have been based on existing agreements or general service tariff rates.

A brief summary of how natural gas is supplied to each of the Company's gas-fired generators is provided below.

Renaissance

DTEE purchases gas at MichCon CityGate from a third-party gas marketer. DTEE has a firm gas-transportation agreement with DTE Gas to transport that gas on its system to the plant. DTEE's agreement with DTE Gas includes approximately 1.2 Bcf of summer storage capacity and 0.8 Bcf of winter storage capacity.

Greenwood and Greenwood Peakers

Greenwood gas supply and transportation is provided by a third-party gas marketer. The marketer-delivered gas is transported to the ANR Pipeline interconnect with the SEMCO lateral. DTEE has a firm gas-transportation agreement with SEMCO to transport gas from the ANR Pipeline interconnect to the plant. DTEE pays for gas based on prices at the Dawn hub, plus applicable transportation costs.

Dean

DTEE purchases gas at MichCon CityGate and Dawn from a third-party gas marketer. DTEE has a firm transportation agreement with DTE Gas to transport that gas to the plant. DTEE also has an agreement with DTE Gas for balancing services, which includes approximately 0.3 Bcf of storage capacity.

Belle River Peakers

DTEE purchases gas from third-party marketers at the China Township point on the Great Lakes Gas Transmission pipeline. DTEE has a firm transportation agreement with SEMCO to transport gas from Great Lakes Gas Transmission to the Belle River Peakers.

Delray and River Rouge

DTEE purchases gas at MichCon CityGate from third-party gas marketers. DTEE has a firm transportation agreement with DTE Gas to transport that gas to the plants. DTEE's transportation agreements with DTE Gas include approximately 0.14 Bcf of storage capacity.

Hancock and Northeast

DTEE purchases delivered natural gas from Consumers Energy under LDC tariff service.

St. Clair Power Plant and Peakers

DTEE purchases delivered natural gas from SEMCO Energy under LDC tariff service.

Blue Water Energy Center

For a 24/7 baseload generator such as BWEC, the Company expects to enter into firm transportation and storage agreements to ensure supply reliability. Three large natural-gas transmission pipelines - Vector Pipeline, DTE Gas Co. and Great Lakes Gas Transmission - run approximately one mile north of the site. The site is further advantaged by several nearby natural gas storage facilities. DTE Gas, Washington 10 Storage Corp., Enbridge Gas, ANR Pipeline Co., and Bluewater Gas Storage have more than 400 Bcf of storage capacity within approximately 50 miles of the site. In addition, natural gas hubs at MichCon (upstream) and Dawn (downstream) provide liquid markets for procuring natural-gas supplies. This IRP assumes estimated annual fixed fuel costs of $15.7 million for transportation and $4.5 million for storage.

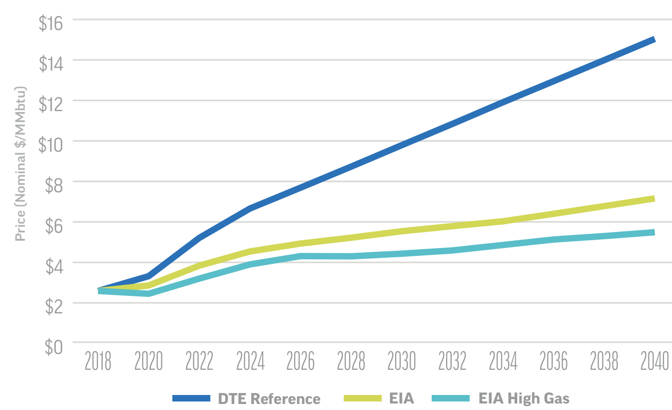
Assumptions for New Gas Sites

For modeling of potential new gas-fired combustion turbines, the Company assumed that the natural-gas price forecast would be the same as for the Belle River Peakers site. For any potential new gas-fired combined-cycle gas turbines, the BWEC costs were applied to the potential CCGT supply resources evaluated in the IRP process by scaling the costs based on the plant capacity. The firm services estimated provide for a high level of natural gas supply reliabiltiy to a power plant.

Natural gas price forecasts utilized for IRP modeling

Three natural-gas price forecasts, at each relevant gas hub, were utilized for modeling; Reference, 2018 EIA, and 2018 EIA High Gas. Figure 13.2.1 shows these natural-gas price forecasts based on the MichCon gas hub and reflects the commodity price used for modeling a combined-cycle gas-turbine alternative. The natural-gas forecast for the Dawn gas hub, also used in IRP modeling, is included in Exhibit A-4 Appendix I.

Figure 13.2.1: Annual Natural Gas Price – MichCon Gas Hub



The DTE Reference natural-gas forecast was used in the REF scenario. As the forecast methodology section states, the first two years were based on forecasted prices at each applicable hub. The next three years were a transition from these forecasted prices to the long-term gas price forecast from Pace Global.

The 2018 EIA natural-gas forecast was used in the three required scenarios, with the 2018 EIA High Gas being used in the high-gas sensitivities. The first two years are again based on forecasted prices at each applicable hub, with the following three years as a transition from these prices to the long-term gas price forecast from the 2018 EIA.

Lastly, the 2018 EIA High Gas natural-gas forecast was used in all the high-gas sensitivities. The first two years were again based on forecasted prices at each applicable hub. However, the next three years were a transition from these prices to the long-term 200 percent gas price based on the forecast from the 2018 EIA.

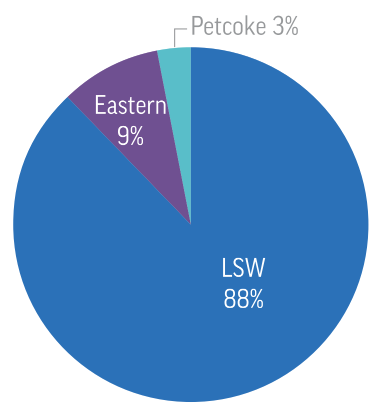
13.3 Coal

Coal Overview

DTEE's coal-fueled power plants consume a combination of Low Sulfur Western coal (LSW), High Sulfur Eastern coal (HSE), and Low Sulfur Southern coal (LSS), along with petroleum coke, as shown in Figure 13.3.1. LSW accounts for approximately 88 percent of the Company's coal consumption annually, due to its favorable pricing and emissions when compared to the eastern (HSE and LSS) coal types. Although LSW is historically lower in cost on a per-ton delivered basis, most of the Company power plants have the ability to blend the previously mentioned eastern coal types with LSW in an effort to utilize their higher heat content and maximize production during high-market opportunities.

Blending of LSW and eastern coal types provides operational flexibility, maximizes customer value, and maintains environmental and regulatory compliance.

FIGURE 13.3.1 - DTE Electric 2018 Coal Consumption



Delivered coal prices to existing utility generating plants

Forecast methodology

Coal commodity costs were added to the applicable transportation rate (including railcar costs if applicable) to determine the delivered cost of coal by route to each generation facility. Beyond the forecast's first five years, the Company utilized the PACE Global forecast.

Forecasted coal prices

The forecasted coal cost was developed by utilizing existing contract prices and forecasted forward-market prices. Forecasted forward-market coal prices for the first three years were based upon existing contract rates and market information obtained from an over-the-counter coal broker. For forecast years four and five, the forecasted coal cost was derived by applying an inflation index factor to the forward-market coal prices. Beyond the five-year forecast, LSW prices from the forecast's last year were escalated by the annual year-over-year change in the PACE Global forecast. For HSE price forecasting, there was a direct switch to the PACE Global forecast after the end of the five-year forecast period.

Forecasted transportation prices

The near-term transportation rates were computed by applying adjustments to the existing contract rates using either prescribed periodic rate increases, or rate increases based upon contractually defined indices. In the latter case, historical data was utilized to project future rate adjustments.

A brief summary of how coal is supplied to each of the Company's coal-fired generators is provided below.

Belle River Power Plant

Belle River consumes exclusively LSW from Montana, which is transported via rail to DTEE's subsidiary, Midwest Energy Resources Co. (MERC), in Superior, Wisc., which provides trans-shipment services to DTEE and other third-party customers. The coal is then held in inventory and subsequently loaded into lake freighters for transportation to the power plant.

Monroe Power Plant

Monroe consumes a combination of LSW from Wyoming, HSE from the Northern Appalachia region, and petcoke. All three of these fuels can be delivered via rail and vessel; petcoke also has a truck delivery option. LSW and petcoke vessel shipments utilize MERC as a trans-shipment facility while HSE vessel shipments utilize various Lake Erie docks for trans-shipment. Monroe also blends petcoke with coal. Petcoke is an economic fuel that provides higher heat content when compared to coal. It is consumed only at Monroe Power Plant due to its emissions-control equipment

River Rouge Power Plant

River Rouge consumes a combination of LSW from Wyoming and LSS from the Central Appalachia region. Both fuels are delivered via rail.

St. Clair Power Plant

St. Clair consumes a combination of LSW from Montana and HSE coal from the Northern Appalachia region. The LSW is transported via rail to MERC and is loaded into lake freighters for transportation to the power plant. HSE deliveries are primarily made via rail.

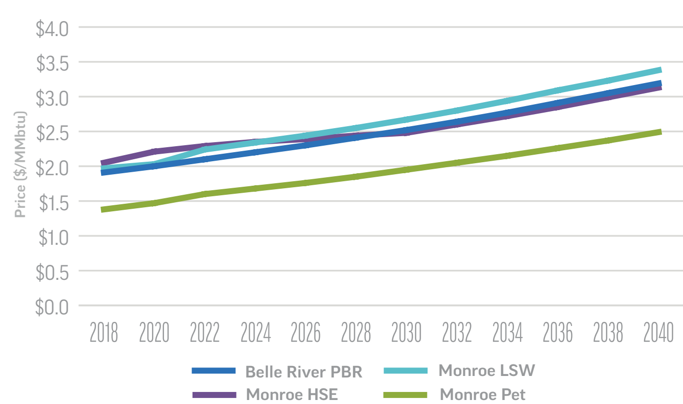
Trenton Channel Power Plant

Trenton Channel consumes a combination of LSW from Wyoming and HSE from the Northern Appalachia region. Both fuels can be delivered via rail or vessel, in the latter case utilizing MERC (LSW) and/or Lake Erie docks (HSE and LSW).

Coal-price forecasts utilized for IRP modeling

The coal-price forecast utilized for the modeling was constant among all scenarios. Please refer to figure 13.3.2 below, which shows the coal prices for Belle River Power Plant LSW, Monroe Power Plant LSW, Monroe Power Plant HSE, and Monroe Power Plant petcoke.

FIGURE 13.3.2 – Annual Delivered Coal Price



13.4 Oil

Oil Overview

The Company uses diesel fuel oil for start-up and over-fire capabilities of its coal-fired generating units. Diesel is also the primary fuel at the Company's diesel peaking generator units.

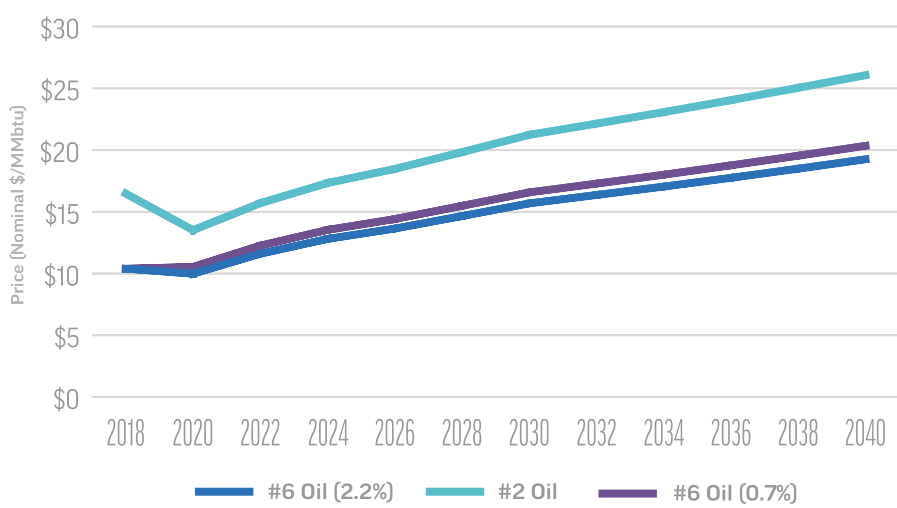
Delivered oil prices to existing utility generating plants

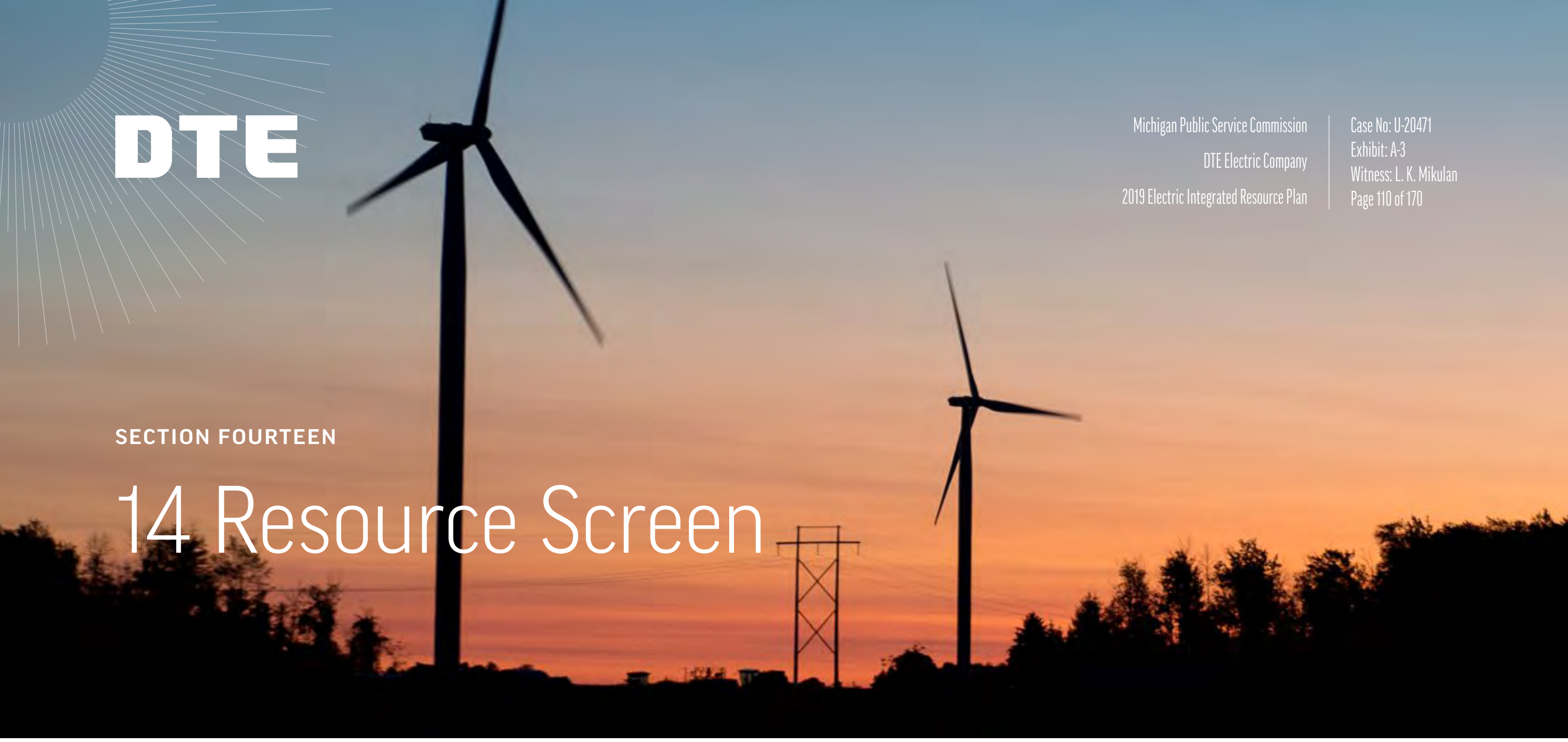
Fuel oil's forecasted delivered cost was determined by using the NYMEX futures prices, in addition to expected transportation costs. Agreements are in place for fuel-oil supply and transportation. Fuel oil is held in inventory and ordered as needed, and delivered via truck to the respective site. For the forecast's first two years, fuel-oil supply and transportation pricing were market-index-based, with a markup applied by the supplier. Starting in the forecast's third year, the PACE Global forecast was utilized exclusively for forecasted fuel-oil pricing.

Oil-price forecasts utilized for IRP modeling

The oil-price forecast used for the modeling was constant among all the scenarios. Please refer to Figure 13.4.1 below, which shows the oil prices for no. 2 oil, no. 6 oil (0.7 percent), and no. 6 oil (2.2 percent).

FIGURE 13.4.1: Delivered Annual Oil Prices





SECTION FOURTEEN

14 Resource Screen

14.1 Overview

The goal of resource screening is to ensure the modeling includes only technologies that are economical or provide a market value benefiting customers. The model was designed to identify the lowest-cost resource options, so including a resource that is uneconomical or is low in market value when compared with other resource alternatives would only result in the model never selecting that resource. Therefore, screening out the uneconomical or low-market-value resources maximizes the modeling effort to identify economical resources.

The IRP considered a multitude of potential supply-side and demand-side resources. DTEE performed a screening process using technical feasibility, levelized cost of energy, and market evaluation to whittle down the number of alternative technologies included in the Strategist® optimization modeling. Reducing the number of alternative technologies available in optimization runs is an important step, as too many alternatives in the model can increase the problem size exponentially and render it unsolvable. (See illustrative example next page).

TABLE 14.1.1: Model Decision Tree Example

	50 Alternatives	10 Alternatives
Model Year	**# of Decision Trees**	**# of Decision Trees**
Year 1	50	10
Year 2	2,500	100
Year 3	125,000	1,000
Year 4	6,250,000	10,000
Year 5	312,500,000	100,000

The methods for screening and evaluating technology options are described below.

14.2 Existing & Planned Resources

As described in Sections 7 and 8, the Company has a diverse portfolio of existing supply-side and demand-side resources to meet our customers' energy needs. In addition to existing resources, the Company has planned resources that are included in the study period, including specific projects approved, or submitted with requests for approval, in prior regulatory proceedings with the Michigan Public Service Commission. As discussed in Section 9, the Company has developed a build plan of future wind and solar assets to meet Michigan's Renewable Portfolio Standards as well as its commitment to achieve 50 percent clean energy by 2030 and an 80 percent CO_2 reduction by 2050. Below is a summary of planned resources that were included in the IRP modeling's starting point:

TABLE 14.2.1: Planned Resources Included in Modeling

Resource	Technology	MW	Status
Blue Water Energy Center	Combined Cycle	1,150	Under construction, COD in 2022
Dearborn Energy Center	Combined Heat & Power	34	Under construction, COD in 2019
Ludington	Pumped Storage	~90	On-going upgrades to units 1 & 3
Demand Response	IAC / Existing Programs	~130	To be added from 2019 - 2025
Future Wind	Renewable	~1,150	To be added from 2019 – 2040
Future Solar	Renewable	~2,550	To be added from 2019 – 2040

14.3 Technical Feasibility Screening

The Company relied upon publicly available data to identify supply-side technology alternatives and their respective costs and operating characteristics (see Table 14.3.1). The screening process's first step evaluated these alternatives based on technical feasibility, which allowed the elimination of alternatives that were impractical, uneconomical, or had geographic limitations. Based on this methodology, three resource alternatives were filtered out of further analysis in the IRP: hydropower, geothermal, and solar-thermal. Each has limitations based on Michigan's geography and are costly options on a $/kW basis compared to other technologies.

TABLE 14.3.1: Alternative Technology Costs Across Scenarios

Technology Alternatives, Based on Publicly Available Information				Scenarios		
				REF and BAU	ET	EP
Unit Type	**Abbreviation**	**Technology Source**	**Source Year**	**Overnight Cost ($/kW)[1]**		
Combined Cycles						
Advanced Combined Cycle	AdvCC	EIA	2018	1133	No Change	
Combined Cycle with Carbon Capture Sequestration	CCwCCS	EIA	2018	1981	No Change	
DTE Combined Cycle	DTECC	DTE		860	No Change	
Combustion Turbines						
Advanced Combustion Turbine	AdvCT	EIA	2018	663	No Change	
Combined Heat and Power	CHP	EPA	2017	1686	1096	1686
Micro Turbine	MT	EPA	2017	2776	No Change	
RICE (5 units at 17MW ea.)	RICE	EIA	2016	1400	No Change	
Renewables						
Wind	Wind	NREL	2018	1712	1412	1113
Solar PV-1 axis tracking	SolarTr	NREL	2018	1434	932	932
Solar PV-fixed tilt	SolarFix	NREL	2018	1325	861	861
Biogas	Bio	NREL	2017	3700	No Change	

Technology Alternatives, Based on Publicly Available Information				Scenarios		
				REF and BAU	ET	EP
Unit Type	Abbreviation	Technology Source	Source Year	Overnight Cost ($/kW)[1]		
Base Load						
Coal with 90% CCS	PCwCCS	EIA	2018	5250	No Change	
Advanced Nuclear	AdvNuc	EIA	2018	5266	No Change	
IGCC with Carbon Capture Sequestration	IGCCwCCS	EPRI	2017	5214	No Change	
Screened out on Feasibility						
Hydropower		NREL	2017	6040		
Geothermal		NREL	2017	4648		
Solar – Thermal		NREL	2017	6893		

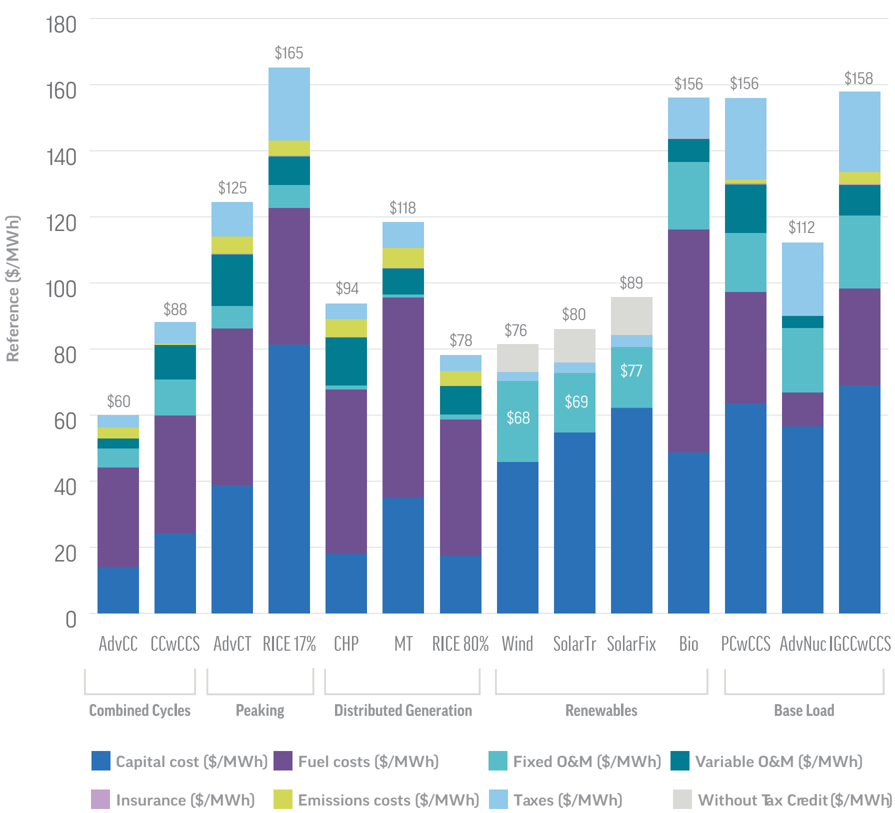
1 Overnight cost is the cost of a construction project if no interest accrued during construction, as if the project was completed "overnight." In table 14.3.1, overnight costs are used to compare the cost of each technology across the IRP scenarios.

See the Master Technology Inputs in Exhibit A-4 Appendix B for additional detail regarding the technology alternatives, operational costs, and operating characteristics.

14.4 Levelized Cost of Energy Screening

The second step in the IRP technology screening process was comparing the levelized cost of energy (LCOE) between alternatives on a consistent basis. This step was particularly helpful when comparing technologies that have common attributes. The LCOE was calculated by forecasting the annual costs to operate a technology over its useful life, dividing it by that technology's forecasted generation, and then levelizing the result. The levelizing function takes a varying stream of numbers over a period and simplifies them to one value, typically represented in $/MWh. Usually costs will increase over time; levelization takes these increasing values, discounts them, and expresses the result as one number, usually in current-year dollars. LCOE results from the Reference Scenario are shown below in figure 14.4.1. Each technology's resulting $/MWh value consists of capital, fuel, fixed O&M, variable O&M, insurance, emissions, and tax costs.

FIGURE 14.4.1: Reference 2024 Levelized Cost of Energy



The other IRP scenarios' key LCOE assumptions and results can be found in Exhibit A-4 Appendix M and N respectively.

The technologies screened out in this step had significantly higher costs compared to similar technologies (i.e. peaking, distributed generation, renewables). Table 14.4.2 highlights the technologies screened out in the LCOE analysis.

TABLE 14.4.2: LCOE Screened Out Technologies

Category	Screened Out Technologies
Peaking	Reciprocating internal combustion engine w/ 17% capacity factor
Distributed Generation	Micro turbines, combined heat & power
Renewables	Solar fixed tilt[1], biogas
Base Load	Pulverized coal and integrated gasification combined cycle w/CCS, advanced nuclear

1 For the purpose of modeling only solar single-axis tracking was modeled.

The LCOE was useful in comparing like technologies to each other i.e. baseload, non-dispatchable, peaking, etc., to illustrate cost-based differences within a category. However, it has shortcomings as a stand-alone screening tool. While LCOE is a representation of costs, it does not show how much market value the technology is creating - either in the energy market or the capacity market. Therefore, the IRP process utilizes a third screening step, known as market valuation, which is performed in Strategist®.

14.5 Market Valuation Screening

After screening IRP alternatives by LCOE, the next step in the IRP process is to analyze an alternative's market value. An associated market value calculated for each alternative was useful in screening out options and providing a standard basis for comparing technologies.

The market valuation step included battery storage, energy waste reduction (EWR), and demand response programs, which typically are not evaluated in an LCOE for the following reasons:

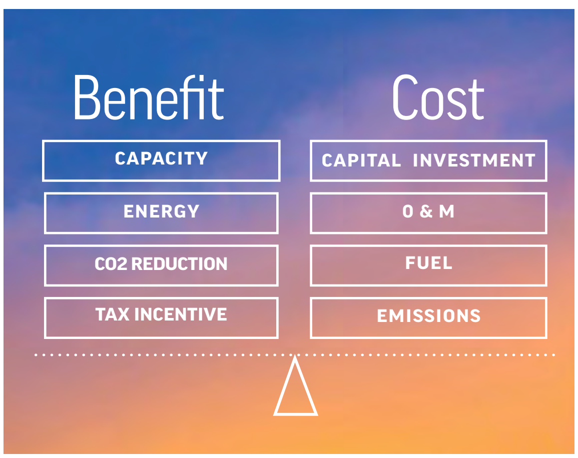
Battery storage - Both charges and generates, making it close to a net-zero energy generator.

Demand response – These programs tend to produce little energy, which will result in a very high LCOE relative to other technologies. A more reasonable comparison tool for DR programs is a levelized cost of capacity (LCOC), or a market valuation.

EWR – EWR savings are made up of a mix of end-uses that are delivered in different years, at different savings levels and costs, and persist for different lengths of time. Thus, an EWR LCOE calculation would not be performed on the same basis with the other alternatives. Instead, the EWR group uses the Utility System Resource Cost Test (USRCT) to calculate each EWR level's cost-effectiveness in the development step.

A market valuation was created by comparing the outputs of two Strategist® runs. The first Strategist® run purchases future energy and capacity needs from the market. The second run places the desired resource being evaluated into service. These runs were conducted with the scenario market data loaded into the Strategist® modeling tool, but prior to resource optimization. The benefits and costs of the resource being evaluated (Figure 14.5.1) were then compared to the benefits and costs of purchasing the equivalent energy and capacity from the market. A benefit-cost ratio is determined by dividing the discounted benefit by the asset's discounted cost.

FIGURE 14.5.1: Market Valuation Benefit Cost



Given the market energy and capacity price forecast, a value of greater than one would indicate that an alternative's total benefits outweigh its total cost. Numbers below one could indicate that purchasing energy and capacity from the market is more cost-effective than offsetting those purchases with an alternative resource. Table 14.5.2 summarizes the benefit-cost ratios for the DTEE Reference scenario market valuation. Market valuation results for the remaining scenarios and select sensitivities are included in appendix O.

DR real-time pricing: Although this alternative had the highest benefit-cost ratio its assumed capacity benefit of approximately 3 MW was the smallest of the resource alternatives. Due to its very small program size, it would not be selected in an optimization. Its exclusion from the optimization runs does not preclude the Company from investigating the program.

Reciprocating Internal Combustion Engine (RICE) 80 percent (CT): This alternative was excluded for modeling purposes as it is similar technology to the Advanced CT, which was

TABLE 14.5.2: Reference Case Market Valuation Results

Rank	Technology	Benefit/ Cost[2]
1	DR - Real Time Pricing	2.88
2	DR - Conservative Volt Reduction	2.81
3	DR - Variable Peak Pricing	2.65
4	DR - Time of Use	1.71
5	DR - Demand Buyback	1.36
6	Advanced CCGT (1x1)	1.12
7	EWR 1.75	0.99
8	Wind with 40% PTC	0.96
9	Solar with 30% ITC	0.93
10	Advanced CT	0.89
11	EWR 2.0	0.88
12	RICE 80% (CT)	0.87
13	CC-CCS	0.76
14	DR - Voltage Optimization	0.61
15	EWR 2.25	0.49
16	DR - DLC Smart Thermostats	0.39
17	DR – Capacity Bidding	0.35

included in the optimization runs.

Other DR programs: Demand response programs that performed well in the market evaluation had sufficient capacity among them to fulfill the forecasted capacity need in 2029 and 2030. Therefore, the other less-economical demand response programs were excluded from the optimization runs.

14.6 Energy Storage Technologies

Grid-scale energy storage systems (ESS) are a collection of methods used to store electrical energy on a large scale within an electrical power grid. Grid-scale ESS help stabilize the grid by balancing electricity supply and demand over short (sub-seconds to minutes) to longer-term (hours, days, weeks, etc.) durations. The three ESS applications that can provide value to the grid in terms of generation application are:

1. Ancillary services: ESS can help maintain the grid's performance by providing ancillary services (e.g., frequency regulation, and/or balancing voltages on the grid). As the level of renewable deployment on the electric system increases, the need for these services may also increase. The extent to which the ESS are compensated for these services depends on the market in which they are operating.

2. Capacity: ESS can be used as a peak shaving resource to reduce or defer investments in additional generation capacity. This includes the use of an ESS as a capacity resource.

3. Price arbitrage: ESS can store energy produced during periods of low demand/prices and sell during periods of higher demand/prices. In the same context, ESS can also increase the value of renewable energy systems by storing and shifting renewable energy output to times of greater system need or to avoid curtailment (i.e., firming renewable energy capacity).

The two ESS applications that can provide value to the grid in terms of distribution application are:

1. Investment deferral in transmission and distribution: ESS can be used as a peak shaving resource on the distribution system to reduce or defer investments in additional distribution assets.

2. Emergency backup: ESS can provide electricity supply during planned or unplanned outage situations.

While batteries are technically capable of providing all of these benefits, the extent to which a single battery can provide all of these services (i.e., the ability to "stack" the available values) will be dependent upon the specifics of the project. For example, a common application for grid-scale battery storage is for peak-shaving, thus deferring or eliminating

Rank	Technology	Benefit/ Cost[2]
18	DR – Behavioral	0.35
19	DR - AC	0.31
20	LITH-ION Battery	0.30
21	DR - DLC Water Heating	0.28
22	EWR 2.5	0.17

2 The higher the number, the greater the benefit.

1 Shaded technologies were excluded from Strategist® optimization modeling runs.

Source: Lazard Levelized Cost of Storage 3.0 (size range and maturity); B. Zakeri & S. Syri Electrical energy storage systems: A comparative life cycle cost analysis (non-lithium-ion cycle life); OEM brochures (lithium-ion cycle life) the need for a conventional wires investment. In this use case, the battery would charge during a time when load on a distribution circuit is low and discharge when load on the circuit is high. However, this usage pattern can potentially conflict with the usage pattern required to maximize energy and capacity benefits. For example, a circuit's peak hours may not be coincident with the peak hours MISO uses for determining capacity credit. If the battery is not sufficiently oversized to serve both peaks, then the operator must choose whether to discharge the battery to serve the distribution system or to provide system capacity. The same logic applies for the energy arbitrage opportunities that exist on a given day. As such, the battery operator may be unable to capture all of the theoretically available values due to the conflicts that exist between them. As indicated previously, some ESS technologies are more suitable for certain applications than others. The following ESS technology categories comprise most of the ESS technologies commercially available today:

- Pumped hydroelectric power
- Compressed air energy storage (CAES)
- Battery storage (e.g., lithium-ion, sodium-sulfur, lead acid, and flow batteries)

In order to determine which storage technologies to incorporate into its modeling, DTEE performed an initial technical screening to assess each technology's feasibility for deployment. The results of this screening exercise are described below.

New Pumped Hydroelectric Storage

Pumped hydroelectric storage uses electricity to pump water to a higher elevation. When required, water is released to drive a hydroelectric turbine. Beyond the existing Ludington facility, deployment of pumped hydro was screened out due to the geographical limitations of siting a new facility.

Compressed Air Energy Storage

CAES uses electricity to compress air into confined spaces. When required, air is released to drive the compressor of a natural gas turbine. CAES was screened out since its deployment is limited by the availability of suitable geologic formations and because there is limited commercial experience in the United States.

Battery storage

Batteries use electricity to store chemical energy, which can later be converted back into electrical energy when required. There is a range of different battery chemistries, which have the potential to operate in grid applications with varying operating characteristics and levels of technology maturity. In Table 14.6.1 below, each technology was ranked based on its cycle life, size, and technology maturity.

TABLE 14.6.1: Battery Technology Comparison Summary

Legend: Most Preferable (filled box) / Least Preferable (outlined box)

	Cycle Life	Size Range	Maturity	
Lead Acid	~2000-~4500 cycles	5kW - 2MW	Mature	Mature technology, but low power and energy density limits system size Poor cycling performance also reduces attractiveness for many grid applications
Sodium	~2500-~4500 cycles	1MW - 100MW+	Mature	Commercially available technology Poor cycling capability and potential flammability issues reduce attractiveness
Flow Batteries	~10,000-~13,000 cycles	25kW - 100MW+	Emergining	Potentially promising technology, particularly for longer-duration applications Limited level of deployments and operating experience to-date
Lithium Ion	~6,000 cycle	5kW - 100MW+	Mature	Current market leader in battery storage deployments Applications in automotive and electronics industries have driven continued technology improvements

Based on this technical assessment, lithium-ion batteries have the most desirable combination of operating parameters, system size, and technology maturity.

DTEE also looked at each of these battery technologies' historical costs and future cost trajectories in order to further distinguish which technologies were most suitable for further inclusion in this IRP. Costs for lithium-ion batteries have declined significantly in recent years and the trend is expected to continue in the near term, driven in part by its applications in other sectors, such as electronics and transportation.

Given their superior combination of cost, cycle life, system size, and technology maturity, lithium-ion batteries were selected for further evaluation in this IRP. See Exhibit A-4 Appendix C for the lithium-ion battery assumed operating characteristics considered for modeling.

The battery storage units evaluated were assumed to have an installed capacity of 100 MW and 400 MWh, which equates to a four-hour duration. The objective for selecting this configuration was to create an asset that can provide both energy arbitrage and capacity value, with the full power rating qualifying for capacity credit in MISO. Given the four-hour duration, capacity credit was assumed to be nearly 100 percent.

While lithium-ion is the most suitable technology in the near-term, DTEE continues to monitor the other battery storage technologies' development, as well as other non-battery storage options, and may update its assessment of these technologies as costs decline, performance improves, and the market framework for storage evolves.

14.7 Distributed Generation Resources

Through 2017, the Company had just over 1,700 net metering sites with approximately 13.6 MW of installed capacity. More than 98 percent of installed net metering capacity is solar. Table 14.7.1 summarizes the total net metering sites and capacity as of the end of 2017, by category. Category 1 is limited to sites with renewable generation less than 20 kW of installed capacity; category 2 is limited to sites with renewable generation of more than 20 kW but less than 150 kW; category 3 is limited to methane digesters between 150 kW and 550kW. Table 14.7.1 also shows the percentage of the statutory cap each category has reached; category 1 is capped at 0.5 percent of the Company's peak; categories 2 and 3 are each capped at 0.25 percent of the Company's peak.

TABLE 14.7.1: Total Net Metering Sites and Capacity

	Sites	Capacity (MW)	Capacity Cap (MW)	Percent of Cap
Category 1	1,675	11.8	54.3	21.8%
Category 2	30	1.8	27.2	6.5%
Category 3	0	0	27.2	0.0%
Total	1,705	13.6	114.2	12.5%

As discussed in Section 10, the Company's load forecast assumes a five to seven percent growth rate for distributed generation through the study period.

14.8 Market Capacity Purchases

As discussed in Section 4 a capacity need is not identified until the 2029 and 2030 timeframe with the retirement of Belle River. It is uncertain how much, if any, capacity will be available in the market for the Company to purchase 10 years from now. Due to this uncertainty in the capacity market, zero capacity purchases was the general assumption for optimization modeling. However, as discussed in Section 15 the IRP modeling did consider an all market purchase sensitivity performed on each scenario. The higher load sensitivities also considered capacity purchases in some years; this is discussed in Exhibit A-4 Appendix F.

14.9 Long-term Power Purchase Agreements

For the purposes of the resource screen within the IRP planning process, the Company's existing long-term power purchase agreements (PPAs) were assumed to be renewed.

SECTION FIFTEEN

15 Modeling Results

15.1 Strategist® Optimization modeling results

The four IRP scenarios were optimized through the Strategist® optimization model. Each optimization model run typically generated from 30 to 1,100 different build plans as outputs, ranked from least-cost to highest-cost. The least-cost plans output from each scenario varied considerably from each other. The least-cost build plans from each of the four scenarios output from the Strategist® optimization are shown in table 15.1.1.

Table 15.1.1: Least-cost plans from each scenario

	REF	BAU	ET	EP
EWR starting in 2020/2021	1.5% EWR	2% EWR	2% EWR	1.75% EWR
2029/2030 build	414 MW 1x1 CC 259 MW DR	414 MW 1x1 CC	1050 MW WIND	3,150 MW wind

Considering the least-cost plan results from the Strategist® optimization, three different levels of EWR were least-cost (or selected) across the four scenarios. In addition, a gas CCGT was selected in two of the four scenarios, while additional renewables energy was selected in the other two. For modeling purposes, if selected, the increased EWR level started in 2020 for 1.75 percent EWR. Similarly, for the least-cost plans that selected 2 percent EWR, the level increased to 1.75 percent in 2020 and then to 2 percent in 2021. The other builds shown all come on in the Strategist® optimization in either 2029 or 2030, when replacement for Belle River is planned.

The Company's Strategist® modeling optimized each level of EWR separately. The following table shows the compilation of the optimization's results.

Figure 15.1.2 shows the build plans of the least-cost plan at the different EWR levels (1.5 percent, 1.75 percent, and 2 percent). Note that REF/BAU have the same least-cost build plans for both the 1.75 percent and 2.0 percent EWR levels. Additionally, ET and EP have the same least-cost plan for the 2.0 percent EWR level. Therefore, the optimization modeling produced nine distinct least-cost build plans across the four scenarios.

Figure 15.1.2 - Least-cost build plans from three EWR levels across four scenarios

REFERENCE			
EWR	1.50%	1.75%	2.00%
CCGT	414	414	414
DR	259	-	-
Wind	-	-	-
	A Comparison Build Plan	E	H

BUSINESS AS USUAL			
EWR	1.50%	1.75%	2.00%
CCGT	414	414	414
DR	167	-	-
Wind	150	-	-
	B	Same as E	Same as H

EMERGING TECHNOLOGY			
EWR	1.50%	1.75%	2.00%
CCGT	414	-	-
DR	-	167	-
Wind	1,500	1,800	1,050
	C	F	I

ENVIRONMENTAL POLICY			
EWR	1.50%	1.75%	2.00%
CCGT	-	-	-
DR	216	-	-
Wind	3,300	3,150	1,050
	D	G	Same as I

Each of the nine build plans seen in Figure 15.1.2 was extracted from the outputs from each of the four scenarios. The Strategist® model calculated the Net Present Value Revenue Requirement (NPVRR) for each of these plans and compared it against a comparison plan. In order to maintain consistency when evaluating build plans across the scenarios, the 1.5 percent EWR plan with a CCGT and DR in 2029-2030 was used as the sole comparison build plan.

Table 15.1.3 shows the same nine build plans from Figure 15.1.2 along with the delta NPVRR against the comparison plan by scenario. To create this table, each of the nine unique build plans from Figure 15.1.2 was found among the resultant build plans in each of the four scenarios. This comparison shows how each build plan's economics change by scenario.

Table 15.1.3 - Nine least-cost plans across four scenarios

EWR Level	2029/30 Build	REF	BAU	ET	EP	Commentary
		TIERED	FLAT HIGH	FLAT LOW	FLAT HIGH	EWR Cost Level used in the scenario
		Delta NPVRR back to Comparison Plan (Millions) 2019-2040				
1.5% 414 MW 1x1 CC 259 MW DR Plan A		-	-	-	-	**REF - Least Cost Plan**. Considered a comparison plan across all scenarios. **All the deltas below are compared back to this plan.**
1.5%	414 MW 1x1 CC 167 MW DR 150 MW WIND	$1	($8)	($17)	($30)	DR was preferred over wind in DTE REF and BAU whereas wind gains value in ET and EP scenarios.
1.5%	414 MW 1x1 CC 1500 MW WIND	$66	($3)	($114)	($254)	The preference of DR over wind in REF and the value of wind in ET and EP was more pronounced in this case. Additionally, wind was preferred over solar in ET because of the significant energy value it produces in the sales market
1.5%	216 MW DR 3300 MW WIND	$316	$206	($75)	($366)	Wind has 17.5 percent Capex reduction in ET vs. 35 percent reduction in EP. So, it's economical in ET and more so in EP because of the discount. Similarly, it was very uneconomical due to absence of these discounts in REF and BAU.
1.75%	414 MW 1x1 CC	$18	($162)	($212)	($157)	With a tiered cost view, 1.75 percent EWR is marginally worse than 1.5 percent EWR, whereas in the flat high and flat low views, 1.75 percent EWR is significantly better.
1.75%	167 MW DR 1800 MW WIND	$154	($93)	($286)	($379)	Wind is preferred over solar in ET because of the significant energy value it produces in the sales market
1.75%	3150 MW WIND	$324	$46	($256)	($463)	EP - Least Cost Plan. Wind is preferred over solar and EWR in EP because of the significant energy value it produces in the sales market
2.0%	414 MW 1x1 CC	$93	($308)	($419)	($294)	BAU - Least Cost Plan. Note that REF and BAU are similar scenarios. The big difference in delta is due to difference in EWR costs where the flat high cost selects the 2 percent EWR and the tiered cost selects the 1.5 percent EWR.
2.0%	1050 MW WIND	$181	($252)	($453)	($416)	ET - Least Cost Plan. Wind is preferred over solar in ET because of the significant energy value it produces in the sales market. Two percent EWR is selected in ET due to the flat low EWR costs.

Under each scenario, multiple sensitivities were run through the Strategist® optimization model. The sensitivity analyses' results are presented in the following sections.

15.2 Reference Scenario Results

Sensitivities under the Reference scenario included: EWR incentive-cost sensitivities, a high CO2 price, high electric-vehicle penetration, high load, assumed retirement of Belle River coal units in 2025/2026, sensitivity N (submitted by an external stakeholder), non-fossil alternative(s) in 2029/2030, addition of CVR, and an alternative discount rate. The sensitivity analyses' results are summarized in the tables below.

Results of the EWR incentive-cost sensitivity

The EWR flat high costs were run on the REF scenario to see how they affected the least-cost plan. The starting-point tiered costs used in the REF scenario assumed higher levels of incentives were needed as the level of EWR increased, whereas the flat high EWR costs assumed 50 percent incentives, regardless of EWR level. Table 15.2.1 summarizes the results.

With the flat high cost assumption, the least-cost plan has 2 percent EWR. With the tiered-cost scenario, the 1.5 percent EWR level is selected as least-cost.

Results of the high CO2 price and high electric-vehicle penetration sensitivities

TABLE 15.2.1: REF Scenario: EWR Incentive-Cost Results

	EWR Level	1.50%	1.75%	2.00%
REF flat high	2029/30 BUILD	414 MW 1x1 CCGT 259 MW DR	414 MW 1x1 CCGT	414 MW 1x1 CCGT
	DELTA, $M	-	($133)	($245)
REF tiered costs	2029/30 BUILD	414 MW 1x1 CCGT 259 MW DR	414 MW 1x1 CCGT	414 MW 1x1 CCGT
	DELTA, $M	-	$18	$93

TABLE 15.2.2: Ref Scenario: High CO2 price and high electric-vehicle penetration results

REF Sensitivities - Least Cost Plan - Tiered Cost			
Sensitivity	**EWR Level**	**2029/30 Build**	**Comments**
Starting Point	1.5%	414 MW 1x1 CCGT 259 MW DR	CCGT is the most economic and efficient unit, hence preferred as first option with assumed inputs.
High CO2	1.5%	4500 MW WIND 200 MW SOLAR	Has higher energy market, hence prefers higher energy renewable source
High EV	1.5%	414 MW 1x1 CCGT 150 MW WIND 167 MW DR	The EV penetration in the market shifts the peak hour from the conventional spot, so a CCGT is preferred to cover the need along with DR to reduce the peak.

The results indicated that the high-CO2 sensitivity selected high levels of renewables in the least-cost plan. It is noteworthy that 4,700 MW of renewables were selected instead of increasing the EWR level. This was due to the large amount of value created through selling excess wind energy into the extremely high market (high due to $30-70/ton CO2 adder).

TABLE 15.2.3: REF Scenario: High-load results

Sensitivity	EWR Level	2021-24 Build	Purchases	Comments
High Load	0.015	1800 MW WIND 50 MW SOLAR 358 MW DR 414 MW CCGT	2020-24 - 0-300 MW 2025-28 - 200-700 MW 2029-40 - 1300-5000 MW	Higher load resulted in the early need of capacity. With the early build constraint of CCGT, renewables were favored

Results of the high load sensitivity

The high-load sensitivity selected a combination of wind, solar, DR, and CCGT by 2024 to fill the capacity required in the near-term years.

Results of the Belle River early retirement sensitivity

In this sensitivity, the Belle River coal units were retired in the Strategist® optimization in 2025 and 2026, instead of 2029 and 2030 as planned. The Strategist® model had the option to "replace" the capacity with the coal units themselves (until 2029 and 2030) or the other IRP alternatives.

The least-cost plan replaced the 2025-2026 retirement of Belle River with coal units at Belle River that retired in 2029 and 2030, which means it's more economical to leave the retirement dates as currently planned. An important point is that Belle River is co-owned with the Michigan Public Power Agency (MPPA). The optimization results shown above include only DTEE's costs, which are 81.39 percent of the total. MPPA's portion of the cost increase is not included. It will also have costs to replace its capacity when Belle River retires. No capacity sales were assumed when capacity was long.

Table 15.2.4 : REF Scenario: Belle River Early Retirement Results

Belle River Retirement Sensitivities					
Sensitivity	**EWR Level**	**Purchase/ Build 2025/2026**	**PVRR, $M**	**Delta, $M**	**Comments**
Least Cost Plan	1.75 %	BLR 1 (coal from 25 to 29) BLR 2 (coal from 26 to 30)	$13,453	-	Least-cost plan prefers to keep Belle River running past 2025
2nd Least Cost Plan	1.75 %	217 MW DR 414 MW 1x1 CCGT	$13,492	39	Plan no. 2 is replacing BLR with CCGT & DR in 2025-2026
First non-CCGT plan	1.75 %	1200 MW WIND 300 MW SOLAR 358 MW DR	$13,663	209	First non CCGT plan requires Renewables build and DR in 2025-2026
Purchase until 2029	1.75 %	414 MW 1x1 CCGT in 2030	$13,510	57	Purchase allowed until 2029 and CCGT built in 2030
Purchase until 2040	1.75 %	PURCHASE	$13,585	131	Purchase allowed all the way to 2040
Least Cost Plan	2%	BLR 1 BLR 2	$13,528	74	Optimization using 2 percent EWR least-cost plan is keeping BLR 2 % less economical than 1.75 percent
2nd Least Cost Plan	2%	167 MW DR 414 MW 1x1 CCGT	$13,578	125	Plan no. 2 is replacing BLR with CCGT and DR in 2025-2026

Results of Sensitivity N

Sensitivity N was submitted by an external stakeholder as a result of the Company's stakeholder engagement process in the months leading up to the IRP filing. This sensitivity was run with the below inputs specified by the stakeholder:

TABLE 15.2.5: Sensitivity N Inputs

Sensitivity N	
1. Load Growth	DTEE forecast plus 24 percent EV sales by 2030 (Bloomberg)
2. EWR	2 percent annually through all years unless more is required to meet no. 9
3. Capital Cost	DTEE CCGT cost
4. Renewable	50 percent clean energy goal and 35 percent renewables by 2030-additional 1,300 MW of solar
5. Gas Price	Reference
6. Retirement	DTEE plan (starting point)
7. Demand Response	Full amount from 2017 State of MI Potential Study (high case)
8. Distributed renewables	450 MW incremental solar
9. Available replacement	Defer second CCGT with EWR, DR, and renewables
10. Conservation Voltage Reduction	150 MW by 2028

A plan similar to the Reference scenario least-cost plan was run with the 24 percent increase in EV loads. This comparison plan was lower-cost than sensitivity N, as shown in Table 15.2.6.

TABLE 15.2.6: REF Scenario: Sensitivity N results

Sensitivity	EWR Level	PURCHASE/ BUILD	PVRR, $M	Delta, $M	Comments
SENSITIVITY N	2.00%	1300 MW SOLAR 974 MW DR 450 MW DG 50 MW CVR/VVO	$14,855	-	Sensitivity ran according to the NRDC request inputs
Comparsion plan same load	1.50%	259 MW DR 414 MW 1x1 CCGT 50 MW CVR/VVO	$14,340	($516)	NRDC sensitivity cannot be compared to the starting point comparison plan because of different loads, comparison build plan is forced in with sensitivity N load to provide a consistent comparison

TABLE 15.2.7 - REF Scenario: Non-fossil Alternative(s) in 2029/2030 Results

Scenario	EWR level	LEAST COST BUILD PLAN	First 'NO GAS' plan	delta, $M 'No Gas - LCP' same EWR level	delta, $M (No gas plan - 1.5% EWR LCP)
REF	1.5%	414 MW 1x1 CCGT 259 MW DR	450 MW WIND 500 MW SOLAR 358 MW DR	$143	$143
REF	1.75%	414 MW 1x1 CCGT	358 MW DR	$84	$102
REF	2.0%	1050 MW WIND	1050 MW WIND	$0	$93

As shown in Table 15.2.7, the least-cost plan in the REF scenario that does not contain a gas-fired unit is the 2 percent EWR and 1,050 MW wind plan, with a cost that is $93 million NPVRR higher than the REF least-cost plan.

Sensitivity N was run exactly as requested with one exception. The request was for 150 MW of CVR/VVO. The costs we used for CVR/VVO came from Table 8.14.3 CVR/VVO Summary Benefits. Here, the first 50 MW of CVR/VVO for groups 1 and 2 have costs in an economic range of $7 million-$10 million for group 1 and $11 million-$14 million for group 2. The other three groups, which don't even reach a total of 150 MW, have extremely high costs that range from $815 million to more than $11 billion. Due to these high costs, the first economic 50 MW of CVR/VVO was included and not the full 150 MW. If the additional 100 MW of CVR/VVO had been included, the NPVRR for sensitivity N would have been more than $1 billion higher. Sensitivity N was higher cost than the comparison plan by $516 million NPVRR.

Results of the no-gas-build in 2029-2030 sensitivity

The Commission requested a sensitivity in the Company's CON order in Case No. U-18419 to model a circumstance where Belle River Power Plant, when retired, was replaced with an alternative other than a combined-cycle gas turbine, including potentially EWR, DR, and renewable energy. The Company determined that reviewing the least-cost build plans and selecting the first plan that did not include a gas unit in 2029-2030 met the requirements. Table 15.2.7 summarizes the results.

Results of the CVR/VVO sensitivity

A sensitivity was run to obtain the CVR/VVO's economic performance. We expect that it would have similar results in the other three scenarios, since the CVR/VVO market valuation was very similar in all scenarios. Table 15.2.8 below summarizes the results.

TABLE 15.2.8: REF Scenario: CVR/VVO Sensitivity Results

	Least Cost Plan (Comparison build)	CVR/VVO sensitivity		Forced in 1x1 and CVR/ VVO
EWR Level	1.5 %	1.5 %	1.75 %	1.75 %
29/30 Build	414 MW CCGT 259 MW DR	414 MW CCGT 167 MW DR 50 MW CVR/ VVO	414 MW CCGT	
Delta, $M		(14)	$18	

The results indicated that CVR/VVO was an economical program at 50 MW in size at both the 1.5 percent EWR and 1.75 percent EWR levels. In the optimization modeling shown above, there was not a capacity need until the 2029-2030 timeframe. However, the Company plans to pursue a CVR/VVO pilot program starting in 2019 based on the encouraging results of the CVR/VVO program when analyzed in the IRP optimization against other alternatives. Data will be gathered during the pilot which will be used to clarify the assumptions either for the next IRP or in a separate project evaluation before the next IRP.

Results of alternative discount rate sensitivity

Tables 15.2.9 shows the results of the analysis using an alternate discount rate of 5 percent, which was subjectively selected. As expected, the NPVRR is higher with an assumed lower utility discount rate. The results are summarized in Table 15.2.9 below.

TABLE 15.2.9: REF Scenario: Alternative discount rate sensitivity results

EWR level	LCP 6.63 % discount rate	LCP 5 % discount rate	Delta, $M (5 %t-6.63%)
1.5 %	414 MW 1x1 CCGT 259 MW DR	2850 MW WIND 259 MW DR	$1,546
1.75 %	414 MW 1x1 CCGT	3150 MW WIND	$1,515
2.0 %	414 MW 1x1 CCGT	1050 MW WIND	$1,557

The results showed a significant change in NPVRR and the build plan with a lower utility discount rate. It should be noted that lower discount rates play a major role in the economics of the outer years in the optimization. Hence, the model prefers wind over a CCGT since wind was more expensive in the first few years compared to CCGT.

15.3 Business as Usual Scenario Results

Sensitivities under the Business as Usual scenario included: EWR incentive-cost sensitivities, high gas (200 percent of the 2018 EIA), high load, 25 percent Electric Choice cap, 50 percent Electric Choice return, 100 percent Electric Choice return, non-fossil alternatives in 2029/2030, and combustion-turbine-only replacement. The sensitivity analyses' results are summarized in the tables below.

Results of the EWR incentive-cost sensitivity

The EWR tiered costs were run on the BAU scenario to see the impact on the least-cost plan. The tiered costs assumed higher levels of incentives are needed as the level of EWR increases, whereas the flat high EWR costs assumed in the BAU scenario's starting point assume 50 percent incentives, regardless of EWR level. Table 15.3.1 summarizes the results.

TABLE 15.3.1: BAU Scenario: EWR incentive-cost-results

	EWR Level	1.50%	1.75%	2.00%
BAU tiered costs	2029/30 BUILD	414 MW 1x1 CCGT 167 MW DR 150 MW WIND	414 MW 1x1 CCGT	414 MW 1x1 CCGT
	DELTA, $M	-	($4)	$38
BAU flat-high costs	2029/30 BUILD	414 MW 1x1 CCGT 167 MW DR 150 MW WIND	414 MW 1x1 CCGT	414 MW 1x1 CCGT
	DELTA, $M	-	($155)	($300)

The tiered-cost sensitivity resulted in a significant tightening of the deltas between the three EWR levels. With the tiered-cost assumption, the least-cost plan has 1.75 percent EWR. The 2 percent level, selected as least-cost in the scenario, had the flat-high costs.

Results of the high gas and 25 percent Electric Choice cap sensitivities

TABLE 15.3.2: BAU Scenario: High gas and 25 percent Electric Choice cap results

BAU Sensitivities - Least Cost Plan - Tiered Cost			
Sensitivity	**EWR Level**	**2029/30 Build**	**Comments**
Starting Point	2 percent	414 MW 1x1 CCGT	.
High CO2	1.75 percent	3150 MW WIND	High gas market leads to higher energy market, which prefers high-energy renewables to be built, hence it picks the lower EWR level and build wind.
High EV	2 percent	-	Lower load leads to no need to build.

The 25 percent Electric Choice cap sensitivity maintained the 2 percent EWR level with no additional build, while the high-gas sensitivity selected the 1.75 percent EWR level in order to maximize the amount of wind built to sell into the high-value energy market the high gas prices created.

Results of the other load sensitivities

Other load sensitivities run on the BAU scenario include high load, the 50 percent Electric Choice return, and the 100 percent Electric Choice return. Earlier build was required in the 2021-2024 timeframe, similar to the higher load sensitivities run on the REF scenario. Table 15.3.3 summarizes the results.

TABLE 15.3.3: BAU Scenario: Other load sensitivity results

Sensitivity	EWR Level	2021-2024 Build	Purchases	Comments
50% Choice Returns	2%	167 MW DR 414 MW 1x1 CCGT	2022 PUR - 54 MW 2023 PUR - 272 MW	Slightly higher load compared to Reference level. Prefers some capacity from market in early years and builds DR in 2024 and a CCGT in 2030. Optimized for years 2024-2039
100% Choice Returns	2%			
High Load	2%	2250 MW WIND 167 MW DR 414 MW 1x1 CCGT	2020-24: 0-300 MW 2025-28: 100-500 MW 2029-39: 1100-5000 MW	Very high load leads to heavy and early renewable build along with DR to reduce peak in 2023. Adds a CCGT in 2024. Partially optimized in years 2020-2023.

In the BAU scenario, the least-cost no-gas plan is the 2 percent EWR level with 1,050 MW wind build. This plan is $56 million higher than the BAU LCP, and is the same least-cost no-gas plan selected in the REF scenario.

Results of the no-gas build in 2029-2030 sensitivity

Similar to the REF scenario, a sensitivity assuming the replacement of the Belle River plant with only non-fossil alternatives was run on the BAU scenario. Table 15.3.4 summarizes the results.

TABLE 15.3.4: BAU Scenario: Non-fossil alternatives in 2029-2030 results

EWR level	Least-cost build plan	First no-gas plan-cost build plan	delta, $M no gas - LCP' same EWR level	delta, $M (no-gas plan - 1.5% EWR LCP)
1.5%	414 MW 1x1 CCGT 167 MW DR 150 MW WIND	1950 MW WIND 358 MW DR	$65	$65
1.75%	414 MW 1x1 CCGT	216 MW DR 1350 MW WIND	$62	-$92
2%	414 MW 1x1 CCGT	1050 MW WIND	$56	-$244
1.75%	414 MW 1x1 CCGT	216 MW DR 1350 MW WIND	$62	-$92
2%	414 MW 1x1 CCGT	1050 MW WIND	$56	-$244

In the BAU scenario, the least-cost no-gas plan is the 2 percent EWR level with a 1,050 MW wind build. This plan is $56 million higher than the BAU LCP, and is the same least-cost no-gas plan as selected in the REF scenario.

15.4 Emerging Technology Scenario Results

Sensitivities under the Emerging Technology scenario included: high gas (200 percent 2018 EIA), high load, combined solar and storage, wind congestion, an alternative discount rate, and early retirement of the Company's Tier 2 coal units. The results of the sensitivity analyses are summarized in the tables below.

Results of the high-gas sensitivity

TABLE 15.4.1: ET Scenario: High-gas results

Sensitivity	EWR Level	2029/30 Build	Comments
Starting Point	2%	1050 MW WIND	Wind was the preferred technology because of high capacity factor and value provided for higher energy in the market
High Gas	1.75%	3150 MW WIND	High-gas market led to higher energy market, which preferred high energy renewables to be built, hence it picked the lower EWR level and built wind.

Results of the high load sensitivity

Table 15.4.2 shows the results of the high load sensitivity. The significant increase in load increases the amount of resources required to fill the need. This sensitivity prefers a combination build of wind and solar in the early 2021-2023 timeframe.

Table 15.4.2 – ET Scenario: High load results

Sensitivity	EWR Level	2029/30 Build	Purchases	Commentary
High Load	2%	1050 MW WIND	2020-24: 0-300 MW 2025-28: 400-800 MW 2029-39: 1400-5000 MW	Very high load leads to heavy and early renewable build. Prefers wind in 2021. Solar and additional wind in 2023 Optimized for years 2020-2024.

Results of the combined solar and storage sensitivity

A sensitivity was run on the ET scenario that added an option to the Strategist® optimization tying a 100 MW block of solar together with a 30 MW lithium ion battery. The results are shown in Table 15.4.3.

TABLE 15.4.3: ET Scenario: Combined solar and storage results

EWR level	29/30 Build	PVRR, $M	delta, $M	
1.75%	167 MW DR 1,800 MW wind	$12,063	-	
1.75%	2,550 MW wind 100 MW solar 30 MW battery	$12,078	$15.5	solar-battery tied
1.75%	2550 MW wind 100 MW solar 30 MW battery	$12,079	$16.1	Not tied to solar battery

The solar and storage combination is $14 million NPVRR higher than the least-cost plan. It was run on the ET scenario, where solar and battery costs were assumed to be the lowest. Additionally, another sensitivity was run that forced a solar block and a battery block into the Strategist® model not tied together. This resulted in approximately $2 million-$3 million NPVRR additional cost over the solar and storage combination. Based on this result, the Company will continue to monitor battery technology costs and characteristics.

Results of the wind-congestion sensitivity

TABLE 15.4.4: ET Scenario: Wind congestion results

EWR level	29/30 Build	PVRR, $M	delta, $M
1.75%	308 MW DR 600 MW Wind	414 MW 1x1 CCGT	-
1.75%	414 MW 1x1 CCGT	3150 MW WIND	-70

Results of alternative discount rate sensitivity

Tables 15.4.5 shows the analysis's results using an alternate different discount rate of 9 percent, which was subjectively selected. As expected, the NPVRR was lower with a higher utility discount rate. The results are summarized in Table 15.4.5.

TABLE 15.4.5: ET Scenario: Alternative discount rate sensitivity results

EWR level	LCP 6.63% discount rate	LCP 9% discount rate	Delta, $M (9%-6.63%)
1.5%	414 MW 1x1 CCGT 1500 MW WIND	259 MW DR 414 MW 1x1 CCGT	($1,663)
1.75%	1800 MW WIND 167 MW DR	414 MW 1x1 CCGT	($1,606)
2.0%	1050 MW WIND	167 MW DR	($1,537)

The higher discount rate sensitivity decreased the least-cost plan's overall cost. This sensitivity's results indicated a CCGT and preferred higher DR over wind.

Results of Tier 2 early retirement sensitivities

As part of the Michigan Integrated Resource Planning Parameters, section 6(t) of 2016 PA 341, the Company performed an analysis to evaluate the effects of the earlier retirement of coal units at the St. Clair and Trenton Channel plants. Table 15.4.6 below highlights the planned retirement years and the sensitivities in which retirements were pulled ahead to earlier years.

TABLE 15.4.6: Tier 2 Early Retirement Sensitivities

Unit	Announced Retirement	Sensitivity 1	Sensitivity 2
River Rouge 3	2020	2020	2020
St. Clair 1	2022	2022	2021
St. Clair 2	2022	2022	2021
St. Clair 3	2022	2022	2021
St. Clair 6	2022	2022	2021
St. Clair 7	2023	2022	2022
Trenton 9	2023	2022	2022

All the Tier 2 units are expected to retire over the next four years. The capacity loss associated with the planned retirement of Tier 2 coal units was addressed in the Company's request for a Certificate of Necessities to construct an 1,150 MW natural gas combined cycle plant, which the MPSC approved in April 2018. Therefore, the analysis for Tier 2 units assumed any capacity shortfall resulting from a retirement pull ahead would be filled by short-term purchases from the market.

The Tier 2 early retirement analysis, from an economic standpoint, compared a case in which the units were retired on the announced dates versus a case that assumed the earlier dates considered in sensitivities 1 and 2. In each case, a net present value was calculated based on cost assumptions to operate the units, dispatch of the units, and any capacity purchases needed to meet reserve margin requirements. The net present values were then compared to determine which case would be more economical for customers. Due to the uncertainty of capacity prices, the analysis considered price sensitivities, as shown in Table 15.4.7.

TABLE 15.4.7: Tier 2 Retirement Analysis, Capacity Price Sensitivities

Capacity Price Sensitivity ($/kW-yr)	2019	2020	2021	2022
$0	-	-	-	-
PACE Forecast	52.7	55.7	54.0	59.1
50 percent of CONE	44.4	44.4	44.4	44.4
CONE	88.8	88.8	88.8	88.8

The results of the analysis across the capacity price assumptions are highlighted in Table 15.4.8. The number in the table represents the net present value delta between the case with the retirement dates considered in the sensitivities versus the case to keep the announced retirement dates.

TABLE 15.4.8: Early Retirement vs. Announced Dates; Delta Net Present Value ($M)

	Capacity Price Assumptions			
	$0	PACE Forecast	50 percent of CONE	CONE
Sensitivity 1 (Pull ahead SC-7 and TC-9 to 2022)	12	17	16	19
Sensitivity 2 (Pull ahead SC-1 thru 6 to 2021, SC-7 and TC-9 to 2022)	13	45	39	65

A positive number in the table means that, from an economic standpoint, it would be more expensive to retire units ahead of the announced retirement dates. The results shown above support keeping the retirement dates as currently planned. The four capacity price sensitivities ranged from $12 million to $65 million.

After considering the results of economic modeling with sensitivity analysis and the Company's planning principles, the Company has decided to retire St. Clair unit 7 and Trenton Channel unit 9 one year earlier than planned, in 2022. This decision is conditional upon two factors: BWEC must successfully start up as planned in 2022, and transmission issues that MISO identified related to the retirement of Company plants in the southern portion of its service area must be successfully resolved.

15.5 Environmental Policy Scenario Results

Sensitivities under the Environmental Policy scenario included: high gas (200 percent 2018 EIA), 50 percent CO2 reduction, and high load. The sensitivity analyses' results are summarized in the tables below.

Results of the high gas and 50 percent CO2 reduction sensitivity

Sensitivity	EWR Level	2029/30 Build	Comments
Starting Point	1.75%	3150 MW WIND	The combination of higher capacity factor and 35 percent reduction of Capex on wind makes it a preferred option
High Gas	1.5%	5100 MW WIND	High gas market led to higher energy market, which preferred high-energy renewables to be built. Hence, it picked the lower EWR level and built wind.
50 percent CO2 Reduction	1.75%	3150 MW WIND	The combination of higher capacity factor and 35 percent reduction of Capex on wind made it a preferred option.

Results of the high load sensitivity

TABLE 15.5.2: EP Scenario: High load results

Sensitivity	EWR Level	2029/30 Build	Purchases	Commentary
High Load	1.75%	2250 MW WIND 900 MW SOLAR	2020-24 – 0-300 2025-29 – 400 -1000 2026-39 – 1500-5000	Very high load leads to heavy and early renewable build. It prefers solar and wind in 2023, followed by additional solar in 2024. Optimized for years 2020-2024.

15.6 Additional Sensitivity Results Across all Scenarios

Additional sensitivities run across all scenarios included: market purchase only, all-solar build plan, demand response only, high EWR levels (>2.0 percent), and avoided transmission and distribution. The sensitivity analyses' results are summarized in the tables below.

Results of the market purchase only sensitivity

TABLE 15.6.1: Market purchase only results

Scenario	EWR level	Least cost plan	Market Purchase (MW)	delta, $M (Mkt Purchase - LCP)
REF	1.5%	414 MW 1x1 CCGT 259 MW DR	2029 – 159 2030 – 585 2031 – 486 2032 – 418 2033 – 370 2034 – 256 2035 – 182 2036 – 105 2037 – 15	$109
BAU	2%	414 MW 1x1 CCGT	2030 – 113	$86
ET	2%	1050 MW WIND	2030 – 113	$98
EP	1.75%	3150 MW WIND	2030 – 364 2031 – 266 2032 – 198 2033 – 150 2034 – 32	$376

The results shown in Table 15.6.1 demonstrate that allowing an all-purchase plan, even if feasible, would be higher cost than the least-cost plan under all of the scenarios.

Results of the solar only build plan sensitivity

TABLE 15.6.2: Solar-only build results

Scenario	EWR level	Least cost plan	All-solar build plan	delta, $M (Solar - LCP)
REF	1.5%	414 MW 1x1 CCGT 259 MW DR	1800 MW SOLAR	$282
BAU	2%	414 MW 1x1 CCGT	400 MW SOLAR	$109
ET	2%	1050 MW WIND	400 MW SOLAR	$126
EP	1.75%	3150 MW WIND	1100 MW SOLAR	$469

An item of note is that the all-solar plan for the REF scenario was lower cost than an-all wind plan or 3300 MW wind/216 MW DR plan, which cost $317M NPVRR. This demonstrates that wind does not always cost less than solar across scenarios, and the competition between the renewable technologies depends on market prices and capital costs.

Results of the demand response only sensitivity

TABLE 15.6.3 – Demand response only results

Scenario	EWR level	Least cost plan	All DR build plan	delta, $M (DR - LCP)
REF	1.5%	414 MW 1x1 CCGT 259 MW DR	572 MW DR	$129
BAU	2%	414 MW 1x1 CCGT	142 MW DR	$84
ET	2%	1050 MW WIND	142 MW DR	$95
EP	1.75%	3150 MW WIND	359 MW DR	$387

The demand response only results show that allowing the optimization to select large amounts of DR did not lead to lower cost plans under any of the scenarios

EWR sensitivity results

The economic viability of the higher levels of EWR, the least-cost plan for the 2.25 percent and 2.5 percent EWR levels, was compared to the least-cost plan from each scenario. The higher levels of EWR (2.25 percent and 2.5 percent) were not economical in any scenario, as shown in Table xxxx

Scenario	EWR LEVELS	2029/30 BUILD	DELTA, $M
REF LCP	1.5%	414 MW 1x1 CC 259 MW DR	-
REF	2.25%	414 MW 1x1 CC	$359
REF	2.5%	-	$1,814
BAU LCP	2%	414 MW 1x1 CC	-
BAU	2.25%	414 MW 1x1 CC	$323
BAU	2.5%	-	$2,116
ET LCP	1.5%	1050 MW WIND	-
ET	2.25%	414 MW 1x1 CC	$219
ET	2.5%	-	$1,429
EP LCP	1.75%	3150 MW WIND	-
EP	2.25%	450 MW WIND	$468
EP	2.5%	-	$2,270

Avoided transmission and distribution sensitivity results

A sensitivity was run on each scenario that applied $7/kW for avoided transmission and distribution (T&D) to the EWR costs. The least-cost plans before and after the avoided T&D benefit is applied are highlighted red in the table. In all four scenarios, the least-cost plan was the same before and after the T&D benefit was applied. The results are shown in Table 15.X.X.

Reference	1.50%	1.75%	2.00%
NPVRR, $M	$13,278	$13,296	$13,371
Total T&D benefits, $M	$72	$85	$101
T&D impact on NPVRR, $M	$13,206	$13,211	$13,270
BAU	**1.50%**	**1.75%**	**2.00%**
NPVRR, $M	$12,687	$12,533	$12,387
Total T&D benefits, $M	$72	$85	$101
T&D impact on NPVRR, $M	$12,615	$12,448	$12,286
ET	**1.50%**	**1.75%**	**2.00%**
NPVRR, $M	$12,303	$12,132	$11,965
Total T&D benefits, $M	$72	$85	$101
T&D impact on NPVRR, $M	$12,231	$12,047	$11,864
EP	**1.50%**	**1.75%**	**2.00%**
NPVRR, $M	$12,398	$12,300	$12,347
Total T&D benefits, $M	$72	$85	$101
T&D impact on NPVRR, $M	$12,326	$12,215	$12,246

15.7 Risk assessment of each scenario

The PCA needs to be a reasonable plan in the face of an uncertain future, especially given the dynamic nature of the energy industry and emerging technologies. Risk analysis helps to hedge the uncertainties by evaluating how different build plans would perform given a range of unexpected possible futures. All seven DTE Electric planning principles (reliability, affordability, clean, flexible and balanced, compliant, reasonable risk, and community impact) were considered when designing the five risk analysis approaches used in this IRP.

Affordability was partially addressed through the modeling optimization. Reliability and compliance were fulfilled through setting the proper constraints in the modeling scenarios to satisfy the MISO reserve margin requirements and comply with all regulations, and ensuring the Strategist® optimization met both of these constraints. The other planning principles of clean, flexible and balanced, reasonable risk, and community impact had to be handled more qualitatively outside of the Strategist® model or by using techniques that quantified these principles and compared alternative portfolios against each other based on how they ranked in each category. The Company used the latter approach.

As the PCA was being determined, multiple risk analyses were conducted to ensure the plan's prudency and robustness considering the planning principles. DTE Electric wanted to minimize risk; therefore, the risk analyses were an essential part of the IRP process. Over time, commodity markets and environmental and regulatory conditions may pan out differently than what was forecasted. Considering the market's uncertainty, the selected portfolio plan should be flexible enough to accommodate changes as they occur.

Stochastic Risk Assessment

For the stochastic risk analysis, several steps were undertaken.

- **Step 1: Formulate assumptions.** A probability distribution used in the Stochastic analysis served to measure the likelihood of possible outcomes given reasonable changes in assumptions. The mean of the probability distributions was generally represented by the underlying assumptions in the BAU and DTE Reference scenarios. PACE Global constructed probability distributions for key drivers, including load growth; gas and coal prices; the price of carbon used for analytic purposes; and the cost of generating technologies. These distributions encompass the other scenarios and generally the sensitivities studied. The key drivers' probability distribution was developed from historical variance and a range of future forecasts. These assumptions are detailed in Appendix Q.
- **Step 2: Set up specific DTEE portfolio builds.** Because this work was used to look at 13 different DTEE resource plans in a probabilistic framework, the assumption was that each specific resource plan would be treated as comprising firm resources that remained online regardless of the probabilistic case (200 iterations). The 13 plans evaluated through stochastic analysis represented a diverse mix of resources that met the reserve margin requirement through 2040, with a focus on a 2029-2030 capacity replacement. Each of the 13 plans was set up, in turn, as a firm, specific resource plan that did not change with market and other uncertainties. It should be noted that the stochastic risk assessment and the IRP scenario modeling were conducted in parallel, therefore the 13 portfolios considered in the stochastic risk assessment do not exactly match the nine least-cost portfolios generated by the IRP scenario modeling and the resultant PCA with its four potential pathways. The purchase listed in the stochastic resource plans can be considered equivalent to DR for modeling purposes. The costs of the capacity purchase and DR are similar and both will be obtaining market purchases for the energy portion of the DR or purchase.
- **Step 3: Run Pace Global' s stochastic version of AURORA Model for the DTEE footprint.** Pace Global ran its proprietary stochastic version of AURORA for the DTEE footprint, with the resources shown in Table 15.5.1 treated as firm resources in each of 13 build plans.
- **Step 4: Compare the 13 build plans**. The analysis provided output probability distribution functions for key outputs, such as electric energy prices.

Because the analysis was probabilistic, each case could be stated in terms of an expected cost and the standard deviation of that cost or associated risk. This allowed a ranking of the cases in terms of expected cost and risk.

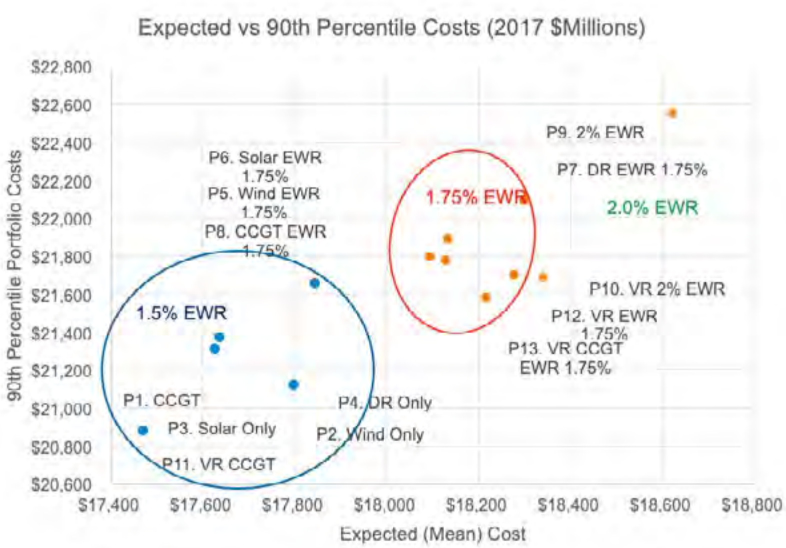
Portfolio	Resource Plans
1	1.5 percent EWR + 430MW CCGT + 170 MW purchase
2	1.5 percent EWR + 2,550 MW Wind + 290 MW purchase
3	1.5 percent EWR + 800 MW Solar + 260 MW purchase
4	1.5 percent EWR + 309 MW DR + 280 MW purchase
5	1.75 percent EWR + 600 MW Wind + 290 MW purchase
6	1.75 percent EWR + 200 MW Solar + 290 MW purchase
7	1.75 percent EWR + 92 MW DR Only + 270 MW purchase
8	1.75 percent EWR + 430 MW CCGT
9	2 percent EWR + 110 MW purchase
10	2 percent EWR + 1,090 MW voluntary renewables
11	1.5 percent EWR + 1,090 MW voluntary renewables + 430 MW CCGT
12	1.75 percent EWR + 1,090 MW voluntary renewables + 30 MW purchase
13	1.75 percent EWR + 1,090 MW voluntary renewables + 430 MW CCGT

Interpretation of the Results of the Stochastic Risk Assessment

The goal of determining the expected (mean) portfolio cost and the 90th percentile NPV (economic risk) is to select a portfolio that is both lowest-cost and lowest-risk. These portfolios are grouped together in the graph's bottom left. The portfolios are also grouped by EWR level, with the 1.5 percent EWR level in the lower left, the 1.75 percent EWR levels in the middle, and the 2 percent EWR levels inthe top right. The overall least-cost and least-economical risk portfolio is portfolio 11, consisting of 1.5 percent EWR, voluntary renewables, and a CCGT. This is not surprising because the 1.5 percent EWR level, CCGT, and some level of renewables had been getting selected as least-cost plans in the IRP Strategist® optimization.

The four IRP PCA pathways are closest to portfolios 8, 12, and 13. They are all in the 1.75 percent EWR middle grouping. This illustrates that the EWR program levels' costs are quite uncertain and have a high level of risk associated with selecting the higher EWR level of 1.75 percent over 1.5 percent. The Company can mitigate this risk by monitoring EWR costs and evaluating whether 1.75 percent EWR remains competitive compared to other IRP alternatives. If EWR costs are found to be higher than what is projected in the defined PCA, then the Company may refine its EWR spend and/or savings as part of its EWR plan filed with the Commission every two years. Portfolios 12 and 13 have slightly higher expected costs than portfolio 8, however portfolio 8 has higher economic risk than 12 and 13. The portfolios containing DR had the highest expected costs and economic risks of their grouping, in both 1.5 percent EWR or 1.75 percent EWR groupings.

The Stochastic results focus on risk's affordability aspect in a quantitative fashion. This will be balanced by the other risk assessments that will focus on non-economic areas of risk using a qualitative approach.



Change Analysis Results

The change analysis, which is summarized in Table 15.7.3, contains a list of outcomes or "situations" that can arise from different drivers or "causations." Each situation presents a likely adaptation of the PCA. The PCA has the flexibility to adapt and accommodate to the constant development of situations. The change analysis covers situations from multiple categories such as fuel, environmental, load, future technology development and evolution, and transmission. In some cases, multiple drivers can lead to similar outcomes. For instance, in the case of fuel prices, increases to gas could result from several drivers listed under causation. The PCA could adapt by reducing the use of gas units in the fleet and considering other options, such as adding renewables in the next IRP. In each case, the PCA's adaptability is demonstrated. The PCA is proven to be flexible and able to adapt to changes of assumptions and new inputs. The change analysis is a qualitative mechanism that demonstrates that there exists an attainable and realistic range of adaptions to the PCA from a diverse set of potential situations that may develop in time.

TABLE 15.7.3: Risk Assessment no. 2: Change analysis

	Situation	Causation	PCA Adaptation
1	Increase in commodity prices (gas)	-Increased regulatory scrutiny on fracking and/or pipeline construction -LNG and pipeline exports increase more than expected -Domestic gas demand increases more than expected	Gas units in fleet run less, additional renewables likely selected in next IRP. The impact on dispatch would be less for BWEC than for our other units (or for other less-efficient CCGTs in MISO) given its high efficiency. A high gas price is more detrimental to inefficient gas units.
2	Stricter environmental rules	U.S. signs on to Paris Agreement, new legislation, CO_2 trading is introduced	Fleet dispatches to new paradigm of CO_2 prices, additional renewables likely selected in next IRP.
3	Increase load	EV, greenhouse expansions or changes to the Electric Choice program	Evaluate capacity position to determine if a new IRP is warranted before 2024 to fill emerging persistent capacity need.
4	Decrease load	Recession, increased adoption of behind-the-meter generation, or changes to Electric Choice program	Decrease pace of modular builds (renewables, EWR, DR) and decide if new IRP is warranted before 2024.
5	Solar preferred over wind	Saturated wind siting or possible community resistance	Shift to solar over wind in renewables build.
6	Wind preferred over solar	Hub heights increase	Shift to wind over solar in renewables build.
7	Capacity credit for solar reduced	High solar growth throughout MISO	Evaluate capacity position and decide if a new IRP is warranted before 2024 to fill emerging persistent capacity need.
8	EWR decreases from potential study	Technology baseline changes and customer adoption trends	Evaluate EWR levels in semi-annual EWR filings and next IRP. Decrease EWR level accordingly. Utilize MISO capacity auction if needed.
9	EWR costs increase at higher levels	Saturation of low-cost EWR measures, including lighting	Evaluate EWR levels in semi-annual EWR filings and next IRP. Decrease EWR level accordingly. Utilize MISO capacity auction if needed.
10	Demand response lack of customer adoption	The risk of interruption does not outweigh the cost benefits for the customer	Evaluate DR levels and programs annually and in next IRP. Decrease DR level accordingly and explore additional pilots for increased customer engagement.
11	Demand response committed MWs are not reached	Solar resources move the net peaks, DR programs/tariffs aren't adjustable	Evaluate DR levels annually and in next IRP. Decrease DR level accordingly and explore additional pilots that are more flexible.
12	Storage technologies become preferred	Storage technologies experience technology breakthrough and possible cost breakthrough	Accelerate testing and studies of storage technologies. Additional storage could be selected in next IRP.
13	DG technologies experience growth	Policies and pricing constructs that advantage DG, significant decreases in DG costs	Decrease pace of modular utility builds (renewables, EWR, DR) and decide if new IRP is warranted before 2024.
14	Difficulty in executing CVR/ VVO to realize the savings	Customers, particularly those at end of feeders, experience low-voltage conditions, in violation of allowable voltage ranges	Re-evaluate the potential savings from CVR/VVO in the next IRP.
15	Transmission import limit declines	MISO system changes	Evaluate impact of resource procurement internal and external to Zone 7.
16	Transmission import limit increases	MISO system changes	Evaluate impact of resource procurement internal and external to Zone 7.

Evaluation of Planning Principles

The application of planning principles is a comparative analysis method that is used to rank each plan by individual planning principles. In our analysis, 12 plans were analyzed and assigned rankings for five of the seven planning principles: reliability, clean, flexible and balanced, reasonable risk, and community impact. The plans were not ranked based on affordability as each plan was identified as a "least-cost" plan, and the plans were not ranked on compliance, as each plan is compliant with current regulations. The 12 plans selected for analysis consisted of the nine least-cost plans and the four pathways, with one pathway and least-cost plan overlapping. The application of planning principles allows for a comprehensive view of each plan's ranking on the individual principles.

TABLE 15.7.4: Application of Planning Principles

Plan #	Description	Reliability	Clean	Flexible and Balanced	Reasonable Risk	Community Impact	
Plan 1	1.5 percent EWR, 216 MW DR, 3300 MW wind	12	3	12	12	2	Least-cost plan D
Plan 2	1.5 percent EWR, CC, 1500 MW wind	6	8	9	9	5	Least-cost plan C
Plan 3	1.5 percent EWR, CC, 167 MW DR, 150 MW wind	5	11	7	3	11	Least-cost plan B
Plan 4	1.5 percent EWR, CC, 259 MW DR	4	12	7	6	12	Least-cost plan A
Plan 5	1.75 percent EWR, 3150 MW wind	11	1	11	11	1	Least-cost plan G
Plan 6	1.75 percent EWR, 167 MW DR, 1800 MW wind	7	4	10	10	4	Least-cost plan F
Plan 7	1.75 percent EWR, 50 MW CVR/VVO, 1100 MW voluntary renewables	7	5	6	3	7	Pathway A
Plan 8	1.75 percent EWR, CC, 1100 MW voluntary renewables	2	7	1	1	3	Pathway B
Plan 9	1.75 percent EWR, CC	3	10	2	2	9	Pathway D
Plan 10	1.75 percent-2 percent EWR, 100 MW DR, 50 MW CVR/VVO	10	5	2	8	10	Pathway C
Plan 11	2 percent EWR, 1050 MW wind	7	1	5	7	6	Least-cost plan I
Plan 12	2 percent EWR, CC	1	9	4	5	8	Least-cost plan H

The four PCA pathways are represented by plans 7, 8,9, and 10 in Figure 15.5.3. All the Pathways have no. 1. to no. 10 rankings across the five evaluated planning Principles. Of the four pathways, B and D have three or more top rankings (1-3). Pathways C and D each have one top ranking. Additionally, the rankings for A and D are all below 7. Of the four pathways, B appears to be the best overall in this qualitative assessment, with its four top-three rankings and the fifth ranking being a 7. More details are shown in Exhibit A-4, Appendix XX.

Determination whether key IRP inputs have changed since initial adoption

The IRP inputs were adopted in May-August of 2018 before the optimization models were built. Right before the filing, in February 2019, most of the inputs were considered again to see if they had changed materially since initial adoption. Inputs considered for changes are shown and the result of whether the change was made is also shown. The decision on whether to update the input was based on how much the input changed, whether scenarios and sensitivities had been run that covered the uncertainty, and how easy it was to update. In general, easier updates included values that only affect the DTEE fleet capacity position, while difficult updates included market parameters that are included in the IRP optimization or that drive the fundamental modeling, because those inputs are incorporated at the beginning of the modeling process.

TABLE 15.7.5 – IRP Input Comparison; Starting Point to Recently Available

	Input	Original input (Starting Point)	Most Recent input	Decision
1	Gas prices	Forwards from 5.10.18	Forwards from 2.5.19	MichCon price 5 percent different, Dawn price 7 percent different: not material, not updated
2	Market prices	Forwards from 5.10.18	Forwards from 2.5.19	LMP RTC 4 percent different: not material, not updated
3	ELCC of wind	11.7%	16%	30 percent increase is a material change and roughly in line with prior history. Update made to wind in PCA runs and capacity position
4	Environmental regulations	As of May 2018	As of February 2019	Not material, not updated
5	Tier 2 retirement schedule	St. Clair 1 in 2022 River Rouge in 2020 St. Clair 7/ Trenton 9 in 2023	St. Clair 1 experienced a maintenance issue, requiring retirement in 2019 River Rouge retired on coal in 2020, extended to 2022 on waste gases St. Clair 7/Trenton 9 in 2022	Updated in PCA runs and capacity position
6	Capital cost of alternatives	Publicly available sources as of Aug 2018	Publicly available sources as of Feb 2019	Revisions of sources were within the 35 percent discount level covered in the EP and ET scenarios: not updated

	Input	Original input (Starting Point)	Most Recent input	Decision
7	EIA gas price forecast	2018 EIA forecast	2019 EIA forecast	Updated EIA forecast was 12 percent lower, but still above the DTEE forecast; it is encompassed within the spread of IRP scenarios: not updated
8	Coal prices	2018 forwards	2019 forwards	3 percent change in fuel supply forecast: not material, not updated
9	ELCC of solar	50 percent in 2018, lowering to 30 percent by 2033	50 percent in 2019, lowering to 30 percent by 2033	Not updated
10	UCAP of DTEE fleet other than wind	Max change in 2022 10,315 MW	Max change in 2020 10,256 MW	Changed by 58 MW: not material, not updated
11	Load forecast	Peak (bundled) in 2030 = 9,951 MW	No updated forecast created, peak (bundled) does not change	No material change to the economic drivers of the forecast based on new economic data
12	Demand response	2019: 731 MW	2019: 709 MW	Updated in PCA capacity position
13	MISO PRMR parameters			Updated in PCA capacity position

After considering the 11 different inputs listed above for potential revision, the Company decided to update just three: the wind ELCC, the demand response forecast, and the Tier 2 retirement dates based on emerging knowledge. These updates affected only the DTEE capacity position. The IRP optimization modeling results were not affected.

Scenarios and Sensitivities

Consideration of scenarios and sensitivities make up the fifth risk assessment. The results are discussed in Sections 15.2 to 15.5.

SECTION SIXTEEN

16 Proposed Course of Action

16.1 Overview

As highlighted in Section 15, modeling results were quite varied. There were wide variances in the least-cost portfolios, depending on which input assumptions were used in each of the four scenarios. The four key drivers of these variances were:

- Future CO2 regulation and resulting CO2 prices
- EWR incentive cost
- Gas-price forecast uncertainty
- Wind and solar power's assumed cost and operating characteristics

A variance in any one of the above four drivers was capable of changing the least-cost plan results on its own. With the exception of the renewables characteristics, the Company had its own view of the key drivers, which were contained in the Reference scenario assumptions. However, the drivers' costs are changing rapidly, leading to future uncertainty. Therefore, the Company does not believe it is prudent to lay out a definite plan in 2019 for what DTE Electric will do in 2030. Instead, the Company will focus on the near-term and will review inputs and assumptions in the next IRP, expected to be filed by January 2025, and in doing so, will not close off any one pathway prematurely. Before the next IRP is filed, the Company expects the four key drivers to evolve, leading us to make an informed, prudent decision, at that time, to replace Belle River. expected to be filed by January 2025, and in doing so, will not close off any one pathway prematurely. Before the next IRP is filed, the Company expects the four key drivers to evolve, leading us to make an informed, prudent decision, at that time, to replace Belle River.

16.2 Proposed Course of Action Defined Component

AAfter reviewing the modeling results, the assumptions about the key drivers, and the planning principles, the Company selected the following resource plan for the PCA's five-year, short-term defined component:

- Adding 11 MW of solar and 855 MW wind by 2024
- Adding a minimum of 465 MW of VGP renewables in 2021, which may ramp up to 715 MW by 2024 depending on customer demand.
- Maintaining existing and adding more customers to the established Demand Response tariffs in order to achieve 859 MW by 2024.
- Continuing to make strides toward our CO2 reduction goals by proceeding with an orderly retirement of our Tier 2 coal units, contingent on maintaining current timelines for replacement capacity (BWEC start-up in 2022) and the resolution of transmission issues caused by Trenton's retirement. In 2020, we will retire River Rouge on coal, and implement a project to transition the River Rouge Unit 3 to utilize recycled industrial gases until 2022; in 2022 we will retire the remaining St. Clair units as well as Trenton Unit 9.
- Increasing the level of EWR to 1.75%, starting with an increase to 1.625% in 2020, with full implementation of 1.75% in 2021 through 2024.
- Continuing to explore and implement pilots in the areas of batteries and CVR/VVO and continue to keep up with new technology developments in all areas.

Consistent with the timing of IRP filings specified in U-18461, the Company estimates that we will file our next IRP no later than January 2025. This future filing will take into consideration updates to technology parameters and costs, as well as new risks or opportunities, that emerge in the next five years. The next IRP is the right point in time to make decisions on what is appropriate, reasonable, and prudent to replace the Belle River coal plant and set ourselves up for the rest of the 2030s.

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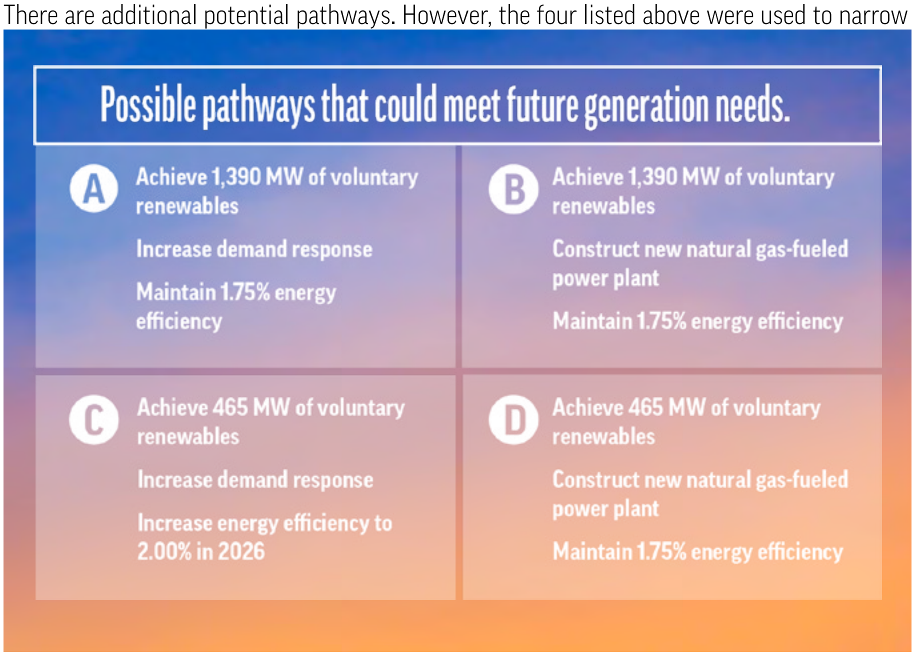
16.3 Proposed Course of Action Flexible Component

The PCA was defined in the near term as discussed above. However, by deferring the 2030 build decision to the next IRP filing, the Company remains flexible, recognizing that there are numerous potential pathways that may evolve into the plan developed by 2025, depending, in part, on the amount of VGP programs subsricbed to. Four of the possible pathways are listed below:

There are additional potential pathways. However, the four listed above were used to narrow



the scope of possibilities to present in the PCA modeling.

DTE is planning to retire the Monroe Power Plant by 2040 and continue expanding renewables to stay on track with clean energy and CO2 reduction goals.

16.4 Proposed Course of Action Modeling Results

Table 16.4.1 compares the four PCA pathways to the least-cost plan identified in the REF scenario. The total cost of these resource plans range from $69 M to $565 M more than the least-cost plan in the REF scenario, as shown in column (i). It is important to note, however, that these additional costs would be borne by those customers who choose to pay extra to increase the portion of renewable resources that serve their energy needs. The amount paid by non-VGP subscribers through general rates under the four PCA pathways would be less than the least-cost plan identified through Strategist modeling, as shown by the negative numbers in column (f). This can be explained by the fact that it takes significantly more nameplate MW of wind and solar assets to achieve the same capacity credit as the CCGT which was selected in the least-cost plan. These additional MW of nameplate wind and solar capacity produce significant energy which is assumed to be sold into the market, which tends to drive down market prices which reduces costs for all customers within the region.

TABLE 16.4.1: Reference Scenario PCA Pathways

Reference PCA Runs								
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Sensitivity	EWR Level	VGP Programs	2029/2030 BUILD	PVRR includes renewables but not cost to build, $M	Delta Back to Least Cost plan, $M	VPG Program Cost PVRR[1], $M	PVRR with cost of VPG Program added in $M	Delta Back to Least Cost Plan, Including VGP Programs Cost, $M
Least Cost Plan	1.50%	300 MW	414 MW 1x1 CCGT 259 MW DR	$13,278		$447	$13,725	
PCA A	1.75% Ramped	Significant	50 MW DR	$12,501	($777)	$1,789	$14,290	$565
PCA B	1.75% Ramped	Significant	414 MW 1x1 CCGT	$12,451	($828)	$1,789	$14,240	$515
PCA C	2% in 2026	Modest	150 MW DR	$13,211	($67)	$693	$13,904	$179
PCA D	1.75% Ramped	Modest	414 MW 1x1 CCGT	$13,102	($177)	$693	$13,794	$69

PCA Results in the Business as Usual Scenario

1 VPG Program Costs in Reference and BAU scenarios

Table 16.4.2 compares the four PCA pathways to the least-cost plan identified in the BAU scenario. The total cost of these resource plans range from $206 M to $681 million more than the least-cost plan in the BAU scenario, as shown in column (i). As in the REF scenario, these incremental costs would be borne by subscribers to VGP renewable programs, while the remaining bundled customer who do not subscribe to VGP renewable programs would pay less as shown by the negative numbers in column (f).

The NPVRR numbers in column (g) are exactly the same for the BAU scenario as in the REF scenario, since the cost assumptions for renewables and the assumed level of VGP renewable subscriptions are the same between those two scenarios. The NPVRR numbers in column (e) for the BAU scenario are lower than those in the REF scenario, due to carbon adder in the REF scenario which more than offsets the higher gas costs and higher EWR incentive costs assumed in the BAU case.

TABLE 16.4.2: BAU Scenario PCA Pathways

BAU PCA Runs								
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Sensitivity	EWR Level	VGP Programs	2029/2030 BUILD	PVRR includes renewables but not cost to build, $M	Delta Back to Least Cost plan, $M	VPG Program Cost PVRR[2], $M	PVRR with cost of VPG Program added in $M	Delta Back to Least Cost Plan, Including VGP Programs Cost, $M
Least Cost Plan	2.00%	300 MW	414 MW 1x1 CCGT	$12,387		$447	$12,834	
PCA A	1.75% Ramped	Significant	50 MW DR	$11,726	($661)	$1,789	$13,516	$681
PCA B	1.75% Ramped	Significant	414 MW 1x1 CCGT	$11,660	($728)	$1,789	$13,449	$615
PCA C	2% in 2026	Modest	150 MW DR	$12,348	($39)	$693	$13,041	$206
PCA D	1.75% Ramped	Modest	414 MW 1x1 CCGT	$12,353	($34)	$693	$13,046	$211

2 1VPG Program Cost in Reference and BAU scenarios

PCA Results in the Emerging Technology Scenario

Table 16.4.3 compares the four PCA pathways to the least-cost plan identified in the ET scenario. The total cost of these resource plans range from $223 M to $477 M more than the least-cost plan in the ET scenario, as shown in column (i). In this scenario, only the PCA pathways with significant volumes of VGP renewable program subscriptions (pathways A and B) result in lower costs for the remaining bundled customer who do not subscribe to VGP renewable programs, as shown by the negative numbers in column (f). When only modest levels of additional VGP subscriptions occur under PCA pathways C and D, all customers -- whether subscribing to VGP renewable programs or not – face higher costs under these PCA pathways than under the least-cost plan identified by the Strategist modeling. The incremental costs for the non-subscribers of VGP renewable programs are very modest, however, with the NPVRR for these PCA pathways being less than 1% higher than the least-cost plan. We consider this small amount of incremental cost to be immaterial and well within the margin of error, given all of the forecast assumptions inherent in long-term IRP modeling.

TABLE 16.4.3: ET Scenario PCA Pathways

ET PCA Runs								
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Sensitivity	EWR Level	VGP Programs	2029/2030 BUILD	PVRR includes renewables but not cost to build, $M	Delta Back to Least Cost plan, $M	VPG Program Cost PVRR[3], $M	PVRR with cost of VPG Program added in $M	Delta Back to Least Cost Plan, Including VGP Programs Cost, $M
Least Cost Plan	2.00%	300 MW	1050 MW WIND	$11,885		$375	$12,260	
PCA A	1.75% Ramped	Significant	50 MW DR	$11,328	($557)	$1,409	$12,737	$477
PCA B	1.75% Ramped	Significant	414 MW 1x1 CCGT	$11,280	($604)	$1,409	$12,689	$430
PCA C	2% in 2026	Modest	150 MW DR	$11,901	$17	$581	$12,482	$223
PCA D	1.75% Ramped	Modest	414 MW 1x1 CCGT	$11,964	$80	$581	$12,545	$286

3 1VPG Program Costs in ET scenarios - Solar capital decreased by 35%, Wind Capital decreased by 17.5%

PCA Results in the Environmental Policy Scenario

Table 16.4.3 compares the four PCA pathways to the least-cost plan identified in the EP scenario. The total cost of these resource plans range from $271 M to $449 M more than the least-cost plan in the EP scenario, as shown in column (i). Similar to the ET scenario, only the PCA pathways with significant volumes of VGP renewable program subscriptions (pathways A and B) result in lower costs for the remaining bundled customer who do not subscribe to VGP renewable programs, as shown by the negative numbers in column (f). Under PCA pathways C and D in this EP scenario, the incremental costs for the non-subscribers of VGP renewable programs -- as shown in column (f) -- are very modest, approximately 1% higher than the least-cost plan. We consider this small amount of incremental cost to be immaterial and well within the margin of error, given all of the forecast assumptions inherent in long-term IRP modeling.

TABLE 16.4.4: EP Scenario PCA Pathways

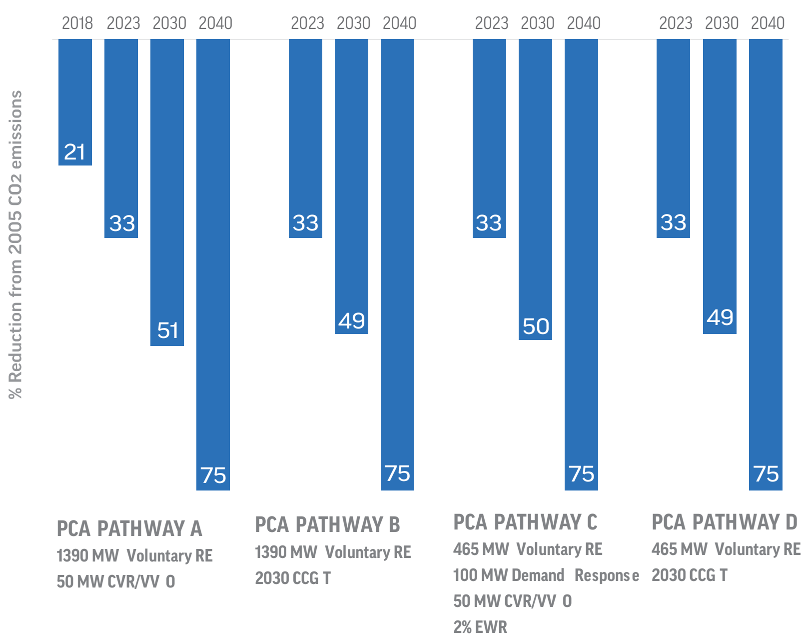
EP PCA Runs								
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Sensitivity	EWR Level	VGP Programs	2029/2030 BUILD	PVRR includes renewables but not cost to build, $M	Delta Back to Least Cost plan, $M	VPG Program Cost PVRR[4], $M	PVRR with cost of VPG Program added in $M	Delta Back to Least Cost Plan, Including VGP Programs Cost, $M
Least Cost Plan	2.00%	300 MW	1050 MW WIND	$11,885		$375	$12,260	
PCA A	1.75% Ramped	Significant	50 MW DR	$11,328	($557)	$1,409	$12,737	$477
PCA B	1.75% Ramped	Significant	414 MW 1x1 CCGT	$11,280	($604)	$1,409	$12,689	$430
PCA C	2% in 2026	Modest	150 MW DR	$11,901	$17	$581	$12,482	$223
PCA D	1.75% Ramped	Modest	414 MW 1x1 CCGT	$11,964	$80	$581	$12,545	$286

4 VPG Program Costs in ET scenarios - Solar capital decreased by 35%, Wind Capital decreased by 17.5%

16.5 CO_2 Reduction Across the Potential PCA Pathways

TThe four PCA pathways were run on the REF scenario in the PROMOD® model to determine the CO2 emissions from the Company's owned generation fleet for each pathway. Figure 16.5.1 shows the Company owned fleet CO2 emissions reduction from 2005 of the four PCA pathways.

FIGURE 16.5.1: CO2 Emissions from Company Owned Electric Fleet



CO2 Accounting Methodology

The Company continues to report all fleet direct emissions from DTEE owned generating assets to the EPA and the MDEQ, as required, and has also accounted for CO2 from market purchases and sales in some previously published sustainability reports. With this IRP, the Company started to explore different methodologies to account for the CO2 associated with the electricity sold to our customers, whether sourced from DTEE owned generating assets, from the purchase of electricity in the market, or through purchased power agreements.

We worked with Electric Power Research Institute (EPRI) to understand different methods that could be used to account for indirect CO2 emissions. EPRI has completed a study which describes five methods of accounting for CO2 emissions. This study, "Methods to Account for Greenhouse Gas Emissions Embedded in Wholesale Power Purchases" will be published at the end of March and available on the EPRI website: https://www.epri.com/#/pages/product/000000003002015044/?lang=en-US

In this IRP, we are using an annual net short approach to CO2 accounting. The standard approach shown above in Figure 16.5.1, only counts CO2 from the Company's fleet, and any CO2 attributable to purchases or sales of power is ignored. In the annual net short method, the Company's generating units are divided into two groups: non-dispatchable and dispatchable.

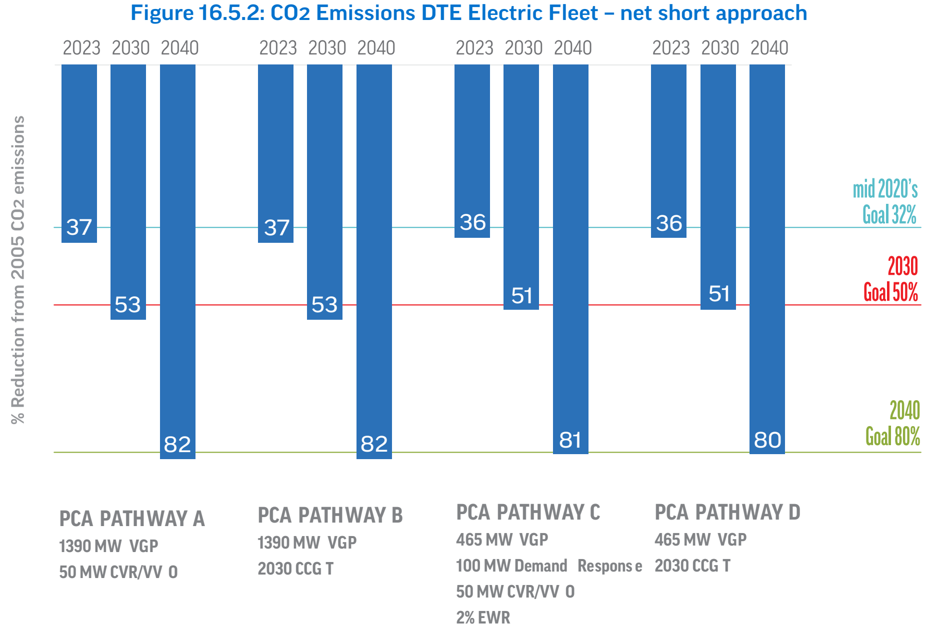
In the traditional sense, dispatchable refers to sources of electricity that can be used on demand and dispatched at the request of MISO, according to market needs. This is in contrast with non-dispatchable energy sources which cannot change their output in response to MISO, such as wind and solar, which are entirely dependent on the weather.

However, for the purposes of the annual net short carbon accounting method and using terminology consistent with EPRI's carbon accounting report discussed above, dispatchable refers to gas units, frequently on the margin serving the broader market ups and downs while non-dispatchable refers to the traditional baseload resources, renewables, and purchase contracts with specific assets. The non-dispatchable units' emissions are assumed to stay with the Company, as these resources are assumed to be serving our customers at all times. Therefore, DTEE's coal, nuclear, and renewable assets, and all PPAs are considered non-dispatchable for the purposes of carbon accounting. Dispatchable units are more likely to be on the margin and able to quickly ramp up and down to supply power to the MISO market and includes all gas units (CCGT and gas peakers).

The generation and the associated emissions from the non-dispatchable units are summed separately. Then the generation from the Company's non-dispatchable units are subtracted from the DTEE customers' load. The difference is what is required to serve our customers' load, beyond the output of the non-dispatchable units. This difference could be positive ("net short") when the Company needs to purchase additional electricity to serve its customers on annual basis, or this difference could be negative if the Company is a net seller of electricity over the course of the year. A CO_2 intensity (pounds/MWh) corresponding to the U.S. natural gas fleet is applied to this difference. A gas fleet intensity was used as the basis for this carbon intensity calculation because gas units (CCGT and CT) are frequently marginal units supplying the market, meaning they are the next units to dispatch and thus set the market price. Renewables, base-load coal, and nuclear are not typically considered marginal units in the market

.The result fo applying this carbon accounting method fo forecast the CO_2 emissions associated with serving the energy needs of DTEE's customers is shown in Figure 16.5.2.

Figure 16.5.2: CO_2 Emissions DTE Electric Fleet – net short approach



With the addition of the renewables and other technologies in the PCA, the Company is forecasted to be in a net long position with respect to energy when an entire year is considered. In some hours, DTE Electric will buy from MISO, and in some hours will sell according to the MISO dispatching operation. Using the annual net short method, the CO_2 emissions associated only with our customers' energy needs will be counted. Under this CO_2 accounting method, each of the 4 PCA pathways is projected to result in a reduction of CO_2 emissions of more than 50% by 2030 and 80% or greater by 2040, when compared to 2005 levels.

By using this approach, the Company is holding itself accountable for the impact to the environment from the energy that we provide to our customers, regardless of whether that energy was produced by Company owned assets or secured through wholesale purchases. The Company is showing an adjustment from fleet direct emissions to estimate the total CO_2 that is attributable to energy that our customers use. DTEE believes this is a better representation of the carbon intensity of delivered electricity. As our customers (industrial, commercial, and residential) move in the direction of their own sustainability goals, accounting for net market purchases gives them a more accurate assessment of their full carbon footprint. Because of the changing market dynamics (plant retirements, increasing amounts of variable resources, and changing reliance on markets), this is a more holistic view of environmental impact beyond the traditional fleet direct source approach. In the Company's view, this method aligns with the intent of the IRP – to take a more holistic approach to resource planning.

SECTION SEVENTEEN

Rate Impact and Financial Information

17.1 Customer Rate Impacts

The year over year revenue requirement associated with each of the Company's four potential PCA pathways were compared to the year over year revenue requirement of the Reference scenario least cost plan. The year over year revenue requirement is inclusive of rate base, fixed and variable O&M, fuel costs, and emission costs.

Based on the comparison above, of the potential PCA pathways modeled PCA C (2% EWR, 100 MW of demand response, & 50 MW of CVR/VVO) was determined to be the highest cost pathway. Comparing PCA C to the Reference scenario least cost plan showed a rate impact that ranged from a high of 0.08 cents per kilowatt-hour increase to a low of -0.11 cents per kilowatt-hour decrease, over the first fifteen-years of the study period, with an average incremental cost during the first five years of 0.04 cents per kilowatt-hour. The annual change in revenue requirement varies over time, but during the years from 2028 through 2039 the revenue requirement for PCA C is forecasted to be actually lower than the Reference scenario. The Compounded Annual Growth Rate (CAGR) of the change in revenue requirement associated with PCA C through 2040 was -0.13%. Keeping in mind that the proxy rate impact is based on PCA C (the highest cost pathway of the four possible pathways), the CAGR associated with the other potential PCA pathways would be lower.

17.2 Financial Assumptions

The Company utilized a levelized cost of energy (LCOE) model and revenue requirement model to provide inputs to the Strategist® optimization model for the resource alternatives considered in the IRP. Both of these models used the financial ratios approved in the U-20105 MPSC Rate Order. The pretax marginal cost of capital was used to calculate the return on rate base. The after tax weighted cost of capital was used to calculate the Allowance for Funds Used During Construction (AFUDC). The pre-tax weighted cost of capital was used as the discount rate in calculating the net present value of the annual revenue requirement streams. A complete list of the financial assumptions is shown in Table 17.2.1.

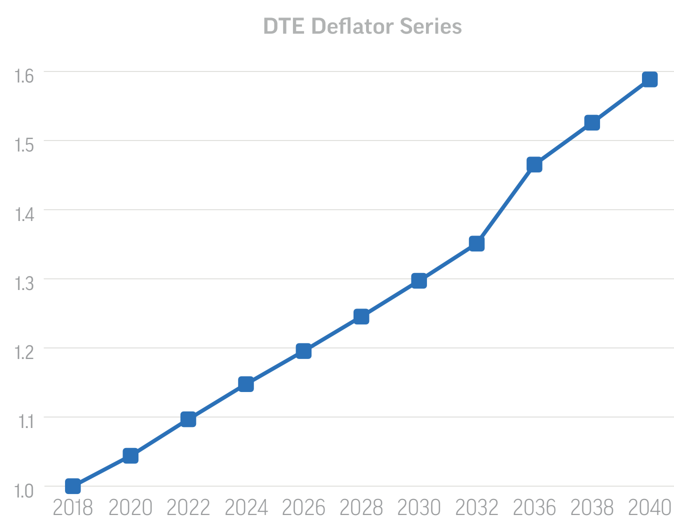
Table 17.2.1 - DTEE Financial Assumptions

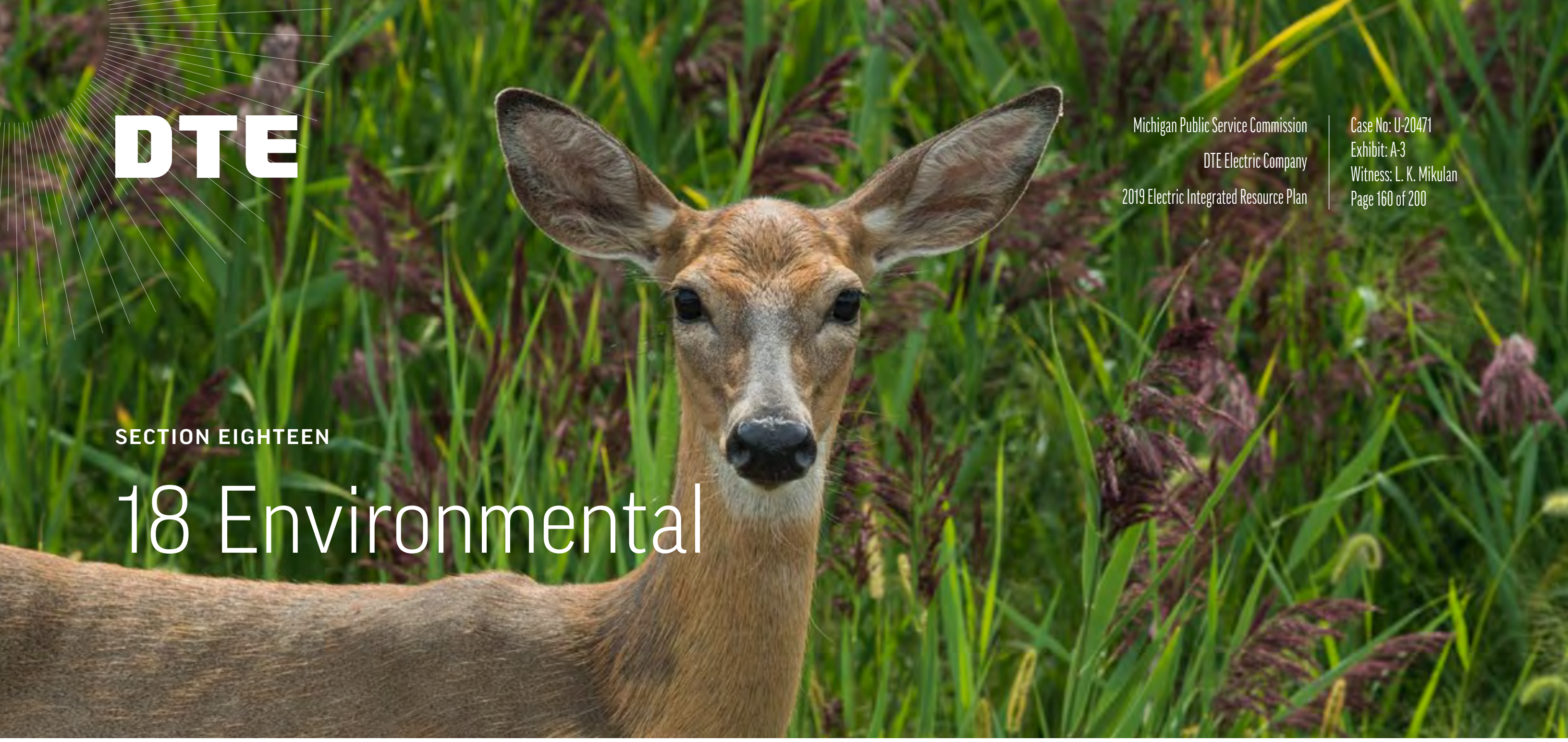
Financial Assumptions	U-20105
Long-term Debt	50.00%
Common Equity	50.00%
Cost of Debt (Pre-tax)	4.42%
Cost of Equity (After-tax)	10.00%
Marginal Cost of Capital (After Tax)	7.210%
Marginal Cost of Capital (Pre-Tax)	8.96%
Cost of Capital for AFUDC	5.34%
Discount Rate	6.63%
Tax Rate	25.90%

Escalation Rate

The modeling used the deflator series shown in Figure 17.2.2, based on the Unadjusted Consumer Price Index (CPI-U). This escalation rate was used throughout the scenario development and in the alternatives development, and was tied to the sales forecast developed by the Load Forecasting group. Fuel prices have their own escalation rates based on commodity supply and demand drivers.

Figure 17.2.2 - DTE Deflator Series





SECTION EIGHTEEN

18 Environmental

18.1 Overview

DTE Electric has a long history of environmental conservation and stewardship, and is committed to protecting its communities, employees, customers, and the planet. In May 2017, DTEE was one of the first energy companies to announce a long-term carbon reduction target to reduce CO_2 emissions by more than 80 percent by 2050, positioning the company as an industry leader in reducing greenhouse gases. In 2018, the clean energy goal was announced, with a 50 percent clean energy by 2030 goal. DTE Electric will accomplish this by using more natural gas, wind and solar, and by improving customers' energy-saving options. The company is also planning to account for the carbon we produce for our customers, and to include the carbon of the power we purchase. The plan for reducing DTEE's CO_2 emissions makes business sense, ensures safe, reliable, affordable, and cleaner energy for its customers, and allows the company to implement a long-term generation transformation strategy in which more than half of the energy produced is generated from zero-emitting resources. With the plans laid out in this IRP, the company is able to take the next step on our clean energy journey, and is able to announce that we are accelerating our carbon reduction goal a full decade, pledging to reduce carbon emissions by 80 percent by 2040. In the near term, we have committed to a 50 percent carbon emissions reduction by 2030. DTEE is committed to operating in a manner that complies with or exceeds federal, state, and local environmental regulations, rules, standards, and guidelines, which are described in this section.

18.2 Environmental Stewardship

DTEE works to take care of the air, land, water, and living creatures within its service territory and beyond. The Company maintains thousands of acres of land in their natural state, which provide habitat for hundreds of species of birds, mammals, fish, and insects. DTEE has 36 sites, including all the DTEE power plants, certified under the Wildlife Habitat Council, a nonprofit organization that helps companies manage their property for the benefit of wildlife. All the DTEE power plants are also ISO 14001:2015 third-party certified. The ISO 14001 standard sets criteria for a company's environmental management system, a set of processes for managing environmental programs. DTEE's system includes employee training, risk assessment and mitigation, monitoring, auditing, top management review, and periodic recertification. For DTEE, environmental stewardship starts with operating its facilities, land, and equipment in a manner that complies with or exceeds governmental standards and is protective of its employees, customers, and surrounding communities, while maintaining affordable service.

The electric power industry across the United States is undergoing a major transformation as the country seeks lower-carbon energy sources. DTEE is an industry leader in this transformation and recognizes its responsibility to conserve the earth's finite natural resources. DTEE is committed to environmental compliance and stewardship and protecting the land, water, and air. DTEE is transforming the way it supplies energy and is using more wind, solar, and cleaner natural gas as well as continuing to invest in energy efficiency and reducing peak loads. DTEE's broad sustainability initiative will reduce the Company's carbon emissions by 50 percent by 2030 and 80 percent by 2040. DTEE will continue to be at the forefront of emissions reductions while being mindful of its customers' needs for affordability and reliability, all of which are considered in the Company's integrated resource planning.

DTEE has 36 sites, including all the DTEE power plants, certified under the Wildlife Habitat Council

DTEE's environmental compliance includes completed environmental controls retrofits for existing coal-fired plants to operate in compliance with all applicable regulations while the plants continue to operate. This includes completion of installation of emission controls on all four units at the Monroe Power Plant in 2014 and at all remaining coal-fired power plant units in 2016 to comply with Mercury and Air Toxics Standards and other regulations.

In addition to the installations and large expenditures for environmental compliance over the last several years, several regulations under the Clean Air Act, Clean Water Act, and the Resource Conservation and Recovery Act will affect coal-fired power plants in the coming years. The regulations have different implementation timelines and will have various outcomes for DTEE. Regulatory compliance and the effects of some of these regulations are discussed further in this section.

18.3 Environmental Compliance

National Ambient Air Quality Standards

The Clean Air Act requires that the EPA set national ambient air quality standards (NAAQS) for six pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM), and sulfur dioxide (SO_2). The EPA sets NAAQS at levels deemed to be protective of public health and the environment. The standards are reviewed periodically and may be revised based on that review. Although all DTEE power plants are subject to NAAQS, two standards in particular are currently affecting its generation fleet: SO_2 and ozone.

In 2010, the EPA established a new one-hour SO_2 NAAQS, which resulted in an area in southern Wayne County being designated as non-attainment in 2013. This area included DTEE's River Rouge and Trenton Channel power plants. DTEE implemented significant SO_2 emissions reductions at both power plants to help provide for attainment in the area.

The same 2010 SO_2 NAAQS that affected the Wayne County plants also affects the future operation of the Belle River and St. Clair power plants in St. Clair County. An area of St. Clair County that includes the two DTEE power plants was designated as non-attainment in late 2016. DTEE is working with MDEQ to develop a plan to achieve attainment, while minimizing expense to its customers and maintaining reliable and efficient energy production in the area.

In 2015, the ozone NAAQS was also lowered from 75 parts per billion (ppb) to 70 ppb. As a result, a seven-county area of southeast Michigan has been designated as non-attainment for ozone. This area includes all DTEE coal-fired power plants. DTEE is working collaboratively with the state to develop a state implementation plan, as required.

For DTEE, environmental stewardship starts with operating its facilities, land, and equipment in a manner that complies with or exceeds governmental standards and is protective of its employees, customers, and surrounding communities, while maintaining affordable service.

Cross-State Air Pollution Rule

The Cross-State Air Pollution Rule (CSAPR) is the most recent EPA regulation targeting interstate and regional transport of air pollution and replaces the Clean Air Interstate Rule (CAIR). Like CAIR, CSAPR establishes a cap-and-trade program to limit SO2 and NOx emissions from electric utilities. It establishes emissions allocations to each generating unit in a group of Midwestern states, including Michigan. These allocations are reduced over time, through a phased approach. Although the allocations are made at the unit level, CSAPR allows for emissions allowance trading among utilities covered by the rule, compliant with CAIR/CSAPR.

In 2016, the EPA promulgated an update to the CSAPR aimed at reducing ozone transport to states downwind from the Midwestern states it covers. The update drastically reduced the ozone season (May through September) emissions allocations. In addition, the update restricted the amount of emissions credits that can be carried over from previous years.

Affordable Clean Energy Rule and Clean Power Plan

In August 2015, the EPA finalized performance standards for emissions of CO2 from existing fossil-fuel fired power plants under Section 111(d) of the Clean Air Act and new sources under Section 111(b) of the act as part of the Clean Power Plan. The rules underwent significant legal challenges and the existing source rule was stayed by a 2016 U.S. Supreme Court decision, pending judicial review. In 2017, an executive order was issued, which instructed the EPA to review the final rules. On Oct. 16, 2017, EPA published a proposal to repeal the Clean Power Plan in the Federal Register. The standards for new sources under Section 111(b) were not part of the stay and remained in effect.

In August 2018, EPA proposed the Affordable Clean Energy Rule. This rule would replace the Clean Power Plan rule for emissions of CO2 from existing sources, which never went into effect. Although the Affordable Clean Energy Rule does not propose state-specific standards as the Clean Power Plan did, states would set performance standards and would have discretion in establishing these standards for each affected unit. A final rule is expected to be published in 2019. The EPA also issued a proposed rule revision to the new source performance standards in December 2018 with changes to standards for new, reconstructed or modified coal-fired units.

Steam Electric Effluent Limitation Guidelines

In late-2015, the EPA issued its final rule related to wastewater discharge or Effluent Limitation Guidelines for steam electric power generators (SEEG or ELG). The new requirements covered some specific wastewater discharges from coal plants. In 2017, EPA agreed to reconsider the 2015 Rule, but only for Bottom Ash Transport Water (BATW) and FGD Wastewater (FGDWW) discharges. The requirements for Fly Ash Wastewater (FAWW) discharges are not being reconsidered. EPA issued a new rule, the “Postponement Rule,” to reconsider the 2015 Rule and delay the compliance dates for BATW and FGDWW set forth in the 2015 Rule. The 2015 Rule originally required compliance "as soon as possible," but provided a window of time between November 1, 2018 and December 31, 2023. The Postponement Rule pushed back the November 1, 2018 date which narrowed the window to achieve compliance to between November 1, 2020 and December 31, 2023, but did not extend the December 31, 2023 compliance deadline. Currently, there is no 2-year postponement of the December 31, 2023 compliance date, but rather a 2-year postponement of the earliest possible compliance date of November 1, 2018 for BATW and FGDWW compliance. The FAWW compliance timeframe remains as November 1, 2018 to December 31, 2023 as originally set in the 2015 ELG Rule as the Postponement Rule made no changes to the FAWW compliance dates. There is currently no extension or waiver available. The ELG rules will impact the Company's coal-fired units. Compliance would require significant modifications at all existing coal-fired power plants, however, plants which are planned for shutdown prior to the December 31, 2023 ELG compliance date will have no ELG requirements for compliance.

Cooling Water Intake (316b)

The EPA finalized regulations on cooling water intake for power plants and other facilities under Section 316(b) of the Clean Water Act in August 2014. Those regulations affect the Company's five coal-fired power plants along with its nuclear plant, Fermi 2. DTEE coal plants currently use once-through cooling, which entails taking water in for cooling, which is then discharged back to the body of water with no recirculation. The cooling water intake structures are equipped with screens that prevent debris from being taken into the plant systems. The regulations affect cooling water intake at existing facilities in two main areas: first, existing facilities are required to reduce fish impingement; second, existing facilities are required to conduct studies to determine whether and what controls would be required to reduce the number of aquatic organisms entrained by the cooling water system. The regulations also include requirements for new units that add electrical generation capacity.

Coal Combustion Residual Rule

The EPA published the Coal Combustion Residual (CRR) Rule in April 2015, with an effective date of Oct. 19, 2015. The EPA also revised the CCR rule in October 2016, which further affected closure plans for CCR units. Recent rule revisions and court action further affect operational and closure plans. On July 17, 2018, the EPA issued a new rule with provisions for state-approved programs that would allow for potential flexibility in groundwater monitoring requirements, among other things. An EPA-approved state program needs to be in place before any changes to the CCR groundwater monitoring programs can be realized. On Aug. 21, 2018, the D.C. Circuit Court of Appeals issued its decision in the CCR litigation addressing issues raised by both industry and environmental petitioners. Most applicable to the Company is the court's decision on the ability of unlined impoundments to continue operating. The actual consequences of the court decision will require the EPA

to revisit elements of the CCR rule. However, the precise actions, timing and impact to the Company are unclear at this time.
On March 13, 2019 the DC Circuit Court of Appeals issued its decision addressing issues raised by environmental petitioners, ordering EPA to undertake a new rulemaking to establish a new deadline for initiating closure of units subject to forced closure. The order remanded the closure deadline back to EPA without vacating the current rule date of October 31, 2020. DTEE has been and remains in compliance with all applicable standards currently in effect. Current CCR rule obligations at the DTEE plants vary based on plant retirement dates. Regardless of the timing of plant retirements, closure of ash basins, long-term ground water monitoring, potential mitigation, inspections and reporting obligations will continue for many years.

18.4 Capital Cost to Comply with Environmental Regulations

The table below summarizes the costs associated with ELG and 316(b) for the Belle River and Monroe Power Plants. No ELG/316(b) costs are expected for the other plants based on their planned retirements. As described above, costs associated with CCR are expected regardless of plant closure dates.

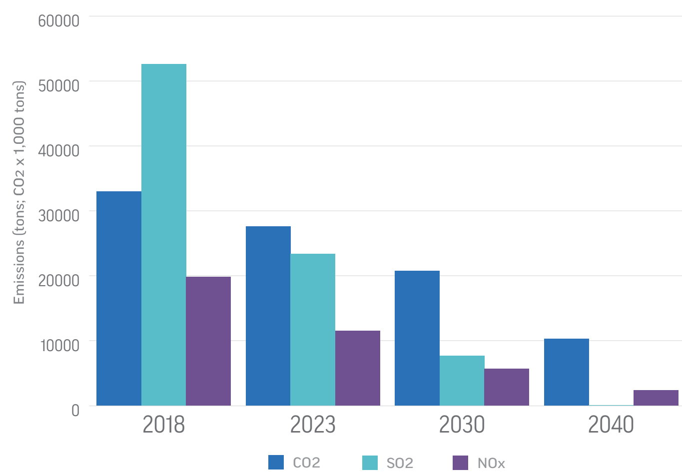
TABLE 18.4.1: Capital Cost Estimate for Environmental Compliance

		Monroe	Belle River
Capital (M$)	ELG	$55	$200
	316(b)	$1	$50

18.5 Emission Projections

The Company outlined four potential PCA pathways. While the details of the pathways are different, the modeling performed shows that all four pathways allow for the Company to meet its CO2 reduction goals. A summary of CO2, SO2, and oxides of nitrogen (NOx) for the PCA and 2018 is shown in Figure 18.4.1

FIGURE 18.5.1: Emissions Summary



The projections for 2023, 2030, and 2040 in this figure represent an average of the emissions from the four PCA pathways as all pathways provide similar emissions reductions. This figure represents mass emissions from DTE Electric sources and does not take into account the CO2 accounting parameters outlined above. Other pollutants not shown in the figure, such as particulate matter and mercury, will decline at similar levels as SO2. The Company's plan for carbon reduction included in this PCA will provide other significant emission reductions as well.

SECTION NINETEEN

19 DTEE IRP Report Summary

Summary

DTE Electric evaluated numerous resource options to determine the recommended combination of supply-side and demand-side options. DTE Electric performed robust scenario and sensitivity analyses, considering the uncertainty around environmental regulations, resource cost and performance, fuel prices, load, and other regulatory and legislative effects. In addition to scenario/sensitivity analysis, the Company conducted four additional risk analyses. The IRP analysis identified that there is not a persistent capacity need until 2029-2030 to cover reserve margin requirements. The need in 2029-2030 arises because of the projected retirements of Belle River units in those same years. The Company's Proposed Course of Action focuses on the next five years (2019 – 2024) and considers the most affordable and reliable mix of supply-side and demand-side resources available today. Given the long-term uncertainty of technological advancements and key market drivers the Proposed Course of Action in the years beyond 2024 considers four alternate long-term options. While these four pathways provide a view into the future the Company will continue to revisit and refine the plan as technology develops, customer desires, and trends become more clear and costs decline.

Overall, the strength of the Company's PCA is the flexibly it affords to adapt to evolving markets, regulations, and technologies. It is both supportive of our environmental goals and requirements, as well as reliable, and balances those factors with minimizing cost impacts to our customers.

Glossary

The following definitions are not intended to set forth official Company policy or interpretation, but are provided solely to assist the reader in the understanding of this report.

ALLOWANCE FOR FUNDS USED DURING CONSTRUCTION (AFUDC): The net cost for the period of construction of borrowed funds used for construction purposes and a reasonable rate on other funds when used.

AVAILABILITY: The percentage of time that a unit is available to generate electricity. It is determined by dividing the total hours the unit is available to generate by the total hours in the period.

CAPACITY FACTOR: A measure of how much a generating facility's capacity is used during a period. Expressed as a percentage, it is calculated by dividing the actual energy produced during a specific period by the unit's rated generating capacity over the same period.

% Capacity Factor = (energy produced) / (plant capacity x time)

COMBINED CYCLE: A generating unit that utilizes a combination of one or more combustion turbines in conjunction with heat recovery steam generator(s) (HRSG) and steam turbine(s), which typically burn natural gas as fuel.

COMBINED HEAT AND POWER: The concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy.

CONSUMER PRICE INDEX (CPI): A relative measure of the purchasing power of a dollar. It is a measure of inflation.

DEMAND: The energy required at the customer's meter.

DEMAND-SIDE MANAGEMENT (DSM): Programs designed to influence customer use of electricity in ways that will produce desired changes in a utility's load shape. The proposed programs support the objectives of conservation, load shifting, and peak clipping.

DEMAND-SIDE OPTION (DSO): A resource option which meets the objectives stated for a DSM program (see previous definition).

DISPATCHING: The assignment of load to specific generating units and other sources to affect the most reliable and economical supply as system load rises or falls.

DTEE 2019 IRP: A set of resources within the 2019 to 2040 study period that is the result of scenario and sensitivity analysis, and risk analysis and encompasses the DTEE's Planning Principles that represents DTEE's proposed course of action.

HEAT RATE: A measure of generating plant efficiency in converting the heat content of its fuel to electrical energy, expressed in BTU/kWh. It is computed by dividing the total BTU content of fuel burned for electric generation by the resulting net kilowatt-hour generation.

LEAST COST PLAN: A set of resources within the 2019 to 2040 study period that aligns with the Company's Planning Principles and selected as the optimal resource plan under a specific scenario.

LEVELIZATION: A mathematical operation whereby a non-uniform series of annual payments is converted into an equivalent uniform series considering the time value of money (discount rate).

LOAD FACTOR: The ratio of the average load supplied during a designated period to the peak or maximum load occurring in that period. It is expressed as a percent.

LOCAL CLEARING REQUIREMENT: A MISO requirement for how much generation must come from local sources.

LOSS OF LOAD EXPECTATION (LOLE): The frequency that there will be insufficient resources (native generation and purchases) to serve firm load. DTEE's reliability criterion is one day in ten years' loss of load expectation.

PLANNING PERIOD: The time during which resource options are added to meet the expected future electrical loads. For this IRP, the planning period is 2019-2040.

PROVIEW: The Strategist automatic expansion planning module, which determines the optimum expansion plan under a prescribed set of constraints and assumptions.

PUMPED STORAGE: The process of producing electricity during peak periods with water driven turbines. The water storage reservoir is filled by motor driven pumps during off-peak hours when inexpensive power is available.

RENEWABLES: An energy source that occurs naturally in the environment, such as solar energy, wind currents, and water flow.

RESERVE MARGIN: The difference between net system capability and system maximum load requirement (peak load). It is the margin of capability available to provide for scheduled maintenance, emergency outages, system operating requirements, and unforeseen loads. This is often expressed as a percentage of peak load.

Reserve margin = 100 x (Total System Capacity – Peak Load) / Peak Load

RESOURCE PLAN: A strategy for meeting the expected future electrical demand through the addition of supply-side and/or demand-side options. For this IRP, resource plans were developed for several different scenarios and sensitivities.

REVENUE REQUIREMENT: The revenue that must be obtained to cover all annual costs, including all fixed and variable cost components.

SCENARIO: A unique set of assumptions grouped to best represent the effect of some potential future occurrence.

SCENARIO STARTING POINT: A scenario with no sensitivities applied was run and was used to compare sensitivities against.

SENSITIVITY: A subset of a scenario in which the same basic assumptions are used as in the controlling scenario, but certain other parameters are modified to determine specific effects that might occur.

SHORTFALL: When the local resources can't meet the reserve margin requirement.

STARTING POINT: When the IRP modeling began, in June 2018, an assessment of the current state of the inputs at that time was completed. This set of resources throughout the 2019 to 2040 study period stayed consistent through the optimization modeling.

SUPPLY RELIABITY: Having sufficient capacity to meet customers' power demands.

SUPPLY-SIDE OPTION (SSO): Typically, any option which adds generating capacity to a system to produce electricity as needed to meet customer electrical demand.

TIME OF USE RATES: Tariffs that vary according to the time of day. They are used to help promote transfer of on-peak to off-peak electricity consumption.

Index Of Abbreviations

ACI – Activated Carbon Injection

AFUDC – Allowance for Funds Used During Construction

AHU – Air Handler Units

ANSI – American National Standards Institute

BAU – Business as Usual (scenario)

BNEF – Bloomberg New Energy Finance

BR – Belle River Power Plant

BWEC – Blue Water Energy Center

BYOD – Bring Your Own Device

CAA – Clean Air Act

CAES – Compressed Air Energy Storage

CAGR – Compound Annual Growth Rate

CAIR – Clean Air Interstate Rule

CC, CCGT – Combined Cycle Gas Turbine

CF – Capacity Factor

CHP – Combined Heat and Power

CME – Chicago Mercantile Exchange

CPP – Clean Power Plan

CO2 – Carbon Dioxide

COG – Coke Oven Gas

CRR– Coal Combustion Residual

CSAPR – Cross-State Air Pollution Rule

CT – Combustion Turbine

CWA – Clean Water Act

CVR – Conservation Voltage Reduction

DG – Distributed Generation

DR – Demand Response

DSI – Dry Sorbent Injection

DSM– Demand-Side Management

DTE – DTE Energy Company

DTEE – DTE Electric Company or The Company

ECIL – Effective Capacity Import Limit

EE – Energy Efficiency

EIA – Energy Information Agency

ELCC – Effective Load Carrying Capability

ELG – Effluent Limitation Guidelines

EO – Energy Optimization

EP – Environmental Policy (scenario)

EPA – Environmental Protection Agency

EPRI – Electric Power Research Institute

ESS – Energy Storage Systems

ESP – Electrostatic Precipitator

ET– Emerging Technologies (scenario)

EWR – Energy Waste Reduction, also referred to as Energy Efficiency

FERC – Federal Energy Regulatory Commission

FGD – Flue Gas Desulfurization

FOM – Fixed Operating and Maintenance

FosGen – Fossil Generation Business Unit

FRAP – Fixed Resource Adequacy Plan

GW – Gigawatt, One Billion Watts

GWh – Gigawatt Hours

HAP – Hazardous Air Pollutant

HELM – Hourly Electric Load Model

HRSG – Heat Recovery Steam Generator

HSE – High-Sulfur Eastern Coal

HVAC – Heating, Ventilation and Air Conditioning

ICAP – Installed Capacity

IGCC – Integrated Gasification Combined Cycle

IPP – Independent Power Producer

IRP – Integrated Resource Plan

ITC – International Transmission Company

ITC – Investment Tax Credit

kW – Kilowatt, One Thousand Watts

kWh – Kilowatt Hours

LCOE – Levelized Cost of Energy

LED – Light Emitting Diode

LF – Load Factor

LCP – Least Cost Plan

LCR – Local Clearing Requirement

LMP – Local Marginal Price

LOLE – Loss of Load Expectation

LOLEWG – Loss of Load Expectation Working Group

LRC – Local Resource Zone

LSS – Low-Sulfur Southern Coal

LSW – Low-Sulfur Western Coal

LTC – Load Tap Changers

MATS – Mercury and Air Toxics Standards

MBtu, mmBtu – Million British Thermal Units

MDEQ – Michigan Department of Environmental Quality

MERC – Midwest Energy Resources Co

MISO – Mid-Continental Independent Transmission System Operator, Inc.

MN – Monroe Power Plant

MPPA – Michigan Public Power Agency

MPSC – Michigan Public Service Commission

MSE – Mid-Sulfur Eastern Coal

MTEP – MISO Transmission Expansion Plan

MW – Megawatt, One Million Watts

MWh – Megawatt Hours

NAAQS – National Ambient Air Quality Standards

NGCC – Natural Gas Combined Cycle

NMP – Non-Metal Processing

NOX – Nitrogen Oxide

NPV – Net Present Value

NPVRR – Net Present Value Revenue Requirement

NYMEX – New York Mercantile Exchange

O&M – Operating and Maintenance

OFA – Over-Fire Air

PA – Public Act

Pace Global – Pace Global, a Siemens Business

PCA – Proposed Course of Action

PEV – Plug-in Electric Vehicle

PPA – power purchase agreement

PRMR – Planning Reserve Margin Requirement

PSCR – Power Supply Cost Recovery

PTC – Production Tax Credit

PURPA – Public Utility Regulatory Policies Act

QF – Qualifying Facility

R-10 – Rider 10 industrial interruptible tariff

RAN – Renewable Integration Impact Assessment

RCRA – Resource Conservation and Recovery Act

REC – Renewable Energy Credit

REF – Reference Scenario

REP – Renewable Energy Plan

RFP – Request for Proposal

RGGI – Regional Greenhouse Gas Initiative

RICE – Reciprocating Internal Combustion Engine

R&MP – Rubber and Plastics

ROR – Random Outage Rate

RPS – Renewable Portfolio Standard

RR – River Rouge Power Plant

SC – St. Clair Power Plant

SCR – Selective Catalytic Reduction

SIP – State Implementation Plan

SO2 – Sulfur Dioxide

TC – Trenton Channel Power Plant

UCAP – Unforced Capacity

UCT – Utility Cost Test

USRCT – Utility System Resource Cost Test

VVO – Volt Var Optimization

ZRC – Zonal Resource Credits

UCT – Utility Cost Test

VOM – Variable Operating and Maintenance (Cost)

Appendix G
Owner Certification of Compliance

TRC

Owner Certification of Site Compliance per 40 CFR 257 Subpart D
Belle River Power Plant Bottom Ash Basins
China Township, Michigan

The United States Environmental Protection Agency (EPA) Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments (40 CFR §257.71(d)), requires that the owner of an existing CCR unit certify the facility is in compliance with the requirements of the CCR Rules (40 CFR 257 Subpart D) except for §257.71(a)(1).

CERTIFICATION

Based on our review of the CCR Rules, I hereby certify that the subject facility is in compliance with the requirements of 40 CFR 257 Subpart D except for §257.71(a)(1).

[signature]
SIGNATURE

11-25-2020
DATE

Lezley Filzek
PRINT NAME

Plant Manager
TITLE

DTE Electric Company
COMPANY NAME

Appendix H
Hydraulic Conductivity Test Results

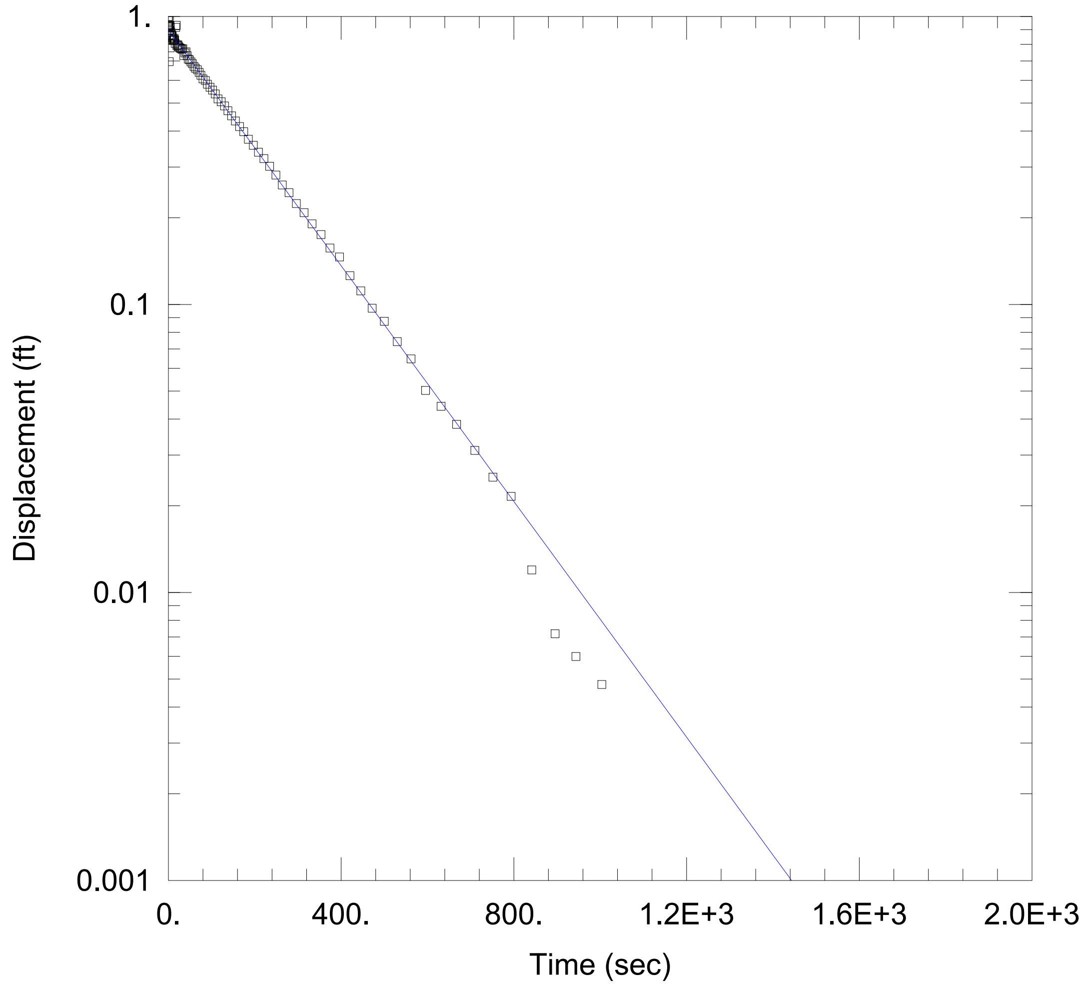
Hydraulic Conductivity Results
DTE Electric Company Belle River Power Plant
ChinaTownship, Michigan

Test Location ID	Date Performed	Test Type	Hydraulic Conductivity (K)	
			cm/sec	ft/day
MW-16-01b	3/1/2016	Falling Head	3.58E-04	1.015
		Rising Head	2.72E-04	0.770
		Average	**3.15E-04**	**0.892**
MW-16-04	3/1/2016	Falling Head	7.93E-05	0.225
		Rising Head	4.11E-05	0.116
		Average	**6.02E-05**	**0.171**
MW-16-05	3/1/2016	Falling Head	4.26E-05	0.121
		Rising Head	2.13E-05	0.060
		Average	**3.19E-05**	**0.090**
MW-16-07	3/1/2016	Falling Head	1.24E-04	0.350
		Rising Head	7.21E-05	0.204
		Average	**9.79E-05**	**0.277**
		Minimum	**3.19E-05**	**9.05E-02**
		Maximum	**3.15E-04**	**8.92E-01**
		Geometric Mean	**8.77E-05**	**0.249**

Conversion:

$$\frac{1\text{ cm}}{1\text{ sec}} \times \frac{86{,}400\text{ sec}}{1\text{ day}} \times \frac{1\text{ ft}}{30.48\text{ cm}} = 2.83\text{E+03} \quad \frac{\text{ft}}{\text{day}}$$

Notes:
Slug test results calculated using the Bower-Rice (1976) Solution.



MW-16-01 FALLING HEAD SLUG TEST

Data Set: P:\...\MW-16-01_IN.aqt
Date: 05/22/17
Time: 13:38:07

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003.0000
Location: China Township, MI
Test Well: MW-16-01
Test Date: 4/13/16

AQUIFER DATA

Saturated Thickness: 52. ft
Anisotropy Ratio (Kz/Kr): 1.

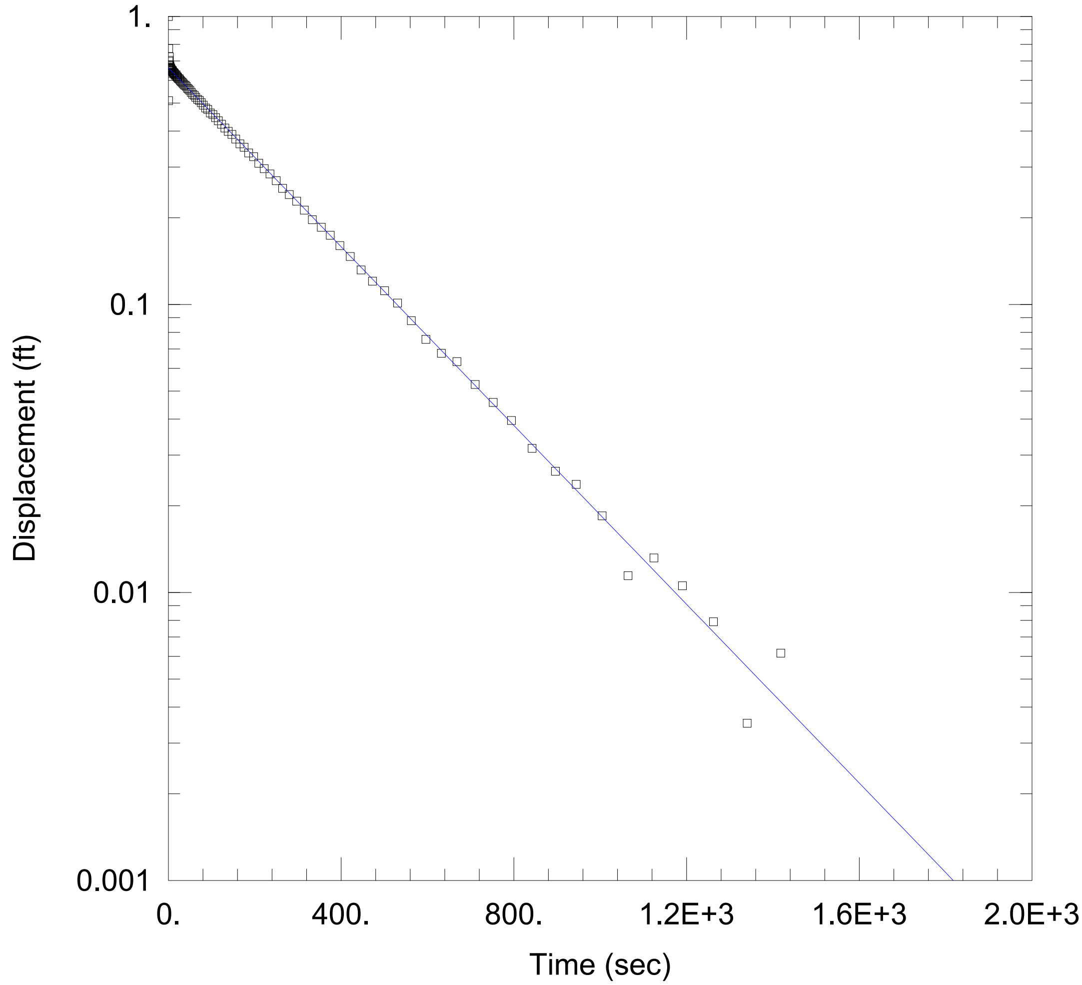
WELL DATA (MW-16-01)

Initial Displacement: 0.835 ft
Static Water Column Height: 84.12 ft
Total Well Penetration Depth: 84.12 ft
Screen Length: 5. ft
Casing Radius: 0.08333 ft
Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.0003581 cm/sec
y0 = 0.7491 ft



MW-16-01 RISING HEAD SLUG TEST

Data Set: P:\...\MW-16-01_OUT.aqt
Date: 05/22/17 Time: 13:40:08

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003.0000
Location: China Township, MI
Test Well: MW-16-01
Test Date: 4/13/16

AQUIFER DATA

Saturated Thickness: 52. ft Anisotropy Ratio (Kz/Kr): 1.

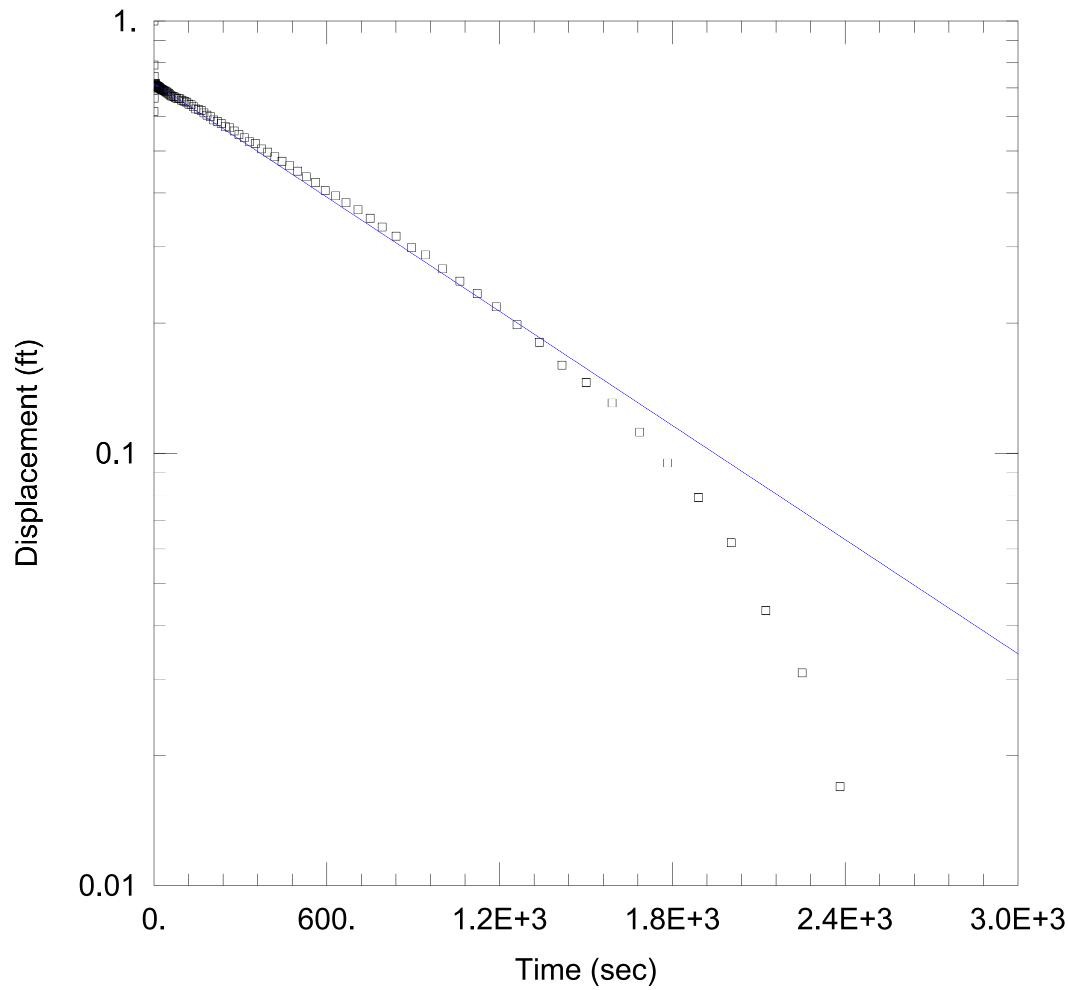
WELL DATA (MW-16-01)

Initial Displacement: 1.138 ft
Total Well Penetration Depth: 84.07 ft
Casing Radius: 0.08333 ft
Static Water Column Height: 84.07 ft
Screen Length: 5. ft
Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0002716 cm/sec y0 = 0.7541 ft



MW-16-04 FALLING HEAD SLUG TEST

Data Set: P:\...\MW-16-04_IN.aqt
Date: 05/22/17 Time: 13:41:00

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003.0000
Location: China Township, MI
Test Well: MW-16-04
Test Date: 4/13/16

AQUIFER DATA

Saturated Thickness: 23.5 ft Anisotropy Ratio (Kz/Kr): 1.

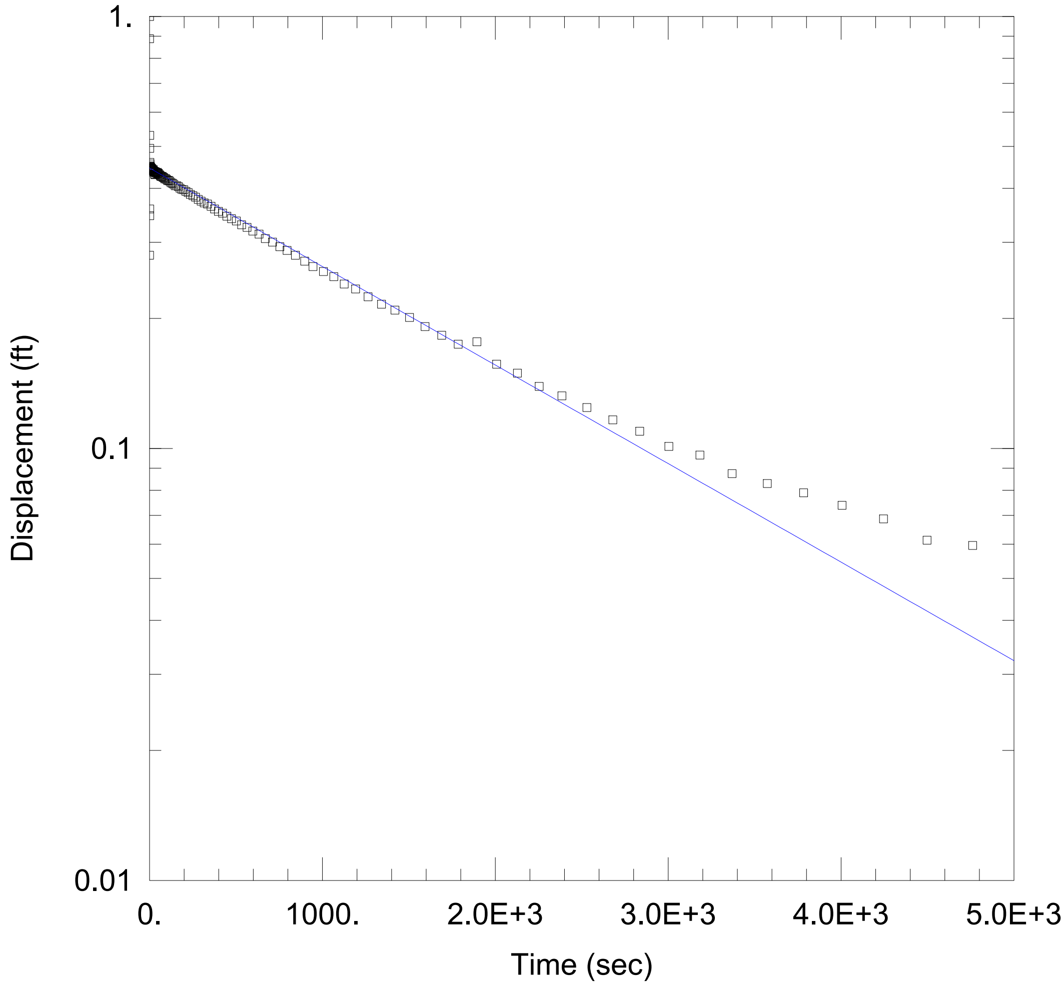
WELL DATA (MW-16-04)

Initial Displacement: 1.064 ft Static Water Column Height: 109.9 ft
Total Well Penetration Depth: 109.9 ft Screen Length: 5. ft
Casing Radius: 0.08333 ft Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 7.93E-5 cm/sec y0 = 0.7646 ft



MW-16-04 RISING HEAD SLUG TEST

Data Set: P:\...\MW-16-04_OUT.aqt
Date: 05/22/17 Time: 13:42:08

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003.0000
Location: China Township, MI
Test Well: MW-16-04
Test Date: 4/13/16

AQUIFER DATA

Saturated Thickness: 23.5 ft
Anisotropy Ratio (Kz/Kr): 1.

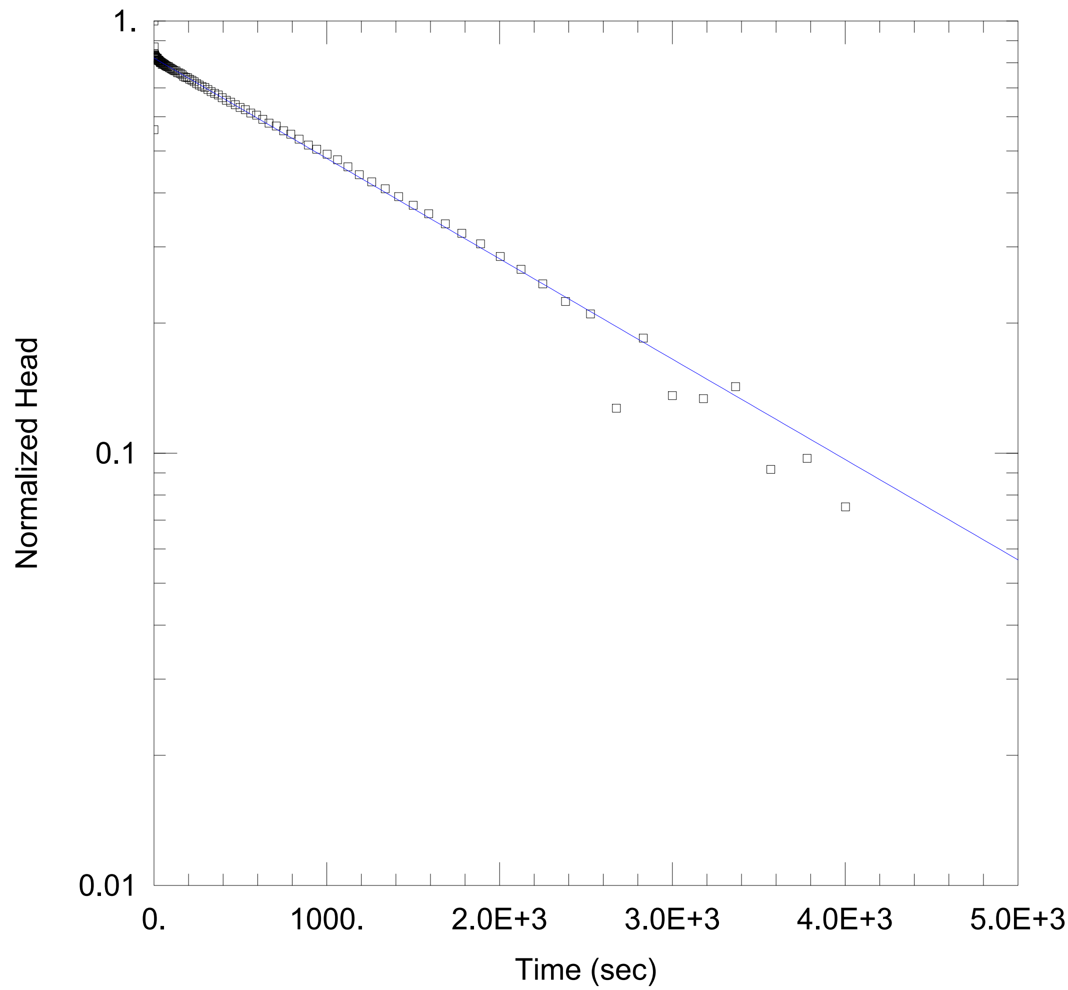
WELL DATA (MW-16-04)

Initial Displacement: 1.761 ft
Static Water Column Height: 109.7 ft
Total Well Penetration Depth: 109.7 ft
Screen Length: 5. ft
Casing Radius: 0.08333 ft
Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.108E-5 cm/sec
y0 = 0.7851 ft



MW-16-05 FALLING HEAD SLUG TEST

Data Set: P:\...\MW-16-05_IN.aqt
Date: 05/22/17 | Time: 13:42:57

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003
Location: China Township, MI
Test Well: MW-16-05
Test Date: 4/13/16

AQUIFER DATA

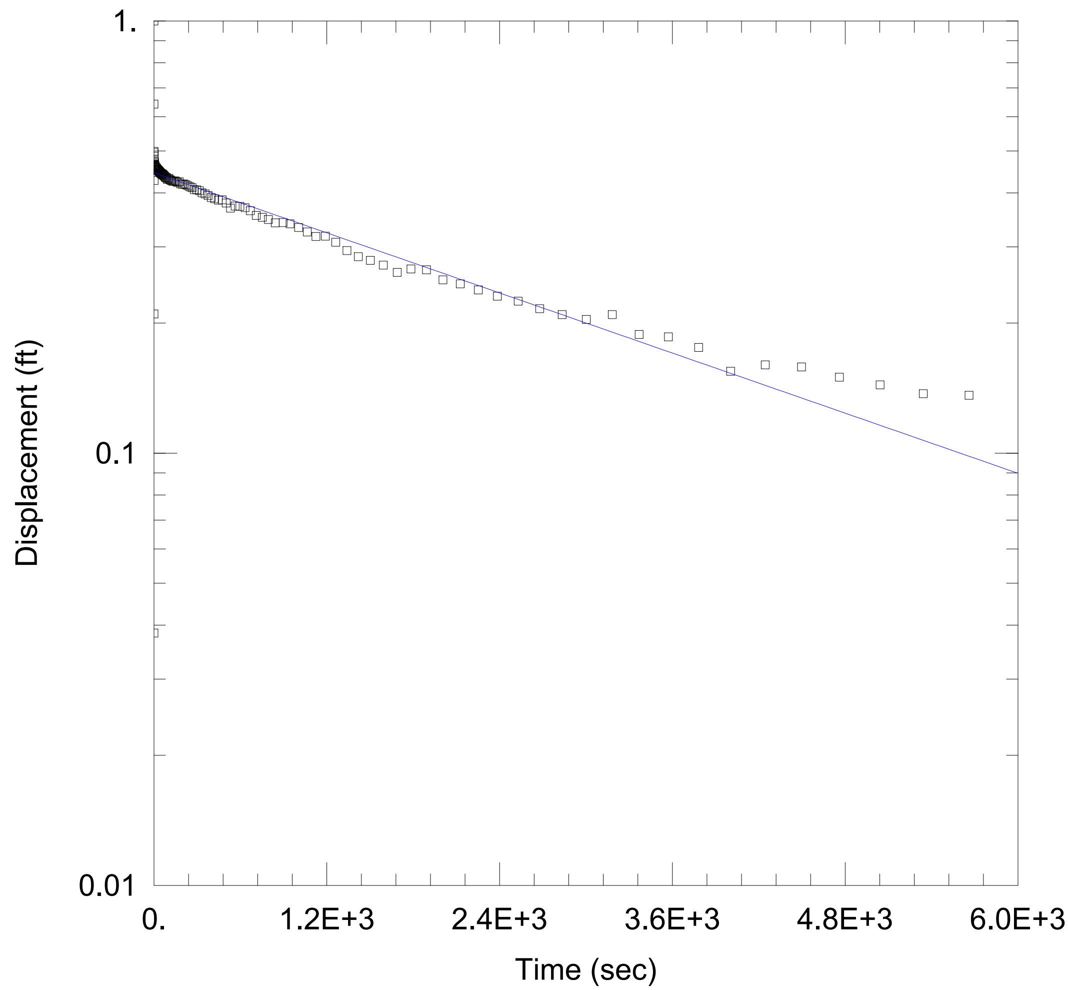
Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-16-05)

Initial Displacement: 0.905 ft
Static Water Column Height: 130.7 ft
Total Well Penetration Depth: 130.7 ft
Screen Length: 5. ft
Casing Radius: 0.08333 ft
Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 4.258E-5 cm/sec
y0 = 0.7426 ft



MW-16-05 RISING HEAD SLUG TEST

Data Set: P:\...\MW-16-05_OUT.aqt
Date: 05/22/17 Time: 13:43:26

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003.0000
Location: China Township, MI
Test Well: MW-16-05
Test Date: 4/13/16

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 1.

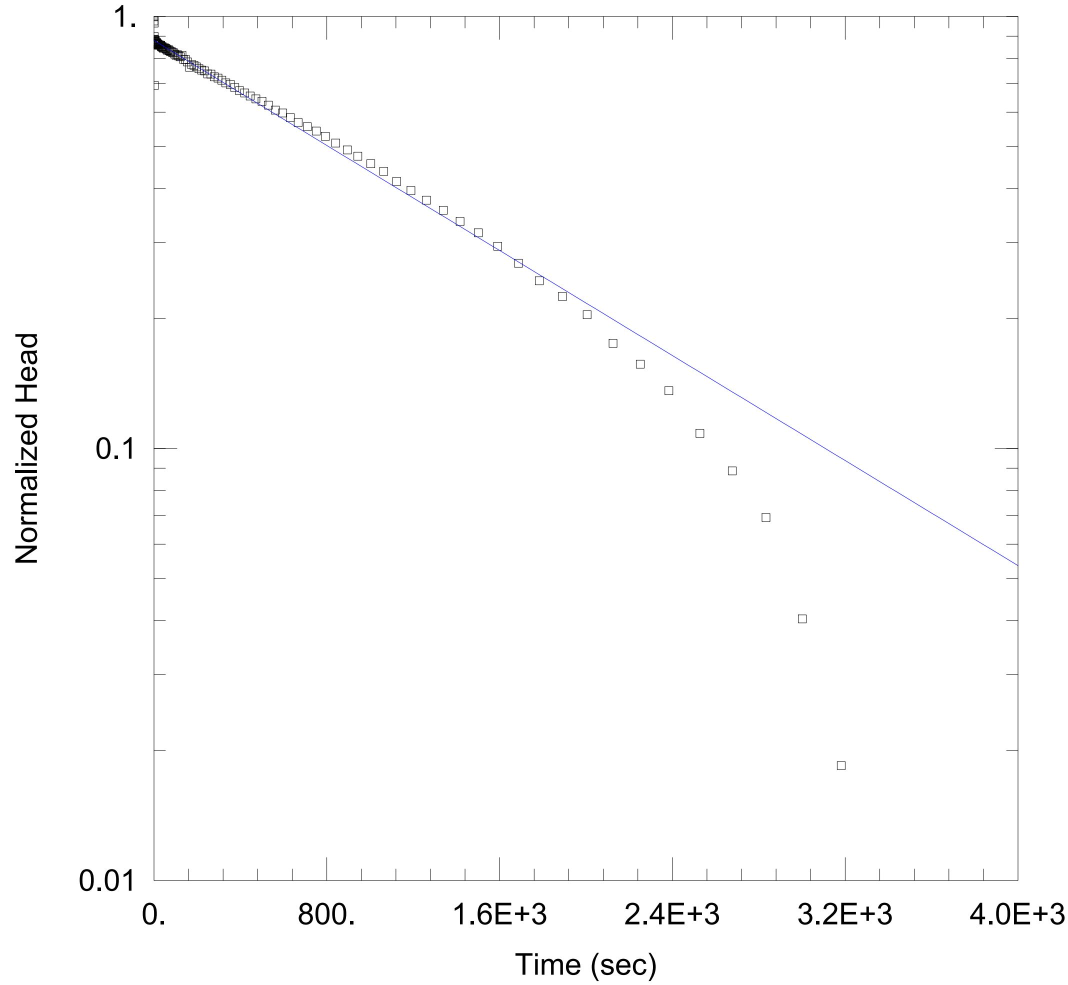
WELL DATA (MW-16-05)

Initial Displacement: 1.668 ft
Static Water Column Height: 130.7 ft
Total Well Penetration Depth: 130.7 ft
Screen Length: 5. ft
Casing Radius: 0.08333 ft
Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.125E-5 cm/sec
y0 = 0.743 ft



MW-16-07 FALLING HEAD SLUG TEST

Data Set: P:\...\MW-16-07_IN.aqt
Date: 05/22/17   Time: 13:44:03

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003
Location: China Township, MI
Test Well: MW-16-07
Test Date: 4/13/16

AQUIFER DATA

Saturated Thickness: 2. ft   Anisotropy Ratio (Kz/Kr): 1.

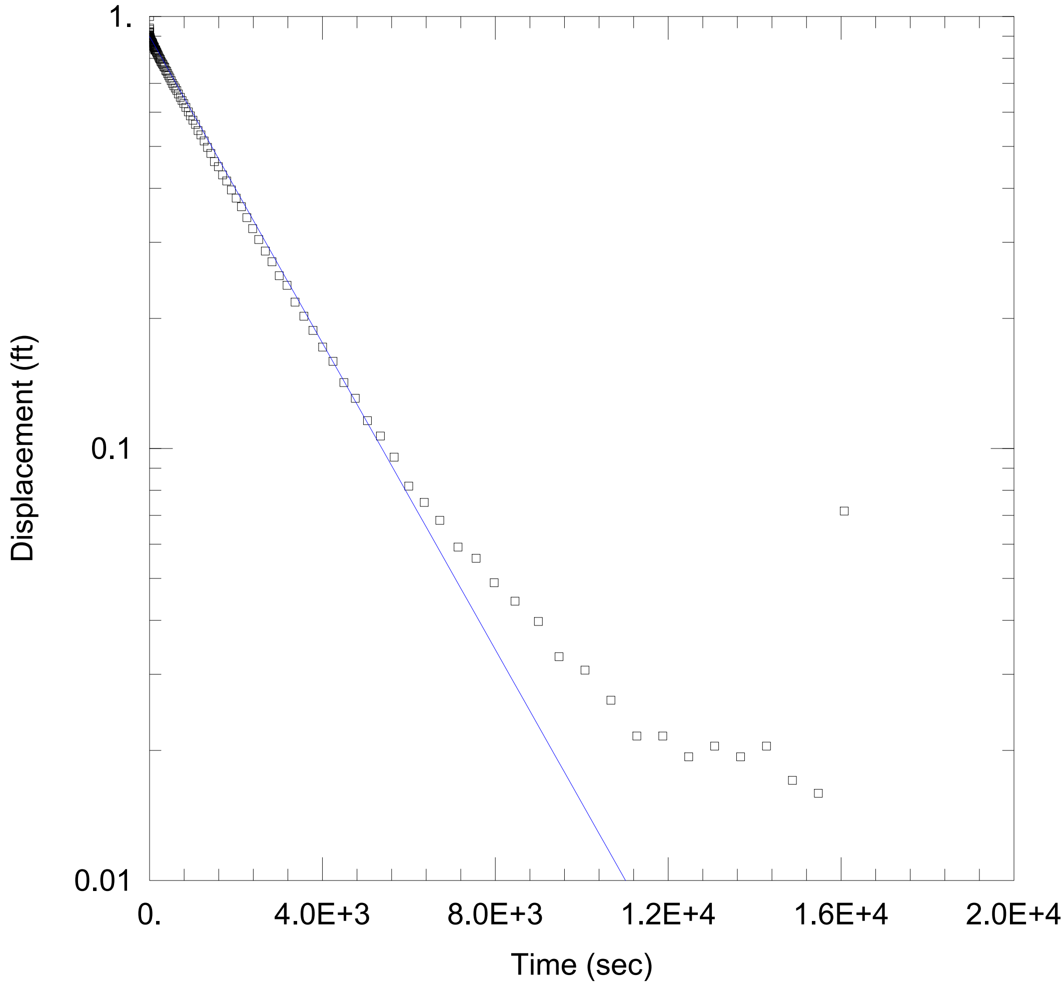
WELL DATA (MW-16-07)

Initial Displacement: 0.868 ft   Static Water Column Height: 124.9 ft
Total Well Penetration Depth: 124.9 ft   Screen Length: 5. ft
Casing Radius: 0.08333 ft   Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined   Solution Method: Bouwer-Rice

K = 0.0001236 cm/sec   y0 = 0.7638 ft



MW-16-07 RISING HEAD SLUG TEST

Data Set: P:\...\MW-16-07_OUT.aqt
Date: 05/22/17 Time: 13:44:45

PROJECT INFORMATION

Company: TRC Environmental Corporation
Client: DTE EC BRPP CCR
Project: 231828.0003.0000
Location: China Township, MI
Test Well: MW-16-07
Test Date: 4/13/16

AQUIFER DATA

Saturated Thickness: 2. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-16-07)

Initial Displacement: 0.88 ft Static Water Column Height: 124.4 ft
Total Well Penetration Depth: 124.4 ft Screen Length: 5. ft
Casing Radius: 0.08333 ft Well Radius: 0.08333 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 7.212E-5 cm/sec y0 = 0.7909 ft

Appendix I
Groundwater Statistical Evaluation Plan – October 2017

Groundwater Statistical Evaluation Plan

Belle River Power Plant Coal Combustion Residual Bottom Ash Basins

4505 King Road
China Township, Michigan

October 2017

Groundwater Statistical Evaluation Plan

Belle River Power Plant Coal Combustion Residual Bottom Ash Basins

4505 King Road
China Township, Michigan

October 2017

Prepared For
DTE Electric Company

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

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

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Section 1
Introduction

1.1 Regulatory Framework

The United States Environmental Protection Agency (U.S. EPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule) on April 17, 2015. The CCR Rule, which became effective on October 19, 2015, applies to the Belle River Power Plant (BRPP) CCR Bottom Ash Basins (BABs). Pursuant to the CCR Rule, no later than October 17, 2017, the owner or operator of a CCR unit must develop the groundwater sampling and analysis program to include selection and certification of the statistical procedures to be used for evaluating groundwater in accordance with Title 40 Code of Federal Regulations (CFR) §257.93. This certification must include a narrative description of the statistical method that will be used for evaluating groundwater monitoring data.

TRC Engineers Michigan, Inc., the engineering entity of TRC Environmental Corporation (TRC), prepared this Groundwater Statistical Evaluation Plan (Statistical Plan) for the BRPP BABs CCR unit on behalf of DTE Electric Company (DTE Electric). This Statistical Plan was prepared in accordance with the requirements of §257.93 and describes how data collected from the groundwater monitoring system will be evaluated. As part of the evaluation, the data collected during detection monitoring events (post October 17, 2017), are evaluated to identify statistically significant increases (SSIs) in detection monitoring parameters (Appendix III of the CCR Rule) to determine if concentrations in detection monitoring well samples exceed background levels.

The CCR Rule is not prescriptive with regards to the actual means and methods to be used for statistically evaluating groundwater data, and there is flexibility in the method selection, as long as specific performance metrics are met. A description of statistical methods that meet the performance objectives of the CCR Rule are described in U.S. EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (*Unified Guidance,* USEPA, 2009).

1.2 Site Hydrogeology

The BRPP BABs CCR unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet-below ground surface (feet-bgs). In general, the BRPP BABs CCR unit is initially underlain by at least 90 to as much as 136 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet within the monitoring well network and rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) to the southeast in the vicinity of SB-16-01 (Figure 1). Consequently, the uppermost aquifer is not laterally contiguous across the entire BRPP BABs CCR unit, and not present in the southeastern corner of the BABs.

The variability in the depth to the uppermost aquifer is a consequence of the heterogeneity of the glacial deposits and is driven by the lateral discontinuity of the sand outwash within the encapsulating fine-grained, silty clay till that confines the uppermost aquifer. There is an apparent lack of interconnection and/or significant vertical variation between the uppermost aquifer sand unit(s) encountered across the BRPP BABs CCR unit as demonstrated by the extensive amount of time (months) it took for water levels in monitoring well MW-16-02 to reach equilibrium after well construction and development (TRC, 2017).

Given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit, the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs, where present varying up to 46 feet vertically), the no-flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area, and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the BRPP BABs CCR unit.

In addition, the elevation of CCR-affected water maintained within the BRPP BABs is approximately 5 feet above the potentiometric surface elevations in the uppermost aquifer at the BABs CCR unit area. This suggests that if the CCR affected surface water in the BABs were able to penetrate the silty clay-rich underlying confining unit that the head on that release likely would travel radially away from the BABs within the uppermost aquifer. However, with the very thick continuous silty clay-rich confining unit beneath the BRPP it is not possible for the uppermost aquifer to have been affected by CCR from BRPP operations that began in the 1980s.

Due to the relatively small footprint of the BABs, the low vertical and horizontal groundwater flow velocity, the potential for radial flow, and the fact that the saturated unit being monitored is isolated by a laterally contiguous silty-clay unit, which significantly impedes vertical groundwater flow thus preventing the monitored saturated zone from potentially being affected by CCR, monitoring of the BRPP BABs CCR unit using intra-well statistical methods is appropriate. In addition, because the uppermost aquifer is not uniformly present across the BABs CCR unit, there are no clear upgradient wells. As such, intra-well statistical approaches will be used during detection monitoring.

Section 2
Groundwater Monitoring System

2.1 Groundwater Monitoring System

A groundwater monitoring system has been established for BRPP BABs CCR unit (TRC, October 2017), which established the following locations for detection monitoring. The locations are shown on Figure 1.

MW-16-01	MW-16-02	MW-16-03
MW-16-04	MW-16-09	

2.2 Constituents for Detection Monitoring

Subsection 257.94 describes the requirement for detection monitoring for Appendix III parameters. Detection monitoring will be performed semiannually unless an alternative frequency is made on a site-specific basis. The detection monitoring parameters are identified in Appendix III of §257.94 and consist of the following:

Boron	Calcium	Chloride
Fluoride	pH	Sulfate
Total Dissolved Solids (TDS)		

2.3 Constituents for Assessment Monitoring

Assessment monitoring per §257.95 is required when a SSI over background has been detected for one or more of the constituents identified in Appendix III to Part 257 – Constituents for Detection Monitoring. In the event that assessment monitoring is triggered through the statistical evaluation of detection monitoring parameters, the following assessment monitoring parameters will be sampled:

Antimony	Arsenic	Barium
Beryllium	Cadmium	Chromium
Cobalt	Fluoride	Lead
Lithium	Mercury	Molybdenum
Selenium	Thallium	Radium 226 and 228 (combined)

Section 3
Statistical Analysis

Groundwater sampling and analytical requirements are described in §257.93. The owner or operator of the CCR unit must select a statistical method specified in §257.93(f) to be used in evaluating groundwater monitoring data. The test shall meet the performance standards outlined in §257.93(g). The goal of the statistical evaluation plan is to provide a means to formulate an opinion or judgement as to whether the CCR unit has released contaminants into groundwater. This plan describes the statistical procedures to be used to determine if a statistical significant increase (SSI) or in the case of pH, a statistically significant difference (SSD), indicating that data is from a different population than background. This plan was developed using applicable guidance, including the *Unified Guidance*. In addition to using applicable guidance documents, commercially available statistical evaluation tools will be utilized by BRPP BABs CCR unit to develop statistically derived limits so that detection monitoring results can be compared to background.

The CCR Rule allows a variety of methods for conducting statistical evaluations. The specific procedure for a given data set depends on several factors including the proportion of the data set with detected values and the distribution of the data. These will not be known until the data are collected. It is generally anticipated, however, that the tolerance or prediction interval procedure will be the preferred method of conducting detection monitoring data evaluation to the extent that the data support the use of that method. This statistical procedure is described below in this section of the plan and in detail in the *Unified Guidance*.

3.1 Establishing Background

Background groundwater quality shall be established prior to October 17, 2017. Per §257.93(d), the owner or operator of the CCR unit must establish background groundwater quality in hydraulically upgradient or background well(s). The development of a groundwater statistical evaluation program for detection monitoring involves the proper collection of background samples, regardless of whether an inter-well or intra-well monitoring strategy is implemented. Background may be established at wells that are not located hydraulically upgradient from the unit if it meets the requirement of §257.91(a)(1). A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where:

1. Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or
2. Sampling at other wells will provide an indication of background groundwater quality that is as representative as or more representative than that provided by the upgradient wells.

The purpose of obtaining adequate background groundwater data is to approximate, as accurately as possible, the true range of ambient concentrations of targeted constituents. Background groundwater data should eliminate, to the extent possible, statistically significant concentration increases not attributable to the CCR unit. Specifically, the owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit. The sampling frequency should be selected so that the samples are physically independent. These background groundwater parameters can be adequately qualified by doing the following:

- Collecting the minimum number of samples that satisfy the requirements of the statistical methods that are used (i.e., that result in adequate statistical power);
- Incorporating seasonal and/or temporal variability into the background data set; and

Incorporating the spatial component of variability into the background data set (i.e., the variability that comes with obtaining samples from different locations within the same groundwater zone).

The initial background/baseline sampling period is a minimum of eight events for Existing CCR units that were in operation on October 19, 2015. This provides a minimal background data set to initiate statistical comparisons. Over time, the short baseline period may result in a high risk of false positive statistical results. The facility may periodically update background data to account for variability in background conditions. The *Unified Guidance* recommends that background data be updated every 4 to 8 measurements (i.e., every two to four years if samples are collected semi-annually, or one to two years if samples are collected quarterly). The background data will be reviewed for trends or changes that may necessitate discontinuation of earlier portions of the background data set.

3.2 Data Evaluation and Data Distributions

DTE Electric will evaluate the groundwater data for each constituent included in the groundwater monitoring program using intra-well tolerance or prediction limits. The tolerance or prediction interval statistical procedure establishes an interval that bounds the ranges of expected concentrations representative of unaffected groundwater using the distribution of background data. The upper tolerance or prediction limit of that interval is then used for comparison to the concentration level of each constituent in each compliance well. Development of the tolerance or prediction limits used for comparison during detection monitoring will be conducted in accordance with the *Unified Guidance.* The following is a summary of descriptive statistics and tolerance or prediction limit choices.

3.2.1 Background Determination

Statistical limits will be calculated after the collection of a minimum of eight independent samples. The analytical results from the eight "background" samples will be used to determine the statistical limits for each individual parameter. For inter-well comparisons, background data should be "pooled" creating a single, combined background dataset from the background monitoring wells. For intra-well, the background data set is comprised of the historical data set established at each individual monitoring well.

The background dataset (and hence the prediction limits) will be updated as appropriate (as discussed above in Section 3.1) to maintain necessary statistical sensitivity. New data will be compared to the existing background data set to determine if there are outlier values, and whether the data are statistically similar. If there are no outliers and the data are statistically similar, the new data will be added to the existing background data set.

3.2.2 Outlier Evaluation

Outliers and anomalies are inconsistently large or small values that can occur as a result of sampling, analytical, or transcription errors; laboratory or field contamination; or shelf-life exceedance; or extreme, but accurately detected environmental conditions (e.g., spills). Data will be reviewed graphically using tools such as time concentration trend plots, box and whisker plots and/or probability plots to illustrate and identify outliers, trends, or otherwise unusual observations at each monitoring location. This will be accomplished prior to further in-depth review of the data sets to identify any obvious field or laboratory anomalies. Data points that are determined to be non-representative will be 'flagged' for further detailed evaluation prior to removing from the background data or designating as an outlier.

3.2.3 Testing for Normality

Statistical tests often assume that data are normally distributed or that data can be normalized by various standard methods. The assumption of normality can be tested in various ways. Formal normality testing such as utilizing the Shapiro-Wilk test (for $n<50$) or the Shapiro-Francia Test (for $n>50$) or calculation of a coefficient of skewness may be utilized in accordance with the *Unified Guidance*. Alternatively, graphing data on a probability plot can also be used to test for normality. If the data appear to be non-normal, mathematical transformations of the data may be utilized such that the transformed data follow a normal distribution (e.g., lognormal distributions). Alternatively, non-parametric tests may be utilized when data cannot be normalized.

The following are guidelines for decision making during normality testing:

1. If the original data show that the data are not normally distributed, then apply a natural log-transformation to the data and test for normality using the above methods.
2. If the original or the natural log-transformed data confirm that the data are normally distributed, then apply a normal distribution test.
3. If neither the original nor the natural log-transformed data fit a normal distribution, then apply a distribution-free test.

3.2.4 Evaluation of Non-Detects

Background concentrations that are reported as less than the practical quantitation limit (PQL) (herein referred to as non-detects) will be evaluated differently, depending upon the percentage of non-detects to the reported concentrations for a given parameter at a given monitoring well. The evaluation of non-detects was as follows:

Less Than 15% Non-detects

For data that was normally or lognormally distributed and less than 15% non-detects, one-half the value of the method detection limit will be used to calculate the prediction limit. If normally or lognormally cannot be met using one-half of the method detection limit, and if the method detection limits were equal, alternating zero with the value of the method detection limit will be considered in order to determine the normality of the data set.

15% to 50% Non-detects

If more than 15% but less than 50% of the overall data are less than the detection limit, either Aitchison's adjustment, or Cohen's adjustment, or the Kaplan Meijer adjustment will be used to determine the statistical limits in accordance with the *Unified Guidance*.

51% to 100% Non-detects

For data sets that contain greater than 50% non-detects, the non-parametric statistical limits will be utilized as described below.

3.3 Parametric Tolerance or Prediction Limits

Tolerance and prediction intervals are similar approaches to establish statistical ranges constructed from background or baseline data. However, tolerance limits define the range of data that fall within a specified percentage with a specified level of confidence (where a proportion of the population is expected to lie), whereas prediction limits involve predicting the upper limit of possible future values based on a background or baseline data set and comparing that predicted limit to compliance well data.

Intra-well tolerance or prediction limits are calculated using baseline period or background data from each well. The tolerance or prediction limit will be calculated in accordance with the *Unified Guidance*. If the data set is log-normally distributed the tolerance or prediction limits will be calculated using the log-normally transformed data, and subsequently un-transformed to normal units.

In §257.93(g)(2) it states that for multiple comparisons, each testing period should have a Type I error rate no less than 0.05 while maintaining an individual well Type I error rate of no less than 0.01. Per §257.93(g)(4), these Type I limits do not apply directly to tolerance intervals or prediction intervals; however, the levels of confidence for the tolerance or prediction limit approach must be at least as effective as any other approach based on consideration of the number of samples, distribution, and range of concentration values in the background data set for each constituent.

3.4 Non-Parametric Tolerance or Prediction Limits

Parameters that consist of mainly non-detect data usually violate the assumptions needed for normal based tolerance or parametric prediction intervals. Therefore, as recommended in the *Unified Guidance*, the non-parametric tolerance or prediction limit method will be chosen.

A non-parametric upper tolerance or prediction limit is constructed by setting the limit as a large order statistic selected from background (e.g., the maximum background value). This method has lower statistical power than parametric methods; therefore, it is important to control outliers within the dataset to maintain adequate statistical power that this method can provide. Due to the lack of statistical power of this method, it will only be used when other methods are not available.

3.5 Double Quantification Rule

The double quantification rule is discussed in Section 6.2.2 of the *Unified Guidance*. In the cases where the background dataset for a given well is 100% non-detect, a confirmed exceedance is registered if any well-constituent pair exhibits quantified measurements (i.e., at or above the reporting limit) in two consecutive sample and resample events. This method will be used for non-detect data sets.

3.6 Verification Resampling

In order to achieve the site wide false positive rates (SWFPR) recommended in the *Unified Guidance*, a verification resampling program is necessary. Without verification resampling, the

SWFPR cannot be reasonably met, and much larger statistical limits would be required to achieve a SWFPR of 5% or less. Furthermore, the resulting false negative rate would be greatly increased. Under these circumstances, if there is an exceedance of a tolerance limit or prediction limit for one or more of the parameters, the well(s) of concern will be resampled within 30 days of the completion of the initial statistical analysis. Only constituents that initially exceed their statistical limit (i.e., have no previously recorded SSIs) will be analyzed for verification purposes. This verification sampling must be performed within the same compliance period as the event being verified. If the verification sample remains statistically significant, then statistical significance will be considered. If the verification sample is not statistically significant, then no SSI will be recorded for the monitoring event.

Section 4
Evaluation of Detection Monitoring Data

4.1 Statistical Evaluation during Detection Monitoring

According to §257.94(e), if the facility determines, pursuant to §257.93(h), that there is a SSI over background levels for one or more of the Appendix III constituents, the facility will, within 90 days of detecting a SSI, establish an assessment monitoring program **<or>** demonstrate that:

- A source other than the CCR unit caused the SSI, or
- The SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

The owner or operator must complete a written demonstration (i.e., Alternative Source Demonstration, ASD), of the above within 90 days of confirming the SSI. If a successful ASD is completed, a certification from a qualified professional engineer is required, and the CCR unit may continue with detection monitoring.

If a successful ASD is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under §257.95, described further in Section 5. The facility must also include the ASD in the annual groundwater monitoring and corrective action report required by §257.90(e), in addition to the certification by a qualified professional engineer.

Section 5
Assessment Monitoring

As discussed in Section 4, the facility must begin assessment monitoring for the CCR unit if a SSI is identified, and the SSI cannot be attributed to an ASD. Per the CCR Rule, assessment monitoring must begin within 90 days of identification of a SSI that is not attributed to an alternative source. During the 90-day period, wells included in the groundwater monitoring system will be sampled for Appendix IV constituents pursuant to §257.95(b). Within 90 days of obtaining the results from the first assessment monitoring event, all of the wells will be sampled for Appendix III and the detected Appendix IV parameters in the initial assessment monitoring event.

If assessment monitoring is triggered pursuant to §257.94(e)(1), data are compared to Groundwater Protection Standards (GPSs) or background groundwater quality. The CCR Rule [§257.95(h)] requires GPSs to be established for Appendix IV constituents that have been detected during baseline sampling. The GPS is set at the EPA maximum contaminant level (MCL) or a value based on background data. The MCLs will be the GPSs for those constituents that have MCLs unless the background concentration is greater than the MCL, which in that case, the statistically-determined background values becomes the GPS. For all other parameters that do not have MCLs, the GPS defaults to a statistically-based limit developed using background data. For GPSs that are established using background, tolerance limits are anticipated to be used to calculate the GPS. The background will be updated every two years, along with the resulting GPS, consistent with the *Unified Guidance*. If additional assessment monitoring parameters become detected during the assessment monitoring, GPSs will be developed for those parameters in the same manner as the initial parameters.

Consistent with the *Unified Guidance*, the preferred method for comparisons to a fixed standard will be confidence limits. An exceedance of the standard occurs when the 95 percent lower confidence level of the downgradient data exceeds the GPS. Confidence intervals will be established in a manner appropriate to the data set being evaluated (proportion of non-detect data, distribution, etc.). If the statistical tests conclude that an exceedance of the GPS or background has occurred, verification resampling may be conducted by the facility. Once the resampling data are available, the comparison to the GPS or background will be evaluated.

Section 6
Certification

Statistical Methods Certification per 40 CFR §257.93(f)
Belle River Power Plant Bottom Ash Basins
China Township, Michigan

The U.S. EPA's Disposal of Coal Combustion Residuals from Electric Utilities Final Rule Title 40 CFR Part 257 §257.93 requires that the owner or operator of an existing CCR unit develop the groundwater sampling and analysis program to include the selection of the statistical procedures to be used for evaluating groundwater monitoring data. The owner or operator must obtain a certification from a qualified professional engineer stating that the selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management area. The certification must include a narrative description of the statistical method selected to evaluate the groundwater monitoring data to meet the requirements of Title 40 CFR §257.93.

CERTIFICATION

By means of this certification, I certify that I am a qualified professional engineer as defined by Title 40 CFR §257.53, that I have reviewed this Statistical Evaluation Plan, and that the statistical methods described herein are appropriate and meet the requirements of Title 40 CFR §257.93. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.93.

Name: David B. McKenzie, P.E.	Date: October 31, 2017	
Company: TRC Engineers Michigan, Inc.	Expiration Date: October 13, 2017	Stamp

Section 7
References

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Figure

LEGEND

- SOIL BORING
- MONITORING WELL
- DECOMMISSIONED MONITORING WELL

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 BY BMJ ENGINEERS & SURVEYORS, INC.

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT: DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
4505 KING ROAD
CHINA TOWNSHIP, MICHIGAN

TITLE: **MONITORING NETWORK AND SITE PLAN**

DRAWN BY:	R SUEMNICHT	PROJ NO.:	265996.0003
CHECKED BY:	C SCIESZKA		FIGURE 1
APPROVED BY:	V BUENING		
DATE:	OCTOBER 2017		

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FILE NO.: 265996-0003-002_Stat.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

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Appendix J
Location Restriction Certification Report

Location Restrictions Demonstrations

DTE Electric Company
Belle River Power Plant Bottom Ash Basins
Coal Combustion Residual Unit

4505 King Road
China Township, Michigan

October 2018

Location Restrictions Demonstrations

DTE Electric Company
Belle River Power Plant Bottom Ash Basins
Coal Combustion Residual Unit

4505 King Road
China Township, Michigan

October 2018

Prepared For
DTE Electric Company

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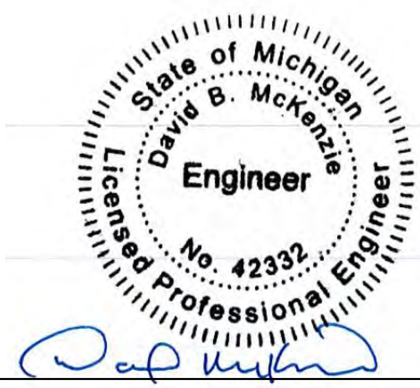
Certification

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.

License No: 6201042332

Section 1
Background

The purpose of this document is to determine whether the Coal Combustion Residual (CCR) Bottom Ash Basins (BABs) at the Belle River Power Plant (BRPP) are 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 BABs are considered CCR surface impoundments 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 BABs comply 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. The facility is generally constructed over a natural clay-rich soil base. The BABs have been in use with the BRPP since it began operation and have collected CCR bottom ash that is periodically cleaned out and either sold for beneficial reuse or disposed of at the Range Road Landfill (RRLF).

The BRPP BABs are two adjacent physical sedimentation basins that are slightly raised CCR surface impoundments referred to as the North and South BABs, located north of the BRPP. These are considered one CCR unit. The BABs receive sluiced bottom ash and other process flow water from the power plant. Discharge water from each BAB flows over an outlet weir that gravity flows to a site storm water conveyance network of ditches and pipes, then flows into the diversion basin (DB) CCR unit, which is monitored as a separate CCR unit in accordance with the CCR Rule. The North and South BABs run roughly east to west and are both approximately 420 feet long by 120 feet wide with bottom elevations of approximately 580 feet relative to the North American Vertical Datum (NAVD) 1988, with outflow weir elevations of approximately 590.25 feet relative to the NAVD 1988.

1.2 Site Setting

A groundwater monitoring system has been established for the BRPP BABs 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 BABs CCR unit currently consists of five monitoring wells that are screened in the uppermost aquifer. Well boring logs are included in Appendix A.

The BRPP BABs CCR unit is located approximately one-mile west of the St. Clair River. The BRPP BABs CCR unit is underlain by more than 130 feet of unconsolidated sediments, with the lower confining Bedford Shale generally encountered from 135 to 145 feet below ground surface (bgs). The BABs are incised into the clay to an elevation 580 ft MSL. In general, the BRPP BABs CCR unit is initially underlain by at least 90 feet to as much as 136 feet of laterally extensive low hydraulic conductivity silty clay-rich deposits. The depth to the top of the confined sand-rich uppermost aquifer encountered immediately beneath the silty clay-rich deposits varies up to 46 feet within the monitoring well network and rapidly thins to the south and east of the BABs and pinches out (e.g., no longer present) to the southeast in the vicinity of SB-16-01. Consequently, the uppermost aquifer is not laterally contiguous across the entire BRPP BABs CCR unit and is not present in the southeastern corner of the BABs.

The variability in the depth to the uppermost aquifer is a consequence of the heterogeneity of the glacial deposits and is driven by the lateral discontinuity of the sand outwash within the encapsulating fine-grained, silty-clay till that confines the uppermost aquifer. There is an apparent lack of interconnection and/or significant vertical variation between the uppermost aquifer sand unit(s) encountered across the BRPP BABs CCR unit as demonstrated by the extensive amount of time (months) it took for water levels in monitoring well MW-16-02 to reach equilibrium after well construction and development (TRC, 2017).

Given the horizontally expansive clay with substantial vertical thickness that isolates the uppermost aquifer from the BRPP BABs CCR unit, the heterogeneity of the glacial deposits (with the top of the uppermost aquifer elevation across the BABs, where present varying up to 46 feet vertically), the no flow boundary where no sand or gravel is present in the southeastern portion of the BABs CCR unit area, and the apparent lack of hydraulic interconnectedness of the uppermost aquifer encountered at the BABs in some areas, it is not appropriate to infer horizontal flow direction or gradients across the BRPP BABs CCR unit.

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, within wetlands, near fault areas, within seismic impact zones, and in unstable areas based on available geologic and geomorphologic information. Supporting information for the demonstrations is included in the appendices to this report.

2.1 §257.60 – Placement above the Uppermost Aquifer

The federal CCR rule requires that CCR units such as the BRPP BABs 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 BABs are incised into the clay to an approximate elevation of 580 ft MSL. The uppermost aquifer is the sand-rich unit found at an elevation of 453 to 498 ft MSL. The base of the BABs and the uppermost aquifer are separated by at least 82 ft of native, low permeability clay. Cross-sections showing the approximate pond bottom elevation for each BAB, and the depth to the uppermost aquifer are included in Appendix B.

Based on this demonstration, the base of each BAB is located greater than five feet above the upper limit of the uppermost aquifer, and there is not a hydraulic connection between the BABs and the underlying groundwater caused by normal fluctuation in groundwater level. Therefore, each BAB 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 the 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 BABs are located in wetlands.

As shown on the site 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 one area located approximately 200 ft north of the BABs as a wetland. NWI also recognizes an area approximately 450 ft west of the BABs as a wetland. These areas are not immediately adjacent to the BABs, and therefore, there is no risk of impact to these areas from the BAB operations.

Based on TRC's review of wetland inventory resources and current site conditions, TRC is of the opinion that the BRPP BABs are not located in an area exhibiting wetland characteristics, and any continued operations at the BABs will have no potential to impact any wetlands near the CCR unit. TRC also concludes that, due to their use as NPDES treatment units, these basins are not wetlands, 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 not cause 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 BABs.

Evidence of active faulting during the Holocene near the BRPP BABs is not supported by this determination; therefore, the existing BABs are 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 BABs are 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 BABs 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 BABs are not located in a seismic impact zone, and therefore the BABs are 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 and topography, and evaluating human-made features in the area of the BRPP BABs.

Geotechnical explorations performed at the BRPP BAB area identified clay with lenses of silt and sand. The soils occur above soft to very hard shale bedrock. These observations suggest that there are no unstable soil or unstable underlying bedrock proximal to the BABs.

Geological and geomorphological information was reviewed to determine potential unstable areas at the BRPP BABs. None of the geological or geomorphological information reviewed suggest the presence of unstable areas at or near the BABs.

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, the BRPP BABs are not located in an unstable area. The BABs are in compliance with the requirements of §257.64.

Section 3
Conclusions

Based on the evaluation provided in this demonstration, the BRPP BABs are 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

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Appendix A
Monitoring Well Boring Logs

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-01

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	2/29/16	2/29/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.17	591.30	120.0	6/4

Boring Location:	Personnel	Drilling Equipment:
Approximately 188 feet off road to the S, W of bottom ash basins. N: 471155.70 E: 13625546.02	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 4/13/16 08:45 ▼ Depth (ft bgs) 14.52

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				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.	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. Original boring abandoned due to compromised screen. Redrilled and installed at survey location noted above within 10 feet of original location.
				CLAY mostly clay, trace fine to coarse gravel, high plasticity, brown (10YR 5/3), moist, stiff.	CL			
1 CS	60		5	Change to dark gray (10YR 4/1), very stiff at 5.0 feet.				
				Change to soft at 8.0 feet.				
			10	Change to no gravel, dark gray (10YR 4/1) mottled with brown (10YR 5/3), very soft at 10.0 feet.				
2 CS	50		15	▼				
			20	Change to dark gray (10YR 4/1) at 20.0 feet.				
3 CS	100		25					
			30					
4 CS	100		35					
			40					

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

Signature: [signature]

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

Checked By: C. Scieszka

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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					
			60					
8 CS	80		65					
			70					
9 CS	100		75					
			80					
10 CS	100		85					
			90	**SAND** mostly fine sand, dark gray (10YR 4/1), saturated.	SP			
11 CS	100		95					
			100	End of boring at 100.0 feet below ground surface.				

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-02

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/14/16	3/15/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	586.27	588.94	100.0	6/4

Boring Location:	Personnel	Drilling Equipment:
325 feet W of haul road, 5 feet N of road, N of bottom ash basins. N: 471409.06 E: 13625991.78	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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
				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.
1 CS	80		5					
				Change to no gravel at 7.0 feet.				
			10	Change to high plasticity, dark gray (10YR 4/1), moist, very soft at 10.0 feet.				
2 CS	80		15	▼				
			20		CL			
3 CS	100		25					
			30					
4 CS	90		35					
			40					

Signature: [signature]

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Checked By: C. Scieszka

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-02

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-03

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	5/25/16	5/31/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.03	590.66	150.0	6/4

Boring Location:	Personnel	Drilling Equipment:
Approximately 100 feet W of haul road, N of bottom ash basins. N: 471391.78 E: 13626202.49	Logged By - J. Reed Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	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
				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.				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.
1 CS	100		5		CL-ML			
			10					
				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.				
2 CS	100		15					
			20					
3 CS	100		25	Change to trace to few fine to coarse sand at 25.0 feet.	CL			
			30					
4 CS	100		35					
			40					
				Change to trace fine to coarse sand at 41.5 feet.				

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

Signature: [signature]

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Firm: TRC Environmental Corporation
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WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-03

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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.				
			50					
6 CS	90		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			
				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.				
			70	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.				
				SANDY SILT mostly silt, little to some fine to medium sand, gray (10YR 5/1), moist, medium dense.	ML			
			80	**CLAY** mostly clay, few silt, few fine to coarse sand, low to medium plasticity, gray (10YR 5/1), moist, stiff.				
9 CS	100		85					
			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					

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

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-04

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/7/16	3/8/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	587.50	590.51	130.0	6/4

Boring Location:	Personnel	Drilling Equipment:
200 feet from W corner of road, S of bottom ash basins. N: 470893.74 E: 13625876.34	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 4/13/16 09:31 ▼ Depth (ft bgs) 13.91

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
			0	**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.	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.
1 CS	80		5					
			10	Change to stiff at 10.5 feet. Change to dark gray (10YR 4/1), very soft at 12.0 feet.				
			13.91	▼				
2 CS	100		15					
			20					
3 CS	100		25					
			30					
4 CS	100		35					
			40					

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

Signature: [signature]

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Checked By: C. Scieszka

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), very soft.	CL			
			50					
6 CS	100		55					
			60	Change to few coarse gravel at 60.0 feet.				
7 CS	100		65					
			70					
				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			
				SANDY CLAY mostly clay, some fine sand, high plasticity, dark gray (10YR 4/1), moist.	CL			
9 CS	100		85	**SILTY CLAY** mostly clay, some silt, high plasticity, dark gray (10YR 4/1), stiff.	CL-ML			
				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.	CL-ML			
10 CS	100		95					
			100	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), very soft.	CL			

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
11 CS	100		105	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), very soft.	CL			
12 CS	100		110, 115	**SILT** mostly silt, few fine sand, nonplastic, dark gray (10YR 4/1), saturated, stiff.	ML			
13 CS	100		120, 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					

WELL CONSTRUCTION LOG

WELL NO. MW-16-05

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/3/16	3/4/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.32	590.82	150.0	6

Boring Location:	Personnel	Drilling Equipment:
S end of haul road, W of diversion basin. N: 470378.15 E: 13626342.79	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 4/13/16 09:55 ▼ Depth (ft bgs) 14.37

Sample Number and Type	Recovery (%)	Blow Counts	Depth in Feet	Lithologic Description	USCS	Graphic Log	Well Diagram	Comments
			0	**CLAY WITH GRAVEL** mostly clay, few to some coarse gravel, high plasticity, dark grayish brown (10YR 4/2), 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.
1 CS	80		5	**CLAY** mostly clay, few fine to coarse gravel, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, hard. Change to no gravel, very stiff at 4.0 feet.	CL			
			10	Change to dark gray (10YR 4/1), very soft at 10.0 feet.				
2 CS	100		15	▼				
			20					
3 CS	100		25	Change to medium stiff at 26.0 feet. Change to very soft at 28.0 feet.				
			30					
4 CS	100		35					
			40					

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

Signature: [signature]

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

Checked By: C. Scieszka

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-05

Columns: SAMPLE (NUMBER AND TYPE, RECOVERY (%)) | BLOW COUNTS | DEPTH IN FEET | LITHOLOGIC DESCRIPTION | USCS | GRAPHIC LOG | WELL DIAGRAM | COMMENTS

Sample Number and Type	Recovery (%)
5 CS	100
6 ST	100
7 CS	100
8 CS	100
9 CS	100
10 CS	60
11 CS	100

Depth in Feet	Lithologic Description	USCS
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
50	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL
60	Change to few fine to coarse gravel at 60.0 feet.	
65	Change to medium stiff at 65.0 feet.	
	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.	CL-ML
	Change to low plasticity, black (10YR 2/1), hard at 77.0 feet.	
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.	CL
	Change to medium stiff at 93.5 feet.	
	Change to soft at 97.5 feet.	
100		

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-05

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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		130, 135	**CLAYEY SILT** mostly silt, some clay, medium plasticity, dark gray (10YR 4/1), wet, medium stiff.	ML-CL			
16 CS	90		140, 145	**SHALE** dark gray (10YR 4/1), dry.				
			150, 155	End of boring at 150.0 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-16-06

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/10/16	3/11/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.98	593.21	140.0	6

Boring Location:	Personnel	Drilling Equipment:
123 feet S of road connecting to haul road, E of diversion basin. N: 470439.03 E: 13626796.04	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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
			0	**GRAVEL WITH SAND** mostly gravel, some fine to coarse sand, brown (10YR 5/3), moist, dense.				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.
				CLAY mostly clay, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, very stiff.				
1 CS	50		5					
			10	Change to few coarse gravel at 10.0 feet.				
				Change to dark gray (10YR 4/1), stiff at 12.0 feet.				
				Change to very soft at 13.0 feet.				
			▼					
2 CS	100		15					
			20		CL			
3 CS	100		25					
			30					
4 CS	100		35					
			40					

Signature: [signature]

Checked By: C. Scieszka

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-06

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
			50					
6 CS	100		55					
			60					
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.	CL-ML			
			80					
9 CS	80		85					
			90	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
10 CS	70		95					
			100					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-06

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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		120, 125	**SILTY CLAY** mostly clay, some silt, medium plasticity, dark gray (10YR 4/1), moist, medium stiff.	CL-ML			
14 CS	100		130, 135	**SILT** mostly silt, dark gray (10YR 4/1), saturated, very soft.	ML			
				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

TRC

WELL NO. MW-16-07

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/8/16	3/9/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.89	592.58	140.0	6

Boring Location:	Personnel	Drilling Equipment:
326 feet S of road connecting to haul road, E of diversion basin. N: 470233.47 E: 13626858.79	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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
				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.
1 CS	60		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.				
				▼ Change to moist, very soft at 13.0 feet.				
2 CS	100		15					
			20		CL			
3 CS	100		25					
			30					
4 CS	100		35					
			40					

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

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WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-07

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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		60					
				CLAYEY SILT mostly silt, little to some clay, few fine to coarse sand, low plasticity, dark gray (10YR 4/1), moist.	ML-CL			
			65	**SAND** mostly fine to coarse sand, dark gray (10YR 4/1), moist, loose.	SW			
				CLAYEY SILT mostly silt, little to some clay, few fine to coarse sand, low plasticity, dark gray (10YR 4/1), moist.	ML-CL			
9 CS	100		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.				
			75					
10 CS	100		80					
			85		CL-ML			
11 CS	100		90					
			95					
			100					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-07

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	COMMENTS
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, 115			
14 CS	100		120, 125, 130			
15 CS	100			**SILT** mostly silt, no plasticity, dark gray (10YR 4/1), saturated, loose.	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

TRC

WELL NO. MW-16-08

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/9/16	3/10/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.31	591.88	140.0	6

Boring Location:	Personnel	Drilling Equipment:
566.6 feet S of road connecting to haul road, E of diversion basin. N: 470002.90 E: 13626846.85	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 4/13/16 12:00 ▼ Depth (ft bgs) 13.19

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				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.
1 CS	50		5	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1) mottled with brown (10YR 5/3), moist, very stiff.				
			10	Change to dark gray (10YR 4/1), very soft at 10.0 feet.				
			▼					
2 CS	100		15					
			20					
3 CS	100		25		CL			
			30					
4 CS	100		35					
			40					

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

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SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL			
			50					
6 CS	100		55					
			60					
7 CS	80		65					
			70	**SILTY CLAY** mostly clay, some silt, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, soft.	CL-ML			
8 CS	100		75					
			80					
9 CS	100		85					
			90					
10 CS	60		95					
			100					

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-08

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				SILTY CLAY mostly clay, some silt, few coarse gravel, high plasticity, dark gray (10YR 4/1), moist, soft.				
11 CS	100		105	Change to few fine sand at 105.5 feet.				
			110	Change to no sand at 110.0 feet.				
12 CS	100		115		CL-ML			
			120					
13 CS	100		125					
			130	**SILT** mostly silt, dark gray (10YR 4/1), saturated, very soft.	ML			
14 CS	100		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

TRC

WELL NO. MW-16-09

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	6/1/16	6/1/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.28	590.80	150.0	6

Boring Location:	Personnel	Drilling Equipment:
E of bottom ash basins, E of haul road. N: 471284.45 E: 13626365.84	Logged By - J. Reed Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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
			0	**TOPSOIL**				
				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.	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.
1 CS	75		5	**CLAY** mostly clay, few silt, trace to few fine to coarse sand, medium plasticity, gray (10YR 5/1), moist, soft.				
			10					
2 CS	85		15	▼ (14.36)				
			20					
3 CS	100		25		CL			
			30	Change to trace to few fine gravel at 30.0 feet.				
4 CS	100		35					
			40					

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

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SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
			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.				
5 CS	100		50	Change to soft to medium stiff at 50.0 feet.				
			55					
			60					
			65					
6 CS	100		70	Change to soft at 70.0 feet.	CL			
			75					
			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					

TRC

WELL CONSTRUCTION LOG

WELL NO. MW-16-09

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	COMMENTS
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.	CL	
			110			
9 CS	80		115			
			120			
			125			
10 CS	100		130			
			135			
				SAND mostly fine sand, trace silt, dark gray (10YR 4/1), moist, loose.	SP	
			140			
				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		145			
				SHALE weathered, gray (10YR 5/1), brittle.		
			150	End of boring at 150.0 feet below ground surface.		
			155			

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-10

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	6/2/16	6/3/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.25	592.26	150.0	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:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time; Depth (ft bgs) After Drilling: Date/Time 6/9/16 07:45 ▼ Depth (ft bgs) 15.30

Sample Number and Type	Recovery (%)	Blow Counts	Depth in Feet	Lithologic Description	USCS	Graphic Log	Well Diagram	Comments
				TOPSOIL				
				CLAY mostly clay, few silt, trace to few fine to coarse sand, dark grayish brown (10YR 4/2), moist, medium stiff to 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.
1 CS	50		5					
			10	Change to gray (10YR 5/1) at 11.0 feet. Change to soft to medium stiff at 12.0 feet.				
2 CS	90		15 ▼					
			20					
3 CS	95		25	Change to soft at 25.0 feet.				
			30	Change to few fine to coarse sand, medium stiff at 30.0 feet. Change to dark gray (10YR 4/1) at 32.0 feet.				
4 CS	100		35	Change to soft at 35.0 feet.				
			40					

Signature: [signature]

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WELL CONSTRUCTION LOG

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WELL NO. MW-16-10

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	100		45	**CLAY** mostly clay, few silt, trace to few fine to coarse sand, dark gray (10YR 4/1), moist, soft.	CL			
			50					
6 CS	100		55					
			60					
7 CS	100		65					
			70	**CLAY WITH SAND** mostly clay, little fine to coarse sand, few silt, trace gravel, dark gray (10YR 4/1), moist, very stiff.	CL			
8 CS	100		75	Change to few to little medium to coarse sand, low to medium plasticity, stiff at 75.0 feet.				
			80	**CLAYEY SAND** mostly fine to coarse sand, some clay, dark grayish brown (10YR 4/2), moist, medium dense.	SC			
9 CS	100		85	**SAND** mostly fine to medium sand, dark grayish brown (10YR 4/2), moist, loose.	SP			
			90	**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			
10 CS	100		95					
			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			

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
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			
				SAND mostly medium to coarse sand, dark gray (10YR 4/1), moist, loose.	SP			
12 CS	100		115	**CLAY** mostly clay, little sand, few to little silt, dark gray (10YR 4/1), moist, stiff.	CL			
			120					
13 CS	95		125					
			130					
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			
				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

TRC

WELL NO. MW-16-11

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	6/3/16	6/6/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.03	591.54	150.0	6

Boring Location:	Personnel	Drilling Equipment:
S of haul road, W of diversion basin. N: 470251.34 E: 13626438.92	Logged By - J. Reed Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 6/21/16 07:45 ▼ Depth (ft bgs) 14.47

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
			0	**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.
1 CS	50		5					
				Change to trace gravel at 8.0 feet.				
			10					
				Change to gray (10YR 5/1) at 12.0 feet.				
				Change to no gravel at 13.0 feet.				
			▼					
2 CS	70		15					
			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 231828.0003.0000.GPJ TRC_CORP.GDT 7/14/16

Signature: [signature]

Checked By: M. Powers

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SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	90		45	**CLAY** mostly clay, few silt, trace to few sand, medium plasticity, gray (10YR 5/1), moist, soft to medium stiff.				
			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.				
					CL			
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					

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-11

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
				CLAY mostly clay, few silt, trace to few sand, trace gravel, low to medium plasticity, gray (10YR 5/1), moist, medium stiff to stiff.				
11 CS	85		105					
			110	Change to medium stiff at 110.0 feet.				
12 CS	80		115					
			120		CL			
13 CS	85		125					
			130					
14 CS	90		135					
				SANDY CLAY mostly clay, some fine sand, few silt, dark gray (10YR 4/1), moist.	CL			
			140	**CLAY** mostly clay, few silt, trace to few sand, trace gravel, low to medium plasticity, gray (10YR 5/1), moist, medium stiff.	CL			
				SHALE dark gray.				
15 CS	90		145					
			150	End of boring 150.0 feet below ground surface.				
			155					

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

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-11A

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	5/11/17	5/12/17	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	589.5	591.66	142.0	6

Boring Location:	Personnel	Drilling Equipment:
North of fuel oil tank number 2, between berm and fence.	Logged By - J. Krenz Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) 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		0–10	**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.	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	60		10–20	▼ (17.79)				
3 CS	70		20–30	Change to high plasticity, gray (10YR 5/1), soft at 19.0 feet.				
4 CS	70		30–40					
5 CS	100		40–50					
6 CS	100		50–60					
7			60–					

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

Signature: [signature] Firm: TRC Environmental

Fax

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SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
CS	100			**CLAY** mostly clay, trace fine to medium gravel, high plasticity, gray (10YR 5/1), medium stiff, moist.				
			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		CL			
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					
15 CS	100			**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			
				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

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company Belle River Power Plant	3/1/16	3/1/16	231828.0003

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	588.69	---	150.0	6

Boring Location:	Personnel	Drilling Equipment:
Corner of E connecting road off haul road, E of bottom ash basins. N: 471096.38 E: 13626276.67	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
China Township	St. Clair	MI	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time Depth (ft bgs)

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
				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.	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.
				CLAY mostly clay, trace fine sand, high plasticity, dark gray (10YR 4/1), mottled with brown (10YR 5/3), moist, very stiff.			
1 CS	50		5				
			10	Change to stiff at 10.0 feet.			
				Change to no sand, dark gray (10YR 4/1), very soft at 13.0 feet.			
2 CS	100		15				
			20		CL		
3 CS	100		25				
			30				
4 CS	100		35				
			40				

SOIL BORING WELL CONSTRUCTION LOG 231828.0003.0000.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: M. Powers

SOIL BORING LOG

BORING NO. SB-16-01

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
5 CS	100		45	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
6 ST	100		50				
7 CS	100		55	**CLAY WITH SAND** mostly clay, little fine to coarse sand, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
8 CS	100		60	**CLAY** mostly clay, high plasticity, dark gray (10YR 4/1), moist, very soft.	CL		
			65	**SANDY SILT** mostly silt, little to some fine to coarse sand, few clay, low plasticity, dark gray (10YR 4/1), moist, stiff.	ML		
9 CS	100		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.	CL		
			75				
10 CS	100		80	Change to few coarse gravel at 80.0 feet.			
			85				
11 CS	100		90				
			95				
			100				

SOIL BORING LOG

TRC

BORING NO. SB-16-01

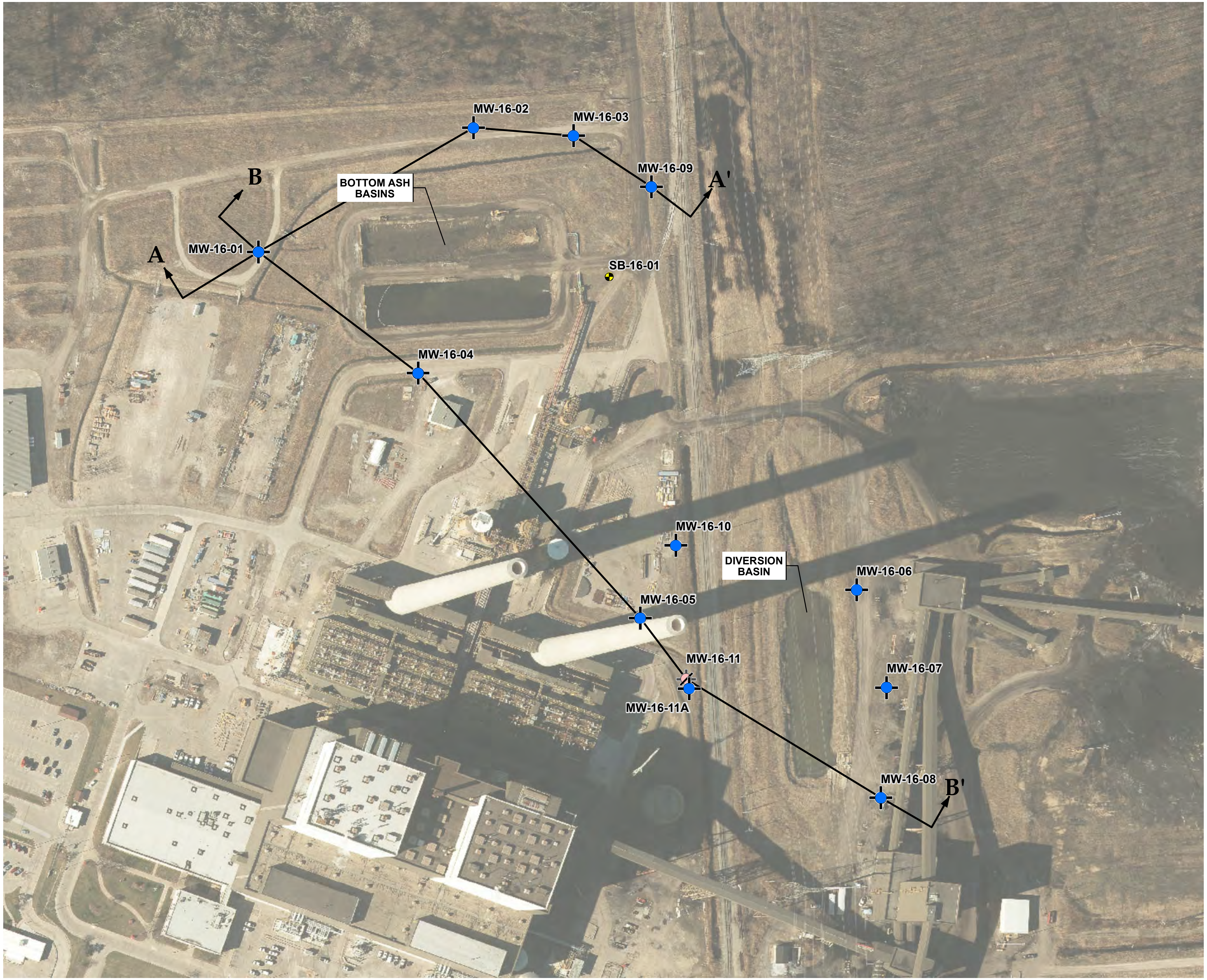
SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	COMMENTS
12 CS	100		105	**CLAY** mostly clay, few coarse gravel, dark gray (10YR 4/1), moist, soft.	CL		
			110				
13 CS	100		115				
			120				
14 CS	100		125				
			130				
15 CS	100		135	**SILT** mostly silt, few fine sand, non plastic, dark gray (10YR 4/1), moist.	ML		
			140				
16 CS	100		145	**SHALE** dark gray (10YR 4/1), dry.			
			150	End of boring at 150.0 feet below ground surface.			
			155				

Appendix B
Cross Sections

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 9/6/2017, 15:16:32 PM by JPAPEZ -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2017_265996\265996-0003-011.mxd



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.

N

0 200 400 Feet

1 " = 200 '
1:2,400

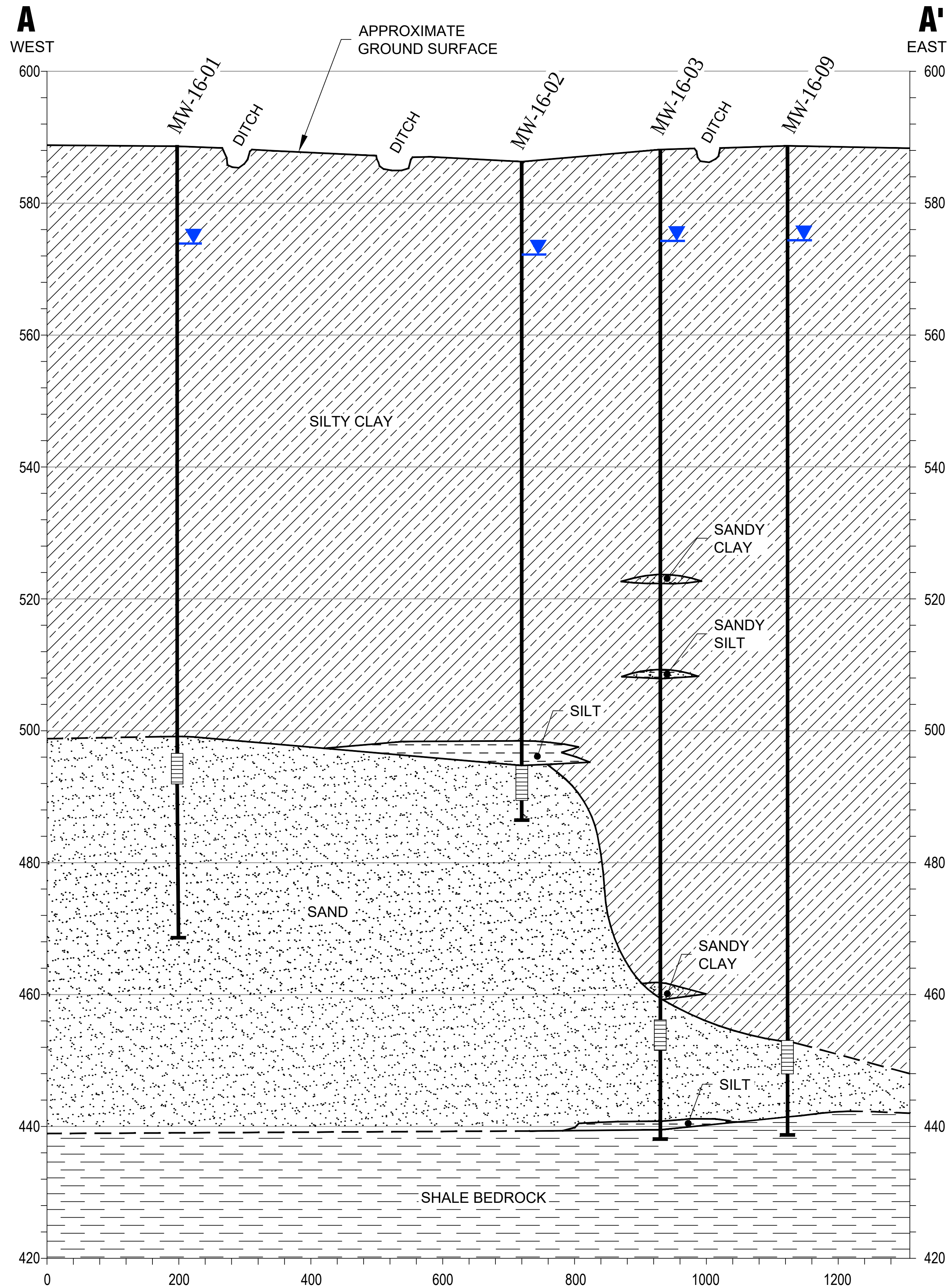
PROJECT:	DTE ELECTRIC COMPANY BELLE RIVER POWER PLANT 4505 KING ROAD CHINA TOWNSHIP, MICHIGAN		
TITLE:	CROSS SECTION LOCATOR MAP		
DRAWN BY:	J. PAPEZ	PROJ NO.:	265996.0003
CHECKED BY:	C SCIESZKA		FIGURE B-1
APPROVED BY:	V BUENING		
DATE:	SEPTEMBER 2017		

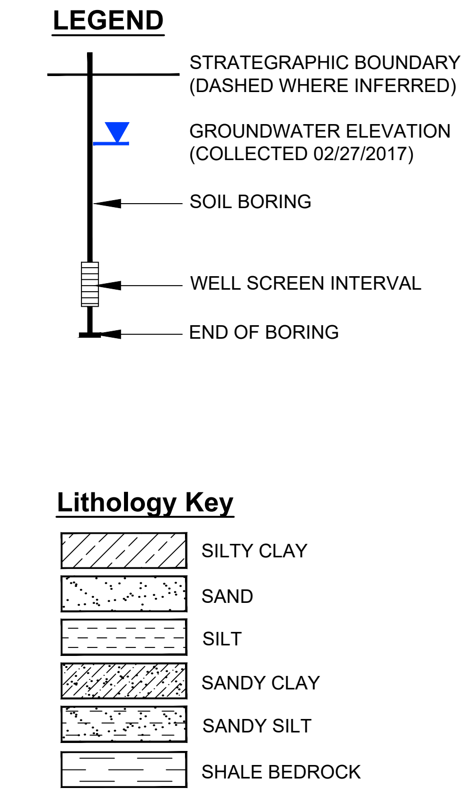
TRC

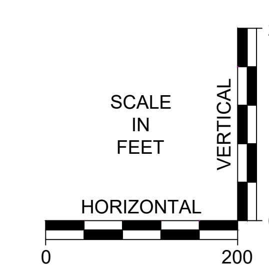
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996-0003-011.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'







PROJECT:
DTE ELECTRIC COMPANY
BELLE RIVER POWER PLANT
CHINA TOWNSHIP, MICHIGAN

TITLE:
GENERALIZED
GEOLOGIC CROSS-SECTION A-A'

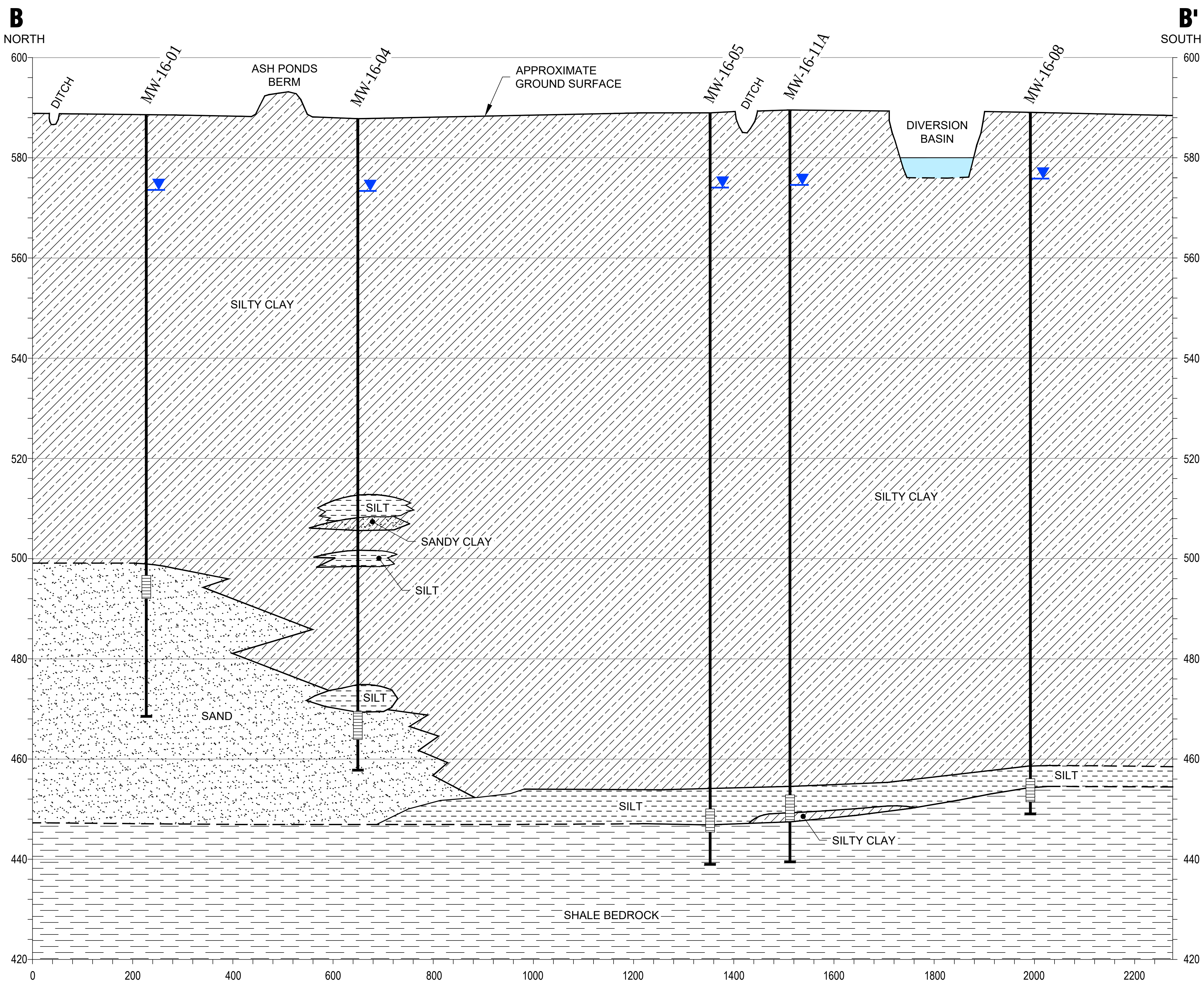
DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0003.01
CHECKED BY:	S.HOLMSTROM	FIGURE B-2	
APPROVED BY:	V.BUENING		
DATE:	SEPTEMBER 2017		

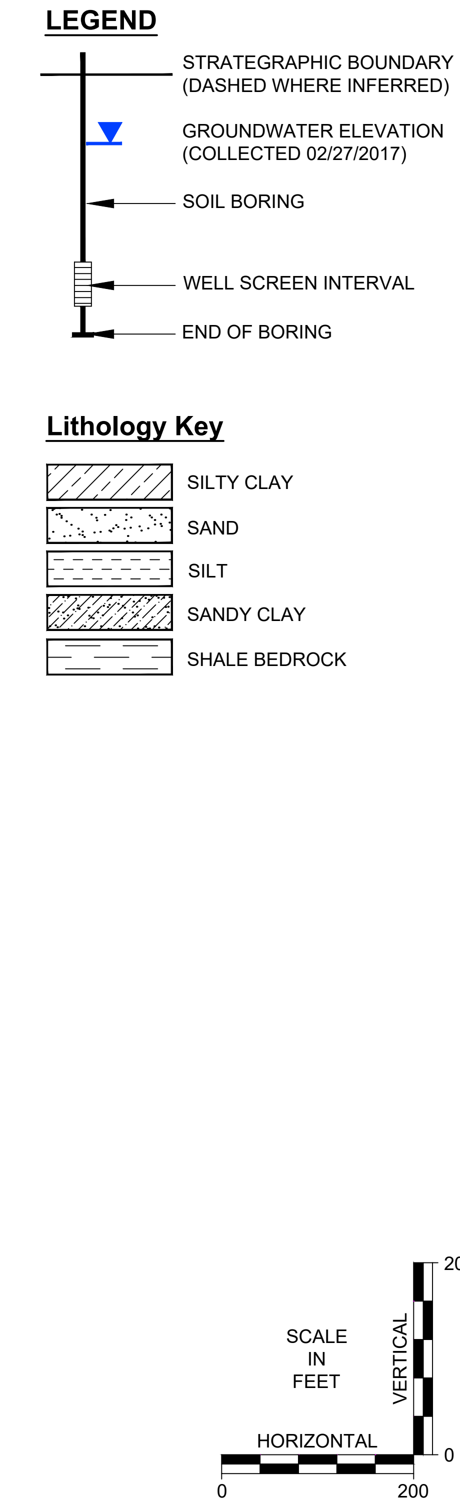
TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0003.01.04-05.dwg

11x17 --- ATTACHED XREF'S: --- 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;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG04 XS AA

GENERALIZED GEOLOGIC CROSS-SECTION B-B'





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		

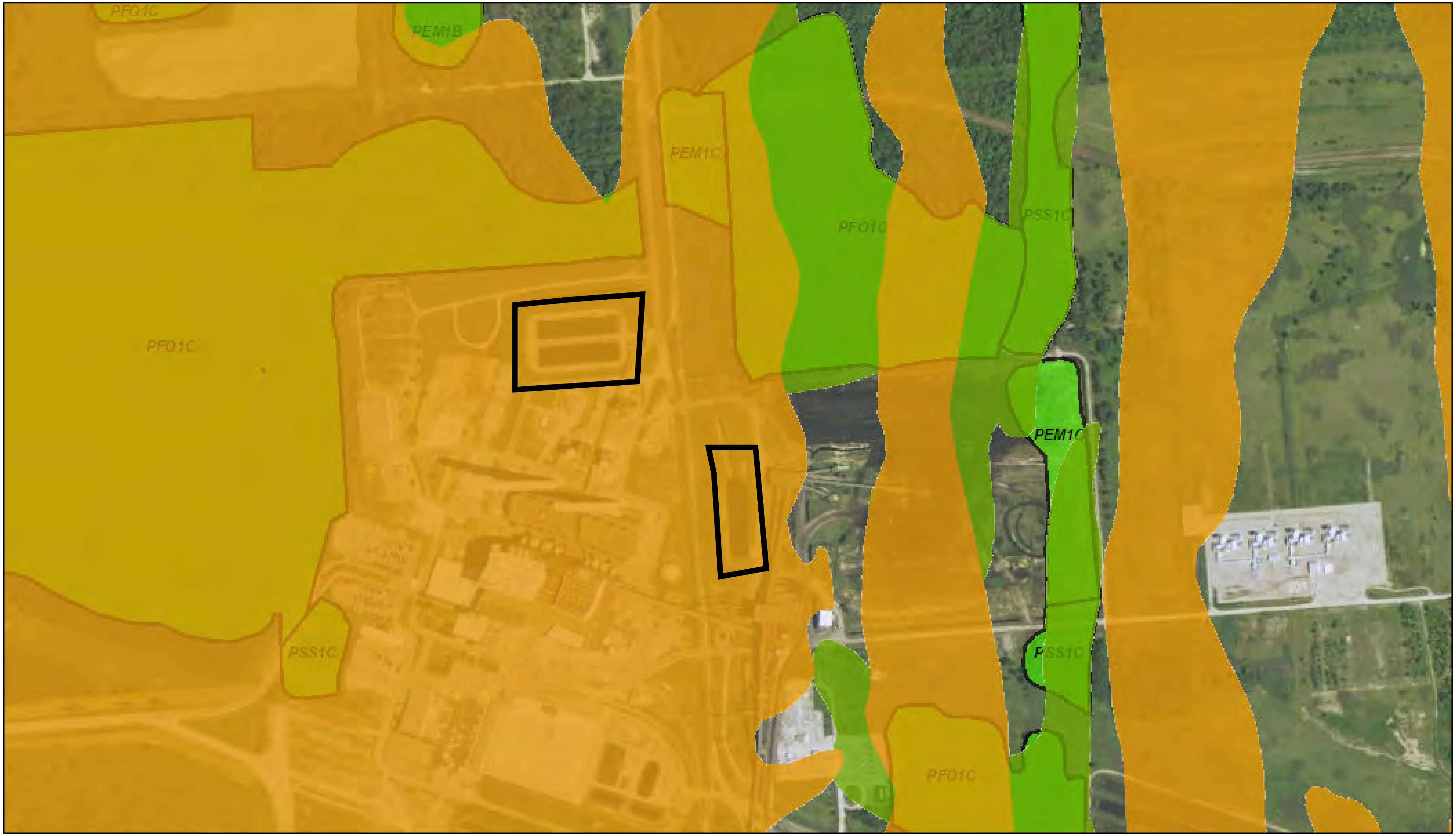
TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 265996.0003.01.04-05.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES: DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_1; DTE BRPP XSs XXXXXXXXXX-02172017092213_Page_2; XS aa wells; XS cc wells; XS DD wells;
DRAWING NAME: J:_TRC\DTE\Belle River PP\265996\0003\265996.0003.01.04-05.dwg --- PLOT DATE: October 10, 2017 - 6:47AM --- LAYOUT: FIG05 XS BB

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
- Gage Stations
- National Wetlands Inventory 2005

1:7,628

0 0.05 0.1 0.2 mi

0 0.1 0.2 0.4 km

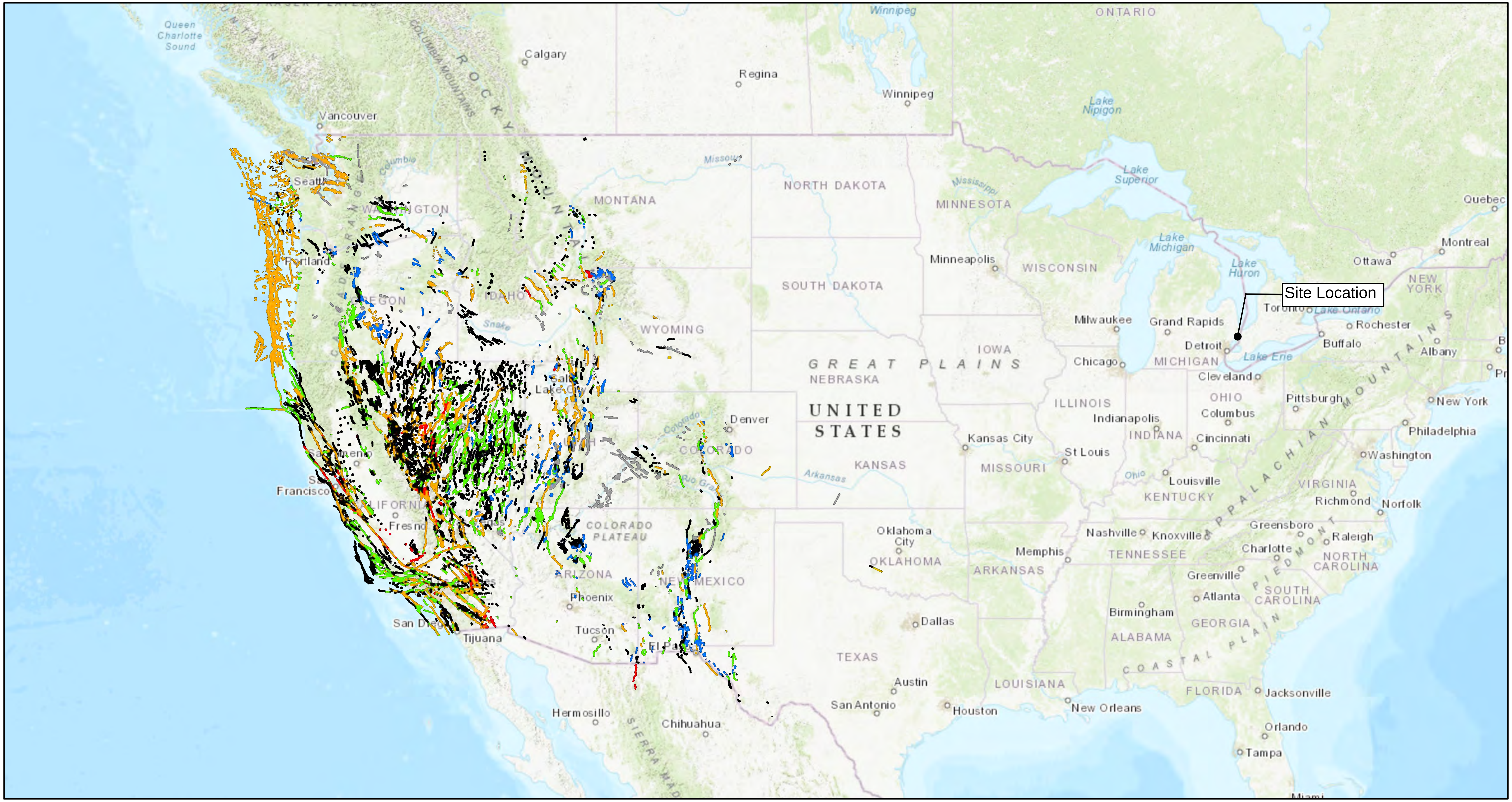
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Disclamer: This map is not intended to be used to determine the specific locations and jurisdictional boundaries of wetland areas subject to regulation. More information regarding this map, including how to obtain a copy can be accessed at www.michigan.gov/wetlands.

Map by: State of Michigan - CSS

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

0 | 175 | 350 | 700 mi
0 | 275 | 550 | 1,100 km

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

Web AppBuilder for ArcGIS
USGS | Esri, FAO, NOAA |

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 BABs - Seismic Impact Zone

Latitude = 42.772°N, Longitude = 82.512°W

Location

Reference Document

2015 NEHRP Provisions

Site Class

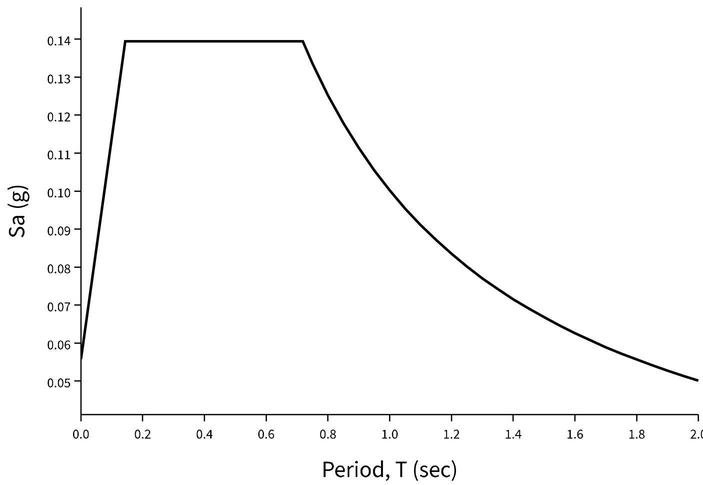
D (default): Stiff Soil

Risk Category

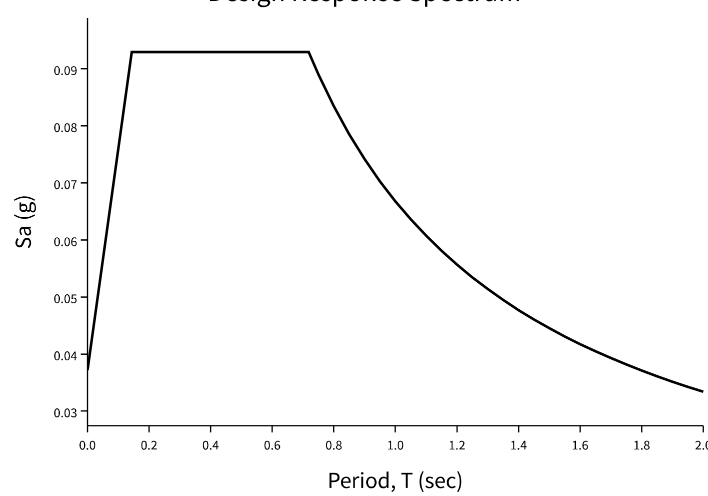
I or II or III

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 maximmum 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	$\overline{v}_S$	$\overline{N}$ or $\overline{N}_{ch}$	$\overline{s}_u$
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: • Plasticity index PI > 20 • Moisture content w ≥ 40%, and • Undrained shear strength $\overline{s}_u$ < 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)

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

Deterministic Ground Motion (0.2 s)

$S_{SD} = 1.500$ g

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

Risk-targeted Ground Motion (1.0 s)

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

Deterministic Ground Motion (1.0 s)

$S_{1D} = 0.600$ g

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

Table 11.4-1: Site Coefficient F_a

Site Class	Spectral Reponse Acceleration Parameter at Short Period					
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S = 1.25$	$S_S \ge 1.50$
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 $S_S \ge 1.0$ 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					
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 = 0.50$	$S_1 \ge 0.60$
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 $S_1 \ge 0.2$ 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)

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

Site-adjusted MCE_R (1.0 s)

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

Design Spectral Acceleration Parameters

Design Ground Motion (0.2 s)

$S_{DS} = ⅔ S_{MS} = ⅔ \times 0.139 = 0.093$ g

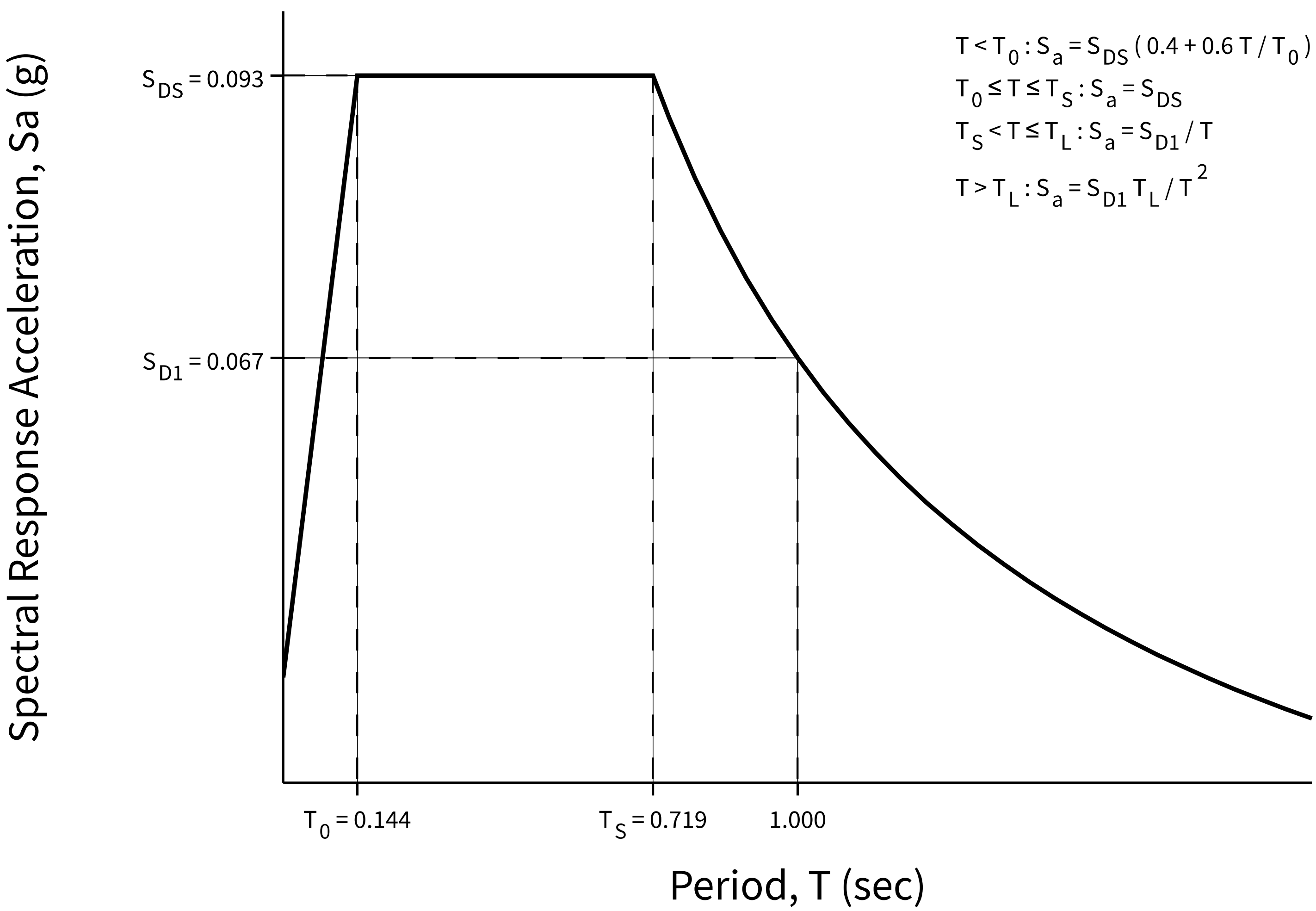
Design Ground Motion (1.0 s)

$S_{D1} = ⅔ S_{M1} = ⅔ \times 0.100 = 0.067$ g

Design Response Spectrum

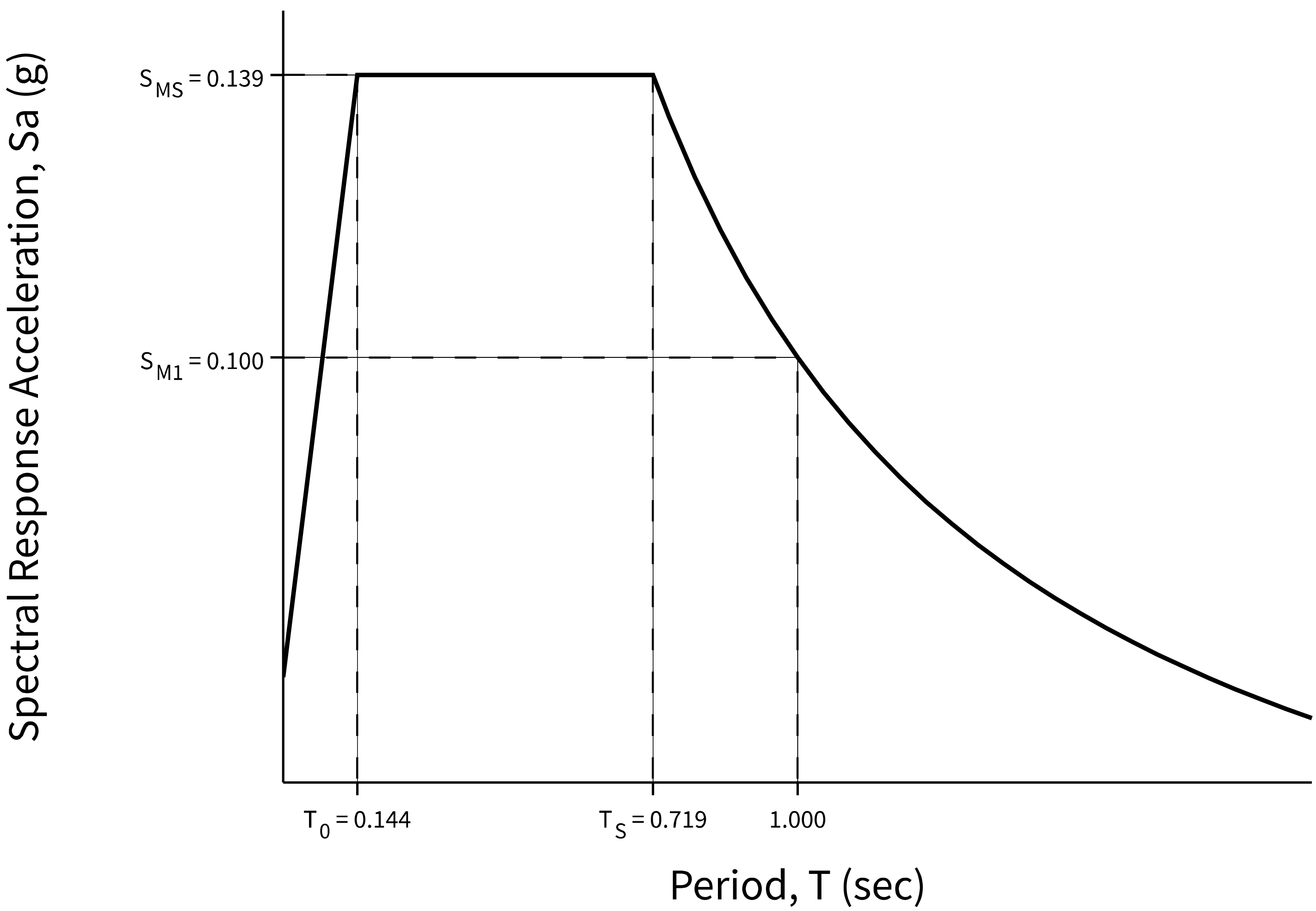
Long-Period Transition Period = T_L = 12 s

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

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

Appendix K
Subsurface Investigation and Foundation Report, Bechtel, 1976

4-G-5-1

SUBSURFACE INVESTIGATION AND FOUNDATION REPORT

THE DETROIT EDISON COMPANY

BELLE RIVER UNITS 1 & 2

JOB 10539

VOLUME 1 OF 2

GEOLOGY AND SOIL PROPERTIES

AUGUST 1976

BECHTEL
ANN ARBOR, MICHIG

SUBSURFACE INVESTIGATION
AND
FOUNDATION REPORT
GEOLOGY AND SOIL PROPERTIES

BELLE RIVER PLANT
UNITS 1 & 2
JOB 10539
THE DETROIT EDISON COMPANY

S. S. Afifi
D. R. Gle
GEOTECHNICAL SERVICES
ANN ARBOR, MI

SUBSURFACE INVESTIGATION
AND
FOUNDATION REPORT
GEOLOGY AND SOIL PROPERTIES

BELLE RIVER PLANT
UNITS 1 & 2
JOB 10539
THE DETROIT EDISON COMPANY

S. S. Afifi
D. R. Gle
GEOTECHNICAL SERVICES
ANN ARBOR, MI

Volume 1 of 2

TABLE OF CONTENTS

APPENDICES

Volume 2 of 2

ABSTRACT

This report presents the results of an extensive subsurface investigation program for the Detroit Edison Company at the Belle River Project site. The proposed project consists of a two-unit coal fired plant and the associated coal handling facilities. The study was directed at evaluation of the geologic and ground water conditions and the development of soil parameters for design and construction of the proposed facilities.

The evaluations presented in this report consist of a review of previous investigations, a literature review, and detailed subsurface investigation and laboratory testing programs. This investigation confirmed the suitability of the site for the proposed facilities and gave the soil mechanics information necessary for planning, design and construction of plant facilities.

PREFACE

This report was prepared by Geotechnical Services in the Ann Arbor Office of Bechtel. The soils sections of this report were prepared by D.R. Gle and the geology sections by J.V. Mrakovich. J.B. Givens also contributed to the soil data evaluations. The Ann Arbor Office review and approval was by S. Mackay and G.T. LeFevre, Engineering Geology Supervisors, and S.S. Afifi, Soils Engineering Supervisor. The San Francisco H & CF review and approval was by M.J. Adair, Chief Geologist, and W.R. Ferris, Chief Soils Engineer. The report was also reviewed by S.L. Blue, Geotechnical Services Manager, H & CF Division, Ann Arbor, Michigan. The report was collated by A.R. Rossmann, Drafting Supervisor, Ann Arbor.

LIST OF TABLES

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NOTATION

$\underline{A}$	Pore pressure parameter (Skempton)
C_c	Compression index
C_r	Swelling index
C_v	Coefficient of consolidation
c	Cohesion intercept for total stresses from Mohr-Coulomb Relationship
c'	Cohesion intercept for effective stresses from Mohr-Coulomb Relationship
$\overline{CU}$	Consolidated-undrained triaxial compression test with pore pressure measurement
D_{50}	Grain size analysis: diameter at which 50% of the sample is finer
E	Young's modulus of elasticity as determined from the initial tangent modulus of the stress-strain curve
e_o	Initial void ratio
k	Permeability
ksf	Kips per square foot
LL	Liquid limit
PI	Plasticity index (LL-PL)
P_c	Preconsolidation pressure
PL	Plastic limit
$\bar{p}$	Effective vertical pressure
P_o	In-situ effective overburden pressure
p	Stress point, $(\sigma_1 + \sigma_3)/2$
p'	Stress point, $(\bar{\sigma}_1 + \bar{\sigma}_3)/2$

pcf	Pounds per cubic foot
psf	Pounds per square foot
q	Stress point, $(\sigma_1 - \sigma_3)/2$
Qu	Unconfined compression test
S	Shear strength
SPT	Standard penetration test (ASTM D 1586)
S_u	Undrained shear strength
UU	Unconsolidated-undrained triaxial compression test
W_o	Initial moisture content
W_f	Moisture content after consolidation ($\overline{CU}$ test)
γ_d	Dry density
γ_t	Total density
γ_{tf}	Total density after consolidation ($\overline{CU}$ test)
ε	Axial strain
σ	Total normal stress on failure plane at failure
σ'	Effective normal stress on failure plane at failure
σ_o	Confining pressure (unconsolidated-undrained triaxial test)
$\bar{\sigma}_3$	Effective confining pressure (consolidated-undrained triaxial test)
ϕ	Angle of internal friction for total stresses
ϕ'	Angle of internal friction for effective stresses
τ	Drained shear strength

1.0 INTRODUCTION

The Detroit Edison Company's proposed Belle River Project consists of a two-unit coal fired power plant and the associated coal handling facilities. The project site is located in St. Clair County, Michigan, between the cities of St. Clair and Marine City. Figure 1 shows the state of Michigan with the site location indicated. This site is just west of the existing Detroit Edison Company St. Clair Power Plant. A general site plan showing all of the existing and proposed facilities is shown in Figure 2.

The coal handling facilities will include a docking facility, transfer houses, radial stackers, underground coal reclaimers and a conveyor system, along with both primary and secondary coal storage areas. The proposed power block will consist of two boiler buildings, two turbine buildings, four precipitators, a smoke stack, service building, administration building, warehouse, and miscellaneous other tanks and treatment basins. Other facilities away from the power block include a switchyard and intake and discharge structures.

The project facilities are superimposed on the boring location plan and are shown in Figure 3. The area proposed for fly ash disposal (Figure 4) has also been considered in the evaluations.

Volume 1 of this report contains the final results of the geological evaluations, laboratory soil testing, soil properties evaluations, and the development of the soil engineering parameters to be used for the entire Belle River 1 & 2 Project area. The results of previous investigations supplied by The Detroit Edison Company are given in Appendix A. Bechtel soil/rock borings are presented in Appendix B, along with a tabulated summary and a key to the notation used on the boring logs.

Volume 2 contains Appendices C and D which include all of the laboratory test results. Appendix C contains the results of laboratory tests performed by Goldberg-Zoino and Associates while Appendix D contains the results of laboratory tests conducted by U. W. Stoll and Associates.

The engineering design criteria for the various portions of this project will not be addressed in this report. Design criteria will be addressed upon reactivation of the project when more details are known about the proposed facilities and the final location of structures.

2.0 SCOPE OF WORK

The purpose of the subsurface investigation and laboratory testing program was to evaluate the soil, rock, and ground water conditions at the site in order to provide sufficient information for planning, design, and construction of the various plant facilities. Upon reactivation of this project, foundation systems and parameters for the various foundation design, construction, and soil structure interaction schemes will be developed based on this information.

This report is based on a review of previous investigations, geologic research, ground water studies, soil and rock drilling and sampling, and a laboratory testing program.

3.0 SUBSURFACE EXPLORATION

3.1 PREVIOUS EXPLORATION FOR THE EXISTING ST. CLAIR PLANT

Borings were made for various structures and facilities of the St. Clair power plant during 1950, 1959, and 1965. These are contained in a report prepared under the direction of W. S. Housel and the University of Michigan's Office of Research Administration, Soil Mechanics Laboratory for the addition to St. Clair Unit No. 7. The 1950 borings were generally in the area of the main plant while the 1959 and 1965 borings were made for the dock area and yard conveyor, respectively.

Included in the Housel report are the individual boring log profiles of borings made during 1965 and composite subsoil analysis profiles extending to bedrock. It also contains information on comparisons with borings made in the same area during 1950 and 1959. Through 1965, a total of 28 borings were drilled east of M-29 along the shore of the St. Clair River and within the St. Clair plant area. Seven borings were drilled west of M-29 along the yard conveyor. The Housel report and other borings in the area made available to Bechtel are included in Appendix A of this volume.

3.2 EXPLORATION FOR THE PROPOSED BELLE RIVER PROJECT

3.2.1 General

The existing docking facility was rebuilt to accommodate larger ships approximately 105 feet wide and 1000 feet long having a draft of about 27.5 feet. The existing conveyor system serving the present St. Clair units will remain in place. A new conveyor system will begin at the docking facility and parallel the existing system to Highway M-29, where it will bridge across M-29 and bisect the new primary coal storage area.

From the primary coal storage area, the conveyor system crosses over the Detroit and Port Huron Railroad tracks and turns northward towards the main plant area and the secondary coal storage pile. The conveyor will then split, with one conveyor going west into the main plant and the other going east, over the railroad tracks, to the secondary coal storage area. Also located along the conveyor system are various transfer houses and stacker-reclaimers as shown in Figures 2, 3 and 4.

The primary coal storage area is separated into three storage locations covering an area of approximately 75 acres. There are two main dead storage piles to the north and south sides of the conveyor, and a smaller live storage pile between the conveyor and the south dead coal storage. An approximate capacity of 2.5 million tons of coal can be stored at these locations.

The secondary coal storage area will consist of a single coal pile located just east of the main plant. This pile will cover an area of approximately 20 acres, and will have a total dead storage capacity of approximately one million tons.

In addition, there will be a large fly ash disposal area to the northwest of the main plant. In general, this area is bounded by the existing Remer Road, King Road, the Detroit and Port Huron Railroad, and a line about one-half mile north of and parallel to Puttygut Road.

3.2.2 Details of Exploration

The subsurface exploration program and foundation evaluation were developed by Bechtel. The drilling, which was done by Raymond International, began in November 1973 and ended in August 1975. Bechtel soil engineer(s) and Bechtel engineering geologist(s) supervised field operations and recorded field logs of the drilling, sampling, and field testing of the foundation materials. Logs of all borings were prepared by Bechtel and are included in Appendix B.

In the docking area, ten 5-inch diameter exploratory borings were drilled and sampled to bedrock. In addition, 74 other rotary wash borings were drilled along the conveyor system, the coal storage areas, and the main plant area. A total of 36 borings were drilled in the fly ash disposal area northwest of the main plant. These borings were located on approximately a 1,000 foot grid and extended to depths of from 70 to 140 feet. Undisturbed samples were obtained in selected borings while split spoon samples were obtained in all of the remaining borings to verify the subsurface materials and consistency.

Throughout this investigation, undisturbed samples were generally taken at 10-foot intervals with standard 3-inch O. D. Shelby tubes. From a depth of approximately 15 to 70 feet, some difficulty was encountered in retaining the very soft clayey soils in the standard Shelby tube, and the Osterberg Sampler was used to recover samples within this depth. Generally, this sampler enabled adequate recovery.

Material in each undisturbed sample was visually classified by the Bechtel field engineer. The tubes were then sealed with a double layer of wax, labeled, and selected tubes were shipped to the laboratory.

Drive samples were obtained at the alternate 10-foot intervals between undisturbed samples using a standard split spoon sampler. This procedure (ASTM D 1586) utilizes a 140-pound hammer falling 30 inches to drive a 1-3/8 inch I.D. split spoon sampler 18 inches. Blows required to advance the sampler through each six inches were recorded. The standard penetration test (SPT) blowcount is the number of blows for the last foot the sampler is driven. Standard penetration test blowcounts are given on the boring logs. In the exceptionally hard materials found at depths of approximately 130 to 135 feet, refusal was considered to have been attained when 100 blows were delivered for any six inch driving increment.

Material recovered in the split spoon sampler was visually classified by the engineer, and a portion of the sample was then stored in a glass jar. Selected jar samples were sent to the testing laboratory for classification.

Classifications made in the field were compared with the laboratory classification during proofreading of each field log and the appropriate corrections were then made on the final boring log. The unified soil classification for each sample is as shown on the boring logs given in Appendix B.

Rock cores were obtained in areas where the foundation system has a possibility of bearing on bedrock. Specified holes were cored a minimum of 20 feet into rock to assure positive penetration through the overburden and to obtain samples to evaluate the competency of the rock.

Cores were placed in partitioned core boxes (each holding about 15 feet of core), classified, and stored at the site. Bechtel geologists prepared logs of the rock core portions of each hole.

At the completion of the investigation, the remaining sample jars, Shelby tube samples, and rock core samples were stored at the St. Clair Power Plant.

4.0 SITE CONDITIONS

This section addresses the geology and generalized subsurface soil conditions for this site. The geological studies were based on a literature review, evaluation of site boring logs, and ground water measurements. The soil conditions were developed from an evaluation of the boring logs and laboratory soil tests, along with geologic and ground water evidence and also a review of previous investigations.

4.1 GEOLOGY

4.1.1 Regional Geology

The site is located in the Lower Peninsula of Michigan on the southeastern margin of the Michigan Basin (Figure 5). This basin is a broad, shallow, tectonic structure approximately 300 miles in diameter and containing up to 14,000 feet of Paleozoic sediments in its central portion near Mount Pleasant. Thickening of strata toward the center of the basin indicates that the Lower Peninsula was a region of slow subsidence with almost continuous deposition throughout the Paleozoic. A large part of basin development occurred during Silurian, Middle and Upper Devonian time when about two-thirds of the total Paleozoic sequence was deposited. Subsidence apparently ceased at the close of Jurassic time, about 135 million years ago, since no rocks of younger age are known to exist in the region.

During the Pleistocene, continental glaciers advanced and retreated across the region many times, modifying the bedrock topography and covering it with glacial drift, which now comprises almost all natural topographic features at the site and in the Lower Peninsula.

Faulting is not common to the region, and no known faults occur near the site. The nearest mapped faulting occurs in the area of the Chatham Sag in eastern Ontario, about 15 miles southeast of the site; however, it is considered inactive (Ref 1).

The Lower Peninsula of Michigan is an area of low seismic activity where only six earthquakes have been recorded in historic time. None of these earthquakes can be related to mapped faults or tectonic structures in the Michigan Basin. According to the seismic risk map of the U.S. (Ref 2), the site is located in Zone 1 which corresponds to Intensities V and VI (Modified Mercalli Scale of 1931), where only minor damage should be expected.

4.1.2 Site Geology

The site is located in St. Clair County, Michigan, 3.5 miles south of the city of St. Clair on an intermorainal glacial lake plain (Figure 6) whose ground surface varies little above or below 587 feet in elevation.

These glacial lake deposits vary in thickness from 125 to 170 feet within the explored area of the site where they overlie an irregular bedrock surface (Figure 7). The underlying bedrock consists of about 4,600 feet of Paleozoic sedimentary rocks whose uppermost unit is the Bedford Shale formation of Mississippian-Devonian Age. The Paleozoic rocks are underlain by metamorphic, igneous, and sedimentary rock of Precambrian Age (Ref 3).

Overburden materials consist primarily of unconsolidated gray to brown, soft to stiff silt and silty clays with scattered fine sand lenses. Figure 8 shows overburden thickness contours throughout the site area and the cross sections of Figure 9, A through N, show local detailed descriptions of site material.

The most prominent feature of the bedrock topography is a generally north-south trending erosional channel in the vicinity of the proposed plant. Subsurface profiles (Figure 9, A through N), normal to and along the trend of the channel, show an associated sand deposit whose known maximum thickness is about 60 feet. Generally, the sand appears to be in contact with the bedrock surface and thins rapidly, or becomes absent, away from the channel. As evidenced by the drill hole logs, the sand occurs sporadically elsewhere across the site. Sand thickness and top of sand contour maps (Figures 10 and 11, respectively), as well as the cross sections in Figure 9, A through N, show that the location of these sand deposits is controlled mainly by the bedrock surface. The deposits generally fill low areas on this bedrock surface, suggesting the basal sand is glaciofluvial outwash in origin and represents some of the first material deposited on bedrock by meltwaters from nearby glaciers.

Except for the basal glaciofluvial sand, all other glacial material underlying the site appears to be glaciolacustrine silty clays and silts with local sand lenses.

Bedrock at the site is the Bedford Shale formation of Mississippian-Devonian Age. The rock, cored to a maximum depth of 50 feet, consists of light to dark gray shale varying from soft to firm. The soft shale in the upper bedrock sequence is generally weathered and highly fractured. The firm shale below is occasionally fractured, but local vein quartz infilling has strengthened the rock by acting as a cementing agent. The estimated top of firm rock (base of the weathered portion) is shown on the subsurface profiles (Figure 9, A through N).

Rock stratigraphy below a depth of 50 feet to the top of the Niagara group was interpreted from logs of five abandoned wildcat oil and gas wells located on the site (Figure 12). The remainder of the Paleozoic interval was interpolated from nearby stratigraphic cross sections (Ref 4) and the Michigan Geological Survey Annual Statistical Summary No. 18, Michigan's Oil and Gas Fields, 1972 (Ref 5). This rock stratigraphy is summarized in the geologic column in Figure 13.

4.1.3 Ground Water

The site is underlain by relatively impermeable glaciolacustrine, silty clays and silts ranging in thickness from 125 to 170 feet with local lenses of glaciofluvial sands. These sand lenses are moderately permeable but are too small to store or transmit much water. Beneath portions of the site, a basal, glaciofluvial, compact sand and silty sand is encountered immediately above the bedrock surface. These sands attain a known maximum thickness of about 60 feet in the vicinity of the proposed plant structures. Water losses, occurring in these basal sands during the site exploration drilling program, indicate they are relatively permeable. Locally, throughout the region surrounding the site, these sands yield enough ground water for domestic and farm use (Ref 6).

A zone of highly fractured shale, between the top of rock and the top of firm rock is moderately permeable. The highly fractured shale ranges in thickness from zero feet to over 45 feet in rock cores, and is indicated on subsurface profiles in Figure 9, A through N. The permeable shale zone and the basal glaciofluvial sands probably act as a single aquifer where they are in direct contact with each other.

Yields from most wells in the area, placed either in glacial deposits or in bedrock, are less than ten gallons per minute. Ground water development is primarily for domestic and farm use. Municipal and industrial water is principally obtained from surface water bodies.

Ground water levels at the site were measured from four observation wells installed during the site exploration program. Hydrographs displaying water level elevations in the four observation wells, with respect to time, are shown in Figure 14. The initial slopes of the hydrographs indicate the time required for water levels in the observation wells to reach a hydrostatic level.

The water level of Observation Well 181, set at Elevation 449.8 near the highly fractured shale bedrock, stabilized 24 hours after installation; whereas, water levels of Observation Wells 7 and 24, set in glaciolacustrine silts at Elevations 450.5 and 452.3 respectively, required several months to stabilize, indicating they are essentially impermeable. The water level of Observation Well 40, placed in a glaciolacustrine silty clay with some sand and gravel, at Elevation 509.1, stabilized in three weeks, also indicating very low permeability.

Ground water contours of the probable water surface beneath the site are shown in Figure 15. Water level data spanning several years, obtained from the Michigan State Geological Survey, was used in constructing the ground water contours.

This data was used in conjunction with water level readings obtained in June 1974 from observation wells on the site.

Elevation of the ground water varies by about ten feet in the site area, generally increasing toward the St. Clair River. Water movement beneath the site appears to be westward away from the St. Clair River which is probably a recharge area. Approximate ground water levels are also shown on the subsurface profiles (Figure 9, A through N).

Depth to ground water on the site varies from 5 to 15 feet. Seepage of ground water into pits excavated below the zone of water saturation will probably be slow due to the very low permeability of the silty clays and silts that underlie the site. Pits excavated to a depth of 30 to 40 feet for the purpose of fly ash disposal were observed to contain no water from ground water seepage when left open for several days. The low permeability of the glaciolacustrine deposits is also indicated by the slow response of water levels in observation wells placed in either silty clays or silts. In cases where local sand or gravel lenses are encountered during excavations, ground water seepage may be substantial. However, a sump pumping system should be sufficient to control ground water seepage from sand and gravel lenses, since these are generally small in size and cannot store much water. When predrilling for piles, water losses may be experienced when drilling through the basal glaciofluvial sand layer.

According to a southeastern Michigan water resources study (Ref 6), ground water from the glacial deposits is of the sodium bicarbonate type. In general, sodium and chloride concentration increase with depth. Water hardness ranges in concentration from 68.4 to 342.0 parts per million calcium carbonate, and iron ranges in concentration from 0.5 to 1.0 parts per million. Water from wells in bedrock varies in chemical composition, usually containing large amounts of calcium, bicarbonate, sulfate, and sodium chloride.

Knutilla's report (Ref 6) also indicates small to moderate supplies of fresh water are available from the highly fractured shale zone, but nearly all water is too highly mineralized for most uses. In general, mineralization of water increases with depth, whether in glacial deposits or bedrock.

4.1.4 Effects of Man's Activities

4.1.4.1 Presence of Oil and Gas

There are no active producing oil or gas fields in the immediate site area. Ten exploratory wells have been drilled on the site to an average depth of 2,500 feet. All wells were nonproductive except for two oil and gas producing wells located in the northwest corner of the site. These wells, producing from Niagaran reef formations, were abandoned in 1970.

Several oil and gas fields associated with reef structures have been developed in St. Clair County. The size of these fields averages 570 acres and oil production rates in 1971 were about 25 gallons per acre per day. All oil and gas fields surrounding the site appear to be fully developed and no further expansion is expected. Present oil and gas extraction are not expected to present problems to the plant structures. Figure 12 shows the locations of oil and gas wells on the site and in the site vicinity.

Isolated pockets of trapped gas occur in the overburden underlying the site. Gas was encountered in seven exploration borings (Table 1). No odor was detected in any of these borings, and in all cases, the gas dissipated after 48 hours. Safety measures for determining the existence of and handling the gas should, however, be included in all earthwork and foundation contracts. No unusual design or construction problems due to the presence of gas are expected.

4.1.4.2 Salt Solution Mining

Thick salt deposits occur in two geologic horizons in Michigan: the Devonian Detroit River group and the Silurian Salina group. Salt beds in the Detroit River group are restricted to the northern half of the Lower Peninsula and do not underlie the site area. However, salt beds in the Salina group have a large areal extent covering the central three-fourths of the Lower Peninsula and occur beneath the site.

Salt solution mining from the Salina group by the Diamond Crystal Salt Company, located approximately one mile north of the site boundary, has been in progress for a number of years. The Salina group underlying the site contains five salt units interbedded with dolomitic shale, limestone, and anhydrite. The aggregate thickness of the salt is about 750 feet with the uppermost and lowermost units occurring, respectively, at depths of approximately 1,400 and 2,500 feet below the site.

The potential for surface subsidence due to the collapse of solution cavities was evaluated from criteria used by the U.S. Bureau of Mines (Ref 7). A potential area of subsidence can be obtained by drawing a cone with sides at a 45° angle upward from the cavity. Surface subsidence due to that cavity will be within the area encircled by the cone's intersection with the ground surface.

A cavity at a depth of 2,500 feet will have a potential area of surface subsidence extending outward 2,500 feet from the cavity's edge. At the present location of the Diamond Crystal Salt Company's operations, surface subsidence due to a salt cavity at a depth of 2,500 feet is not expected within the site. It should be emphasized that further solution mining should not be permitted to develop cavities closer than 2,500 feet (horizontally) from any plant structures.

4.2 SUBSURFACE SOIL CONDITIONS

4.2.1. General

The soil profile at this site may be divided into three major strata. These divisions were based upon field observations combined with results of all laboratory testing. These strata have been designated as the upper, middle, and lower strata and refer to depths of 0 to 20 feet, 20 to 50 feet, and below 50 feet, respectively. Except for the dock, secondary coal storage area, and fly ash disposal areas, the entire site has a surface elevation of about Elevation 586, generally ranging from Elevation 585 to Elevation 590. The dock area is lower at Elevation 580 to Elevation 582, while the secondary coal storage area and fly ash disposal area are higher at approximately Elevation 590 and 600 respectively. Therefore, the depths of the different strata are approximate and are expected to vary within 5 to 15 feet throughout the entire project site. For any particular location, the boring logs should be consulted to associate the soil properties with a particular stratum. Generalized ground surface contours are shown in Figure 16.

Selected subsurface profiles throughout the entire site are shown in Figure 9, A through N. The distribution of standard penetration blowcount with depth for various areas is shown in Figure 17.

4.2.2 Upper Stratum (0-20 Feet)

The upper stratum consists primarily of mottled brown and gray, stiff to very stiff, clays (Classification CL-CH) with traces of fine sand and pebbles. Standard penetration blowcounts increased from approximately 5 to 15 at the ground surface to a range of from 10 to 40 at a depth of 10 feet (Figure 17). Below this depth, the blowcounts decreased to a range of from 3 to 12 at a depth of approximately 20 feet. Below 20 feet, there is an observable change in the color and consistency of the clay; therefore, a depth of 20 feet is considered the bottom of the upper stratum at this site.

Laboratory consolidation testing has shown this stratum to be overconsolidated. This preconsolidation was also confirmed by the results of consolidated-undrained triaxial testing, the empirical Skempton relationship as used to determine preconsolidation pressure based on the undrained shear strength of the soil and the liquid limit (Ref 8), and also a comparison of the natural moisture content with the

Atterberg limits. It is believed that this stratum was preconsolidated by desiccation based on undrained shear strength behavior and other geologic evidence. The estimated preconsolidation pressure ranges between 4,000 to 9,000 psf. This corresponds to an overconsolidation ratio between 4 and 8.

4.2.3 <u>Middle Stratum (20 to 50 Feet)</u>

Below the upper stratum, there is a very soft to soft gray silty clay (Classification CL) which extends from approximately 20 feet below the ground surface to 50 feet below the ground surface. However, this stratum was encountered as close as 11 feet from the ground surface in the dock area.

Standard penetration blowcounts in this stratum ranged between fairly close limits. In all areas except the docking facility, blowcounts ranged from 2 to 7 blows per foot. Generally, the higher blowcounts were noted at the top and bottom of the stratum and decreased in the center. At the docking facility, the average blowcounts remained constant at about 2 blows per foot throughout the entire depth, and the higher blowcounts remained constant at an average of 15 blows per foot. Although blowcounts at the docking facility were somewhat lower than other locations, laboratory engineering properties were not significantly different.

Consolidation tests and other empirical evaluations show this stratum to be slightly overconsolidated, with preconsolidation pressures ranging between 3,500 to 4,500 psf. This corresponds to an overconsolidation ratio between 1.3 and 2.0.

4.2.4 Lower Stratum (Below 50 Feet)

This stratum consists primarily of a firm gray plastic silty clay Classification (CL). However, some fine sand seams and silty clays with an appreciable amount of sand (as much as 40%) were encountered at varicus depths as shown in the subsurface profiles (Figure 9, A through N). Significant sand deposits were also found beneath the main plant area as noted in Section 4.1.2.

Blowcounts in this stratum varied depending on the amount of sand present. Typical standard penetration blowcounts ranged from 2 to 7 blows per foot at a depth of 50 feet, to 10 to 25 blows per foot at a depth of 70 feet. Below the 70 foot depth, the standard penetration blowcount in the clay soils increased to an average of approximately 20 blows per foot at a depth of 125 feet (range of 5 to 40). Below this depth, the blowcounts in all areas increased until bedrock was encountered at depths of 125 to 145 feet. Within this depth range, clays with high sand content, sand deposits, hardpan, or combinations were encountered above the bedrock. Standard penetration blowcounts in the sandy zones above the bedrock are quite variable, although the average was found to be 40 to 50 blows per foot.

Except where a significant amount of sand was present, this stratum can be subdivided into three layers based on the degree of overconsolidation. These layers are from 50 to 70 feet (transition zone between upper and middle strata), 70 to 90 feet and below 90 feet, respectively.

4.2.4.1 Layer From 50 to 70 Feet (Transition Zone)

The first of these layers is designated as the transition zone and ranges from 50 to 70 feet deep. According to Skempton's statistical relationship and the natural moisture content and plasticity ranges, the soils within this layer are slightly overconsolidated. The Skempton empirical procedure was used to evaluate the preconsolidation pressure because of the lack of a sufficient number of consolidation tests for this layer. The estimated preconsolidation pressure for this layer ranges between 4,000 to 8,000 psf. This corresponds to an overconsolidation ratio between 1.0 and 1.6.

4.2.4.2 Layer From 70 to 90 Feet

Based on consolidation tests and the same Skempton relationship, the soils within the depth range of 70 to 90 feet are considered slightly overconsolidated but to a greater degree than the transition zone. Apparently, the normal geological process of deposition of the clay was interrupted at this depth. Since the soil appears to be virtually the same type as that below it, this increased overconsolidation must be due to either additional deposition above 70 feet and then erosion to the 70-foot depth, or desiccation as was noted in the upper layer, followed by deposition to its present elevation. The undrained shear strengths have the general tendency to decrease very slightly with depth below 70 feet, thus the apparent overconsolidation is likely due to desiccation. The estimated preconsolidation pressure for this layer ranges between 6,000 and 9,000 psf. This corresponds to an overconsolidation ratio between 1.0 and 2.4.

4.2.4.3 Layer Below 90 Feet

The soil properties below 90 feet are very similar to those immediately above, except for the degree of overconsolidation and undrained shear strength. Consolidation test results and evaluation of the moisture content versus Atterberg limits show these soils to be very slightly overconsolidated to normally consolidated. The estimated preconsolidation pressure for this strata ranges between 6,000 and 9,000 psf. This ccrresponds to an overconsolidation ratio between 1.0 and 1.2.

5.0 LABORATORY SOIL TESTING

5.1 INTRODUCTION

The laboratory testing program consisted of the classification and engineering properties tests listed below and further described in this Section. The testing program was developed by Bechtel and conducted by Goldberg-Zoino and Associates and U. W. Stoll and Associates under the direction of Bechtel.

a) Visual and Laboratory Classification

b) Moisture Content and Dry Unit Weight

c) Atterberg Limits

d) Specific Gravity

e) Mechanical Analysis

f) Unconfined Compression Test (Qu)

g) Laboratory Vane Shear Test

h) Unconsolidated-Undrained Triaxial Compression Test (UU)

i) Consolidated-Undrained Triaxial Compression Test With Pore Pressure Measurement ($\overline{CU}$)

j) Consolidation Test

k) Permeability Test

l) Compaction Test

The majority of testing was carried out by Goldberg-Zoino and Associates of Newton Upper Falls, Massachusetts, from January 1974 through January 1975. Additional tests were made by U. W. Stoll & Associates of Ann Arbor, Michigan, during the summer of 1975. This was to provide more detailed information for the coal reclaim hopper south of Transfer House 5 (Figure 2).

The test data are presented in Appendix C of Volume 2 in the form of tables and figures. Selected properties such as dry density, moisture content, Atterberg limits, and soil cohesion from unconfined compression, unconsolidated-undrained triaxial testing and vane shear tests have also been included on the boring logs presented in Appendix B. Interpretation of test data and development of soil properties for design are presented in Section 6.

5.2 CLASSIFICATION TESTS

Visual classification was in accordance with ASTM D 2488, and laboratory classification was in accordance with ASTM D 2487.

5.2.1 Moisture Content and Dry Unit Weight

Moisture content and dry unit weight were determined for all undisturbed soil samples selected for any type of testing, along with the moisture contents for other selected split spoon samples. Determination of moisture content was made in accordance with ASTM D 2216 and the unit weight was determined by direct measurement.

5.2.2 Atterberg Limits

Atterberg limits determinations were made in accordance with ASTM D 423 (liquid limit) and ASTM D 424 (plastic limit) on all samples selected for unconfined and triaxial shear testing, consolidation testing, and on other selected plastic soils.

5.2.3 Specific Gravity

Specific gravity tests were made on all samples subjected to consolidation testing, as well as on other selected samples, in accordance with ASTM D 854.

5.2.4 Mechanical Analysis

Mechanical and hydrometer analysis determinations were made in accordance with ASTM D 422 on selected samples.

5.3 ENGINEERING PROPERTIES TESTS

5.3.1 Unconfined Compression Tests

Unconfined compression tests were performed on representative samples of all strata to evaluate the in situ shear strength. The tests were also performed on remolded samples to evaluate the soil sensitivity and the available shear strength under remolded conditions. All tests were performed in accordance with ASTM D 2166. Stress versus strain curves have also been presented in Appendix C. These allowed an evaluation of the shear strength at different strain levels and also the initial tangent modulus. Dry density, moisture content, and Atterberg limits are also reported for each test. Results for undisturbed samples are summarized in Table 2 while the results for compacted samples are summarized in Table 3.

5.3.2 Laboratory Vane Shear Tests

Vane shear tests were performed on selected soil samples from the dock area to evaluate both the undisturbed and remolded shear strengths. This was done primarily to determine the degree of sensitivity of the soil and also to compare the results with those of other undrained shear strengths. This data is summarized in Table 4.

5.3.3 Unconsolidated-Undrained Triaxial Compression Tests (UU)

Unconsolidated-undrained triaxial compression tests were made on selected undistrubed samples to compare with the results obtained from the unconfined compression testing. This test is also considered appropriate for cohesive samples which contain appreciable amcunts of silt or sand size particles. Procedures utilized were in accordance with ASTM D 2850.

All unconsolidated-undrained triaxial tests were performed at confining pressures approximately equal to the effective overburden pressure at the sample depth. The stress-strain curves, moisture contents, and dry densities are also given on the laboratory test result sheets in Appendix C. The results are summarized in Table 5.

5.3.4 Consolidated-Undrained Triaxial Compression Tests with Pore Pressure Measurements ($\overline{CU}$)

Consolidated-undrained triaxial compression tests with pore pressure measurements were made on undisturbed samples from all strata and on selected remolded samples using the Harvard Minature Compaction Method. All samples were saturated by the back pressure method. A minimum of three separate samples at the same approximate depth were then consolidated to confining pressures approximately equal to 0.5, 1.0, and 2.0 times the effective overburden pressure, respectively, before testing. Confining pressures, moisture contents, dry densities, etc. are shown on the test data sheets. Effective and total strength envelopes were obtained for each series tested. Plots of pore water pressure, deviator stress, principal stress ratio, and Skempton's A parameter versus strain are given in Appendix C. All results are summarized in Table 6.

5.3.5 Consolidation Tests

Consolidation tests on selected soil samples were made by loading test specimens up to applied pressures as high as 24 ksf in accordance with ASTM D 2435. A modification of ASTM D 2435 to provide a rebound-recompression curve near the overburden pressure (Burmister Loop) was also used on selected samples (Ref 9). This modification consisted of loading the test specimens to the approximate in-situ overburden pressure, or slightly above, and then reducing the load to either 2 or 4 ksf. Samples were then reloaded to the maximum pressure and rebounded to zero load. The consolidation bowl was filled with water when the pressure reached the approximate effective confining pressure at the sample depth. Tests on compacted samples were also made. Results of the consolidation tests and a summary of the coefficient of consolidation by both the square root and logarithm of time fitting method are included in Appendix C. The results of undisturbed and compacted samples are summarized in Tables 7 and 8, respectively.

5.3.6 Permeability Tests

Laboratory permeability tests were performed on representative clay specimens. Specimens were saturated by the back pressure method and tested under a confining pressure equal to the effective overburden pressure. Permeability was determined by using the constant head permeability test as adapted to triaxial equipment. All permeability results are summarized in Table 9.

5.3.7 Compaction Tests

Compaction tests were made in accordance with ASTM D 1557 on selected samples representative of the upper soils that could be excavated and used as a fill material. The curves of dry unit weight versus moisture content are presented, along with the Zero air voids curve in Appendix C.

6.0 SOIL PROPERTIES FOR DESIGN

6.1 INTRODUCTION

In this section, the results of laboratory tests are discussed along with the ranges and recommended design values of soil properties. The generalized design values are believed to be conservative for the entire site. Higher values may be justified based on a localized evaluation of subsurface conditions and on the nature of the engineering problem under consideration. The recommended design properties of the site soils are compiled in Table 10.

6.2 INTERPRETATION OF LABORATORY TEST DATA

6.2.1 Natural Moisture Content and Dry Unit Weight

The natural moisture content and dry unit weights for the entire site have been plotted in Figure 18. In addition, for each sample, the corresponding total unit weight has also been calculated and presented. Although the figure for moisture content shows a fairly narrow range at all depths, there is considerably more scatter in the measured dry unit weight, thus producing a moderate scatter for the total unit weight. The design value for total unit weight versus depth has been based upon the predcminant density at each depth with appropriate consideration fcr the scatter. Generally, as shown in Figure 18, a constant value of total unit weight can be used for each major stratum. Following are the ranges and recommended design values for each major stratum:

Ranges of Natural Properties

Depth (Ft)	Dry Density (PCF)	Moisture Content (%)	Total Density (PCF)	Design Total Density (PCF)
0-20	95-105	22-34	115-133	125
20-50	80-90	30-45	110-125	115
50-110	95-105	15-30	120-130	125
110+	80-100	20-40	110-124	120

The scatter in dry unit weights below a depth of 110 feet as shown in Figure 18, is likely due to the presence of a slightly higher percentage of sand in some of the samples at this depth.

6.2.2 Atterberg Limits

Atterberg limits results are presented in Figures 19 and 20. Figure 19 contains three plasticity charts showing values of plasticity index (PI) and the liquid limit (LL) for the upper, middle, and lower strata. As shown in this figure, the upper stratum is the most plastic and the lower stratum the least plastic. This is attributed to the higher silt and sand content of the lower stratum. Ranges of liquid limit, plastic limit (PL), and plasticity index were derived for each of the three strata.

Depth	LL	PL	PI
0-20	39-63	17-26	18-39
20-50	35-55	16-25	15-32
50+	20-55	12-25	8-31

Figure 20 shows the plasticity ranges and the corresponding moisture content versus depth for the main plant area, the main coal storage area, and the dock area. The figure shows that the plasticity characteristics of these three areas are similar.

6.2.3 Mechanical Analysis

This site is predominantly a clay site with the exception of the 60 foot thick sand deposit above rock in the vicinity of the main plant. Localized sand and silt lenses of nominal thickness were also found at variable locations and elevations throughout the site.

Grain size distribution curves for the upper, middle, and lower strata are shown on Figures 21 and 22. Figure 22 further subdivides the grain size distribution curves of the lower stratum for five major areas of the site.

Nearly uniform conditions were encountered in the upper stratum with very little evidence of sand. This is shown in Figure 21 by the very close grouping of the grain size distribution curves within the clay size range.

Below 20 feet, a significantly greater percentage of sand size particles is apparent from Figures 21 and 22. Figures 21 and 22 show that in general, the cohesive soils within the middle and lower strata do not contain more than about 40 percent sand, and most have no more than 20 to 30 percent sand.

The grain size results for the site are presented in Figure 23 in a different manner. This figure is a presentation of the mean grain diameter D•• versus depth. It shows that, above the 90 to 100 foot depth, the majority of the data points fall within the clay and silt range while, below the 90 to 100 foot depth, the majority of the data points fall within the silt and sand ranges.

6.2.4. Activity of Clay

The activity of a clay is determined by plotting the plasticity index versus the percent of clay size particles less than two microns on an activity chart as shown in Figure 24. The figure shows that the activity values of the different samples represented are generally similar, making it possible to fit a single straight line through all the data. This line has a slope of 0.4 indicating the activity. The values generally ranged between 0.3 and 0.5. These activity values put the clays at the site in the inactive category according to Skempton (Ref 10).

6.2.5 Undrained Shear Strength

The results of all unconfined and unconsolidated-undrained compression tests along with all of the laboratory vane shear tests are combined in Figure 25. This figure shows the results of each type of test with a different symbol. Other than for the upper stratum where the unconsolidated-undrained shear strengths were somewhat higher, all three types of tests gave comparable results. The shear strength was also evaluated for each major area separately (dock, coal hopper, main plant); however, it was found that the generalized interpretation shown by the dashed line in Figure 25 is conservative and representative for all areas.

The shear strength results from previous borings in the St. Clair Power Plant area are presented in Figure 26. The interpretations of the two sets of data shown in Figures 25 and 26 are superimposed in Figure 27 for comparison. This figure shows that the strength values obtained from the two separate investigations are in good agreement.

In addition, the empirical Skempton relationship:

$$S_u/\bar{P} = 0.1 + 0.004\ PI \qquad (1)$$

has been used to calculate the undrained shear strength (S_u) for known values of plasticity index under two overburden pressure ($\bar{P}$) conditions. One assumption is that $\bar{P}$ is equal to the effective overburden pressure (Figure 28a) and the other assumes that $\bar{P}$ is equal to the overconsolidation pressure determined by Casagrande's Method (Figure 28b). These assumptions give the anticipated upper and lower boundaries of undrained shear strength as determined by this relationship. The range of plasticity index for the soils tested during this investigation (Section 6.2.2) fall within the range of applicability of Equation 1 as shown in Reference 8.

The design recommendations presented below were based on the results shown in Figure 25 with consideration of the results of previous investigations (Figure 26) and the empirical undrained shear strength values obtained from the Skempton relationship (Figure 28).

Stratum	Depth Below Ground Surface (Feet)	Peak Undrained Shear Strength (psf) Effective Range	Design Value
Upper	0-20	1,100-3,000	550
Middle	20-50	350-1,500	550
Lower	50-90	500-3,000	1,000
	90+	500-1,500	850

The basis for the selection of the design undrained shear strength for the upper stratum is discussed below.

6.2.5.1 Upper Stratum

Based upon the laboratory test results from this investigation, the undrained shear strengths for the upper stratum were found to range between 1,100 and 3,000 psf. The most predominant value of undrained shear strength was approximately 2,000 psf. These undrained shear strengths generally tend to decrease with depth which is indicative of a clay preconsolidated by dessication.

However, it should be emphasized that for preconsolidated clays having overconsolidation ratios of four to eight as in this case, the peak undrained shear strength often cannot be depended upon. The laboratory peak strength for soils of this type will give higher undrained shear strength than that which will actually develop in the field under long term conditions. This is because high negative pore pressures develop during shearing of the soil in the laboratory (Ref 11) and these are not expected to develop to the same extent or remain for any long period of time in the field. In addition, as the soil dries out (desiccates), the soil contracts and shrinkage cracks form within the desiccated layer. This allows failure to occur on pre-formed failure planes and the full undrained strength of the soil is not developed. For this situation, the available long term strength is closer to the residual strength (Ref 12).

In evaluating the shear strength to be used for the upper stratum, the typical shape of the stress-strain curves during failure of the sample was also considered. These curves are shown for each sample on pages C-271 through C-341 of Appendix C in Volume 2. The curves show a "brittle" soil which reaches its maximum strength at relatively low strain (2-5%), at which point the strength drops off fairly rapidly. This stratum will reach its maximum strength first with respect to the lower stratum, if subjected to the same strain.

It should be noted however that the reduction in strength with increasing strain was noted primarily in the unconfined compression tests which represented the majority of available data. This strength reduction is partially caused by the lack of sample confinement inherent in the test.

Considering all of the above factors, a design shear strength of 550 psf is recommended for the upper stratum. This value is approximately one half the lower bound strength predicted from the laboratory tests. Values up to 1100 psf may be justified in some situations.

Comparing the above laboratory test results with the empirical shear strength values obtained by the Skempton procedure, the average undrained shear strength for the stratum would range between 250 psf, for a normally consolidated soil (Figure 28a), to 1,000 psf for an overconsolidated soil (Figure 28b). It should be noted, however, that the values of shear strength are influenced by the effective overburden or preconsolidation pressure substituted into the Skempton relationship. In reality, the shear strength for the upper stratum will be higher than that indicated in Figure 28a for a normally consolidated soil. This is primarily because of the influence of the shallow depth and the preconsolidated nature of this stratum. Since this stratum is cverconsolidated, the empirical shear strength value of 1,000 psf, as shown in Figure 28b, should be closer to the actual shear strength.

Although higher shear strengths were obtained from undrained shear strength testing, the higher values cannot be recommended because of the potential pre-formed failure planes and also the relatively high negative pore pressures that develop in testing but do not exist to the same degree in the field. Both of these tend to decrease the measured shear strength, although the amount of decrease cannot be adequately determined. Thus, a value of 550 psf is recommended primarily based upon the residual shear strengths obtained from unconsolidated-undrained shear strength testing and the results of triaxial testing.

6.2.5.2 Middle Stratum

The middle stratum has been found to be the weakest stratum at this site. Undrained shear strengths based on laboratory test results range from 300 tc 1,000 psf with the most predominant value being 550 psf. Unlike the upper stratum, the stress-strain curves for this stratum typically peak at low strains (about 2%) with only a slight reduction in strength at higher strains. As shown in Figure 25, the shear strength from test results can be taken as approximately constant with depth at 550 psf over the range of 20 to 50 feet. This value is recommended for design. The strength of 550 psf was found to be within the range obtained from the Skempton's relationship utilizing both the effective overburden pressure and preconsolidation pressure (Figure 28a and b, respectively).

If normally consolidated conditions are assumed as shown in Figure 28a, the resulting shear strength is very nearly equal to that obtained by laboratory testing. The figure shows a gradual increase in shear strength with depth ranging from about 400 psf at a depth of 20 feet to about 650 psf at a depth of 50 feet. This increase is imposed by the nature of Skempton's relationship and should be expected for normally consolidated clays if perfect samples are obtained. The laboratory results do not show this trend, and this is an indication of sample disturbance. A slightly higher shear strength is obtained when the preconsolidation pressures are used as shown in Figure 28b: the average shear strength decreases from 900 psf at a depth of 20 feet to 800 psf at a depth of 50 feet. This reduction in strength with depth is caused by the reduction in preconsolidation pressure determined from consolidation testing.

6.2.5.3 Lower Stratum

The lower stratum can be taken as beginning at a depth of approximately 50 feet and extending to bedrock at depths ranging from approximately 125 to 145 feet. This stratum may be further subdivided into two layers as far as the undrained shear strength is concerned.

6.2.5.3.1 Layer From 50-90 Feet

As shown in Figure 25, distinctly higher shear strengths were obtained from depths of 50 to 90 feet. The soils in this layer are considered to be moderately overconsolidated. Comparing the natural moisture content and dry unit weight in this layer with the layer below, the natural moisture content did not decrease significantly with increasing depth nor did the dry unit weight increase significantly with increasing depth. Thus, it is possible that this layer was also preconsolidated by desiccation, although the trend in shear strength variation with depth does not provide enough evidence to conclude this.

A fairly wide range of laboratory shear strengths was obtained as shown in Figure 25. These values ranged from about 500 to 3,000 psf with approximately two-thirds of the data ranging between 500 and 1,500 psf and the other third between 1,500 and 3,000 psf. The most predominant value between 500 and 1,500 psf was 1,000 psf. As shown in Figure 28, the estimated shear strength at a depth of 50 feet, based on the Skempton statistical procedure, was found to be either 650 or 850 psf, depending on whether normally consolidated or overconsolidated conditions are assumed. Both procedures give a shear strength of approximately 1,000 psf at a depth of 90 feet.

Typical stress-strain curves for soils between 50 and 90 feet either remain constant with strain near the peak stress or drop somewhat as can be seen on pages C-271 thru C-341 of Appendix C in Volume 2. However the drop in stress occurred at a higher strain in the range of 10-12%.

Considering the higher strain at which the peak soil strength occurs and not discounting completely the lower shear strengths as predicted by the Skempton procedure, the shear strength of 1,000 psf is recommended for this layer.

6.2.5.3.2 Soils Below 90 Feet

Indications are this layer is normally to very slightly overconsolidated. Based upon the laboratory test results, the shear strength in this layer ranges between 500 and 1,500 psf with an average of approximately 850 psf. The decrease in undrained shear strength, as compared to the layer above, was also noted in the laboratory test results obtained from the previous investigations. Figure 26 shows values of shear strength between 200 and 1,000 psf with an average of 600 psf.

Comparison of the strength predicted from Skempton's equation (Figure 28) and the strength data in Figure 25 shows that the upper bound of the laboratory strength (1,500 psf) is close to the strength predicted by the Skempton equation. However, it should be noted that in this case, the Skempton procedure is also influenced by the greater depth (the actual value of the effective vertical pressure), and it is possible that the actual shear strength may be lower than predicted by this method.

The actual shear strength reduction associated with the soil below 90 feet may be due to several causes, the most plausible of which is sample disturbance. This was borne out by running both undisturbed and remolded unconfined compression tests (at the same moisture content and dry density) on the same sample, see Tables 2 and 3. The ratio between these two tests (undisturbed strength divided by remolded shear strength) is called sensitivity. These tables show that the sensitivity of the site soils was generally between 1.0 and 1.5. This is another indication that, but not necessarily a conclusion that, the samples have been disturbed.

One additional consideration in explaining the reduced strengths at great depths is the amount of sand present (Figures 21, 22, and 23). This could cause a reduction of the laboratory strength in unconfined compression tests.

Since the standard penetration blowcounts do not decrease within this depth (Figure 17), and the Skempton empirical relationship shows a high strength, the average strength of 850 psf obtained from laboratory tests is considered conservative and is recommended for the soils below 90 feet.

6.2.6 Shear Strength From $\overline{CU}$ Tests

The long term (drained) shear strength has been determined by consolidated-undrained triaxial tests with pore pressure measurements. In addition to the Mohr-Coulomb envelopes for total and effective stresses, the deviator stress, effective stress ratio, change in pore pressure, and Skempton's A parameter have also been plotted versus strain and are included in Appendix C of Volume 2. The failure criteria presented was based on the peak deviator stress. If a maximum stress ratio failure criteria is desired, it can be readily obtained.

In order to evaluate the total and effective stress parameters, the stress point or "p-q" diagram as suggested by Lambe and Whitman (Ref 13) has been used. These diagrams are shown in Figures 29 and 30 for total and effective stress parameters, respectively. These figures show that the "p-q" diagram for effective and total stress can be idealized by two straight lines intersecting at a pressure corresponding to a depth in the range of 55 to 62 feet. This depth also corresponds to the division between the middle and lower stratum. The "p-q" diagrams are used to calculate the effective and total stress parameters required to determine shear strength from the Mohr-Coulomb relationships (Ref 13).

The Mohr-Coulomb relationship for effective stresses is given by:

$$\tau = c' + \sigma' \tan \phi' \qquad (2)$$

Where τ = drained shear strength

σ' = effective normal stress on failure plane at failure

c' = cohesion intercept for effective stresses

ϕ' = angle of internal friction for effective stresses,

and the Mohr-Coulomb relationship for total stresses is given by:

$$S = c + \sigma \tan \phi \qquad (3)$$

where S = shear strength

σ = total normal stress on failure plane at failure

c = cohesion intercept for total stresses

ϕ = angle of internal friction for total stresses.

Recommended values of effective and total stress parameters for each stratum are given below:

	Total Stress Basis		Effective Stress Basis	
Depth (Ft)	ϕ	c (PSF)	ϕ'	c' (PSF)
0-20	13°	450	28°	0
20-50	13°	450	28°	0
50+	10°	700	22°	250

6.2.7 Tangent Modulus of Elasticity

The initial modulus of elasticity has been plotted versus depth on Figure 31 for all of the undrained shear strength tests. Although there is some scatter, a reasonable design value can be determined for each of the three strata. These values are given below and are further discussed in this section.

		Undrained Tangent Modulus E (ksf)		
Stratum	Depth (ft)	Effective Range	Average	Design Values
Upper	0-20	100-200	175	700
Middle	20-50	25-120	65	330
Lower	50+	25-240	100	550

It has been found that for settlement calculations the values obtained from undrained shear strength tests should be increased by a factor of four to five to give results that agree with measured settlements (Ref 13). The lower measured test values can be attributed to sample disturbance. Bjerrum (Ref 14) has suggested that the modulus can be obtained by multiplying the undrained shear strength by a factor of 400 to 600. However, for this site, the ratio E/S_u has been found to be approximately 100 for all of the soils tested, except the middle stratum which showed a slightly higher ratio of approximately 140. Therefore, the values of E/S_u obtained in this investigation are apparently lower by a factor of four to six than what would be generally expected. Both the modulus of elasticity and the undrained shear strength are apparently lower, with the greater reduction in the modulus of elasticity.

Therefore, an increase in the modulus of elasticity from test results by a factor of as high as four to five is justified in the average modulus of elasticity values as determined from the undrained shear strength tests. Based on this criteria, and the corresponding criteria of 400 to 600 times the undrained shear strength, initial static modulus of elasticity values of 700, 330, and 550 ksf are recommended for the upper, middle, and lower strata, respectively.

6.2.8 Consolidation

6.2.8.1 Preconsolidation Pressure

Figure 32 shows the variation of preconsolidation pressure with depth as determined by Casagrande's Procedure. Samples believed to be relatively disturbed based on the shape of the consolidation curve have been designated with a different symbol in Figure 32. Also included in this figure is a plot of moisture content with respect to Atterberg limits versus depth for all of the consolidation tests to assist in estimating the degree of overconsolidation. A natural moisture content near the plastic limit indicates an overconsolidated soil, whereas a natural moisture content near the liquid limit indicates a normally consolidated soil. These data are shown on the left side of Figure 32 for each of the consolidation test results presented. This figure shows the subsurface soils at this site are preconsolidated to some degree, for their entire depth.

To help determine a design preconsolidation pressure, Skempton's procedure has also been used to estimate the preconsolidation pressure from the plasticity index and the unconfined and unconsolidated-undrained compression tests. This interpretation is shown in Figure 33.

As shown in Figure 32, almost all of the soils at this site, with the exception of the upper stratum soils (0-20 feet) and soils from 50 to 90 feet, can be considered normally to slightly overconsolidated for design purposes. This is because of the relatively slight overconsolidation shown by consolidation tests.

The soils from 0 to 20 feet (upper stratum) have been preconsolidated by desiccation. This judgement is based primarily on the general decrease in shear strength with depth as shown in Figure 25 as opposed to soils preconsolidated by either glaciation or preloading which will have shear strengths increasing with depth.

The design preconsolidation pressure for the upper stratum has been determined by drawing the precompression line along the lower bound of preconsolidation pressure as determined by consolidation test results. This is nearly parallel to and slightly lower than the preconsolidation line as determined by the Skempton procedure (Figure 33).

Preconsolidated soils were also noted between 50 and 90 feet based on consolidation tests and the Skempton equation (Figures 32 and 33). This is also the depth range in which higher undrained shear strengths were obtained from laboratory tests (Figure 25). Although it cannot be said conclusively, it appears that the soil from 50 to 90 feet was also preconsolidated by desiccation as with the upper stratum rather than by glaciation. Since the soils below 90 feet appear to be only slightly overconsolidated at the most, desiccation appears to be the most plausible explanation for the preconsolidation.

Considering the scatter in the preconsolidation pressure based on Casagrande's Method and the predicted preconsolidation pressure based on Skempton's relationship, the recommended design curve for preconsolidation pressure is as shown in Figure 33.

6.2.8.2 Settlement Parameters

The compression index (C_c), swelling index (C_r), initial void ratio (e_o) and the settlement parameter ($C_c/1+e_o$) all versus depth are shown in Figures 34, 35, 36, and 37. The range of values is small enough that a constant value can be used throughout each major stratum, and the design curves shown are drawn to reflect this. Presented below are the ranges and recommended design values for the various parameters.

Depth (ft)	C_c Range	C_r Range	e_o Range
0-20	0.14-0.16	0.05-0.07	0.65-0.80
20-50	0.33-0.45	0.09-0.10	0.72-1.10
50+	0.18-0.41	0.05-0.08	0.60-1.00

	$C_c/1+e_o$		$C_r/1+e_o$
Depth (ft)	Range	Design	Design
0.20	0.10-0.15	0.13	0.04
20-50	0.15-0.24	0.20	0.04
50+	0.11-0.21	0.14	0.04

Values of the compression index (C_c) and the swelling index (C_r) are plotted versus liquid limit, for the soils tested, in Figure 38. The soils from the upper stratum are identified with different symbols because of the overconsolidation of this stratum. The empirical relationship:

$$C_c = 0.009\ (LL - 10) \qquad (4)$$

and the plus or minus 30 percent upper and lower bounds suggested by Terzaghi and Peck (Ref 12) are superimposed in Figure 38. The compression index values (C_c) measured in this investigation compare favorably with the empirical relationship. The data for the upper stratum fall around the lower bound of this relationship, as should be expected because of the overconsolidation.

Similar results were obtained for the swelling index (C_r) values. Based on the data in Figure 38, the relationship between swelling index and liquid limit for the soils tested can be expressed by the equation:

$$C_r = 0.002\ (LL - 2.5). \qquad (5)$$

Figure 38 also shows an upper and lower bound representing a variation of plus or minus 30 percent from the above relationship. It was found that these lines represent good upper and lower bounds for the data.

6.2.8.3 Coefficient of Consolidation

Figure 39 shows values of the coefficient of consolidation (C_v) versus pressure for the three major strata. The relationship between C_v and the logarithm of pressure is represented by a band and an average curve for each stratum as shown in the figure. These bands and average curves conform to the general relationship presented by Lambe (Ref 15). As shown in the figure, the effective range of the coefficient of consolidation is 0.05 to 0.25 square feet per day for all samples tested over the pressures involved. An overall average of 0.15 square feet per day is recommended for design.

6.2.9 Permeability

Constant head permeability tests were performed on samples of silty clay taken from depths ranging from 20 to 90 feet. All samples were saturated in a triaxial cell by back pressure and tested at a confining pressure approximately equal to the effective overburden pressure. The coefficient of permeability was found to range from 1.6×10^{-8} cm/sec to 2.6×10^{-8} cm/sec for void ratios between 0.4 and 0.9. Thus, for any engineering analysis, an average permeability of 2 x 10^{-8} cm/sec may be used for the silty clays found at this site.

6.2.10 Compaction

The results of all laboratory compaction tests are shown in Figure 40. The tests were performed on samples from the upper stratum and the results grouped according to soil type. Since the soils below this depth are soft to very soft, only the upper stratum is expected to be used for fill material. The zero air void curves (100% saturation) were plotted assuming specific gravities of 2.70 and 2.75. The two diagrams on the left side of the figure (CL and CH soils) show results from samples taken northwest of the plant site near the intersection of King and Puttygut roads. This is within the proposed fly ash disposal area and is a potential borrow area for the remainder of the plant. The diagram on the right side of this figure (CL-CH soils) shows results from samples taken in the vicinity of the proposed main coal pile.

Since the most predominant natural moisture content for the upper stratum soils is about 26%, this indicates that on the order of 10% to 16% reduction in moisture content will be necessary to compact these soils to the maximum dry density, and approximately 6% to 10% reduction will be necessary to obtain 95% of the maximum. Because of the relatively large amount of drying required, compaction of these soils will be difficult.

7.0 SUMMARY AND CONCLUSIONS

An extensive subsurface investigation program was conducted at the Belle River Project site. The investigation consisted of geologic studies, ground water measurements, soil/rock borings, and laboratory soil testing, along with an evaluation of previous investigations at the site. The subsurface investigation was directed at confirming the suitability of the site and providing generalized soil parameters and information for design of the various plant facilities.

The investigation showed that:

a. Geologic and subsurface soil conditions at the site are suitable for the development of the site.

b. Ground water information, based on four observation wells monitored for a period of one year, have been accumulated and presented.

c. The soil parameters for design and construction evaluations have been developed in the report and are further summarized in the Tables. The results are considered to be conservative and are applicable for the entire site. Soil boring logs showing the pertinent soil parameters are also presented in Appendix B.

Depending on the engineering problem under consideration, localized and more extensive evaluations or investigations may be required to expand upon the available information.

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TABLES

TABLE 1

GAS ENCOUNTERED IN DRILL HOLES

Drill Hole No	Depth to Gas Infiltration (ft)	Soil Type	Remarks
12	118.0	Sand	Bubbles in drill fluid, gas dissipated after 24 hours, no odor
20	136.0	Sand	Bubbles in drill fluid, gas dissipated after 24 hours, no odor
30	50.0	Clay	Bubbles in drill fluid, gas dissipated after 48 hours, no odor
50	98.0	Clay	Bubbles in grout after pulling casing, gas dissipated after 24 hours, no odor
52	70.5	Sand	Bubbles in grout after pulling casing, gas dissipated after 24 hours, no odor
59	124.5	Silt	Bubbles in drill fluid, gas dissipated after 24 hours, no odor
131	104.0	Sand	Drill fluid ejected several feet above drill hole, gas dissipated after 6 hours, no odor

TABLE 2

UNCONFINED COMPRESSION TEST RESULTS
UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	PARTICLE SIZE ANALYSIS % FINER THAN							SPECIFIC GRAVITY	ATTERBERG LIMITS			NATURAL CONDITIONS			UNCONFINED COMPRESSION TEST RESULTS				REMARKS
	FROM	TO		4	10	20	40	100	200	2μ		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	S_u PSF	E 10^3 PSF	ε %	E/S_u	
15/4	8.6	8.9	CL									44	19	25	32	93	123	1257	156	6.0	127	
15/6	18.1	18.4	CL									42	20	22	34	87	117	508	25	15.0	69	
15/14	59.2	59.6	CL									34	18	16	23	104	128	1067	31	15.2	36	
25/1	4.5	4.8	CH									59	23	36	22	108	132	3456	174	5.0	50	
26/9	39.4	39.7	CL									38	20	18	37	86	118	445	67	1.6	151	
26/17	78.2	78.5	CL									36	20	16	25	101	126	580	22	12.0	38	Sandy
27/4	8.6	8.9	CL-CH									51	23	28	31	94	123	1722	58	15.0	34	
28/3	5.8	6.1	CL									47	23	24	25	100	125	1981	222	4.0	112	
28/9	28.8	29.1	CL									42	20	12	38	84	116	425	57	7.0	134	
38/3	8.7	9.0	CL-CH	--	--	--	--	--	97	61	2.70	49	24	25	24	102	126	2122	267	3.0	126	
38/4	14.3	14.6	CL-CH	--	--	--	--	--	97	61	2.71	46	22	24	29	96	124	1505	125	4.0	83	
38/12	54.2	54.5	CL-CH	--	--	--	--	--	98	55	2.70	44	21	23	33	90	120	985	105	5.0	107	
38/16	73.7	74.0	CL-CH	--	--	--	--	--	97	63	2.72	55	24	31	41	79	111	703	41	4.8	58	
38/18	84.6	84.9	CL	--	--	--	--	--	97	47	2.70	33	19	14	22	104	127	603	33	14.0	55	Gravelly
38/24	114.2	114.5	CL	--	--	--	--	--	99	61	2.70	45	25	20	32	92	121	500	63	6.0	126	
41/2	4.5	4.8	CH	--	--	--	--	--	98	63	2.70	63	28	35	29	94	121	1024	143	5.0	140	
41/7	20.6	20.9	CL-CH	--	--	--	--	--	99	57	2.66	47	24	23	39	83	115	338	357	3.0	1056	
41/9	30.9	31.2	CL-CH									45	21	24	37	86	118	697	67	15.0	96	
41/11	40.6	41.0	CL-SC	--	92	86	80	68	58	17	2.70	20	12	8	16	118	137	647	25	15.0	39	Sample slightly disturbed.
41/23	101.8	102.1	CL	--	--	--	--	--	95	47	2.70	34	20	14	26	99	125	534	67	10.0	125	Sandy
41/29	130.7	131.0	GC-SC	--	96	90	80	65	57	23	2.69	25	17	8	14	124	141	1749	154	8.0	88	
48/2	3.2	3.5	CH									63	24	39	27	97	123	1466	137	3.2	93	
48/14	61.2	61.5	CL									34	16	18	25	100	125	745	22	15.0	30	Sandy
49/4	24.0	24.3	CL									42	22	20	34	90	121	1028	69	6.0	67	

TABLE 2

UNCONFINED COMPRESSION TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	PARTICLE SIZE ANALYSIS % FINER THAN							SPECIFIC GRAVITY	ATTERBERG LIMITS			NATURAL CONDITIONS			UNCONFINED COMPRESSION TEST RESULTS				REMARKS
	FROM	TO		4	10	20	40	100	200	2μ		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	S_u PSF	E 10^3 PSF	ε %	E/S_u	
49/9	73.9	74.3	CL									33	22	11	26	100	126	2254	100	15.0	36	Sandy
50/6	29.3	29.7	CH-CL	--	--	--	--	--	97	53	2.70	51	18	33	46	75	110	197	45	2.4	228	
50/8	38.9	39.2	CH									55	23	32	51	70	106	550	113	2.0	205	
50/10	49.0	49.3	CL	99	96	94	92	86	81	37	2.70	36	16	20	24	99	123	526	39	15.0	74	Sandy
50/12	58.6	58.9	CL									39	18	21	26	99	125	1007	200	9.0	199	
50/16	78.6	78.9	CL									39	20	19	28	95	122	1270	161	10.0	127	
52/3	20.5	20.9	CL-CH									49	20	29	30	92	120	2737	263	4.0	96	
52/4	28.6	28.9	CL									35	18	17	32	94	124	489	61	9.0	125	
52/6	49.2	49.5	CL-ML									22	18	4	25	100	125	317	100	2.5	315	
52/7	59.0	59.3	CL	97	94	87	83	72	58	16	2.70	23	14	9	13	116	131	1798	150	6.0	83	Sandy
52/8	68.2	68.5	CL									24	14	10	14	115	131	1676	133	13.0	79	Sandy
52/10	88.6	88.9	CL									39	18	21	27	97	123	2435	230	8.0	94	Sandy
53/3	19.6	19.9	CL-CH									49	20	29	32	88	116	1155	172	5.0	149	
53/4	29.6	29.9	CL-CH									49	22	27	40	80	112	1006	200	5.0	199	
53/6	49.2	49.5	CL									43	18	25	28	94	120	561	65	15.0	116	
53/9	80.1	80.4	CL									39	21	18	26	99	125	1275	182	6.0	143	
54/5	59.3	59.6	CL									38	17	21	26	99	125	557	114	11.0	205	Sandy
54/7	68.5	68.8	CL									37	18	19	26	98	123	788	58	8.9	74	Sandy
59/3	18.8	19.1	CL-CH									48	20	28	33	90	120	1056	107	6.9	101	
59/5	38.7	39.0	CL									38	18	20	26	99	125	625	104	14.9	166	Sandy
59/7	58.6	58.9	CL									36	18	18	26	98	123	835	200	8.0	240	Sandy
60/3	17.6	18.0	CL	--	--	--	--	--	98	52	2.70	39	21	18	24	105	130	1143	26	15.0	23	
60/5	25.6	25.9	CH									51	22	29	37	86	118	1001	143	4.0	143	
60/6	30.5	30.8	CL-CH									48	25	23	35	88	119	3153	222	3.7	141	
																						Sheet 2 of 3

TABLE 2

UNCONFINED COMPRESSION TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	PARTICLE SIZE ANALYSIS % FINER THAN							SPECIFIC GRAVITY	ATTERBERG LIMITS			NATURAL CONDITIONS			UNCONFINED COMPRESSION TEST RESULTS				REMARKS
	FROM	TO		4	10	20	40	100	200	2μ		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	S_u PSF	E 10^3 PSF	ε %	E/S_u	
60/8	40.6	41.0	CL									47	25	22	40	83	116	337	50	3.0	148	
60/10	50.9	51.2	CL									34	16	18	26	100	126	1255	75	15.0	60	
60/11	55.6	56.0	CL	95	89	86	84	79	76	34	2.70	33	18	15	25	103	129	1299	133	15.0	102	Sandy
60/14	75.1	75.4	CL									40	20	20	27	97	123	651	71	5.0	109	
60/19	100.1	100.4	CL									38	20	18	27	101	128	1131	100	7.0	88	Sandy
60/23	119.6	120.0	CL-ML	--	94	90	86	71	61	18	2.70	17	11	6	15	115	132	335	55	6.0	164	Sandy
101/2	8.9	9.2	CL-CH									50	22	28	28	96	123	1828	200	2.4	109	
101/4	19.6	20.2	CL-CH									49	24	25	36	86	117	1014	75	6.0	74	
101/7	34.9	35.2	CL-CH									46	24	22	40	81	113	795	55	2.4	76	
101/10	50.1	50.4	CL-CH									40	22	18	33	90	120	722	71	5.0	89	
101/13	65.2	65.6	CL									36	19	17	27	97	123	1337	43	15.0	32	
101/17	85.2	85.5	CL									37	19	18	25	97	121	1923	102	15.0	53	Sandy
119/9	81.6	81.9	CL									33	20	13	21	107	129	3072	111	15.0	36	Sandy
126/3	8.2	8.6	CL-CH									47	24	23	26	99	125	1725	208	2.4	121	
136/4	8.8	9.2	CL-CH									48	22	26	24	102	126	5446	769	3.0	141	
144/4-1	8.5	8.8	CL-CH									48	21	27	26	97	122	861	192	1.7	223	
144/4-2	8.9	9.2	CL-CH									48	21	27	24	99	123	1002	119	3.0	119	
185/3	7.5	7.8	CL-CH									50	23	27	24	104	129	2947	400	4.0	136	
185/7	18.5	18.8	CL-CH									49	22	27	39	81	113	831	94	2.4	113	
																						Sheet 3 of 3

TABLE 3

UNCONFINED COMPRESSION TEST RESULTS

REMOLDED AND COMPACTED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	PARTICLE SIZE ANALYSIS % FINER THAN							SPECIFIC GRAVITY	ATTERBERG LIMITS			PRE TEST CONDITIONS			UNCONFINED COMPRESSION STRENGTH TEST			REMARKS
	FROM	TO		4	10	20	40	100	200	2μ		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	S_u PSF	E 10^3 PSF	ε %	
38/3	8.7	9.0	CL-CH	-	-	-	-	-	97	61	2.71	49	24	25	24	103	128	761	46	7.0	Remolded
38/18	84.6	84.9	CL	-	-	-	-	-	99	61	2.70	33	19	14	22	105	128	547	27	17.4	Remolded
41/2	4.5	4.8	CH	-	-	-	-	-	98	63	2.70	63	28	35	29	95	123	962	80	9.0	Remolded
60/3	17.6	18.0	CL	-	-	-	-	-	98	52	2.70	39	21	18	24	103	128	1,052	13	15.0	Remolded
60/11	55.6	56.0	CL	95	89	86	84	79	76	34	2.70	33	18	15	25	103	129	817	13	15.0	Remolded
127/3	5.6	7.0	CL-CH									49	22	27	14	113	129	9,403	869	3.2	Compacted (97% ASTM D1557)
136/6	13.0	14.6	CL									43	22	21	18	100	118	2,773	400	2.0	Compacted (89% ASTM D1557)
141/2	8.0	10.0	CL-CH									49	23	26	18	103	122	5,558	592	2.0	Compacted (90% ASTM D1557)
144/4	8.0	10.0	CL-CH									-	-	-	24	100	124	1,482	58	15.0	Remolded
146/7	14.0	16.1	CL									46	22	24	17	104	122	3,282	484	2.0	Compacted (85% ASTM D1557)
158/2	7.5	9.7	CL-CH									50	21	29	17	104	122	3,416	481	2.0	Compacted (87% ASTM D1557)

NOTE: Remolded samples run at same dry density and water content as undisturbed samples.

TABLE 4

LABORATORY VANE SHEAR TEST RESULTS

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	ATTERBERG LIMITS			PRETEST CONDITIONS			UNDRAINED STRENGTH UNDISTURBED		UNDRAINED STRENGTH REMOLDED		SENSITIVITY	REMARKS
	FROM	TO		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	COHESION PSF	ANGLE OF ROTATION DEGREES	COHESION PSF	ANGLE OF ROTATION DEGREES	UNDISTURBED STRENGTH DIVIDED BY REMOLDED STRENGTH	
50/6	28.1	28.3	CL	39	18	21	35	82	111	479	8	178	7	2.7	
50/10	48.1	48.4	CL	36	16	20	26	96	121	520	32	480	52	1.1	
52/4	28.9	29.2	CL	35	18	17	31	89	117	560	10	266	7	2.1	
52/6	49.6	49.8	CL	-	-	-	24	101	125	2,165	30	-	-	-	
52/10	89.1	89.4	CL	39	18	21	26	96	121	1,660	15	1,525	51	1.1	
53/6	49.7	50.0	CL	43	18	25	27	94	119	520	13	312	40	1.2	
53.9	79.5	79.8	CL	39	21	18	28	95	122	1,375	22	-	-	-	
54/5	59.7	60.0	CL	38	17	21	28	92	118	1,200	54	-	-	-	
59/3	18.5	18.8	CL-CH	48	20	28	33	90	120	1,250	15	-	-	-	
59/5	39.4	39.7	CL	38	18	20	26	96	121	640	15	-	-	-	
59/7	59.0	59.3	CL	36	18	18	24	102	127	735	22	-	-	-	

TABLE 5

UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST RESULTS
UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	ATTERBERG LIMITS			NATURAL CONDITIONS			UNCONSOLIDATED UNDRAINED STRENGTH TEST					REMARKS
							W_o	γ_d	γ_t	σ_o	S_u	E	ε	E/S_u	
	FROM	TO		LL	PL	PI	%	PCF	PCF	PSF	PSF	10^3 PSF	%	——	
15/2	3.7	4.1	CL	45	21	24	25	101	126	475	2386	240	8.0	101	
18/3	20.6	20.9	CL	44	21	23	40	83	116	2448	410	150	4.0	366	
18/6	51.4	51.7	CL	39	18	21	31	92	121	4104	827	100	3.0	121	
18/10	88.8	90.1	CL	29	15	14	17	111	130	6336	2862	240	15.0	84	Sandy
25/10	88.9	89.2	CL	36	19	17	23	104	128	6192	2213	162	11.0	73	
27/2	4.5	4.8	CL-CH	48	24	24	24	103	129	576	2099	121	8.0	58	
41/17	72.9	73.2	CL	25	15	10	20	105	126	8654	453	21	14.0	46	Sandy
48/14	60.8	61.1	CL	34	16	18	26	99	125	4608	746	36	15.0	48	Sandy
50/8	38.1	38.4	CH	55	23	32	46	74	108	3456	643	75	4.0	117	
50/10	49.3	49.6	CL	36	16	20	23	100	123	4320	721	73	15.0	101	Sandy
50/12	59.1	59.4	CL	39	18	21	24	101	125	4608	1132	218	10.0	193	Sandy
52/3	21.2	21.5	CL-CH	49	20	29	31	92	121	2016	1590	157	8.0	99	
52/8	69.0	69.4	CL	24	14	10	16	111	129	5184	1890	127	15.0	66	Sandy
52/9	78.6	78.9	CL	35	18	17	22	105	128	5760	1156	130	14.0	112	
52/12	109.3	109.6	CL	46	22	24	36	87	118	7632	1586	230	3.0	145	
53/3	20.1	20.4	CL-CH	49	20	29	32	91	120	2405	1425	176	8.9	124	
53/4	30.1	30.4	CL-CH	49	22	27	34	88	118	3024	972	200	2.4	206	
54/4	53.2	53.5	ML-CL	21	17	4	24	99	123	4320	533	54	15.0	101	
54/5	59.0	59.3	CL	38	17	21	25	99	124	4464	767	35	15.0	46	Sandy
54/6	63.1	63.4	CL	36	18	18	26	98	123	5040	796	100	13.0	126	Sandy
54/7	68.8	69.1	CL	37	18	19	26	98	123	5112	1148	142	12.0	124	Sandy
101/15	74.6	74.9	CL	36	21	15	23	105	129	5328	1054	44	15.0	42	Sandy
101/19	94.9	95.3	CL	36	20	16	25	100	125	6480	547	32	15.0	59	
101/23	119.8	120.2	CL	44	22	22	37	85	116	7920	721	70	8.0	97	
															Sheet 1 of 2

TABLE 5

UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	ATTERBERG LIMITS			NATURAL CONDITIONS			UNCONSOLIDATED UNDRAINED STRENGTH TEST					REMARKS
	FROM	TO		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	σ_o PSF	S_u PSF	E 10^3 PSF	ϵ %	E/S_u	
126/11	49.1	49.4	CH	59	25	34	41	81	114	4032	498	50	4.0	100	
126/23	108.6	108.9	CL	36	20	16	25	96	120	7200	1344	60	15.0	45	
129/3	8.7	9.0	CL-CH	48	23	25	22	108	132	1080	3381	250	6.0	74	
129/15	74.0	74.3	CL	36	21	15	25	101	126	5760	954	62	7.0	65	
129/24	124.1	124.4	CL-CH	46	22	24	31	95	124	7920	679	30	8.0	44	
151A/3	13.0	13.3	CL-CH	48	20	28	28	95	122	1555	2325	167	10.0	72	

TABLE 6

CONSOLIDATED-UNDRAINED TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	ATTERBERG LIMITS			NATURAL CONDITIONS			CONSOLIDATION CONDITIONS	CONDITIONS AFTER CONSOLIDATION		CONSOLIDATED UNDRAINED STRENGTH TEST			SKEMPTON'S $\bar{A}$ PARAMETER (FINAL)	SHEAR STRENGTH PARAMETERS			
																	TOTAL STRESS		EFFECTIVE STRESS	
							W_o	γ_d	γ_t	$\bar{\sigma}_3$	W_f	γ_{tf}	E	$(\sigma_1-\sigma_3)^1$	E/S_u		ϕ	C	ϕ'	C'
	FROM	TO		LL	PL	PI	%	PCF	PCF	PSF	%	PCF	10^3 PSF	PSF	——		deg.	PSF	deg.	PSF
18/12	108	110	CL	46	22	24	35	87	117	3,744	33.7	116	316	3,900	161	0.28	10	900	22	300
							31	92	120	7,488	29.3	119	400	5,200	154	0.68				
							31	92	120	15,120	27.7	117	1,500	8,170	367	1.04				
26/2	3.5	5.5	CL-CH	53	24	29	23	104	127	360	27	132	225	2,200	204	0.15	34	350	27	320
							24	103	128	691	27	131	346	3,450	200	0.19				
							22	108	132	1,296	25	135	450	4,800	187	0.20				
26/5	18	20	CL-CH	--	--	--	35	89	120	1,080	31	116	125	1,350	185	0.23	16	250	27	50
							35	86	116	2,160	31	113	273	1,680	325	0.72				
							36	86	117	5,040	28	110	500	4,350	230	0.56				
26/11	48	50	CL	41	21	20	36	88	120	2,304	34	118	250	1,790	279	0.57	9	400	24	0
							37	86	118	4,608	23	106	666	2,440	546	1.11				
							30	93	121	9,216	24	115	666	4,410	302	1.34				
33/7	28	30.5	CL	46	22	24	39	82	114	1,440	37	112	300	1,480	405	0.39	10	300	24	0
							40	82	115	2,880	37	112	750	1,930	776	0.77				
							38	84	116	5,760	32	111	500	3,040	328	1.17				
33/9	38.0	40.5	CL	43	23	20	37	83	114	7,200	36	113	175	1,600	110	0.51	9	400	22	150
							37	85	116	7,200	34	114	300	2,160	277	0.93				
							36	86	117	12,960	31	113	300	3,320	180	1.31				
48/6	18.0	20.0	CL-CH	47	25	22	33	90	120	1,152	32	119	166	1,860	179	0.05	9	700	21	300
							34	89	119	2,304	33	118	375	2,610	287	0.24				
							36	88	120	4,608	31	115	500	3,160	316	0.78				
48/22	98	100	CL	36	19	17	27	99	126	3,312	25	124	375	4,030	186	0.19	11	1050	25	0
							26	96	121	6,624	24	119	666	5,760	231	0.49				
							28	97	124	13,248	23	119	1,200	8,820	272	0.83				

TABLE 6

CONSOLIDATED-UNDRAINED TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	ATTERBERG LIMITS			NATURAL CONDITIONS			CONSOLIDATION CONDITIONS	CONDITIONS AFTER CONSOLIDATION		CONSOLIDATED UNDRAINED STRENGTH TEST			SKEMPTON'S A PARAMETER (FINAL)	SHEAR STRENGTH PARAMETERS			
																	TOTAL STRESS		EFFECTIVE STRESS	
							W_o	γ_d	γ_t	$\bar{\sigma}_3$	W_f	γ_{tf}	E	$(\sigma_1-\sigma_3)^1$	E/S_u		ϕ	C	ϕ'	C'
	FROM	TO		LL	PL	PI	%	PCF	PCF	PSF	%	PCF	10^3 PSF	PSF	——		deg.	PSF	deg.	PSF
49/6	43	45	CL-CH	53	22	31	44	78	112	1,872	42	111	158	1,840	172	0.46	9	500	22	200
							46	75	110	3,744	45	109	333	2,710	246	0.70				
							45	77	112	7,488	39	107	583	3,860	311	1.10				
49/13	113.0	115.0	CL	33	22	11	24	100	124	3,816	23	123	400	3,570	223	0.43	10	900	25	0
							29	95	123	7,632	27	121	666	4,850	274	0.87				
							29	93	120	15,264	24	115	857	8,260	207	1.16				
50/6	28.0	30.0	CL	39	18	21	33	88	117	1,440	32	116	250	1,680	296	0.32	11	450	26	100
							33	90	120	2,880	27	114	300	2,100	285	0.74				
							34	86	115	5,760	29	111	500	3,440	291	1.06				
50/18	88.0	90.0	CL	39	23	16	28	97	124	3,456	26	122	214	3,850	111	0.27	10	900	25	200
							28	97	124	6,912	26	122	461	5,180	178	0.69				
							28	96	123	13,824	23	118	461	7,980	115	1.01				
54/4	53.0	55.0	CL	31	18	13	23	102	125	4,320	21	123	500	4,040	247	0.42	15	450	26	0
							23	102	125	8,640	20	122	461	7,730	119	0.50				
							23	101	124	2,160	22	123	285	2,860	199	0.11				
							24	100	124	6,480	20	120	666	5,610	237	0.55				
52/6	48.0	50.5	ML	--	--	--	21	101	122	2,160	22	123	533	30,320	35	0.29	42	4,000	36	0
							23	99	122	4,320	22	121	1,000	35,020	57	0.24				
							22	104	127	8,640	22	127	1,000	55,550	36	0.18				
54/6	63.0	65.0	CL	36	18	18	26	98	123	2,448	26	123	166	2,730	122	0.30	11	700	25	150
							25	98	123	4,896	23	120	562	4,010	280	0.61				
							26	98	123	9,792	22	119	900	5,860	307	1.00				
60/2	8.0	10.0	CH	53	26	27	30	94	118	590	32	124	157	1,060	298	0.01	18	260	22	170
							29	95	123	1,152	31	124	273	1,750	301	0.09				
							29	96	124	2,304	30	125	375	2,670	280	0.16				

TABLE 6

CONSOLIDATED-UNDRAINED TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	ATTERBERG LIMITS			NATURAL CONDITIONS			CONSOLIDATION CONDITIONS	CONDITIONS AFTER CONSOLIDATION		CONSOLIDATED UNDRAINED STRENGTH TEST			SKEMPTON'S $\bar{A}$ PARAMETER (FINAL)	SHEAR STRENGTH PARAMETERS: TOTAL STRESS		SHEAR STRENGTH PARAMETERS: EFFECTIVE STRESS	
	FROM	TO		LL	PL	PI	W_o	γ_d	γ_t	$\bar{\sigma}_3$	W_f	γ_{tf}	E	$(\sigma_1-\sigma_3)^1$	E/S_u		ϕ	C	ϕ'	C'
							%	PCF	PCF	PSF	%	PCF	10^3 PSF	PSF	——		deg.	PSF	deg.	PSF
Remolded 60/2	8.0	10.0	CH	53	26	27	29	96	124	560	29	124	100	1,750	114	-0.18	19	450	27	125
							29	99	128	1,152	26	125	187	2,490	150	0.10				
							29	98	126	2,304	26	123	214	3,500	122	-0.04				
60/4	21.0	23.0	CL	43	17	26	30	94	122	1,296	31	123	102	2,780	73	-0.09	13	800	24	250
							31	94	123	5,184	30	122	900	5,130	350	0.37				
							31	95	124	2,016	30	123	281	3,180	177	0.07				
60/9	45.0	47.0	CL	38	16	22	27	99	126	2,016	26	125	500	2,530	394	0.24	10	600	25	100
							27	98	124	4,032	26	123	321	2,990	214	0.72				
							26	102	129	8,064	23	125	750	5,020	298	0.97				
60/13	67.0	69.0	CL-ML	40	19	21	24	103	128	2,520	22	126	180	3,890	93	0.12	13	1,000	25	0
							32	91	120	5,040	28	116	462	3,445	268	0.70				
							20	104	125	10,080	18	123	923	8,120	227	0.56				
							16	114	132	5,760	15	131	923	9,225	200	0.13				
							21	104	126	8,640	19	124	545	6,357	171	0.72				
105/2	9.0	11.0	CL	46	24	22	26	99	125	1,152	28	127	113	2,453	92	-0.05	27	150	25	250
							27	96	122	2,304	28	123	389	4,381	177	-0.05				
							28	98	125	864	29	126	250	2,377	210	-0.02				
105/5	40.0	42.5	CL	44	21	23	36	84	114	1,800	35	113	196	2,136	183	0.29	8	700	23	0
							36	85	116	3,600	34	114	450	2,753	327	0.56				
							35	85	115	7,200	31	111	900	3,660	491	1.13				
							39	84	117	7,200	33	112	643	3,803	169	1.12				
119/2	8.0	10.0	CL-CH	53	26	27	28	95	122	576	29	122	245	1,773	138	0.00	22	375	26	290
							28	99	127	2,304	28	127	450	4,024	223	0.09				
							29	94	121	1,440	30	122	245	2,481	99	0.17				

TABLE 6

CONSOLIDATED-UNDRAINED TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	ATTERBERG LIMITS			NATURAL CONDITIONS			CONSOLIDATION CONDITIONS	CONDITIONS AFTER CONSOLIDATION		CONSOLIDATED UNDRAINED STRENGTH TEST			SKEMPTON'S A PARAMETER (FINAL)	SHEAR STRENGTH PARAMETERS			
							W_o	γ_d	γ_t	$\bar{\sigma}_3$	W_f	γ_{tf}	E	$(\sigma_1-\sigma_3)^1$	E/S_u		TOTAL STRESS ϕ	TOTAL STRESS C	EFFECTIVE STRESS ϕ'	EFFECTIVE STRESS C'
	FROM	TO		LL	PL	PI	%	PCF	PCF	PSF	%	PCF	10^3 PSF	PSF	—		deg.	PSF	deg.	PSF
							37	86	118	1,512	35	116	333	1,970	333	0.24				
119/4	30.0	32.0	CL	41	22	19	39	85	118	3,024	36	116	500	2,460	406	0.57	8	700	26	50
							35	87	117	6,048	30	113	375	3,310	226	1.20				
							34	90	121	1,152	33	120	136	2,200	123	-0.03				
129/5	18.0	21.0	CL-CH	48	21	27	32	90	119	4,608	--	--	346	4,170	165	0.42	14	450	24	0
							33	90	120	2,304	32	119	750	2,550	588	0.26				
							24	99	123	3,240	22	121	187	3,035	123	0.45				
129/19	93.0	95.5	CL	41	21	20	26	99	125	6,480	23	122	500	6,090	164	0.44	13	500	26	0
							27	99	126	12,960	22	121	750	8,900	168	0.81				
							36	86	117	1,152	36	117	180	2,079	173	0.15				
141/4	18.0	20.0	CL	45	21	24	36	87	118	2,304	35	117	818	2,780	587	0.29	9	750	21	350
							*35 / 37	85 / 84	115 / 115	4,608 / 4,637	31 / 34	111 / 113	529 / 529	3,249 / 3,251	326 / 325	0.73 / 0.79				
							38	83	114	1,080	37	114	600	1,569	765	0.17				
158/4	17.5	20.0	CL	46	19	25	34	87	117	2,160	32	115	214	1,942	220	0.51	8	550	21	200
							37	83	114	4,320	33	110	428	2,593	330	0.95				
							15	113	130	1,008	21	137	150	4,261	70	-0.38				
101,105 127,128 180,183 Combined Samples	2.0	10.0	CL-CH	--	--	--	16	114	132	2,016	19	136	210	7,531	56	-0.43	34	500	24	250
							16	114	132	3,168	18	134	276	10,123	54	-0.39				

NOTES:
[1]At peak stress or at 15% strain, whichever is smaller.
* Two tests run on same sample. Second test run after rebounding first sample to original consolidation pressure.

TABLE 7

CONSOLIDATION TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	PARTICLE SIZE ANALYSIS % FINER THAN				SPECIFIC GRAVITY	ATTERBERG LIMITS			NATURAL CONDITIONS				P_c	C_c	C_r	SETTLEMENT PARAMETERS		REMARKS
	FROM	TO		40	100	200	2μ		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	e_o —	10^3 PSF	—	—	$\frac{C_c}{1+e_o}$	$\frac{C_r}{1+e_o}$	
27/10	34.0	34.5	CL					2.73	41	22	19	39	84	117	1.02	3.4	0.44	0.10	0.22	0.05	
27/24	104.2	104.5	CL					2.74	43	25	18	34	90	121	0.91	8.0	0.31	0.10	0.16	0.05	Silty Clay, Sandy
38/4*	14.6	14.7	CL-CH	-	-	98	60	2.71	46	22	24	29	96	124	0.77	10.0	0.19	0.06	0.11	0.03	
38/16	74.0	74.1	CH	-	-	98	60	2.72	55	24	31	36	87	118	0.94	9.4	0.38	0.06	0.20	0.03	
41/5*	10.8	11.0	CL-CH	-	-	98	57	2.72	46	23	23	30	94	122	0.80	11.9	0.23	0.08	0.13	0.04	
41/7	21.0	21.1	CL-CH					2.70	47	24	23	38	82	113	1.06	2.5	0.34	0.09	0.17	0.04	
41/13	53.0	53.2	CL-CH					2.75	52	25	27	47	77	113	1.24	3.5	0.35	0.10	0.16	0.04	
41/17	73.3	73.5	CL	85	74	65	24	2.68	25	15	10	27	98	124	0.70	5.3	0.21	0.05	0.12	0.03	Silty Clay, Sandy
41/25*	113.0	113.2	CL					2.71	29	19	10	24	103	128	0.64	9.4	0.18	0.05	0.11	0.03	Silty Clay, Sandy
41/29*	130.9	131.1	GC-SC					2.69	25	17	8	11	123	137	0.37	10.0	0.10	0.04	0.07	0.03	Clayey Sand, Gravelly
48/10	39.2	39.4	CL-CH					2.73	47	24	23	39	84	117	1.03	4.0	0.33	0.09	0.16	0.04	
49/3	13.7	14.0	CL-CH					2.72	47	23	24	33	91	121	0.86	6.4	0.26	0.07	0.14	0.04	
49/11*	93.8	94.0	CL					2.68	37	22	15	29	98	126	0.70	5.6	0.20	0.05	0.12	0.03	
50/8	38.5	38.9	CH					2.75	55	23	32	52	72	109	1.38	4.0	0.55	0.12	0.23	0.05	
52/4	29.9	30.2	CL-CH					2.70	49	20	29	41	84	118	1.01	4.4	0.45	0.09	0.22	0.04	
53/5	39.5	39.8	CL	85	76	66	30	2.72	39	20	19	31	91	119	0.87	6.5	0.30	0.09	0.16	0.05	Silty Clay, Sandy
54/6*	63.5	63.8	CL	89	83	77	33	2.71	36	18	18	26	99	125	0.70	6.2	0.24	0.07	0.14	0.04	Silty Clay, Sandy
54/8	73.7	74.0	CL	96	94	92	46	2.73	45	21	24	39	86	120	0.98	5.6	0.41	0.08	0.21	0.04	
60/2*	9.8	10.0	CL-CH	-	-	-	60	2.71	53	26	27	30	94	122	0.79	9.2	0.23	0.07	0.13	0.04	
60/16*	85.2	85.4	CL	83	80	78	34	2.73	40	19	21	28	98	125	0.74	9.0	0.27	0.07	0.16	0.04	
105/1*	5.1	5.4	CH					2.72	53	24	29	24	103	128	0.64	4.0	0.10	0.05	0.06	0.03	
105/8	70.9	71.2	CL					2.70	37	19	18	24	103	128	0.63	7.2	0.21	0.06	0.13	0.04	Sheet 1 of 2
118/5	38.6	38.9	CL					2.70	41	22	19	37	86	118	0.97	4.6	0.39	0.10	0.20	0.05	* INDICATES SAMPLES BELIEVED TO BE RELATIVELY DISTURBED.
118/9*	78.7	79.0	CL					2.70	42	23	19	28	97	124	0.74	8.6	0.24	0.06	0.14	0.03	

TABLE 7

CONSOLIDATION TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	PARTICLE SIZE ANALYSIS % FINER THAN				SPECIFIC GRAVITY	ATTERBERG LIMITS			NATURAL CONDITIONS				P_c	C_c	C_r	SETTLEMENT PARAMETERS		REMARKS
	FROM	TO		40	100	200	2μ		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	e_o —	10^3 PSF	—	—	$\frac{C_c}{1+e_o}$	$\frac{C_r}{1+e_o}$	
129/9	39.1	39.3	CL					2.73	41	22	19	40	82	115	1.08	2.9	0.39	0.09	0.19	0.04	
129/21	103.7	104.0	CL					2.71	39	21	18	28	99	127	0.70	6.4	0.23	0.06	0.14	0.04	Silty Clay, Sandy
142/6	20.1	20.5	CL					2.70	45	22	23	38	83	115	1.02	4.6	0.43	0.05	0.21	0.02	
185/3*	7.9	8.1	CL-CH					2.72	50	23	27	29	96	124	0.76	8.0	0.18	0.04	0.10	0.02	

* INDICATES SAMPLES BELIEVED TO BE RELATIVELY DISTURBED.

TABLE 8

CONSOLIDATION TEST RESULTS

REMOLDED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	SPECIFIC GRAVITY	ATTERBERG LIMITS			PRETEST CONDITIONS				P_c	C_c	C_r	SETTLEMENT PARAMETERS		REMARKS
								W_o	γ_d	γ_t	e_o				$\frac{C_c}{1+e_o}$	$\frac{C_r}{1+e_o}$	
	FROM	TO			LL	PL	PI	%	PCF	PCF	—	10^3 PSF	—	—			
136/6	13.0	14.6	CL	2.74	43	22	21	17	102	119	0.68	2.5	0.18	0.05	0.11	0.03	
146/7	14.0	16.1	CL	2.75	46	22	24	16	102	118	0.68	3.3	0.15	0.06	0.09	0.04	

TABLE 9

PERMEABILITY TEST RESULTS

UNDISTURBED SAMPLES

BORING & SAMPLE NUMBER	DEPTH (FEET)		UNIFIED SOIL CLASSIFICATION	PARTICLE SIZE ANALYSIS % FINER THAN					SPECIFIC GRAVITY	ATTERBERG LIMITS			PRETEST CONDITIONS				CONSOLIDATION PRESSURE	VOID RATIO, e, AFTER CONSOLIDATION	PERMEABILITY
	FROM	TO		4	40	100	200	2μ		LL	PL	PI	W_o %	γ_d PCF	γ_t PCF	e_o ——	kg/cm^2		10^{-8}cm/sec.
50/6	28.3	28.5	CL	--	--	--	97	53	2.70	39	18	21	37	84	115	1.00	1.50	0.875	3.0
50/10	48.6	48.8	CL	98	92	86	82	37	2.70	36	16	20	27	97	123	0.73	2.00	0.645	2.6
52/7	58.6	58.9	CL	98	83	72	57	12	2.70	23	14	9	15	119	137	0.41	2.30	0.374	2.2
53/5	39.5	39.8	CL	96	85	77	67	30	2.72	39	20	19	30	104	135	0.73	1.74	0.685	3.5
54/6	63.5	63.8	CL	98	89	83	77	34	2.71	36	18	18	27	98	124	0.72	2.40	0.641	3.0
54/6	73.7	74.0	CL	--	96	93	91	45	2.73	45	21	24	32	90	119	0.85	2.71	0.729	2.3
60/3	18.1	18.3	CL	--	--	--	98	52	2.70	39	21	18	26	103	130	0.71	1.05	0.686	1.6
60/11	56.1	56.4	CL	95	84	79	76	34	2.70	33	18	15	27	98	124	0.73	2.20	0.575	1.8
60/16	85.6	86.1	CL	96	82	80	78	33	2.73	40	19	21	29	96	124	0.75	3.00	0.605	2.6

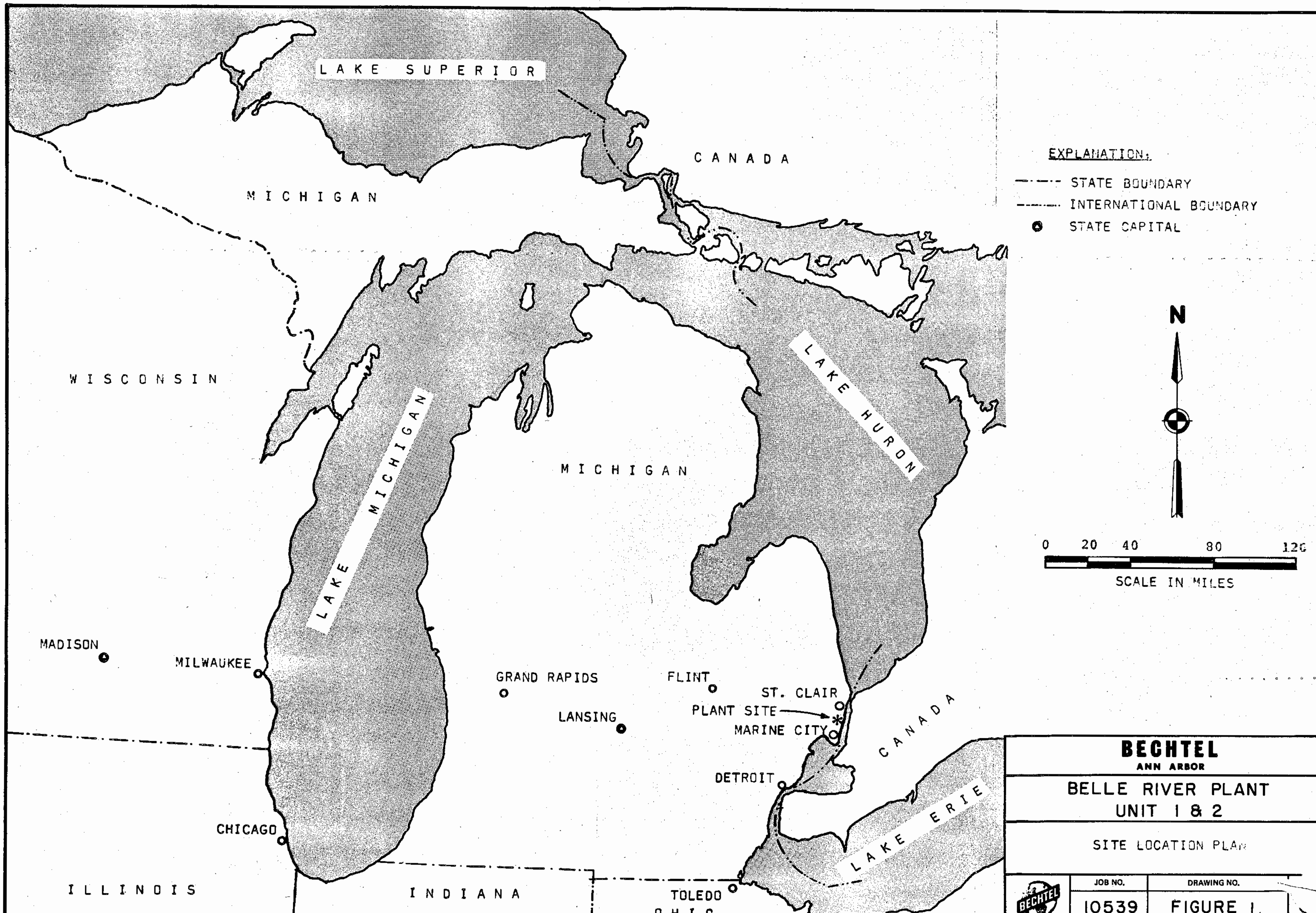
TABLE 10

RECOMMENDED DESIGN PROPERTIES FOR SITE SOILS

Static Properties	Upper Stratum[1] 0 - 20 Ft	Middle Stratum[1] 20 - 50 Ft	Lower Stratum[1] 50 + Ft
In Situ Total Density (PCF)	125	115	125
In Situ Moisture Content (%)	25	35	25
Degree of Saturation (%)	100	100	100
Specific Gravity	2.72	2.72	2.71
Poisson's Ratio[2]			
Drained	0.4	0.4	0.4
Undrained	0.5	0.5	0.5
Initial Modulus of Elasticity (KSF)	700	330	350
Maximum Dry Density per ASTM 1557	118-112[3]	-	-
Optimum Moisture Content	13-16[3]	-	-
Permeability (cm/sec x 10^{-8})	2	2	2
Unconfined Compression Shear Strength			
Cohesion (PSF)	550	550	850
Consolidated Undrained Shear Strength			
Effective Stress Basis			
ϕ' (Deg.)	28	28	25
c' (PSF)	0	0	0
Total Stress Basis			
ϕ (Deg.)	13	13	10
c (PSF)	460	460	710
Settlement Parameter $C_c/1+e_o$	0.13	0.20	0.14
Coefficient of Consolidation (C_v) Ft^2/day	0.15	0.15	0.15

[1]The depths of the different strata are approximate (see text). [3]Refer to Figure 40 for additional information.
[2]Typical values.

FIGURES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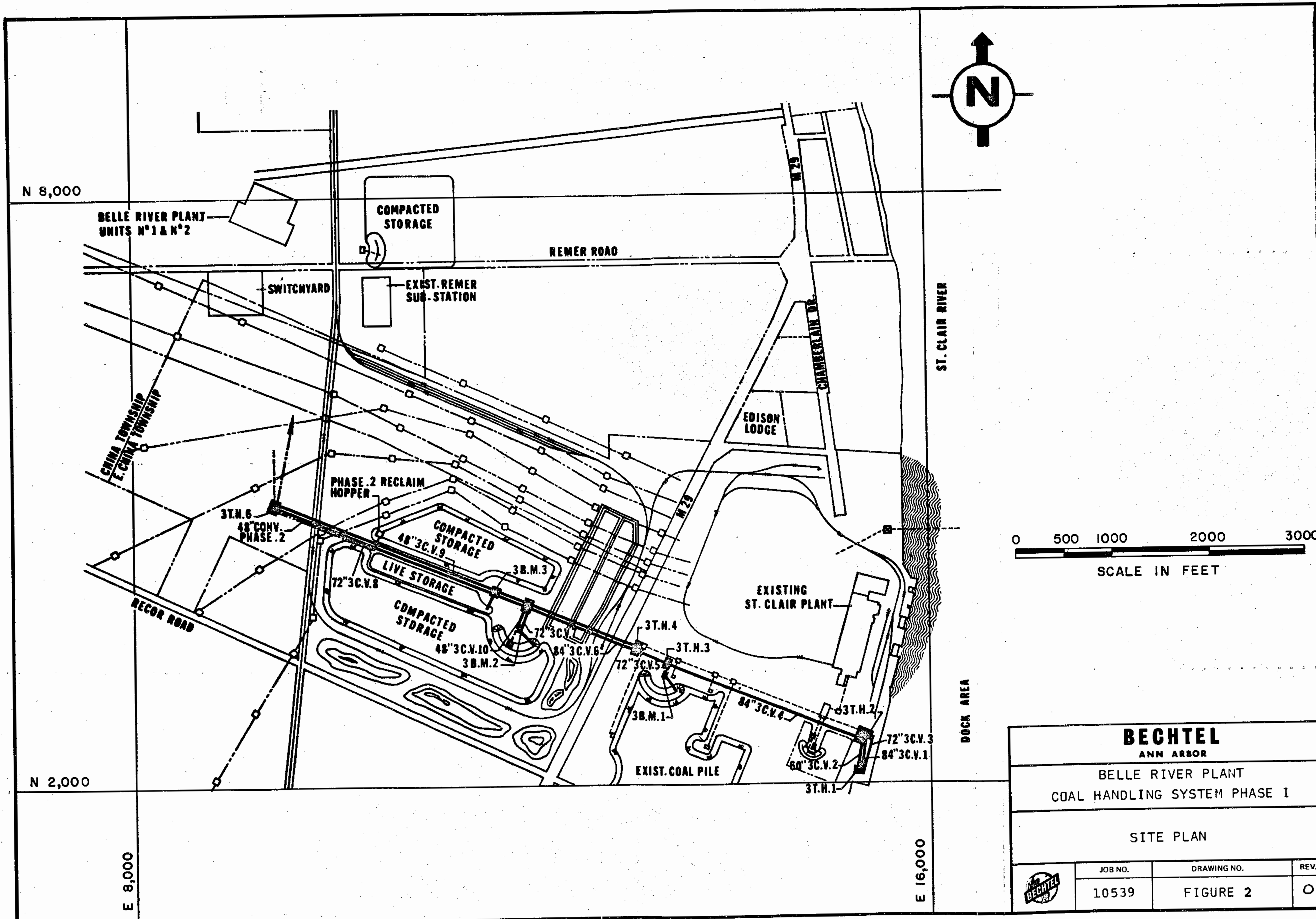
CANADA
MICHIGAN
WISCONSIN
LAKE MICHIGAN
LAKE HURON
MICHIGAN
MADISON
MILWAUKEE
GRAND RAPIDS
FLINT
ST. CLAIR
PLANT SITE
MARINE CITY
LANSING
CANADA
DETROIT
LAKE ERIE
CHICAGO
ILLINOIS
INDIANA
TOLEDO
OHIO
EXPLANATION:
STATE BOUNDARY
INTERNATIONAL BOUNDARY
STATE CAPITAL
N
0 20 40 80 120
SCALE IN MILES
BECHTEL
ANN ARBOR
BELLE RIVER PLANT
UNIT 1 & 2
SITE LOCATION PLAN
JOB NO.
10539
DRAWING NO.
FIGURE 1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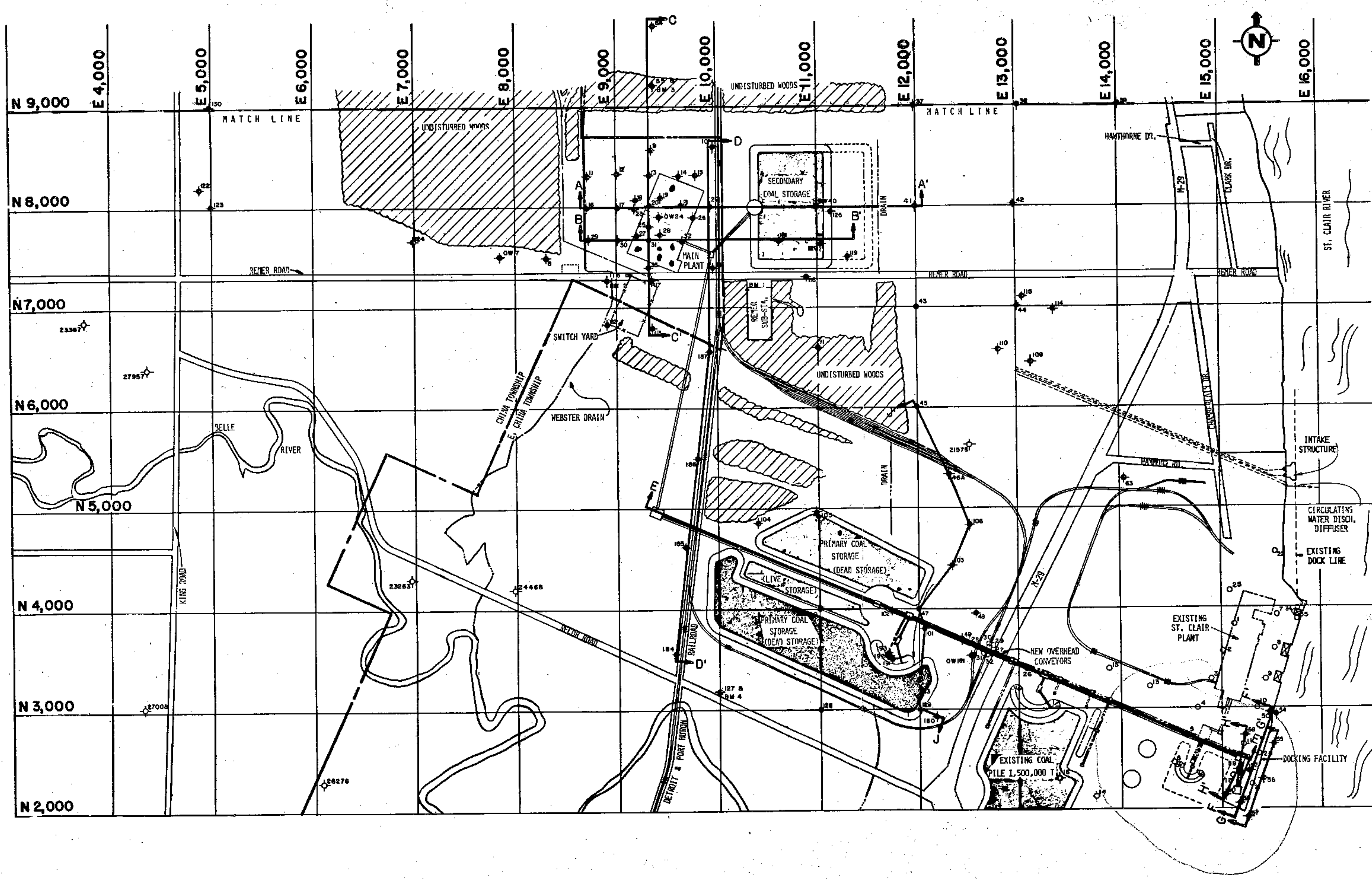
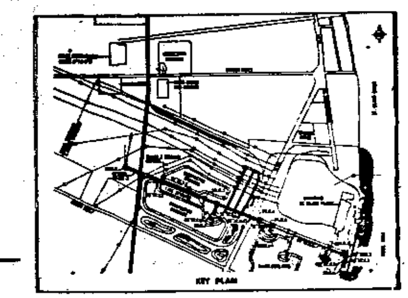
BELLE RIVER PLANT UNITS N°1 & N°2
COMPACTED STORAGE
REMER ROAD
M 29
SWITCHYARD
EXIST. REMER SUB. STATION
CHAMBERLAIN DR.
ST. CLAIR RIVER
EDISON LODGE
CHINA TOWNSHIP
E. CHINA TOWNSHIP
PHASE 2 RECLAIM HOPPER
3T.H.6
48" CONV. PHASE 2
48"3C.V.9
COMPACTED STORAGE
LIVE STORAGE
72"3C.V.8
3B.M.3
COMPACTED STORAGE
72"3C.V.7
84"3C.V.6
48"3C.V.10
3B.M.2
RECOR ROAD
3T.H.4
3T.H.3
72"3C.V.5
3B.M.1
84"3C.V.4
3T.H.2
72"3C.V.3
84"3C.V.1
60"3C.V.2
3T.H.1
EXISTING ST. CLAIR PLANT
EXIST. COAL PILE
DOCK AREA
N 2,000
E 8,000
E 16,000
0 500 1000 2000 3000
SCALE IN FEET
BECHTEL
ANN ARBOR
BELLE RIVER PLANT
COAL HANDLING SYSTEM PHASE I
SITE PLAN
JOB NO. 10539
DRAWING NO. FIGURE 2
REV. 0





NOTES:

1. FOR SUBSURFACE PROFILES SEE FIGURE 9, A THROUGH N.
2. SECTIONS A, B, AND C ARE BASED ON ORIGINAL PLANT LOCATION.
3. SEE FIGURE 4 FOR ADDITIONAL BORING LOCATIONS.

EXPLANATION

TOWNSHIP BOUNDARY

N N' SUBSURFACE PROFILE N–N'

187 BORING LOCATION

OW DENOTES OBSERVATION WELL

BM 4 BENCH MARK

35 BORING LOCATIONS FROM PREVIOUS INVESTIGATIONS FOR ST. CLAIR PLANT

26278 WELLS DRILLED FOR OIL OR GAS EXPLORATION - SHOWING PERMIT NUMBER (ALL HOLES WERE DRY)

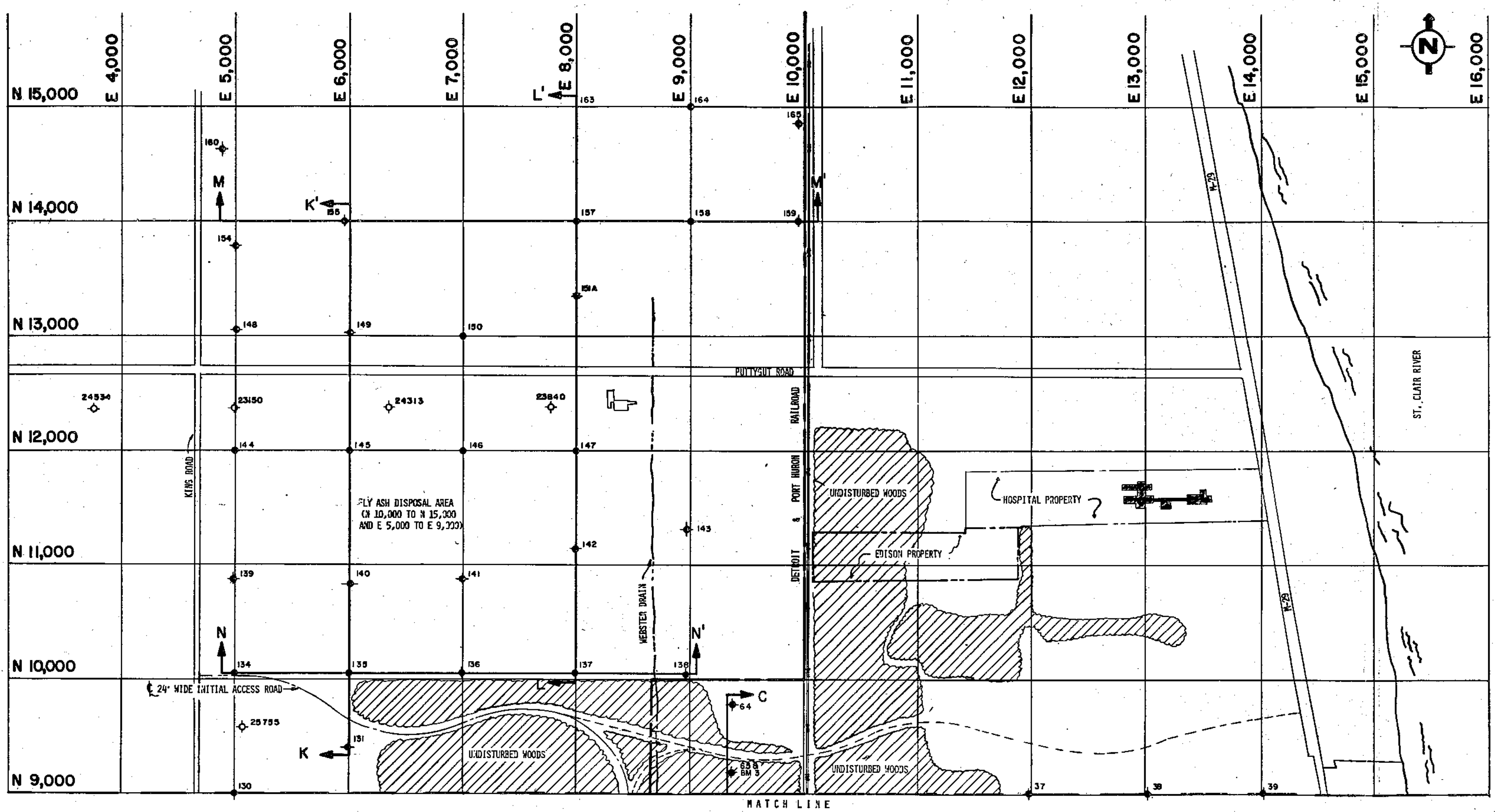
0 100 200 400 800 1200 Feet
SCALE

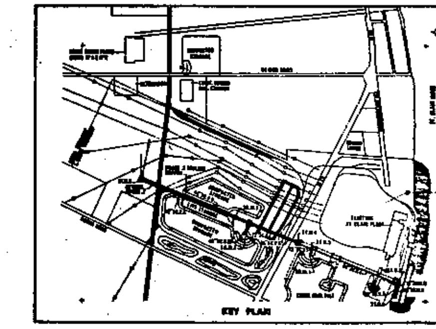
BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

BORING LOCATION PLAN
SOUTH AREA

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 3	2





NOTES:
1. FOR SUBSURFACE PROFILES, SEE FIGURE 9, A THROUGH N.
2. SEE FIGURE 3 FOR ADDITIONAL BORING LOCATIONS.

EXPLANATION

TOWNSHIP BOUNDARY

SUBSURFACE PROFILE N-N'

BORING LOCATION FROM THIS INVESTIGATION

BENCH MARK

WELLS DRILLED FOR OIL OR GAS EXPLORATION - SHOWING PERMIT NUMBER (ALL HOLES WERE DRY)

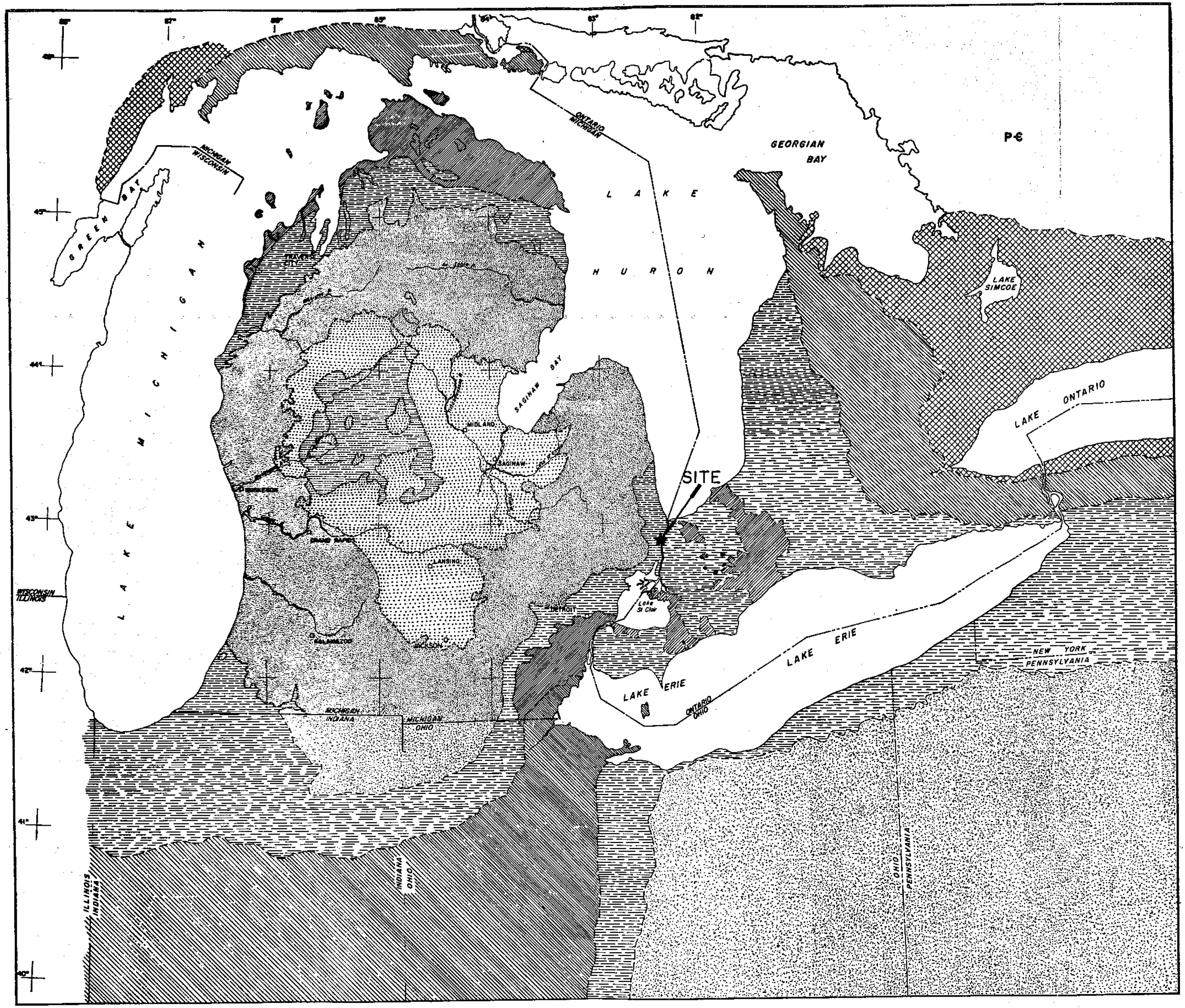
0 400 800 1200
SCALE IN FEET

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

BORING LOCATION PLAN
NORTH AREA

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 4	1



EXPLANATION

Era	Period	Description
MESOZOIC	JURASSIC	Former "Permo-Carboniferous red beds"; shale, clay and sandy shales.
PALEOZOIC	PENN-SYLVANIAN	Grand River Formation and Saginaw Formation; chiefly sandstone, some shaly limestone and coal.
	MISSISSIPPIAN	Grand Rapids Group, Marshall Sandstone and Coldwater Shale; chiefly shale and dolomitic shale, some limestone and sandstone
		Ellsworth Shale, Bedford Shale, and Antrim Shale; shale with some sandstone.
	DEVONIAN	Traverse Group and Detroit River Group; chiefly limestone and dolomite, some shale, sandstone and salt.
	SILURIAN	Bass Islands Group, Salina Group, Manistique Group, Burnt Bluff Group, and Cataract Group; dolomitic shale, dolomite and limestone, some salt.
	ORDOVICIAN	Undifferentiated; shale, siltstone, limestone and dolomite.
PRE CAMBRIAN		P€ Undifferentiated; complex sequence of metamorphosed igneous and sedimentary rocks.

N

NOTE:

Geology is generalized from the following:

(1) The Centennial Geologic Map of the Southern Peninsula of Michigan, 1936, Mich. Geol. Survey.
(2) Stratigraphic Succession in Michigan, Chart I, 1964, Mich. Geol. Survey.
(3) Bedrock of Michigan, Small Scale Map 2, 1968, Mich. Geol. Survey.
(4) Geology of Toronto — Windsor Area, 1969, Geological Survey of Canada.
(5) Geologic Map of North America, 1965, U.S. Geological Survey.

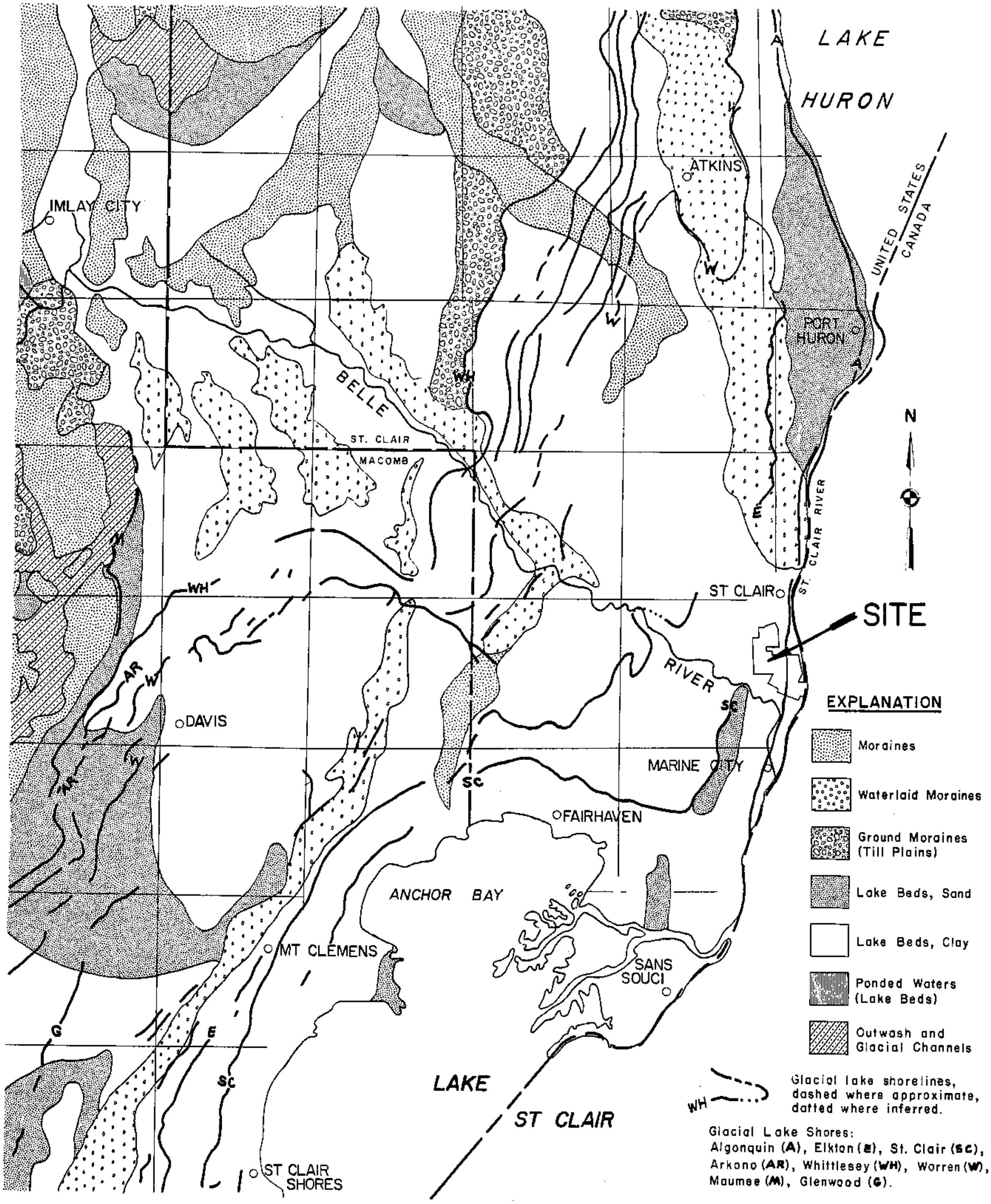
10 0 10 20 30 40 50
SCALE IN MILES

BECHTEL
SAN FRANCISCO

BELLE RIVER POWER PLANT
UNITS 1 & 2

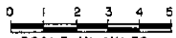
BEDROCK GEOLOGY LOWER PENINSULA MICHIGAN

JOB No.	DRAWING No.	REV.
10539	FIGURE 5	0



NOTE:

From Map of Surface Formations of the Southern Peninsula of Michigan, Michigan Department of Conservation, Geologic Survey Division, 1955.

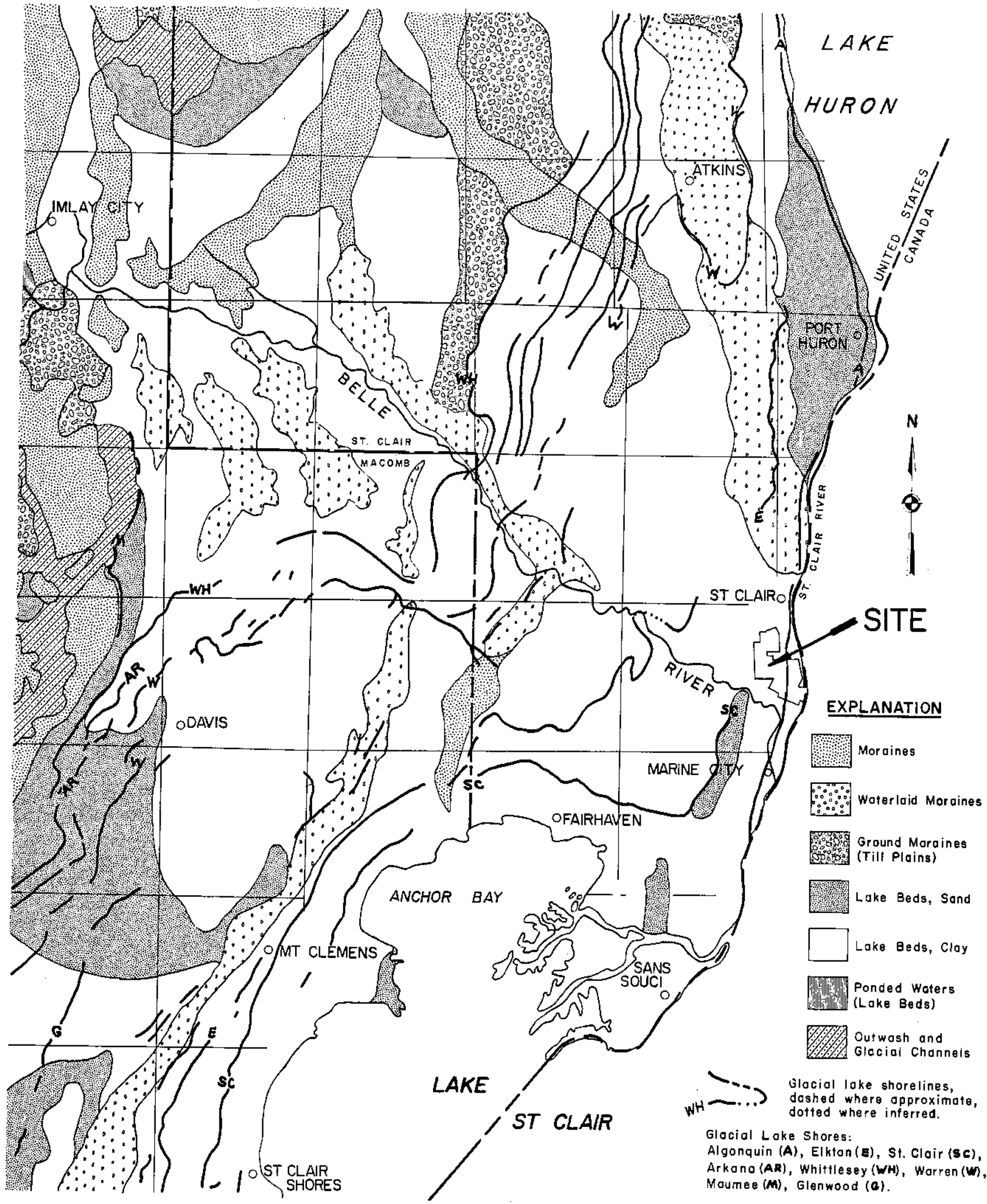


BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SURFICIAL GEOLOGY
ST. CLAIR AND MACOMB COUNTIES

	JOB NO.	DRAWING NO.	REV.
BECHTEL	10539	FIGURE 6	0



NOTE:

From Map of Surface Formations of the Southern Peninsula of Michigan, Michigan Department of Conservation, Geologic Survey Division, 1955.

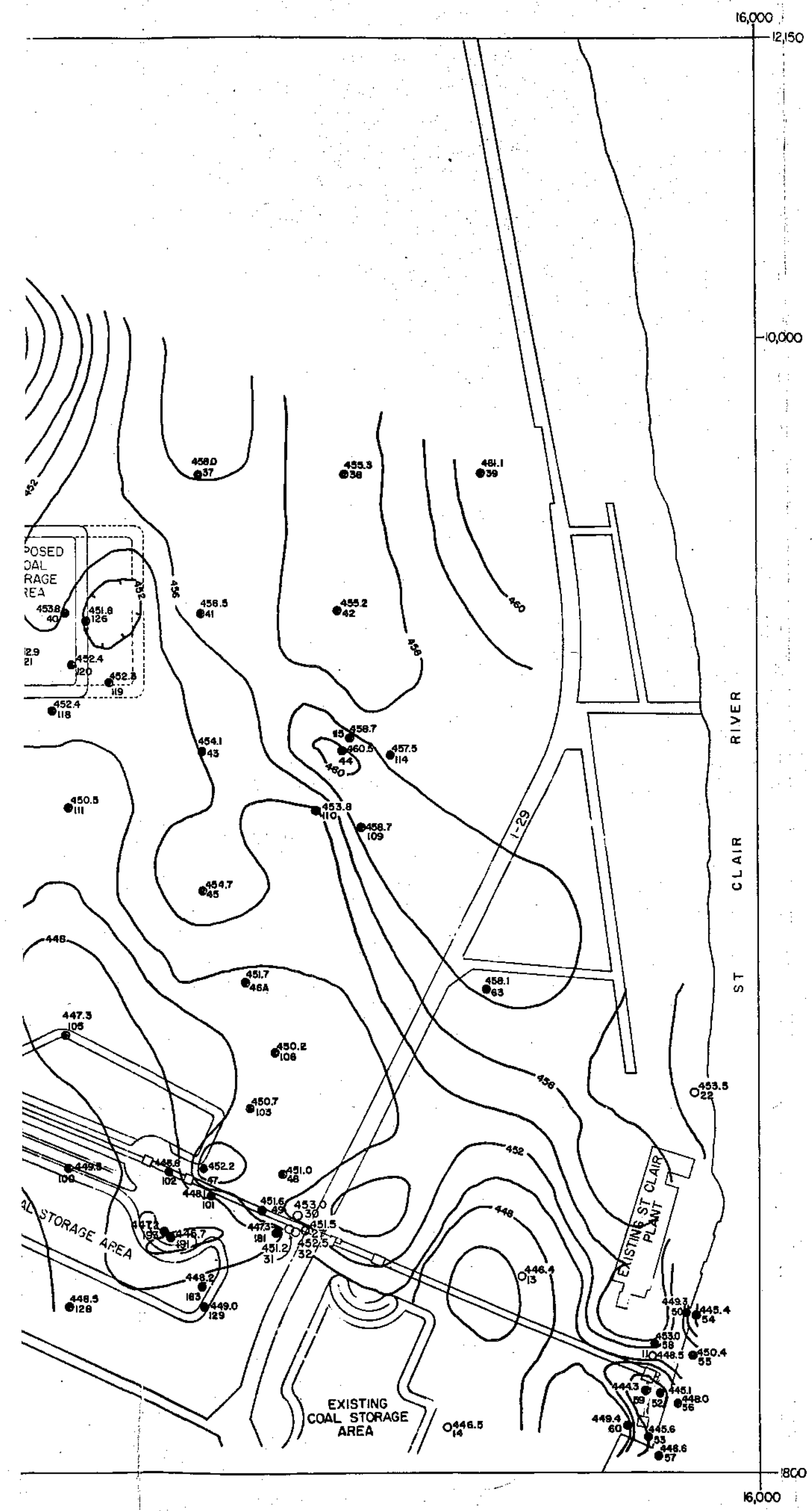
0 1 2 3 4 5
SCALE IN MILES

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SURFICIAL GEOLOGY
ST. CLAIR AND MACOMB COUNTIES

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 6	0



EXPLANATION

434.4 Top of rock elevation (ft)
120 Boring number (present investigation)

452.5 Top of rock elevation (ft)
32 Boring number (previous investigations for St Clair plant)

NOTES:

1. Contours generated from drill hole data by McDonnell Douglas Automation Company's SURMAP computer program.
2. Computer interpretation modified manually to accommodate additional data points.
3. Detail A (plant area) enlarged for clarity, to twice graphic scale shown below.

N

0 200 400 800 1200
SCALE IN FEET

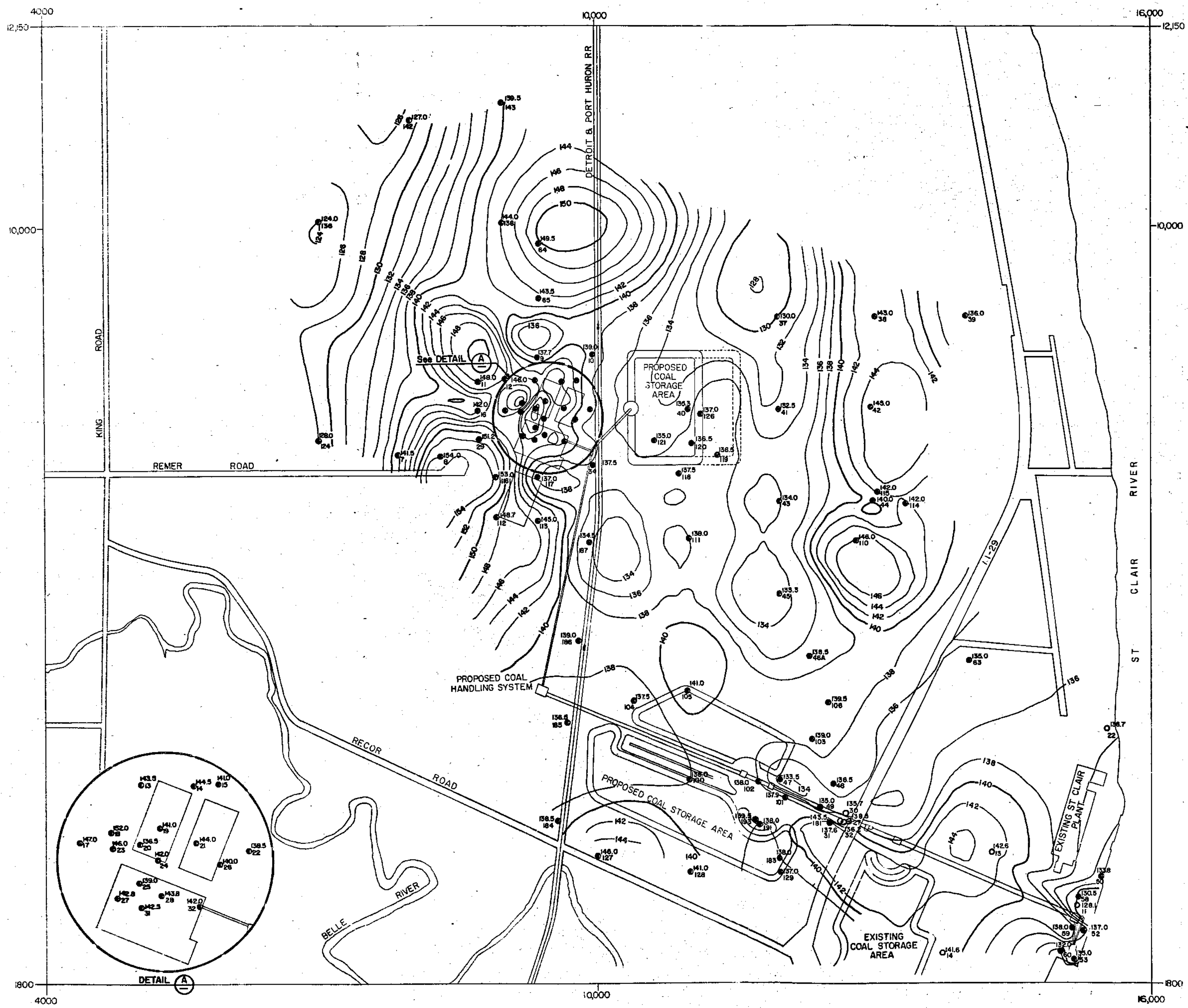
CONTOUR INTERVAL = 2 FT

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

TOP OF ROCK CONTOUR MAP

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 7	1



EXPLANATION

- 134.5 — Overburden thickness (ft); 187 — Boring number (present investigation)
- 136.2 — Overburden thickness (ft); 32 — Boring number (previous investigations for St. Clair plant)
- 150 — Line through points of equal thickness of overburden in feet

NOTES:

1. Thickness contours generated from drill hole data by McDonnell Douglas Automation Company's SURMAP computer program.
2. Computer interpretation modified manually to accommodate additional data points.
3. Detail A (plant area) enlarged for clarity, to twice graphic scale shown below.

N

0 200 400 800 1200

SCALE IN FEET

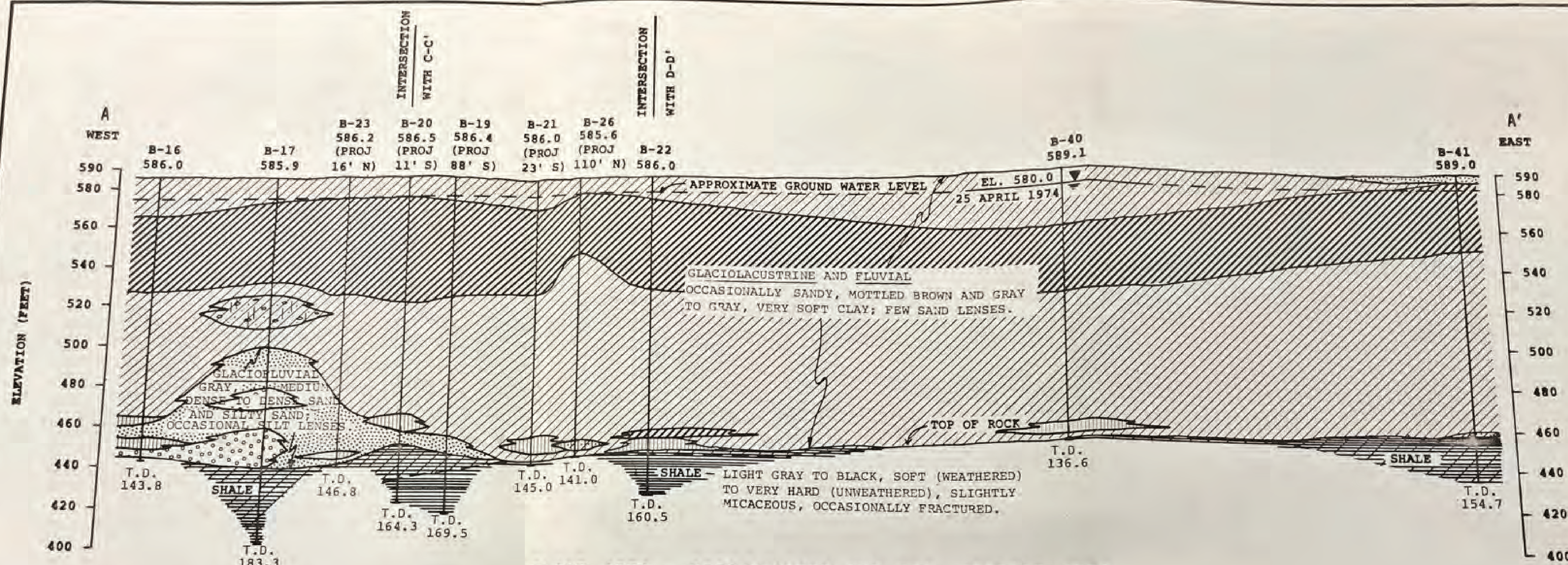
THICKNESS INTERVAL = 2 FT

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

OVERBURDEN THICKNESS
CONTOUR MAP

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 8	1



PLANT AREA - PRECIPITATORS AND COAL STORAGE AREA

LEGEND

- Clay (CL)
- Clay (CH)
- Sand (SP)
- Sand (SW)
- Silt (ML)
- Clayey Sand (SC)
- Silty Sand (SM)
- Gravel (GM)
- Shale (weathered)
- Shale (unweathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

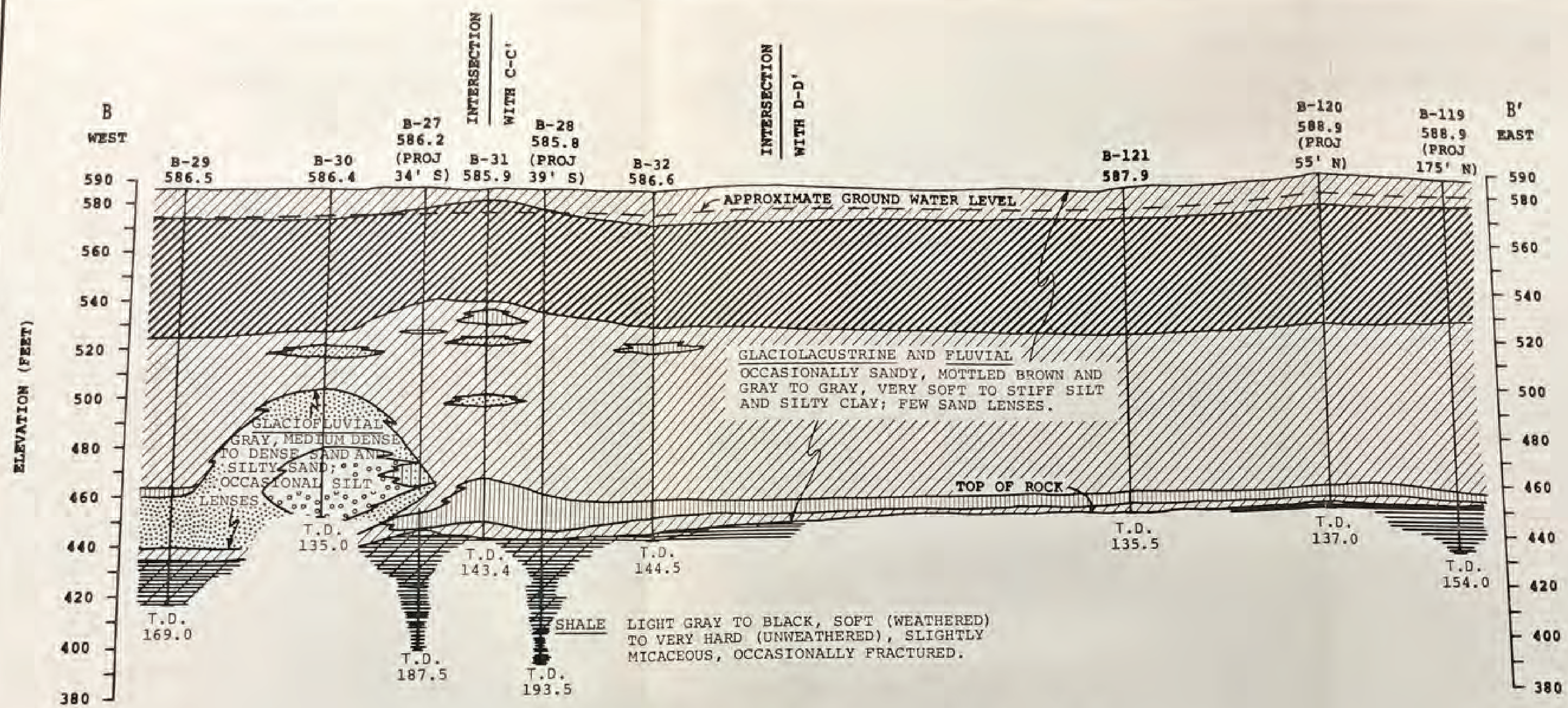
0 100 200 400 600

SCALE IN FEET

NOTES:

1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

BECHTEL ANN ARBOR	
BELLE RIVER PLANT UNIT 1 & 2	
SUBSURFACE PROFILE SECTION A-A'	
JOB NO. 10539	DRAWING NO. FIGURE 9
REV. 0	



EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

0 100 200 400 600

SCALE IN FEET

PLANT AREA – UNITS 1 & 2 COAL STORAGE AREA

LEGEND

Clay (CL)	Sand (SW)	Silty Sand (SM)
Clay (CH)	Silt (ML)	Shale (weathered)
Sand (SP)	Clayey Sand (SC)	Shale (unweathered)

NOTES:

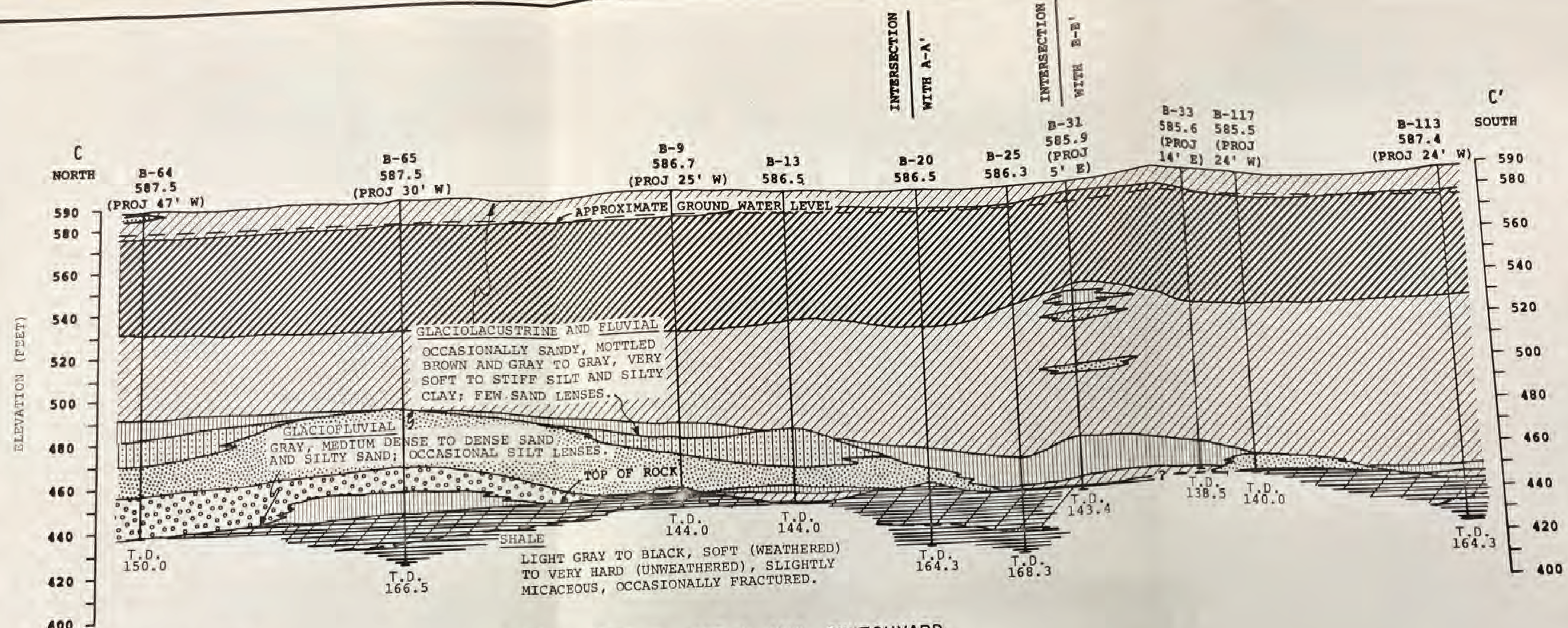
1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION B-B'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



PLANT AREA - UNIT I AND SWITCHYARD

LEGEND

- Clay (CL)
- Clay (CH)
- Sand (SP)
- Sand (SW)
- Silt (ML)
- Clayey Sand (SC)
- Silty Sand (SM)
- Shale (weathered)
- Shale (unweathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

0 100 200 400 600

SCALE IN FEET

NOTES:

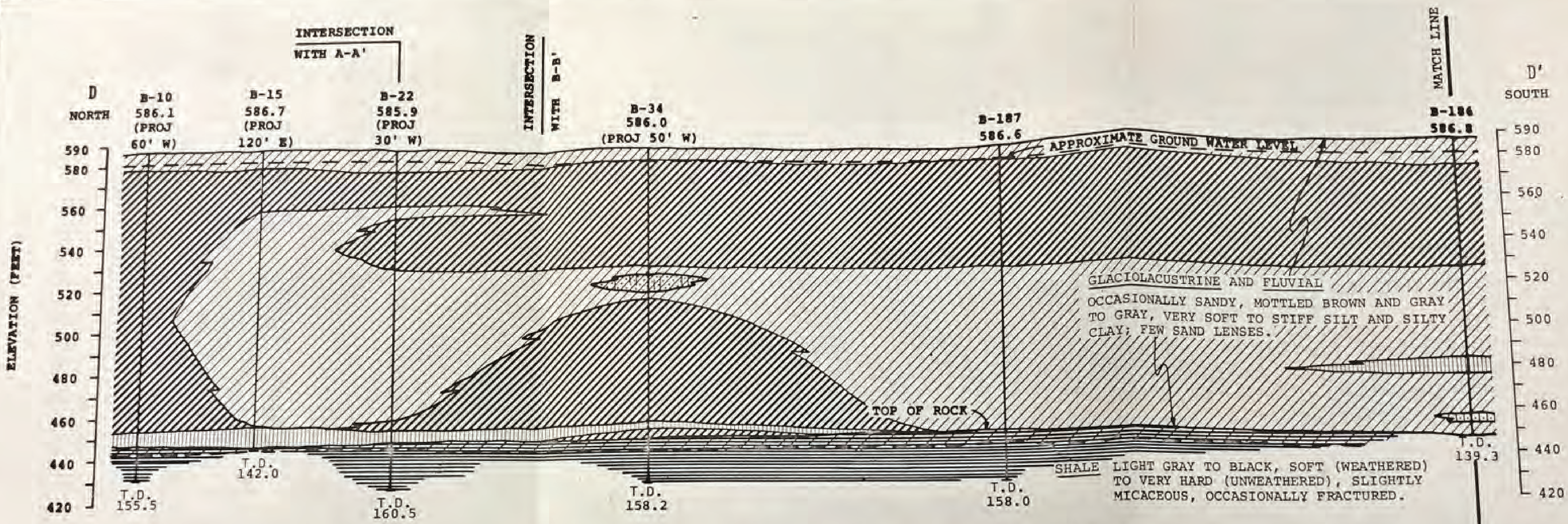
1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.3.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION C-C'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



PLANT AREA AND COAL HANDLING CONVEYOR SYSTEM

LEGEND

- Clay (CL)
- Clay (CH)
- Silt (ML)
- Clayey Sand (SC)
- Silty Sand (SM)
- Shale (weathered)
- Shale (unweathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

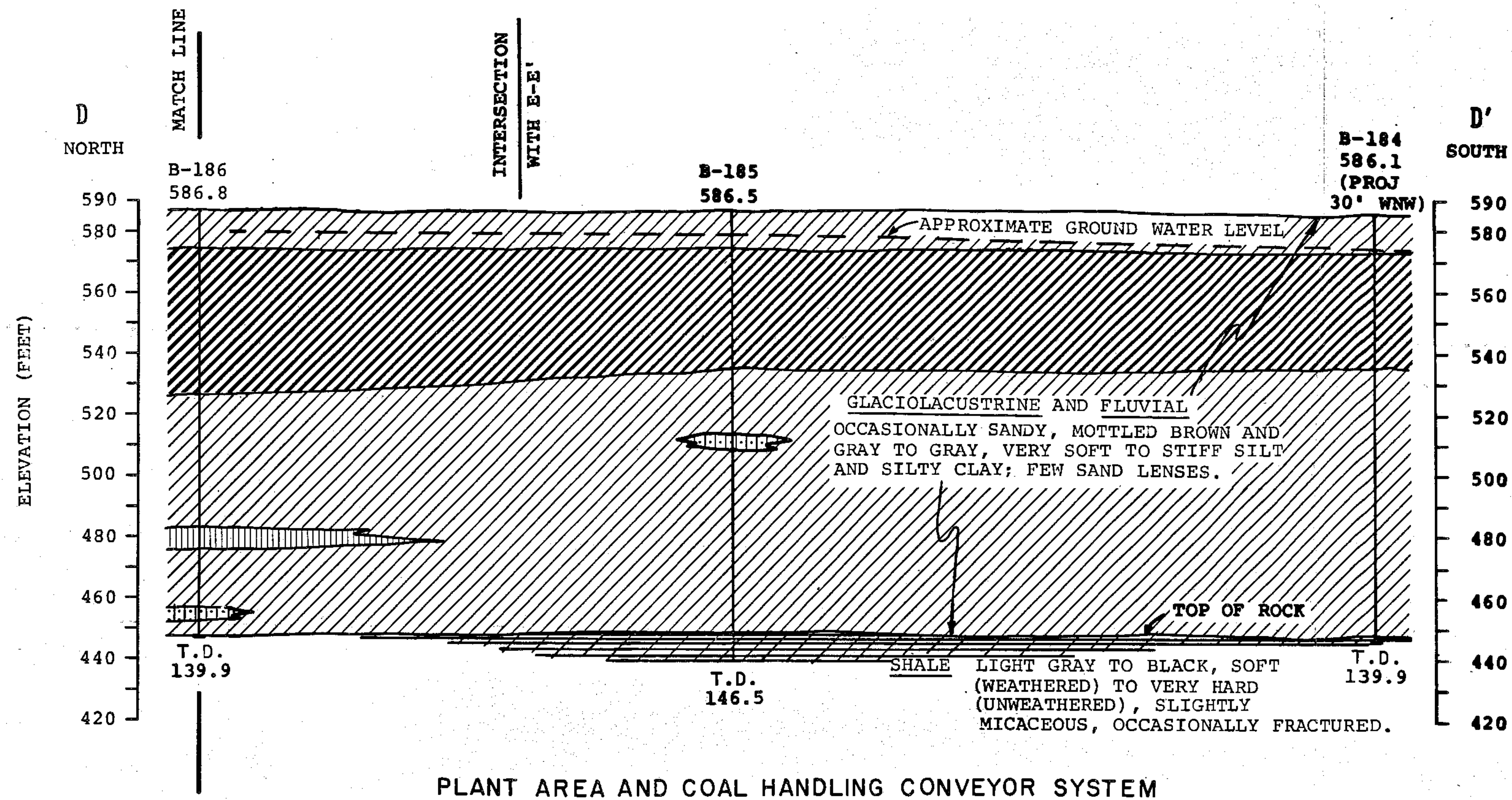
0 100 200 400 600

SCALE IN FEET

NOTES:

1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
SUBSURFACE PROFILE SECTION D-D' SHEET 1 OF 2		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



PLANT AREA AND COAL HANDLING CONVEYOR SYSTEM

LEGEND

- Clay (CL)
- Clay (CH)
- Silt (ML)
- Silty Sand (SM)
- Shale (weathered)

EXPLANATION

B-187	Bechtel borings (1973-1974)
T.D.	Total depth drilled (ft)

0 100 200 400 600

SCALE IN FEET

NOTES:

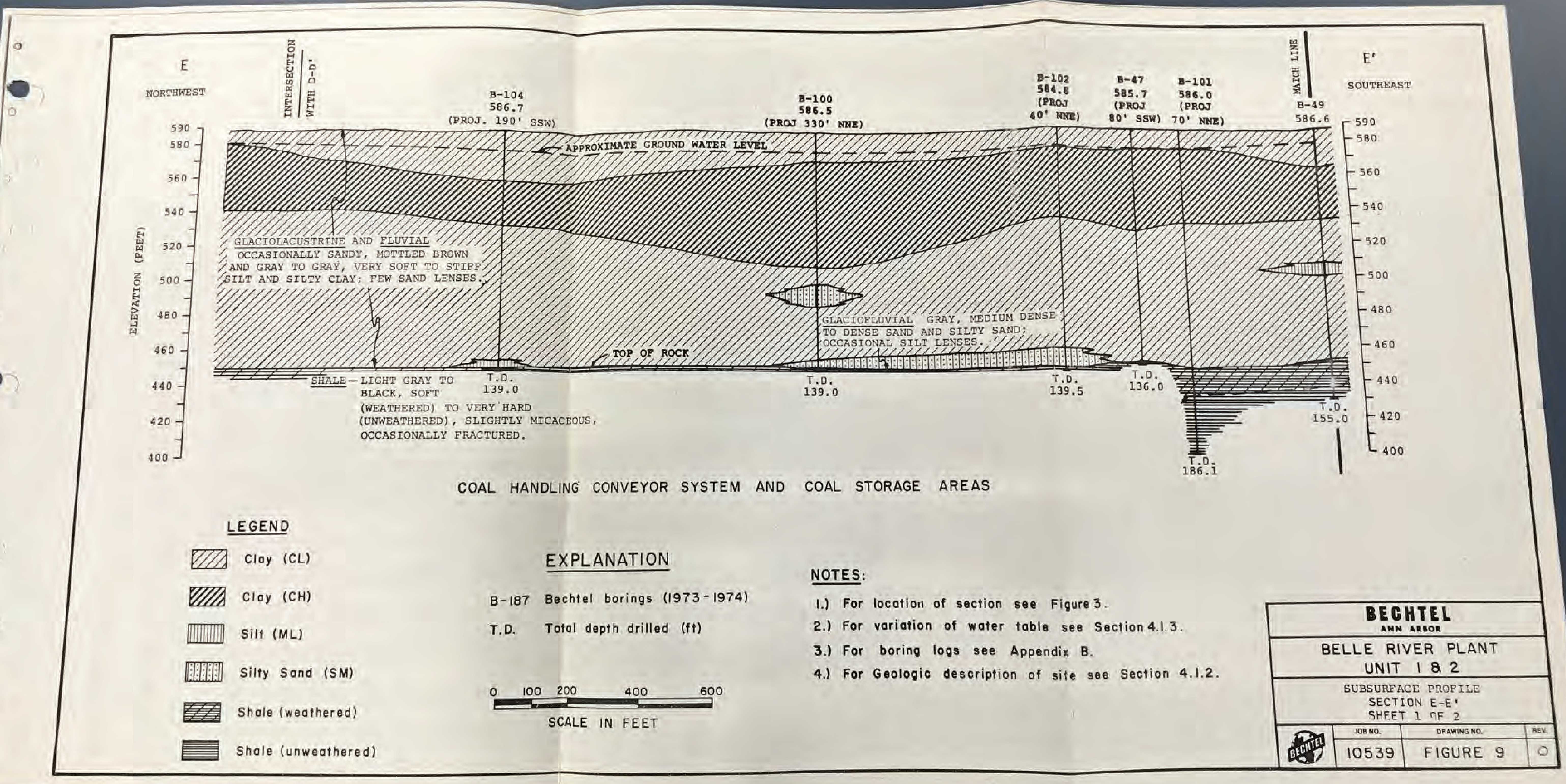
1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

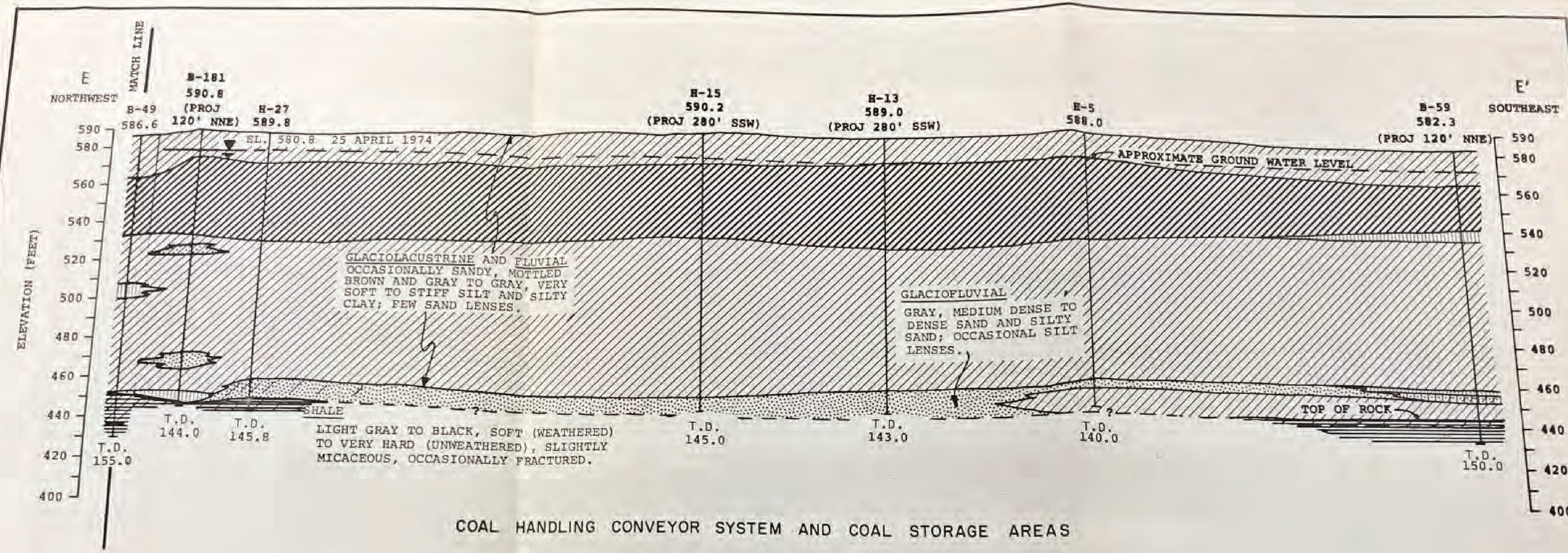
BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION D-D'
SHEET 2 OF 2

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0


E
NORTHWEST
INTERSECTION WITH D-D'
B-104
586.7
(PROJ. 190' SSW)
B-100
586.5
(PROJ 330' NNE)
B-102
584.8
(PROJ
40' NNE)
B-47
585.7
(PROJ
80' SSW)
B-101
586.0
(PROJ
70' NNE)
MATCH LINE
B-49
586.6
E'
SOUTHEAST
ELEVATION (FEET)
590
580
560
540
520
500
480
460
440
420
400
APPROXIMATE GROUND WATER LEVEL
GLACIOLACUSTRINE AND FLUVIAL
OCCASIONALLY SANDY, MOTTLED BROWN AND GRAY TO GRAY, VERY SOFT TO STIFF SILT AND SILTY CLAY; FEW SAND LENSES.
GLACIOFLUVIAL GRAY, MEDIUM DENSE TO DENSE SAND AND SILTY SAND; OCCASIONAL SILT LENSES.
TOP OF ROCK
SHALE — LIGHT GRAY TO BLACK, SOFT (WEATHERED) TO VERY HARD (UNWEATHERED), SLIGHTLY MICACEOUS, OCCASIONALLY FRACTURED.
T.D.
139.0
T.D.
139.0
T.D.
139.5
T.D.
136.0
T.D.
186.1
T.D.
155.0
COAL HANDLING CONVEYOR SYSTEM AND COAL STORAGE AREAS
LEGEND
Clay (CL)
Clay (CH)
Silt (ML)
Silty Sand (SM)
Shale (weathered)
Shale (unweathered)
EXPLANATION
B-187 Bechtel borings (1973-1974)
T.D. Total depth drilled (ft)
0 100 200 400 600
SCALE IN FEET
NOTES:
1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.
BECHTEL
ANN ARBOR
BELLE RIVER PLANT
UNIT 1 & 2
SUBSURFACE PROFILE
SECTION E-E'
SHEET 1 OF 2
JOB NO.
10539
DRAWING NO.
FIGURE 9
REV.
0



COAL HANDLING CONVEYOR SYSTEM AND COAL STORAGE AREAS

LEGEND

- Clay (CL)
- Clay (CH)
- Sand (SP)
- Silt (ML)
- Clayey Sand (SC)
- Silty Sand (SM)
- Shale (weathered)
- Shale (unweathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

H-15 Housel borings (1950-1967)

T.D. Total depth drilled (ft)

0 100 200 400 600

SCALE IN FEET

NOTES:

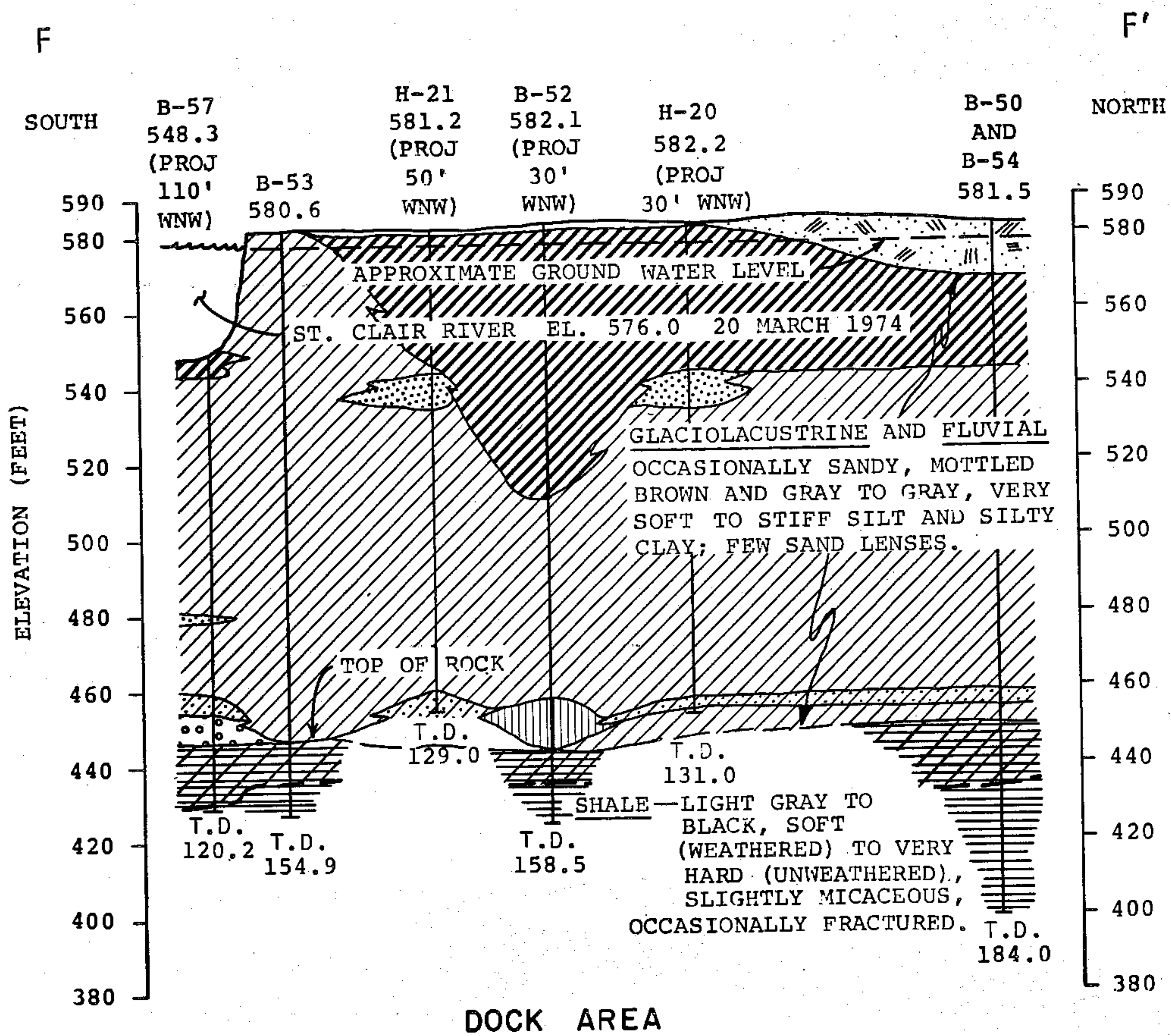
1.) For location of section see Figure 3.

2.) For variation of water table see Section 4.1.3.

3.) For boring logs see Appendix B.

4.) For Geologic description of site see Section 4.1.2.

BECHTEL ANN ARBOR	
BELLE RIVER PLANT UNIT 1 & 2	
SUBSURFACE PROFILE SECTION E-E' SHEET 2 OF 2	
JOB NO. 10539	DRAWING NO. FIGURE 9	REV. 0



LEGEND

- Clay (CL)
- Clay (CH)
- Sand (SP)
- Sand (SW)
- Silt (ML)
- Clayey Sand (SC)
- Fill
- Shale (weathered)
- Shale (unweathered)

0 100 200 400 600

SCALE IN FEET

NOTES:

1.) For location of section see Figure 3.

2.) For variation of water table see Section 4.1.3.

3.) For boring logs see Appendix B.

4.) For Geologic description of site see Section 4.1.2.

EXPLANATION

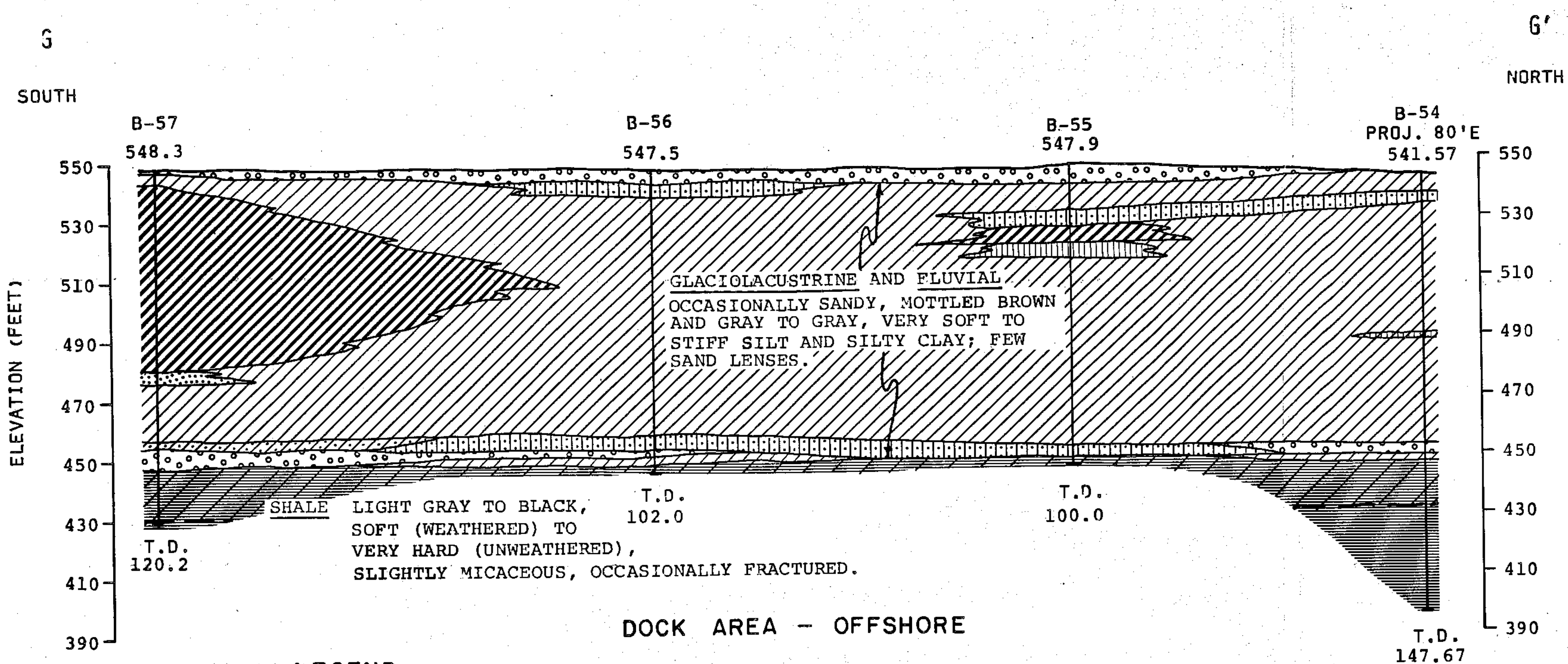
B-187	Bechtel borings (1973-1974)
H-15	Housel borings (1950-1967)
T.D.	Total depth drilled (ft)

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION F-F'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



LEGEND

- Clay (CL)
- Clay (CH)
- Sand (SP)
- Sand (SW)
- Silt (ML)
- Clayey Sand (SC)
- Silty Sand (SM)
- Shale (weathered)
- Shale (unweathered)

SCALE IN FEET

EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

NOTES:

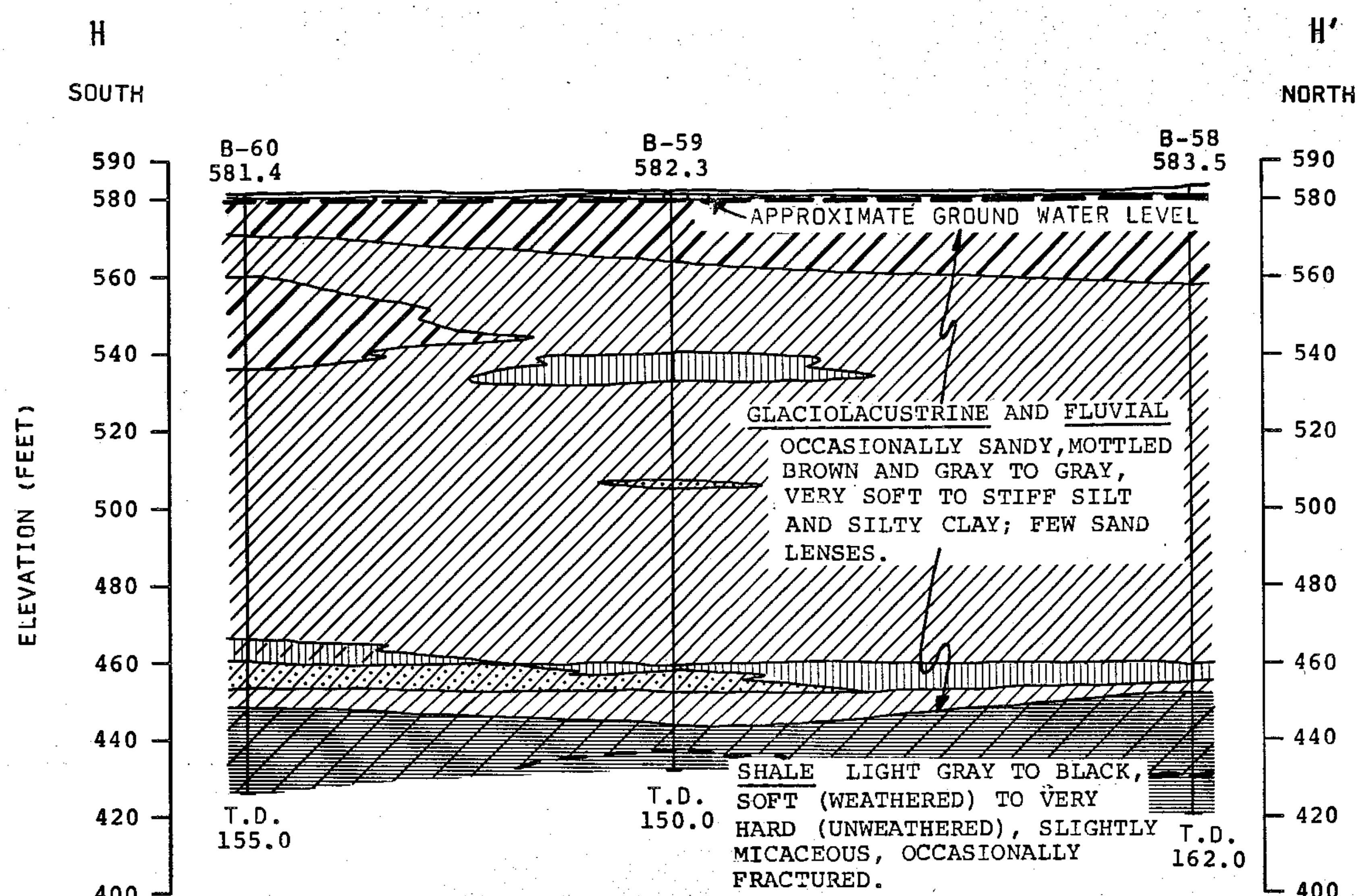
1.) For location of section see Figure 3.
2.) Depth of the St. Clair River water is approximately 31 feet throughout this section.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

BECHTEL
ANN ARBOR

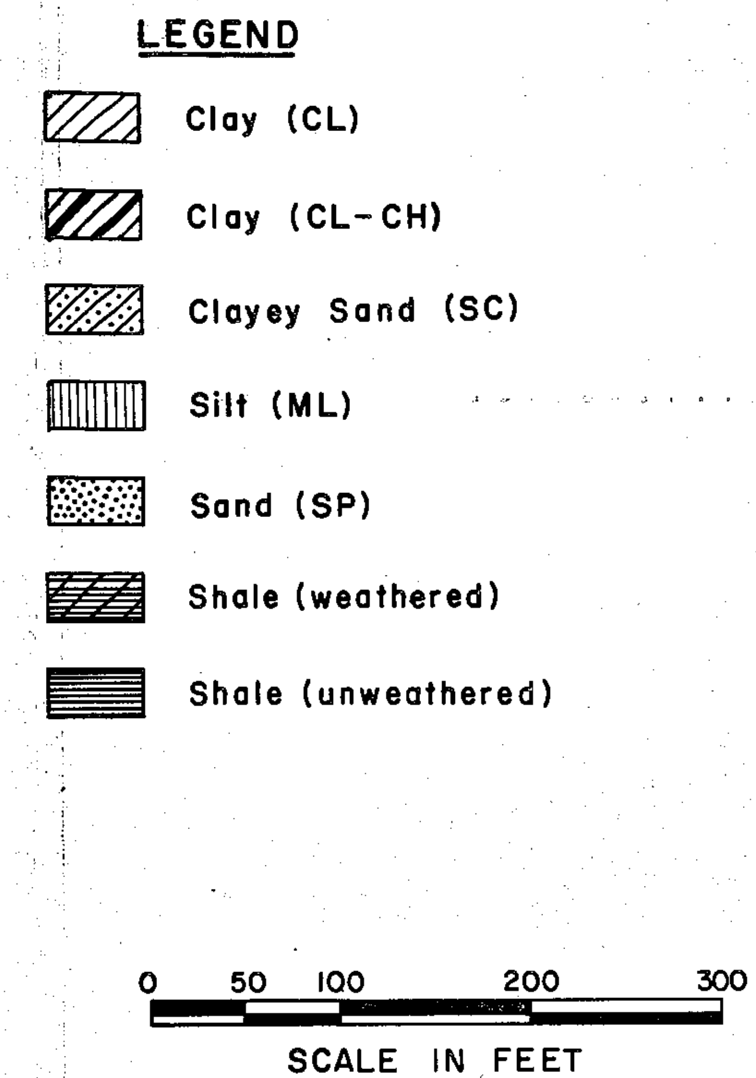
BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION G-G'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



DOCK AREA — TRANSFER HOUSES 1 & 2



EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

NOTES:

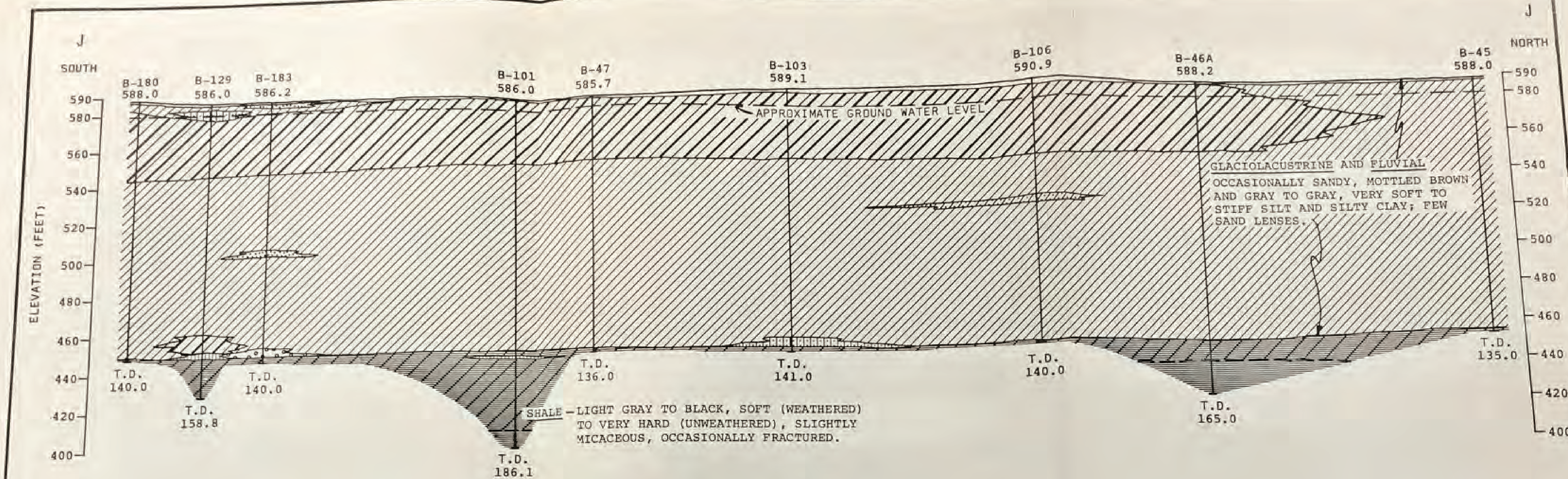
1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION H-H'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



LEGEND

- Clay (CL)
- Clay (CL-CH)
- Sand (SP)
- Sand (SW)
- Clayey Sand (SC)
- Silty Sand (SM)
- Silt (ML)
- Shale (weathered)
- Shale (unweathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

0 100 200 400 600

SCALE IN FEET

NOTES:

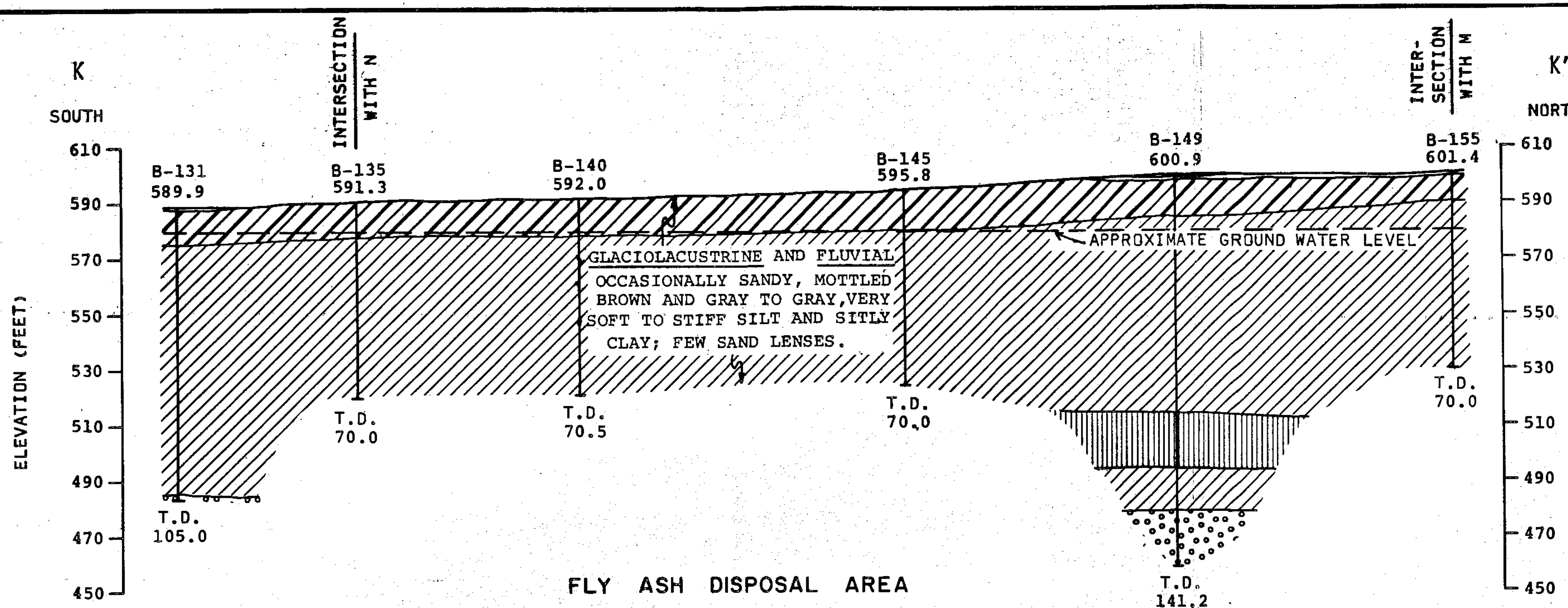
1.) For location of section see Figure 3.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION J-J'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



LEGEND

- Clay (CL)
- Clay (CL-CH)
- Sand (SW)
- Silt (ML)

EXPLANATION

B-187 Bechtel borings (1973 - 1974)

T.D. Total depth drilled (ft)

0 200 400 800 1200

SCALE IN FEET

NOTES:

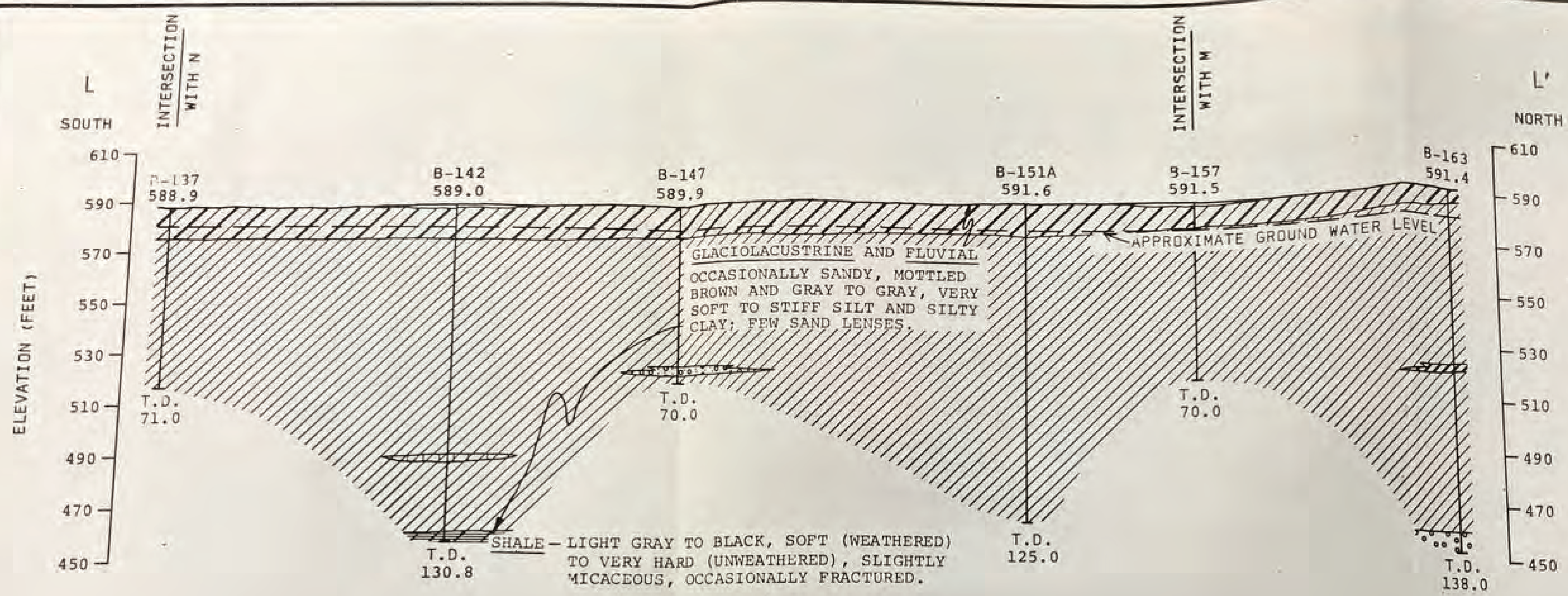
1.) For location of section see Figure 4.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION K-K'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



FLY ASH DISPOSAL AREA

NOTES:

1.) For location of section see Figure 4.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

0 200 400 800 1200
SCALE IN FEET

LEGEND

- Clay (CL)
- Clay (CH)
- Clay (CL-CH)
- Sand (SP)
- Sand (SW)
- Silt (ML)
- Shale (weathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

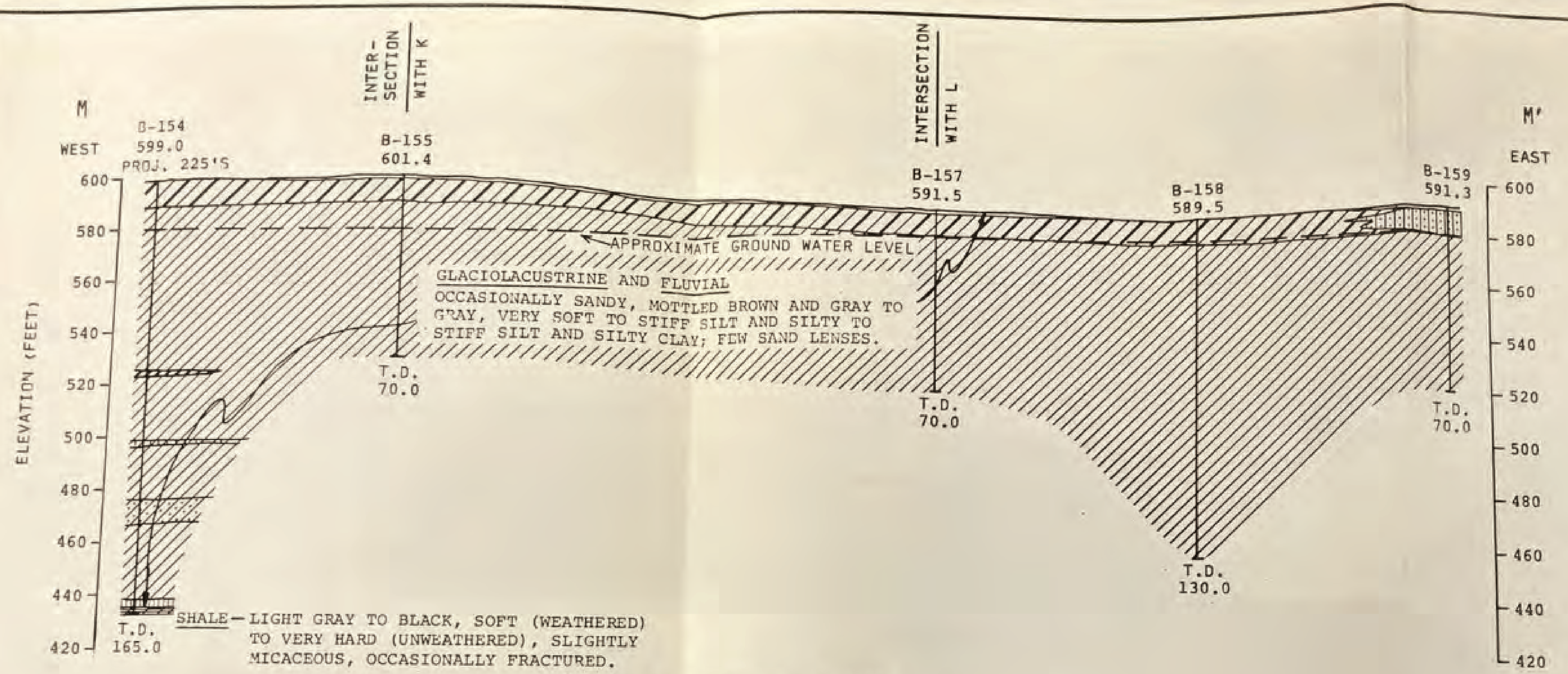
T.D. Total depth drilled (ft)

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION L-L'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	O



FLY ASH DISPOSAL AREA

NOTES:

1.) For location of section see Figure 4.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

0 200 400 800 1200

SCALE IN FEET

LEGEND

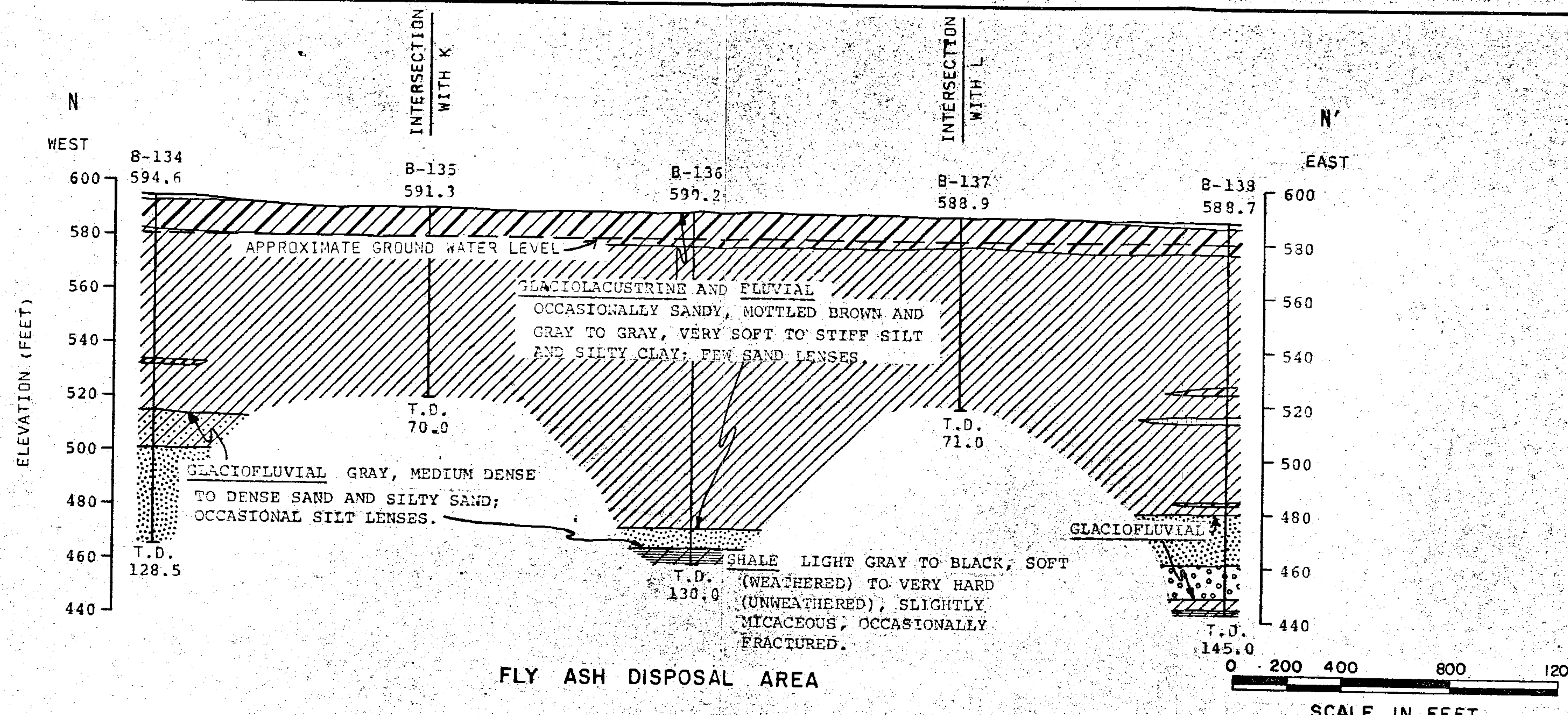
- Clay (CL)
- Clay (CH)
- Clay (CL-CH)
- Sand (SP)
- Silt (ML)
- Silty Sand (SM)
- Clayey Sand (SC)
- Shale (weathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
SUBSURFACE PROFILE SECTION M-M'		
JOB NO. 10539	DRAWING NO. FIGURE 9	REV. 0



FLY ASH DISPOSAL AREA

LEGEND

- Clay (CL)
- Clay (CH)
- Clay (CL-CH)
- Sand (SP)
- Sand (SW)
- Silt (ML)
- Clayey Sand (SC)
- Shale (weathered)

EXPLANATION

B-187 Bechtel borings (1973-1974)

T.D. Total depth drilled (ft)

NOTES:

1.) For location of section see Figure 4.
2.) For variation of water table see Section 4.1.3.
3.) For boring logs see Appendix B.
4.) For Geologic description of site see Section 4.1.2.

NO.	DATE	REVISIONS	BY	CK'D	GROUP SUPV.	ENG'R	PROJ. ENG'R	MICRO FILM
B	8-26-76	ISSUED FOR PROJ USE						
A	6-13-76	ISSUED FOR FINAL EVAL.						

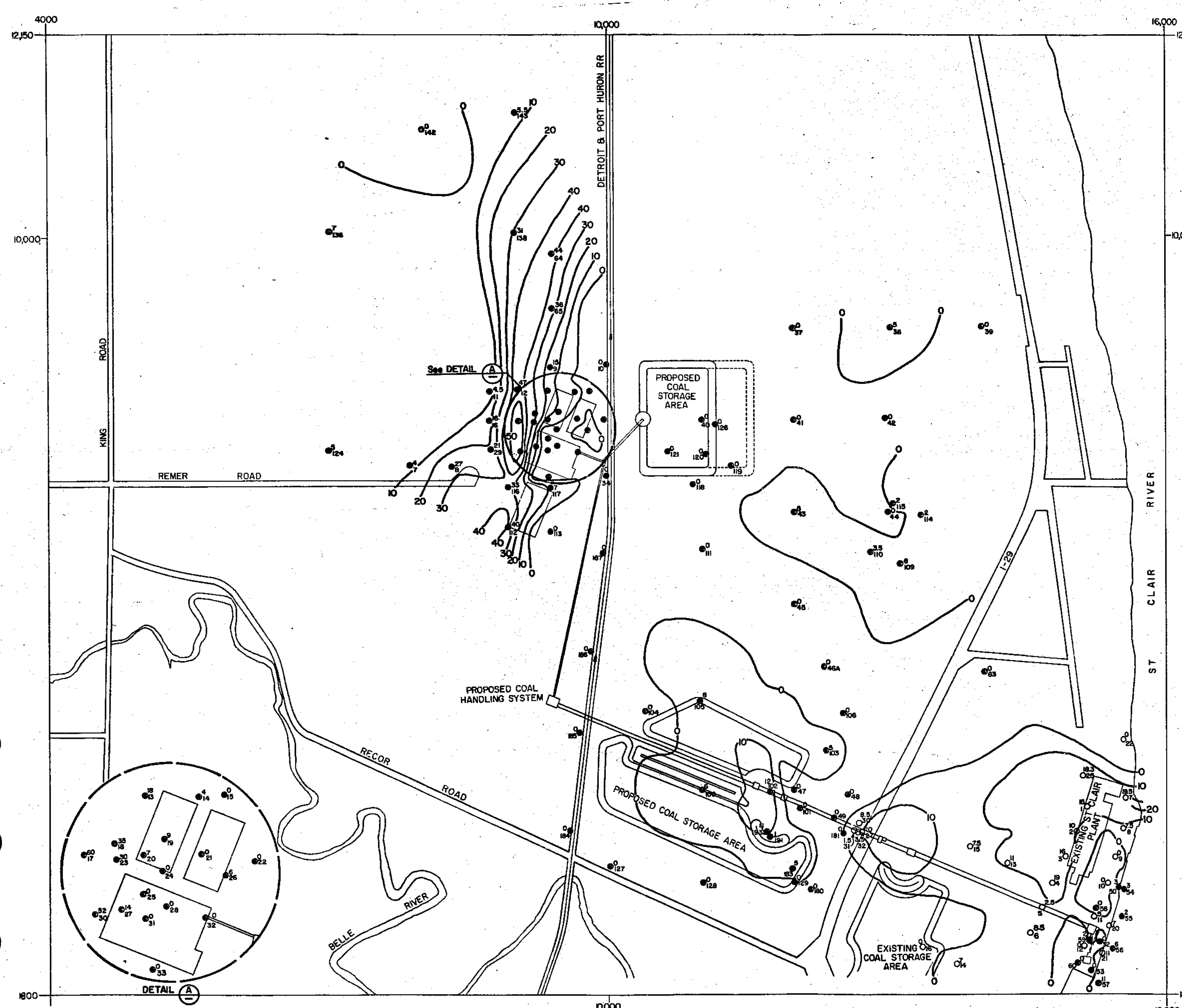
SCALE 1"=400' DESIGNED DRG/JBG DRAWN ARR

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

SUBSURFACE PROFILE
SECTION N-N'

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 9	0



EXPLANATION

- 7 — Basal sand thickness (ft)
- 117 — Boring number (present investigation)
- 3.5 — Basal sand thickness (ft)
- 32 — Boring number (previous investigations for St. Clair Plant)

NOTE: Detail A (plant area) enlarged for clarity, to twice graphic scale shown below.

N

0 200 400 800 1200

SCALE IN FEET

CONTOUR INTERVAL = 10 FT

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
BASAL SAND THICKNESS CONTOUR MAP		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 10	1

EXPLANATION

- 7 — Basal sand thickness (ft)
- 117 — Boring number (present investigation)
- 3.5 — Basal sand thickness (ft)
- 32 — Boring number (previous investigations for St. Clair Plant)

NOTE: Detail A (plant area) enlarged for clarity, to twice graphic scale shown below.

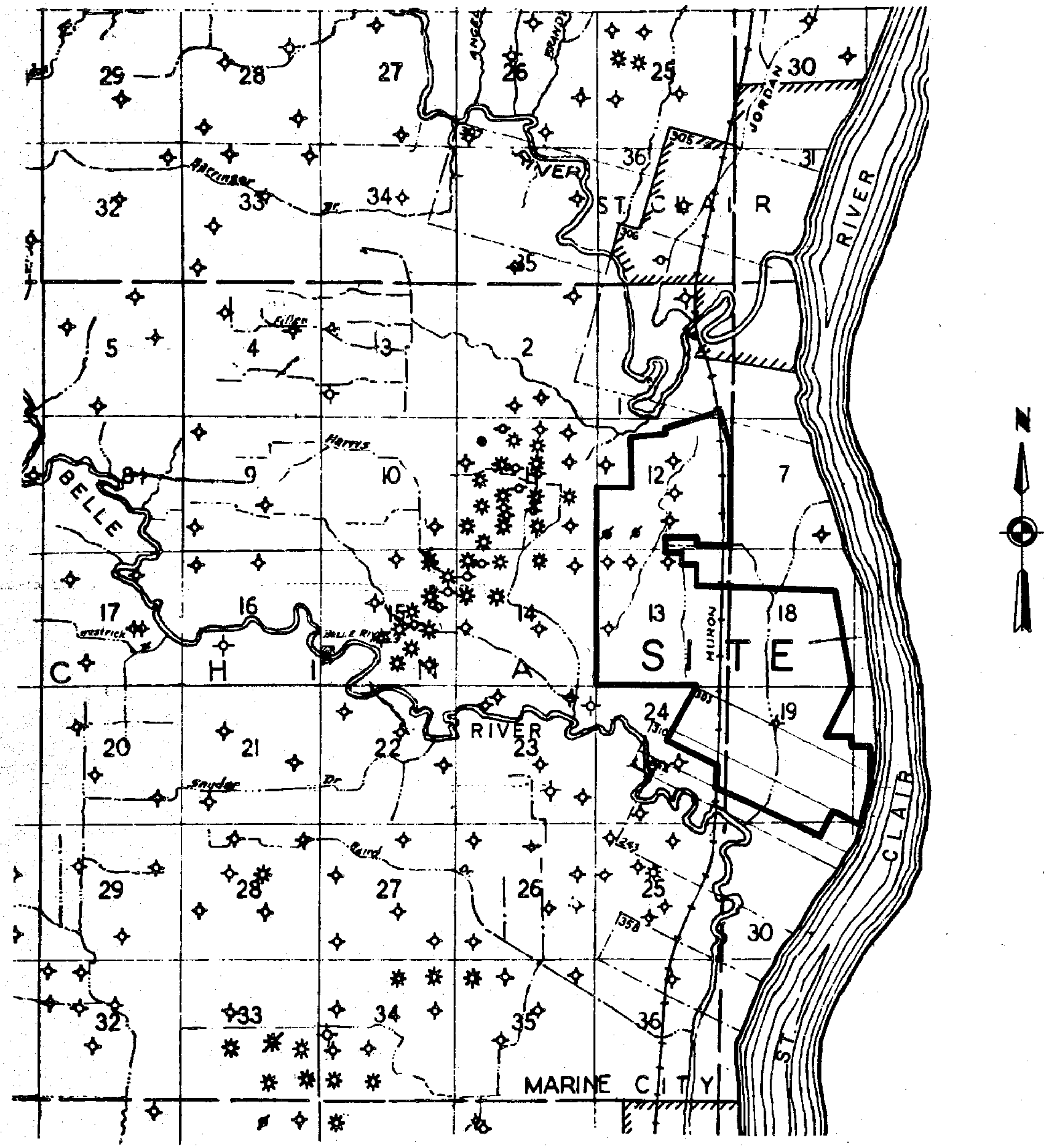
N

0 200 400 800 1200

SCALE IN FEET

CONTOUR INTERVAL = 10 FT

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
BASAL SAND THICKNESS CONTOUR MAP		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 10	1



EXPLANATION

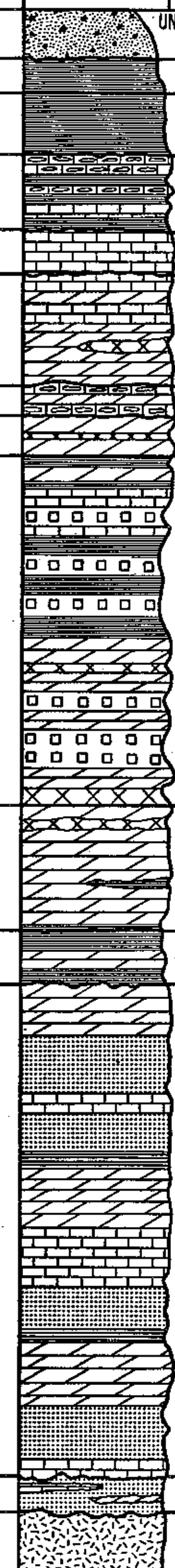
- Oil Well
- Gas Well
- Dry Hole
- Other
- Abandoned Well

REFERENCE:

Modified from Michigan Geological Survey Oil and Gas Well Map 3689A, St. Clair County.

0 1/2 1 2
SCALE IN MILES

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
LOCATION OF OIL AND GAS WELLS		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 12	0

APPROXIMATE DEPTH (FT)	ERA	PERIOD	ROCK GROUPS AND FORMATIONS	GRAPHIC LOG	LITHOLOGY	APPROXIMATE THICKNESS AT SITE
	CENOZOIC ERA QUATERNARY PERIOD		GLACIAL DRIFT		UNCONSOLIDATED DEPOSITS OF SAND, SILT AND CLAY. TWO MAJOR TYPES OCCUR: GLACIOLACUSTRINE-FLUVIAL CLAYS AND SILTS AND GLACIOFLUVIAL SANDS	133-157 (FT)
	PALEOZOIC	MISS.-DEVONIAN	BEDFORD SHALE		GRAY AND DARK GRAY SHALE	100
	PALEOZOIC	MISS.-DEVONIAN	ANTRIM SHALE		BLACK AND DARK BROWN SHALE WITH SOME PYRITE AND MARCASITE	200
	PALEOZOIC	DEVONIAN	TRAVERSE GROUP		GRAY, LIGHT GRAY, AND BROWN CHERTY LIMESTONE WITH BEDS OF GRAY SHALE. GRAY AND BLUE SHALE BELOW WITH MINOR LIMESTONE BEDS	240
	PALEOZOIC	DEVONIAN	DUNDEE LIMESTONE		BUFF, GRAY, AND BROWNISH-GRAY FINELY CRYSTALLINE LIMESTONE	130
1000	PALEOZOIC	DEVONIAN	DETROIT RIVER GROUP		BUFF TO WHITE LIMESTONE AND DOLOMITE WITH ANHYDRITE	360
	PALEOZOIC	DEVONIAN	BOIS BLANC FORMATION		WHITE TO GRAY CHERTY LIMESTONE AND DOLOMITE	90
	PALEOZOIC	SILURIAN	BASS ISLAND GROUP		BUFF TO CREAM DOLOMITE WITH MINOR ANHYDRITE	135
2000	PALEOZOIC	SILURIAN	SALINA GROUP		GRAY SHALE WITH SOME DOLOMITE BROWN LIMESTONE AND SALT GRAY SHALE AND SALT BROWN DOLOMITE WITH ANHYDRITE AND SALT	1100
	PALEOZOIC	SILURIAN	NIAGARA GROUP		GRAY, TAN, AND BROWN DOLOMITE WITH ANHYDRITE IN TOP SECTION, SHALE BELOW	400
3000	PALEOZOIC	SILURIAN	CATARACT GROUP		RED AND BLUE SHALE AND LIGHT GRAY BLUE DOLOMITE	160
4000	PALEOZOIC	ORDOVICIAN	(UNDIFFERENTIATED)		PRIMARILY DOLOMITE AND SANDSTONE WITH SHALE AND MINOR LIMESTONE	1550
	PALEOZOIC	CAMBRIAN	(UNDIFFERENTIATED)		PRIMARILY SANDSTONE WITH LIMESTONE AND DOLOMITE	100
			PRECAMBRIAN		IGNEOUS, METAMORPHIC AND SEDIMENTARY ROCKS	UNKNOWN

EXPLANATION

- Glacial Drift
- Shale
- Limestone
- Cherty Limestone
- Dolomite
- Anhydrite
- Salt
- Sandstone
- Igneous, Metamorphic, and Sedimentary Rock Complex

NOTE:

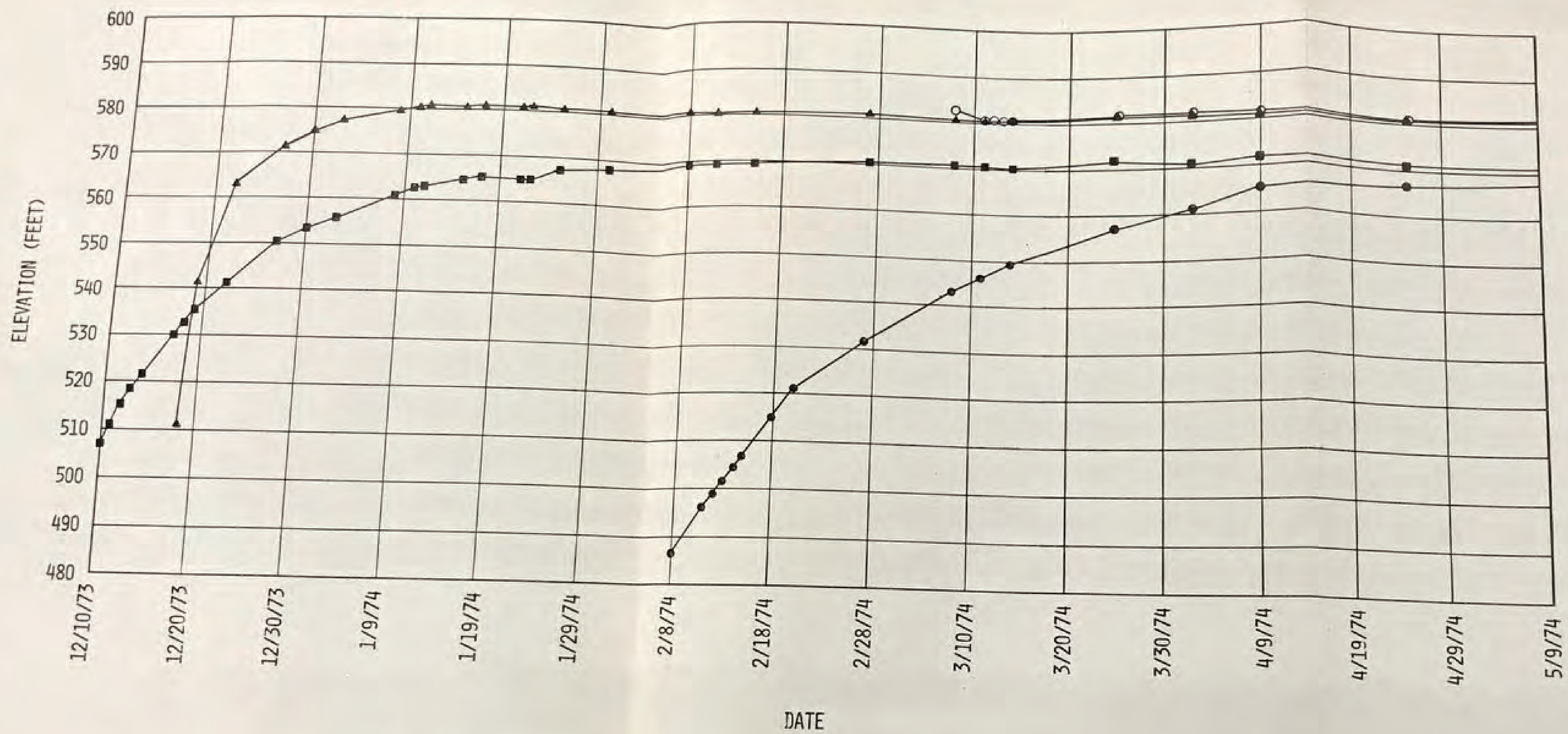
Overburden thickness determined from Bechtel logs. Thickness and description of geologic bedrock units above the Niagara group are based on logs of Wildcat wells drilled in China and East China Townships. These logs are on file with the Michigan Geological Survey in Lansing. Thickness and description of units below the Salina group were interpolated from Stratigraphic Cross-section Michigan Basin, Michigan Basin Geological Society, 1969; and Michigan's Oil and Gas Fields, 1972; Michigan Geological Annual Statistical Summary No. 18, 1973.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

GENERALIZED GEOLOGIC COLUMN
CHINA AND EAST CHINA TOWNSHIPS

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 13	1



EXPLANATION

- ■ Observation Well 7, bottom of screen at Elevation 450.5
- ● Observation Well 24, bottom of screen at Elevation 452.3
- ▲ Observation Well 40, bottom of screen at Elevation 509.1
- ○ Observation Well 181, bottom of screen at Elevation 449.3

NOTE:

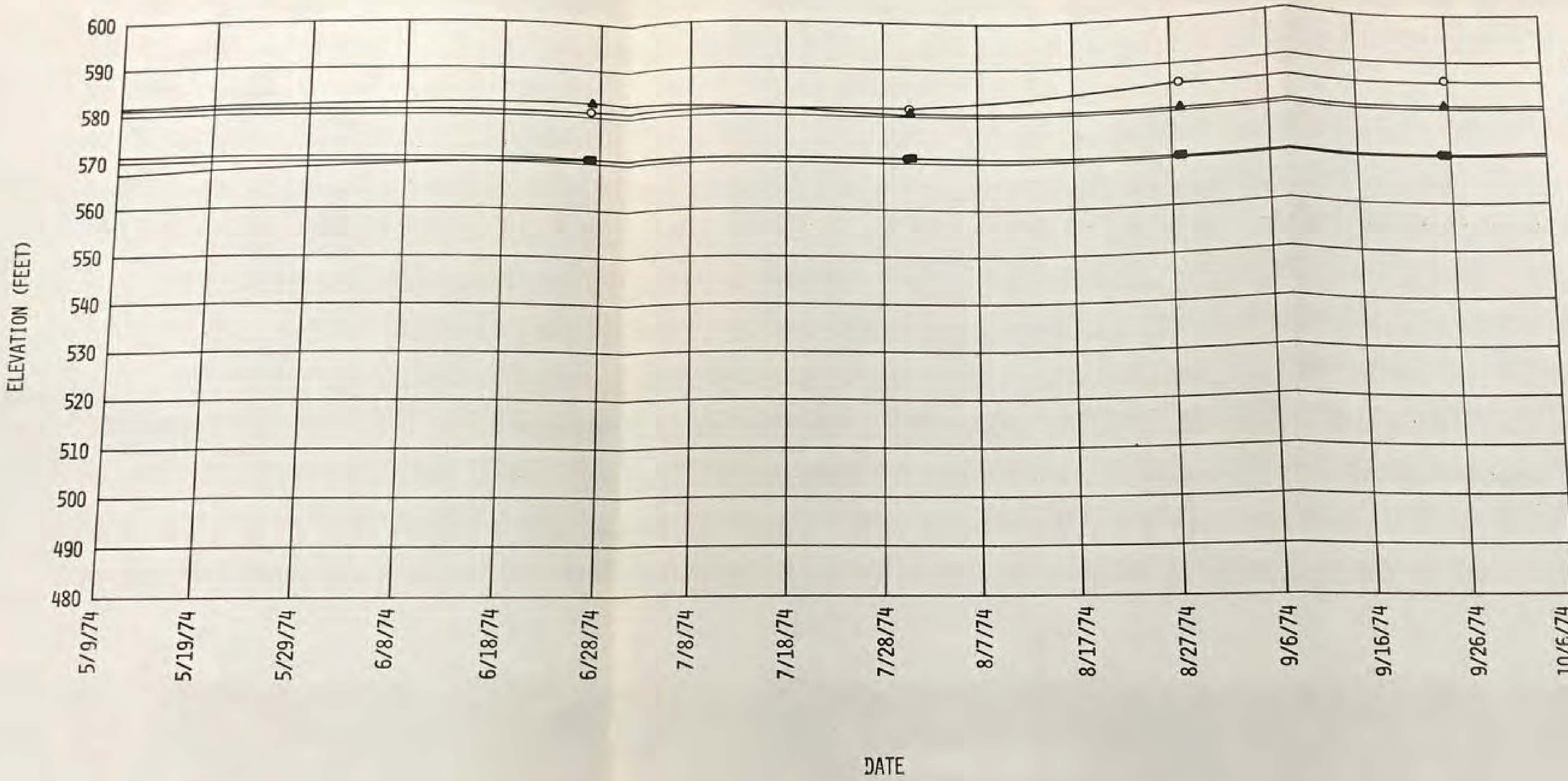
For location of Observation Wells see Figure 3.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

HYDROGRAPHS OF OBSERVATION WELLS
SHEET 1 OF 3

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 14	1



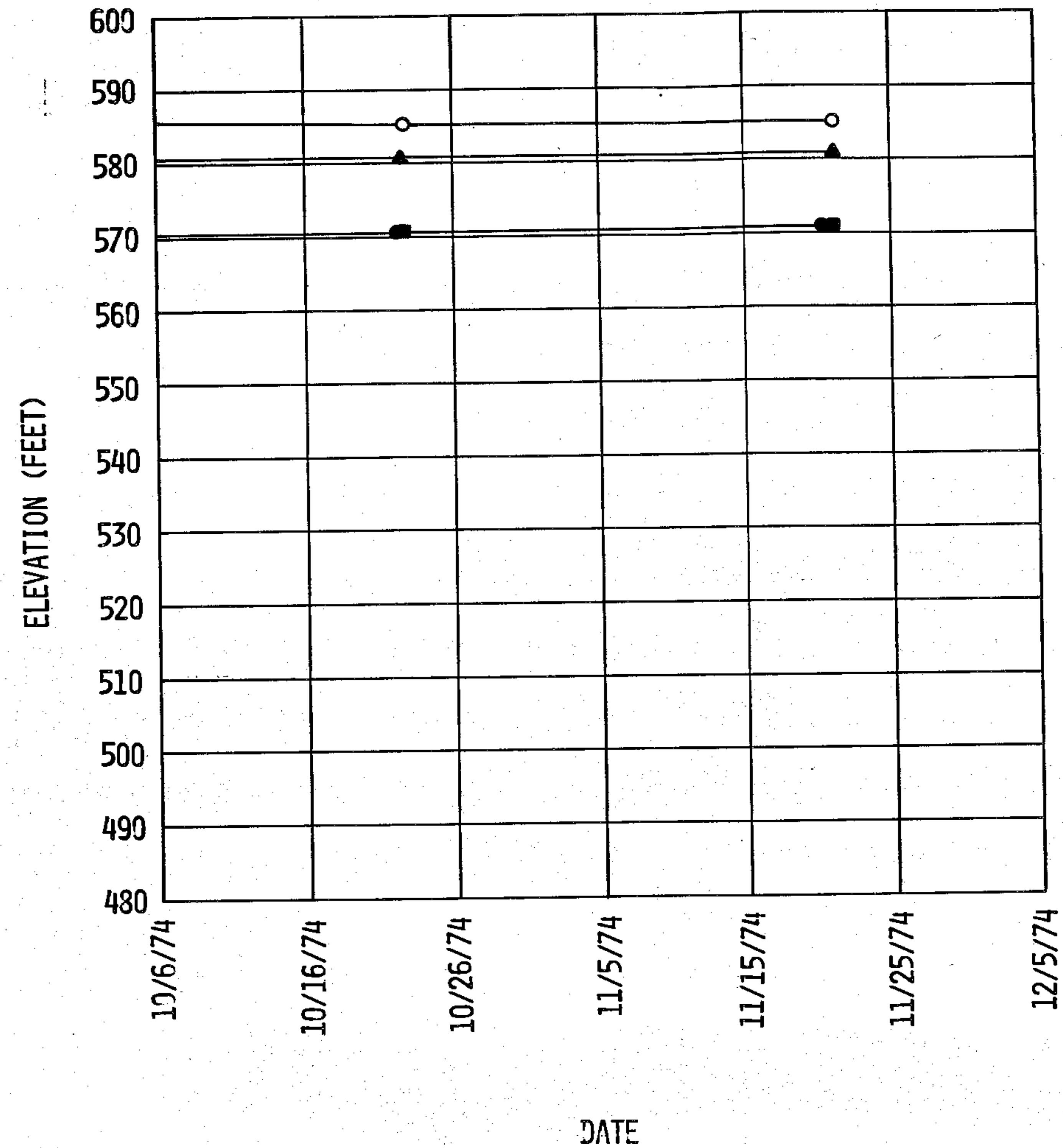
EXPLANATION

- ■ Observation Well 7, bottom of screen at Elevation 450.5
- ● Observation Well 24, bottom of screen at Elevation 452.3
- ▲ Observation Well 40, bottom of screen at Elevation 509.1
- ○ Observation Well 181, bottom of screen at Elevation 449.3

NOTE

For location of Observation Wells see Figure 3.

BECHTEL ANN ARBOR			
BELLE RIVER PLANT UNIT 1 & 2			
HYDROGRAPHS OF OBSERVATION WELLS SHEET 2 OF 3			
BECHTEL	JOB NO. 10539	DRAWING NO. FIGURE 14	REV. 1



EXPLANATION

- ■ Observation Well 7, bottom of screen at Elevation 450.5
- ● Observation Well 24, bottom of screen at Elevation 452.3
- ▲ Observation Well 40, bottom of screen at Elevation 509.1
- ○ Observation Well 181, bottom of screen at Elevation 449.3

NOTE:

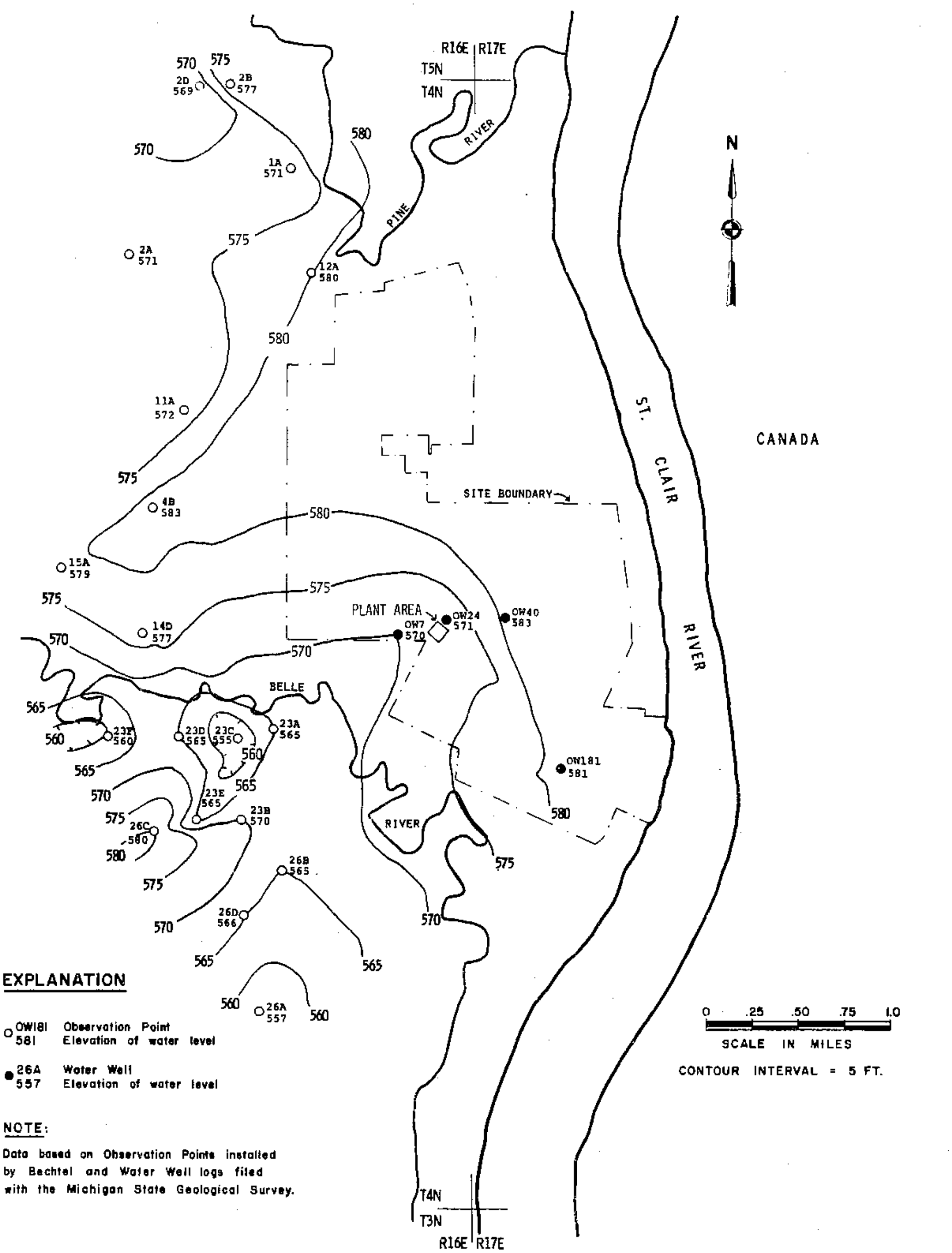
For location of Observation Wells see Figure 3.

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

HYDROGRAPHS OF OBSERVATION WELLS
SHEET 3 OF 3

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 14	1



EXPLANATION

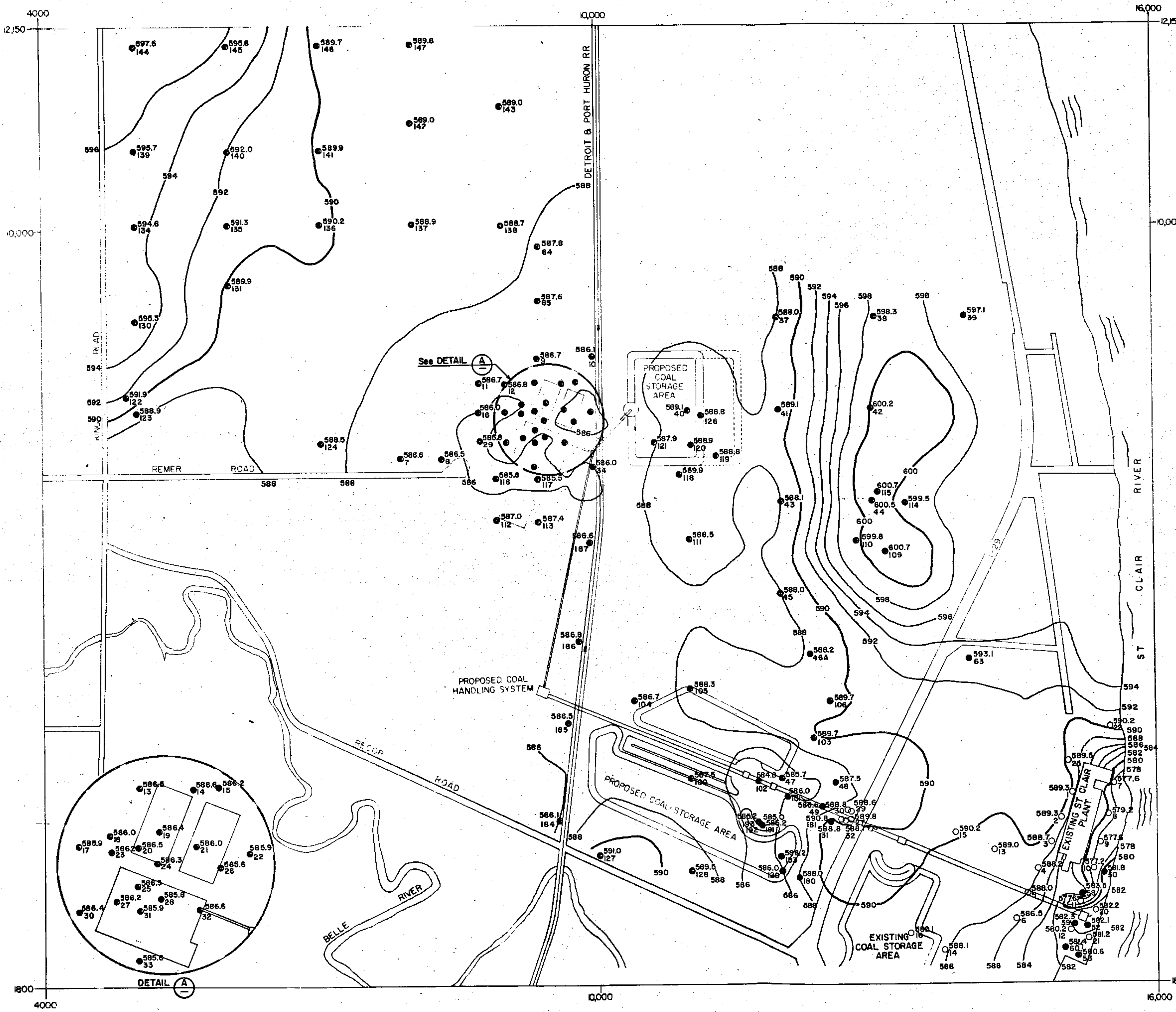
○ OW181 581 — Observation Point, Elevation of water level

● 26A 557 — Water Well, Elevation of water level

NOTE:

Data based on Observation Points installed by Bechtel and Water Well logs filed with the Michigan State Geological Survey.

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
GROUND WATER LEVEL CONTOUR MAP		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 15	1



EXPLANATION

- 586.6 / 187 — Ground surface elevation (ft); Boring number (present investigation)
- 588.7 / 32 — Ground surface elevation (ft); Boring number (previous investigations for St Clair plant)

NOTES:

1. Contours generated from drill hole data by McDonnell Douglas Automation Company's SURMAP computer program.
2. Computer interpretation modified manually to accommodate additional data points.
3. Detail A (plant area) enlarged for clarity, to twice graphic scale shown below.

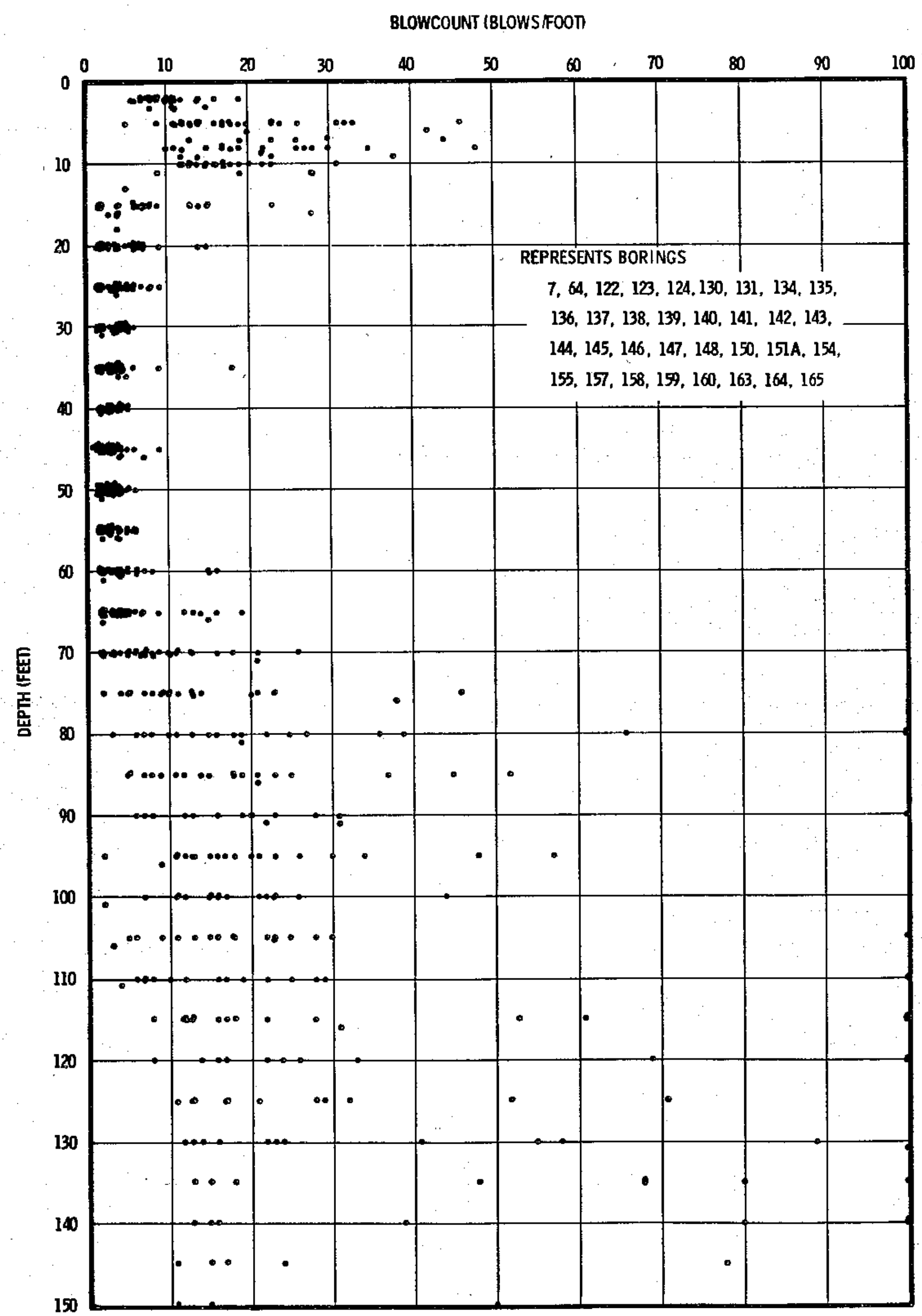
N

0 200 400 800 1200

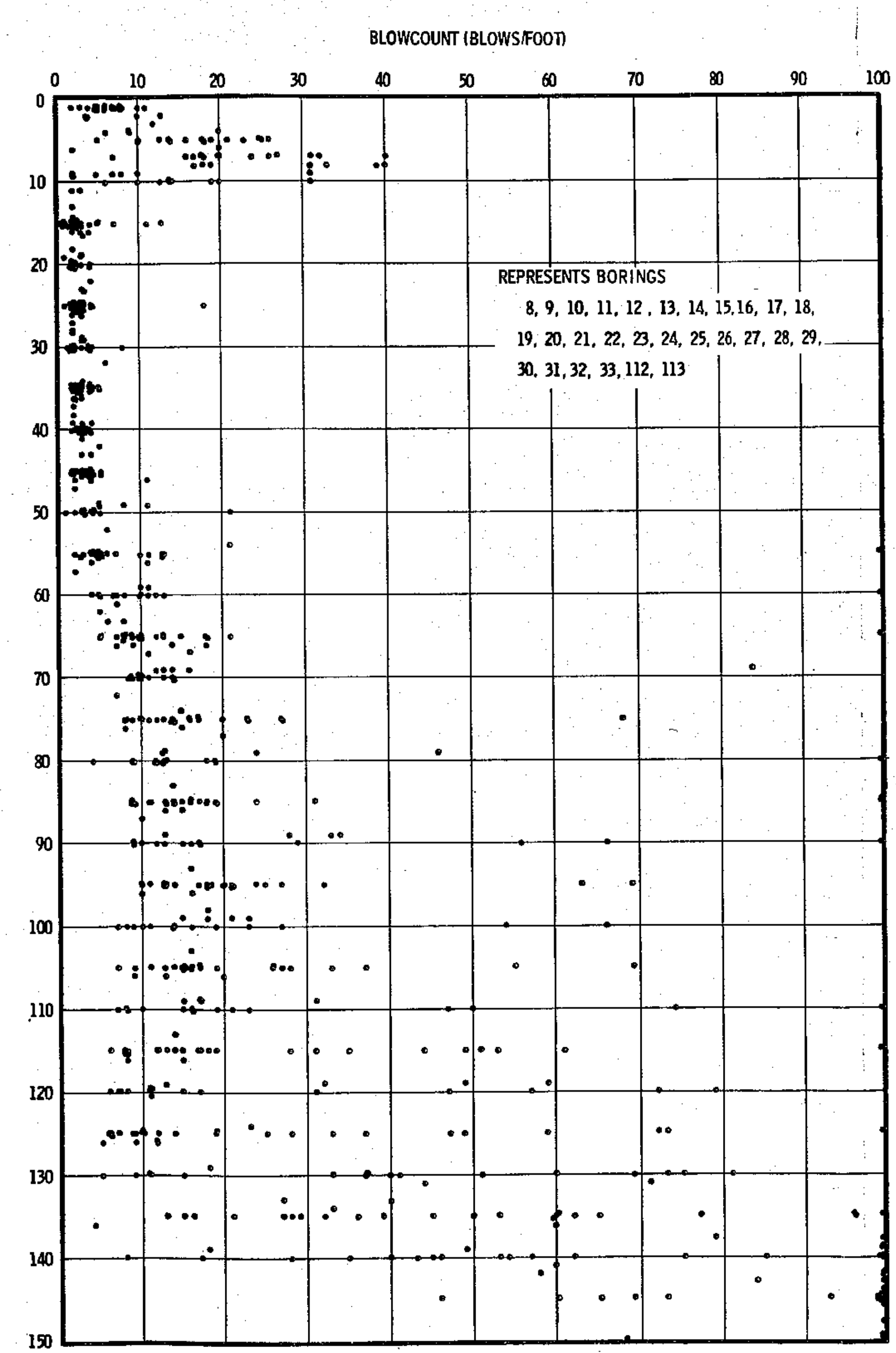
SCALE IN FEET

CONTOUR INTERVAL = 2 FT

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
GROUND SURFACE CONTOUR MAP		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 16	1



NORTH AREA



MAIN PLANT AREA

BECHTEL
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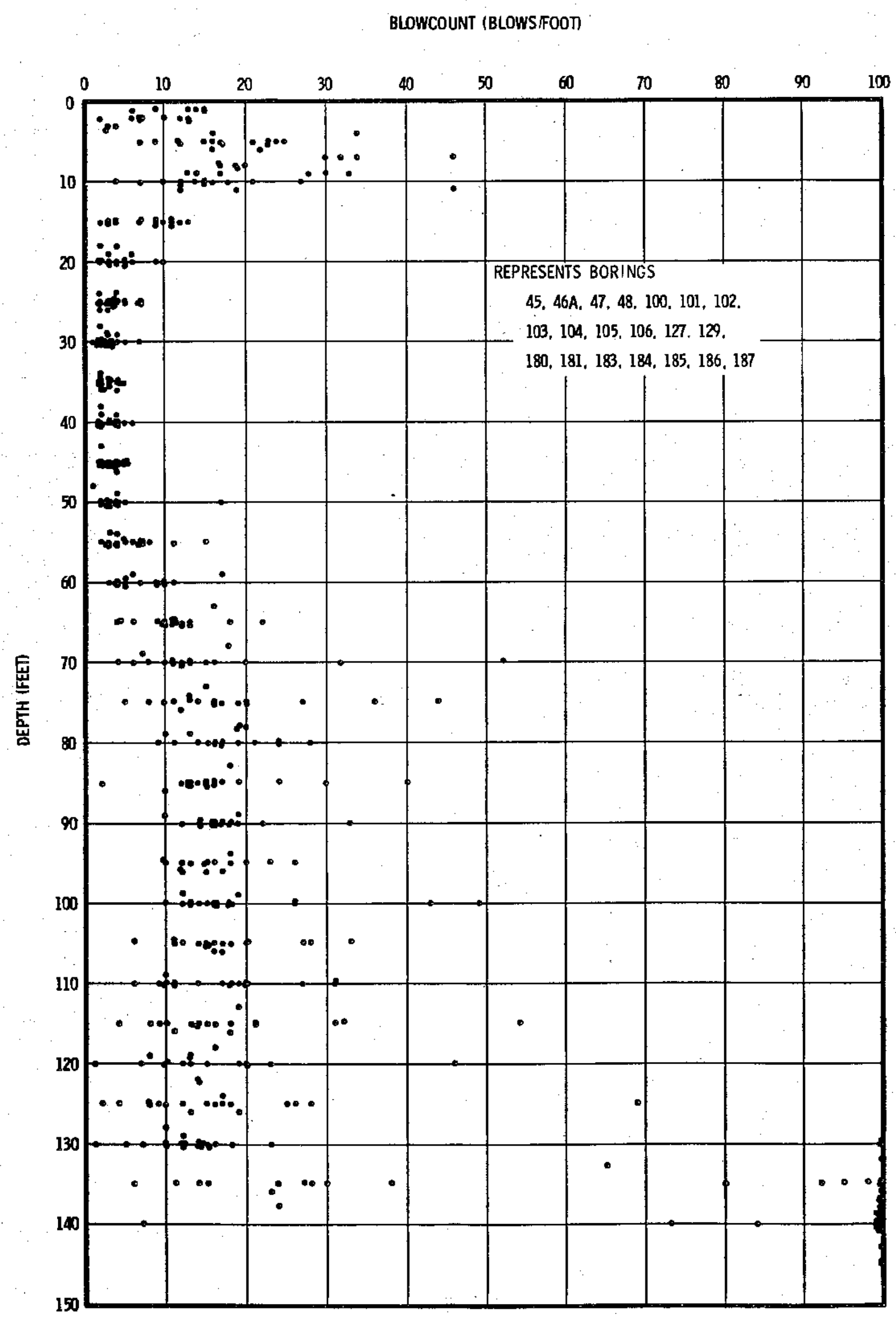
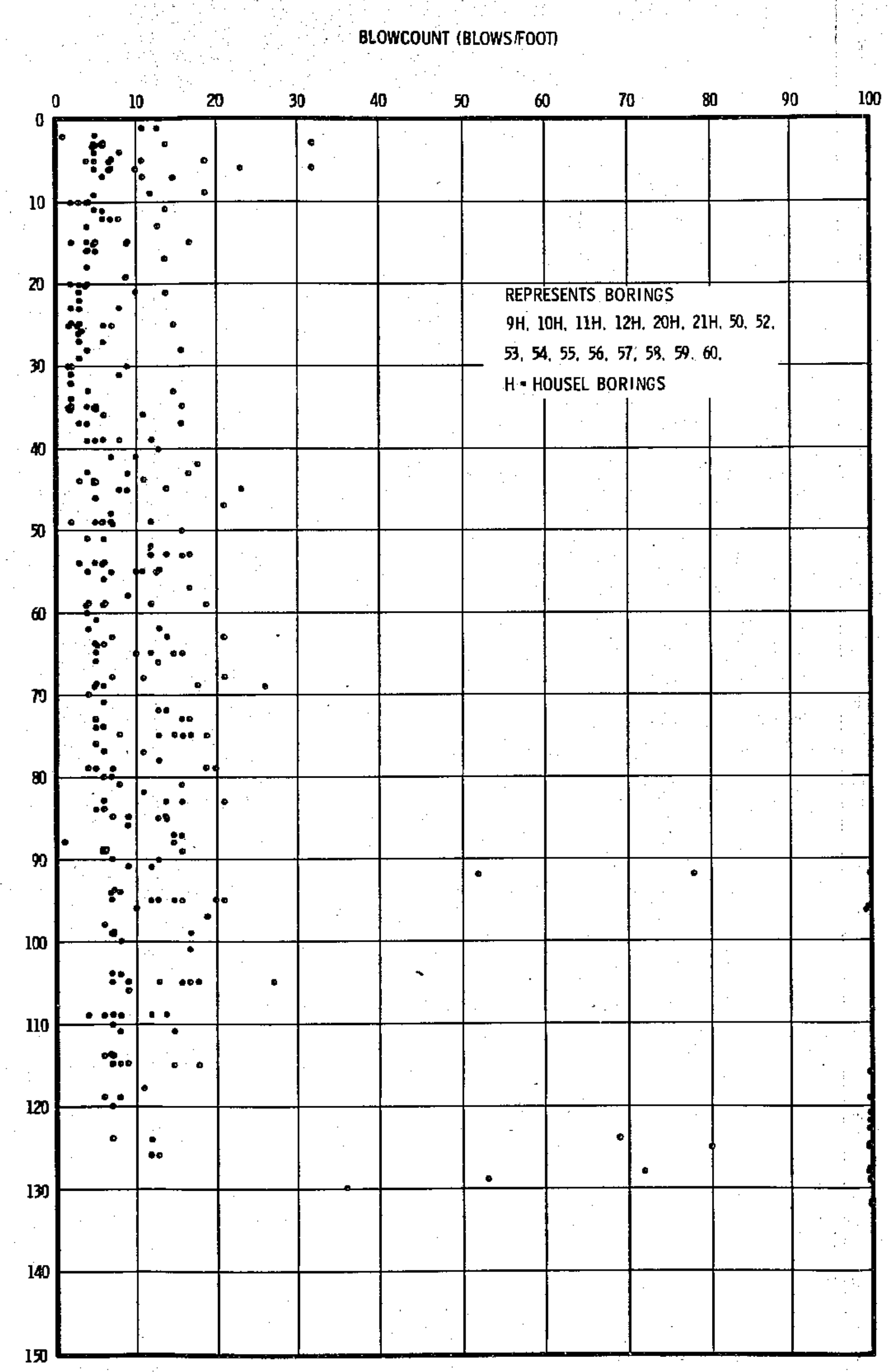
BELLE RIVER PLANT
UNITS 1 & 2

BLOWCOUNT vs DEPTH
SHEET 1 OF 2

JOB No.	DRAWING No.	REV.
10539	FIGURE 17	0



COAL STORAGE AREA



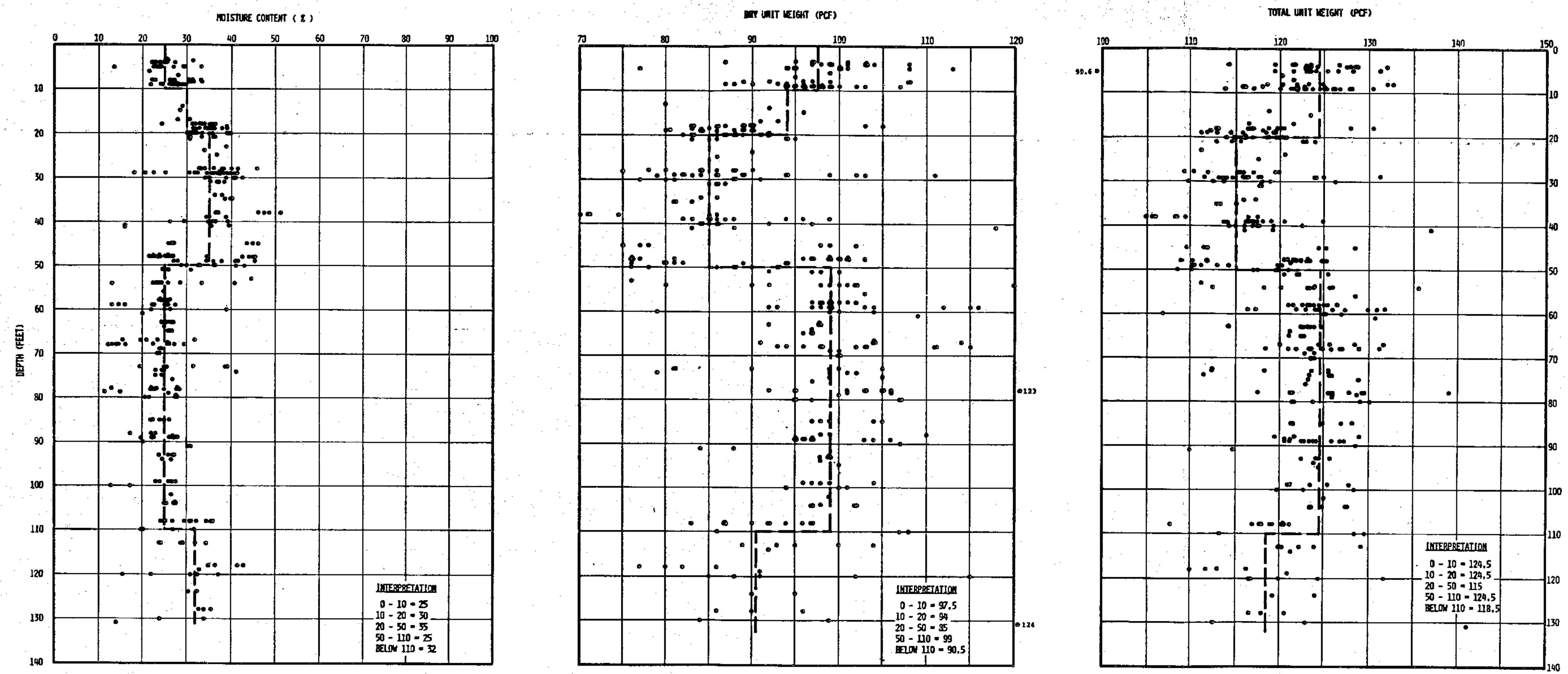
DOCK AREA

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNITS 1 & 2

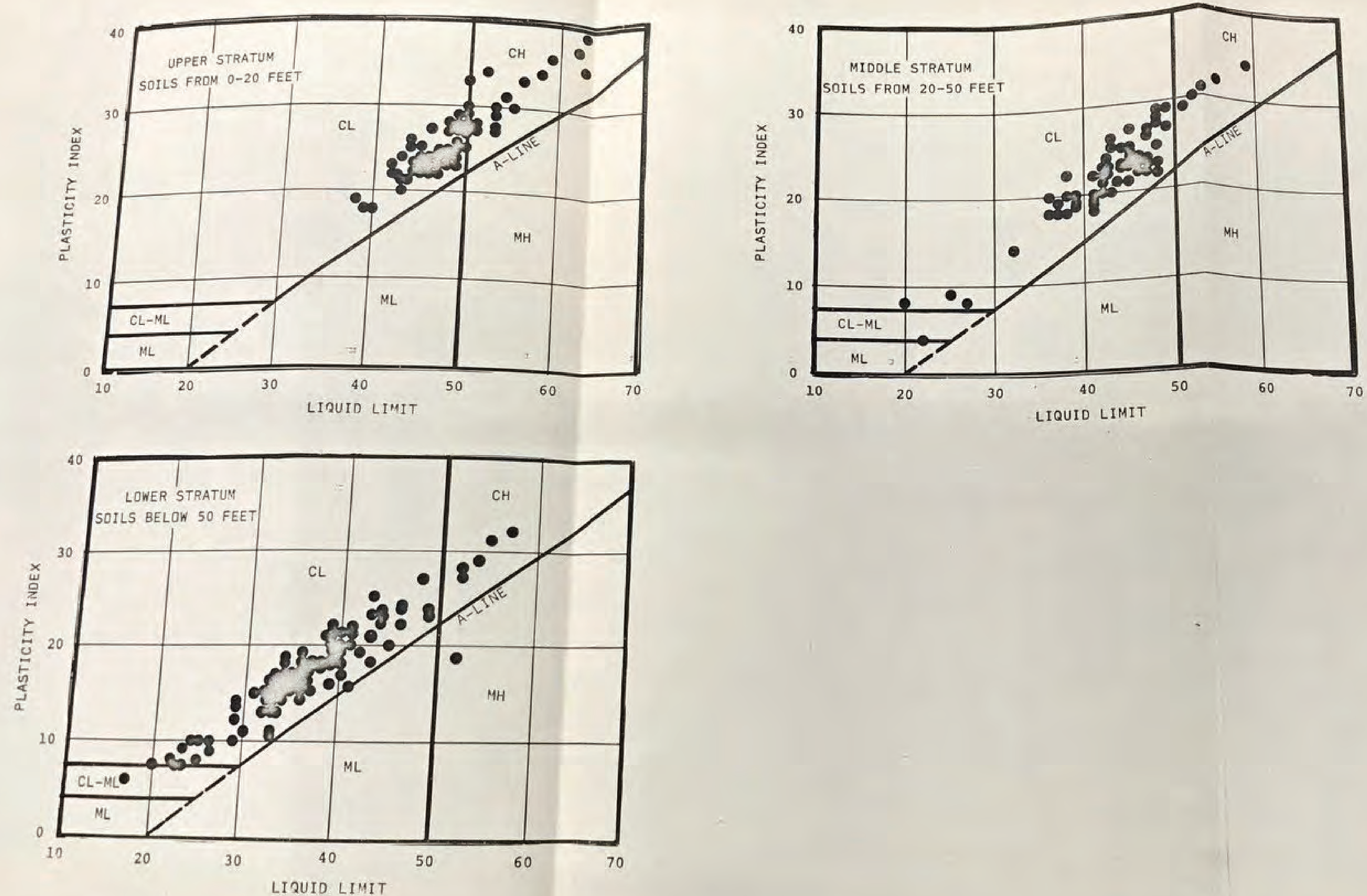
BLOWCOUNT vs DEPTH
SHEET 2 OF 2

JOB No.	DRAWING No.	REV.
10539	FIGURE 17	O



NOTE: DATA INCLUDES RESULTS OF ALL TESTS PERFORMED THROUGHOUT THE ENTIRE SITE.

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
MOISTURE CONTENT, DRY UNIT WEIGHT, AND TOTAL UNIT WEIGHT VS DEPTH		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 18	0



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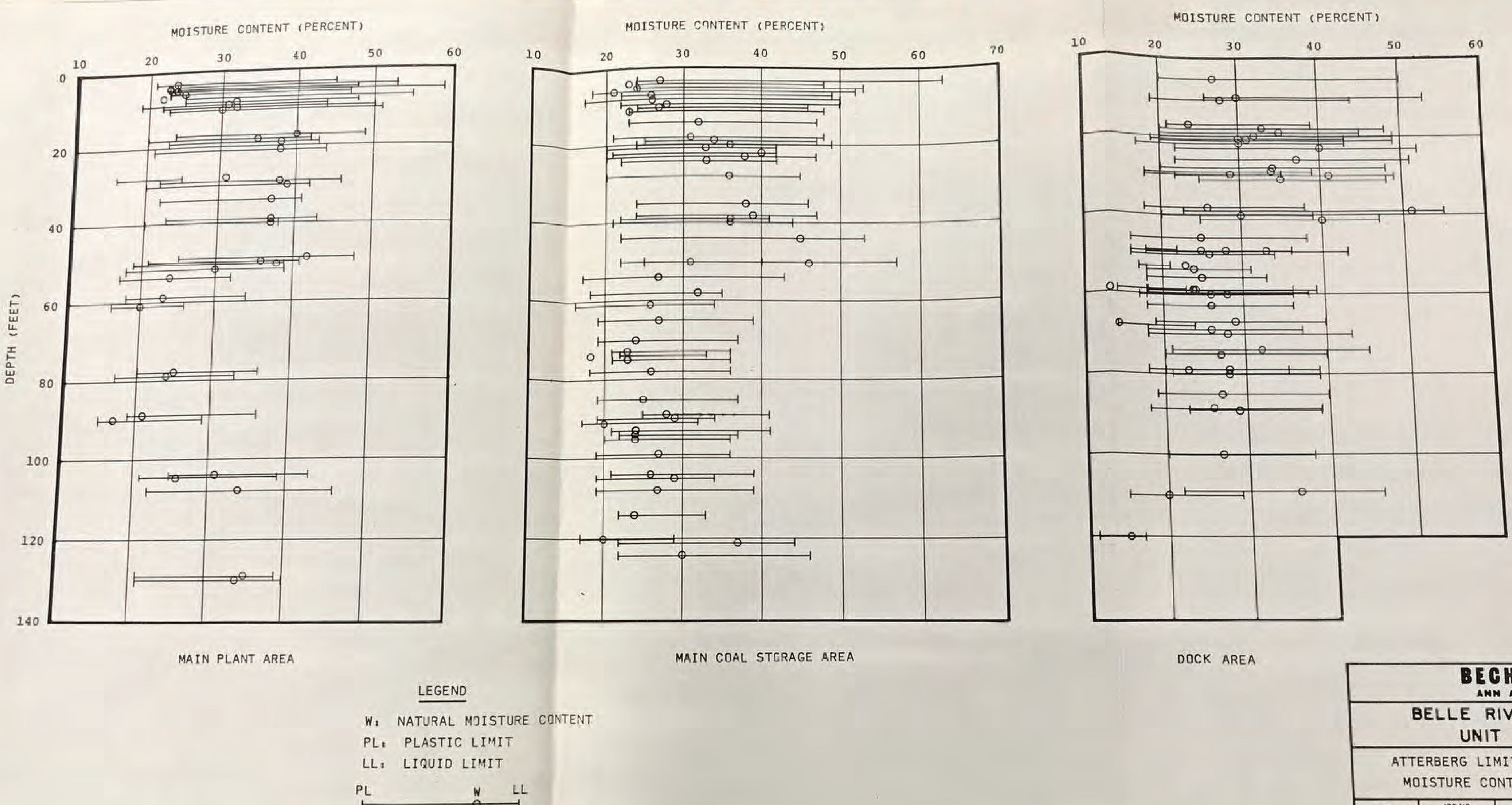
BELLE RIVER PLANT
UNIT 1 & 2

PLASTICITY CHART

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 19	0



BECHTEL
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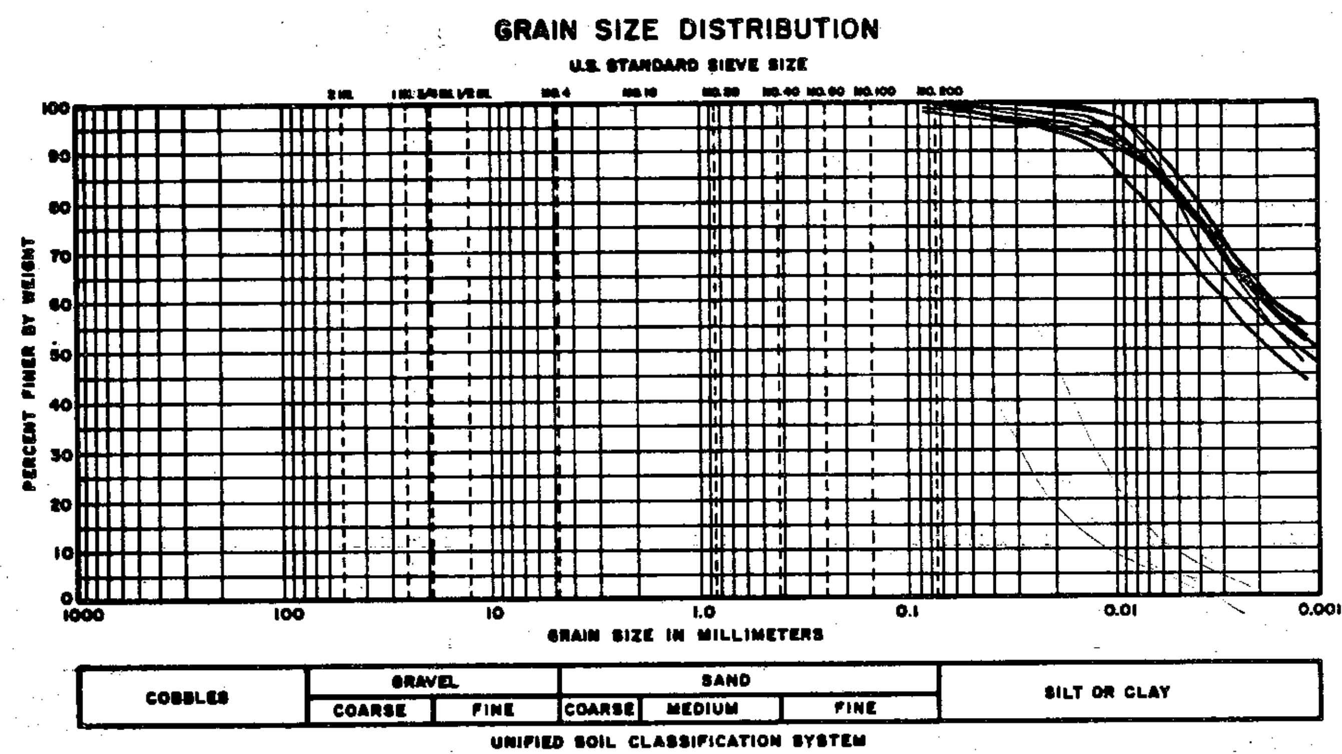
BELLE RIVER PLANT
UNIT 1 & 2

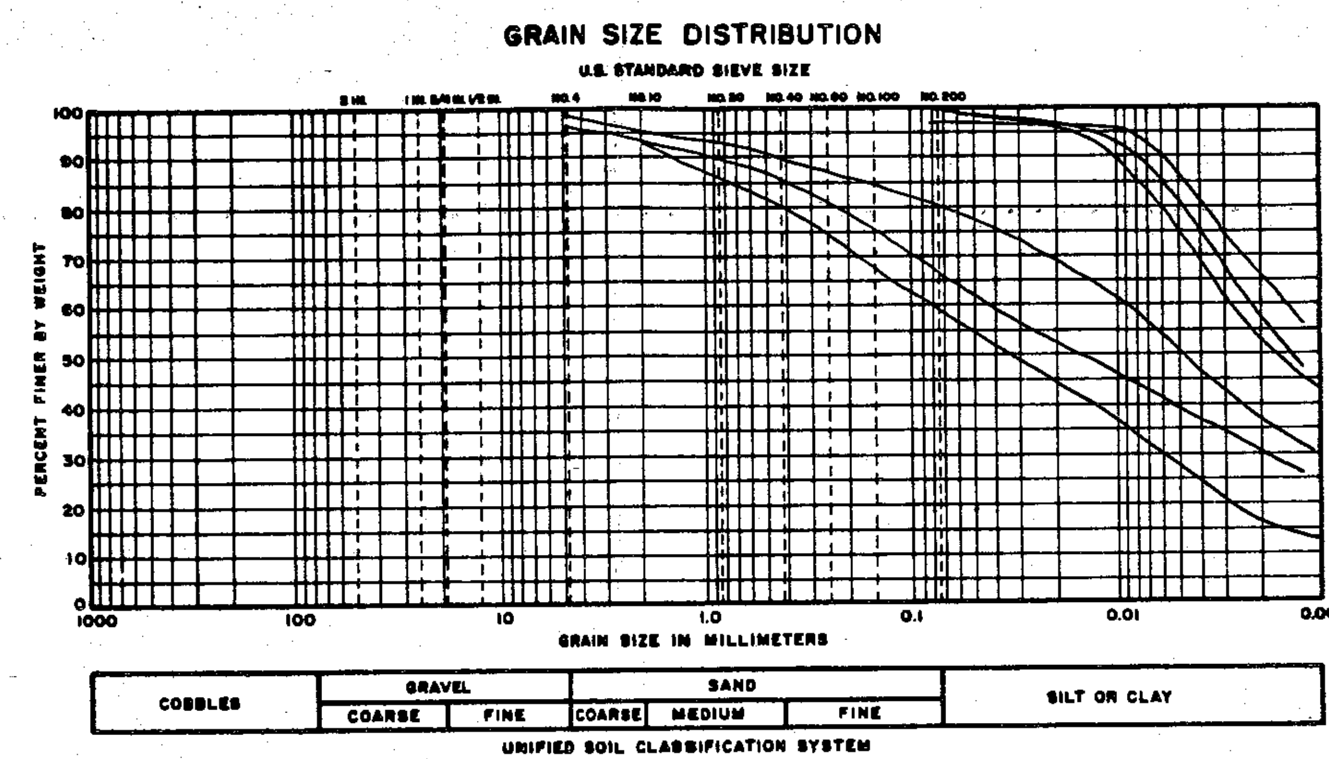
ATTERBERG LIMITS AND NATURAL MOISTURE CONTENT VS DEPTH

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 20	0



UPPER STRATUM (0-20 FEET)

BORING NUMBER	SAMPLE DEPTH (FEET)
38 (CL-CH)	9
38 (CL-CH)	15
41 (CH)	5
48 (CL-CH)	9
60 (CL-CH)	5
60 (CL)	11
60 (CL)	18
60 (CL)	19
137 (CL-CH)	2
144 (CL)	14
151A (CL-CH)	8



MIDDLE STRATUM (20-50 FEET)

	BORING NUMBER	SAMPLE DEPTH (FEET)
A	41 (CL)	20
B	41 (SC)	40
C	50 (CL)	28
D	50 (CL)	48
E	53 (CL)	39
F	60 (CL-CH)	27

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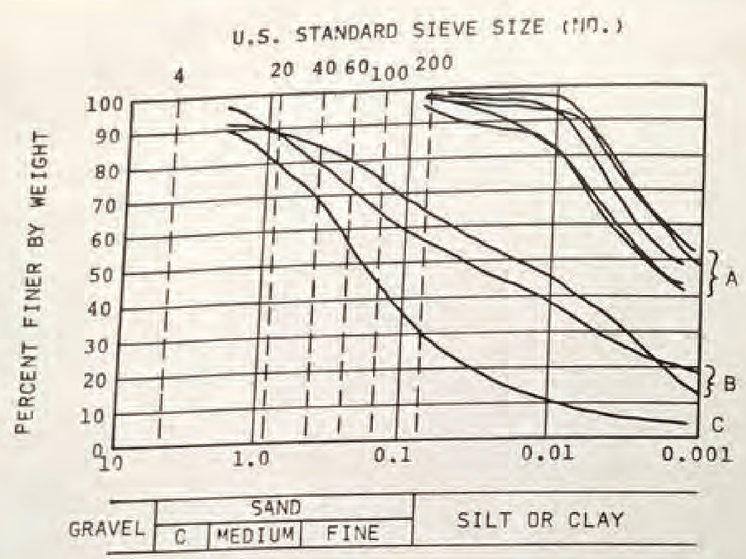
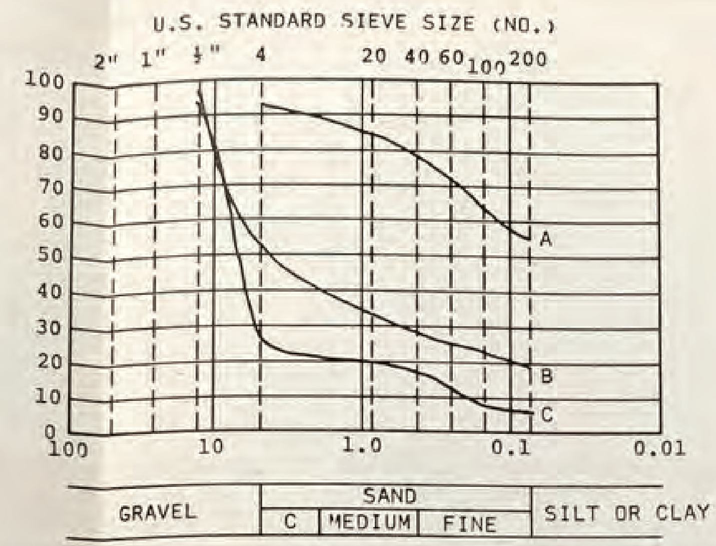
BELLE RIVER PLANT
UNIT 1 & 2

GRAIN SIZE DISTRIBUTION
UPPER AND MIDDLE STRATA

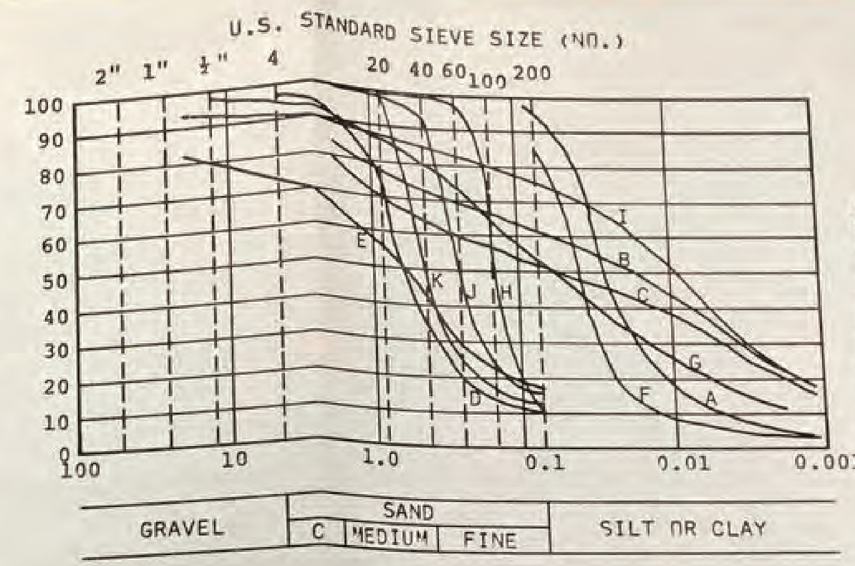
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 21	0



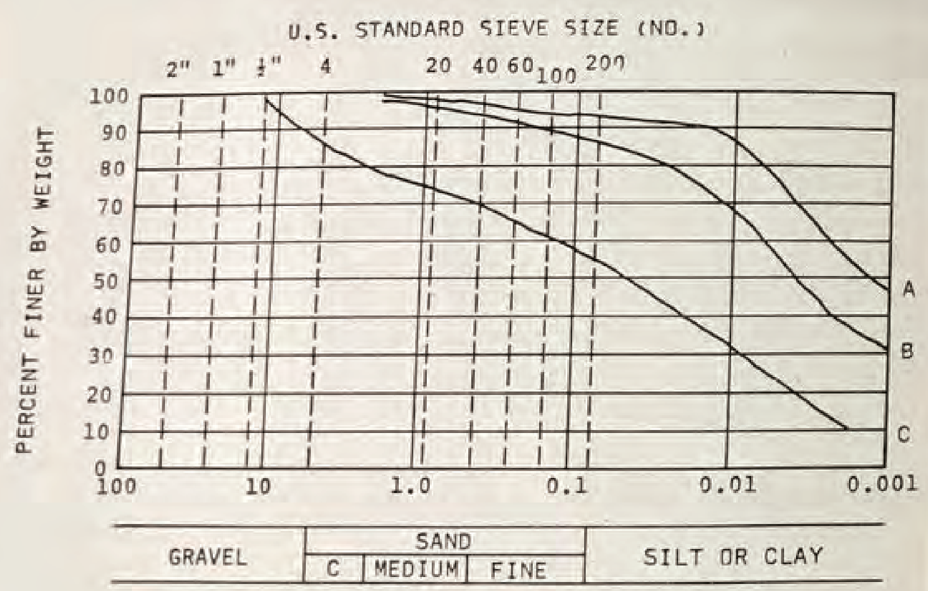
SECONDARY COAL STORAGE AREA EAST OF MAIN PLANT



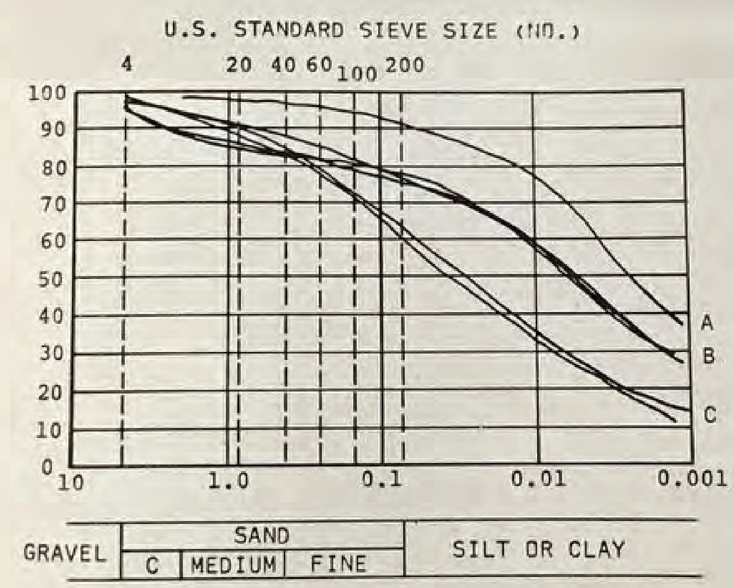
NORTHWEST FLY ASH DISPOSAL AREA



MAIN PLANT AREA



MAIN COAL STORAGE AREA



DOCK AREA

NORTHWEST FLY ASH DISPOSAL AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
C	139 (GP)	100
B	141 (GM)	115
A	141 (SM-SC)	145

MAIN COAL STORAGE AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
A	48 (CL)	118
B	49 (CL)	63
C	187 (CL-ML)	59

DOCK AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
C	52 (CL)	58.6
B	54 (CL)	63.5
A	54 (CL)	73.7
B	60 (CL)	56.1
B	60 (CL)	85.6
C	60 (CL)	119.5

MAIN PLANT AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
A	7 (CL-ML)	130
B	7 (CL-ML)	139
C	10 (CL-ML)	141
D	18 (SM-SW)	104
E	18 (SM)	140
F	22 (CL-ML)	134
G	27 (CL-ML)	69
H	27 (SM-SP)	114
I	30 (CL)	69
J	30 (SM)	99
K	30 (SM)	119

SECONDARY COAL STORAGE AREA EAST OF MAIN PLANT

	BORING NUMBER	SAMPLE DEPTH (FEET)
A	38 (CL)	54.1
A	38 (CH)	74.0
A	38 (CL)	84.6
A	38 (CL)	114.2
C	38 (SM)	138.5
B	41 (CL-SC)	72.9
A	41 (CL)	101.9
B	41 (GC-SC)	130.7

NOTES:

1) ALL SOILS ARE BELOW 50 FEET.
2) SOIL DIVISIONS AS PER UNIFIED SOIL CLASSIFICATION SYSTEM

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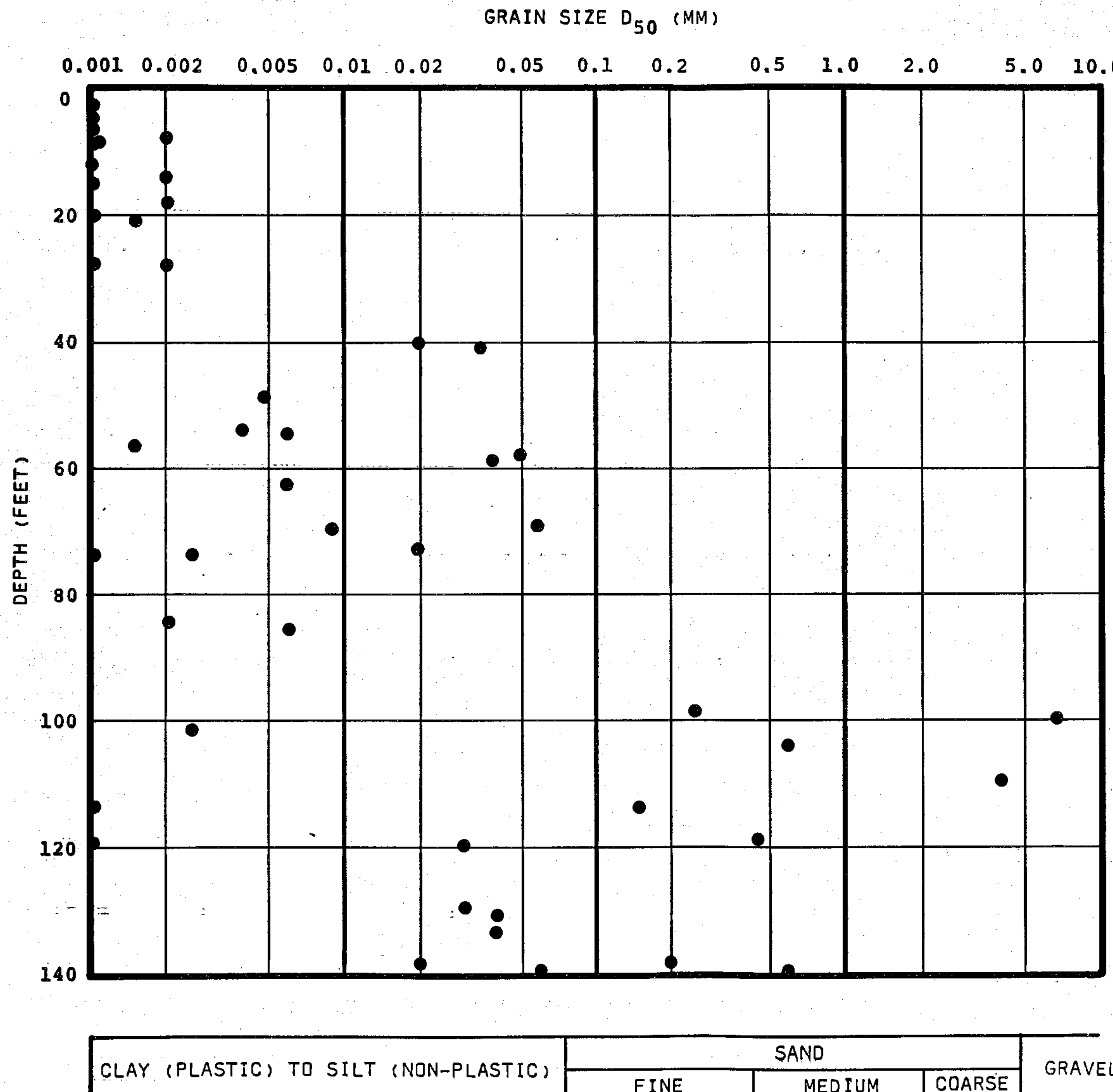
BELLE RIVER PLANT
UNIT 1 & 2

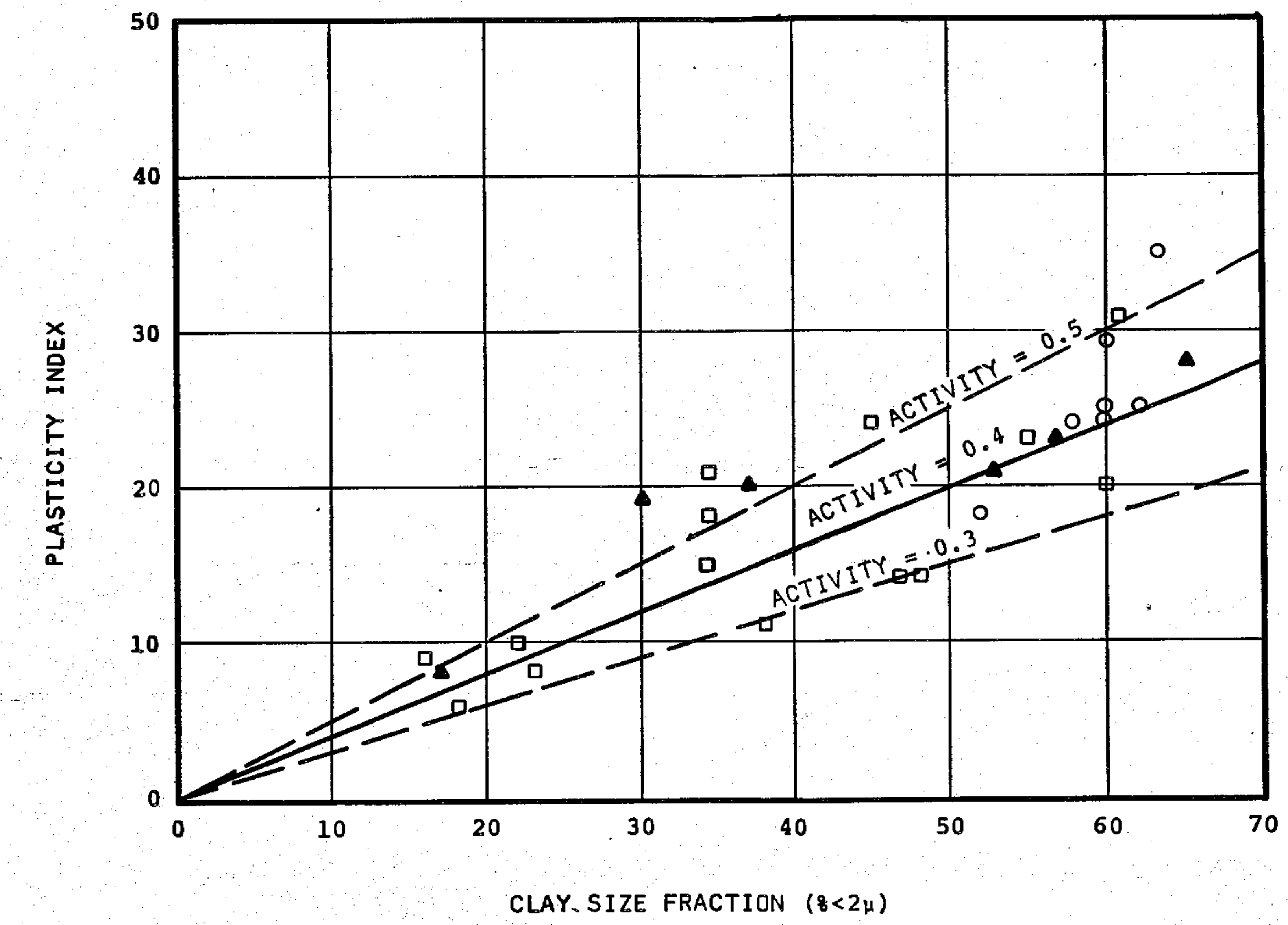
GRAIN SIZE DISTRIBUTION
LOWER STRATUM

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 22	0



UNIFIED SOIL CLASSIFICATION SYSTEM

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
GRAIN SIZE (D_{50}) vs DEPTH		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 23	0



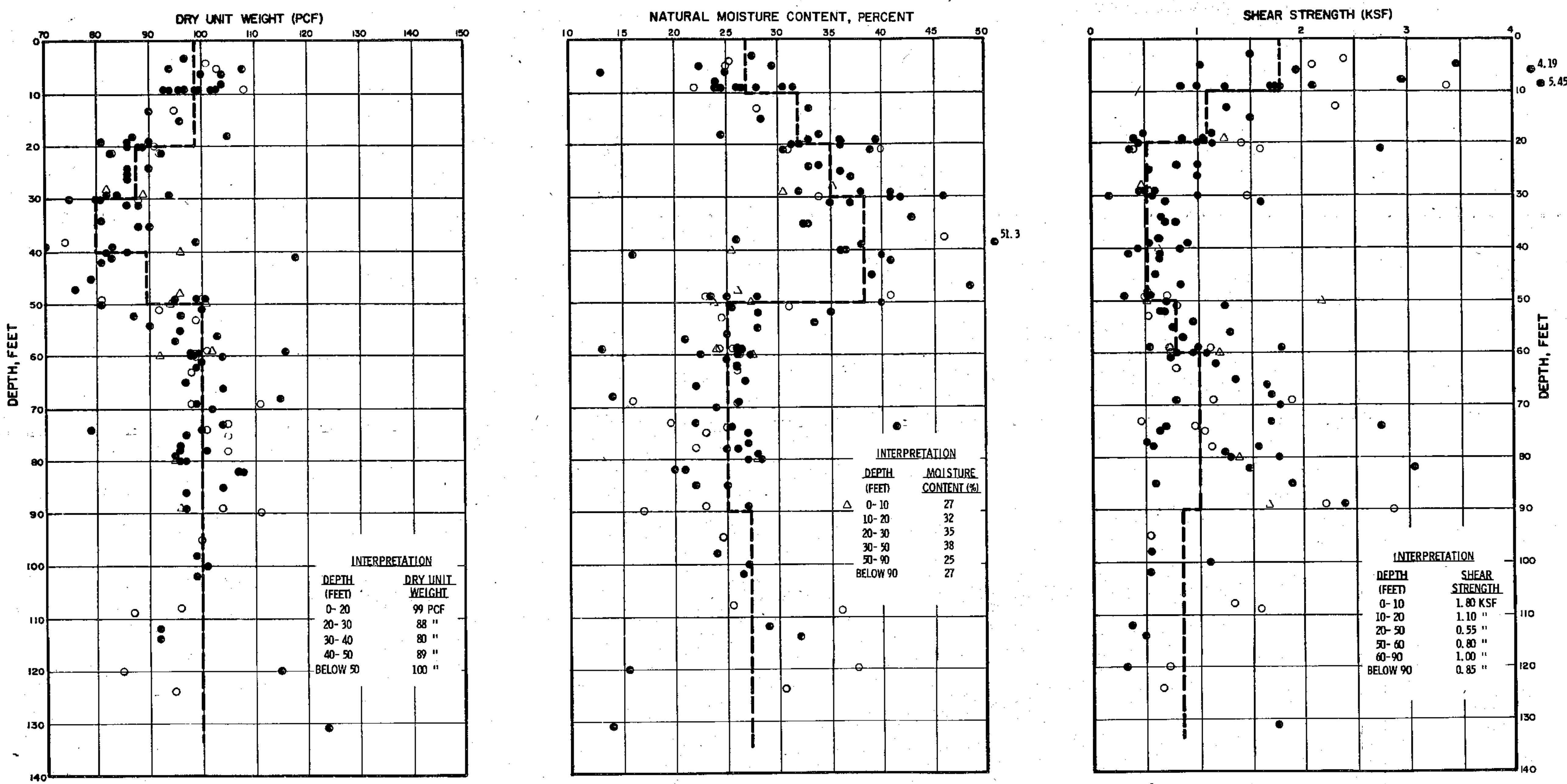
○ SOILS FROM 0-20 FEET

▲ SOILS FROM 20-50 FEET

□ SOILS BELOW 50 FEET

ACTIVITY = PI/%<2μ

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNITS 1 & 2		
ACTIVITY OF CLAY SOILS		
JOB No.	DRAWING No.	REV.
10539	FIGURE 24	C



EXPLANATION

- ● UNCONFINED COMPRESSION TESTS
- ○ UNCONSOLIDATED UNDRAINED TESTS
- △ LABORATORY VANE SHEAR TESTS

NOTES:

1.) ALL VALUES REPRESENT PEAK STRENGTHS.

2.) DRY UNIT WEIGHT AND NATURAL MOISTURE CONTENT CORRESPOND TO SHEAR STRENGTH TEST RESULTS.

BECHTEL
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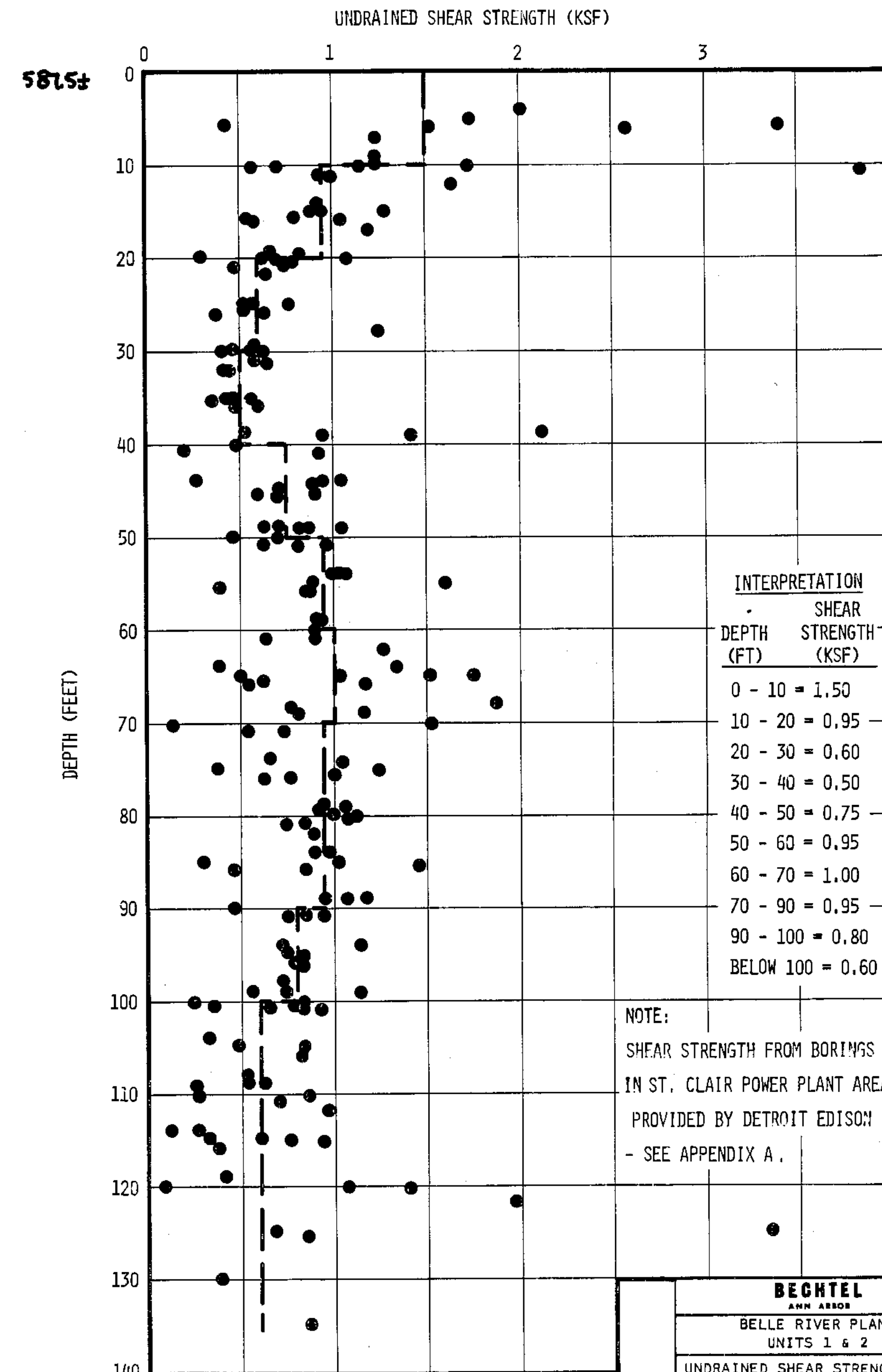
BELLE RIVER PLANT
UNIT 1 & 2

DRY UNIT WEIGHT, NATURAL WATER CONTENT, AND SHEAR STRENGTH VS DEPTH, ENTIRE SITE

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 25	0



BECHTEL
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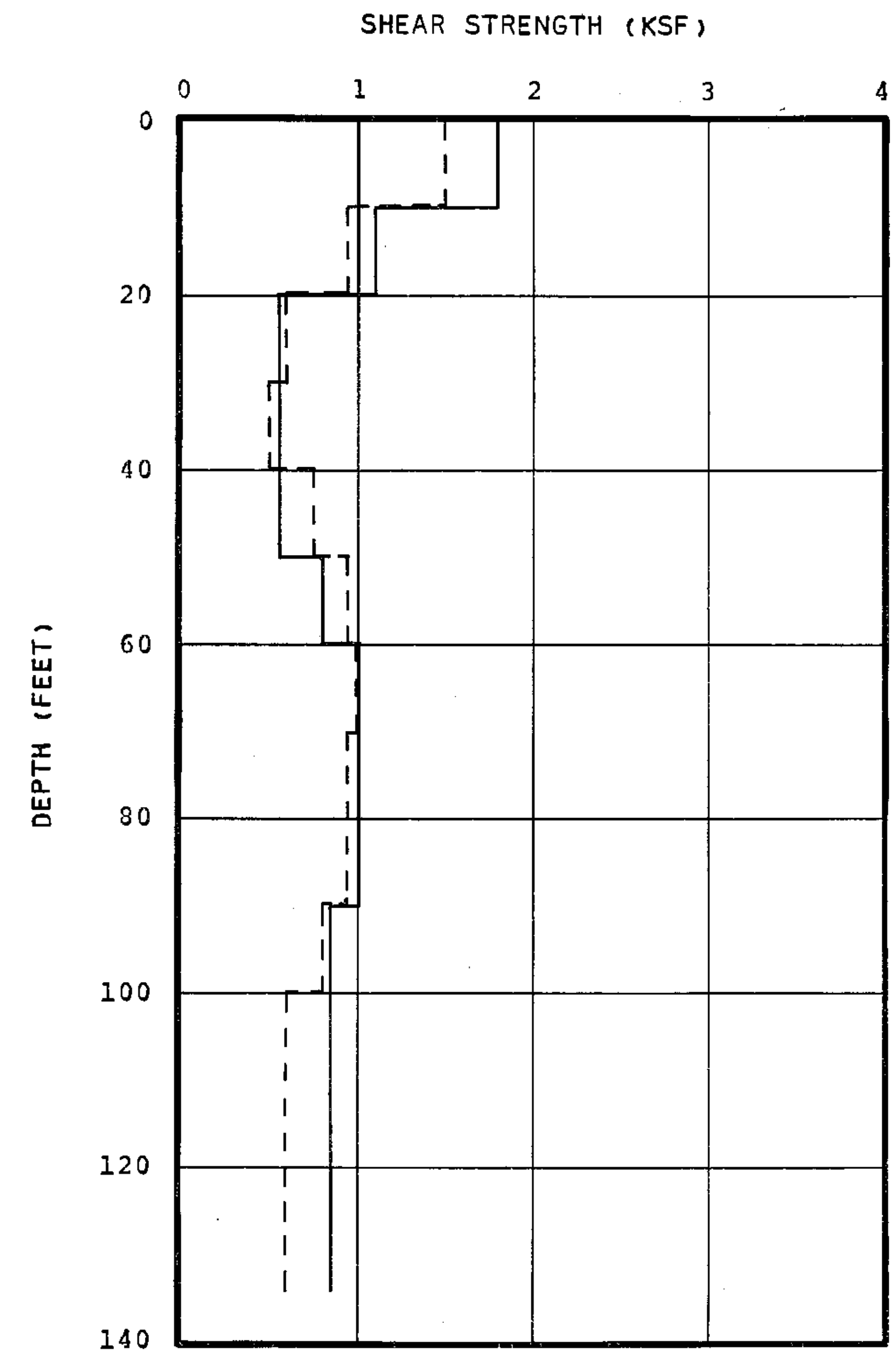
BELLE RIVER PLANT
UNITS 1 & 2

UNDRAINED SHEAR STRENGTH FROM PREVIOUS INVESTIGATIONS

JOB No.	DRAWING No.	REV
10539	FIGURE 26	



- - - HOUSEL UNDRAINED SHEAR STRENGTH DATA (SEE FIG. 26)

——— BECHTEL UNDRAINED SHEAR STRENGTH DATA (SEE FIG. 25)

BECHTEL
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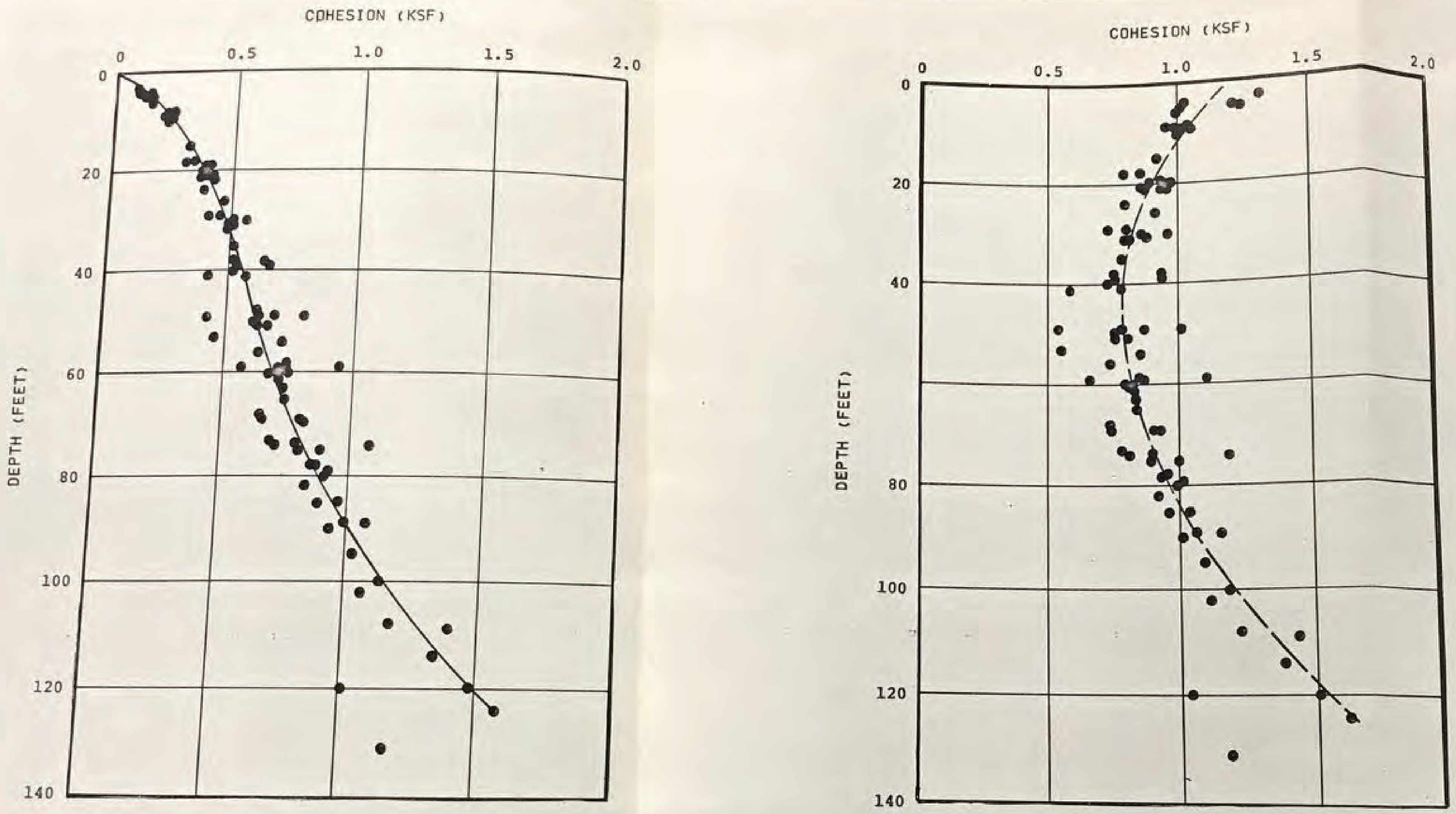
BELLE RIVER PLANT
UNITS 1 & 2

COMPARISON OF HOUSEL AND BECHTEL UNDRAINED SHEAR STRENGTH

JOB No.	DRAWING No.	REV.
10539	FIGURE 27	0



NOTE:

EFFECTIVE OVERBURDEN PRESSURE (P_0) WAS SUBSTITUTED FOR $\overline{P}$ IN THE SKEMPTON RELATIONSHIP $C/\overline{P}$ = 0.11 + 0.0037 x PI TO OBTAIN COHESION VALUES.

A) NORMALLY CONSOLIDATED SOILS ASSUMED

NOTE:

PRECONSOLIDATION PRESSURE P_C (CASAGRANDE'S METHOD) WAS SUBSTITUTED FOR $\overline{P}$ IN THE SKEMPTON RELATIONSHIP $C/\overline{P}$ = 0.11 + 0.0037 x PI TO OBTAIN COHESION VALUES.

B) PRECONSOLIDATED SOILS ASSUMED

SOIL DATA

DEPTH (FT)	TOTAL UNIT WEIGHT (PCF)	EFFECTIVE UNIT WEIGHT (PCF)
0-20	125	63
20-50	115	53
50+	125	63

NOTE:

WATER TABLE ASSUMED TO BE AT A DEPTH OF 10 FEET.

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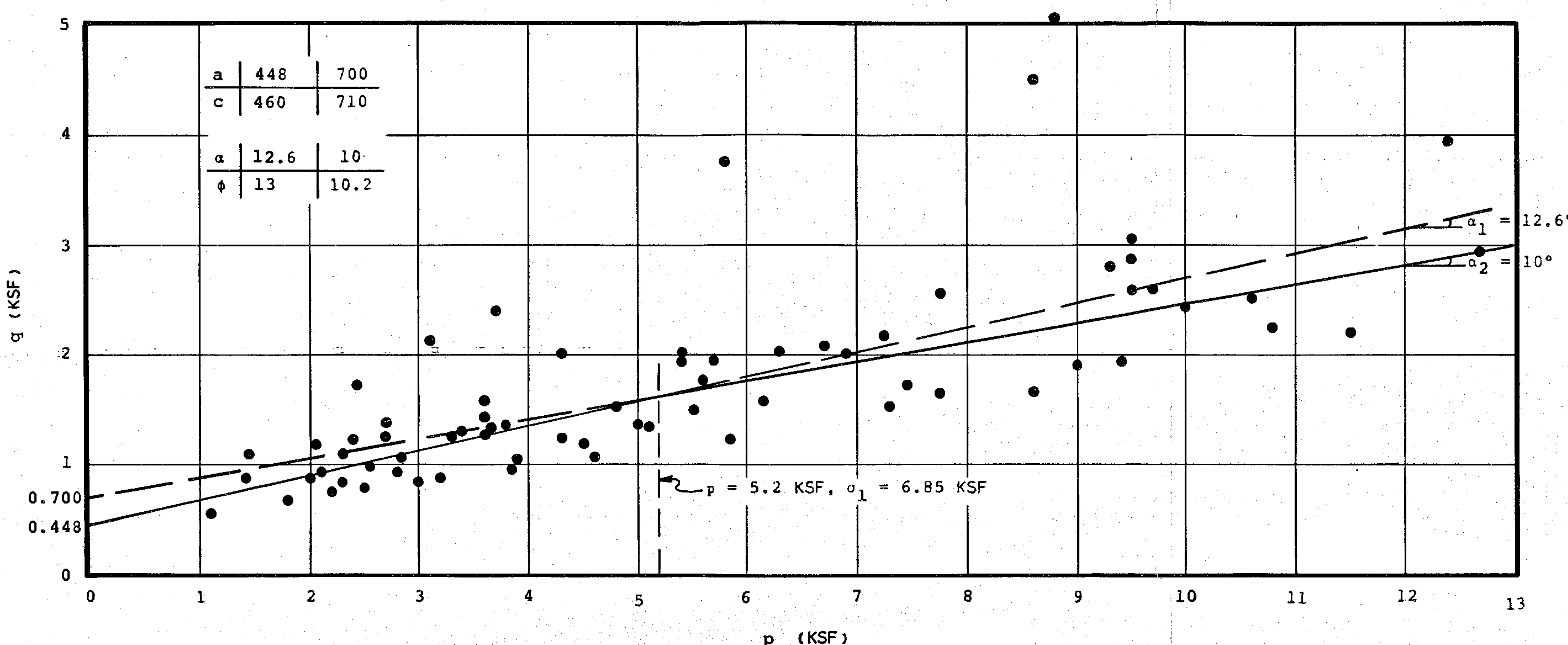
BELLE RIVER PLANT
UNIT 1 & 2

UNDRAINED SHEAR STRENGTH FROM SKEMPTON'S RELATIONSHIP

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 28	0



$$p = \frac{\sigma_1 + \sigma_3}{2} \qquad q = \frac{\sigma_1 - \sigma_3}{2}$$

BECHTEL
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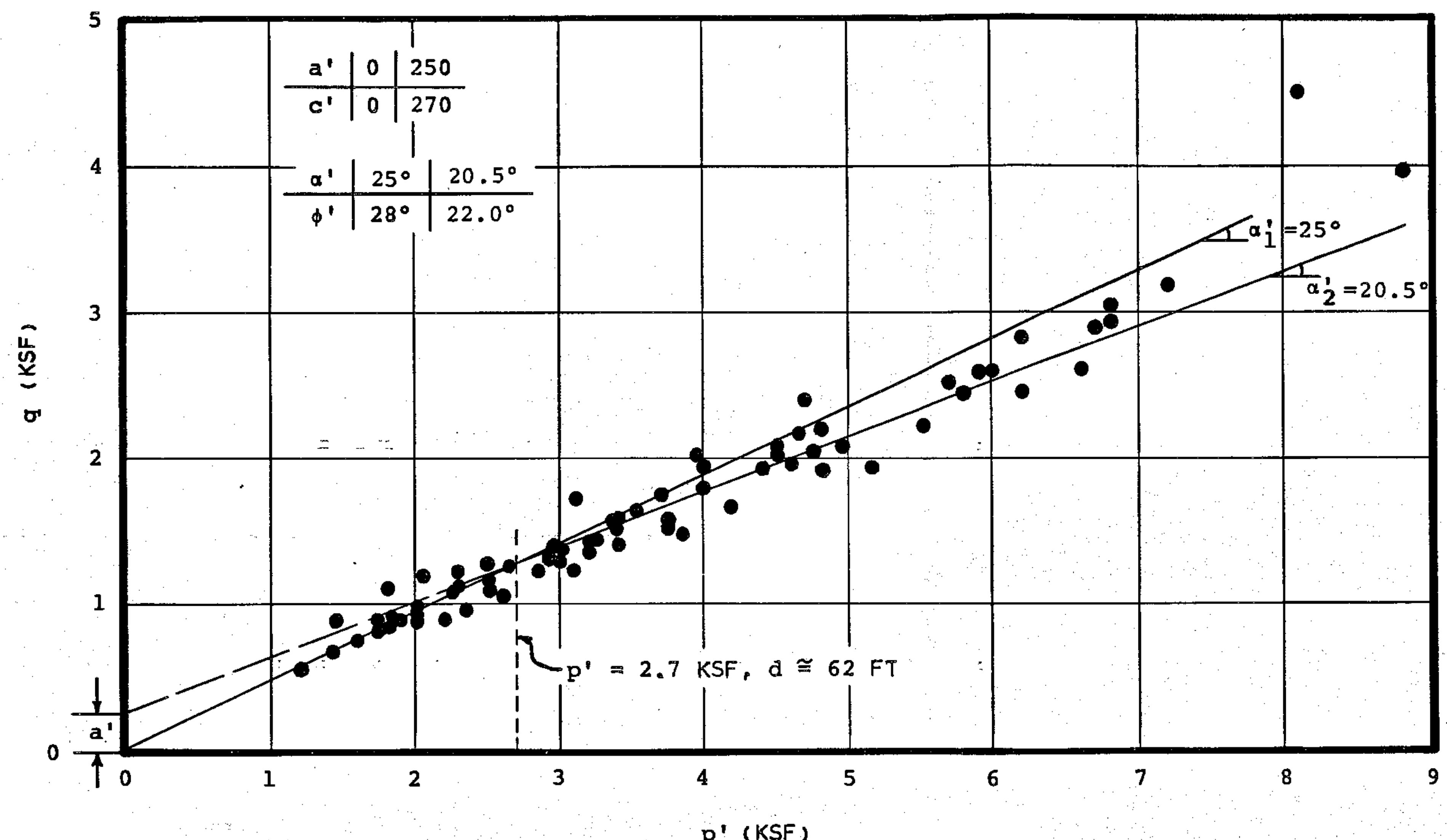
BELLE RIVER PLANT
UNITS 1 & 2

p - q DIAGRAM
ALL CLAYEY SOILS

JOB No.	DRAWING No.	REV
10539	FIGURE 29	A



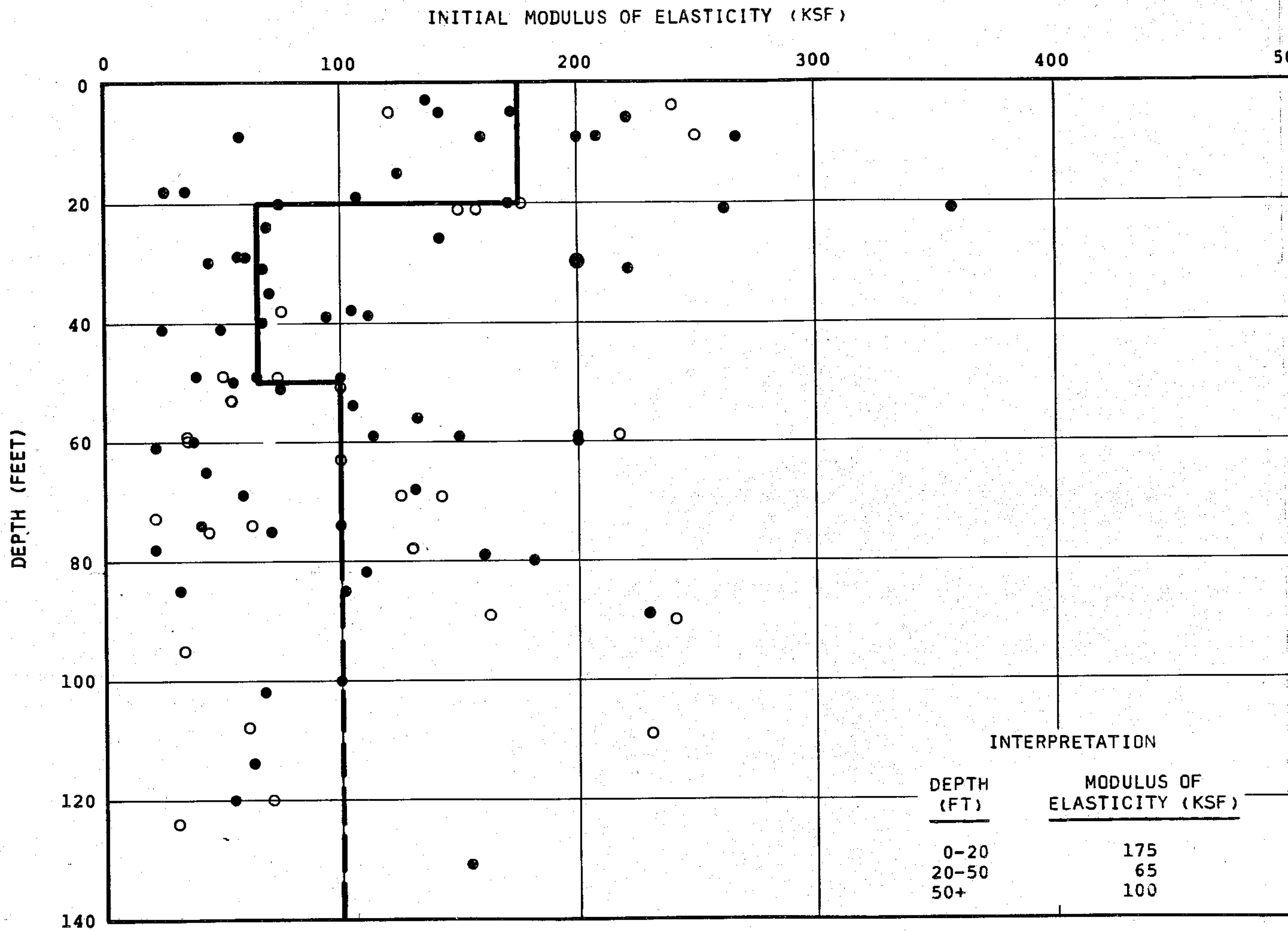
$$p' = \frac{\sigma_1' + \sigma_3'}{2} \qquad q = \frac{\sigma_1' - \sigma_3'}{2}$$

BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNIT 1 & 2

p' – q DIAGRAM
ALL CLAYEY SOILS

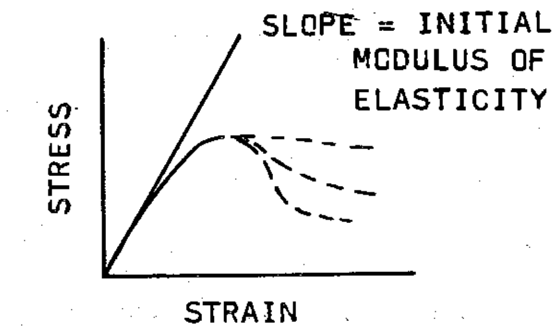
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 30	0



INTERPRETATION

DEPTH (FT)	MODULUS OF ELASTICITY (KSF)
0-20	175
20-50	65
50+	100

DEFINITION



● FROM Qu TEST

○ FROM UU TEST

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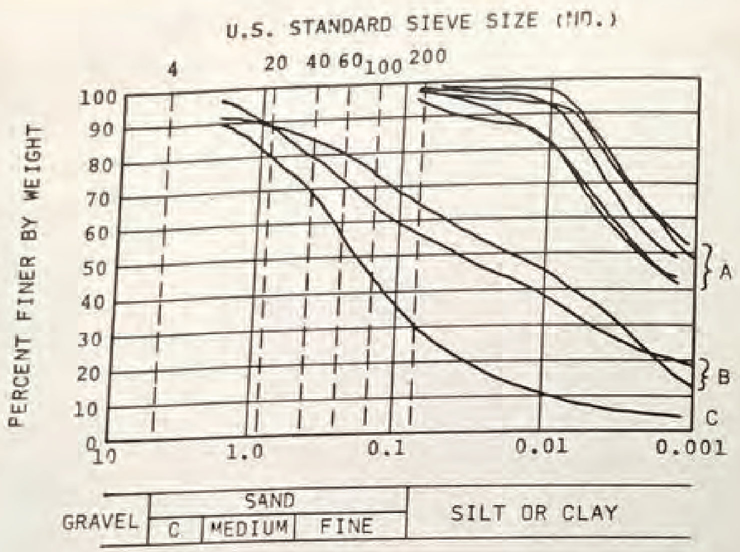
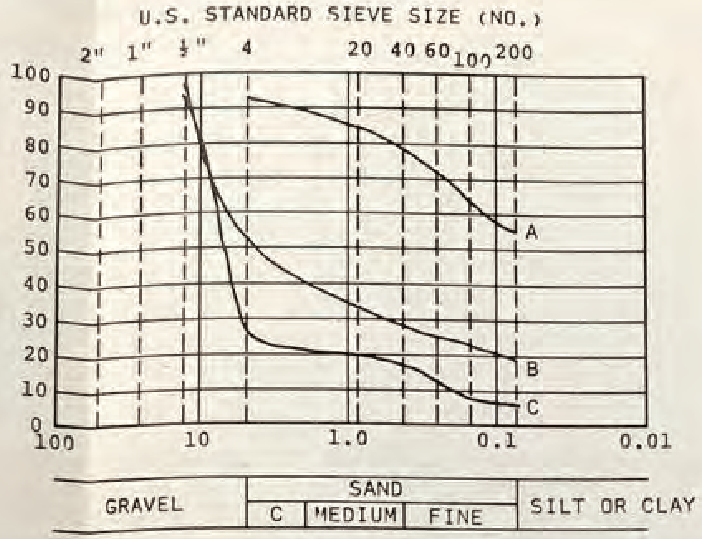
BELLE RIVER PLANT
UNIT 1 & 2

INITIAL MODULUS OF ELASTICITY VS DEPTH

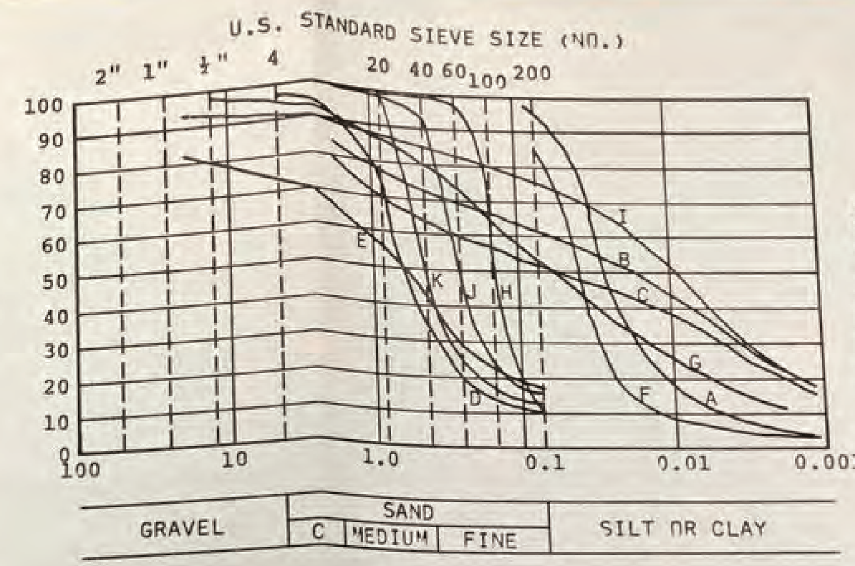
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 31	0



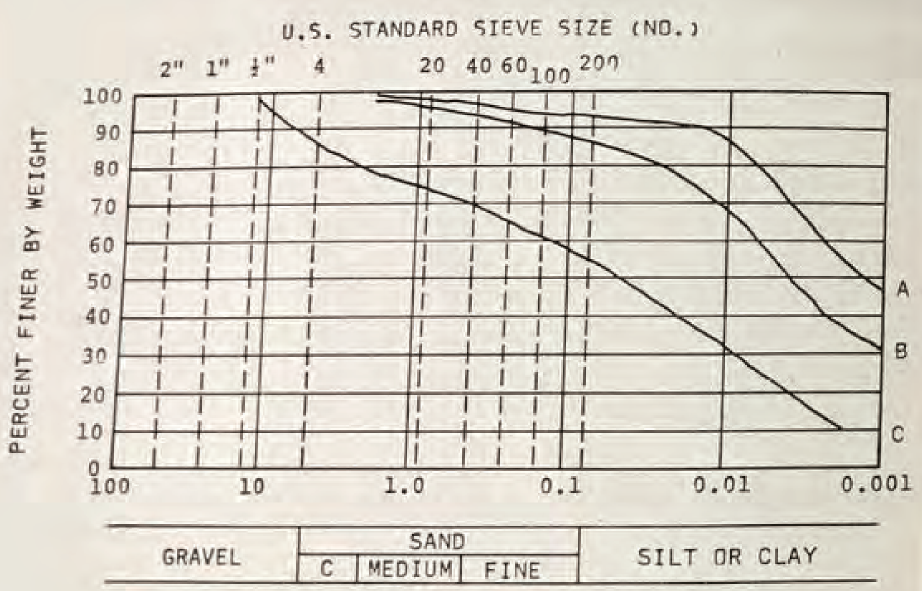
SECONDARY COAL STORAGE AREA EAST OF MAIN PLANT



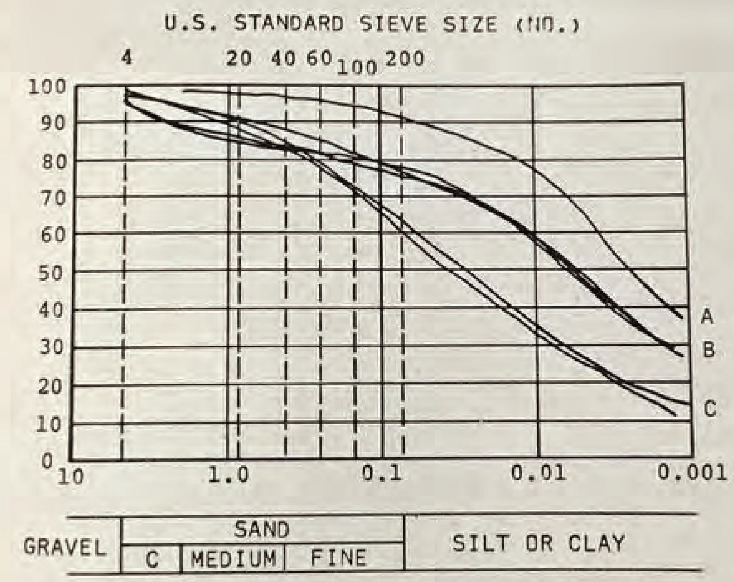
NORTHWEST FLY ASH DISPOSAL AREA



MAIN PLANT AREA



MAIN COAL STORAGE AREA



DOCK AREA

MAIN PLANT AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
A	7 (CL-ML)	130
B	7 (CL-ML)	139
C	10 (CL-ML)	141
D	18 (SM-SW)	104
E	18 (SM)	140
F	22 (CL-ML)	134
G	27 (CL-ML)	69
H	27 (SM-SP)	114
I	30 (CL)	69
J	30 (SM)	99
K	30 (SM)	119

SECONDARY COAL STORAGE AREA EAST OF MAIN PLANT

	BORING NUMBER	SAMPLE DEPTH (FEET)
A	38 (CL)	54.1
A	38 (CH)	74.0
A	38 (CL)	84.6
A	38 (CL)	114.2
C	38 (SM)	138.5
B	41 (CL-SC)	72.9
A	41 (CL)	101.9
B	41 (GC-SC)	130.7

NORTHWEST FLY ASH DISPOSAL AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
C	139 (GP)	100
B	141 (GM)	115
A	141 (SM-SC)	145

MAIN COAL STORAGE AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
A	48 (CL)	118
B	49 (CL)	63
C	187 (CL-ML)	59

DOCK AREA

	BORING NUMBER	SAMPLE DEPTH (FEET)
C	52 (CL)	58.6
B	54 (CL)	63.5
A	54 (CL)	73.7
B	60 (CL)	56.1
B	60 (CL)	85.6
C	60 (CL)	119.5

NOTES:

1) ALL SOILS ARE BELOW 50 FEET.
2) SOIL DIVISIONS AS PER UNIFIED SOIL CLASSIFICATION SYSTEM

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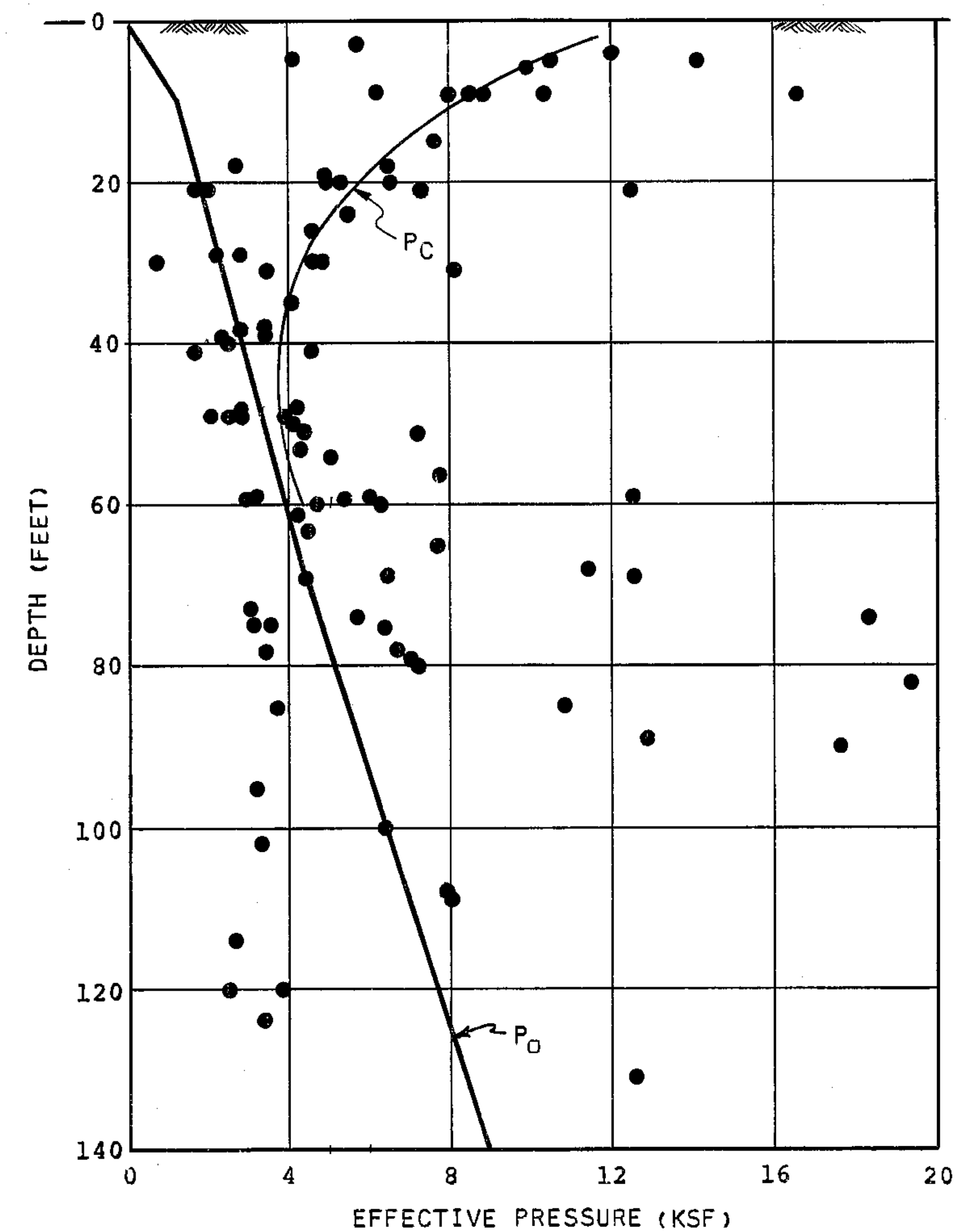
BELLE RIVER PLANT
UNIT 1 & 2

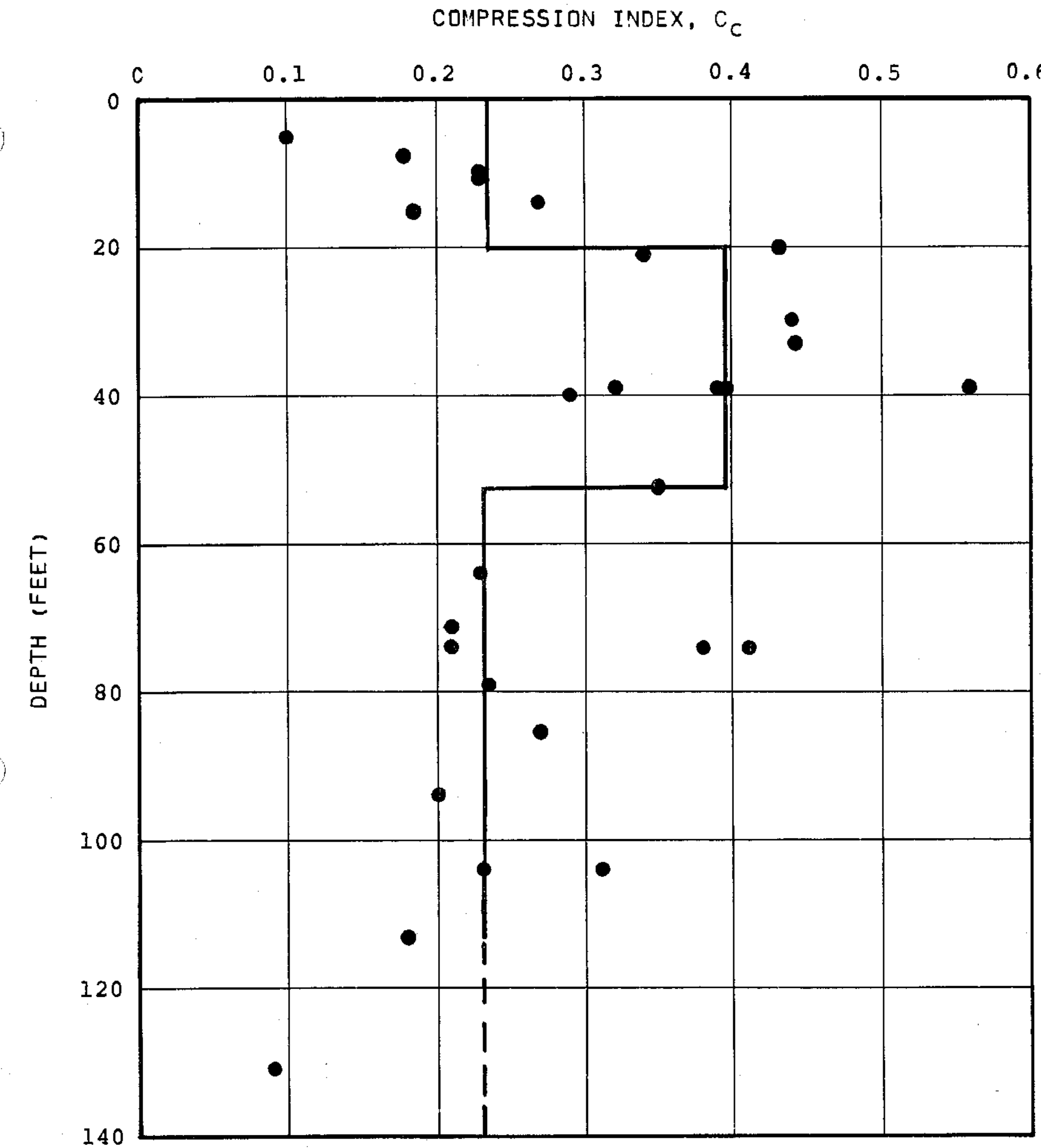
GRAIN SIZE DISTRIBUTION
LOWER STRATUM

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 22	0



NOTE: COHESION (C) FROM UU & QU TESTS SUBSTITUTED FOR "C" IN SKEMPTON'S RELATIONSHIP $C/\bar{P}$ = 0.11 + .0037 x PI.

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNITS 1 & 2		
P_C OBTAINED FROM SKEMPTON'S RELATIONSHIP		
JOB No.	DRAWING No.	REV.
10539	FIGURE 33	0



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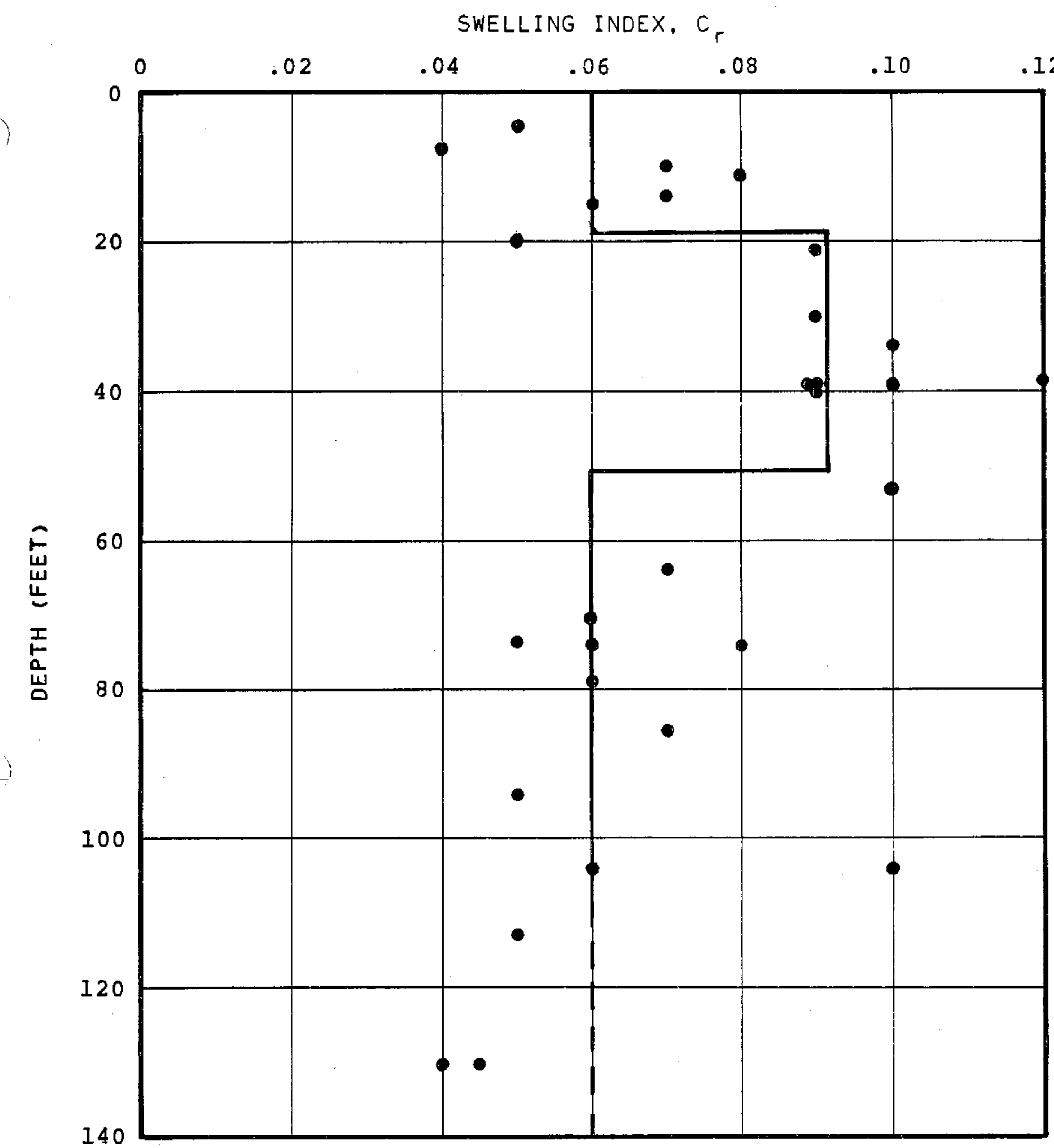
BELLE RIVER PLANT
UNITS 1 & 2

COMPRESSION INDEX VS DEPTH

JOB No.	DRAWING No.	REV
10539	FIGURE 34	B

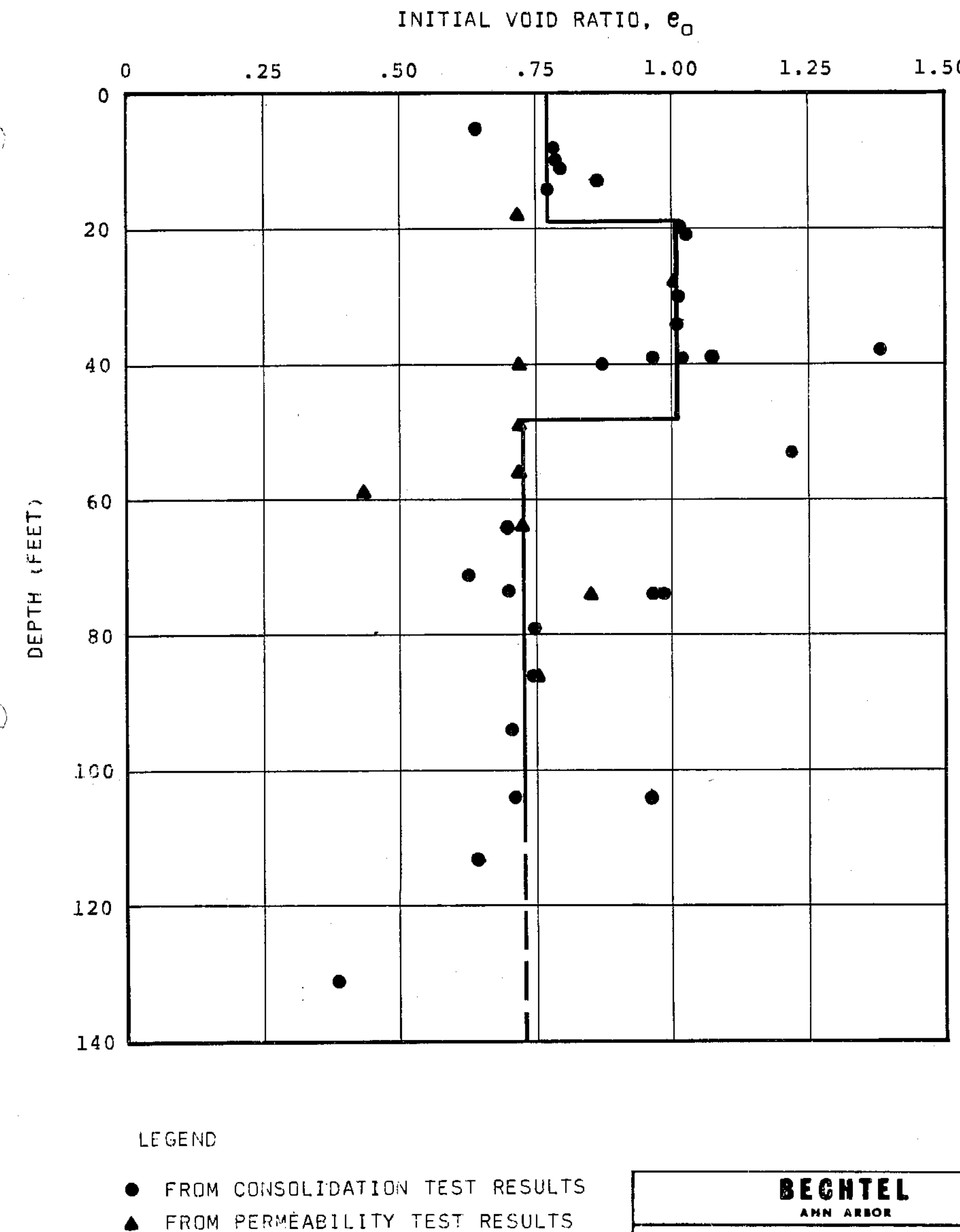


BECHTEL
ANN ARBOR

BELLE RIVER PLANT
UNITS 1 & 2

SWELLING INDEX vs DEPTH

JOB No.	DRAWING No.	REV.
10539	FIGURE 35	B



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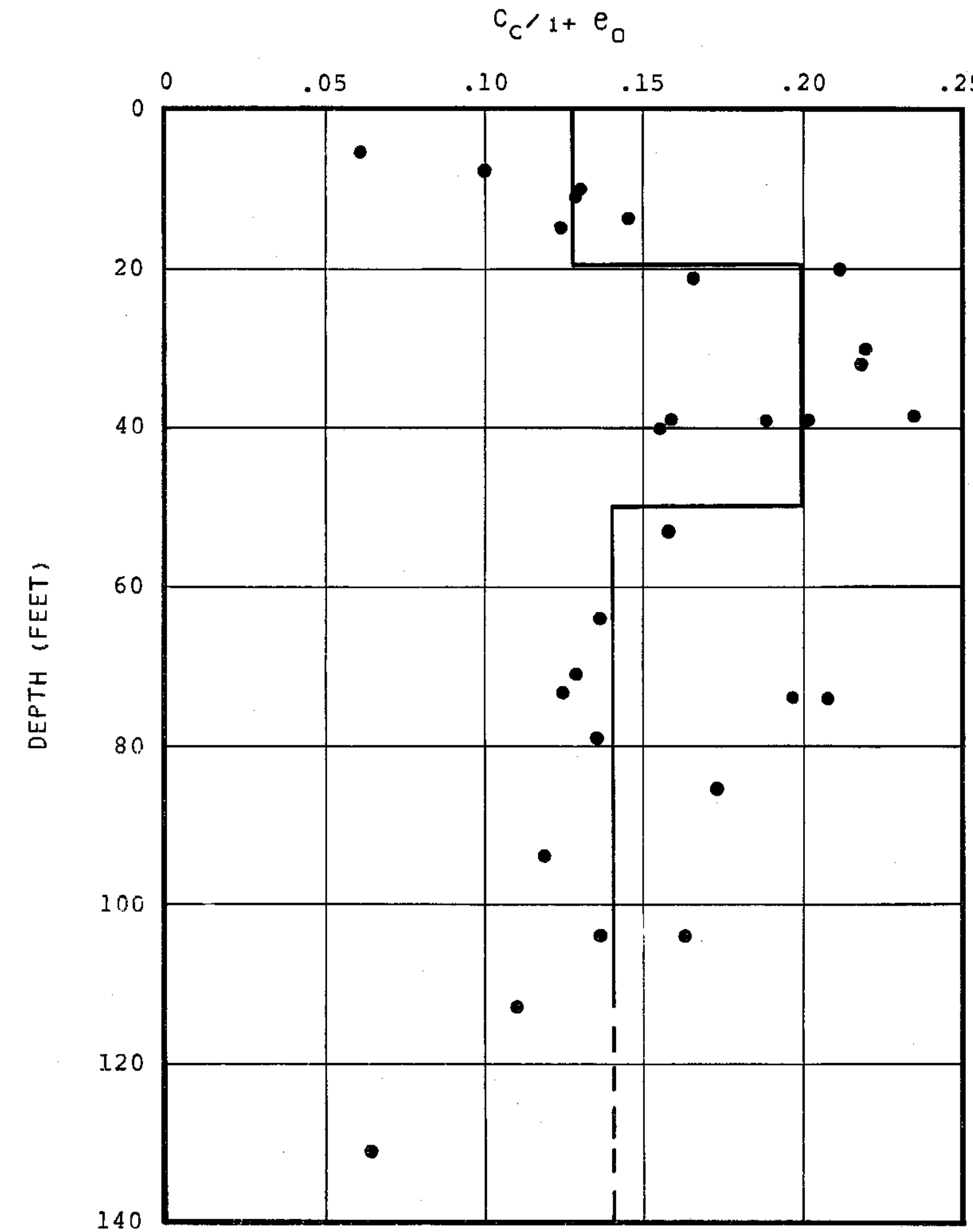
BELLE RIVER PLANT
UNITS 1 & 2

INITIAL VOID RATIO VS DEPTH

JOB No.	DRAWING No.	REV.
10539	FIGURE 36	B



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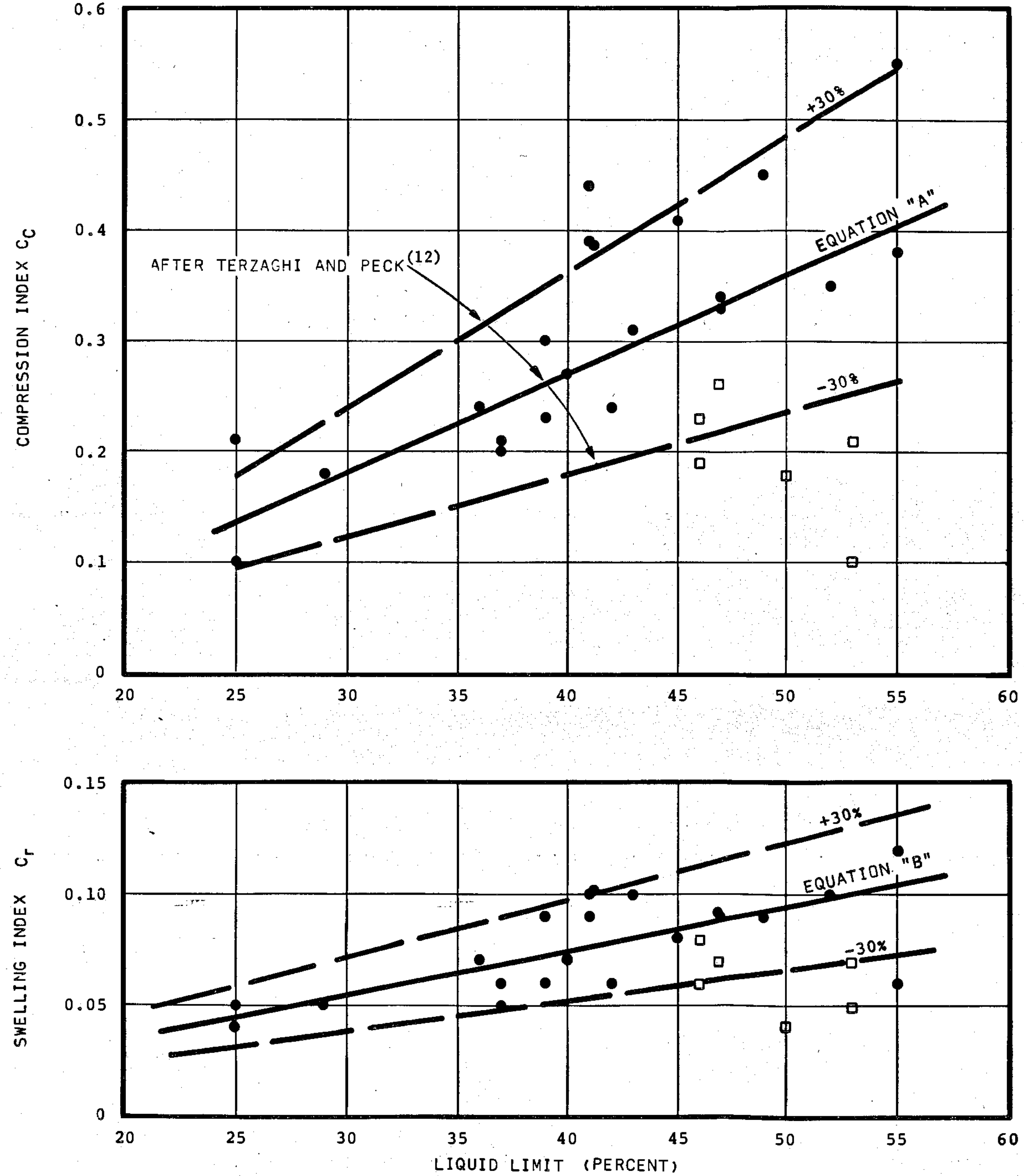
BELLE RIVER PLANT
UNITS 1 & 2

SETTLEMENT PARAMETER
$C_c/1+e_o$ VS DEPTH

JOB No.	DRAWING No.	REV.
10539	FIGURE 37	B



NOTES:

□ UPPER STRATUM (0-20 FEET) OVERCONSOLIDATION RATIO GREATER THAN 4.

● MIDDLE AND LOWER STRATA (BELOW 20 FEET) OVERCONSOLIDATION RATIO LESS THAN 2.

EXPLANATION

EQUATION "A" — COMPRESSION INDEX
$C_c = 0.009(LL-10)$

EQUATION "B" — SWELLING INDEX
$C_r = 0.002(LL-2.5)$

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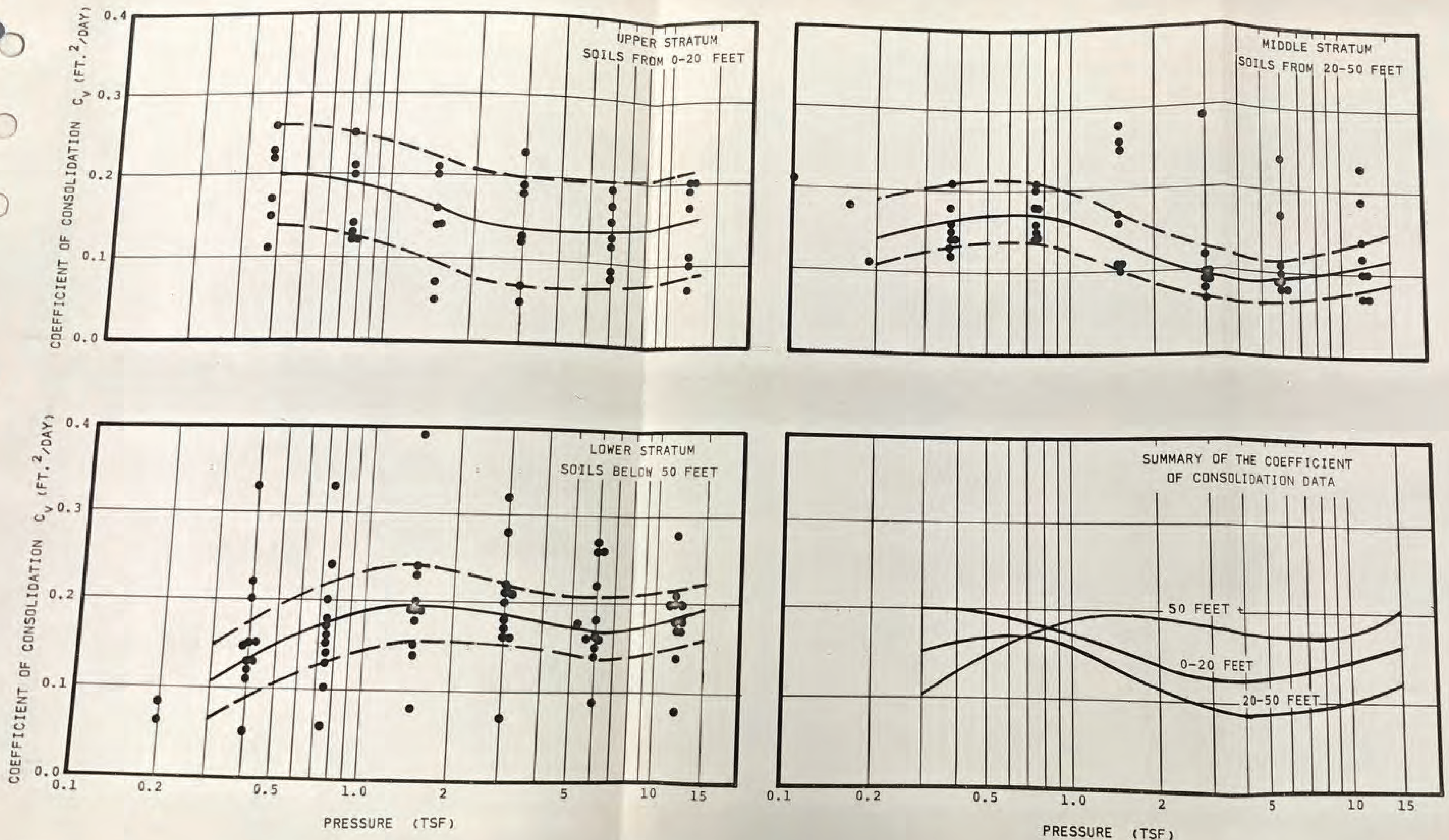
BELLE RIVER PLANT
UNIT 1 & 2

LIQUID LIMIT vs COMPRESSION AND SWELLING INDICIES

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 38	0



NOTE:

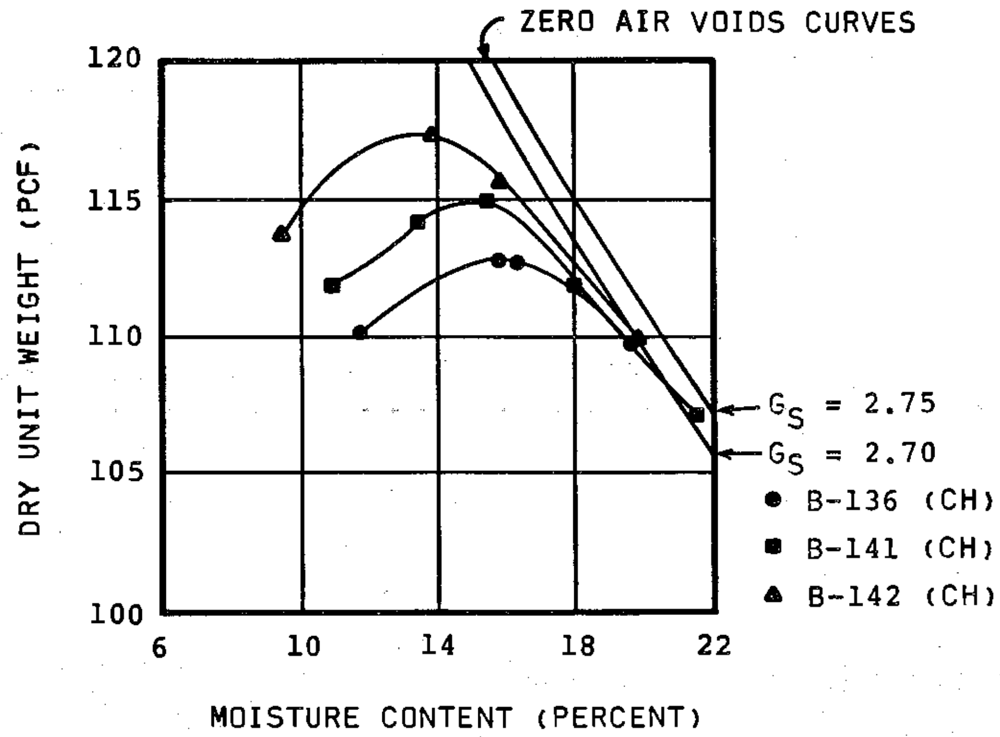
COEFFICIENT OF CONSOLIDATION BASED ON THE SQUARE ROOT OF TIME METHOD.

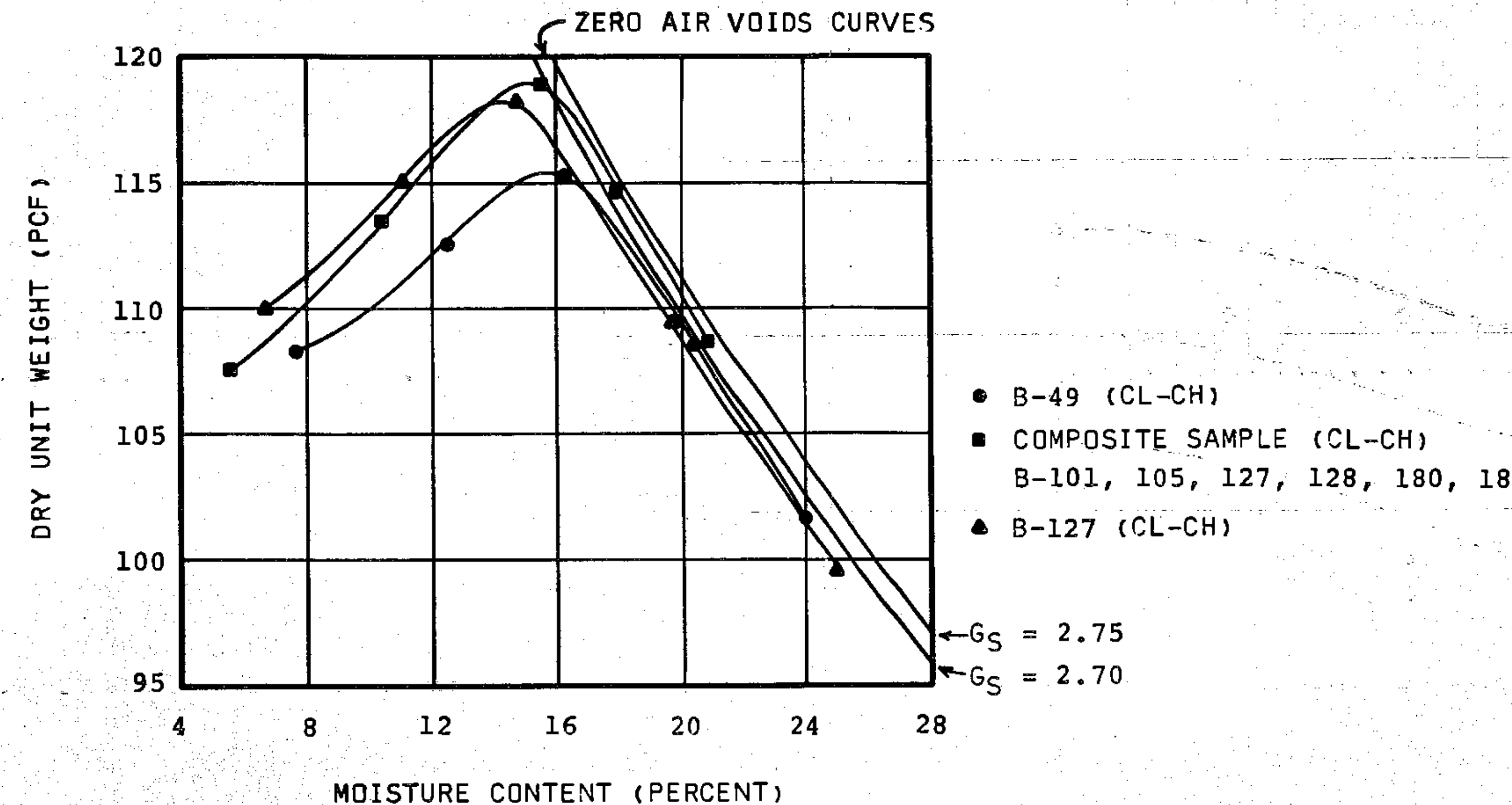
EXPLANATION:

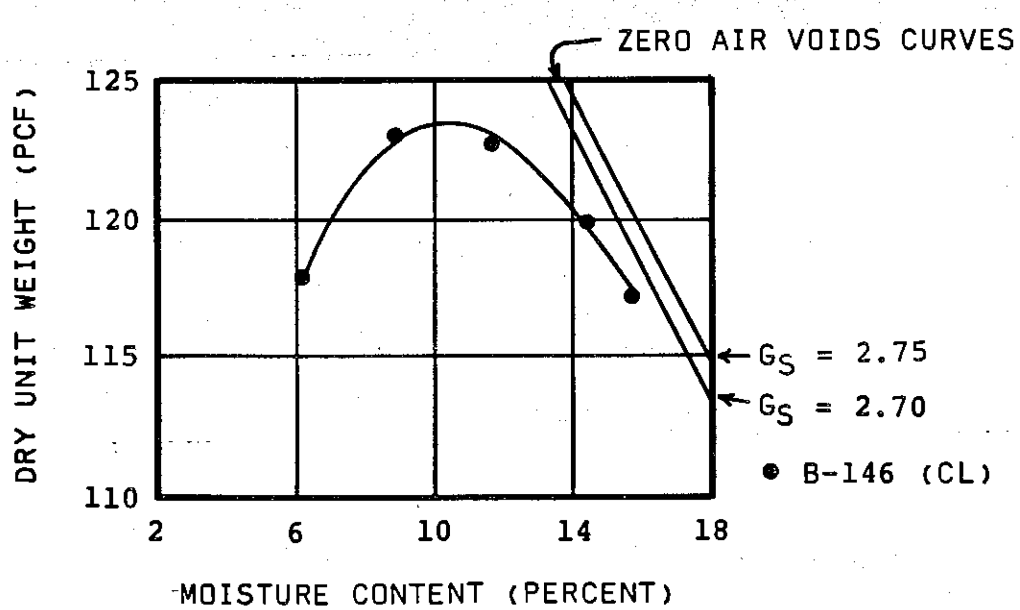
— — — RANGE OF VALUES

——— DESIGN CURVE

BECHTEL ANN ARBOR		
BELLE RIVER PLANT UNIT 1 & 2		
COEFFICIENT OF CONSOLIDATION VS PRESSURE		
JOB NO.	DRAWING NO.	REV.
10539	FIGURE 39	0







NOTES:

1) ALL TESTS WERE MADE ACCORDING TO ASTM D-1557 METHOD C.

2) THE ZERO AIR VOIDS CURVES HAVE BEEN DRAWN FOR ASSUMED SPECIFIC GRAVITY (G_S) OF 2.70 AND 2.75.

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BELLE RIVER PLANT
UNITS 1 & 2

SUMMARY OF COMPACTION TESTS
UPPER STRATA SOILS

JOB NO.	DRAWING NO.	REV.
10539	FIGURE 40	O

Appendix A

P. O. Box 619
Ann Arbor, Michigan 48107
April 5, 1966

Mr. Joseph Funston
The Detroit Edison Company
Room 604 S.B.
2000 Second Avenue
Detroit 26, Michigan

Re: Soil Investigation at the St. Clair Power Plant

Dear Mr. Funston:

Enclosed you will find two sets of the results of the soil investigation made in connection with the extension of Unit No. 7 and the yard's conveyor area.

Each set includes the individual boring log profile of the 1965 borings (22, 25, and 27), followed by two Composite Subsoil Analysis Profiles. One composite is for the Power House Area. Here, superimposed on the composite chart of the 1965 borings, are both the transverse and compression shearing resistances, together with the ASTM standard penetration values from the 1950 borings. Similarly, the soil investigation results from the 1950 borings (13, 14, 15, and 16) are superimposed on the second composite for the yard's conveyor area. Shown on these two composites are three averages for the shear and penetration values. Dotted lines represent the 1965 borings, red lines the 1950 borings, and heavy lines the average of all borings.

As seen on the two composites, a comparison of the soil resistances of the soil strata encountered between the 1950 and 1965 borings is rather clear. However, two tables were prepared to facilitate reference to such comparison. In general, the soil resistances measured in the 1965 borings are lower than those of the 1950 borings, with few exceptions occurring at the lower strata. However, the averages from all borings which are recommended as design values, are closer to the 1965 borings.

It should not be overlooked that the shear values from the 1965 borings are available only from Borings 22 and 25 for one area, and only

Mr. Joseph Funston
The Detroit Edison Company
Detroit 26, Michigan

April 5, 1966
Page Two

Boring 27 for the other area. For this reason, only few values were available in each stratum, and the 1965 average alone should not be considered as representative of the area involved. Because more penetration values are available from all of the 1965 borings, the averages are now more representative and closer to the averages of both the 1950 and 1965 borings. A more detailed report of this investigation will be prepared if desired.

Very truly yours,

Georges Selim
For W. S. Housel

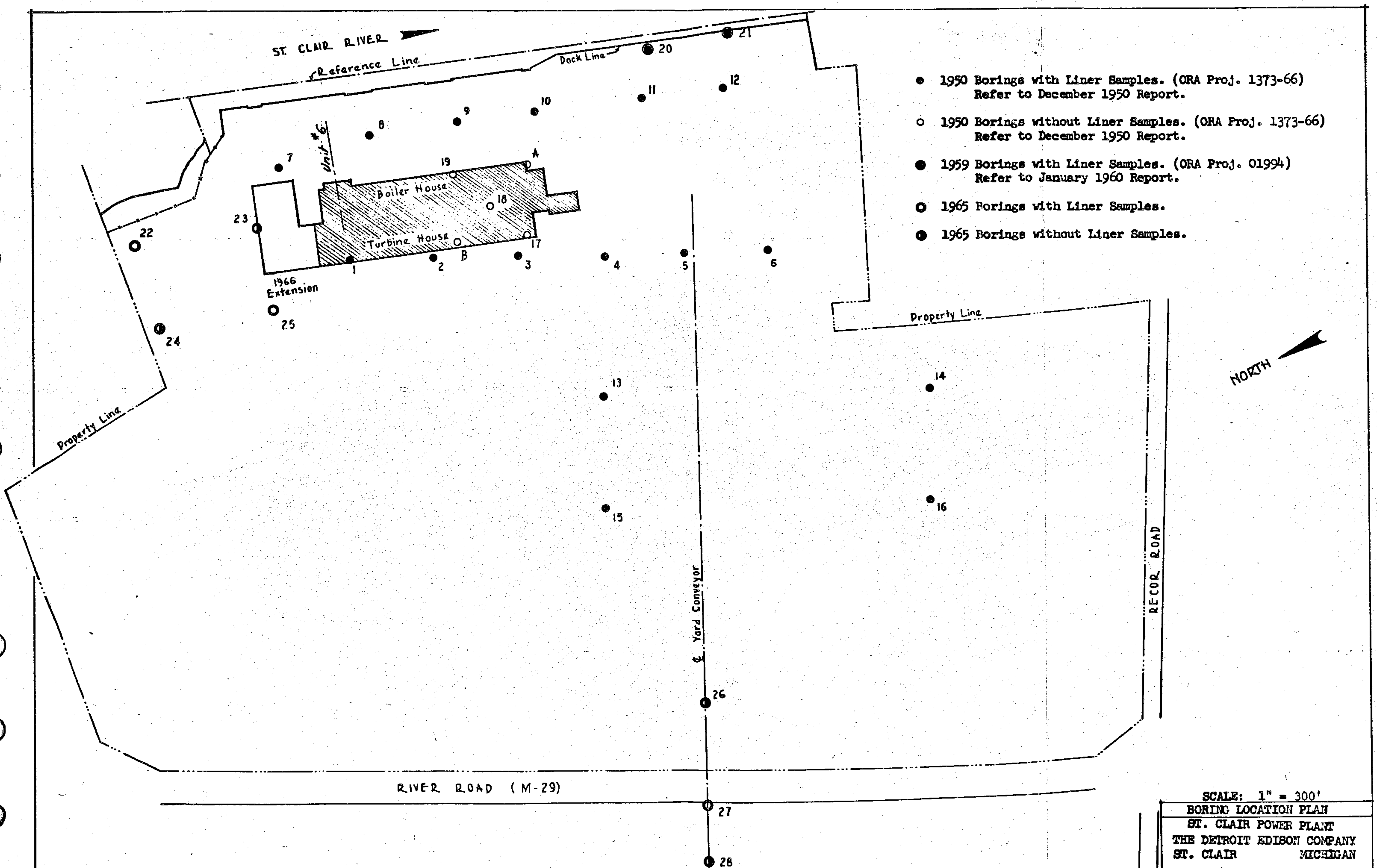
GS:kd
Enclosures

cc: Mr. Robert A. Briggs

SOIL INVESTIGATION AT

ST. CLAIR POWER PLANT

THE DETROIT EDISON COMPANY



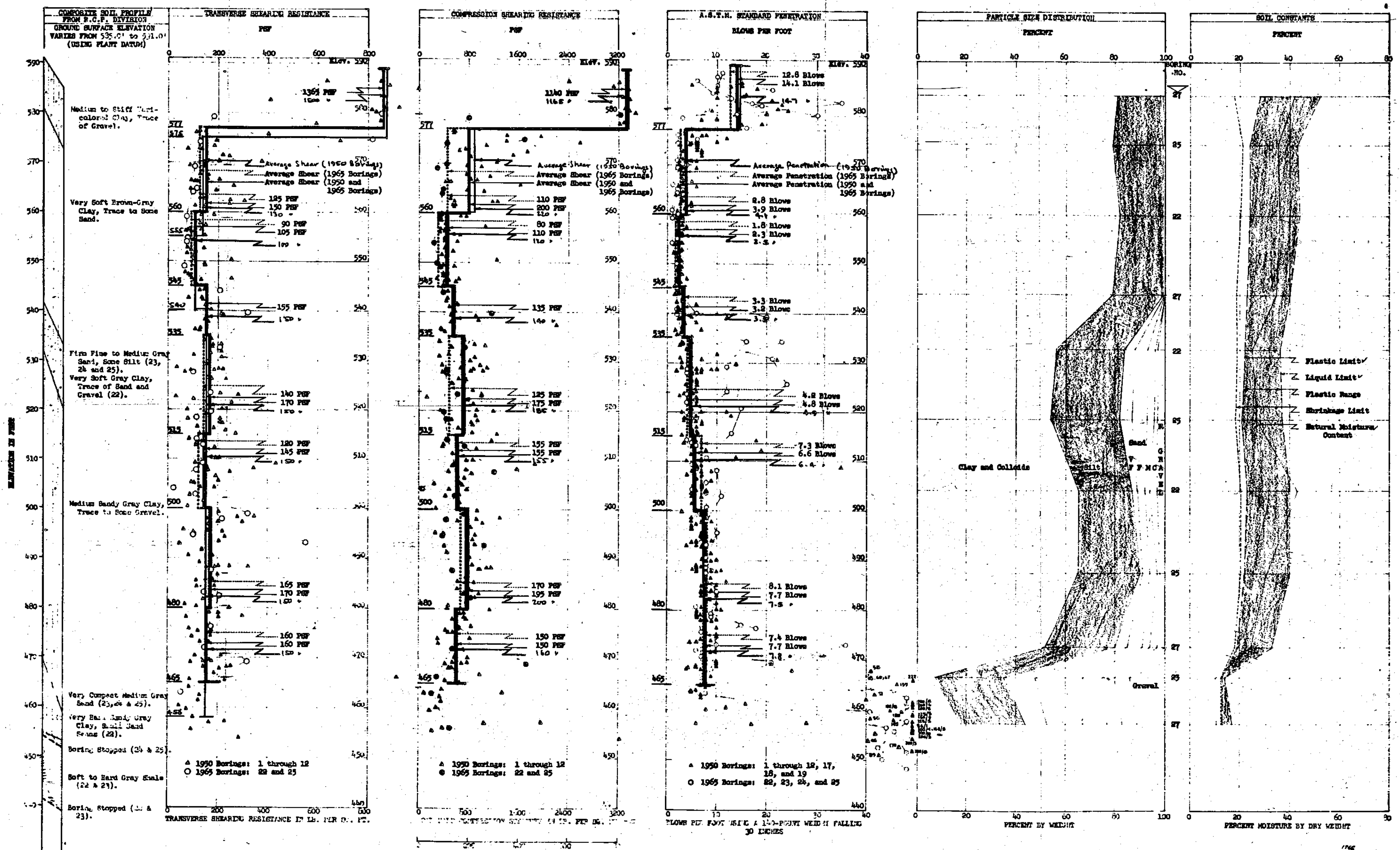
ORA PROJECT NO. 01994

COMPARISON OF AVERAGE SOIL RESISTANCES BETWEEN 1950 AND 1965 BORINGS IN THE POWER PLANT AREA ST. CLAIR POWER PLANT

1950 Borings: 1 through 12, 17, 18, and 19
1965 Borings: 22, 23, 24, and 25

Soil Type	S_c PSF			$S_{uc}/4$ PSF			N Blows/Ft.			Elev. Ft.
	1950 (1)	1965 (2)	All (1 & 2)	1950 (1)	1965 (2)	All (1 & 2)	1950 (3)	1965 (4)	All (3 & 4)	
591 Ground Surface										591
Medium to stiff vari-colored clay, trace of gravel. (591–577)	1500 (591–575)	*	1364	1167	*	1142	14.7	12.8	14.1	577
Very soft brown-gray clay, trace to some sand. (577–535)	130 (575–555)	123	151	221	112	201	4.1	2.8	3.9	560
	100 (555–540)	90	106	118	81	111	2.5	1.8	2.3	545
	150 (540–458)	*	154	140	*	137	3.5	3.3	3.2	535
Medium sandy gray clay, trace to some gravel. (535–465)		142	168	186	124	175	4.9 [12.8]	4.2 [17.3]	4.8 [14.7]	515
		122	143	155	155	155	6.4	7.3	6.6	500
		167	172	201	168	195	7.5	8.1	7.7	480
		159	158	151	149	151	7.8	7.4	7.7	465

(1) Based on shear test from Borings 1 through 12 only.
(2) Based on shear test from Borings 22 and 25 only.
(3) Based on ASTM penetration from Borings 1 through 12, 17, 18 and 19.
(4) Based on ASTM penetration from Borings 22 through 25.
* Only one or two samples available.
[ ] Represent ASTM penetration for the sand layer found in variable thickness in Borings 1, 2, 3, 4, 17, 19, 23, 24, and 25 only between Elevs. 540 and 510.



The above Composite Soil Profile is intended only to present average conditions throughout the group of borings represented. See individual Boring Charts for details.

OFFICE OF RESEARCH ADMINISTRATION
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN
COMPOSITE SUBSOIL ANALYSIS OF BORINGS NO. 22,23,24,25
ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY
ST. CLAIR MICHIGAN
APPROVED: W. H. Housel DATE: 4-5-1966
PROJECT: 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION 590.2 FT. (USING PLANT DATUM)

ELEVATION IN FEET

Elevation	Soil description
590	Cinders.
	Medium Sandy Brown Clay, Gravel, Vegetation.
	Stiff Sandy Varicolored Clay, Trace of Gravel.
580	Hard Sandy Varicolored Clay, Trace of Gravel.
	Medium Sandy Varicolored Clay.
570	Soft Gray-Brown Clay, Some Sand.
535	Very Soft Gray Clay, Trace of Sand and gravel.
490	Medium Sandy Gray Clay With Some Gravel.
475	Stiff Sandy Gray Clay, Some Gravel, Few Large Stones.
465	Medium Sandy Gray Clay.
455	Very Hard Sandy Gray Clay With Small Sand Seams.
450	Soft Gray Shale.
445	Hard Gray Shale. 90% Recovery.
440	Boring Stopped.

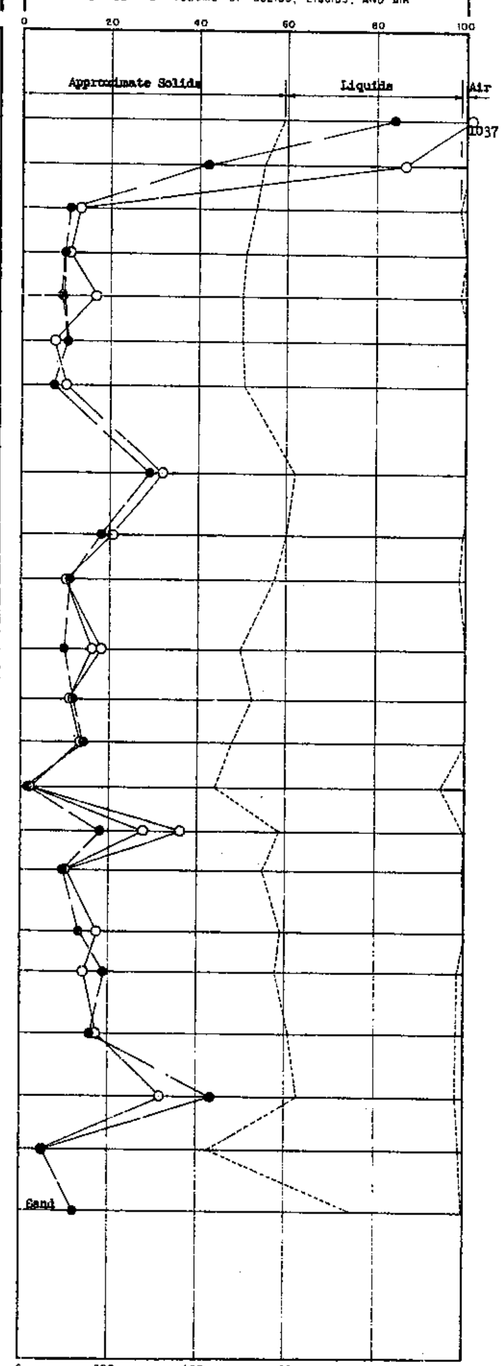
SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA NO.	ELEV	LAB CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT	DRY WT LBS. PER CU. FT.	REMARKS
1-BS	587.7	--	10	12			
2-BS	585.2	--	21	12			
3-BS	582.7	--	35	12			
4-LS	580.2	Stiff	14	12	25.8	99.2	4-LS: Uniform. Silty brown-gray laminated clay, trace of gravel.
5-LS	575.2	Plastic to Firm	6	12	33.5	91.8	5-LS: Uniform. Silty brown-gray laminated clay.
6-LS	570.2	Soft	3	12	32.5	88.6	6-LS: Uniform. Gray clay, little silt.
7-LS	565.2	Very Soft	2	12	36.4	84.9	7-LS: Uniform. Gray clay, little silt.
8-LS	560.2	Very Soft	2	12	35.9	84.9	8-LS: Uniform. Gray clay, little silt.
9-LS	555.2	Very Soft	2	12	38.7	83.6	9-LS: Uniform. Gray clay, little silt.
10-LS	550.2	Very Soft	2	12	37.4	84.2	10-LS: Uniform. Gray clay, little silt.
	545.2	--	2	12			
11-LS	540.2	Plastic	6	12	23.9	102.3	11-LS: Uniform. Silty gray clay, trace of very fine sand and fine gravel.
	535.2	--	5	12			
12-LS	533.2	Soft	4	12	25.0	98.9	12-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
13-LS	528.2	Soft	4	12	27.5	94.2	13-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
	522.2	--	4	12			
14-LS	520.2	Soft	4	12	38.6	81.7	14-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
15-LS	514.7	Soft	4	12	34.6	86.1	15-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
16-LS	509.7	Soft	5	12	41.6	78.6	16-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
17-LS	504.7	Very Soft	5	12	43.1	73.6	17-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
18-LS	499.7	Plastic	6	12	26.3	98.0	18-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
19-LS	495.2	Soft	7	12	30.5	91.7	19-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
	489.7	--	8	12			
20-LS	488.2	Soft	9	12	26.1	98.6	20-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
21-LS	483.7	Soft	10	12	26.4	96.7	21-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
	479.7	--	9	12			
22-LS	476.7	Soft	18	12	23.0	101.7	22-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
	473.2	--	36	12			
23-LS	469.7	Plastic	21	12	21.1	104.8	23-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
24-LS	463.7	Very Soft	8	12	49.8	71.1	24-LS: Uniform. Gray clay, some silt.
25-LS	456.7	Compact	117	12	12.1	126.0	25-LS: Uniform. Clayey coarse gray sand.
	450.2	--	100	12			

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

▭ Failure to recover Liner Sample.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



○———○ TRANSVERSE SHEARING RESISTANCE IN LBS. PER SQ. FT.

0 800 1600 2400 3200 4000

●- - -● ONE HALF COMPRESSION STRENGTH IN LBS. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN

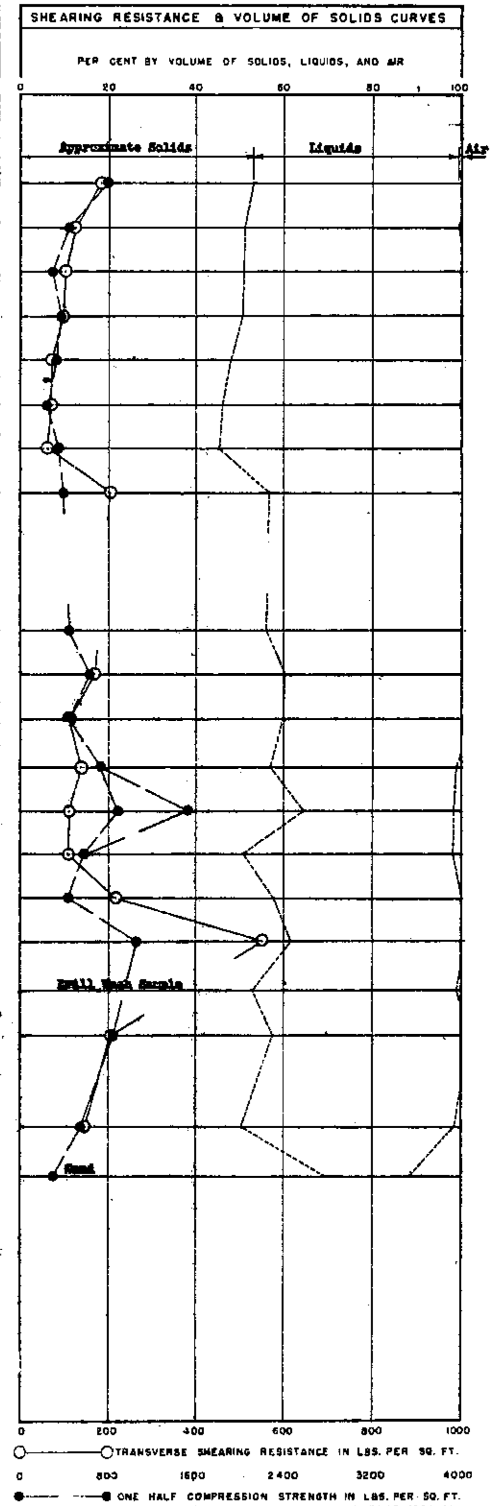
Boring Log and all sampling by Raymond Concrete Pile Division of Raymond International, Inc. Their Job No. CB-4043-D
Date of Boring: 7-31-1965

UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE SOIL MECHANICS LABORATORY	
ANN ARBOR	MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 22 ST. CLAIR POWER PLANT	
THE DETROIT EDISON COMPANY	ST. CLAIR, MICHIGAN
APPROVED: W. A. Housel	DATE: 4-5-1966

PROJECT: 01994

LOG OF SOIL PROFILE BY R.C.P. DIVISION. GROUND SURFACE ELEVATION 589.5 FT. (USING PLANT DATUM)	SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION: NO. OF BLOWS	PENETRATION: DRIVE IN INCHES	% H_2O BY DRY WT	DRY WT. LBS. PER CU. FT.	LABORATORY VISUAL INSPECTION: REMARKS
Medium Sandy Varicolored Clay, Some Gravel.	1-SS	587.0	--	6	12			
	2-SS	584.5	--	9	12			
Stiff Sandy Brown Clay.	3-SS	582.0	--	10	12			
	4-LS	579.5	Soft	3	12	33.6	89.8	4-LS: Uniform. Gray clay, little silt.
Soft Brown Clay, Some Sand.	5-LS	574.5	Very Soft	2	12	35.3	85.3	5-LS: Uniform. Gray clay, little silt.
	6-LS	569.5	Very Soft	2	12	36.8	85.5	6-LS: Uniform. Gray clay, little silt.
	7-LS	564.5	Very Soft	2	12	36.4	84.9	7-LS: Uniform. Gray clay, little silt.
Very Soft Gray Clay, Some Sand, Trace of Gravel.	8-LS	559.5	Very Soft	1	12	41.0	80.5	8-LS: Uniform. Gray clay, little silt.
	9-LS	554.5	Very Soft	1	12	43.2	77.4	9-LS: Uniform. Gray clay, little silt.
	10-LS	549.5	Very Soft	2	12	45.6	76.1	10-LS: Uniform. Gray clay, little silt.
	11-LS	544.5	Soft	3	12	29.4	90.2	11-LS: Uniform. Gray Clay, little silt.
	12-SS	539.5	--	20	12			
Firm Medium to Fine Gray Sand.	13-SS	534.5	--	25	12			
	14-LS	529.0	Soft	4	12	30.1	92.4	14-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
Soft Sandy Gray Clay, Trace of Gravel.	15-LS	524.0	Soft	4	12	25.0	99.2	15-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
	16-LS	519.0	Soft	3	12	27.8	98.2	16-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
	17-LS	513.5	Soft	6	12	28.1	93.6	17-LS: Uniform. Silty gray clay, little sand and trace of fine gravel.
	18-LS	508.5	Soft to Plastic	10	12	18.6	108.8	18-LS: Uniform. Silty gray clay, some sand, trace of gravel.
Medium Sandy Gray Clay, Some Gravel.	19-LS	503.5	Soft	11	12	34.8	84.9	19-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
	20-LS	498.5	Soft	8	12	28.7	96.7	20-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
	21-LS	493.5	Plastic	8	12	25.9	--	21-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
	22-LS	488.0	Very Soft	8	12	31.0	88.8	22-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
	23-LS	483.0	Soft	8	12	28.4	96.7	23-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
Firm Fine to Medium Gray Sand.	24-SS	477.5	--	48	12			
Medium Sandy Gray Clay.	25-LS	472.5	Soft	6	12	33.6	84.2	25-LS: Uniform. Silty gray clay.
Very Compact Medium Gray Sand.	26-LS	467.0	Loose	67	12	18.1	116.7	26-LS: Uniform. Fine gray sand, trace of clay.
Very Compact Fine to Medium Gray Sand, Few Seams of Clayey Sand.	27-SS	462.7	--	200	12			
Boring Stopped.	28-SS	458.0	--	208	12			

ELEVATION IN FEET: 580, 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450



PENETRATION: Number of blows required to drive tube sampler distance given using a 140-pound weight falling 30 inches.

▭ Failure to recover Liner Sample.

UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
ANN ARBOR MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 25
ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY ST. CLAIR, MICHIGAN
APPROVED: W. S. Housel DATE: 4-5-1966
PROJECT: 01994

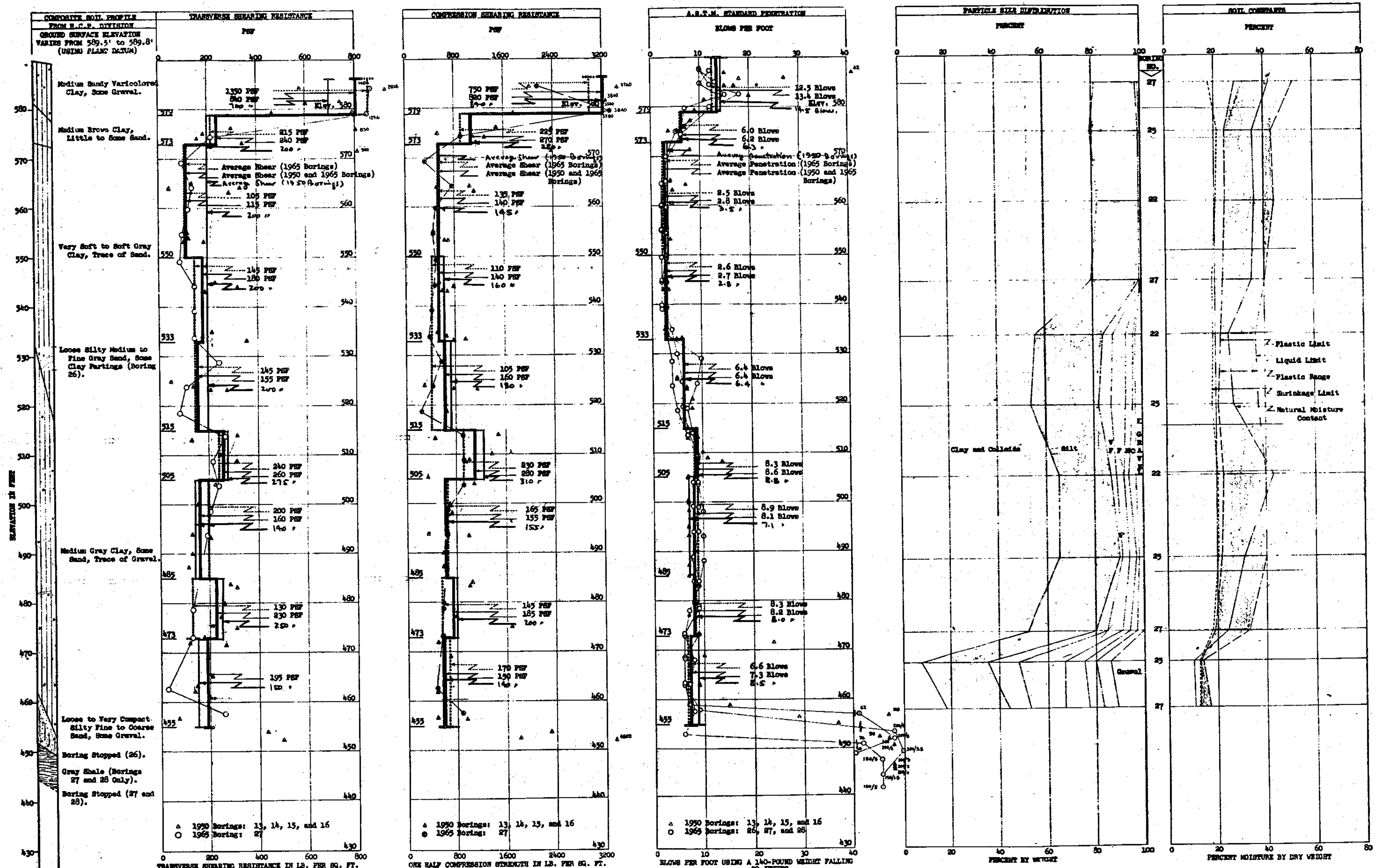
Boring Log and all sampling by Raymond Concrete Pile Division of Raymond International, Inc.
Their Job No. CB-4043-D
Date of Boring: 7-1-1965

COMPARISON OF AVERAGE SOIL RESISTANCES BETWEEN 1950 AND 1965 BORINGS FOR THE YARD'S CONVEYOR ST. CLAIR POWER PLANT

1950 Borings: 13, 14, 15, and 16
1965 Borings: 26, 27, and 28

Elev.	Soil Type	S_c PSF			$S_{uc}/4$ PSF			N Blows/Ft.			Elev. Ft.
		1950[1]	1965[2]	All[1,2]	1950[1]	1965[2]	All[1,2]	1950[1]	1965[3]	All[1,3]	
590	Ground Surface										590
579	Medium sandy vari-colored clay, some gravel.	700	1350[5]	840	840	750[5]	818	14.5	12.5	13.4	579
573	Medium brown clay, little to some sand.	200	216[4]	241	280	226[4]	270	6.3	6.0	6.2	573
	Very soft to soft gray clay, trace of sand.	200	106	116	144	136	142	3.5	2.5	2.8	550
533		200	144	178	159	108	142	2.8	2.6	2.7	533
	Medium gray clay, some sand, trace of gravel.	200	145	155	182	103	159	6.4	6.4	6.4	515
		275	240	260	312	232	278	8.8	8.3	8.6	505
		140	198[5]	161	154	165[5]	156	7.1	8.9	8.1	485
		250	130[5]	230	202	144[5]	185	8.0	8.3	8.2	473
455		150	259[4]	195	140	170[5]	150	8.5	6.6	7.3	455

(1) Based on shear tests and ASTM penetration values from Borings 13, 14, 15, and 16.
(2) Based on shear tests from Boring 27 only.
(3) Based on ASTM penetration values from Borings 26, 27, and 28.
(4) Based on one shear value only.
(5) Based on two shear values only.



The above Composite Soil Profile is intended only to present average conditions throughout the group of borings represented. See individual Boring Charts for details.

OFFICE OF RESEARCH ADMINISTRATION,
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN
COMPOSITE SUBSOIL ANALYSIS OF BORINGS NO. 26, 27 & 28
ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY
ST. CLAIR MICHIGAN
APPROVED W. S. Housel DATE 4-5-1966
OFFICE OF RESEARCH ADMINISTRATION PROJECT NO. 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION 589.8 FT. (USING PLANT DATUM)

Elevation in Feet	Description
	Clay, Silt.
	Medium Sandy Variecolored Clay, Some Gravel.
	Stiff Sandy Variecolored Clay, Some Gravel.
580	Medium Sandy Variecolored Clay.
	Medium Brown Gray Clay.
570	
560	Soft Gray Clay, Trace of Sand.
550	
540	
530	
520	
510	
500	Medium Sandy Gray Clay, Trace of Gravel, Some Coarse Sand.
490	
480	
470	
	Medium Gray Clay, Seams and Partings of Fine to Medium Silty Gray Sand.
460	Loose Silty Clayey Fine to Medium Gray Sand.
	Very Compact Medium to Coarse Gray Sand.
450	Gray Shale, Seams of Hard Gray Clay.
	Boring Stopped.
440	

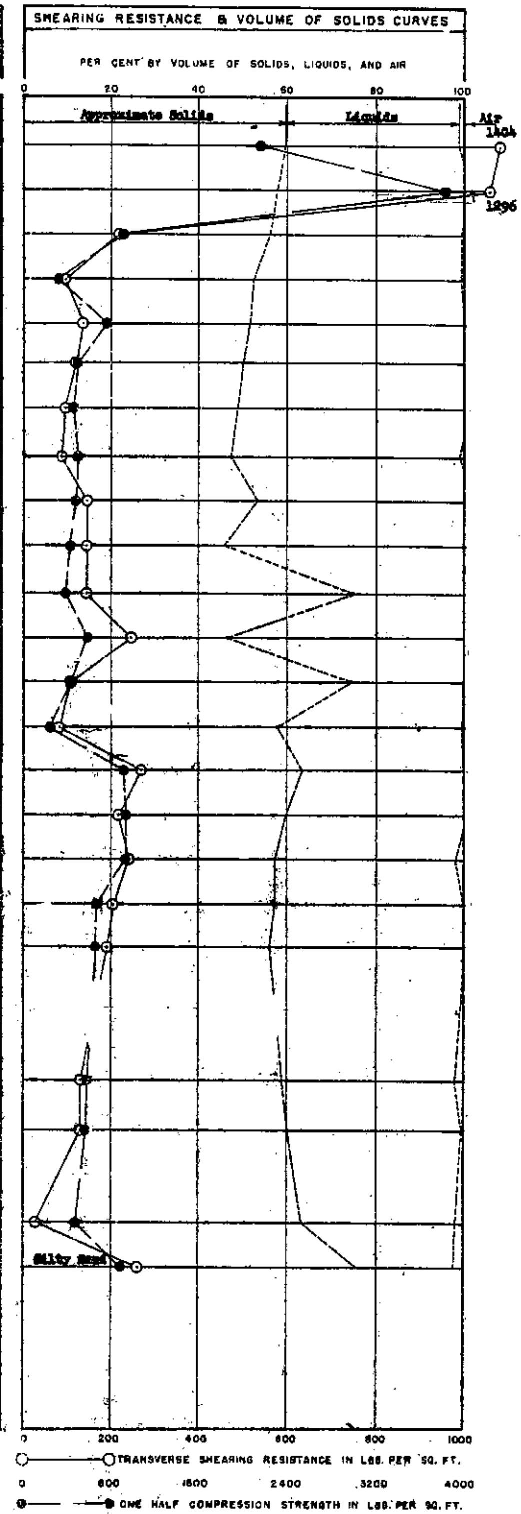
Boring Log and all sampling by Raymond Concrete Pile Division of Raymond International, Inc. Their Job No. CH-4043-D Date of Boring: 7-8-1964

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV	LAB. CONSISTENCY	PENETRATION: NO OF BLOWS	PENETRATION: DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LBS. PER CU. FT.	REMARKS
1-DS	587.3	—	10	12			
2-LS	584.3	Firm	18	12	24.6	99.8	2-LS: Uniform. Brown-gray laminated clay, little silt, trace of sand.
3-DS	582.3	—	18	12			
4-LS	579.3	Stiff	18	12	28.3	96.7	4-LS: Uniform. Brown-gray laminated clay, little silt, trace of sand.
5-LS	574.3	Soft	6	12	28.8	94.2	5-LS: Uniform. Brown-gray laminated clay, little silt, trace of sand.
6-LS	569.3	Soft	3	12	33.3	88.0	6-LS: Uniform. Gray clay, little silt, trace of sand.
7-LS	564.3	Soft	8	12	34.8	86.7	7-LS: Uniform. Gray clay, little silt, trace of sand.
8-LS	559.8	Soft	2	12	40.0	84.2	8-LS: Uniform. Gray clay, little silt, trace of sand.
9-LS	554.8	Soft	2	12	40.0	81.7	9-LS: Uniform. Gray clay, little silt, trace of sand.
10-LS	549.3	Soft	3	12	40.7	79.8	10-LS: Uniform. Gray clay, little silt, trace of sand.
11-LS	544.3	Soft	3	12	34.7	89.2	11-LS: Uniform. Gray clay, little silt, trace of sand.
12-LS	539.3	Soft	3	12	44.0	76.8	12-LS: Uniform. Gray clay, little silt, trace of sand.
13-LS	533.8	Soft	3	12	12.6	124.8	13-LS: Uniform. Silty gray clay, some pockets of fine sand.
14-LS	528.8	Soft	15	12	45.0	76.1	14-LS: Uniform. Silty gray clay.
15-LS	523.8	Soft	9	12	13.0	122.6	15-LS: Uniform. Silty gray clay, some pockets and layers of sand.
16-LS	518.8	Very Soft	7	12	27.3	95.5	16-LS: Uniform. Silty gray clay, little sand.
17-LS	513.8	Soft	8	12	16.7	104.2	17-LS: Uniform. Silty gray clay, little sand.
18-LS	508.8	Soft	9	12	26.0	98.6	18-LS: Uniform. Silty gray clay, little sand.
19-LS	503.8	Soft	8	12	27.4	94.2	19-LS: Uniform. Silty gray clay, little sand.
20-LS	498.8	Soft	8	12	28.0	95.5	20-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
21-LS	493.8	Soft	9	12	29.4	93.6	21-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
22-DS	487.3	—	8	12			
[illegible]	483.8	—	9	12			
23-LS	478.8	Soft	8	12	24.6	98.6	23-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
24-LS	473.3	Soft	9	12	[illegible].5	102.3	24-LS: Uniform. Silty gray clay, little sand, trace of fine gravel.
25-DS	468.3	—	6	12			
26-LS	462.8	Very Soft	6	12	20.4	106.1	26-LS: Uniform. Silty gray clay, honeycombed.
27-LS	457.8	Soft	9	12	18.8	127.3	27-LS: Uniform. Silty gray sand, some clay and gravel.
28-DS	453.3	—	200	12			
29-DS	449.3	—	350	12			
30-DS	444.6	—	190	12			

PENETRATION: Number of blows required to drive case sampler distance given using a 140-pound weight falling 30 inches.

DS Failure to recover Liner Sample.



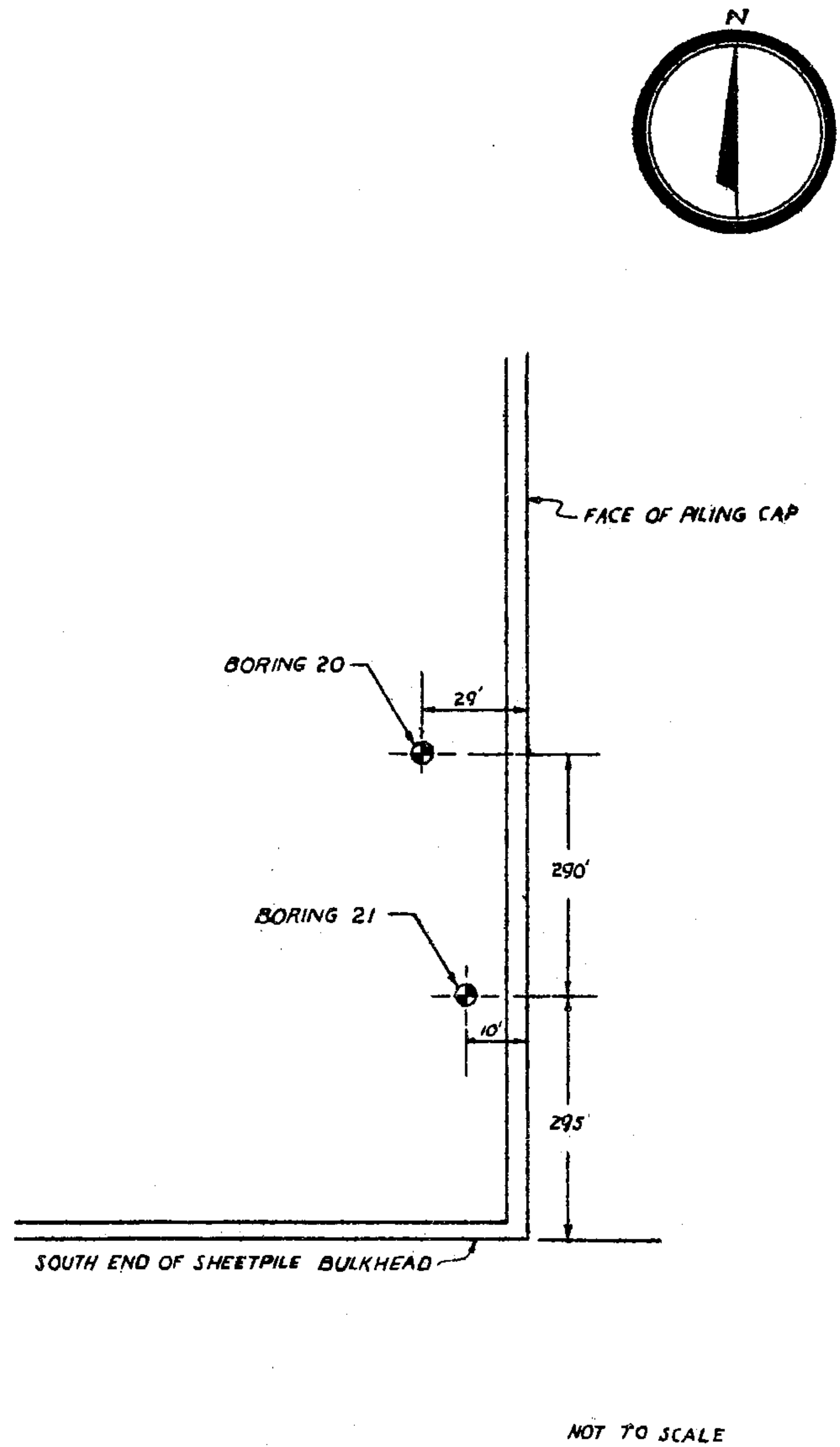
UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
ANN ARBOR MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 27
ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY ST. CLAIR, MICHIGAN

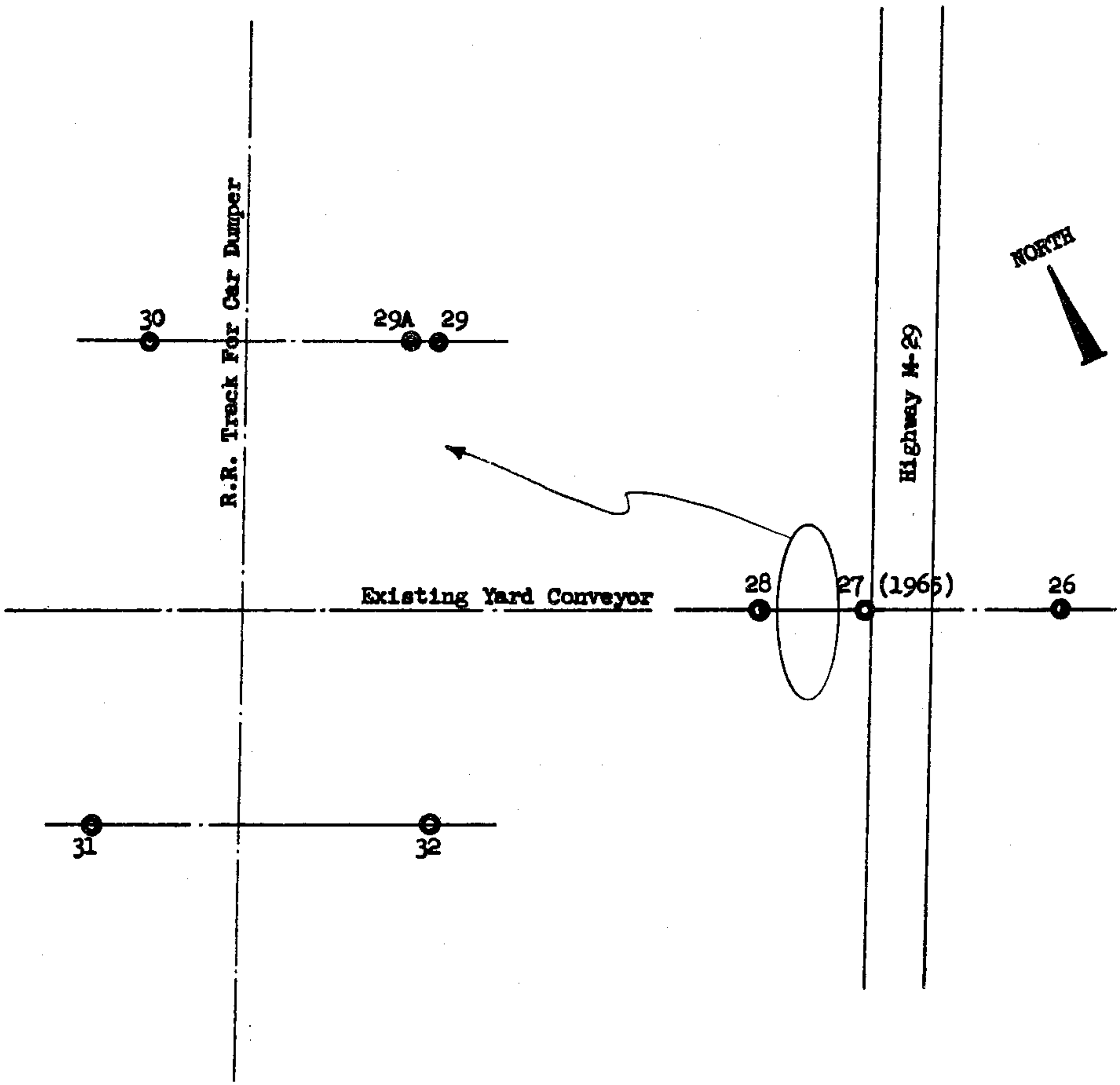
APPROVED: W. A. Hoasel DATE: 4-5-1966

PROJECT: 01994

ADDITIONAL St. CLAIR PLANT INFORMATION



BORING LOCATION PLAN
ST. CLAIR POWER PLANT
DETROIT EDISON COMPANY
DETROIT MICHIGAN
UNIV. OF MICHIGAN PROJECT 01994



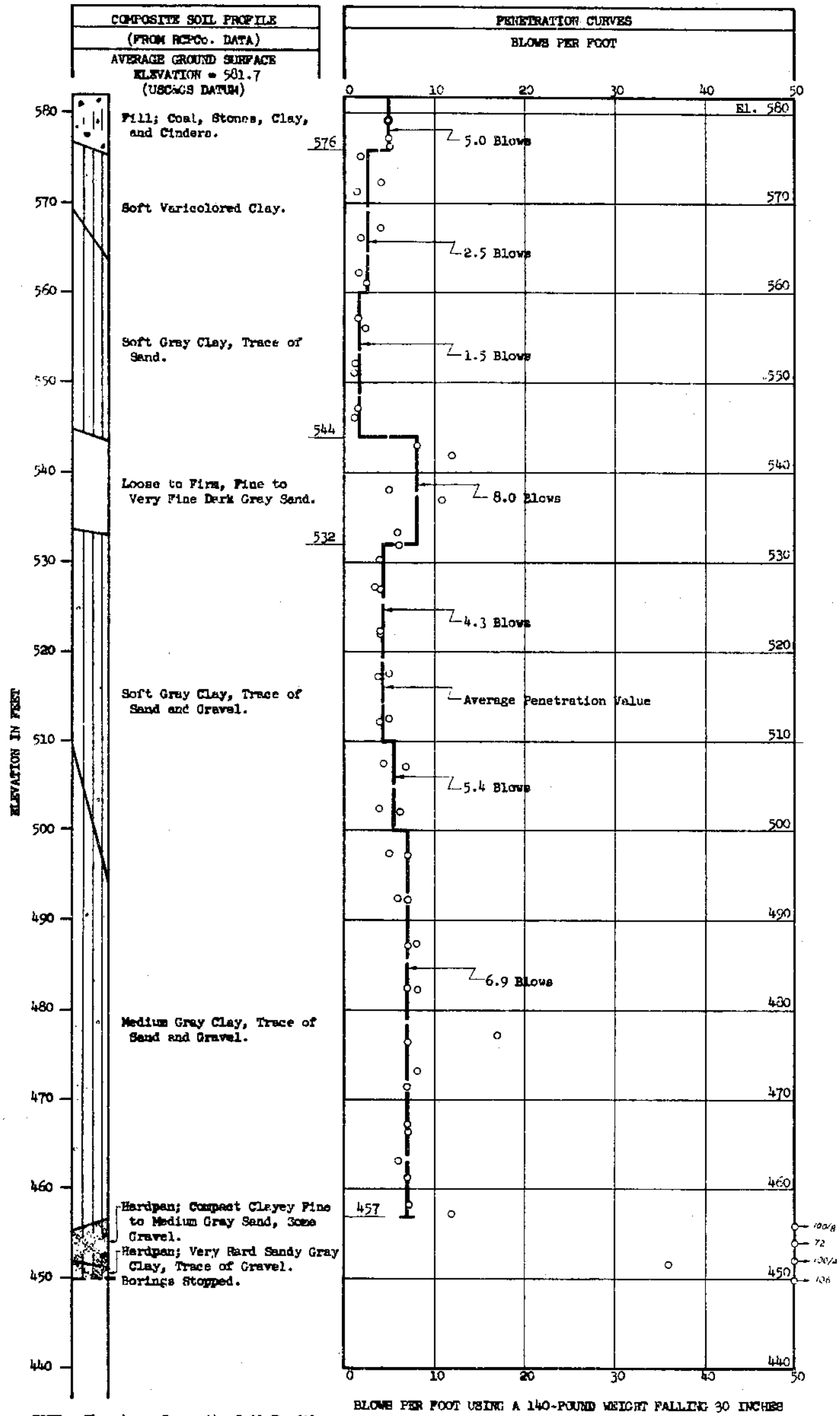
Scale: 1" = 30'

- ● 1965 and 1966 Borings with Liner Samples
- ◉ 1965 Borings without Liner Samples

Scale: 1" = 300'

BORING LOCATION PLAN	
CAR DUMPER HOUSE	
ST. CLAIR POWER PLANT	
THE DETROIT EDISON CO.	
BELLE RIVER	MICHIGAN

CRA PROJECT NO. 01994



NOTE: The above Composite Soil Profile is intended only to present average conditions throughout the group of borings represented. See individual boring charts for details.

UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE SOIL MECHANICS LABORATORY	
ANN ARBOR	MICHIGAN
PENETRATION VALUES OF BORINGS NO. 20 and 21 ST. CLAIR POWER PLANT - DETROIT EDISON COMPANY	
DETROIT	MICHIGAN
APPROVED: [illegible signature]	DATE: - 2 - 5 -

Boring Logs

LOG OF SOIL PROFILE

BY RCPCo VISUAL INSPECTION

GROUND SURFACE ELEVATION = 588.7' (USC & GS DATUM)

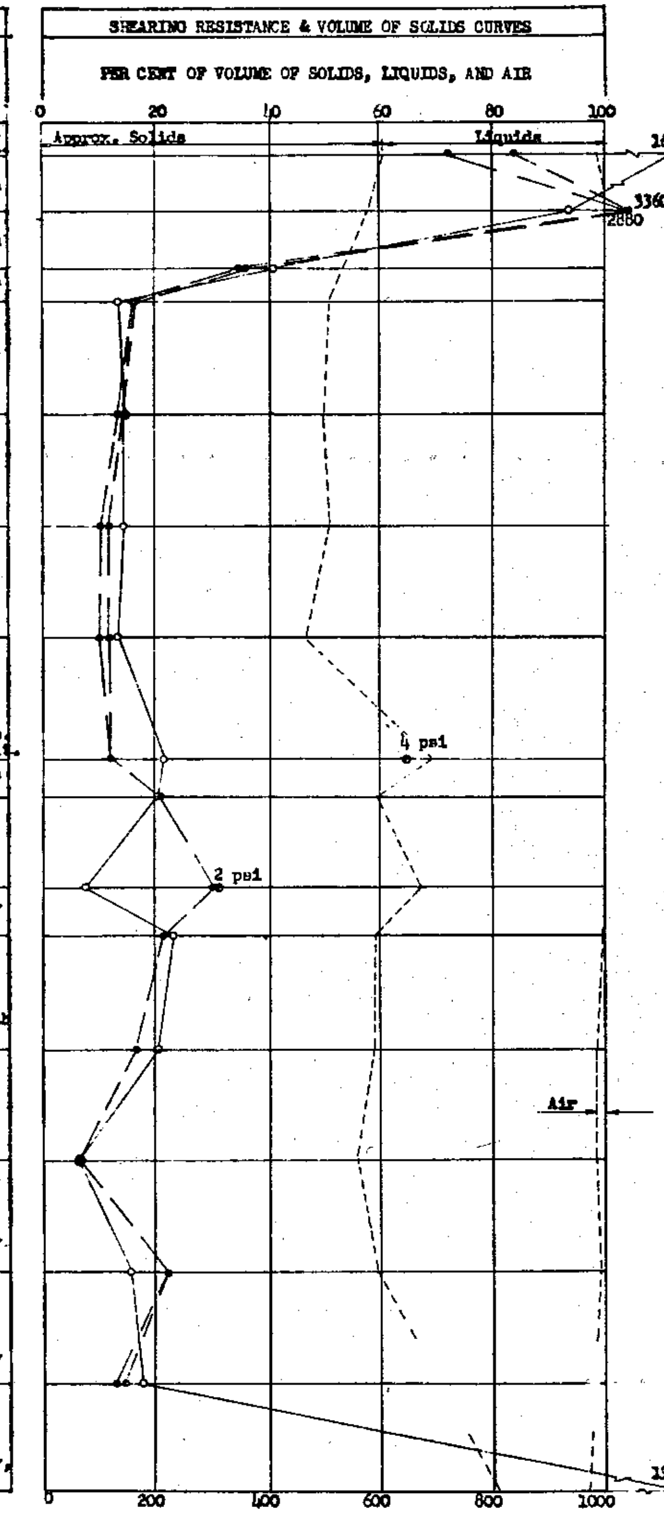
- Topsoil.
- Med. V.-Colored Clay.
- Hard Vari-Colored Clay, Little Sand, Trace of Gravel.
- Med. Vari-Colored Clay, Tr. Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Clayey, Med. Dark Sand, Little Gravel.
- Soft Blue Clay, Little Sand & Gravel, Seams of Sand.
- Clayey, V.Fine, Dark Sand, Little Gravel.
- Seam of Clayey, Fine Gray Sand.
- Medium Blue Clay, Little Sand & Gravel, Few Sand Seams.
- Medium Blue Clay, Little Sand & Gravel. Sand Inclusions.
- Hardpan; Compact Clayey Fine Gray Sand, Seams of Clean Sand & Gr., Few Boulders.
- Boring Stopped.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.

SOIL SAMPLE			PENETRATION				LABORATORY VISUAL INSPECTION
SA. NO.	ELEV.	LAB. CONSIS-TENCY	NO. OF BLOWS	DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-LS	585.7	Hard	15	12	23.3	101.7	1-LS: Uniform, very fine texture. Smooth vari-colored clay. Little silt. Sl. tr. sand.
2-LS	580.7	V. Stiff	24	12	27.4	97.3	2-LS: Uniform, very fine texture. Smooth vari-colored clay. Little silt.
3-LS	575.7	Stiff	7	12	36.9	86.1	3-LS: Uniform, very fine texture. Smooth vari-colored clay. Little silt.
4-LS	572.7	Soft	3	12	35.8	85.5	4-LS: Uniform, very fine texture. Smooth blue clay. Little silt.
5-LS	562.7	Soft	3	12	38.4	83.6	5-LS: Uniform, very fine texture. V. smooth blue clay. Little silt.
6-LS	552.7	Soft	3	13	36.7	84.9	6-LS: Uniform, very fine texture. V. smooth blue clay. Little silt.
7-LS	542.7	Soft	3	12	43.1	78.0	7-LS: Uniform, very fine texture. V. smooth silty blue clay.
8-LS	531.7	W.C.	10	12	16.9	114.8	8-LS: Uniform, very fine to fine texture. V.f. to f. gray sand. Some cl., little silt.
9-LS	528.4	Soft	5	12	24.8	100.2	9-LS: Uniform, very fine texture. Smooth blue clay. Little silt, tr. sand.
10-LS	520.2	W.C.	12	12	19.0	111.1	10-LS: Uniform, very fine texture. Dark gray clayey silt and very fine sand.
11-LS	515.9	Plastic	7	13	25.6	99.2	11-LS: Uniform, very fine texture. Silty blue clay. Trace sand.
12-LS	505.7	Plastic	7	12	24.7	98.6	12-LS: Uniform, very fine texture. Smooth blue clay with little silt and sand.
13-LS	495.7	V. Soft	8	13	28.0	94.2	13-LS: Uniform, very fine texture. Blue clay with some silt & little sand.
14-LS	485.7	Soft	8	12	25.2	99.2	14-LS: Uniform, very fine texture. Silty blue clay with little sand.
15-LS	475.7	Soft	8	12	42.8	- -	15-LS: Uniform, very fine texture. Silty blue clay.
16-LS	466.2	Hard	222	12	7.3	136.0	16-LS: Uniform, very fine texture. Sandy, silty gray clay with pebbles.
	461.4	- -	200	6			PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.
	456.5	- -	200	4			

⊠ Indicates failure to recover Liner Sample.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



○——○ TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

●— —● ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

● TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE AS INDICATED.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

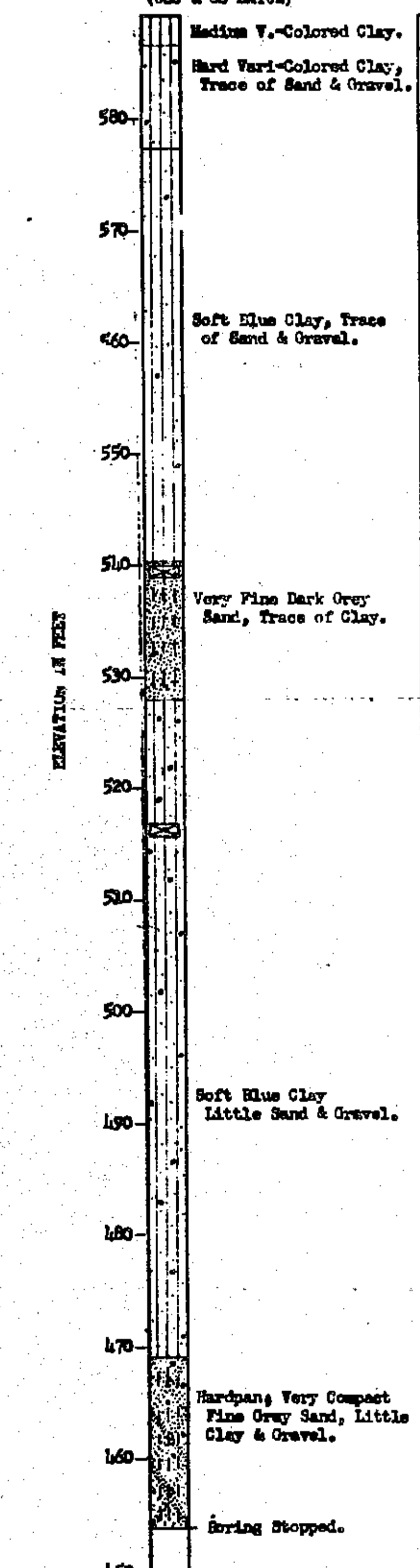
SUBSOIL ANALYSIS OF BORING NO. 3
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: W.S. Housel DATE: 12-5-50

UNIVERSITY OF MICHIGAN PROJECT M373-66

LOG OF SOIL PROFILE

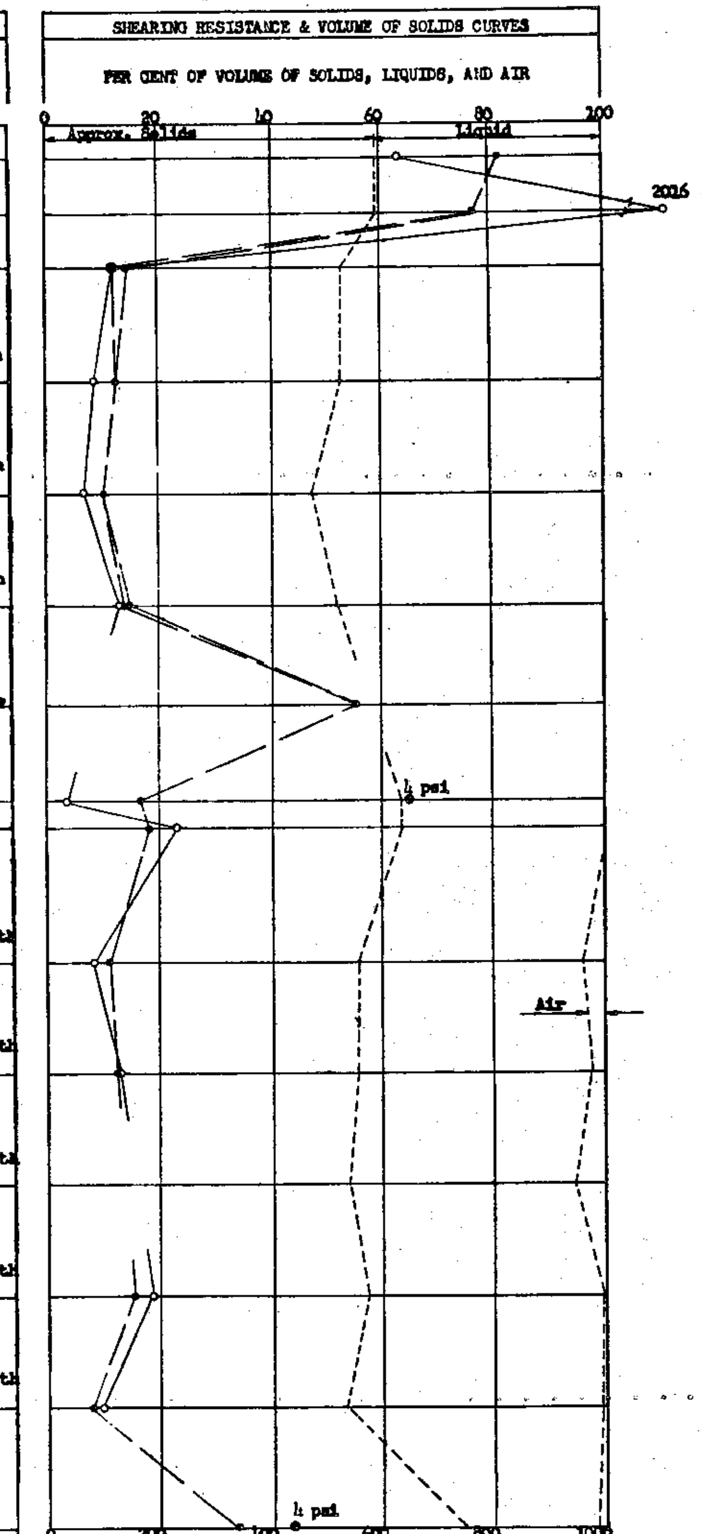
BY BORCo VISUAL INSPECTION
GROUND SURFACE
ELEVATION = 589.3'
(USC & GS DATUM)



Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. 3-7153-D.

SOIL SAMPLE							LABORATORY VISUAL INSPECTION
SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION: NO. OF BLOWS	PENETRATION: DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-LS	586.3	V.Stiff	14	12	26.5	99.8	1-LS: Uniform, very fine texture. Silty vari-colored clay with trace organic.
2-LS	581.3	Hard	22	12	26.5	99.2	2-LS: Uniform, very fine texture. Silty vari-colored clay. Trace pebbles.
3-LS	576.5	Soft	4	13	35.5	88.6	3-LS: Uniform, very fine texture. Silty blue clay. Sl. trace sand.
4-LS	566.3	Soft	3	12	34.8	88.0	4-LS: Uniform, very fine texture. Smooth blue clay with little silt.
5-LS	556.3	V.Soft	2	11	42.3	79.2	5-LS: Uniform, very fine texture. Smooth blue clay with little silt.
6-LS	546.3	Soft	2	11	36.0	86.7	6-LS: Uniform, very fine texture. Smooth blue clay with little silt.
	539.5	- -	12	12			
7-LS	537.3	Weakly Coherent	3	12	20.0	- -	7-LS: Uniform, very fine texture. Gray very fine to fine sand with little silt.
8-LS	528.7	Weakly Coherent	7	12	21.8	104.8	8-LS: Uniform, very fine texture. Gray very fine sand with some clay & silt.
9-LS	526.3	Soft	6	12	22.0	106.1	9-LS: Uniform, very fine texture. Blue clay with little silt and sand. Tr. pebb.
	516.3	- -	6	12			
10-LS	514.3	V.Soft	7	12	26.9	93.0	10-LS: Uniform, very fine texture. Smooth silty blue clay with little sand.
11-LS	504.3	Soft	8	12	28.1	93.0	11-LS: Uniform, very fine texture. Smooth silty blue clay.
12-LS	494.3	V.Soft	9	12	28.0	90.5	12-LS: Uniform, very fine texture. Smooth silty blue clay.
13-LS	484.3	Soft	9	12	27.6	96.1	13-LS: Uniform, very fine texture. Smooth silty blue clay.
14-LS	474.3	V.Soft	9	12	31.9	89.9	14-LS: Uniform, very fine texture. Smooth silty blue clay.
15-LS	463.5	Weakly Coherent	71	12	11.8	124.8	15-LS: Uniform, v.fine to fine texture. Clayey v.fine to fine gray sand.
16-BS	459.1	Compact	225	5			16-BS: Uniform, v.fine to fine texture. Clayey v.fine to fine grey sand.
	454.3	- -	200	3			

[X] Indicates failure to recover Liner Sample.
PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.



o———o TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.
0 800 1600 2400 3200 4000
●— —● ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.
● TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE OF 4 psi.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 1
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

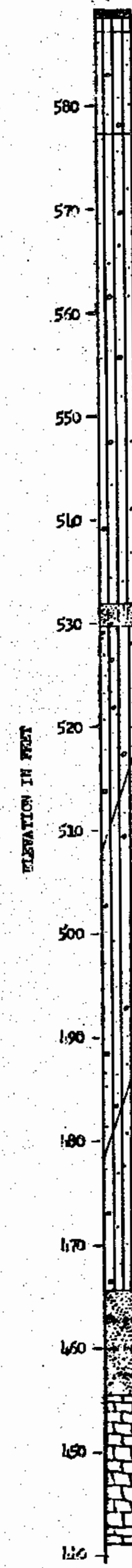
APPROVED: W.S. Housel DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT M373-66

LOG OF SOIL PROFILE

BY RCPCo VISUAL INSPECTION

GROUND SURFACE ELEVATION = 589.3' (USC & GS DATUM)



- Topsoil.
- Med. Vari-Colored Clay.
- Hard Vari-Colored, Trace of Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Med. to Course Sand & Gravel, Little Clay.
- Soft Blue Clay, Little Sand & Gravel.
- Medium Blue Clay, Little Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Hardpan; Compact Fine to Medium Gray Sand, Little Gravel and Clay, Seams of Clayey Sand. Few Boulders.
- Probably Fractured Blue Shale.
- Boring Stopped.

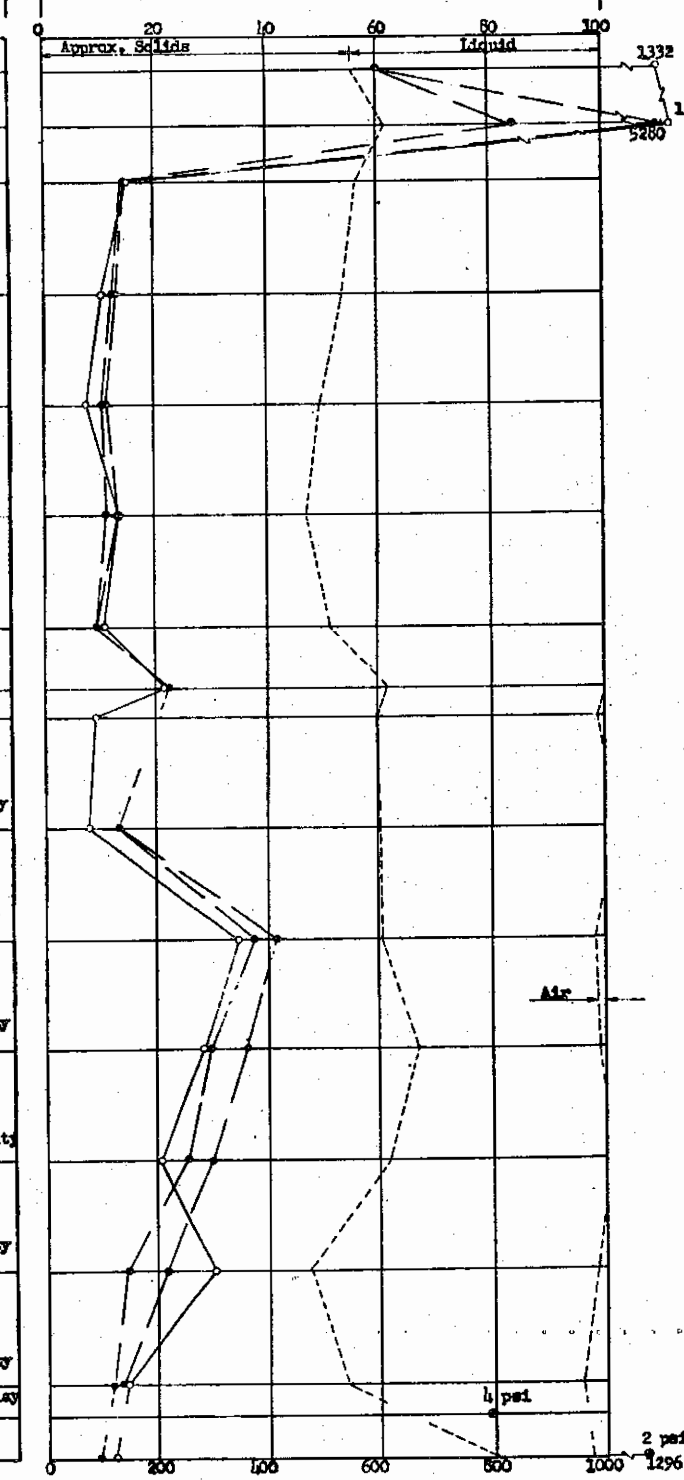
Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. 9-7153-D.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION: NO. OF BLOWS	PENETRATION: DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-LS	586.3	V.Stiff	15	12	29.7	93.6	1-LS: Uniform, very fine texture. Vari-colored with little silt.
2-LS	581.3	V.Stiff	14	12	25.2	103.0	2-LS: Uniform, very fine texture. Silty vari-colored clay.
3-LS	576.3	Soft	4	13	29.7	94.2	3-LS: Uniform, very fine texture. Silty blue clay.
4-LS	566.3	Soft	3	12	33.3	90.5	4-LS: Uniform, very fine texture. Silty blue clay.
5-LS	556.3	Soft	3	13	38.5	83.0	5-LS: Uniform, very fine texture. Silty blue clay.
6-LS	546.3	Soft	3	13	41.3	79.2	6-LS: Uniform, very fine texture. Silty blue clay.
7-LS	536.3	Soft	4	14	34.9	86.1	7-LS: Uniform, very fine texture. Silty blue clay. Trace sand and pebbles.
8-LS	530.8	Soft to Plastic	22	12	23.8	103.0	8-LS: Uniform, very fine texture. Blue clay with little silt. Tr. sand & pebs.
9-LS	528.3	V.Soft	6	12	23.0	100.5	9-LS: Uniform, very fine texture. Blue clay with little silt. Tr. pebbles.
10-LS	518.3	Soft	7	12	26.0	101.1	10-LS: Uniform, very fine texture. Sandy blue clay with some silt. Tr. pebbles.
11-LS	508.3	Plastic to Firm	9	12	23.4	101.1	11-LS: Uniform, very fine texture. Blue clay with some silt. Tr. pebbles.
12-LS	498.3	Plastic	9	12	17.7	112.3	12-LS: Uniform, very fine texture. Silty blue clay.
13-LS	488.3	Plastic	11	12	23.8	103.6	13-LS: Uniform, very fine texture. Silty blue clay with pebbles.
14-LS	478.3	Plastic	8	12	40.1	79.9	14-LS: Uniform, very fine texture. Silty blue clay. Tr. sand. Internal voids.
15-LS	468.3	Plastic	8	12	39.5	78.0	15-LS: Uniform, very fine texture. Silty blue clay. Internal voids.
16-LS	465.4	Non.C.	159	12	--	--	16-LS: Non-uniform. Varies from blue clay to medium gray sand.
17-LS	461.0	W.C.	200	8	7.9	136.0	17-LS: Uniform, coarse texture. Clayey silt and sand with little gravel.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE AS INDICATED.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 2
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: W.S. Housel DATE: 12-15-50

UNIVERSITY OF MICHIGAN PROJECT 1873-66

LOG OF SOIL PROFILE
BY RCPCo VISUAL INSPECTION
GROUND SURFACE ELEVATION = 588.2'
(USC & GS DATUM)

ELEVATION IN FEET

- Topsoil
- Hard Vari-Colored Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Few Sand Inclusions.
- Clayey Fine Dark Sand, Little Gravel.
- Medium Blue Clay, Little Sand & Gravel, Few Seams of Sand.
- Sandy Medium Blue Clay, Seams of Sand, Little Gr.
- Hardpan; Compact Fine Gray Sand, Trace Gravel, Seams of Sandy Clay.
- Boring Stopped.

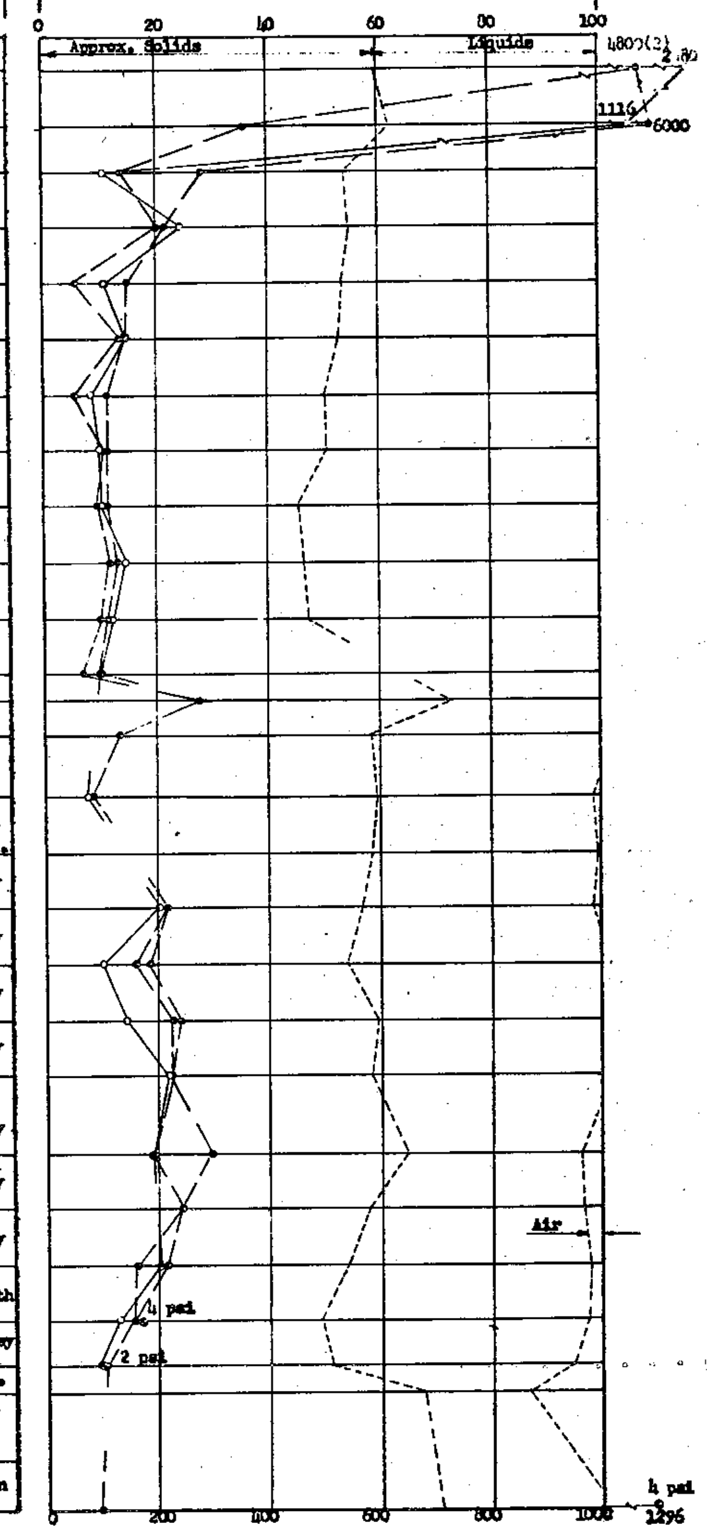
Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.

SOIL SAMPLE							LABORATORY VISUAL INSPECTION
SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-LS	585.2	Hard	18	12	24.8	99.8	1-LS: Uniform, fine texture. Vari-colored clay with little silt.
2-LS	580.2	V.Stiff	20	12	23.0	104.2	2-LS: Uniform, very fine texture. Silty vari-colored clay. Trace pebbles.
3-LS	576.2	Plastic	4	13	32.4	90.5	3-LS: Uniform, very fine texture. Silty blue clay.
4-LS	571.2	Plastic	3	12	30.6	91.7	4-LS: Uniform, very fine texture. Silty blue clay. Trace of pebbles.
5-LS	566.2	Soft	4	14	32.9	89.2	5-LS: Uniform, very fine texture. Smooth silty blue clay.
6-LS	561.2	Soft	4	13	33.8	88.6	6-LS: Uniform, very fine texture. Blue clay with little silt.
7-LS	556.2	Soft	3	12	38.4	84.2	7-LS: Uniform, very fine texture. Silty blue clay.
8-LS	551.2	Soft	3	14	36.4	85.5	8-LS: Uniform, very fine texture. Silty blue clay.
9-LS	546.2	Soft	3	14	45.3	76.1	9-LS: Uniform, very fine texture. Silty blue clay with little sand.
10-LS	541.2	Soft	3	14	43.3	77.4	10-LS: Uniform, very fine texture. Silty blue clay.
11-LS	536.2	Soft	3	12	42.3	79.2	11-LS: Uniform, very fine texture. Silty blue clay.
12-LS	531.2	Soft	3	13	43.4	- -	12-LS: Uniform, very fine texture. Silty blue clay.
13-LS	528.9	W.C.	10	12	14.2	119.8	13-LS: Uniform, fine texture. F. to med. gray clayey sand, tr. of gravel.
14-LS	525.7	V.Soft	6	12	28.1	98.0	14-LS: Uniform, very fine texture. Silty blue clay. Trace pebbles.
15-LS	520.2	V.Soft	7	12	24.6	99.8	15-LS: Uniform, very fine texture. Silty blue clay with tr. of gravel.
16-LS	515.2	V.Soft	8	13	26.4	98.0	16-LS: Uniform, very fine texture. Silty blue clay, little sand. Tr. gr. Disturbed.
17-LS	510.2	V.Soft	7	12	27.1	95.5	17-LS: Uniform, very fine texture. Silty blue clay. Trace pebbles.
18-LS	505.2	V.Soft	7	12	32.7	90.5	18-LS: Uniform, very fine texture. Silty blue clay.
19-LS	500.2	Plastic	8	13	27.8	94.8	19-LS: Uniform, very fine texture. Silty blue clay. Some sand. Trace pebbles.
20-LS	495.2	Plastic	8	12	28.2	97.3	20-LS: Uniform, very fine texture. Silty blue clay. Some sand. Trace pebbles.
	490.2	- -	9	12			
21-LS	488.2	Plastic	9	12	18.3	108.6	21-LS: Uniform, very fine texture. Silty blue clay. Some sand. Trace pebbles.
22-LS	483.2	Soft	10	12	25.1	96.7	22-LS: Uniform, very fine texture. Silty blue clay. Little sand. Trace pebbles.
23-LS	478.2	Plastic	9	12	30.1	90.5	23-LS: Uniform, very fine texture. Silty blue clay with little sand.
24-LS	473.2	Soft	8	12	36.8	82.4	24-LS: Uniform, very fine texture. Smooth blue clay with little silt. Int. voids.
25-LS	469.2	Soft	10	12	31.4	86.1	25-LS: Uniform, very fine texture. Clayey gray silt with little sand.
26-LS	466.7	W.C.	60	12	10.3	114.2	26-LS: Uniform, fine texture. Clean v.f. to f. gray sand. Seams silty clay.
27-BS	460.8	Compact	200	5			27-BS: Uniform, fine texture. Silty very fine to fine gray sand.
28-LS	455.8	Hard	320	10	16.5	117.3	28-LS: Uniform, very fine texture. Clean v.f. gray sand and silt. Seams of clay.

[X] Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.
0 800 1600 2400 3200 4000
ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.
TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE AS INDICATED.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 4
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

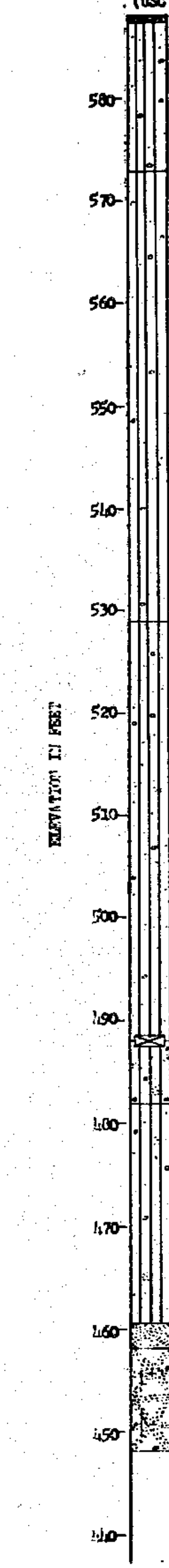
APPROVED: W.S. Housel DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT M373-66

LOG OF SOIL PROFILE

BY RCPCo VISUAL INSPECTION

GROUND SURFACE ELEVATION = 588.± (USC & GS DATUM)



- Topsoil.
- Hard Vari-Colored Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Sand Inclusions.
- Medium Blue Clay, Little Sand & Gravel, Few Sand Seams.
- Med. Hard Blue Clay, Some Sand Inclusions, Little Gravel.
- Soft Blue Clay, Trace of Sand, Gravel & Sand Inclusions.
- Hardpan; Fine to Med. Gray Sand.
- Hardpan; Some Clay, Trace of Gravel, Seams of Sand and Hard Sandy Clay.
- Boring Stopped.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

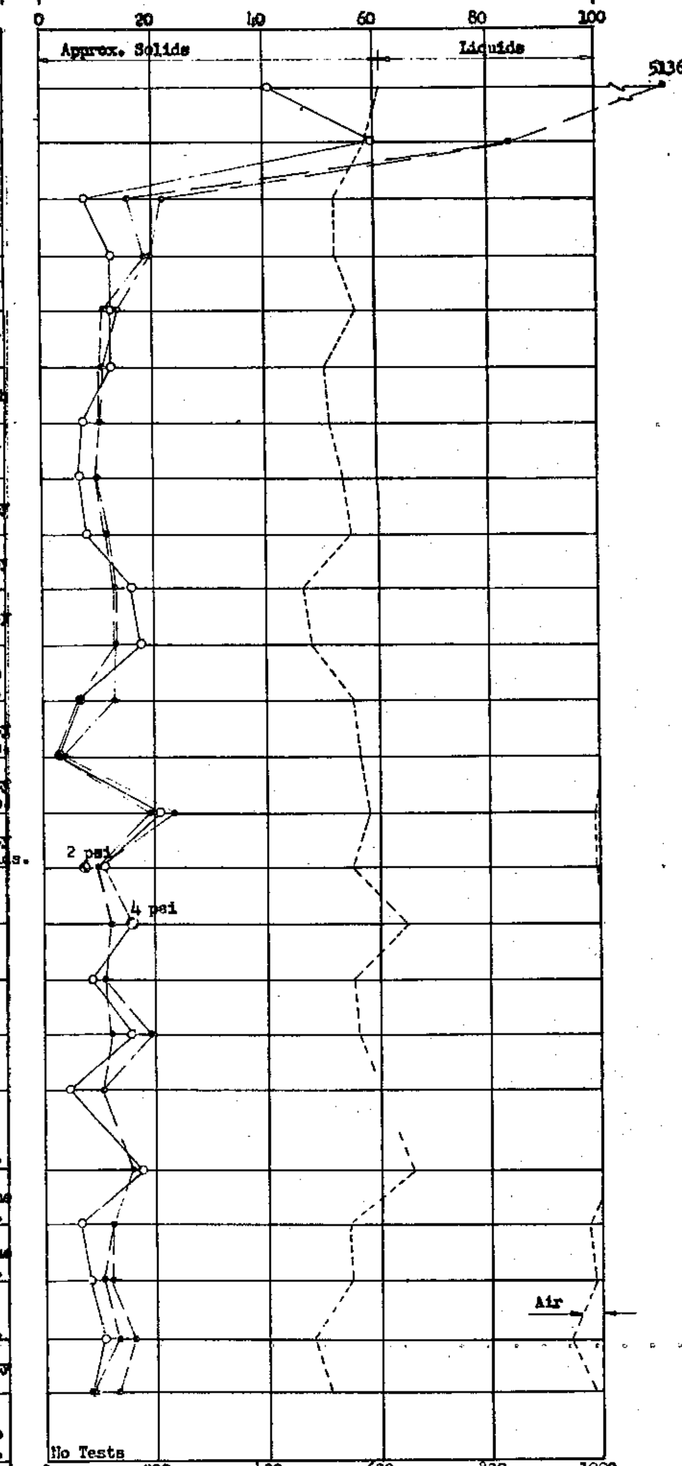
SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-BS	584.5	- -	10	12			
2-LS	583.0	F.Stiff	21	12	24.9	102.3	2-LS: Uniform, very fine texture. Vari-colored clay with little silt.
3-LS	578.0	Plastic	15	12	26.8	98.6	3-LS: Uniform, very fine texture. Silty vari-colored clay with tr. pebbles.
4-LS	573.0	Soft	6	12	33.7	88.6	4-LS: Uniform, very fine texture. Silty blue clay.
5-LS	568.0	Soft	4	14	33.0	88.6	5-LS: Uniform, very fine texture. Silty blue clay.
6-LS	563.0	Soft	3	12	28.9	94.8	6-LS: Uniform, very fine texture. Silty blue clay with pebbles.
7-LS	558.0	Soft	3	12	35.3	86.1	7-LS: Uniform, very fine texture. Silty blue clay.
8-LS	553.0	Soft	3	12	35.2	86.4	8-LS: Uniform, very fine texture. Smooth silty blue clay with pebbles.
9-LS	548.0	Soft	3	12	32.5	90.5	9-LS: Uniform, very fine texture. Silty blue clay.
10-LS	543.0	Soft	3	12	31.8	92.4	10-LS: Uniform, very fine texture. Silty blue clay.
11-LS	538.0	Soft to Plastic	4	13	44.2	78.6	11-LS: Uniform, very fine texture. Silty blue clay with little sand.
12-LS	533.0	Soft to Plastic	4	12	39.6	81.1	12-LS: Uniform, very fine texture. Silty blue clay with little sand.
13-LS	528.0	V.Soft	5	12	29.5	93.0	13-LS: Uniform, very fine texture. Blue clay with little silt. Tr. sand & pebs.
14-LS	523.0	V.Soft	6	12	28.5	95.5	14-LS: Uniform, very fine texture. Silty blue clay with little sand. Tr. pebbles.
15-LS	518.0	Soft to Plastic	7	12	25.5	98.6	15-LS: Uniform, very fine texture. Silty blue clay with little sand. Tr. pebbles.
16-LS	513.0	Soft to Plastic	7	12	29.5	93.0	16-LS: Uniform, very fine texture. Silty blue clay. Little sand. Tr.pebs.Int.voids.
17-LS	508.0	Soft	7	12	20.3	108.0	17-LS: Uniform, fine texture. Silty sandy blue clay with pebbles.
18-LS	503.0	Soft	7	12	29.3	93.0	18-LS: Uniform, fine texture. Silty sandy blue clay with pebs. Int. voids.
19-LS	498.0	Soft	7	12	29.0	94.8	19-LS: Uniform, fine texture. Silty sandy blue clay with pebs. Int. voids.
20-LS	493.0	V.Soft	8	13	23.6	92.2	20-LS: Uniform, fine texture. Silty sandy blue clay with pebbles.
	488.0	- -	10	12			
21-LS	486.0	Plastic	12	12	19.9	111.7	21-LS: Uniform, fine texture. Blue clay. Some silt. Little sand. Tr. pebs.
22-LS	481.0	Soft	7	12	29.1	91.7	22-LS: Uniform, fine texture. Silty blue clay. Some sand.Tr.pebbles. Int. voids.
23-LS	476.0	Soft to Plastic	8	12	29.6	92.4	23-LS: Uniform, fine texture. Silty blue clay. Some sand.Tr.pebbles. Int. voids.
24-LS	471.0	Soft to Plastic	6	12	35.4	81.1	24-LS: Uniform, fine texture. Silty blue clay with little sand. Int. voids.
25-LS	466.0	Soft	8	12	34.2	86.1	25-LS: Uniform, very fine texture. Silty blue clay with internal voids.
		Weakly	16	12			
26-LS	459.6	Coherent	180	12	13.9	- -	26-LS: Uniform, very fine texture. Fine to med. gray sand. Some clay. Tr. pebs.
	457.1	- -	225	5			
	[illegible]	- -	200	3			

[symbol] Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES

PER CENT OF VOLUME OF SOLIDS, LIQUIDS, AND AIR



○- - - - ○ TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

●——● ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

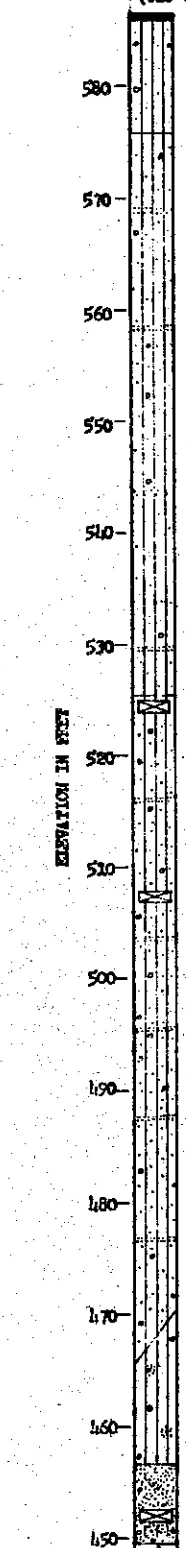
⊗ TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE AS INDICATED.

Boring Log and all sampling by Raymond Concrete Pile Company. [illegible] Job No. [illegible]

ENGINEERING RESEARCH INSTITUTE SOIL MECHANICS LABORATORY UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 5 ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN THE DETROIT EDISON COMPANY
APPROVED: [signature] DATE: [illegible]

UNIVERSITY OF MICHIGAN PROJECT 2373-[illegible]

LOG OF SOIL PROFILE BY RCPCo VISUAL INSPECTION. GROUND SURFACE ELEVATION = 586.5' (USC & GS DATUM)	SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION: NO. OF BLOWS	PENETRATION: DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	LABORATORY VISUAL INSPECTION: REMARKS
Topsoil. Hard Vari-Colored Clay, Trace of Sand & Gravel.	1-LS	583.5	Hard	10	12	23.0	103.0	1-LS: Uniform, fine texture. Vari-colored clay with trace of gravel.
	2-LS	578.5	Hard	19	12	24.3	103.0	2-LS: Uniform, very fine texture. Vari-colored clay with little silt.
	3-LS	574.5	Soft to Plastic	6	12	30.9	94.2	3-LS: Uniform, very fine texture. Blue clay with little silt.
	4-LS	569.5	Soft	3	12	33.9	88.6	4-LS: Uniform, very fine texture. Blue clay with little silt.
	5-LS	564.5	Soft	3	12	36.0	87.4	5-LS: Uniform, very fine texture. Blue clay with little silt.
	6-LS	559.5	Soft	3	12	33.3	89.2	6-LS: Uniform, very fine texture. Blue clay with little silt.
Soft Blue Clay, Trace of Sand & Gravel, Few Seams of Sand.	7-LS	554.5	Soft	3	12	37.5	84.2	7-LS: Uniform, very fine texture. Blue clay with little silt.
	8-LS	549.5	Soft	3	12	33.9	89.3	8-LS: Uniform, very fine texture. Silty blue clay.
	9-LS	544.5	Soft	3	12	37.0	86.7	9-LS: Uniform, very fine texture. Silty blue clay.
	10-LS	539.5	Soft	3	12	46.6	74.3	10-LS: Uniform, very fine texture. Silty blue clay with silt inclusions.
Few Sand Inclusions and Seams.	11-LS	534.5	Soft	3	12	36.0	83.0	11-LS: Uniform, very fine texture. Blue clay with little silt. Tr. sand.
	12-LS	529.5	Soft	3	12	43.4	77.6	12-LS: Uniform, very fine texture. Blue clay with little silt and silt inclusions
		523.5	- -	5	12			
	13-LS	522.5	Soft to Plastic	6	12	31.2	92.4	13-LS: Uniform, very fine texture. Silty blue clay with little sand.
	14-LS	517.5	Soft to Plastic	6	12	24.7	101.1	14-LS: Uniform, very fine texture. Silty blue clay with little sand.
Medium Blue Clay, Little Sand & Gravel, Few Sand Seams.	15-LS	512.5	Plastic	8	12	23.9	102.3	15-LS: Uniform, very fine texture. Silty blue clay with silt inclusions.
		507.5	- -	7	12			
	16-LS	505.5	Soft	7	12	29.0	94.2	16-LS: Uniform, fine texture. Silty blue clay with pebbles. Int. voids.
	17-LS	500.5	Soft	7	12	31.4	89.2	17-LS: Uniform, very fine texture. Blue clay with some silt and sand.
	18-LS	494.5	Soft to Plastic	8	12	26.8	94.2	18-LS: Uniform, very fine texture. Blue clay with some silt and sand.
	19-LS	490.5	Soft to Plastic	10	12	26.9	93.6	19-LS: Uniform, very fine texture. Blue clay with some silt and sand. Tr. pebs.
	20-LS	485.5	V.Soft	10	12	28.3	91.7	20-LS: Uniform, very fine texture. Blue clay with little silt & sand. Tr. pebs.
	21-LS	480.5	Soft to Plastic	11	12	29.0	93.0	21-LS: Uniform, very fine texture. Blue clay with little silt & sand. Tr. pebs.
	22-LS	475.5	Soft to Plastic	10	12	17.8	111.7	22-LS: Uniform, fine texture. Blue clay with little silt & sand. Int. voids.
	23-LS	470.5	Plastic	8	12	30.3	89.9	23-LS: Uniform, fine texture. Blue clay with little silt & sand.
Medium Blue Clay, Some Sand Inclusions, Trace of Gravel.	24-LS	465.5	Plastic	7	12	26.4	- -	24-LS: Uniform, fine texture. Silty blue clay with some sand. Int. voids.
	25-LS	460.5	Soft	8	12	15.8	114.2	25-LS: Uniform, very fine texture. Silty blue clay with some sand.
Hardpan; Fine to V.Fine Grey Sand, Tr. of Grav.	26-LS	455.5	Non.C.	6 / 75	12 / 12	15.1	114.8	26-LS: Uniform, very fine texture. Fine gray sand and silt.
Hardpan; Compact Clayey Fine Gray Sand, Little Gravel. Refusal.	27-BS	451.3	V.Hard	200	8	- -	- -	27-BS: Uniform, very fine texture. Silty sandy dark blue clay. Silt partings.



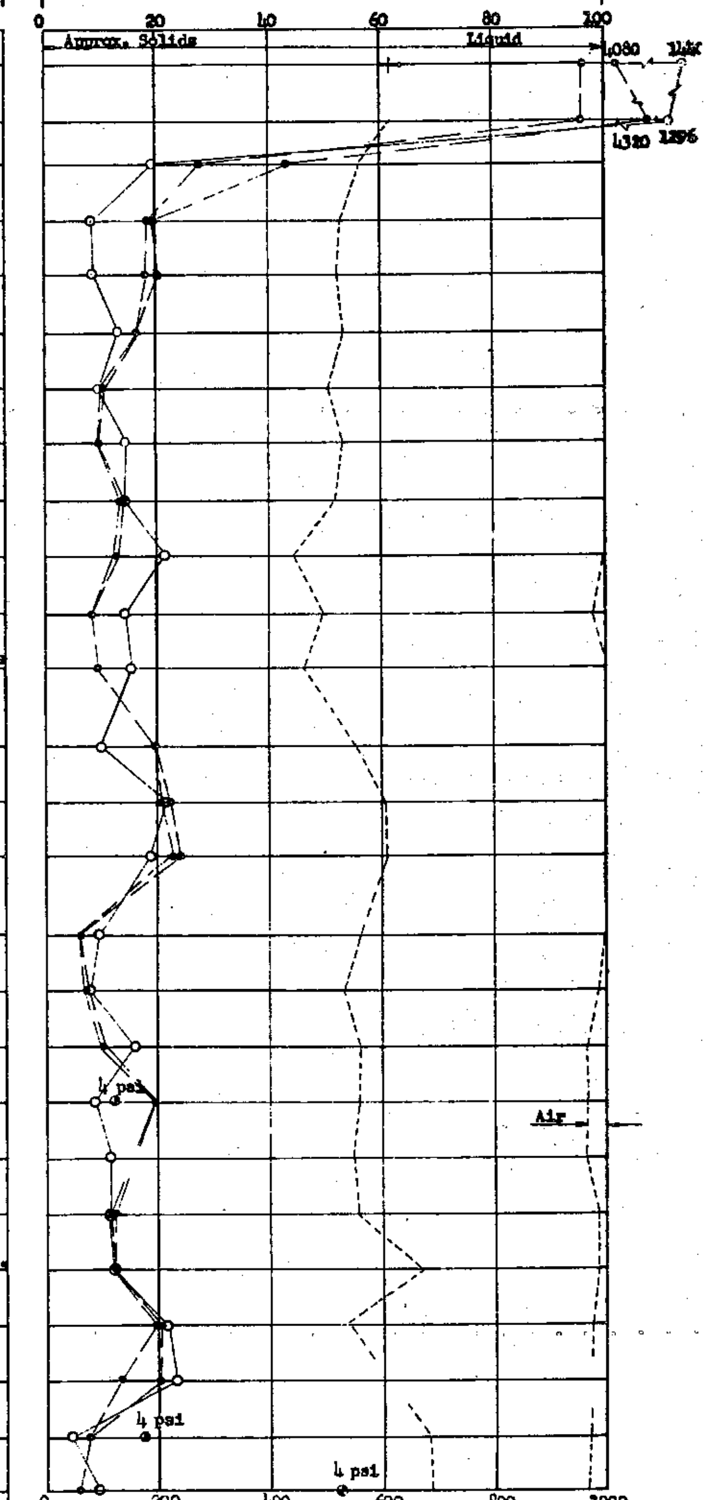
[symbol] Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES

PER CENT BY VOLUME OF SOILDS, LIQUIDS, AND AIR



o———o TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

•—— ——• ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN

• TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE 4 psi.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 6
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: W. C. Housel DATE: 12-13-52

LOG OF SOIL PROFILE

BY RCPCo VISUAL INSPECTION

GROUND SURFACE ELEVATION = 579.2 (USC & GS DATUM)

Stratum
Topsoil.
Hard Vari-Colored Clay, Trace of Sand & Gravel.
Soft Yellow Clay, Trace of Sand & Gravel.
Soft Blue Clay, Trace of Sand & Gravel.
Soft Blue Clay, Little Sand & Gravel.
Hardpan; Compact Fine Gray Sand & Seams of Clayey Sand & Shale Chips.
Boring Stopped.

ELEVATION IN FEET

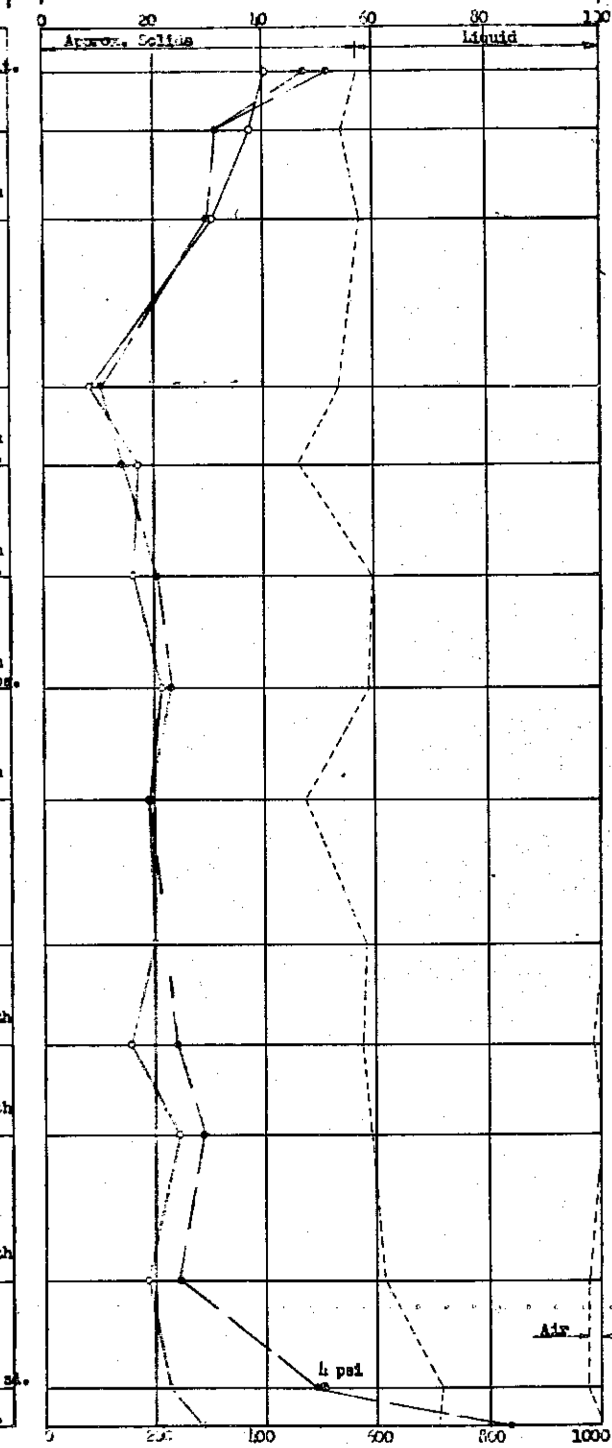
SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION: NO. OF BLOWS	PENETRATION: DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-LS	575.2	Firm	12	12			1-LS: Uniform, very fine texture. V. smooth vari-colored clay with little silt.
2-LS	570.2	Firm	3	14			2-LS: Uniform, very fine texture. V. smooth, silty yellow clay.
3-LS	562.2	Plastic	3	13			3-LS: Uniform, very fine texture. Smooth blue clay with little silt.
	552.2	- -	2	15			
4-LS	547.2	Soft	4	12			4-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
5-LS	540.2	Soft to Plastic	2	12			5-LS: Uniform, very fine texture. Smooth silty blue clay with tr. sand & pebbles.
6-LS	530.2	Soft	3	12			6-LS: Uniform, very fine texture. Smooth silty blue clay with tr. sand & pebbles.
7-LS	520.2	Soft to Plastic	3	12			7-LS: Uniform, very fine texture. Smooth blue clay. Some silt, little sand, tr. pebs.
8-LS	510.2	Soft to Plastic	4	12			8-LS: Uniform, very fine texture. Smooth silty blue clay with little sand.
	500.2	- -	3	12			
9-LS	497.2	Plastic	5	12			9-LS: Uniform, very fine texture. Blue clay with some silt. Trace sand.
10-LS	488.2	Soft to Plastic	6	12			10-LS: Uniform, very fine texture. Smooth silty blue clay. Little sand.
11-LS	480.2	Soft to Plastic	6	12			11-LS: Uniform, very fine texture. Smooth silty blue clay. Little sand.
	470.2	- -	10	12			
12-LS	467.2	Plastic	9	12			12-LS: Uniform, very fine texture. Smooth silty blue clay. Little sand.
13-LS	457.4	Weakly Coherent	17	12			13-LS: Non-uniform, very fine texture. Varies from sdy. silty gray cl. to f. gray sd.
14-LS	454.0	Plastic to Firm	46	12			14-LS: Uniform, v. fine to fine texture. V. dark grey silty clay. Some sd. & grav.

⊠ Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-T.



TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE OF 4 psi.

ENGINEERING RESEARCH INSTITUTE SOIL MECHANICS LABORATORY UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 3 ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN THE DETROIT EDISON COMPANY
APPROVED: W.S. House DATE: 12-3-54

UNIVERSITY OF MICHIGAN PROJECT M373-54

LOG OF SOIL PROFILE

BY RCPCo VISUAL INSPECTION
GROUND SURFACE ELEVATION = 577.6'
(USC & GS DATUM)

ELEVATION IN FEET

- Fine Brown Sand.
- Hard Vari-Colored Clay, Trace of Sand & Gravel.
- Soft Yellow Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Little Sand & Gravel.
- Foreman Reports Sandy Clay with Some Gravel.
- Hardpan; Compact Fine Gray Sand, Seams of Clayey Sand with Some Gravel.
- Boring Stopped.

(Elevation scale: 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450)

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

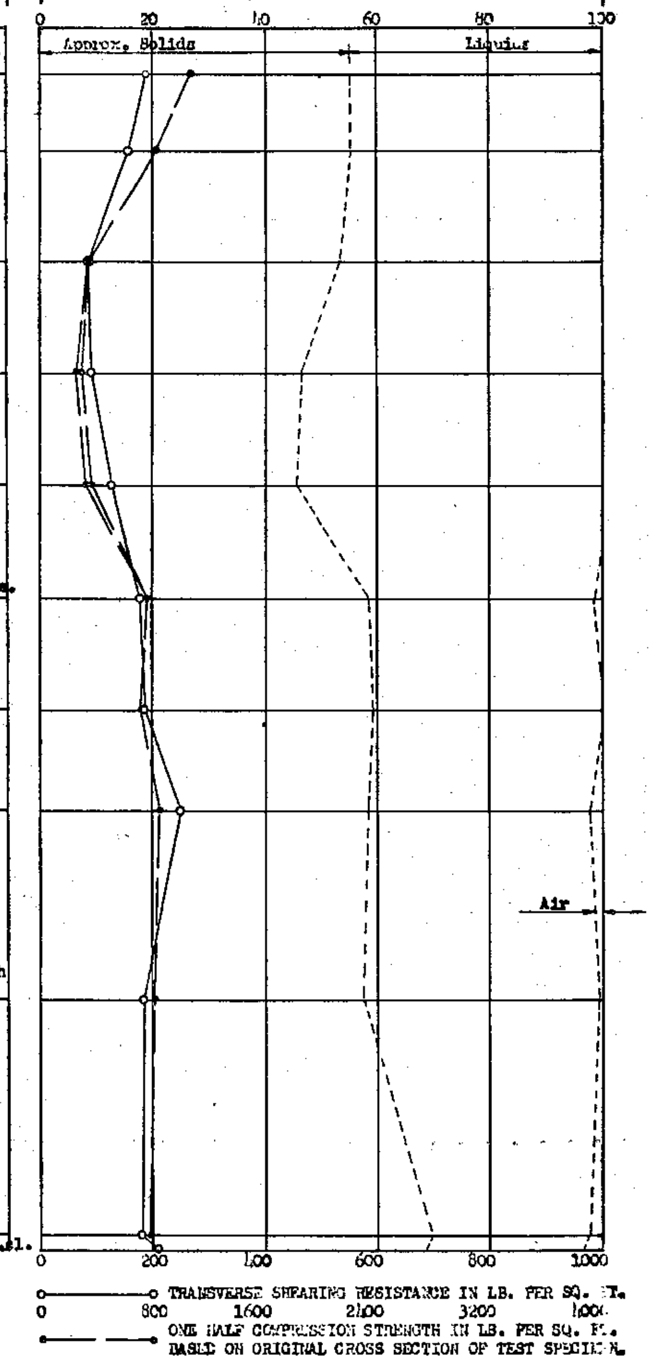
SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-LS	573.6	Plastic	6	12	29.8	93.0	1-LS: Uniform, very fine texture. Smooth vari-colored clay with little silt.
2-LS	563.6	Soft	3	12	30.4	93.6	2-LS: Uniform, very fine texture. Yellow clay with little silt. Tr. sand & pebs.
3-LS	556.6	V.Soft	2	12	33.0	89.9	3-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
4-LS	546.6	V.Soft	2	12	43.0	78.6	4-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
5-LS	536.6	Soft	2	14	45.4	76.8	5-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
6-LS	526.6	Soft	5	12	25.5	98.0	6-LS: Uniform, very fine texture. Blue clay with some silt, little sd. Sl. tr. pebs.
7-LS	516.6	Soft	5	12	25.8	99.8	7-LS: Uniform, very fine texture. Silty blue clay with little sand.
8-LS	507.6	Plastic	4	12	25.0	98.0	8-LS: Uniform, very fine texture. Silty blue clay with little sand.
	496.6	- -	5	12			
	493.6	- -	4	12			
9-LS	490.6	Plastic	7	12	27.0	96.7	9-LS: Uniform, very fine texture. Smooth blue clay with some silt.
	480.6	- -	10	12			
	478.6	- -	10	12			
	473.6	- -	10	12			
10-LS	469.6	Plastic	21	10	15.0	116.7	10-LS: Uniform, very fine texture. Blue clay with little silt and sand.
11-LS	468.4	N.C.	58	12	15.3	114.8	11-LS: Unif. v.f.text. Gray silty vfs. Tr. cl.
12-SS	458.6	- -	56	12			
13-SS	451.2	- -	59	12			

(symbol) Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



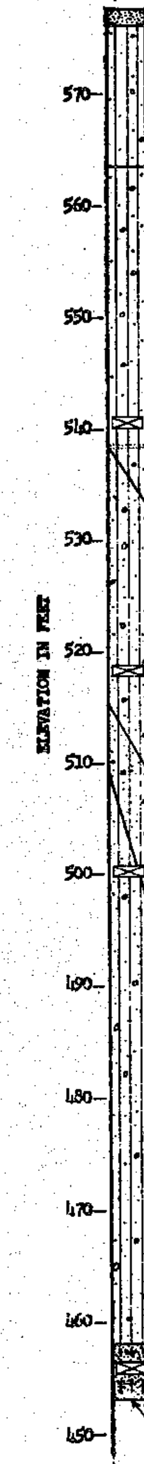
ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 7
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: W. J. Gauel DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT M573-66

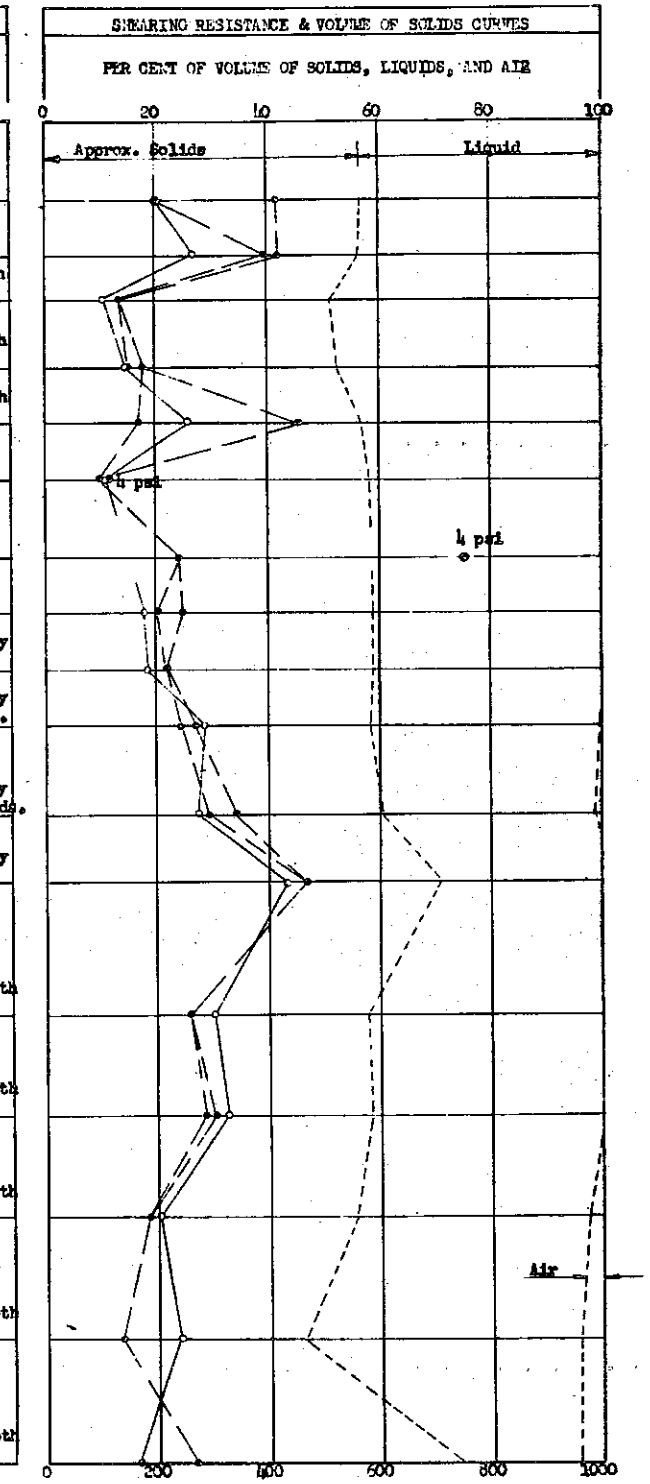
LOG OF SOIL PROFILE BY RCPCo VISUAL INSPECTION. GROUND SURFACE ELEVATION = 577.6' (USC & GS DATUM)	SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	LABORATORY VISUAL INSPECTION REMARKS
Brown Sand.	1-BS	574.1	--	6	12			
Medium Vari-Colored Clay, Trace of Sand & Gravel.	2-LS	570.6	Plastic	6	12	29.8	95.5	2-LS: Uniform, very fine texture. Silty vari-colored clay.
	3-LS	565.?	Plastic	6	12	31.9	94.2	3-LS: Uniform, very fine texture. Silty vari-colored clay.
	4-LS	561.6	Soft	5	12	37.5	86.1	4-LS: Uniform, very fine texture. Smooth silty blue clay.
Soft Blue Clay, Trace Sand & Gravel.	5-LS	555.6	Soft	3	12	34.4	88.0	5-LS: Uniform, very fine texture. Smooth silty blue clay.
	6-LS	550.6	Plastic	3	12	29.4	95.5	6-LS: Uniform, very fine texture. Smooth silty blue clay.
	7-LS	545.6	Weakly Coherent	2	14	27.3	97.3	7-LS: Uniform, fine texture. Blue clay with some silt. Little sand.
		540.6	--	3	12			
Seam of V. Fine Gray Sand, Tr. of Clay.	8-LS	538.6	Non-Coherent	4	13	20.9	107.3	8-LS: Non-uniform, fine texture. Varies from gray silt to silty gray clay.
	9-LS	533.6	Plastic	3	13	25.4	99.2	9-LS: Uniform, very fine texture. Silty blue clay with pebbles.
	10-LS	528.6	Plastic	2	12	26.1	99.2	10-LS: Uniform, very fine texture. Silty blue clay with pebbles.
Soft Blue Clay, Little Sand & Gravel.	11-LS	523.6	Plastic	3	13	26.2	98.0	11-LS: Uniform, very fine texture. Silty blue clay with little sand. Tr. pebbles.
		518.6	--	4	13			
	12-LS	515.6	Plastic	4	14	23.6	101.1	12-LS: Uniform, very fine texture. Silty blue clay. Little sand. Tr. pebs. Int. voids.
	13-LS	509.6	Plastic	7	12	16.7	119.2	13-LS: Uniform, very fine texture. Silty blue clay. Little sand.
Sandy Medium Blue Clay, Some Gravel.		500.6	--	6	12			
	14-LS	497.6	Plastic	6	12	26.8	97.3	14-LS: Uniform, very fine texture. Smooth silty blue clay with some silt & sand.
	15-LS	488.6	Plastic	6	13	26.4	98.6	15-LS: Uniform, very fine texture. Smooth blue clay. Some silt. Tr. sand & pebs.
Soft Blue Clay, Little Sand & Gravel.	16-LS	479.6	Plastic	6	12	27.9	93.6	16-LS: Uniform, very fine texture. Smooth silty blue clay.
	17-LS	468.6	Soft to Plastic	4	12	39.6	77.4	17-LS: Uniform, very fine texture. Smooth blue clay. Little silt.
Gas Pocket. Hardpan; Fine to Med. Gray Sand, Tr. of Clay.	18-LS	457.5	F. Stiff	28	12	10.7	124.8	18-LS: Uniform, very fine texture. Smooth blue clay. Little silt.
Hardpan; Compact Clayey F. Gray Sand, Seams of Clean Sand. Refusal.	19-BS	456.1	--	160	8	--	--	



▭ Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.



TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. (o———o)

0 800 1600 2400 3200 4000

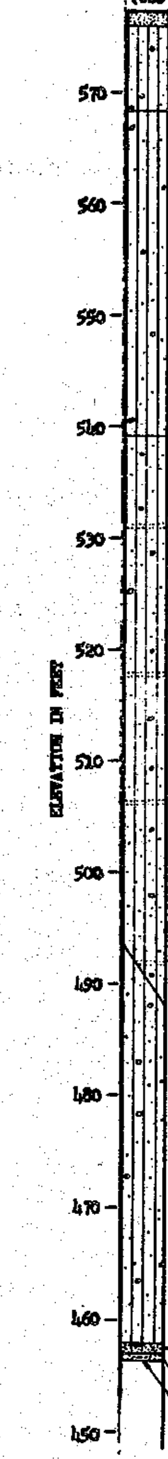
ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN. (•— —•)

• TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE OF 4 psi.

ENGINEERING RESEARCH INSTITUTE SOIL MECHANICS LABORATORY UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 9 ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN THE DETROIT EDISON COMPANY
APPROVED: W. S. Housel DATE 12-13-50

UNIVERSITY OF MICHIGAN PROJECT M373-66

LOG OF SOIL PROFILE
BY RCPCo VISUAL INSPECTION
GROUND SURFACE ELEVATION = 577.2' (USC & GS DATUM)



- Yellow Sand.
- Medium Yellow Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Little Sand & Gravel, Few Sand Seams.
- Medium Blue Clay, Little Sand & Gravel, Few Sand Seams.
- Comp. Clayey F. Gray Sand, Some Gr. Seams
- Clean Sand.
- Foreman Reports Sdy. Hard-pan. Refusal.

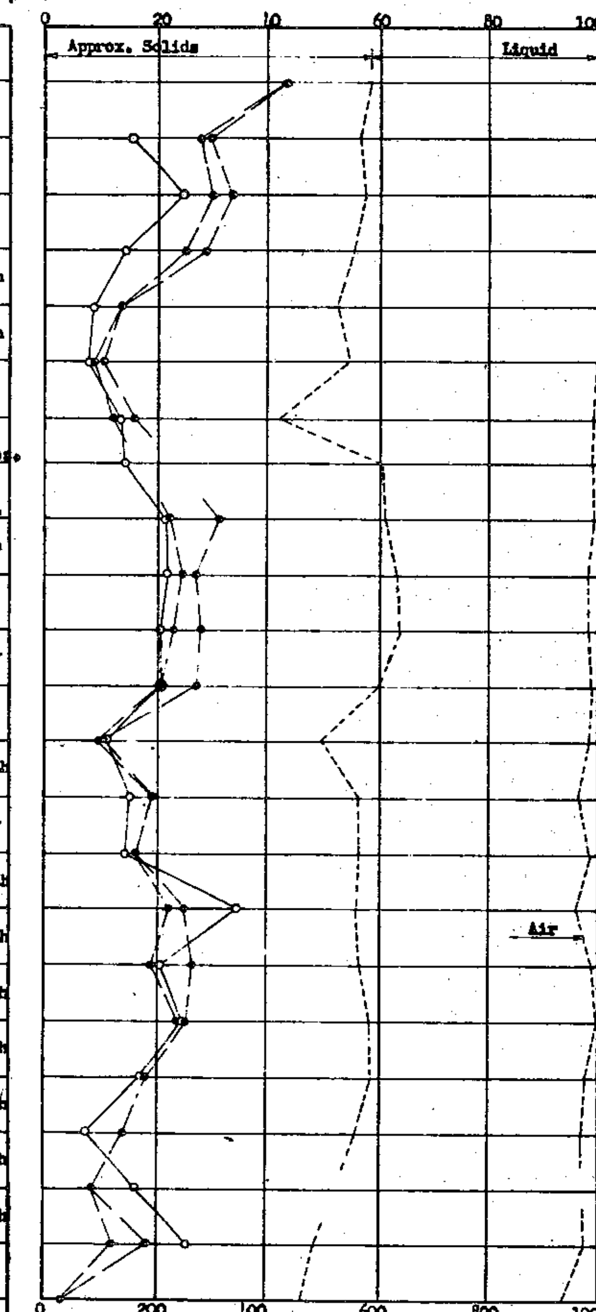
SOIL SAMPLE							LABORATORY VISUAL INSPECTION
SA. NO.	ELEV.	LAB. CONSIS-TENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-BS	573.7	- -	6	12			
2-LS	572.2	Plastic	7	12	26.9	98.6	2-LS: Uniform, very fine texture. Silty yellow clay.
3-LS	567.2	Soft to Plastic	3	12	29.6	94.8	3-LS: Uniform, very fine texture. Silty blue clay.
4-LS	562.2	Plastic	5	12	28.4	96.1	4-LS: Uniform, very fine texture. Silty blue clay.
5-LS	557.2	Soft to Plastic	4	12	30.1	93.0	5-LS: Uniform, very fine texture. Silty blue clay.
6-LS	552.2	Soft	3	14	35.2	87.7	6-LS: Uniform, very fine texture. Smooth silty blue clay.
7-LS	547.2	V.Soft	3	14	31.3	91.1	7-LS: Uniform, very fine texture. Smooth silty blue clay.
8-LS	542.2	Soft	2	12	50.0	70.5	8-LS: Uniform, very fine texture. Blue clay with little silt and sand.
9-LS	538.2	Soft	6	12	23.6	102.1	9-LS: Uniform, very fine texture. Blue clay with little silt. V.f.s.incl.Tr.pebs.
10-LS	533.2	Soft to Plastic	5	13	23.2	102.3	10-LS: Uniform, very fine texture. Blue clay with little silt and sand. Tr.pebs.
11-LS	528.2	Plastic	7	12	20.4	106.1	11-LS: Uniform, fine texture. Silty blue clay with little sand and pebbles.
12-LS	523.2	Plastic	6	12	20.4	106.1	12-LS: Uniform, fine texture. Blue clay with some silt, little sd. & pebbles.
13-LS	518.2	Plastic	6	12	24.2	100.5	13-LS: Uniform, very fine texture. Silty blue clay with little sand.
14-LS	513.2	Soft	5	12	37.4	82.4	14-LS: Uniform, very fine texture. V. smooth silty blue clay.
15-LS	508.2	Soft	5	12	26.8	94.2	15-LS: Uniform, very fine texture. Smooth silty blue clay.
16-LS	503.2	Soft	5	12	27.3	94.8	16-LS: Uniform, very fine texture. Silty blue clay with little sand.
17-LS	498.2	Plastic	5	12	26.6	93.6	17-LS: Uniform, very fine texture. Smooth blue clay with some silt.
18-LS	493.2	Plastic	6	12	27.2	95.5	18-LS: Uniform, very fine texture. Smooth silty blue clay with little sand.
19-LS	488.2	Plastic	6	12	26.5	98.0	19-LS: Uniform, very fine texture. Smooth silty blue clay. Little sand. Tr. pebs.
20-LS	483.2	Soft to Plastic	7	12	24.4	98.6	20-LS: Uniform, very fine texture. Smooth silty blue clay.
21-LS	478.2	Soft	7	12	27.2	93.6	21-LS: Uniform, very fine texture. Smooth blue clay with little silt. Tr. pebbles.
22-LS	473.2	Soft	8	12	41.7	73.7	22-LS: Uniform, very fine texture. Smooth blue clay with little silt. Tr. pebbles.
23-LS	468.2	Plastic	7	12	36.3	81.7	23-LS: Uniform, very fine texture. Smooth blue clay with little silt. Tr. pebbles.
24-LS	463.2	V.Soft	7	12	37.7	77.4	24-LS: Uniform, very fine texture. Silty blue clay with some sand. Tr. pebbles.
25-BS	455.7	- -	150 56	9 1			

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES

PER CENT BY VOLUME OF SOLIDS, LIQUIDS, AND AIR



o———o TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

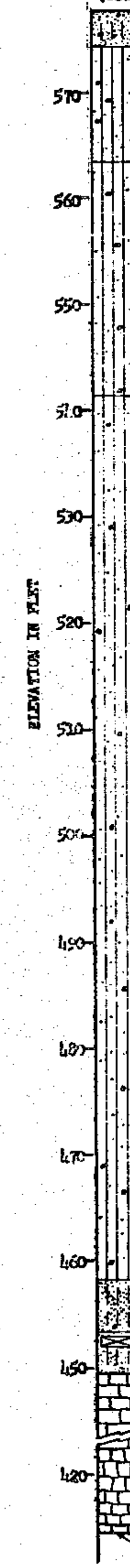
●— —● ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

ENGINEERING RESEARCH INSTITUTE SOIL MECHANICS LABORATORY UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 10 ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN THE DETROIT EDISON COMPANY
APPROVED: W. E. Toukel   DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT M373-66

LOG OF SOIL PROFILE

BY RCPCo VISUAL INSPECTION
GROUND SURFACE
ELEVATION = 577.6'
(USC & GS DATUM)



- F. to Med. Gray Sand, Little Gravel & Silt.
- Medium Yellow Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Medium Blue Clay, Little Sand & Gravel, Few Sand Seams.
- Hardpan; Comp. Fine Gray Sand, Little Clay & Gravel.
- Hardpan; Comp. Clayey Sand & Shale Chips, Seams of Clean Sand, Few Small Boulders.
- Probably Fractured Blue Shale.
- Refusal.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. 8-7453-L.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

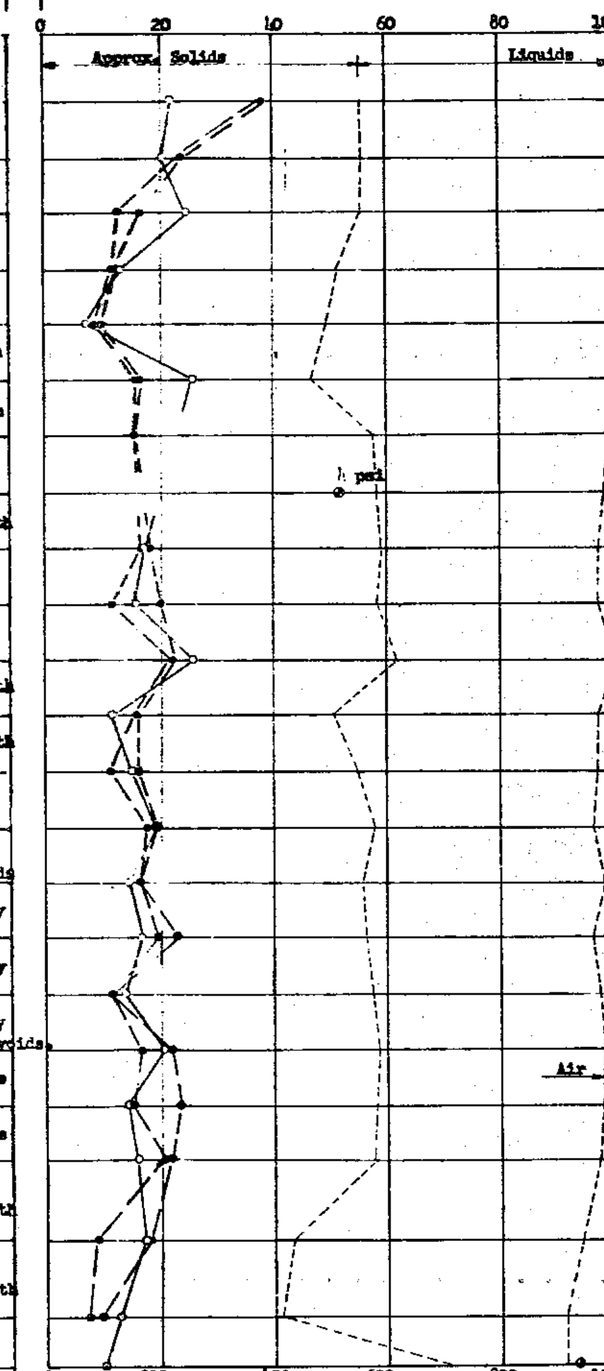
SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-BS	574.1	- -	5	12			
2-BS	572.6	- -	7	12			
3-LS	571.6	Plastic	7	12	28.8	93.6	3-LS: Uniform, very fine texture. V. smooth yellow clay with little silt.
4-LS	566.6	Plastic	5	12	29.5	94.2	4-LS: Uniform, very fine texture. V. smooth silty yellow clay.
5-LS	561.6	Plastic	4	12	31.3	93.6	5-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
6-LS	556.6	Soft	3	14	36.5	86.1	6-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
7-LS	551.6	Soft	3	14	38.5	83.0	7-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
8-LS	546.6	Soft to Plastic	2	12	44.2	78.6	8-LS: Uniform, very fine texture. Smooth silty blue clay.
9-LS	541.6	Soft	6	12	27.6	96.1	9-LS: Uniform, very fine texture. Smooth silty blue clay.
10-LS	536.6	Weakly Coherent	7	12	26.2	96.1	10-LS: Uniform, very fine texture. Clayey blue silt and v.f. sand.
11-LS	531.6	Soft to Plastic	5	12	24.2	99.2	11-LS: Uniform, very fine texture. Smooth blue clay with little silt. Tr. sand.
12-LS	526.6	Soft to Plastic	6	12	24.9	98.6	12-LS: Uniform, very fine texture. Blue clay with little silt. Tr. sand.
13-LS	521.6	Plastic	6	12	23.2	103.6	13-LS: Uniform, very fine texture. Blue clay with little silt. Tr. sand.
14-LS	516.6	Soft	5	12	34.0	85.5	14-LS: Uniform, very fine texture. Smooth silty blue clay.
15-LS	511.6	Soft	5	12	28.8	92.4	15-LS: Uniform, very fine texture. Smooth silty blue clay.
16-LS	506.6	Soft to Plastic	6	12	24.9	97.3	16-LS: Uniform, very fine texture. Blue clay with some silt. Internal voids.
17-LS	501.6	Soft	5	12	28.4	93.9	17-LS: Uniform, very fine texture. Blue clay with some silt & pebbles. Int. voids
18-LS	496.6	Soft to Plastic	8	12	26.7	94.2	18-LS: Uniform, very fine texture. Silty blue clay with some sand. Int. voids.
19-LS	491.6	Soft	9	12	26.3	96.1	19-LS: Uniform, very fine texture. Silty blue clay with some sand. Int. voids.
20-LS	486.6	Soft to Plastic	9	12	25.8	97.3	20-LS: Uniform, very fine texture. Silty blue clay with some silt, little sd. Int. voids.
21-LS	481.6	Plastic	10	12	25.7	97.3	21-LS: Uniform, fine texture. Silty blue clay. Little sand and pebbles.
22-LS	476.6	Plastic	10	12	25.9	95.5	22-LS: Uniform, fine texture. Silty blue clay with some sand and pebbles.
	471.6	- -	9	12			
23-LS	469.6	Soft	8	12	43.6	73.0	23-LS: Uniform, very fine texture. Smooth colloidal blue clay. Internal voids.
	464.6	- -	8	12			
24-LS	462.6	Soft	7	12	45.1	69.3	24-LS: Uniform, very fine texture. Smooth colloidal blue clay. Internal voids.
25-LS	458.3	Very Weakly Coherent	145	12	10.9	119.2	25-LS: Uniform, very fine texture. Gray silt and very fine sand. Some clay.
26-BS	452.6	V. Hard	170	12	- -	- -	26-BS: Uniform, very fine texture. V. silty dark blue clay. Some sand & pebs.

⊠ Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES

PER CENT BY VOLUME OF SOLIDS, LIQUIDS, AND AIR



○———○ TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

●— —● ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

◉ TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE OF 4 psi.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 11
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: W.S. Housel DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT 2373-56

LOG OF SOIL PROFILE

BY RCPCo VISUAL INSPECTION

GROUND SURFACE ELEVATION = 580.2' (USC & GS DATUM)

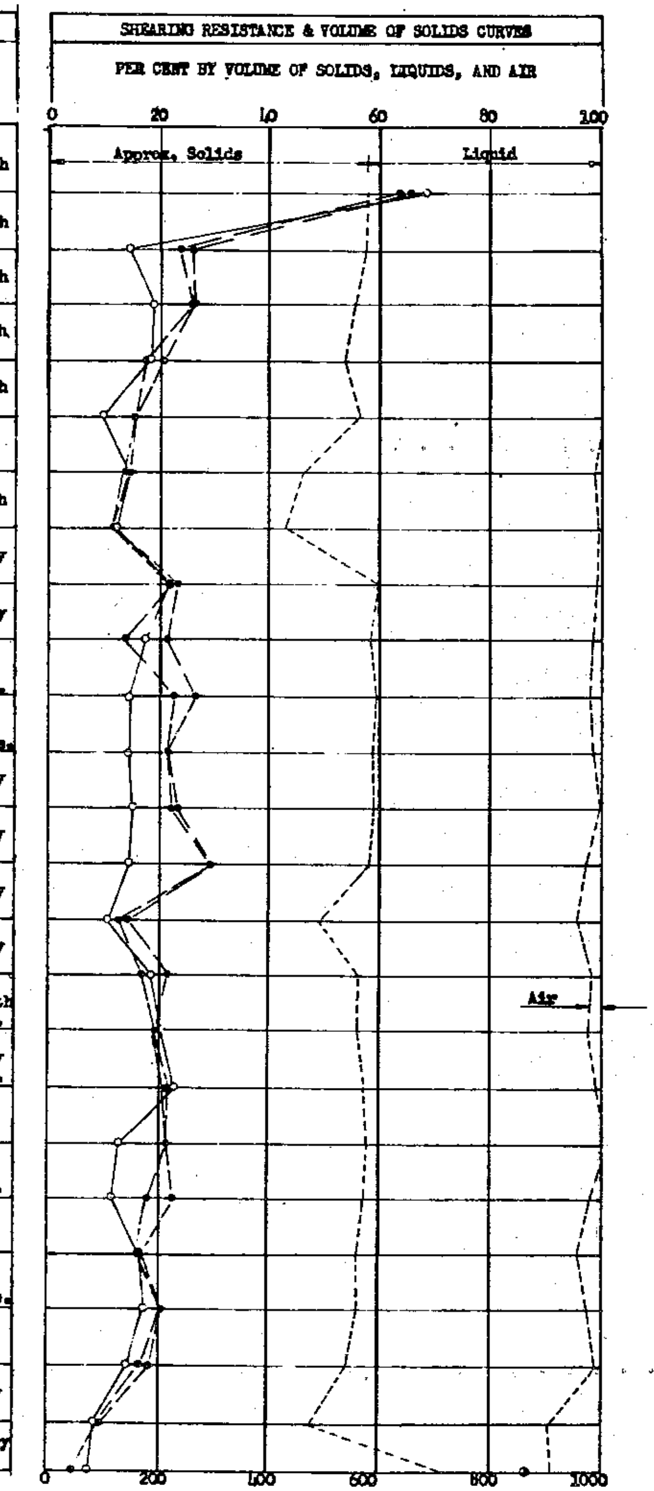
Elev. scale	Description
580	Topsoil.
	F. Silty Sd., Little Veg.
	Med. Gray Sd., Little Silt.
	Medium Yellow Clay, Trace of Sand & Gravel.
570	
560	
	Soft Blue Clay, Trace Sand & Gravel.
550	
540	
530	
520	
510	Medium Blue Clay, Little Sand & Gravel, Few Sand Seams.
500	
490	
480	
470	
460	Hardpan; Comp. Fine Gray Sand, Little Grav. & Clay.
	Refusal.
450	

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-SS	576.7	- -	5	12			
2-SS	574.?	- -	6	12			
3-LS	574.2	Firm	10	12	27.2	97.3	3-LS: Uniform, very fine texture. Smooth silty yellow clay.
4-LS	569.2	Plastic	6	12	28.5	96.7	4-LS: Uniform, very fine texture. Smooth silty blue clay.
5-LS	564.2	Plastic	4	12	30.2	93.0	5-LS: Uniform, very fine texture. Smooth silty blue clay.
6-LS	559.2	Soft	3	12	33.2	90.5	6-LS: Uniform, very fine texture. Smooth blue clay with little silt.
7-LS	554.2	Soft	3	14	29.4	94.5	7-LS: Uniform, very fine texture. Smooth blue clay with little silt.
8-LS	549.2	Soft	3	14	42.4	77.4	8-LS: Uniform, very fine texture. Silty blue clay.
9-LS	544.2	Soft	2	12	48.9	72.1	9-LS: Uniform, very fine texture. Smooth blue clay with some silt.
10-LS	539.2	Soft to Plastic	5	12	24.4	100.5	10-LS: Uniform, very fine texture. Silty blue clay with little sand and pebbles.
11-LS	534.2	Soft to Plastic	5	12	25.3	98.6	11-LS: Uniform, very fine texture. Silty blue clay with pebbles.
12-LS	529.2	Soft to Plastic	5	12	23.9	99.8	12-LS: Uniform, very fine texture. Blue clay with little silt and sand. Tr.pebs.
13-LS	524.2	Plastic	6	12	25.0	98.9	13-LS: Uniform, very fine texture. Blue clay with some silt. Little sand.Tr.pebs.
14-LS	519.2	Plastic	6	12	25.7	99.2	14-LS: Uniform, very fine texture. Silty blue clay with pebbles.
15-LS	514.2	Soft to Plastic	6	12	24.5	98.6	15-LS: Uniform, very fine texture. Silty blue clay with some sand. Tr. pebs.
16-LS	509.2	Soft to Plastic	6	12	34.9	83.0	16-LS: Uniform, very fine texture. Silty blue clay with some sand. Int. voids.
17-LS	504.2	Soft to Plastic	6	12	27.7	94.8	17-LS: Uniform, very fine texture. Silty blue clay. Internal voids.
18-LS	499.2	Soft to Plastic	7	12	27.6	94.3	18-LS: Uniform, very fine texture. Smooth silty blue clay, some sand. Tr. pebbles.
19-LS	494.2	Plastic	6	12	26.8	96.7	19-LS: Uniform, very fine texture. Silty blue clay.Little sand.Tr.pebs.Int.voids.
20-LS	489.2	Soft to Plastic	6	12	27.7	97.3	20-LS: Uniform, very fine texture. Blue clay with some silt and little sand.
21-LS	484.2	Soft to Plastic	7	12	26.5	96.1	21-LS: Uniform, very fine texture. Blue clay with some silt.Little sd.Int.voids.
22-LS	479.2	Soft to Plastic	7	12	26.6	94.2	22-LS: Uniform, very fine texture. Blue clay with little silt and sand.
23-LS	474.2	Soft to Plastic	7	12	26.8	94.2	23-LS: Uniform, very fine texture. Blue clay with little silt and sand.Int.voids.
24-LS	469.2	Soft	6	12	30.5	91.1	24-LS: Uniform, very fine texture. Blue clay with little sand & silt.
25-LS	464.2	Soft	6	12	34.5	79.2	25-LS: Uniform, very fine texture. Silty blue clay with some sand. Int. voids.
26-LS	459.8	Weakly Coherent	40 / 100	12 / 10	10.1	120.4	26-LS: Uniform, very fine texture. Clayey silt and grey very fine to fine sand.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. D-7453-D.



o———o TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

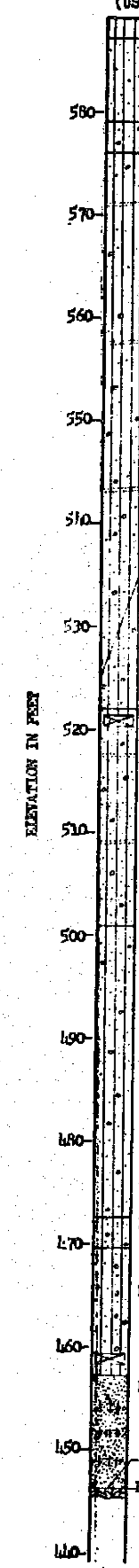
●— —● ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

● TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE 4 psi.

ENGINEERING RESEARCH INSTITUTE SOIL MECHANICS LABORATORY UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 12 ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN THE DETROIT EDISON COMPANY
APPROVED: W.C. Housel DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT M273-56

LOG OF SOIL PROFILE
BY RCPCo VISUAL INSPECTION
GROUND SURFACE ELEVATION = 589.0' (USC & GS DATUM)



Med. Vari-colored Clay.

Hard Vari-Colored Clay, Trace Sand.

Med. Hard Blue Clay, Trace of Sand & Gravel.

Soft Blue Clay, Trace of Sand & Gravel, Few Sand Seams.

Soft Blue Clay, Little Sand & Gravel.

Soft Blue Clay, Some Sand & Gravel, Few Sand Seams.

Soft Blue Clay, Little Sand & Gravel.

Med. Hard Blue Clay, Some Sand, Little Gr.

Medium Blue Clay, Trace of Sand & Gravel.

Hardpan; Compact Fine Gray Sand, Seams of Clayey Sand & Shale.

Broken Shale.

Boring Stopped.

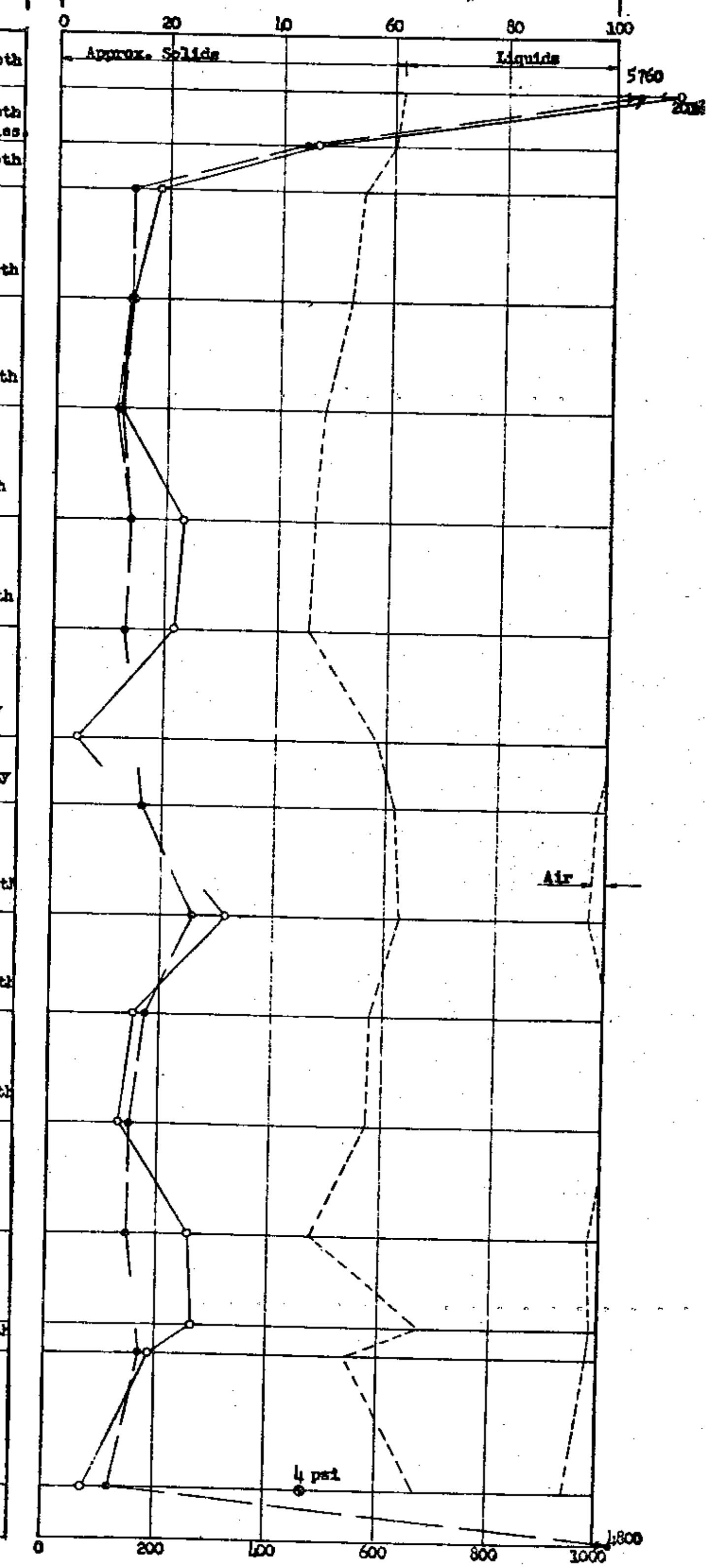
SOIL SAMPLE							LABORATORY VISUAL INSPECTION
SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-LS	585.5	--	18	12			
2-LS	584.0	Hard	17	12	23.5	103.0	2-LS: Uniform, very fine texture. Smooth vari-colored clay with little silt.
3-LS	579.0	Plastic to Firm	14	12	26.4	101.1	3-LS: Uniform, very fine texture. Smooth blue clay with little silt. Sl. tr. pebbles.
4-LS	575.0	Soft	4	13	32.2	91.7	4-LS: Uniform, very fine texture. Smooth blue clay with little silt. Tr. v. f. s.
5-LS	565.0	Soft	4	12	33.6	88.9	5-LS: Uniform, very fine texture. Smooth silty blue clay. Sl. tr. of pebbles.
6-LS	555.0	Soft	3	13	40.4	81.1	6-LS: Uniform, very fine texture. Smooth blue clay with little silt.
7-LS	545.0	Soft	3	13	43.5	79.2	7-LS: Uniform, very fine texture. Smooth blue clay with little silt.
8-LS	535.0	Soft	3	13	44.6	77.4	8-LS: Uniform, very fine texture. Smooth blue clay with little silt.
9-LS	525.0	V. Soft	5	12	27.5	98.0	9-LS: Uniform, very fine texture. Silty blue clay with little sand.
	521.0	--	8	12			
10-LS	519.0	Soft	8	12	22.1	103.6	10-LS: Uniform, very fine texture. Silty blue clay with little sand.
11-LS	509.0	Plastic	11	12	20.1	106.1	11-LS: Uniform, very fine texture. Smooth silty blue clay. Trace of sand.
12-LS	500.0	Soft	7	12	28.4	96.7	12-LS: Uniform, very fine texture. Smooth silty blue clay. Trace of sand.
13-LS	490.0	Soft	8	12	28.6	96.7	13-LS: Uniform, very fine texture. Smooth silty blue clay. Trace of sand.
14-LS	480.0	Soft to Plastic	8	12	39.2	79.9	14-LS: Uniform, very fine texture. V. smooth blue clay with little silt.
15-LS	471.7	Plastic	24	12	17.5	112.6	15-LS: Uniform, very fine texture. Blue clay with little silt and sand.
16-LS	469.0	Soft	10	12	30.0	71.1	16-LS: Uniform, very fine texture. Smooth blue clay with little silt.
	459.0	--	15	12			
17-LS	457.0	Weakly Coherent	108	12	8.3	111.1	17-LS: Uniform, fine texture. Clayey fine to medium gray sand.
18-LS	452.0	Hard	140	12	--	--	18-LS: Uniform, very fine texture. Silty dark blue clay.
19-US	446.8	--	200	5	--	--	

[X-box symbol] Indicates failure to recover Liner Sample.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. (open circles, solid line)

0 800 1600 2400 3200 4000

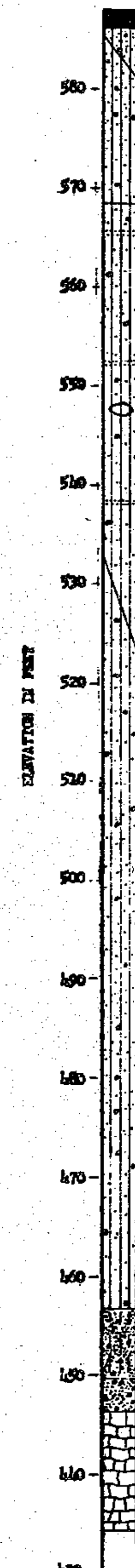
ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN. (solid dots, dashed line)

TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE OF 4 psi. (circled dot)

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 13
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

LOG OF SOIL PROFILE
BY RCPCo. VISUAL INSPECTION
GROUND SURFACE
ELEVATION = 588.1'
(USC & GS DATUM)



Topsoil.
Hard Vari-Colored Clay, Little Sand & Gravel.
Medium Yellow Clay, Trace Sand & Gravel.
Soft Blue Clay, Trace Sand & Gravel, Few Sand Seams.
Boulder.
Soft Blue Clay, Little Sand & Gravel.
Hardpan; Clayey Med. Gray Sd., Some Gravel & Sand, Shale Chips, Seams of Clean Sand.
Hardpan; Broken Shale Fractured Seamy Soft Blue Shale.

Cored	Recovered
4'7"	2'9"
5'0"	3'6"
3'11"	2'10"

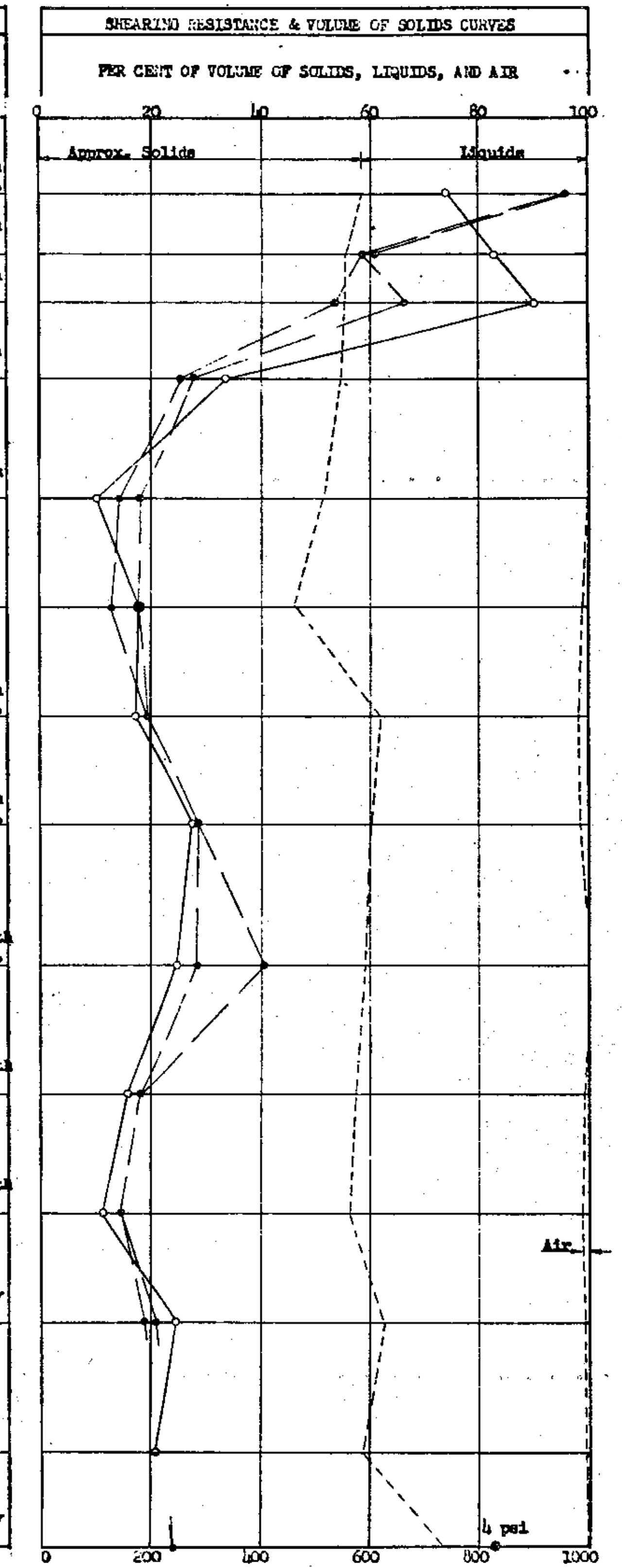
Boring Stopped.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. A-7453-D.

SOIL SAMPLE							LABORATORY VISUAL INSPECTION
SA. NO.	ELEV.	LAB. CONSIS-TENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-DS	585.6	- -	27	12			
2-LS	581.1	Stiff	11	12	26.6	98.6	2-LS: Uniform, very fine texture. Smooth var-colored clay with little silt. Tr. sd.
3-LS	575.6	Firm to Stiff	7	12	30.4	93.0	3-LS: Uniform, very fine texture. Smooth yellow clay with little silt. Tr. sd.
4-LS	571.1	Stiff	9	13	31.2	93.0	4-LS: Uniform, very fine texture. Smooth yellow clay with little silt. Tr. sd.
5-LS	564.1	Plastic	7	12	31.4	91.7	5-LS: Uniform, very fine texture. Smooth silty blue clay with tr. sand.
6-LS	553.1	Soft	3	14	35.2	86.1	6-LS: Uniform, very fine texture. Smooth blue clay with little silt.
7-LS	543.1	Soft	3	14	42.9	77.4	7-LS: Uniform, very fine texture. Blue clay with some silt and little sand.
8-LS	533.1	Soft	5	12	21.8	104.2	8-LS: Uniform, very fine texture. Smooth blue clay with little silt and tr. sand.
9-LS	523.1	Plastic	7	12	23.8	100.5	9-LS: Uniform, very fine texture. Smooth blue clay with little silt and tr. sand.
	513.1	- -	9	12			
10-LS	510.1	Plastic	10	12	26.4	98.6	10-LS: Uniform, very fine texture. Smooth blue clay with little silt. Tr. sd. & pebs.
	500.1	- -	7	12			
11-LS	498.1	Soft	7	12	27.1	96.1	11-LS: Uniform, very fine texture. Smooth blue clay with some silt.
12-LS	487.1	Soft	7	12	28.0	94.8	12-LS: Uniform, very fine texture. Smooth silty blue clay.
13-LS	477.1	Soft to Plastic	7	12	21.7	105.5	13-LS: Uniform, very fine texture. Silty blue clay with little sand.
	467.1	- -	7	12			
14-LS	465.1	Plastic	7	12	26.1	98.6	14-LS: Uniform, very fine texture. Blue clay with some silt and little sand.
15-LS	456.4	Non-Coherent	29	12	13.1	124.2	15-LS: Uniform, very fine texture. Silty very fine to fine gray sand. Tr. clay.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



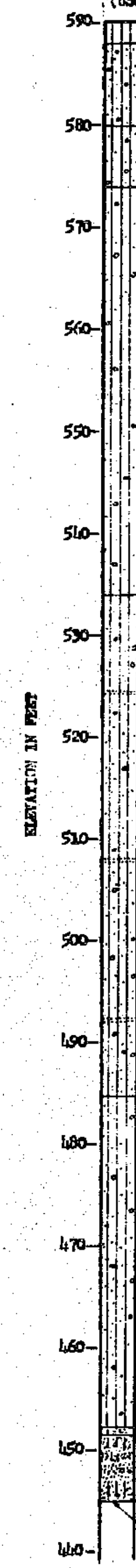
TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.
0 800 1600 2400 3200 4000
ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.
TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE OF 4 psi.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 14
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: [signature] DATE: 12-13-52

LOG OF SOIL PROFILE
BY RCPCo VISUAL INSPECTION
GROUND SURFACE ELEVATION = 590.2' (USC & GS DATUM)

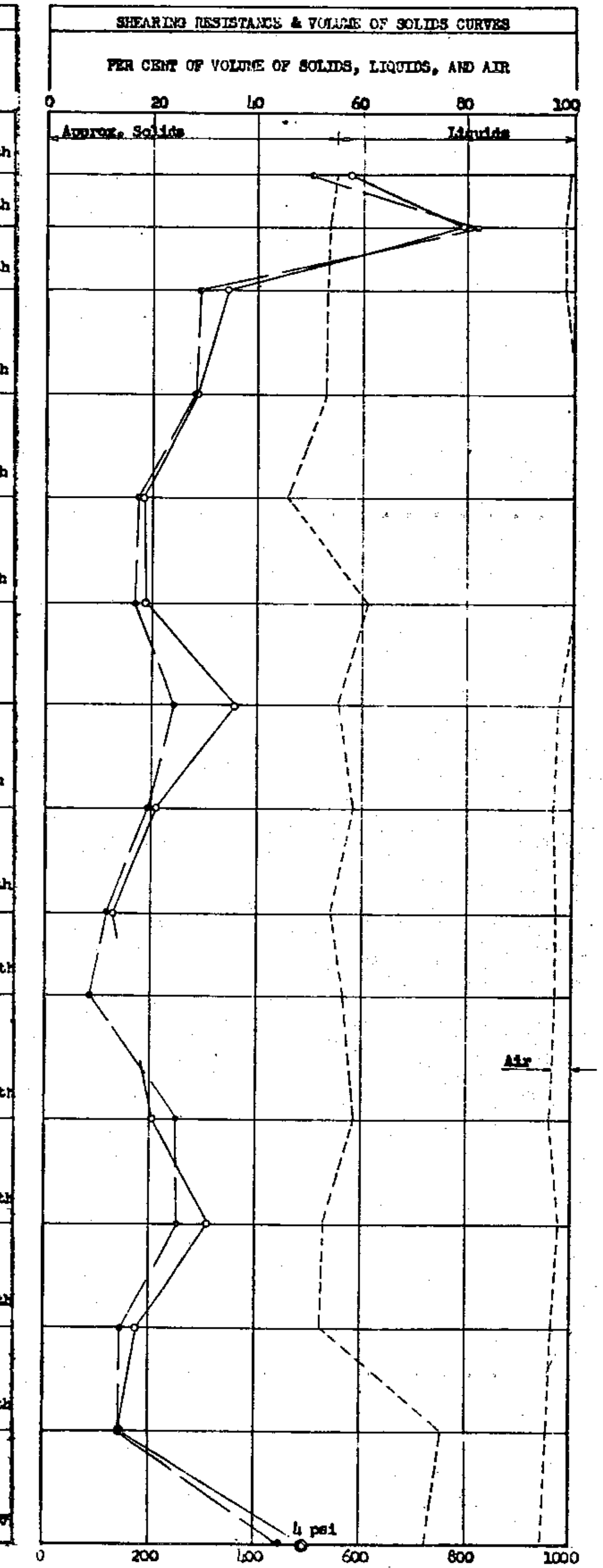


- Med. Vari-colored Clay.
- Hard Vari-Colored Clay, Little Sand & Gravel.
- Medium Yellow Clay, Trace Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Little Sand & Gravel, Few Sand Seams.
- Medium Blue Clay, Trace of Sand & Gravel.
- Hardpan; Sand.
- Hardpan; Compact Fine to Med. Gray Sand Seams, Clayey Sand with Some Gravel.
- Refusal.

SOIL SAMPLE							LABORATORY VISUAL INSPECTION
SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-BS	586.7	- -	42	12			
2-LS	584.2	Firm	15	12	29.8	93.0	2-LS: Uniform, very fine texture. Smooth vari-colored clay with little silt.
3-LS	579.2	Stiff	9	12	30.7	90.5	3-LS: Uniform, very fine texture. Smooth yellow clay with little silt.
4-LS	573.2	Plastic	6	12	31.2	89.9	4-LS: Uniform, very fine texture. Smooth yellow clay with little silt.
5-LS	563.2	Plastic	5	13	33.0	89.2	5-LS: Uniform, very fine texture. Smooth blue clay with little silt.
6-LS	553.2	Soft	5	14	43.0	77.4	6-LS: Uniform, very fine texture. Smooth blue clay with little silt.
7-LS	543.2	Soft	4	13	36.4	84.9	7-LS: Uniform, very fine texture. Smooth blue clay with little silt.
8-LS	533.2	Plastic	6	12	23.9	102.7	8-LS: Uniform, very fine texture. Blue clay with little silt and tr. of sand.
9-LS	523.2	Soft to Plastic	7	12	28.5	93.0	9-LS: Uniform, very fine texture. Smooth silty blue clay.
10-LS	513.2	Soft	7	12	24.5	98.0	10-LS: Uniform, very fine texture. Smooth silty blue clay.
	508.2	- -	14	12			
11-LS	505.2	V.Soft	7	12	29.4	91.1	11-LS: Uniform, very fine texture. Smooth silty blue clay.
	495.2	- -	7	12			
12-LS	493.2	Plastic	7	12	26.3	95.5	12-LS: Uniform, very fine texture. Smooth silty blue clay with tr. of sand.
13-LS	483.2	Plastic	9	12	23.4	99.2	13-LS: Uniform, very fine texture. Smooth blue clay with little silt.
14-LS	473.2	Soft	9	12	31.3	89.2	14-LS: Uniform, very fine texture. Smooth blue clay with little silt.
15-LS	463.2	Soft	9	12	30.7	88.6	15-LS: Uniform, very fine texture. Smooth silty blue clay.
16-LS	452.3	Firm	90	12	9.9	127.9	16-LS: Uniform, very fine texture. Clayey fine gray sand. Little silt.
17-BS	446.0	- -	200	2	- -	- -	

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



o———o TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

•—— ——o ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

• TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT. UNDER NORMAL PRESSURE OF 4 psi.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7463-D.

ENGINEERING RESEARCH INSTITUTE SOIL MECHANICS LABORATORY UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 15 ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN THE DETROIT EDISON COMPANY
APPROVED: [signature] DATE: 2-3-56

UNIVERSITY OF MICHIGAN PROJECT 2173-66

LOG OF SOIL PROFILE

BY ROPOs VISUAL INSPECTION
GROUND SURFACE
ELEVATION = 589.1'
(USC & GS DATUM)

ELEVATION IN FEET

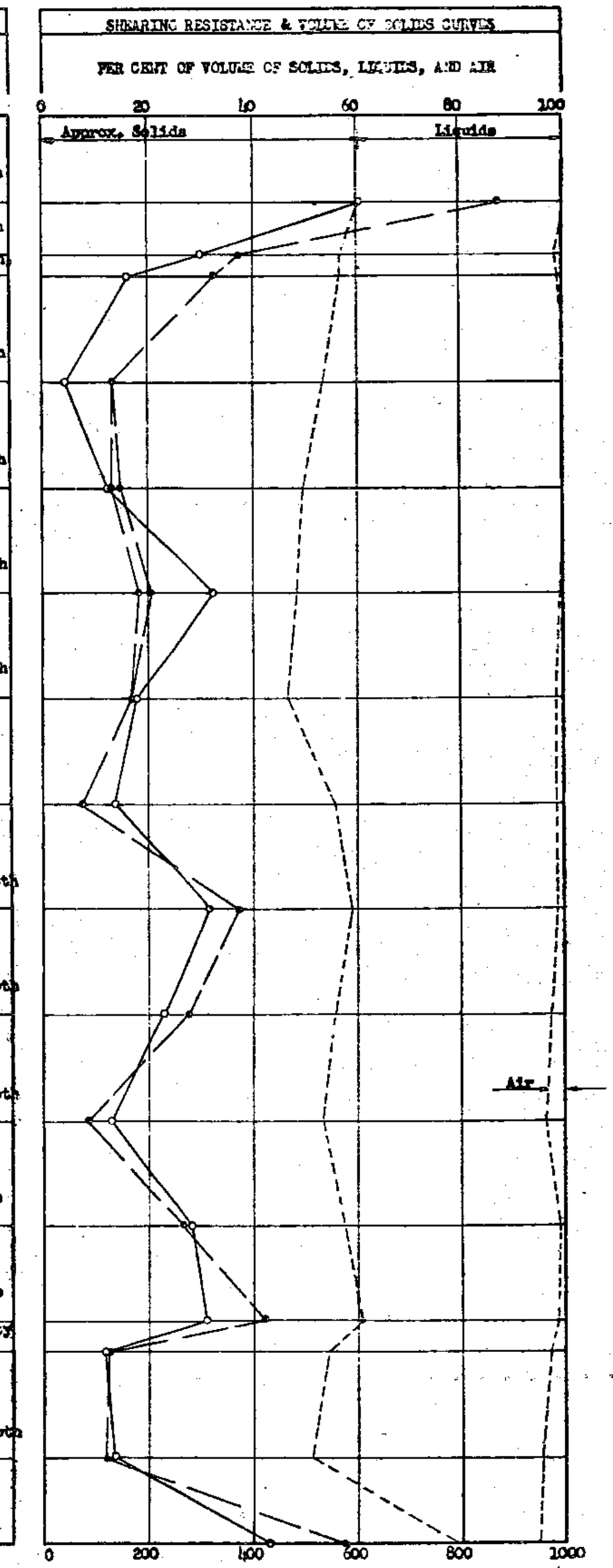
- Med. Vari-colored Clay.
- Med. Hard V.-Colored Clay, Little Sand & Gravel.
- Hard Yellow Clay, Trace Sand & Gravel.
- Med. Yellow Clay, Trace Sand & Gravel.
- Soft Blue Clay, Trace of Sand & Gravel.
- Soft Blue Clay, Little Sand & Gravel.
- Sandy Med. Blue Clay, Little Gravel.
- Med. m Blue Clay, Little Sand & Gravel.
- Hardpan; Comp. Clayey F. to C. Grey Sd. & Gr.
- Hardpan; V. Comp. Fine Grey Sd., Little Cl. & Gr. Broken Shale in Bottom of Spoon.
- Boring Stopped.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-BS	585.6	- -	15	12			
2-LS	581.1	Stiff	20	12	24.4	102.3	2-LS: Uniform, very fine texture. Smooth vari-colored clay with little silt.
3-LS	576.1	Plastic to Firm	8	12	26.9	96.7	3-LS: Uniform, very fine texture. Smooth gray clay with little silt.
4-LS	574.1	S. to Pl.	6	13	27.9	95.5	4-LS: Uniform, very fine texture. Smooth silty blue clay.
5-LS	564.1	V. Soft	4	12	32.8	89.9	5-LS: Uniform, very fine texture. Smooth blue clay with little silt.
6-LS	554.1	Soft	3	12	37.8	83.6	6-LS: Uniform, very fine texture. Smooth blue clay with little silt.
7-LS	544.1	Soft to Plastic	3	13	39.9	81.1	7-LS: Uniform, very fine texture. Smooth blue clay with little silt.
8-LS	534.1	Soft	3	12	41.9	78.0	8-LS: Uniform, very fine texture. Smooth blue clay with little silt.
9-LS	524.1	Soft	5	12	28.5	93.6	9-LS: Uniform, very fine texture. Blue clay with little silt and sand.
10-LS	514.1	Plastic	7	12	25.1	99.2	10-LS: Uniform, very fine texture. Smooth silty blue clay with little sand.
11-LS	504.1	Plastic	7	12	27.8	93.6	11-LS: Uniform, very fine texture. Smooth silty blue clay with little sand.
12-LS	494.1	Soft	7	12	29.7	89.9	12-LS: Uniform, very fine texture. Smooth silty blue clay with little sand.
13-LS	484.1	Plastic	7	12	26.9	96.7	13-LS: Uniform, very fine texture. Blue clay with some silt. Little sand.
14-LS	475.1	Plastic	17	12	23.3	101.7	14-LS: Uniform, very fine texture. Blue clay with some silt. Little sand.
15-LS	472.1	Soft	9	12	29.3	91.1	15-LS: Uniform, very fine texture. Silty blue clay with little sand.
16-LS	462.1	Soft	9	12	32.2	86.1	16-LS: Uniform, very fine texture. Smooth silty blue clay with trace sand.
17-LS	454.2	Firm to Stiff	37	12	7.5	132.9	17-LS: Uniform, very fine texture. Sandy, silty blue clay. Trace pebbles.
18-BS	449.6	- -	200	6			
19-BS	444.8	- -	200	4	- -	- -	

PENETRATION NOTE: Number of blows required to drive core sampler distance given using 140-pound weight falling 30 inches.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-7453-D.



TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.

0 800 1600 2400 3200 4000

ONE HALF COMPRESSION STRENGTH IN LB. PER SQ. FT. BASED ON ORIGINAL CROSS SECTION OF TEST SPECIMEN.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 16
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: W.S. Housel DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT [illegible]

LOG OF SOIL PROFILE

BY ENGR. VISUAL INSPECTION

GROUND SURFACE ELEVATION = 582.2 (USCAGS DATUM)

- Fill; Coal and Stones.
- Fill; Medium Varicolored Clay, Some Cinders.
- Soft Varicolored Clay.
- Soft Gray Clay, Trace of Sand.
- Loose Fine to Very Fine Dark Gray Sand.
- Soft Gray Clay, Trace of Sand.
- Medium Gray Clay, Trace of Sand and Fine Gravel.
- Sandy Medium Hard Gray Clay, Few Sand Seams.
- Medium Gray Clay, Trace of Sand.
- Hardpan; Compact Clayey Fine to Medium Gray Sand, Some Gravel.
- Hardpan; Compact Medium to Fine Gray Sand, Little Clay.
- Hardpan; Very Hard Sandy Gray Clay, Trace of Gravel.
- Boring Stopped.

ELEVATION IN FEET: 580, 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450, 440

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-25056-D.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT LBS PER CU. FT.	REMARKS
1-BS	579.2	--	5	12			
2-BS	576.2	--	5	12			
3-BS	572.2	--	4	12			
4-LS	567.2	Plastic	4	12	30.9	91.1	4-LS: Uniform. Gray clay, some silt, trace of sand.
5-LS	562.2	Soft	2	14	32.6	89.2	5-LS: Uniform. Gray clay, some silt, trace of sand.
6-LS	557.2	Soft	2	14	37.1	83.0	6-LS: Uniform. Gray clay, some silt, trace of sand.
7-LS	552.2	Soft	2	16	40.3	80.5	7-LS: Uniform. Gray clay, some silt, trace of sand.
8-LS	547.2	Soft	2	15	45.0	76.1	8-LS: Uniform. Gray clay, some silt, trace of sand.
9-LS	543.2	Plastic	8	12	25.4	95.5	9-LS: Uniform. Clayey gray silt, little sand.
10-LS	538.2	Very Soft	5	12	27.6	93.9	10-LS: Non-uniform. Varies from silty gray clay, trace of sand to clayey gray silt, little sand.
11-LS	533.2	Soft	6	12	23.1	99.2	11-LS: Uniform. Clayey gray silt, little sand.
12-LS	531.2	Plastic	4	12	22.7	101.1	See Note A.
13-LS	527.2	Plastic	4	13	23.3	101.7	13-LS: Uniform. Silty gray clay, some sand, trace of gravel.
14-BS	522.2	--	4	12			
15-LS	517.2	Plastic	5	14	24.9	99.8	15-LS: Uniform. Silty grey clay, some sand, trace of gravel.
	512.2	--	4	12			
16-LS	507.2	Plastic	8	13	25.9	100.5	16-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
17-LS	502.2	Plastic	7	13	28.0	93.0	17-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
	497.2	--	7	12			
18-LS	492.2	Soft	7	12	27.3	94.3	18-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
19-LS	487.2	Soft to Plastic	7	12	26.4	95.5	19-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
20-LS	482.2	Soft to Plastic	8	12	25.7	96.7	20-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
21-LS	477.2	Soft to Plastic	17	12	11.3	123.6	21-LS: Non-uniform. Varies from silty gray clay to clayey silty gray sand.
22-LS	473.2	Very Soft	8	12	33.3	86.1	22-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
23-LS	468.2	Soft	7	12	38.0	82.4	23-LS: Uniform. Gray clay, some silt, trace of sand.
24-LS	463.2	Soft	6	12	45.0	70.5	24-LS: Uniform. Gray clay, trace of silt and sand.
	458.2	--	7	12			
25-BS	454.1	--	72	12			
26-BS	451.7	--	36	12			
27-BS	449.9	--	106	12			

⊠ Indicates failure to recover Liner Sample

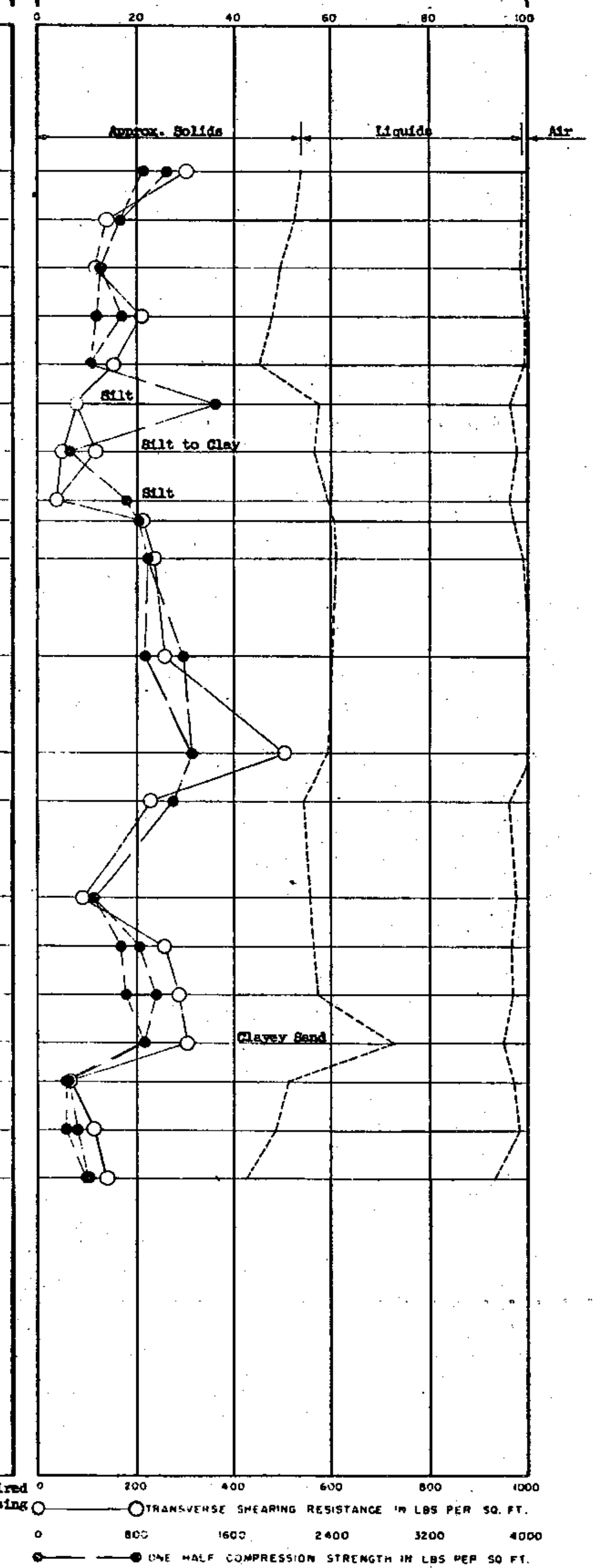
NOTE: Permanent Ground Water Level assumed to be the level of the St. Clair River adjacent to the site.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

Note A

12-LS: Uniform. Silty grey clay, some sand, trace of gravel.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE SOIL MECHANICS LABORATORY	
ANN ARBOR	MICHIGAN
SUBSOIL ANALYSIS OF BORING NO 20 ST. CLAIR POWER PLANT - DETROIT EDISON COMPANY	
DETROIT	MICHIGAN
APPROVED: [illegible]	DATE: [illegible]-2-57

UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE PROJECT 01994

LOG OF SOIL PROFILE

BY ENGRG. VISUAL INSPECTION

GROUND SURFACE ELEVATION = 581.2 (DETROIT DATUM)

ELEVATION IN FEET: 580, 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450

- Fill; Cinders.
- Fill; Clay and Cinders.
- Soft Silty Yellow Clay.
- Soft Varicolored Clay.
- Soft Gray Clay, Trace of Sand.
- Firm Fine to Very Fine Dark Gray Sand.
- Medium Gray Clay, Some Sand and Gravel.
- Soft Gray Clay, Trace of Sand and Gravel.
- Medium Gray Clay, Trace of Sand and Gravel.
- Firm Fine Gray Sand, Some Clay.
- Hardpan; Very Compact Clayey Very Fine to Medium Gray Sand.
- Boring Stopped.

Boring Log and all sampling by Raymond Concrete Pile Company. Their Job No. B-25056-D.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT	DRY WT. LBS. PER CU. FT.	REMARKS
1-BS	579.2	--	5	12			
2-BS	577.2	--	5	12			
3-LS	575.2	Soft	2	12	38.2	83.0	3-LS: Uniform. Yellow clay, some silt, trace of sand.
4-LS	571.2	Soft	2	15	39.3	81.4	4-LS: Uniform. Yellow clay, some silt, trace of sand.
5-LS	566.2	Soft	2	12	37.9	81.1	See Note A.
6-LS	561.2	Plastic	3	14	30.7	92.4	6-LS: Uniform. Gray clay, some silt, trace of sand.
7-LS	556.2	Soft	3	14	32.6	88.6	7-LS: Uniform. Gray clay, some silt, trace of sand.
8-LS	551.2	Soft	2	18	40.4	81.1	8-LS: Uniform. Gray clay, some silt, trace of sand.
9-LS	546.2	Soft	2	16	42.8	76.8	9-LS: Uniform. Gray clay, some silt, trace of sand.
10-LS	542.1	Firm	12	12	20.2	104.8	10-LS: Uniform. Clayey gray silt, little sand.
11-LS	537.2	Plastic	11	12	20.8	105.5	11-LS: Uniform. Clayey gray silt, little sand.
12-LS	532.2	Plastic	7	13	21.4	103.6	12-LS: Uniform. Clayey gray silt, little sand.
13-LS	527.2	Plastic	5	14	23.2	101.7	13-LS: Uniform. Silty gray clay, some sand, trace of gravel.
14-LS	522.2	Plastic	4	12	24.0	99.2	14-LS: Uniform. Silty gray clay, some sand, trace of gravel.
15-LS	517.2	Plastic	5	12	18.0	109.2	15-LS: Uniform. Silty gray clay, some sand, trace of gravel.
16-LS	512.2	Plastic	5	12	33.8	85.8	16-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
17-LS	507.2	Plastic	5	13	27.2	94.8	17-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
18-LS	502.2	Plastic	4	12	26.7	99.8	18-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
19-LS	497.2	Plastic	5	12	26.1	96.1	19-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
20-LS	492.2	Plastic	6	12	26.0	92.4	20-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
21-LS	487.2	Plastic	8	12	27.2	94.2	21-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
22-BS	482.2	--	7	12			
23-LS	476.2	Soft	7	12	26.5	95.2	23-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
24-LS	471.2	Soft to Plastic	7	12	28.7	91.4	24-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
25-LS	466.2	Soft	7	12	31.8	88.0	25-LS: Uniform. Gray clay, some silt, trace of sand and gravel.
	461.2	--	7	12			
	457.2	--	12	12			
26-BS	455.8	--	100	8			
27-BS	451.9	--	100	4			

⌧ Indicates failure to recover Liner Sample

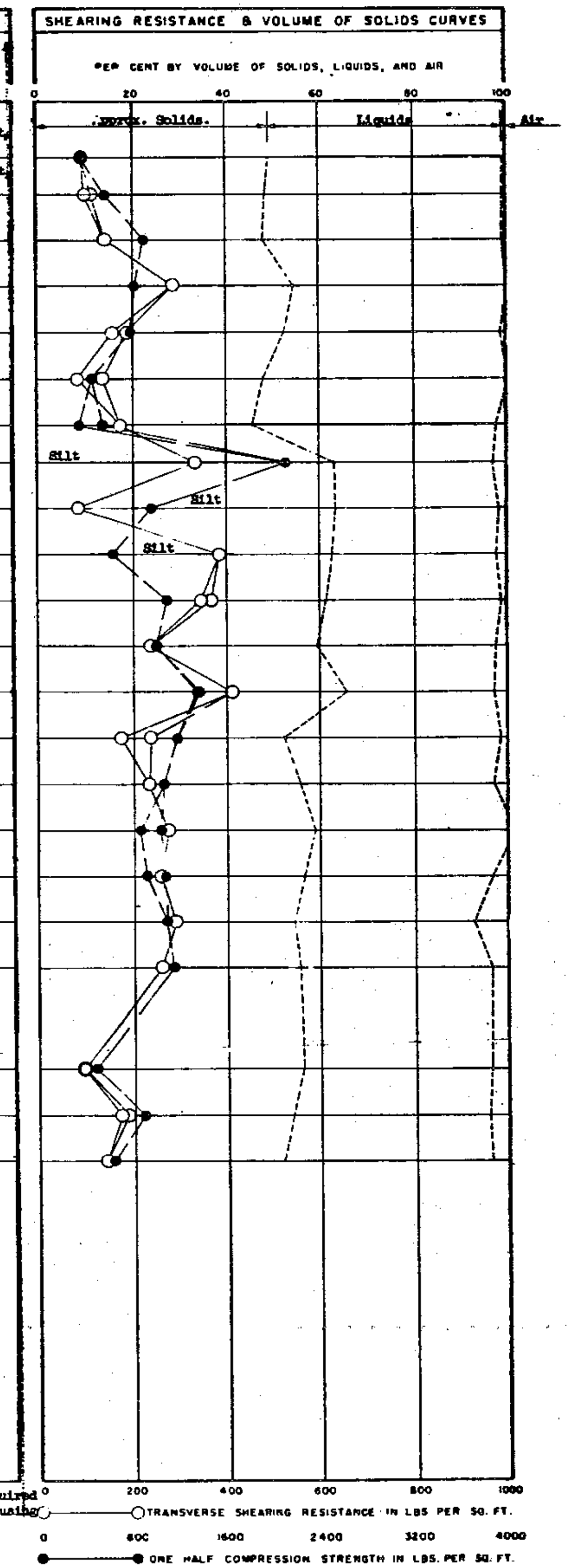
NOTE: Permanent Ground Water Level assumed to be the level of the St. Clair River adjacent to the site.

PENETRATION NOTE: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

Note A

5-LS: Uniform. Mottled yellow and gray clay, some silt, trace of sand with pocket of clayey gray silt, trace of organic matter.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
ANN ARBOR MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 21
ST. CLAIR POWER PLANT - DETROIT EDISON COMPANY
DETROIT MICHIGAN

APPROVED: [signature] DATE: 11-2-59

UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE PROJECT 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION = 588.60 Ft. (USING USC & GS DATUM)

Elevation in feet	Log of soil profile
588–580	Stiff Sandy Varicolored Clay.
580–573	Medium Sandy Brown Clay
573–531	Soft Gray Clay, Some Sand, Trace of Gravel (W.L. at 5-LS)
531–455	Medium Gray Clay, Some Sand, Trace of Gravel.
455–453	Very Compact Medium Clayey Gray Sand. Boring Stopped.

Boring Log and all Sampling by Raymond Concrete Pile Division of Raymond International, Inc. Their Job No. RCE-11914-D. Date of Boring: 12-20-66.

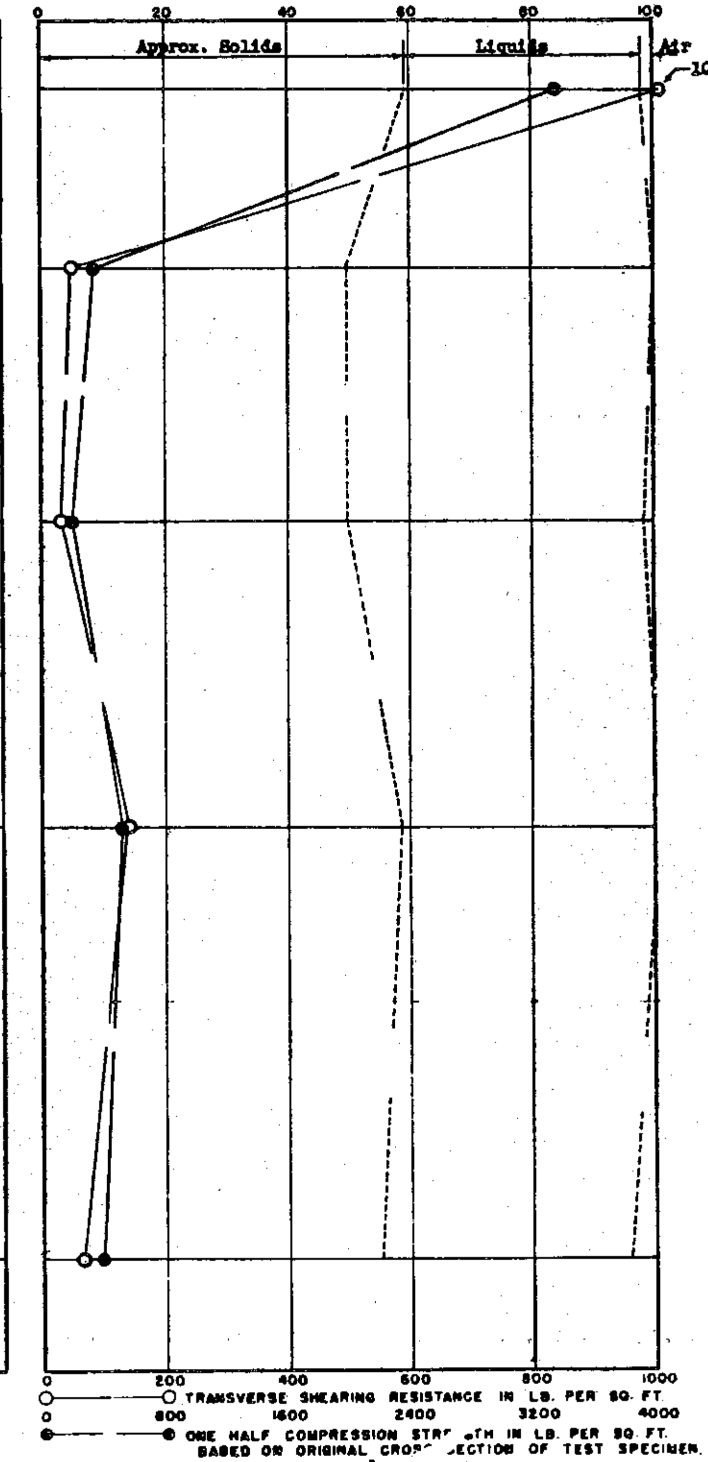
SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LB. PER CU. FT.	REMARKS
1-BS	586.1	--	16	12			
2-LS	583.1	Stiff	15	12	24.2	99.2	2-LS: Uniform. Silty mottled brown-gray clay.
3-BS	578.6	--	10	12			
4-BS	573.1	--	5	12			
5-LS	568.6	Very Soft	4	12	37.4	84.2	5-LS: Uniform. Silty gray clay, trace of very fine sand.
6-BS	563.6	--	2	12			
7-BS	558.1	--	2	11			
8-BS	553.1	--	2	11			
9-LS	548.1	Very Soft	3	13	35.0	86.7	9-LS: Uniform. Silty gray clay.
10-BS	543.1	--	2	12			
11-BS	538.1	--	2	12			
12-BS	533.1	--	3	12			
13-BS	528.6	--	6	12			
14-LS	523.1	Soft	9	12	26.8	98.6	14-LS: Uniform. Silty gray clay, trace of sand and gravel.
15-BS	518.6	--	10	12			
16-BS	513.6	--	11	12			
17-BS	508.6	--	12	12			
18-BS	503.6	--	13	12			
19-BS	498.6	--	14	12			
20-BS	493.1	--	11	12			
21-LS	488.1	Very Soft	9	12	27.3	93.0	21-LS: Uniform. Silty gray clay, trace of sand and gravel.
22-BS	483.6	--	10	12			
23-BS	478.6	--	10	12			
24-BS	473.6	--	10	12			
25-BS	468.6	--	10	12			
26-BS	463.6	--	10	12			
27-BS	458.6	--	8	12			
28-BS	453.4	--	100	5			

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

(symbol) Failure to recover Liner Sample.
WL: Water Level 16 hours after completion.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 29
CAR DUMPER HOUSE - ST. CLAIR POWER PLANT
THE DETROIT EDISON CO. BELLE RIVER, MICHIGAN

APPROVED: W.D. Hours DATE: 6-14-67
PROJECT: 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION = 572 Ft. (USING USC & GS DATUM)

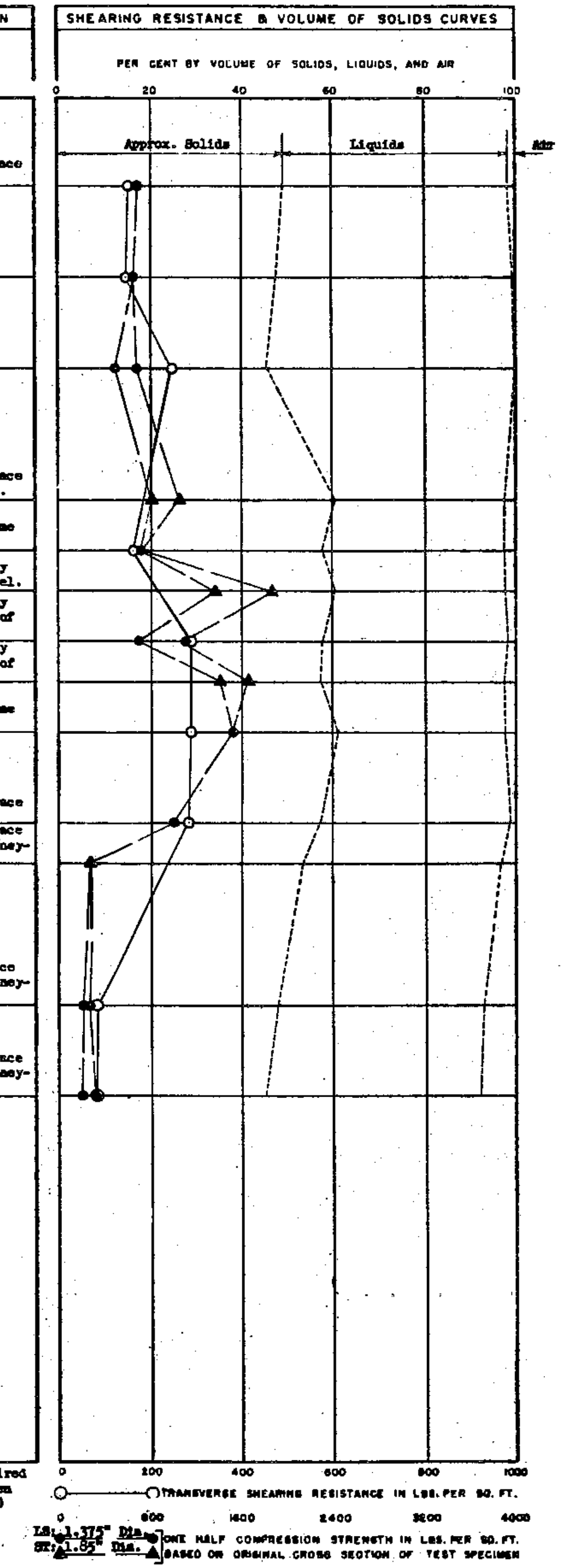
- Soft Gray Clay, Trace of Fine Sand.
- Medium Gray Clay with Fine Sand and Traces of Gravel.
- Medium Gray Clay with Fine Sand.
- Very Compact Clayey, Fine to Coarse Gray Sand and Gravel.
- Boring Stopped.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LBS. PER CU. FT.	REMARKS
1-SS	567.0	--	3	12			
2-LS	562.0	Soft	2	12	36.7	84.2	2-LS: Uniform. Silty gray clay, trace of gravel.
Lost SS	557.0	--	2	12			
3-LS	552.0	Soft	2	12	39.5	81.7	3-LS: Uniform. Silty gray clay.
4-SS	547.0	--	2	12			
5-LS	542.0	Soft	3	12	44.3	76.1	5-LS: Uniform. Silty gray clay.
6-SS	537.0	--	3	12			
Lost LS	532.0	--	3	12			
7-ST	527.0	Soft	Pushed		22.6	102.1	7-ST: Uniform. Silty gray clay, trace of gravel. Few sand pockets.
8-LS	522.0	Soft	8	12	25.7	97.3	8-LS: Uniform. Silty gray clay, some fine sand, trace of gravel.
9-ST	517.0	Plastic	Pushed		22.8	102.3	9-ST: Uniform. Silty laminated gray clay, trace of sand and gravel.
10-LS	512.0	Soft to Plastic	9	12	26.2	97.3	10-LS: Uniform. Silty laminated gray clay, some fine sand, trace of gravel.
11-ST	507.0	Plastic	Pushed		25.9	96.7	11-ST: Uniform. Silty laminated gray clay, some fine sand, trace of gravel.
12-LS	502.0	Plastic	13	12	21.9	103.6	12-LS: Uniform. Silty gray clay, some fine sand, trace of gravel.
Lost ST	497.0	--	Pushed				
13-LS	492.0	Plastic	11	12	26.8	96.7	13-LS: Uniform. Silty gray clay, trace of fine sand and gravel.
14-ST	487.0	Very Soft	Pushed		29.7	91.1	14-ST: Uniform. Silty gray clay, trace of fine sand and gravel. Honey-combed.
Lost LS	482.0	--	10	12			
Lost ST	477.0	--	Pushed				
Lost ST	474.0	--	Pushed				
15-LS	472.0	V.Soft	13	12	34.5	81.4	15-LS: Uniform Silty gray clay, trace of fine sand and gravel. Honey-combed.
16-BS	467.0	--	14	12			
17-LS	462.0	Very Soft	14	12	38.2	77.1	17-LS: Uniform. Silty gray clay, trace of fine sand and gravel. Honey-combed.
Lost LS	457.0	--	14	12			
18-SS	453.7	--	100	10			

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



Boring Log and all sampling by Raymond Concrete Pile Division of Raymond International, Inc. under their Job No. RCB-11914-D.
Date of Boring: 2-11-67

- (symbol) Failure to recover Liner Sample.
- LS: Undisturbed Liner Sample 1.375" diameter.
- BS: Disturbed Sample.
- ST: Undisturbed Shelby Tube Sample 1.85" diameter.
- SS: Standard Spoon Sample.
- Water Level Not Given.

OFFICE OF RESEARCH ADMINISTRATION SOIL MECHANICS LABORATORY	
UNIVERSITY OF MICHIGAN,	ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 29A CAR DUMPER HOUSE - ST. CLAIR POWER PLANT	
DETROIT EDISON COMPANY	BELLE RIVER, MICHIGAN
APPROVED: W.G. Housel	DATE: 6-14-67

OFFICE OF RESEARCH ADMINISTRATION PROJECT 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION: 588.80 Ft.

(USING USC & GS DATUM)

ELEVATION IN FEET

- Fill; Soft Varicolored Clay, Limestone.
- Medium Varicolored Sandy Clav.
- 580 — Stiff Varicolored Clay, Trace of Gravel.
- Medium Varicolored Clay.
- 570
- 560
- Soft Grey Clay.
- 550
- 540
- Soft Gray Clay, With Seams of Fine Silty Gray Sand.
- 530 — Firm Coarse Gray Sand, Some Gravel.
- 520
- 510
- Medium Sandy Gray Clay, with Gravel.
- 500
- 490
- 480
- 470
- 460 — Firm Medium Gray Sand, Some Gravel, Clay Binder.
- Refusal.
- 450

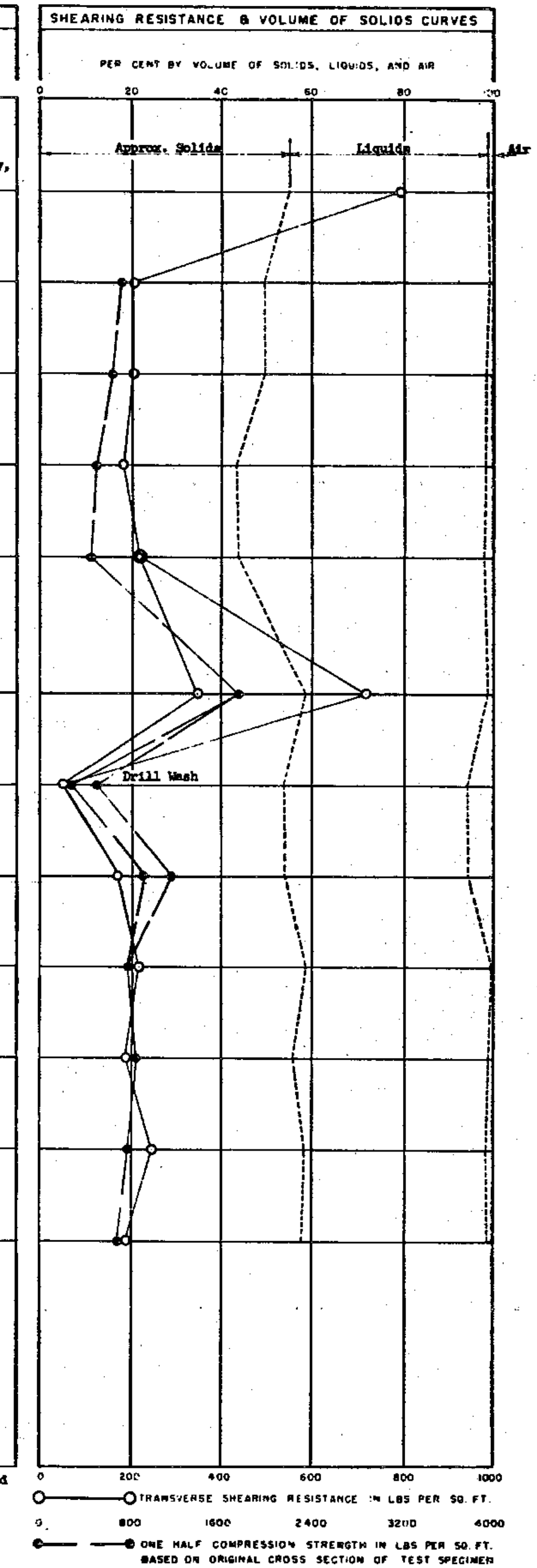
Boring Log and all Sampling by Raymond Concrete Pile Division of Raymond International, Inc. under their Job No. ECB-11914-F
Date of Boring: 1-13-67

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA NO	ELEV	LAB CONSISTENCY	PENETRATION NO OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT	DRY WT LBS PER CU FT	REMARKS
1-BS	586.3	--	4	12			
2-BS	583.8	--	12	12			
3-LS	578.8	Firm to Stiff	16	12	28.8	94.8	3-LS: Uniform. Silty, brown-gray clay, trace of sand.
4-BS	573.8	--	7	12			
5-LS	568.8	Soft	4	12	36.6	84.9	5-LS: Uniform. Silty gray clay, trace of sand.
6-BS	563.8	--	3	12			
7-LS	558.8	Soft	4	12	35.5	85.5	7-LS: Uniform. Silty gray clay, trace of sand.
8-BS	553.8	--	3	12			
9-LS	548.8	Soft	3	12	46.2	74.3	9-LS: Uniform. Silty gray clay.
10-BS	543.8	--	3	12			
11-LS	538.8	Soft	3	12	45.0	75.2	11-LS: Uniform. Silty gray clay.
12-BS	533.8	--	4	12			
13-BS	526.8	--	23	12			
14-LS	523.8	Plastic to Firm	12	12	25.1	99.6	14-LS: Uniform. Silty laminated gray clay, some fine sand, trace of gravel.
15-BS	518.8	--	14	12			
16-LS	513.8	Soft	14	12	27.7	91.2	16-LS: Uniform. Silty gray clay, some fine sand, trace of gravel.
17-BS	508.8	--	14	12			
18-LS	503.8	Soft	14	12	27.6	93.0	18-LS: Uniform. Silty laminated gray clay, some fine sand, trace of gravel
19-BS	498.8	--	13	12			
20-LS	493.8	Soft	11	12	25.8	99.2	20-LS: Uniform. Silty gray clay, some fine sand, trace of gravel.
21-BS	488.8	--	10	12			
22-LS	483.8	Soft	9	12	28.2	94.8	22-LS: Uniform. Silty gray clay, some fine sand, trace of gravel.
23-BS	478.8	--	10	12			
24-LS	473.8	Soft	11	12	25.4	98.6	24-LS: Uniform. Silty laminated gray clay, some fine sand, trace of gravel.
25-BS	468.8	--	10	12			
26-LS	463.8	Soft	10	12	26.2	98.0	27-LS: Uniform. Silty gray clay, some fine sand, trace of gravel. Honeycombed.
27-BS	458.8	--	11	12			
28-BS	453.8	--	10	12			
	452.6	--	100	1			

Water Level not given.

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.



OFFICE OF RESEARCH ADMINISTRATION
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 30
CAR DUMPER HOUSE - ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY BELLE RIVER, MICHIGAN

APPROVED: [signature] DATE: 6-14-67

01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION = 588.80 Ft. (USING USC & GS DATUM)

ELEVATION IN FEET

Elevation (ft)	Description
approx. 580	Stiff Sandy Varicolored Clay, Some Gravel.
approx. 575	Medium Gray Clay, Trace of Gravel.
approx. 550	Soft Gray Clay, Trace of Gravel.
approx. 505	Medium Gray Clay, Some Sand, Trace of Gravel.
approx. 454	Medium Sandy Grey Clay, Some Rouge Streaks.
approx. 451	Very Compact Medium Gray Sand.
approx. 448	Soft Gray Shale.
approx. 445	Hard Gray Shale. Boring Stopped.

W.L. (at approx. 568.8)

Boring Log and all sampling by Raymond Concrete Pile Division of Raymond International, Inc. under their Job No. MCB-11914-D. Date of Boring: December 1966 to January 1967

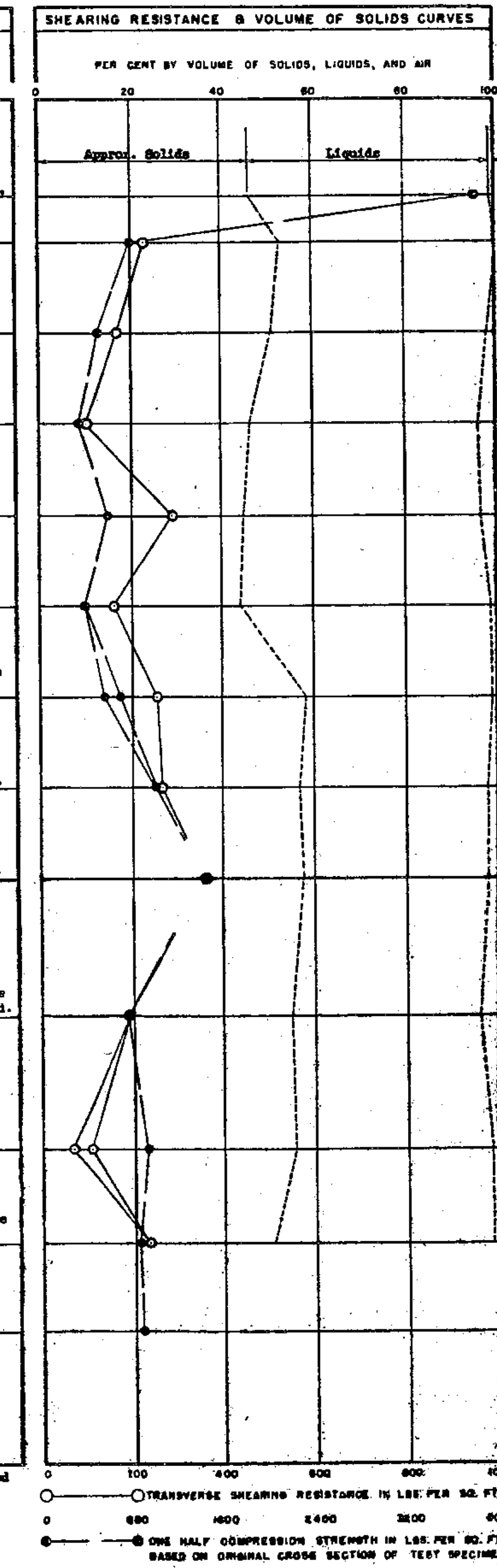
SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION: NO. OF BLOWS	PENETRATION: DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LBS. PER CU. FT.	REMARKS
1-BS	586.3	--	21	12			
2-BS	583.8	--	22	12			
3-LS	578.3	Stiff	17	12	41.7	79.2	3-LS: Uniform. Silty varicolored clay.
4-LS	573.3	Soft	5	12	32.5	91.1	4-LS: Uniform. Silty gray clay.
5-BS	568.8	--	3	11			
6-LS	563.3	Soft	3	12	33.3	88.0	6-LS: Uniform. Silty grey clay.
7-BS	558.8	--	3	12			
8-LS	553.3	Very Soft	4	12	38.5	81.1	8-LS: Uniform. Silty gray clay.
9-BS	548.3	--	4	12			
10-LS	543.3	Soft	4	12	42.1	77.4	10-LS: Uniform. Silty gray clay.
11-BS	538.8	--	4	12			
12-LS	533.3	Soft	4	12	45.1	76.1	12-LS: Uniform. Silty gray clay.
13-BS	528.8	--	4	12			
14-LS	523.3	Soft	6	12	25.9	98.6	14-LS: Uniform. Silty gray clay, trace of sand and gravel.
15-BS	518.8	--	9	12			
16-LS	513.3	Plastic	10	12	26.7	96.1	16-LS: Uniform. Silty laminated gray clay, trace of sand and gravel.
17-BS	508.8	--	10	12			
18-LS	503.3	--	11	12	26.6	97.3	18-LS: Uniform. Silty laminated gray clay, trace of sand and gravel.
19-BS	498.8	--	10	12			
	493.3	--	11	12			
20-LS	488.3	Soft to Plastic	9	12	27.7	93.0	20-LS: Uniform. Silty gray clay, trace of sand and gravel. Honeycombed.
	478.8	--	16	12			
21-LS	473.8	Soft	9	12	28.6	94.0	21-LS: Uniform. Silty gray clay, some sand, trace of gravel.
22-BS	468.8	--	14	12			
23-LS	463.3	Soft	8	12	34.7	86.1	23-LS: Uniform. Silty gray clay, trace of sand. Honeycombed.
24-BS	458.8	--	9	12			
25-LS	453.8	Soft	12	12	17.4	--	25-LS: Non-uniform. Silty sandy gray clay. Honeycombed.
26-BS	[illegible]	--	100	3			
27-BS	448.2	--	200	3			
	444.3	--	200	1			

WL: Water Level 24 hours after completion.

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



OFFICE OF RESEARCH ADMINISTRATION
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 31
CAR DUMPER HOUSE - ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY BELLE RIVER, MICHIGAN

APPROVED: W.A. Housel DATE: 6-14-67

OFFICE OF RESEARCH ADMINISTRATION PROJECT 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION= 588.70 Ft. (USING USC & GS DATUM)

WL. (Water level marked at approx. elev. 572)

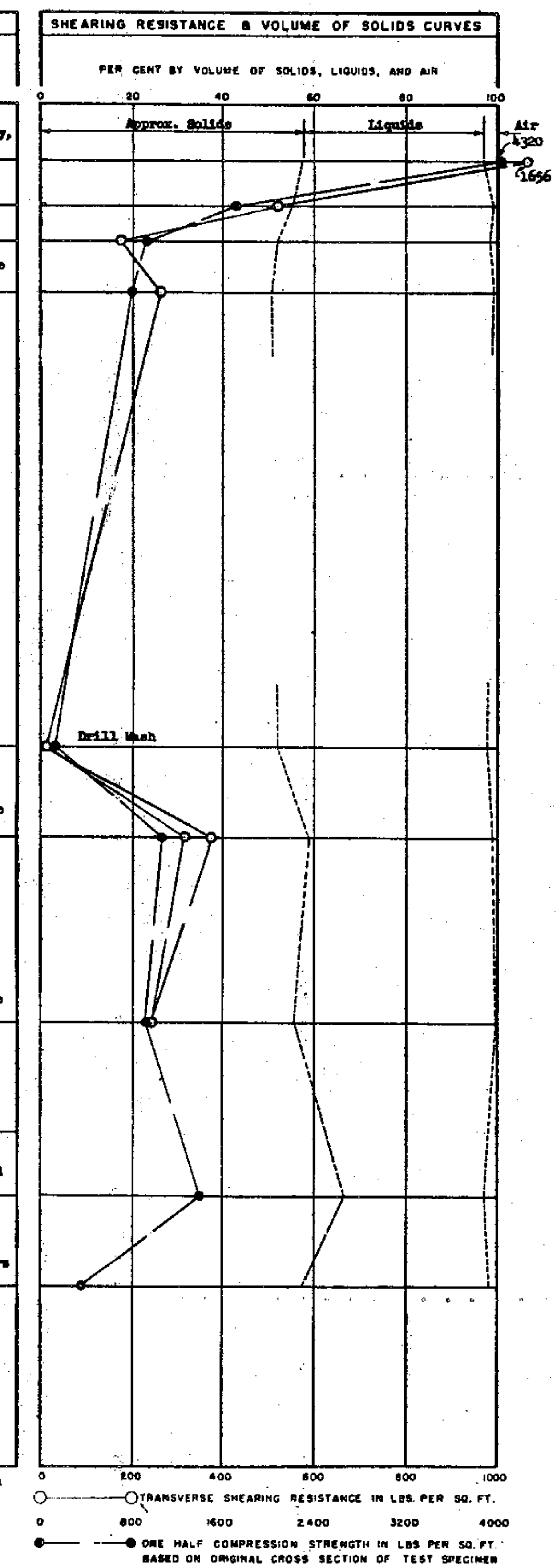
Elevation in feet (approx.)	Description
588.7–575	Medium Sandy Varicolored Clay.
575–521	Soft Gray Clay, Some Sand, Trace of Gravel.
521–456	Medium Sandy Gray Clay. Trace of Gravel.
456–452	Very Compact Medium Gray Sand.
452–443	Soft Gray Shale.
443–437	Hard Gray Shale.
437	Boring Stopped.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT. LBS. PER CU. FT.	REMARKS
1-BS	586.2	--	11	12			
2-LS	582.7	Hard	20	12	24.7	99.2	2-LS: Uniform. Silty varicolored clay, trace of sand.
3-LS	577.7	Plastic	11	12	29.0	94.3	3-LS: Uniform. Silty brown-gray clay.
4-LS	573.7	Soft	5	12	32.5	89.2	4-LS: Uniform. Silty gray clay.
5-LS	568.2	Soft	3	12	35.1	86.1	5-LS: Uniform. Silty gray clay, trace of very fine sand.
6-BS	563.7	--	3	12			
7-BS	558.7	--	3	12			
8-BS	553.7	--	3	11			
9-BS	548.7	--	3	12			
10-BS	543.7	--	3	12			
11-BS	538.7	--	3	11			
12-BS	533.7	--	3	12			
13-BS	528.7	--	4	12			
14-BS	523.7	--	5	12			
15-LS	518.2	Very Soft	6	12	32.6	88.0	15-LS: Uniform. Silty gray clay, some fine sand, trace of gravel.
16-BS	513.7	--	10	12			
17-LS	508.2	Plastic	15	12	24.8	100.2	17-LS: Uniform. Silty gray clay, trace of fine sand and gravel.
18-LS	504.7	--	12	11			
	498.7	--	8	12			
	495.7	--	10	12			
	492.7	--	10	12			
19-LS	487.7	Plastic	12	12	29.1	94.2	19-LS: Uniform. Silty gray clay, trace of fine sand and gravel.
	483.7	--	22	12			
	481.7	--	16	12			
	478.7	--	11	12			
20-LS	475.7	--	14	12	--	--	20-LS: Not Received.
21-LS	468.7	Plastic	16	12	17.0	112.3	21-LS: Uniform. Silty gray clay, some fine sand and gravel. Fine sand pockets.
22-BS	463.7	--	8	12			
23-LS	458.7	Very Soft	12	12	26.1	97.3	23-LS: Uniform. Silty gray clay, layers or lenses of silt.
24-BS	454.0	--	100	9			
25-BS	448.7	--	300	5			
26-BS	444.0	--	200	2			
	439.4	--	200	1/4			

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



WL: Water Level 96 hours after completion.

Boring Log and all Sampling by Raymond Concrete Pile Division of Raymond International, Inc. under their Job No. RCB-11914-D. Date of Boring: January 1967

OFFICE OF RESEARCH ADMINISTRATION
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 32
CAR DUMPER HOUSE - ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY BELLE RIVER, MICHIGAN

APPROVED: W.S. Housel DATE: 6-14-67

OFFICE OF RESEARCH ADMINISTRATION PROJECT 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION = 579.0 Ft. (USC & GE DATUM)

Elevation in feet	Soil profile
	Fill; Cinder.
570	Fill; Soft Clay, Loose Fine Brown Sand.
560	
550	Very Soft Gray Clay.
540	
	Medium Gray Clay, Some Fine Sand, Little Gravel.
530	
520	
	Medium Sandy Gravelly Gray Clay, Pockets of Fine Sand.
510	
500	Boring Stopped.
490	

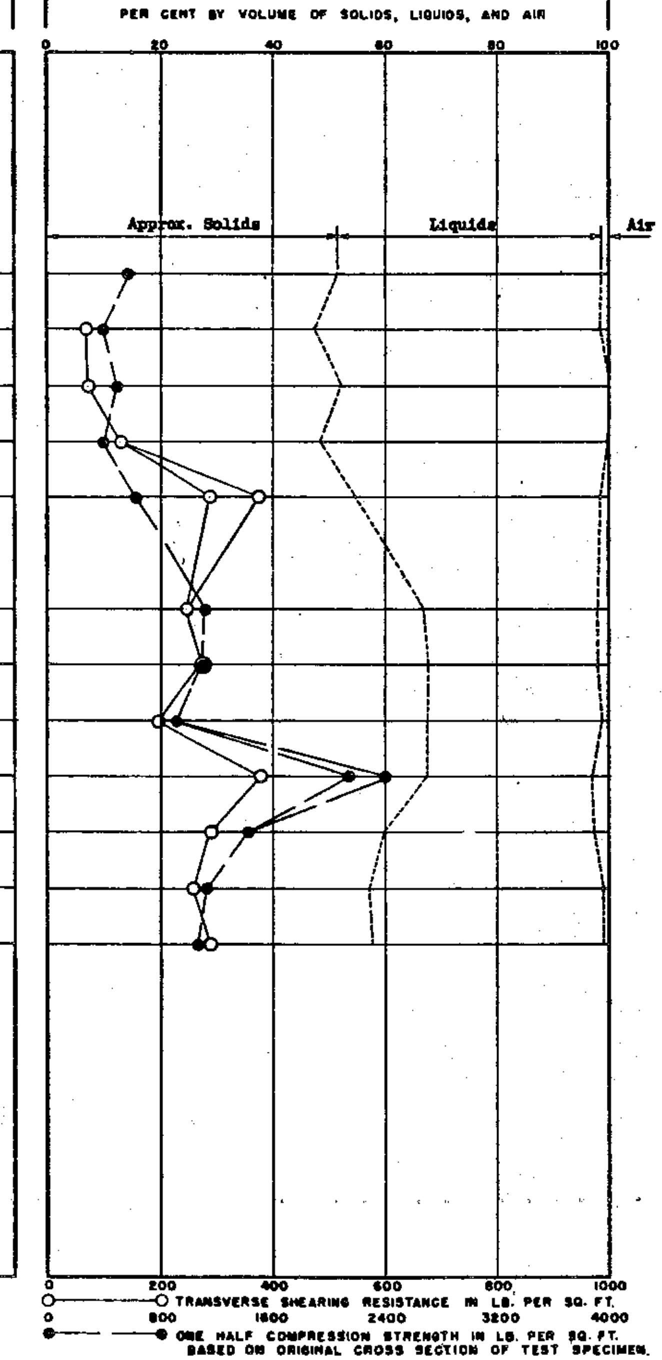
W.L. (at 569.0)

SOIL SAMPLE — LABORATORY VISUAL INSPECTION

SA. NO	ELEV	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT	DRY WT LB PER CU. FT	REMARKS
1-BS	574.0	--	1	12			
2-BS	569.0	--	2	12			
3-BS	564.0	--	4	12			
4-LS	559.5	Soft	2	12	33.9	[illegible].7	4-LS: Uniform. Silty mottled tan clay, trace of fine sand, gravel and organic matter. Laminated.
5-LS	554.5	V.Soft	1	12	40.1	[illegible].6	5-LS: Uniform. Silty gray clay.
6-LS	549.5	V.Soft	2	12	34.3	[illegible].0	6-LS: Uniform. Silty gray clay.
7-LS	544.5	V.Soft	2	12	39.4	[illegible].7	7-LS: Uniform. Silty gray clay.
8-LS	539.5	Soft to Plastic	3	12	29.6	[illegible].4	8-LS: Uniform. Silty gray clay, silt pocket, trace of very fine sand.
	534.0	--	5	12			
9-LS	529.5	Soft to Plastic	8	12	17.2	11[illegible].9	9-LS: Uniform. Silty gray clay, some sand, trace of gravel.
10-LS	524.5	Soft to Plastic	8	12	16.5	114.2	10-LS: Uniform. Silty gray clay, some sand, trace of gravel.
11-LS	519.5	Soft	8	12	17.5	111.7	11-LS: Uniform. Silty gray clay, some sand, trace of gravel.
12-LS	514.5	Plastic to Firm	8	12	16.1	113.9	12-LS: Uniform. Silty gray clay, some sand, trace of gravel.
13-LS	509.5	Plastic	11	12	23.2	101.1	13-LS: Uniform. Silty gray clay, some very fine sand, trace of gravel. Laminated.
14-LS	504.5	Plastic	10	12	27.4	96.1	14-LS: Uniform. Silty gray clay, some very fine sand, trace of gravel. Laminated.
15-LS	499.5	Plastic	10	12	26.6	97.3	15-LS: Uniform. Silty gray clay, some very fine sand, trace of gravel. Laminated.

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



Boring Log and all Sampling by Raymond Concrete Pile Division of Raymond International, Inc.
Their Job No. RCB-12371-D
Date of Boring: April 12, 1967

W.L. Water Level at Completion.

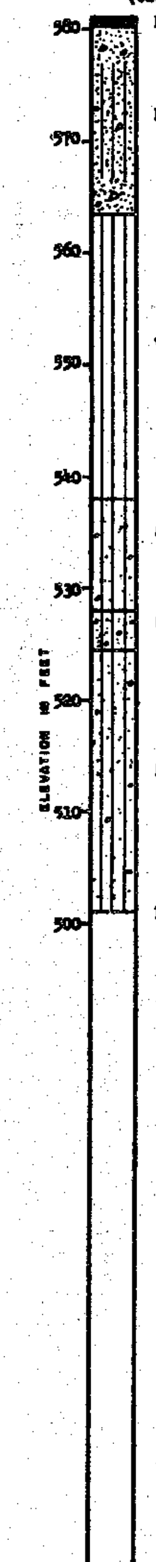
ENGINEERING RESEARCH INSTITUTE SOIL MECHANICS LABORATORY UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
SUBSOIL ANALYSIS OF BORING NO. 33 ST. CLAIR POWER PLANT THE DETROIT EDISON CO. BELLE RIVER, MICHIGAN
APPROVED: W.S. Housel . DATE: 6-14-67

PROJECT NO. 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION = 581.0 Ft. (USC & GS DATUM)



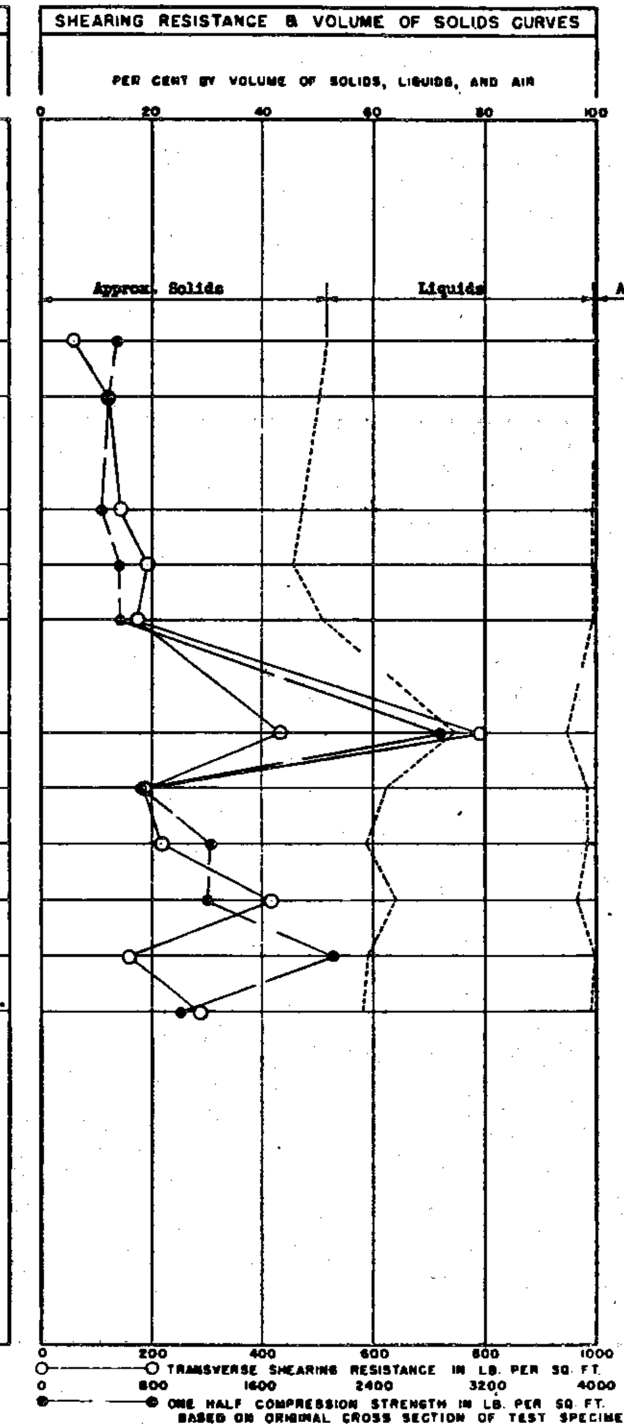
Elevation (ft)	Description
580	Fill; Cinder.
	Fill; Clay, Sandy Gravel, Concrete. W.L.
	Very Soft Gray Clay.
	Soft Gray Clay, Trace of Fine Sand and Little Gravel.
	Stiff Sandy Gravelly Gray Clay.
	Medium Gray Clay, Some Fine Sand and Small Gravel.
500	Boring Stopped.

SOIL SAMPLE / LABORATORY VISUAL INSPECTION

SA NO	ELEV	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT	DRY WT. LB PER CU FT	REMARKS
1-BS	576.0	--	4	12			
2-BS	571.0	--	8	12			
3-BS	566.0	--	5	12			
4-LS	561.5	V.Soft	3	12	34.7	87.4	4-LS: Uniform. Silty gray clay.
5-LS	556.5	V.Soft	2	12	36.3	84.9	5-LS: Uniform. Silty gray clay.
	551.0	--	2	12			
6-LS	546.5	Soft	2	12	41.3	79.2	6-LS: Uniform. Silty gray clay.
7-LS	541.5	Soft	2	12	43.8	76.8	7-LS: Uniform. Silty gray clay.
8-LS	536.5	Soft	4	12	35.6	85.5	8-LS: Uniform. Silty gray clay, trace of very fine sand.
	531.0		4	12			
9-LS	526.5	Firm	23	12	9.9	126.0	9-LS: Uniform. Clayey gravelly gray sand to sandy dark gray clay, trace of organic matter.
10-LS	521.5	Soft	7	12	21.6	104.8	10-LS: Uniform. Silty gray clay, some sand, trace of gravel.
11-LS	516.5	Soft to Plastic	8	12	24.9	99.2	11-LS: Uniform. Silty gray clay, some sand, trace of gravel.
12-LS	511.5	Plastic	10	12	18.9	108.0	12-LS: Uniform. Silty gray clay, some sand, trace of gravel.
13-LS	506.5	Plastic	13	12	25.5	99.9	13-LS: Uniform. Silty gray clay, some sand, trace of gravel.
14-LS	501.5	Plastic	10	12	26.2	98.0	14-LS: Uniform. Silty gray clay, some sand, trace of gravel. Laminated.

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



Boring Log and all Sampling by Raymond Concrete Pile Division of Raymond International, Inc.
Their Job No. RCB-12371-D
Date of Boring: April 10, 1967

W.L. Water Level at completion.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 34
ST. CLAIR POWER PLANT
THE DETROIT EDISON CO. BELLE RIVER, MICHIGAN

APPROVED *[signature]* DATE 6-14-67

PROJECT NO. 01994

LOG OF SOIL PROFILE

BY R.C.P. DIVISION

GROUND SURFACE ELEVATION = 579.4 Ft. (USC & GS DATUM)

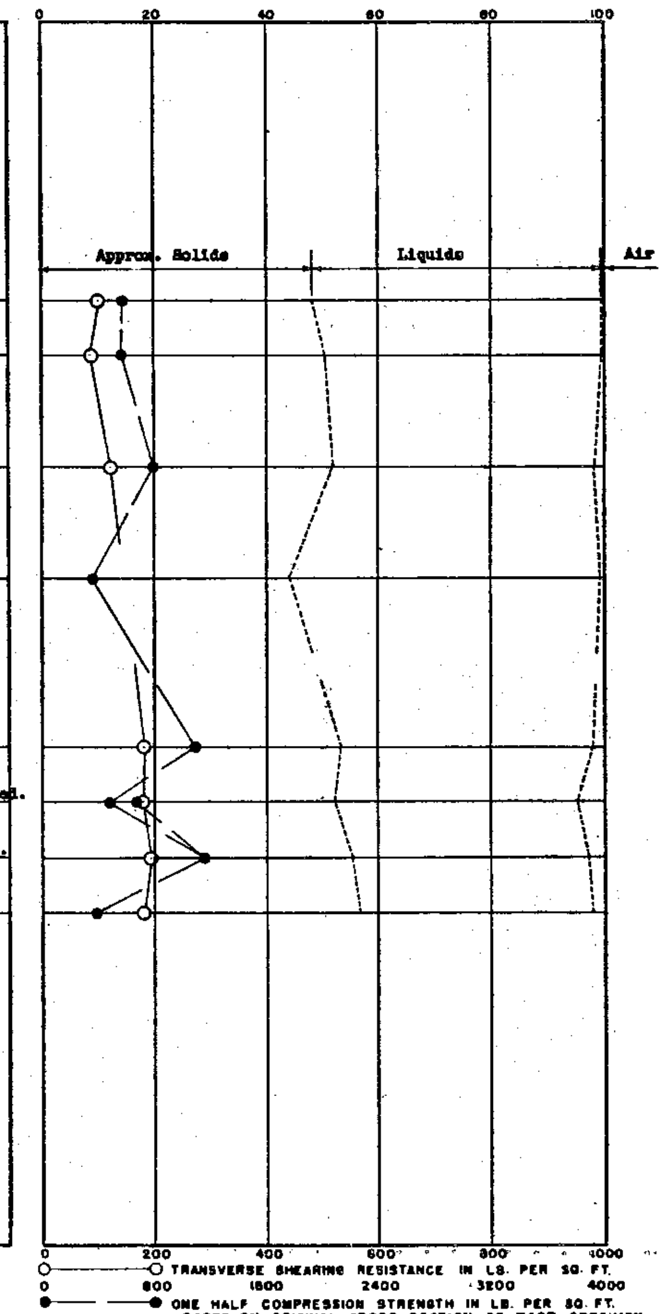
Elevation (ft)	Soil Profile
	Fill; Cinder.
	Fill; Loose Sand and Clay. (W.L.)
570	Fill; Loose Fine Sand.
560	
550	Very Soft Gray Clay.
540	
530	Soft Gray Clay, Some Fine Sand, Little Gravel.
520	Medium Sandy Gravelly Gray Clay, Pockets of Fine Sand.
510	
500	Boring Stopped.
490	

SOIL SAMPLE

SA. NO.	ELEV.	LAB. CONSISTENCY	PENETRATION NO. OF BLOWS	PENETRATION DRIVE IN INCHES	% H_2O BY DRY WT.	DRY WT LB. PER CU FT.	LABORATORY VISUAL INSPECTION REMARKS
1-BS	574.4	--	3	12			
2-BS	569.4	--	3	12			
3-BS	564.4	--	1	15			
4-BS	559.4	--	2	15			
5-LS	554.9	Soft	2	12	39.6	81.1	5-LS: Uniform. Silty gray clay.
6-LS	549.9	Soft	2	12	36.3	84.9	6-LS: Uniform. Silty gray clay.
	544.4	--	2	12			
7-LS	539.9	Soft	2	12	33.1	87.4	7-LS: Uniform. Silty gray clay, trace of fine sand and silt lenses.
	534.4	--	4	12			
8-LS	529.9	V.Soft	4	12	46.6	74.3	8-LS: Uniform. Silty gray clay, trace of very fine sand.
	524.4	--	8	12			
	521.9	--	8	12			
9-LS	519.4	--	8	12			
10-LS	514.9	Soft	7	12	30.9	89.9	10-LS: Uniform. Silty gray clay, some sand, trace of gravel.
11-LS	509.9	Soft	6	12	30.8	87.7	11-LS: Uniform. Silty gray clay, some sand, trace of gravel. Honeycombed.
12-LS	504.9	Soft	8	12	28.1	93.0	12-LS: Uniform. Silty gray clay, some sand, trace of gravel. Laminated.
13-LS	499.9	Soft	9	12	26.9	95.5	13-LS: Uniform. Silty gray clay, trace of sand.

PENETRATION: Number of blows required to drive core sampler distance given using a 140-pound weight falling 30 inches.

SHEARING RESISTANCE & VOLUME OF SOLIDS CURVES



Boring Log and all Sampling by Raymond Concrete Pile Division of Raymond International, Inc.
Their Job No. ECB-18371-D
Date of Boring: April 12, 1967

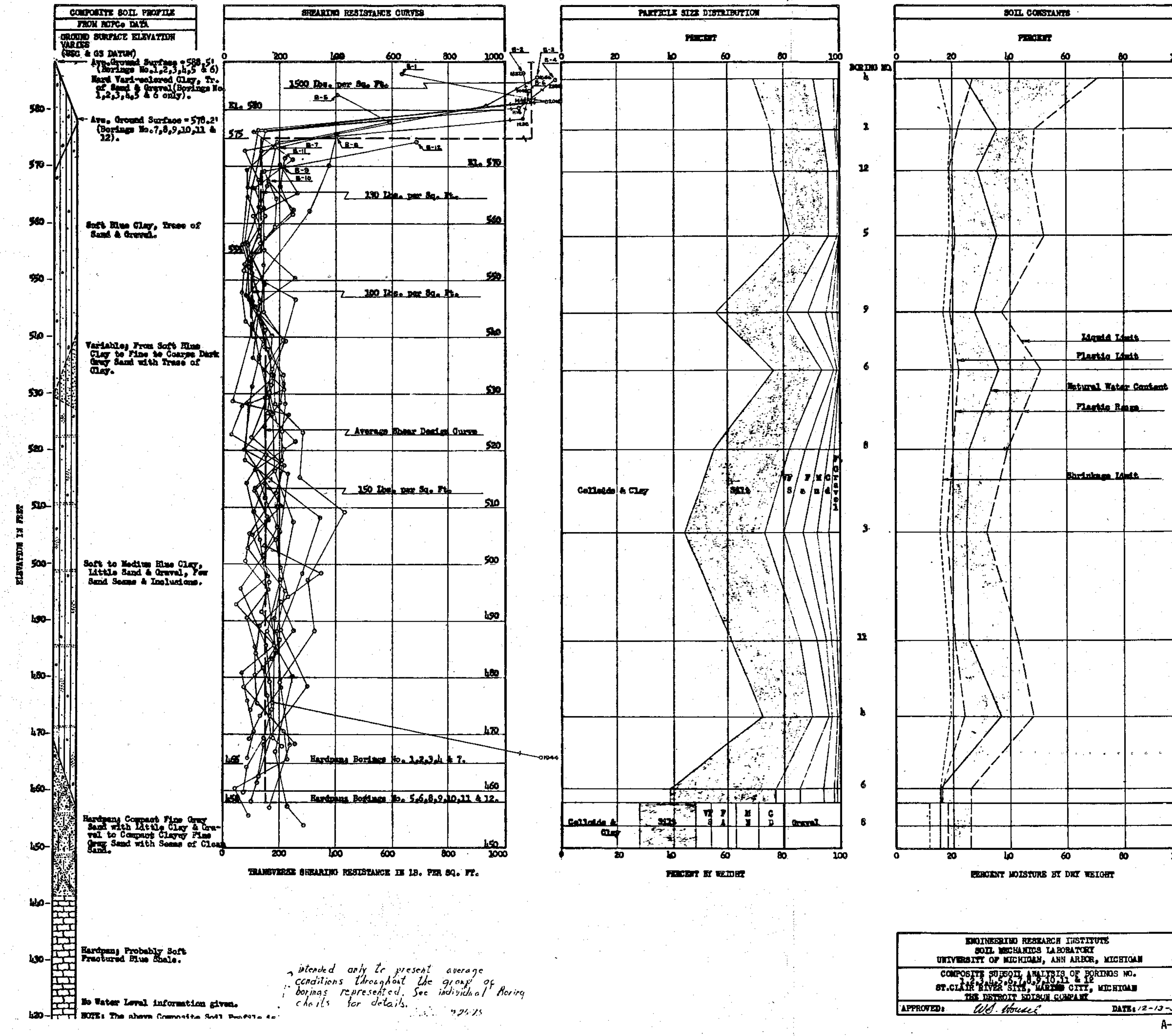
W.L. Water Level at Completion.

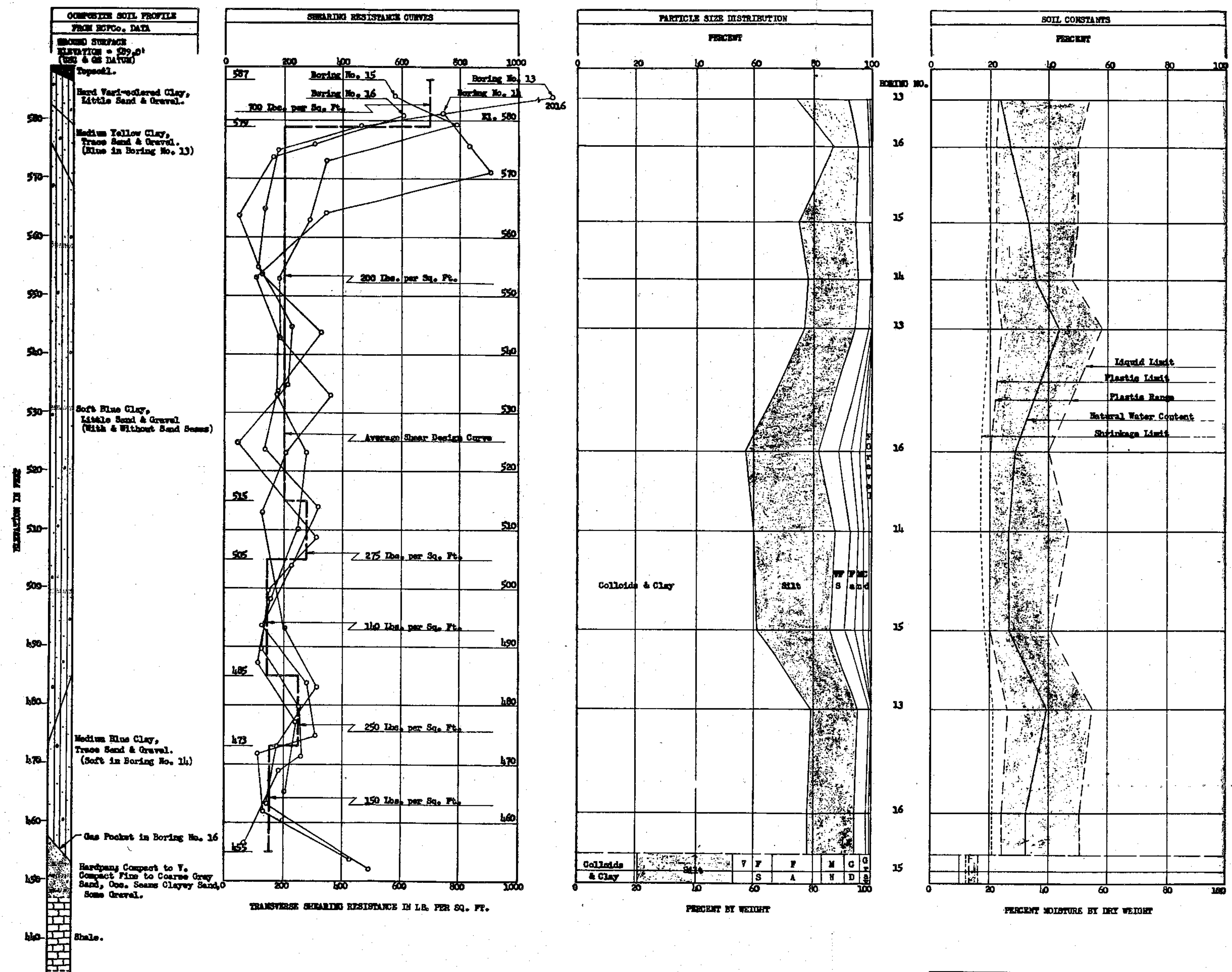
ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

SUBSOIL ANALYSIS OF BORING NO. 35
ST. CLAIR POWER PLANT
THE DETROIT EDISON CO. BELLE RIVER, MICHIGAN

APPROVED: W.S. Housel DATE 6-14-67

PROJECT NO. 01994


COMPOSITE SOIL PROFILE
FROM RUPCo DATA
GROUND SURFACE ELEVATION VARIES (USC & GS DATUM)
Ave. Ground Surface = 588.5' (Borings No. 1,2,3,4,5 & 6)
Hard Vari-colored Clay, Tr. of Sand & Gravel (Borings No. 1,2,3,4,5 & 6 only).
Ave. Ground Surface = 578.2' (Borings No. 7,8,9,10,11 & 12).
Soft Blue Clay, Trace of Sand & Gravel.
Variable; From Soft Blue Clay to Fine to Coarse Dark Grey Sand with Trace of Clay.
Soft to Medium Blue Clay, Little Sand & Gravel, Few Sand Seams & Inclusions.
Hardpan; Compact Fine Grey Sand with Little Clay & Gravel to Compact Clayey Fine Grey Sand with Seams of Clean Sand.
Hardpan; Probably Soft Fractured Blue Shale.
No Water Level information given.
NOTE: The above Composite Soil Profile is
ELEVATION IN FEET
SHEARING RESISTANCE CURVES
1500 Lbs. per Sq. Ft.
El. 580
El. 570
130 Lbs. per Sq. Ft.
100 Lbs. per Sq. Ft.
Average Shear Design Curve
150 Lbs. per Sq. Ft.
Hardpan; Borings No. 1,2,3,4 & 7.
Hardpan; Borings No. 5,6,8,9,10,11 & 12.
TRANSVERSE SHEARING RESISTANCE IN LB. PER SQ. FT.
PARTICLE SIZE DISTRIBUTION
PERCENT
Colloids & Clay
Silt
VF S
F S
M S
C S
Gravel
PERCENT BY WEIGHT
BORING NO.
SOIL CONSTANTS
PERCENT
Liquid Limit
Plastic Limit
Natural Water Content
Plastic Range
Shrinkage Limit
PERCENT MOISTURE BY DRY WEIGHT
intended only to present average conditions throughout the group of borings represented. See individual Boring charts for details.
ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
COMPOSITE SUBSOIL ANALYSIS OF BORINGS NO. 1,2,3,4,5,6,7,8,9,10,11 & 12
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY
APPROVED: W.S. House
DATE: 12-13-50
A-43



No Water Level information given.

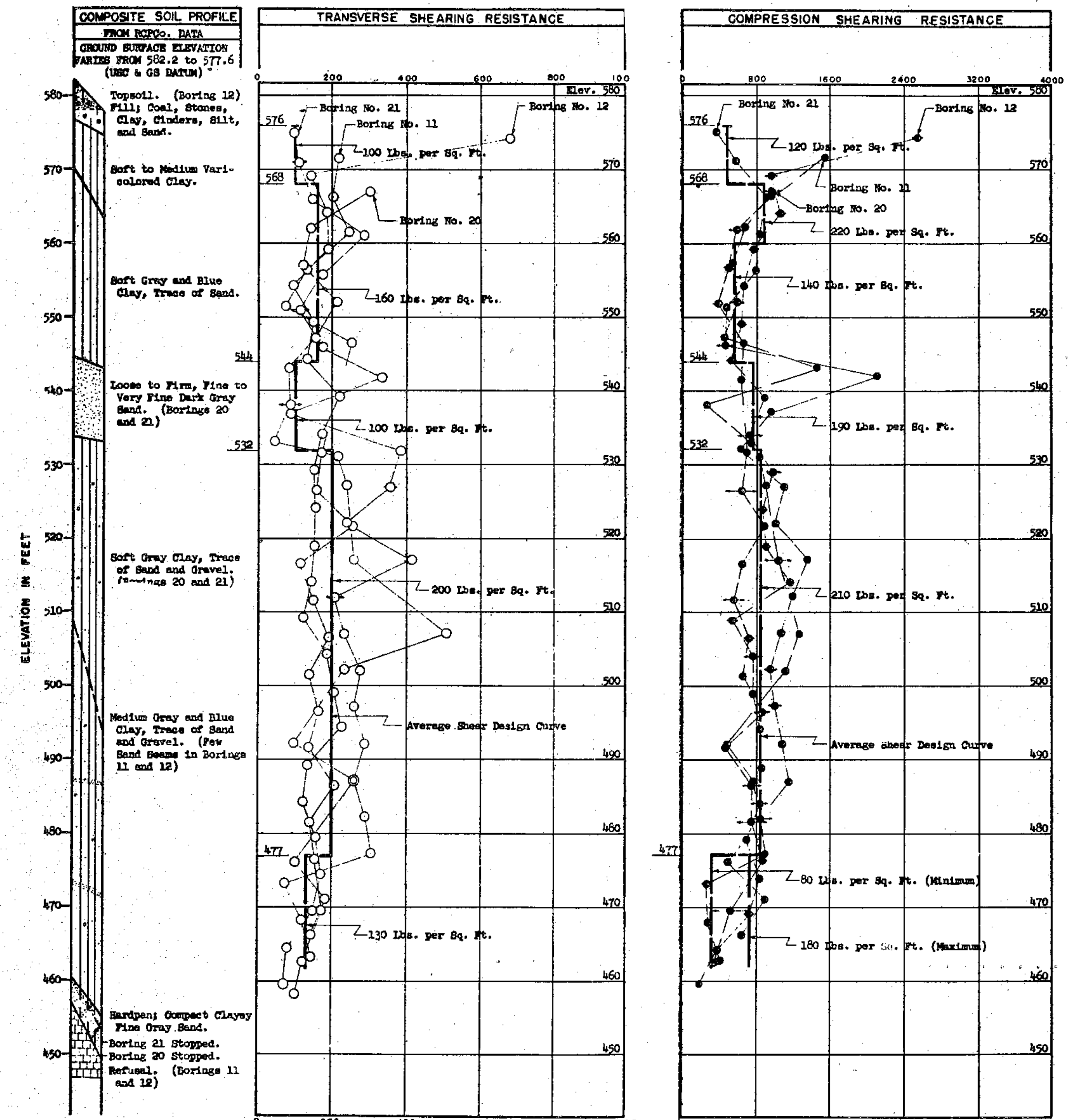
NOTE: The above Composite Soil Profile is intended only to present average conditions throughout the group of borings represented. See individual Boring Charts for details.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

COMPOSITE SUBSOIL ANALYSIS OF BORINGS NO.13,14,15 & 16
ST. CLAIR RIVER SITE, MARINE CITY, MICHIGAN
THE DETROIT EDISON COMPANY

APPROVED: W.J. Housel DATE: 12-13-50

UNIVERSITY OF MICHIGAN PROJECT M373-66



NOTE: The above Composite Soil Profile is intended only to present average conditions for Borings No. 11, 12, 20, and 21.

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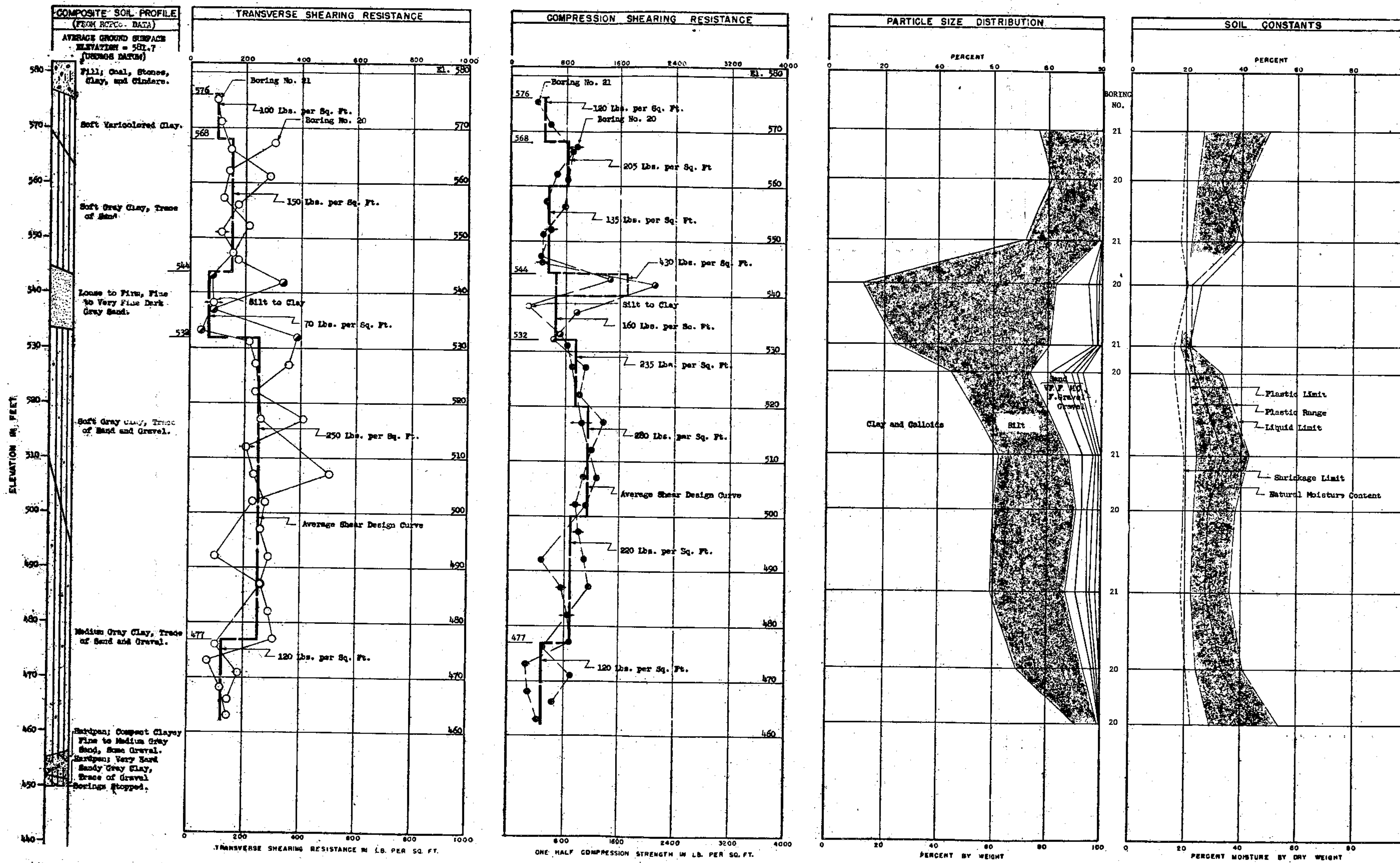
COMPOSITE SUBSOIL ANALYSIS OF BORINGS NO. 11, 12, 20 and 21
ST. CLAIR POWER PLANT -- DETROIT EDISON COMPANY
DETROIT MICHIGAN

APPROVED: DATE:



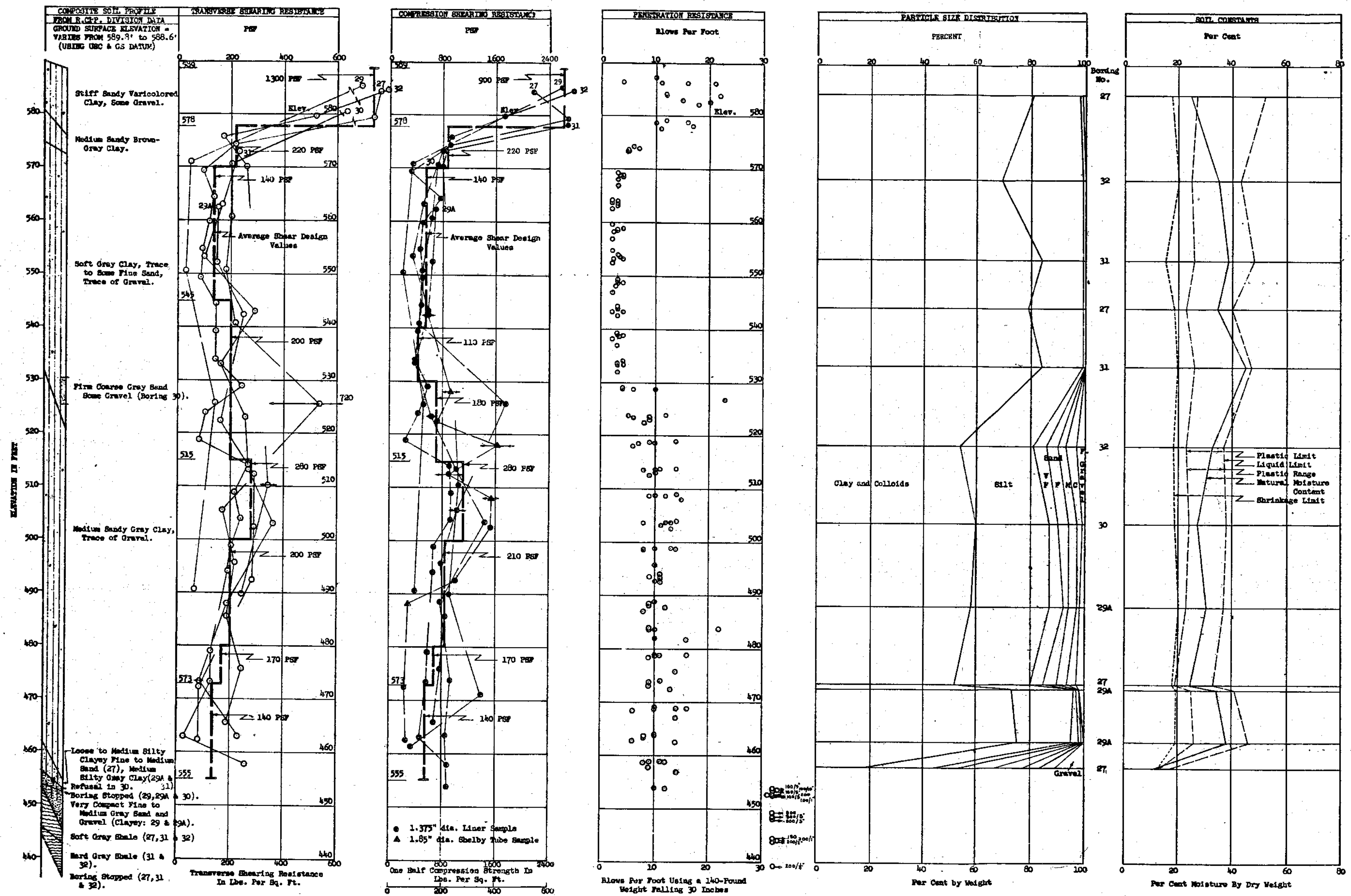
NOTE: The above Composite Soil Profile is intended only to present average conditions throughout the group of borings represented. See individual boring charts for details.

ENGINEERING RESEARCH INSTITUTE
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

COMPOSITE SUBSOIL ANALYSIS OF BORINGS NO. 20 and 21
ST. CLAIR POWER PLANT - DETROIT EDISON COMPANY
DETROIT MICHIGAN

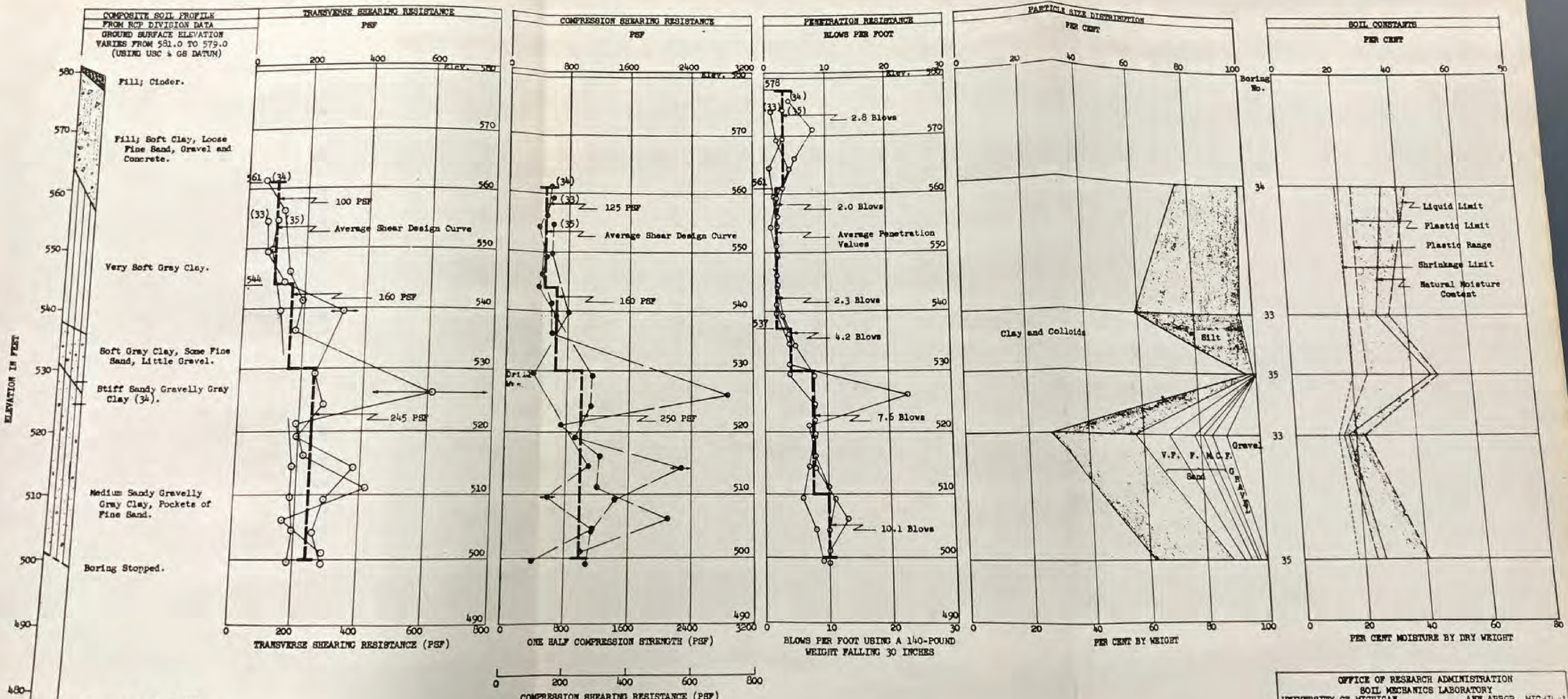
APPROVED: W. Hugel DATE: 1-2-59

UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE PROJECT 01994



The above Composite Soil Profile is intended only to present average conditions throughout the group of borings represented. See individual Boring Charts for details.
Date of Borings: December 1966 to February 1967

OFFICE OF RESEARCH ADMINISTRATION
SOIL MECHANICS LABORATORY
ANN ARBOR MICHIGAN
COMPOSITE SUBSOIL ANALYSIS OF BORINGS NOS. 27, 29, 29A, 30, 31 AND 32
CAR DUMPER HOUSE - ST. CLAIR POWER PLANT
THE DETROIT EDISON COMPANY BELLE RIVER, MICH.
APPROVED: [signature] DATE: 6-14-67
OFFICE OF RESEARCH ADMINISTRATION PROJECT: 01994



The above Composite Soil Profile is intended only to present average conditions throughout the group of borings represented. See individual Boring Charts for details.
Date of Boring: April 1967.

OFFICE OF RESEARCH ADMINISTRATION
SOIL MECHANICS LABORATORY
UNIVERSITY OF MICHIGAN — ANN ARBOR, MICHIGAN
COMPOSITE SUBSOIL ANALYSIS OF BORINGS NOS. 33, 34 & 35
ST. CLAIR POWER PLANT
THE DETROIT EDISON CO. — BELLE RIVER, MICHIGAN
APPROVED: [signature] — DATE:
PROJECT NO. 01994

TABLE OF DRILL HOLES

Hole No	Location	Depth(ft)	Surface Elevation	Purpose	Type Drilling	Number and Type U.D. Samples Taken	Ground Water Level[1] Depth(ft)	Date
7	N 7,507 E 7,851	143.0	586.6	Observation Well	Rotary Wash, Standard Pen ASTM	None	10.0	4-25-74
8	N 7,495 E 8,304	165.1	586.5	Original Proposed Plant Area	Rotary Wash, Standard Pen ASTM, NX Core	None		
9	N 8,576 E 9,361	144.0	586.7	Proposed Plant Area	Rotary Wash, Standard Pen ASTM	None		
10	N 8,600 E 9,965	155.5	586.1	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, NX Core	None		
11	N 8,316 E 8,715	150.0	586.7	Proposed Plant Area	Rotary Wash, Standard Pen ASTM	None		
12	N 7,884 E 9,005	174.2	586.8	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, NX Core	Shelby 9		
13	N 8,321 E 9,336	144.0	586.5	Proposed Plant Area	Rotary Wash, Standard Pen ASTM	None		
14	N 8,306 E 9,627	145.0	586.6	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, Shelby, Osterberg	Shelby 11 Osterberg 3		
15	N 8,320 E 9,786	142.0	586.2	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, Shelby, Osterberg	Shelby 6 Osterberg 6		
16	N 7,996 E 8,712	143.8	586.0	Proposed Plant Area	Rotary Wash, Standard Pen ASTM	None		
17	N 8,000 E 9,004	183.3	585.9	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 6		

NOTE: Borings 1-6 not drilled.

Hole No	Location	Depth(ft)	Surface Elevation	Purpose	Type Drilling	Number and Type U.D. Samples Taken	Ground Water Level[1] Depth(ft)	Date
27	N 7,719 E 9,205	187.5	586.2	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 15		
28	N 7,724 E 9,443	193.5	585.8	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 10		
29	N 7,685 E 8,724	169.0	585.8	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, NX Core	None		
30	N 7,673 E 9,015	135.0	586.4	Proposed Plant Area	Rotary Wash, Standard Pen ASTM	None		
31	N 7,669 E 9,331	143.4	585.9	Proposed Plant Area	Rotary Wash, Standard Pen ASTM	None		
32	N 7,663 E 9,659	144.5	586.6	Proposed Plant Area	Rotary Wash, Standard Pen ASTM	None		
33	N 7,400 E 9,322	138.5	585.6	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, Shelby	Shelby 13		
34	N 7,398 E 9,963	158.17	586.0	Proposed Plant Area	Rotary Wash, Standard Pen ASTM, NX Core	None		
37	N 9,006 E 11,987	133.0	588.0	Original Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM	None		
38	N 9,007 E 13,035	153.0	598.3	Original Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 11		

NOTE: Borings 35&36 not drilled.

Hole No	Location	Depth(ft)	Surface Elevation	Purpose	Type Drilling	Number and Type U.D. Samples Taken	Ground Water Level[1] Depth(ft)	Date
49	N 3,695 E 12,440	155.0	586.6	Proposed Conveyor System	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 15		
50	N 2,951 E 15,471	153.75	581.8	Proposed Dock Area	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 10		
52	N 2,375 E 15,271	158.5	582.1	Proposed Dock Area	Rotary Wash, Standard Pen ASTM, Shelby, Osterberg, NX Core	Shelby 2 Osterberg 11		
53	N 2,052 E 15,176	154.91	580.6	Proposed Dock Area	Rotary Wash, Standard Pen ASTM, Shelby, Osterberg, NX Core	Shelby 8 Osterberg 5		
54	N 2,937 E 15,537	147.67	541.6	Proposed Dock Area	Rotary Wash, Standard Pen ASTM, Shelby, Osterberg, NX Core	Shelby 17 Osterberg 2		
55	N 2,645 E 15,506	100.0	547.9	Proposed Dock Area	Rotary Wash, Standard Pen ASTM	None		
56	N 2,296 E 15,399	102.0	547.5	Proposed Dock Area	Rotary Wash, Standard Pen ASTM	None		
57	N 1,907 E 15,247	120.2	548.3	Proposed Dock Area	Rotary Wash, Standard Pen ASTM, Osterberg, NX Core	Osterberg 1		
58	N 2,725 E 15,224	162.0	583.5	Proposed Dock Area	Rotary Wash, Standard Pen ASTM, NX Core	None		

NOTE: Boring 51 not drilled.

Hole No	Location	Depth(ft)	Surface Elevation	Purpose	Type Drilling	Number and Type U.D. Samples Taken	Ground Water Level[1] Depth(ft)	Date
105	N 4,979 E 10,998	160.3	588.3	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM, Shelby, Pitcher, Osterberg, NX Core	Shelby 4 Pitcher 2 Osterberg 6		
106	N 4,836 E 12,528	140.0	589.7	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM	None		
109	N 6,450 E 13,140	142.7	600.7	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM	None		
110	N 6,570 E 12,830	146.3	599.8	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM, Shelby, Osterberg	Shelby 12 Osterberg 5		
111	N 6,600 E 11,000	140.0	588.5	Original Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM	None		
112	N 6,824 E 8,900	160.5	587.0	Original Proposed Switchyard	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 3		
113	N 6,800 E 9,360	164.3	587.4	Proposed Switchyard	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 3		
114	N 6,980 E 13,360	144.2	599.5	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM	None		
115	N 7,100 E 13,060	144.0	600.7	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM, Shelby	Shelby 14		
116	N 7275.71 E 8897.94	180.5	585.6	Benchmark	Rotary Wash, Standard Pen ASTM, Shelby, NX Core	Shelby 14		

NOTE: Borings 107&108 not drilled.

Hole No	Location	Depth(ft)	Surface Elevation	Purpose	Type Drilling	Number and Type U.D. Samples Taken	Ground Water Level[1] Depth(ft)	Date
128	N 3,000 E 11,000	141.5	589.5	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM	None		
129	N 3,000 E 12,000	158.8	586.0	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM, Pitcher, Osterberg, NX Core	Pitcher 9 Osterberg 3		
130	N 9,014 E 4,993	145.0	595.3	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
131	N 9,400 E 6,000	105.0	589.9	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
134	N 10,050 E 4,995	128.5	594.6	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
135	N 10,050 E 6,000	70.0	591.3	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
136	N 10,050 E 7,000	130.0	590.2	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM, Shelby	Shelby 3		
137	N 10,050 E 8,000	71.0	588.9	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
138	N 10,030 E 8,977	145.0	588.7	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
139	N 10,866 E 4,990	145.5	595.7	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
140	N 10,850 E 6,003	70.5	592.0	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		

NOTE: Borings 132&133 not drilled.

Hole No	Location	Depth(ft)	Surface Elevation	Purpose	Type Drilling	Number and Type U.D. Samples Taken	Ground Water Level[1] Depth(ft)	Date
154	N 13,785 E 8,000	165.0	599.0	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
155	N 14,001 E 5,996	70.0	601.4	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
157	N 14,000 E 8,000	70.0	591.5	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
158	N 14,000 E 9,000	130.0	589.6	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM, Shelby	Shelby 4		
159	N 14,000 E 9,950	70.0	591.3	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
160	N 14,522 E 4,880	159.0	595.5	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
163	N 15,000 E 8,000	138.0	591.4	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
164	N 15,000 E 9,000	70.0	591.4	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
165	N 14,830 E 9,938	156.5	594.3	Proposed Ash Disposal Area	Rotary Wash, Standard Pen ASTM	None		
180	N 2,925 E 12,180	140.0	588.0	Proposed Coal Storage Area	Rotary Wash, Standard Pen ASTM	None		
181	N 3,525 E 12,533	144.0	590.8	Observation Well	Rotary Wash, Standard Pen ASTM	None	10.0	4-25-74

NOTE: Borings 152,153,156,161,162 and 165-179 not drilled.

CONSISTENCY OF COHESIVE & SEMI-COHESIVE SOILS

V. Soft
Almost completely lacks resistance to external forces causing deformation.
Will slump or deform of its own weight.
When squeezed in fist, it will riboon or ooze out between fingers.
Sometimes referred to as "toothpaste" consistency.
Moisture content near or above liquid limit (wet).

Soft
Only slightly resistant to external forces causing deformation.
Will support its own weight.
When squeezed in fist, impression of fingers is marked and soil will squeeze between fingers.
Can be molded to any shape without resistance.
Mositure content well above plastic limit (very moist).

Medium (Plastic)
May be deformed readily without rupture.
When squeezed in fist, impression by fingers will be pronounced but it will not squeeze.
Can be molded to any shape, but offers some resistance--will probably "check" or crack slightly.
Moisture content slightly above plastic limit (moist).

Firm
Moderately resistant to external forces causing rupture.
Lumps or cores can be broken by fingers.
When squeezed in fist, impression by fingers is slight. No tendency to squeeze.
Will rupture and lose structure if molding is attempted from original shape. Once structure is lost, however, it can be molded or "packed."
Moisture content near the plastic limit (damp to moist).

Stiff
Resistant to external forces causing deformation.
Lumps or cores can be broken by fingers.
When squeezed in fist, or pressed by thumb, indentation by fingers is only slight regardless of pressure applied.
Cannot be molded from original shape.
Moisture content near the shrinkage limit (damp).

Hard
Very resistant to external forces causing deformation.
Lumps or cores can be broken by fingers, but with difficulty.
Cannot be indented by fingers or thumb, but can be scored readily by fingernail.
Moisture content below the shrinkage limit (dry).

V. Hard
Extremely resistant to external forces causing deformation.
Lumps or cores cannot be broken by fingers.
Cannot be indented by fingers or thumb; can be scored only slightly by fingernail.
Moisture content below the shrinkage limit (dry).

CONSISTENCY OF GRANULAR SOILS (by standard penetration index)

V. Loose	-- 0-4 blows
Loose	-- 5-10 blows
Medium Compact	-- 11-25 blows
Compact	-- 26-50 blows
V. Compact	-- 50+ blows

LOCATION: N 7,495 E 8,304

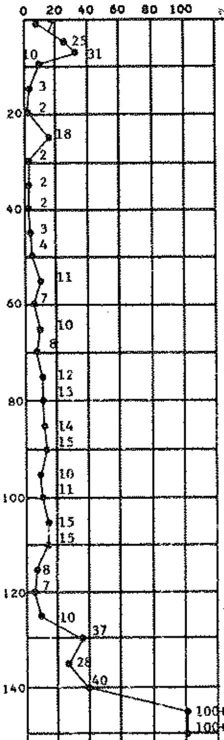
GROUND ELEVATION 586.5

DATE DRILLED: 11-26-73 12-3-73

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	% CORE RECOVERY	SYMBOL	DESCRIPTION
0 500 1000 1500 2000	0 10 20 30 40 50 60 70 80	40 50 60 70 80 90 100 110		NO UNDISTURBED SAMPLES TAKEN	0 20 40 60 80 100	74		

DEPTH IN FEET. 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340



DESCRIPTION

- black clayey Topsoil (OH)
- med. mottled brown & gray, silty Clay (CL) trace of sand
- stiff to hard, gray, silty, some sand and gravel
- stiff, gray, silty, trace of sand, few pebbles
- very soft to soft, gray, silty, trace of fine sand
- med., gray, silty, some sand & pebbles
- soft, gray, silty, trace of sand & gravel
- fine silty Sand (SC) & seams of med. gray silty clay
- compact, gray, clayey silty Sand (SM-SC)
- compact, gray, silty fine Sand (SM)
- same, some gravel & clay
- 15 gallon water loss at 145.5 & 150.5ft
- compact, gray, sandy Gravel (GC) some clay
- 154.0 - 165.1ft Shale, dark gray, soft

Bottom of Hole-Elevation-421.4
-Depth-165.1ft

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite slurry in soil and cement in rock.

SOIL BORING NO. 8

BECHTEL Belle River

LOCATION: N 8,600 E 9,965

GROUND ELEVATION: 586.1

DATE DRILLED: 11-9-73

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

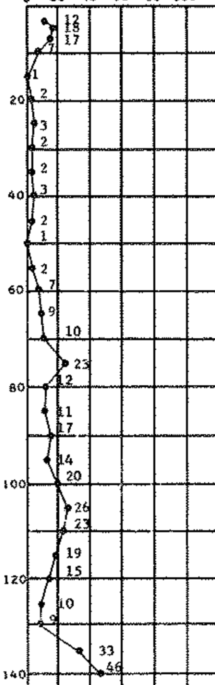
MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER: NO UNDISTURBED SAMPLES TAKEN

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100



% CORE RECOVERY: 90, 99

SYMBOL

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

DESCRIPTION

- black, clayey Topsoil (OH) some roots
- firm to stiff, mottled brown & gray, Clay (CL) streaks of sand & gravel
- firm, silty brown
- soft to plastic, gray silty Clay (CH)
- very soft
- soft, trace of fine sand
- plastic
- plastic to firm, trace of very fine sand
- soft
- soft to plastic, some silty & very fine sand parting

Dark gray, silty Clay (CL-ML) low plasticity

141.3-155.5ft Shale, black, slightly micaceous, abundent clay seams, 153.0-154.0ft contorted bedding.

Bottom of Hole-Elevation-430.6
-Depth-155.5ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite and natural soil in soil and cement in rock.

SOIL BORING NO. 10

BECHTEL

Belle River

LOCATION: N 7,884 E 9,005

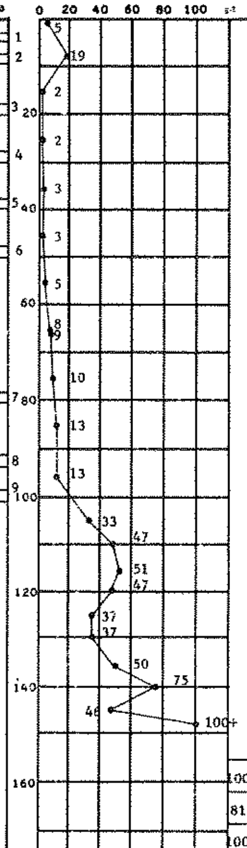
GROUND ELEVATION 586.8

DATE DRILLED: 2-11-74 2-18-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	CORE RECOVERY	SYMBOL	DESCRIPTION

Sample type: SHELBY TUBES (samples 1–9)



DESCRIPTION

- bottom ash, fill
- clayey topsoil
- soft, brown, silty Clay (CL), trace fine sand
- stiff, some fine sand
- very soft to soft, gray, silty Clay (CH)
- plastic, gray, silty Clay (CL) some fine sand
- fairly compact, gray, very fine sandy Silt (SM)
- compact, gray, fine Sand (SP)
- trace gas at 118.0ft
- compact, fine to medium, gray Sand (SW) trace coarse sand
- compact, gray, gravelly, medium Sand(SW) pieces broken Shale
- 146.0 - 174.2ft Shale, dark gray to gray, soft to moderately firm, fractured, horizontal bedding, scattered silty seams
  - 154.2 - 154.9 light gray silty seam
  - 154.9 - 155.5 gray, silty clay seam
  - 160.5 - 162.2 local bedding dips 20°

Bottom of Hole-Elevation-412.6
-Depth-174.2ft

Water loss of 20 gallons in sand.

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite and natural soil in soil and cement grout in rock.

DEPTH IN FEET

SOIL BORING NO. 12

BECHTEL Belle River

DUNN 10-72

LOCATION: N 8,306 E 9,627

GROUND ELEVATION: 586.6

DATE DRILLED: 1-28-74 1-31-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120

SYMBOL

DEPTH IN FEET

OSTERBERGS | SHELBY TUBES

Sample No.	Blows per foot	Description
	7	cinders, Topsoil
2	18	plastic, brown & gray, silty Clay (CL) some topsoil
4		firm, brown, some fine sand
6	2	very soft to soft, gray, silty Clay (CH)
8	2	
10	4	
12	5	
14	6	
	13	plastic, gray, silty Clay (CL) some fine sand
16	17	
18	19	
20	17	
22		medium compact, gray, clayey Sand (SC)
	28	plastic, gray, silty Clay (CL), few sand lenses or pockets
24	31	plastic to firm, some very fine sand
26	18	soft, trace fine sand
28	19	compact, gray, fine Sand (SP)
	49	firm, gray, clayey Silt (ML)
	65	144.5 - 145.0ft Shale, gray, soft

Bottom of Hole-Elevation-441.6
-Depth-145.0ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite and natural soil.

SOIL BORING NO. 14

BECHTEL Belle River

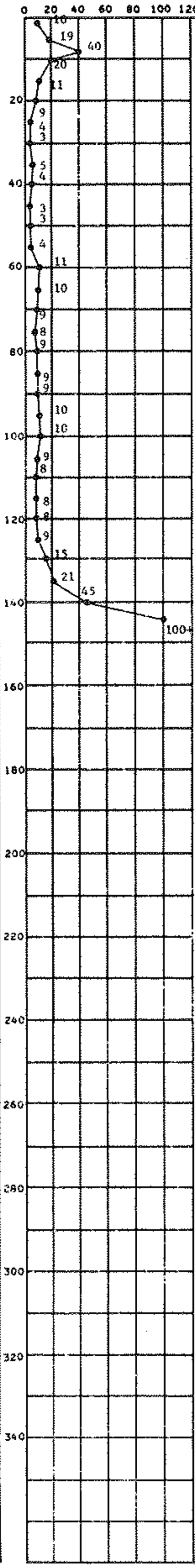
LOCATION: N 7,996 / E 8,712 GROUND ELEVATION 586.0

DATE DRILLED: 2-12-74 / 2-14-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	SYMBOL	DESCRIPTION
0 500 1000 1500 2000	0 10 20 30 40 50 60 70 80	40 50 60 70 80 90 100 110		NO UNDISTURBED SAMPLES TAKEN	0 20 40 60 80 100 120		

DEPTH IN FEET



DESCRIPTION

Cinders, bottom ash

Firm, brown & gray, silty clay (CL) some fine sand

Stiff, brown

Plastic, gray, trace fine sand

Very soft to soft, gray, silty clay (CH)

Plastic, gray, silty clay (CL) some fine sand

Medium compact, gray, clayey silt (ML)

Compact, gray, very fine sand (SP)

Compact, gray, silt (ML) some fine sand

Compact, gray, very fine to medium sand (SW)

142.0-143.75 ft. shale, gray, soft

Bottom of hole - Elevation - 442.25
- Depth - 143.75 ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite and natural soil.

SOIL BORING NO. 16

BECHTEL Belle River

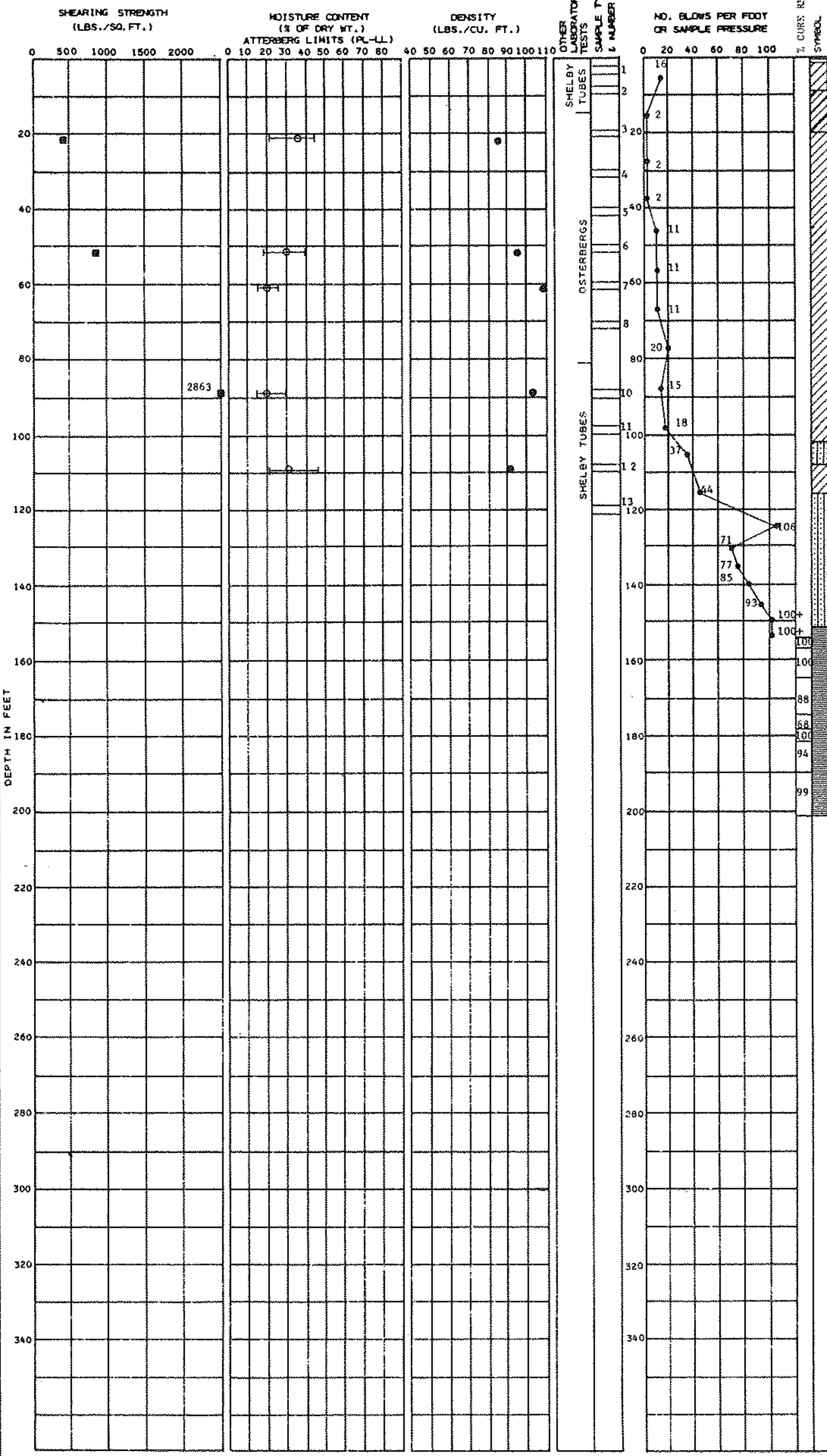
DUNN 10-72

LOCATION: N 8,081 E 9,193

GROUND ELEVATION: 586.0

DATE DRILLED: 1-16-74 / 1-29-74

SHEET 1 OF 1



DESCRIPTION

- fill, cinders
- peaty topsoil
- firm to stiff, brown, silty Clay (CL) trace fine sand
- very soft to soft, gray silty Clay (CH-CL)
- soft to firm, moderate to high plasticity, dark gray, silty Clay (CL) trace fine to coarse sand and gravel
- firm to stiff, moderately plastic, trace fine sand
- 30% fine to coarse sand
- plastic to firm, few pebbles
- very stiff, moderate plasticity, some fine to coarse sand and gravel
- few sand seams
- Silty Sand (SM-SW) fine to coarse sand grains with trace fines
- stiff, moderate to high plasticity, gray, silty Clay (CL) lenses of silty sand (30% of sample)
- 25 gallons water lost at 130ft
- silty Sand (SM) some fine to coarse sand and gravel, little fines
- 152.0 - 201.0ft Shale, gray, horizontal bedding, moist to dry
  - 152.0 - 156.0ft soft, interbedded shale and clay seams
  - 156.0 - 201.0ft firm to very firm, fractured to solid, silty seams
  - 156.0 - 159.8ft Quartz veins

Bottom of Hole-Elevation-385.0
-Depth-201.0ft

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite in soil and cement grout in rock.

■ Unconsolidated Undrained

├─┤ Atterberg Limits

○ Moisture Content

SOIL BORING NO. 18

BECHTEL Belle River

LOCATION: N 8,011 / E 9,337

GROUND ELEVATION: 586.5

DATE DRILLED: 1-17-74 / 1-23-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

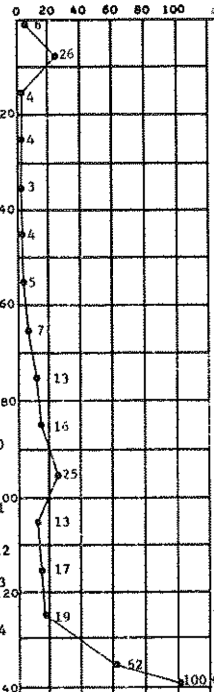
SAMPLE TYPE & NUMBER: SHELBY TUBES, 1–14

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100

% CORE RECOVERY: 25, 96, 90

SYMBOL

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



DESCRIPTION

- bottom ash fill
- Topsoil
- plastic, brown, silty Clay (CL), trace sand
- firm, brown & gray
- very soft to soft, gray, silty Clay(CH)
- plastic to firm, gray, silty Clay (CL) some fine sand, trace pebbles
- firm, few pebbles
- plastic, trace fine sand
- medium compact, fine sandy Silt (ML), trace clay
- medium compact, very fine Sand (SP), trace silt, trace gas at 136.0ft
- 136.5 - 145.8ft Shale, gray, soft, disintegrated, moist, silty
- 145.8 - 147.9ft Sand gray, fine to medium grain, clayey
- 147.0 - 164.3ft Shale, gray, firm, fractured, horizontal bedding, dry 147.0 - 152.8ft soft, fractured to disintegrated

Bottom of Hole-Elevation-422.2 -Depth-164.3ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite and natural soil in soil and cement grout in rock.

SOIL BORING NO. 20

BECHTEL Belle River

LOCATION: N.8,002 E.9,943

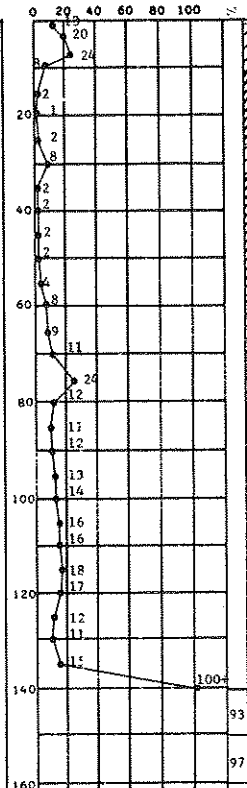
GROUND ELEVATION 585.9

DATE DRILLED: 11-20-73

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) | MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) | DENSITY (LBS./CU. FT.) | OTHER LABORATORY TESTS | SAMPLE TYPE & NUMBER | NO. BLOWS PER FOOT OR SAMPLE PRESSURE | SYMBOL | DESCRIPTION

NO UNDISTURBED SAMPLES TAKEN



DESCRIPTION

Depth (ft)	Description
	black clayey Topsoil (OH)
	firm to stiff, mottled brown, silty Clay (CL) trace of sand.
	plastic, gray, silty, some fine sand
	very soft gray silty Clay (CH)
	plastic, dark gray sandy Clay (CL) some pebbles.
	soft, gray silty Clay (CH)
	soft to plastic gray silty Clay (CL) some fine sand
	med., gray, silty some sand & gravel
	med., gray, silty trace of sand, a few pebbles
	med. gray silty Clay (CH)
	Slight to low plasticity, dark gray, clayey Silt (CL-ML)
	138.5-160.5ft Shale, black, slightly micaceous, highly weathered to a depth of 140.75ft, crumbles easily.

Bottom of Hole-Elevation-425.4
-Depth-160.5ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite slurry in soil and cement grout in rock

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

SOIL BORING NO. 22

BECHTEL Belle River

LOCATION: N 7,904 E 9,436

GROUND ELEVATION: 586.3

DATE DRILLED: 1-30-74 2-5-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

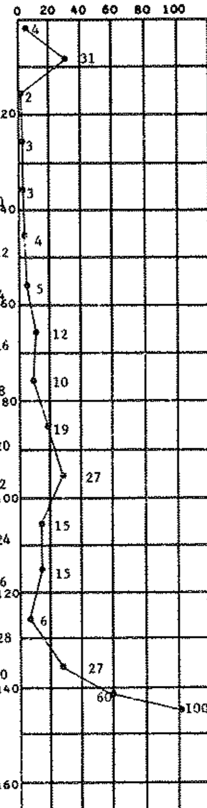
DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30 — SHELBY TUBES

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100



% CORE RECOVERY: 100, 100

SYMBOL

DESCRIPTION

cinders

sand, topsoil

soft, brown & gray, silty Clay (CL) trace very fine sand

stiff, brown, trace fine sand

very soft to soft, gray, silty Clay (CH)

▽ 4-25-74: Elevation of water-566.7
Depth of water-19.6 ft.

plastic, gray, silty Clay (CL) some fine sand

— firm

— soft to plastic

fairly compact, gray, clayey Silt (ML)

plastic, gray, silty Clay (CL) trace very fine sand

compact, gray Silt (ML) some very fine sand

142.0 - 164.0ft Shale, medium to dark gray, soft, disintegrated to fractured, horizontal bedding, with Quartz veins from 145.2 to 147.7, more firm below 154.0ft

Bottom of Hole-Elevation-422.3
-Depth-164.0ft

Piezometer Installation:
cement backfill from 164.0' to 139.0', 5.0' of sludge pipe with bentonite around sludge pipe from 139.0' to 134.0', 4.0' of #80 Screen from 134.0' to 130.0' with sand pack around screen, 134.41' of 2" PVC from 130.0' to 4.41' above surface, backfill with bentonite around casing from 130.0' to ground surface.

For Water Table information consult Section 4.1.3.

SOIL BORING NO. 24

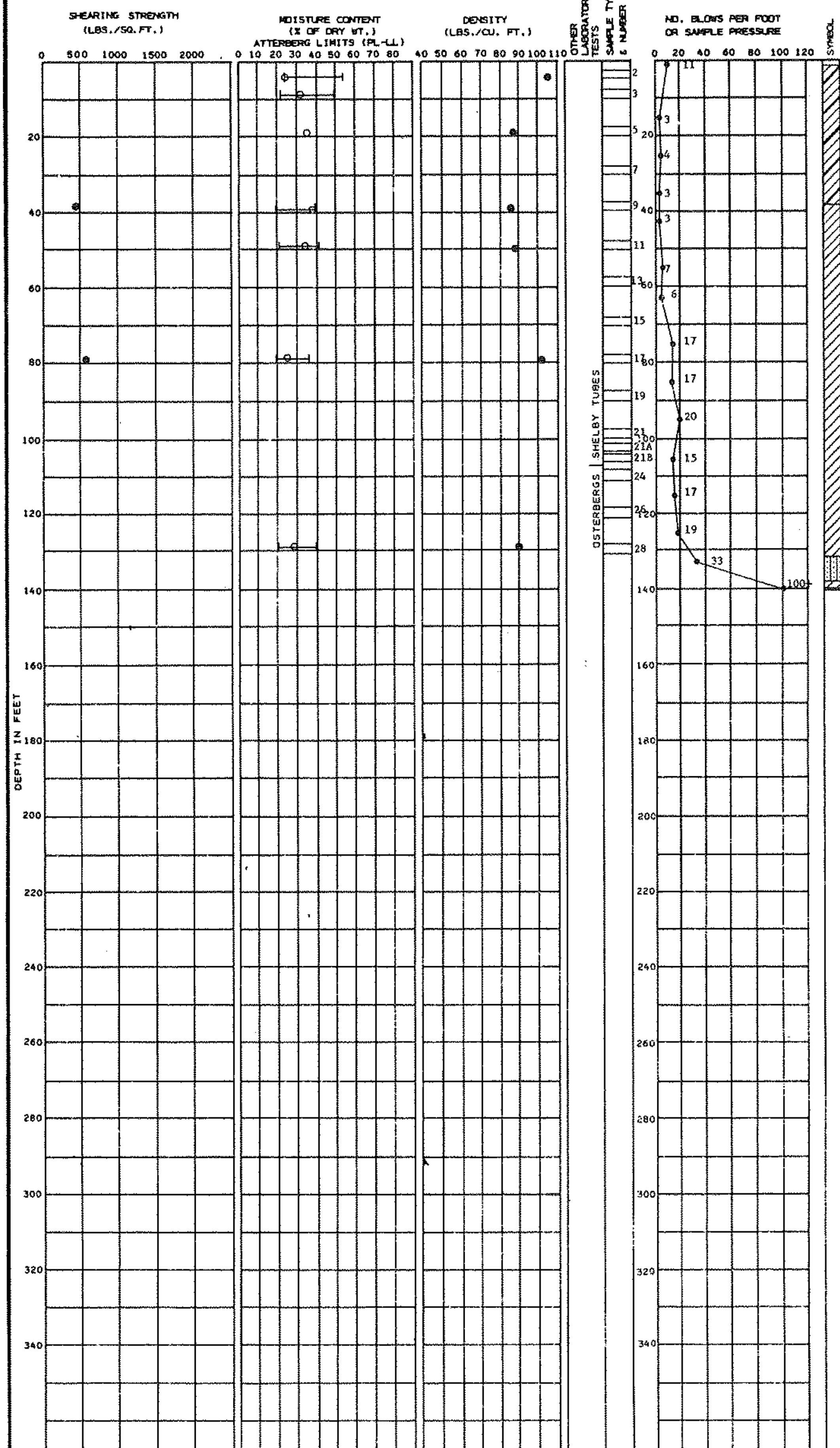
BECHTEL Belle River

LOCATION: N 7,890 E 9,763

GROUND ELEVATION: 585.6

DATE DRILLED: 12-12-73 / 12-19-73

SHEET 1 OF 1



DESCRIPTION

- black sandy topsoil
- very stiff, moderate to high plasticity brown, silty Clay (CL-CH) some fine to coarse sand and fine gravel
- firm, gray
- 15% fine gravel and coarse sand
- Soft to firm, highly plastic, gray, silty Clay (CL)
- 20% fine to coarse sand
- firm to stiff, medium plasticity, 35% sand and gravel
- 30-40% fine sand & silt in thin layers
- compact, gray, silty Sand (SM-SC) some clay
- hard, gray Clay (CL) with shale, crumbles easily (Hardpan)
- 140.0-140.5 ft. Shale, soft, gray

Bottom of Hole - Elevation - 444.6
- Depth - 141.0 ft.

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite

● Unconfined Compression

├──┤ Atterberg Limits

O Moisture Content

SOIL BORING NO. 26

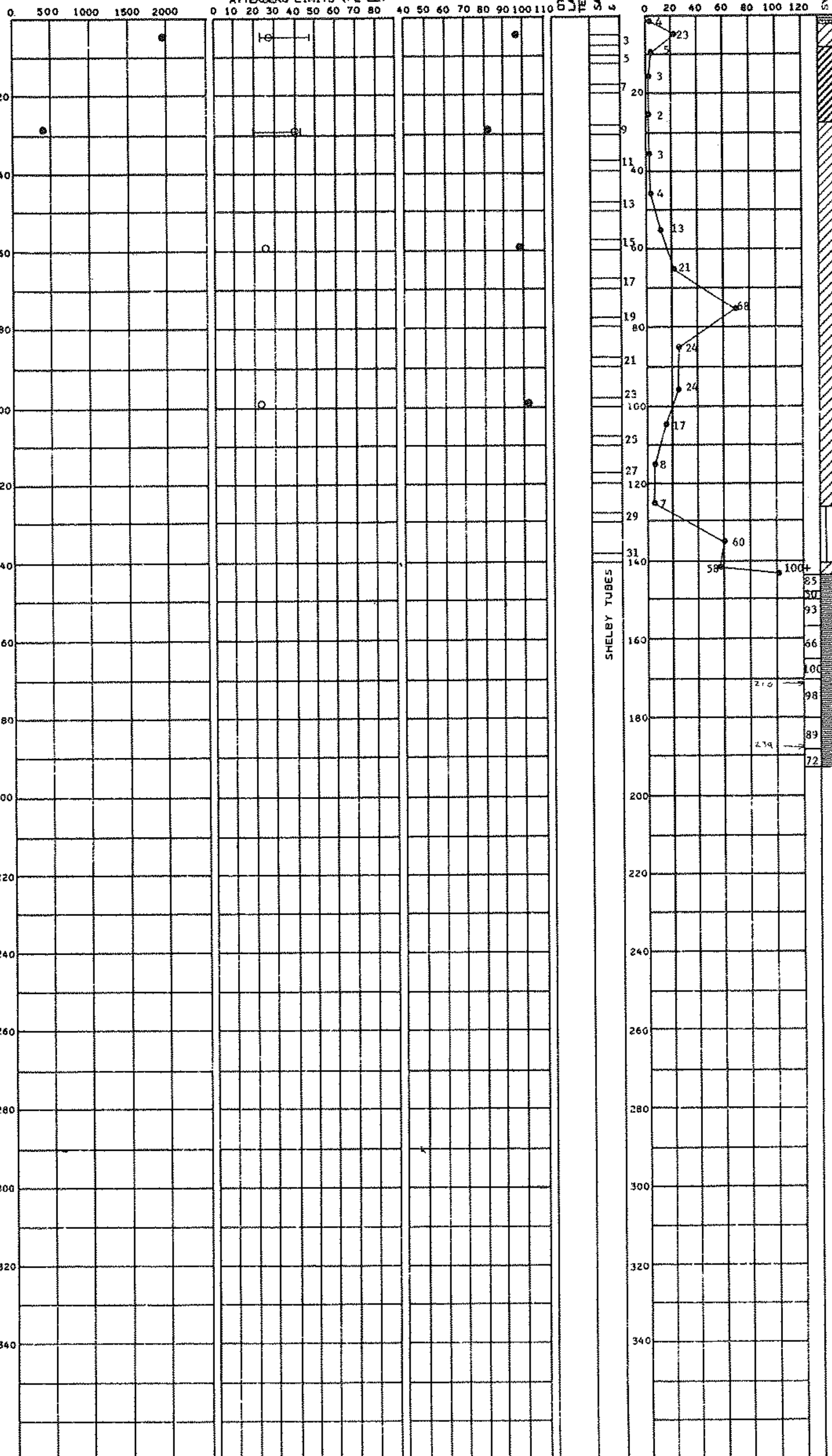
BECHTEL Belle River

LOCATION: N 7,724 E 9,443 GROUND ELEVATION 585.8

DATE DRILLED: 1-15-74 1-22-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) | MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) | DENSITY (LBS./CU.FT.) | OTHER LABORATORY TESTS | SAMPLE TYPE & NUMBER | NO. BLOWS PER FOOT OR SAMPLE PRESSURE | SYMBOL



DESCRIPTION

- cinders fill
- black sandy Topsoil
- brown, silty, fine Sand (SM)
- medium to stiff, brown & gray, silty Clay (CL) medium to high plasticity
- stiff
- soft, gray, silty Clay (CH)
- soft, medium to high plasticity, gray silty Clay (CL)
- medium to stiff, medium plasticity, 15% fine to coarse sand
- very stiff, gray, silty fine sandy, with seams of fine sand, trace pebbles
- plastic to firm, gray silty, trace of fine sand
- stiff, 15% fine to coarse sand, medium to high plasticity
- med. compact, clayey Silt (ML), trace of fine sand
- hard, very sandy Clay (CL) some pebbles, some decomposed Shale (Hardpan)
- 143.8 - 193.5ft Shale, gray, soft to firm, disintegrated to fractured, moist to dry, horizontal bedding

Bottom of Hole-Elevation-392.3 -Depth-193.5ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and natural soil in soil and cement grout in rock.

● Unconfined Compression

⊢—⊣ Atterberg Limits
O Moisture Content

SOIL BORING NO. 28

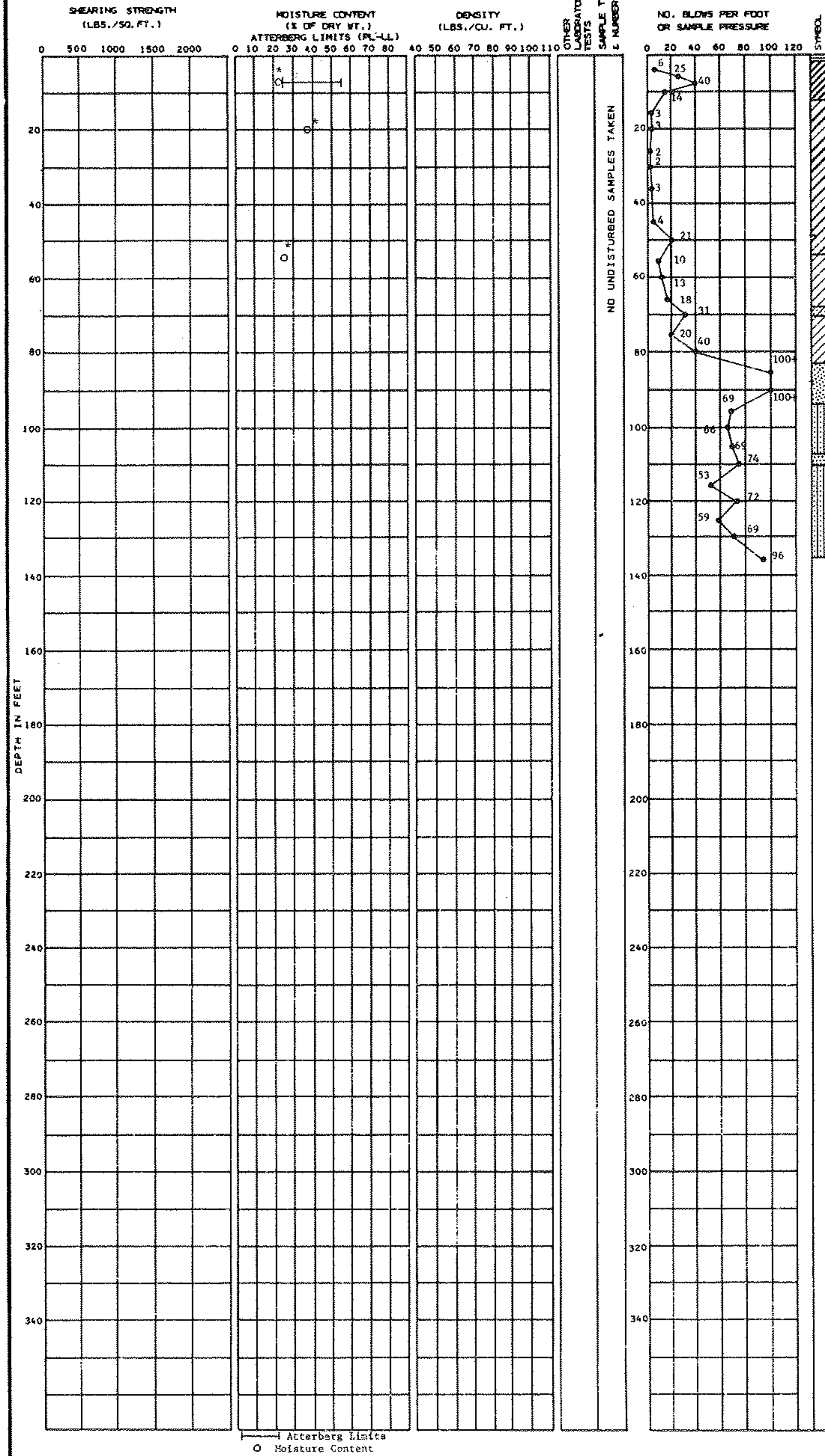
BECHTEL Belle River

LOCATION: N 7,673 E 9,015

GROUND ELEVATION 586.4

DATE DRILLED: 2-7-74 2-11-74

SHEET 1 OF 1



DESCRIPTION

- Cinders, fill
- Sandy topsoil
- Soft, brown & gray, silty Clay (CH) trace fine sand, high plasticity
- Stiff, brown, some fine sand
- Very soft to soft, gray, silty Clay (CH-CL)
- Firm, gray, sandy clay layer
- Gray, silty Clay (CL) medium plasticity, 20% fine to coarse sand
- Stiff, dark, gray clayey sand (SC)
- Firm to stiff, gray, silty clay (CL), silt lenses
- Hard, some fine sand
- Compact, gray, fine sani (SP)
- silty fine sand (SM) 15% nonplastic fines
- Compact, gray, very fine to coarse sand (SW)
- Silty sand (SM) 15% nonplastic fines

Bottom of hole - Elevation - 451.4
- Depth - 135.0 ft

This hole stopped at 135.0 ft. due to gas.

With casing at 110.0' no gas. Casin pulled to 57.0'. No gas. Pulled to 50.0', gas bubbling in hole. Capped hole and left for 48 hours. After 48 hours no gas (pocket only)

2-8-74 No gas
2-11-74 Gas
2-11-74 Pulled to 50.0', capped
2-11-74 1400 hours removed cap (no gas)

82.5' - 107.0' used Gel to keep open

For Water Table information consult Section 4.1.3.

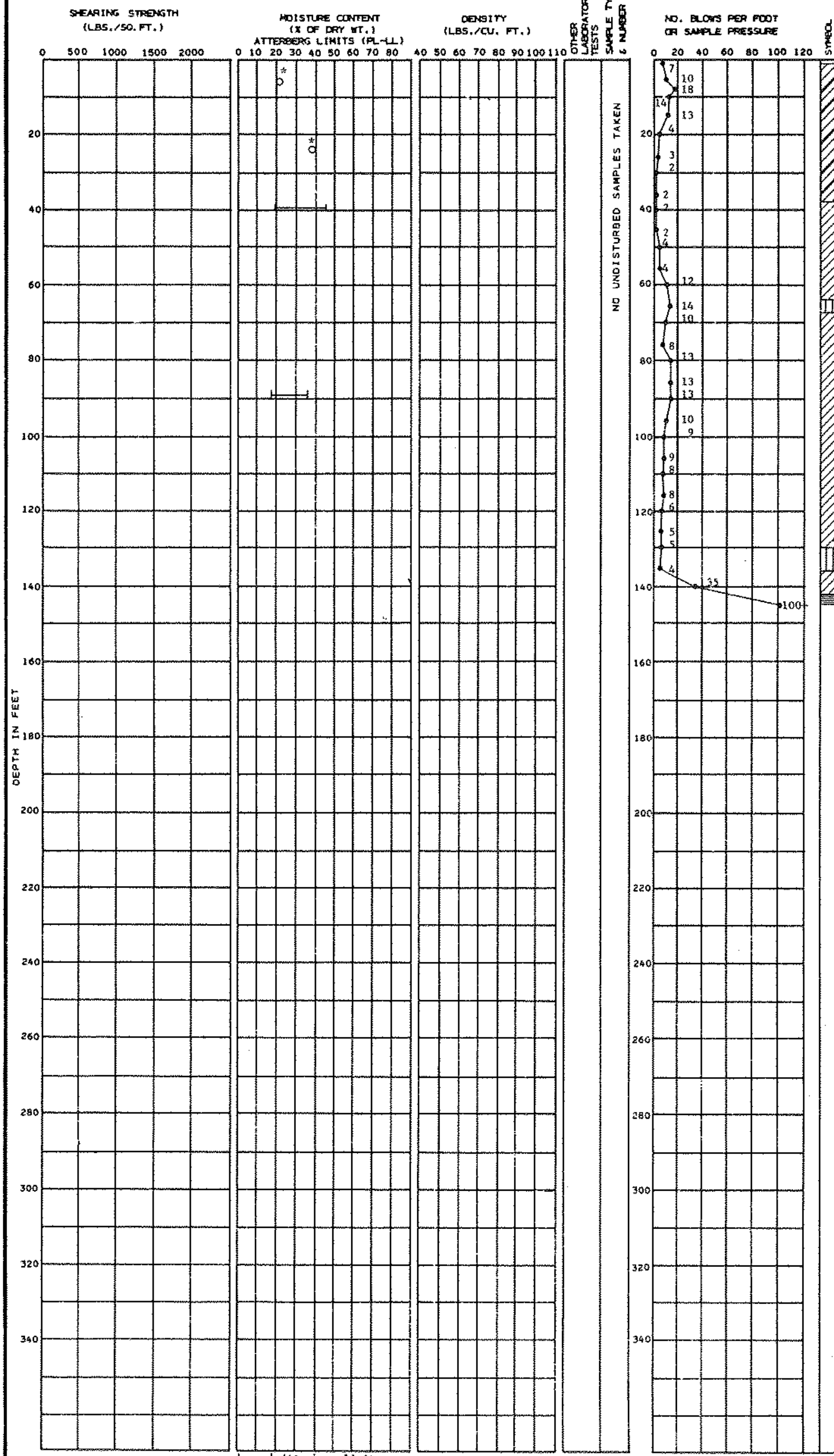
Hole backfilled with Quik-Gel in soil

SOIL BORING NO. 30

BECHTEL Belle River

LOCATION: N 7,663 E 9,659   GROUND ELEVATION 586.6   DATE DRILLED: 2-6-74 2-12-74

SHEET 1 OF 1



DESCRIPTION

cinders, fill

medium stiff, brown & gray, silty Clay (CL-CH) highly plastic, trace fine sand

very stiff, brown

plastic, gray, some fine sand

same, sandy

very soft to soft, gray, medium to high plasticity

Gray, silty Clay (CL) medium to high plasticity

plastic, fine sand lenses

medium compact, gray, clayey Silt (ML)

plastic, gray, silty Clay (CL) some fine sand

10% fine to coarse sand

soft, trace fine sand

fairly compact, gray, clayey Silt (ML)

very stiff, gray, silty Clay (CL) sandy, few pebbles

142.0 - 144.5ft Shale, gray, soft

Bottom of Hole-Elevation-442.1
-Depth-144.5ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and natural soil.

|—| Atterberg Limits
O Moisture Content
* Sample Jar Unsealed

SOIL BORING NO. 32

BECHTEL   Belle River

LOCATION: N 7,398 E 9,963

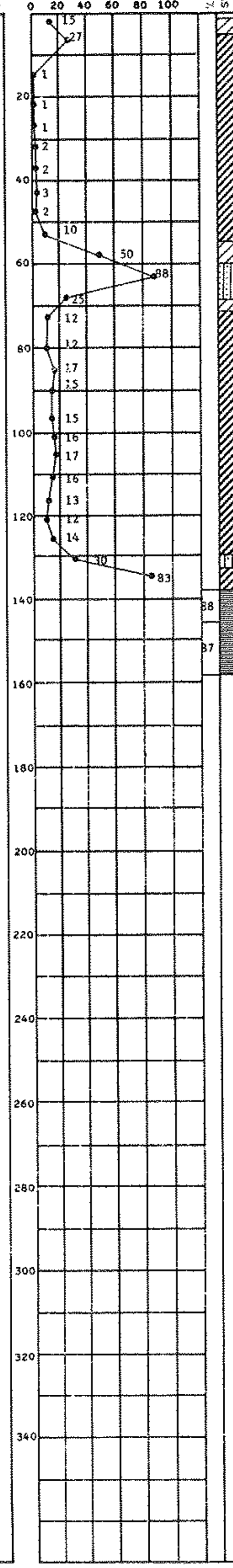
GROUND ELEVATION: 586.0

DATE DRILLED: 11-8-73

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	% CORE RECOVERY	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN				

DEPTH IN FEET



DESCRIPTION

black clayey Topsoil (OH) some sand

firm, gray & brown, silty Clay (CL) trace of sand

firm, gray, silty Clay (CH) very soft to soft

firm to stiff, gray, fine sandy Clay (CL) silt seams

compact, gray, medium silty Sand (SM-SC) some silt, trace of clay.

plastic to firm, gray silty Clay (CL) a few sand & silt pockets

soft to plastic, gray, silty Clay(CH) trace of fine sand

medium compact, clayey Silt (ML) some fine sand, trace of pebbles

hard, gray, sandy Clay (CH) trace of shale fragments

137.5-158.2ft Shale, black, slightly micaceous, highly weathered to a depth of 142.5ft, some clay seams.

Bottom of Hole-Elevation-427.83
-Depth-158.17ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel in soil and cement grout in rock.

SOIL BORING NO. 34

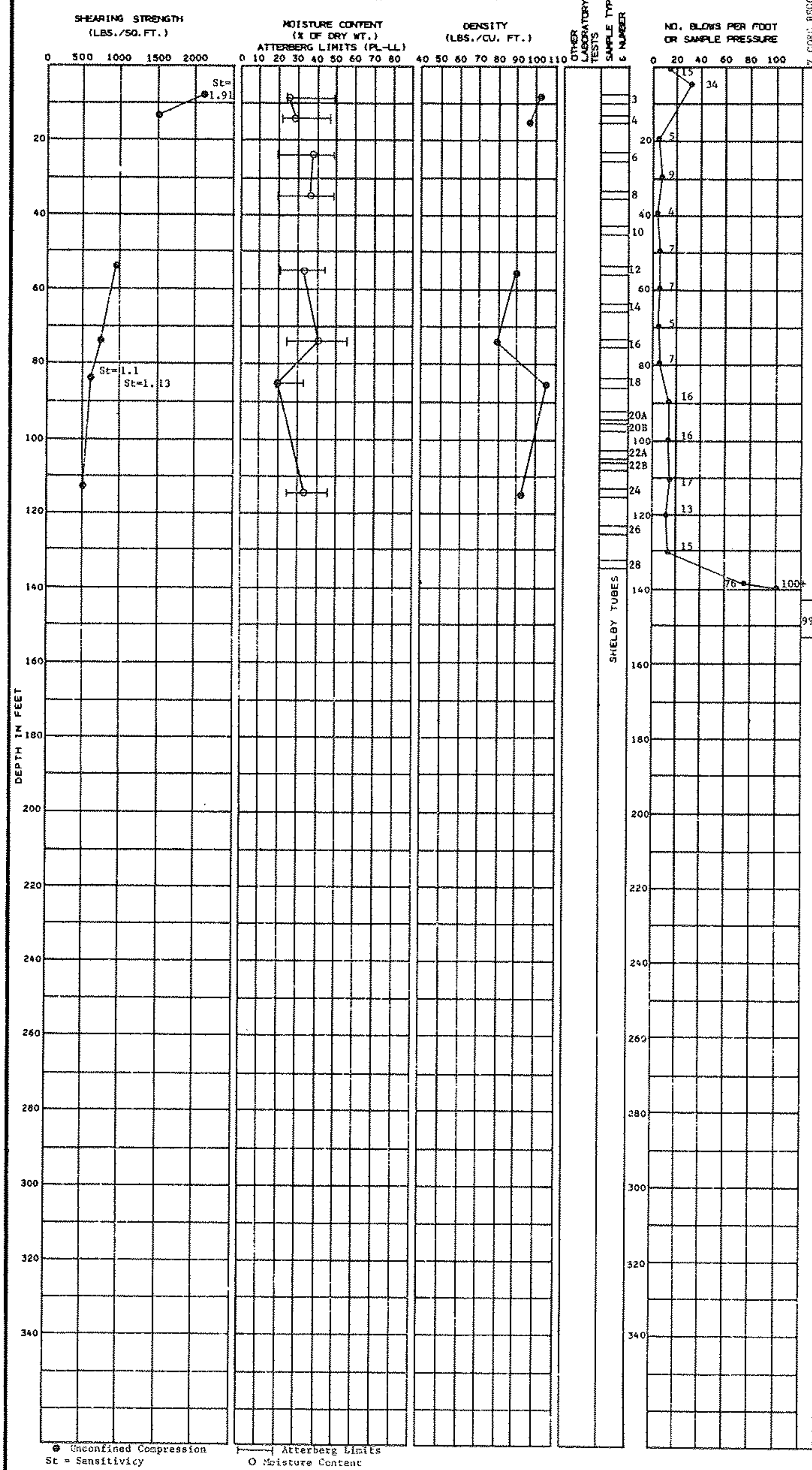
BECHTEL Belle River

LOCATION: N 9,007 E 13,035

GROUND ELEVATION 598.3

DATE DRILLED: 12-6-73 12-12-73

SHEET 1 OF 1



DESCRIPTION

- black sandy Topsoil (OH)
- silty Clay (CL-CH)
  - firm, brown, some sand
  - hard, highly plastic, dark grayish brown mottled, trace sand & fine gravel
  - medium to very stiff
  - soft, gray
  - dark gray, high plastic, (sample greatly disturbed)
  - (sample greatly disturbed)
  - medium, highly plastic
- medium stiff, dark gray, silty Clay (CH) highly plastic
- plastic, gray, silty Clay (CL-CH) trace sand, few pebbles
- stiff, moderate plasticity, dark gray, silty Clay (CL) 10% medium to coarse sand, 15% gravel
  - firm, trace of sand & pebbles
- soft to medium, moderately to highly plastic, gray, silty Clay (CL-CH) trace sand
- compact, gray, fine sandy Silt (ML) some clay
- compact, gray, silty fine Sand (SM) some pebbles, 30% nonplastic fines
- 143.0-153.0ft Shale, black, soft, micaceous, trace of pebbles, crumbles easily

Bottom of Hole-Elevation-445.3
-Depth-153.0ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel in soil and cement grout in rock.

SOIL BORING NO. 38

BECHTEL Belle River

DUNN 10-72*

LOCATION: N 8,003 E10,993

GROUND ELEVATION 589.1

DATE DRILLED: 12-14-73 12-18-73

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

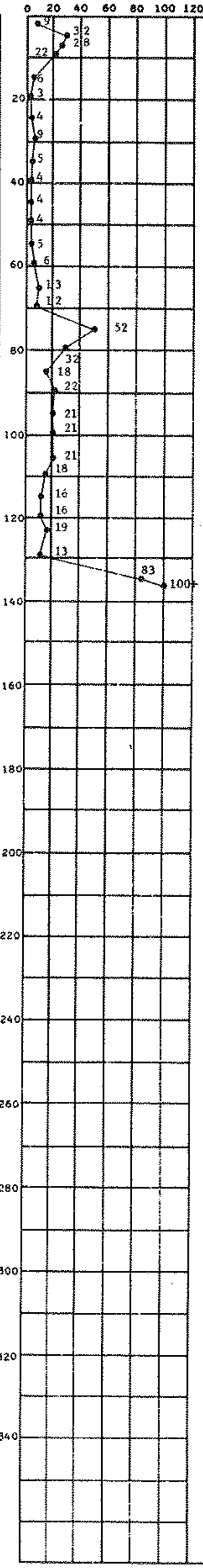
DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER

NO UNDISTURBED SAMPLES TAKEN

NO. BLOWS PER FOOT OR SAMPLE PRESSURE



SYMBOL

DEPTH IN FEET 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

DESCRIPTION

black clayey Topsoil (OH)

med., brown, silty Clay(CL) trace sand

loose, brown, silty Sand (SM) trace pebbles

stiff, brown & gray, silty Clay (CL) trace sand

▽ 4-25-74: Elevation of water-580.8
Depth of water-8.3 ft.

stiff, gray, trace sand

soft

very soft, gray silty Clay (CH)

plastic, gray, silty Clay (CL), trace sand & pebbles

stiff, gray, sandy, silty, some pebbles

med. gray, silty, some fine sand, few pebbles

plastic to firm, gray, silty trace fine sand & pebbles

gray sandy Silt (ML) some clay

hard, gray, silty fine sandy Clay(CL) few pebbles trace shale

135.3-136.6ft Shale, gray, very hard, clayey

Bottom of Hole-Elevation-452.5
-Depth-136.6ft

No gain or loss of water

Piezometer Installation:
4' of 2" PVC Blank Casing from 84' to 80'; 5' #80 screen from 80' to 75', 78.48' of 2" PVC Blank Casing from 75' to 3.48' above ground surface. Sand pack around casing from bottom of hole to 70', bentonite seal around casing at top of sand pack, annulus backfilled with grout to ground surface.

For Water Table information consult Section 4.1.3.

SOIL BORING NO. 40

BECHTEL Belle River

LOCATION: N 8,016 E 12,991

GROUND ELEVATION: 600.2

DATE DRILLED: 11-19-73 11-21-73

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100	% CORE RECOVERY	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN	17, 30, 42, 18			black sandy Topsoil; stiff, brown, silty Clay (CL) trace of fine sand; hard, some gray mottling; plastic to firm, gray, trace of sand, few pebbles
					6, 4, 7, 4			soft, gray, silty Clay (CL-CH); plastic, dark gray, fine sandy silty Clay (CL) some pebbles; very soft, gray, silty Clay (CH)
					4, 2, 3, 3, 3, 4, 5			
					16, 10, 15, 14, 13, 13, 19			plastic, gray, silty Clay (CL) some fine sand; —plastic, trace of sand, some pebbles
					20, 23, 26, 23, 14, 13			—plastic to firm, some fine sand; —soft to plastic
					79	20		med. compact, gray, fine sandy Silt (ML) trace of clay; —stiff, gray, clayey Silt (ML) sand lenses, some pebbles; 145.0-156.0ft Shale, black, soft, some thin laminae of sand
								Bottom of Hole-Elevation-444.2 -Depth-156.0ft

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite slurry in soil and cement grout in rock.

SOIL BORING NO. 42

BECHTEL Belle River

LOCATION: N 7,004 E13,000

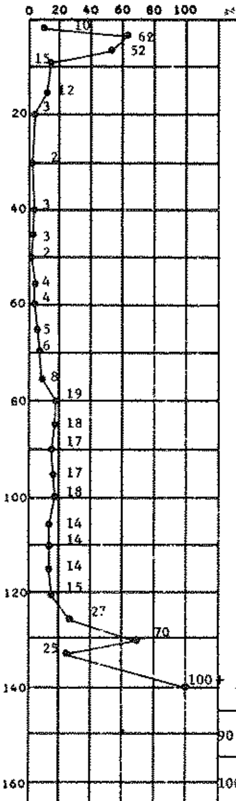
GROUND ELEVATION 600.5

DATE DRILLED: 11-20-73

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	% CORE RECOVERY	SYMBOL	DESCRIPTION
0 500 1000 1500 2000	0 10 20 30 40 50 60 70 80	40 50 60 70 80 90 100 110		NO UNDISTURBED SAMPLES TAKEN	0 20 40 60 80 100			

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



DESCRIPTION:

clayey & sandy Fill

stiff, brown silty Clay (CL) trace of sand

med. brown & gray silty Clay (CL)

soft, gray silty Clay (CH)

med. compact, gray clayey Silt (ML)

compact, gray Silt (ML) some sand

med. to firm gray sandy Clay (CL)

compact, gray clayey Silt (ML)

med. gray silty Clay (CL) some sand

hard, gray sandy Clay (CL) trace of shale (hardpan)

140.0-164.5ft Shale, black, decomposed & weathered, slightly micaceous crumbles easily

Bottom of Hole-Elevation-436.0
-Depth-164.5ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel in soil and cement grout in rock

SOIL BORING NO. 44

BECHTEL Belle River

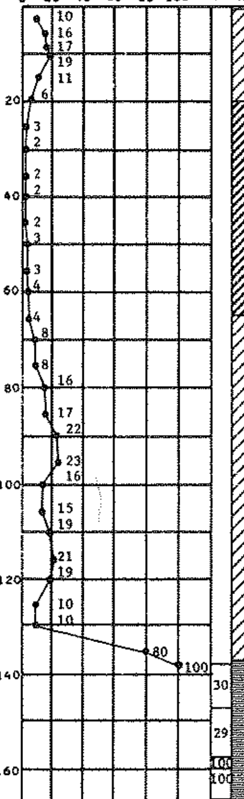
LOCATION: N 5,344 E 12,319

GROUND ELEVATION: 588.2

DATE DRILLED: 1-22-74 / 1-28-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	% CORE RECOVERY	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN				



DESCRIPTION (DEPTH IN FEET)

Topsoil

firm, brown, silty <u>Clay</u> (CL), some gray mottling, trace fine sand

stiff

— plastic, gray, some fine sand

very soft to soft, gray, silty <u>Clay</u> (CH)

plastic, gray, silty <u>Clay</u> (CL) some fine sand

— firm, sandy, trace pebbles

— plastic, some fine sand, few pebbles

— firm, some pebbles

— plastic, trace fine sand

— hard, sandy, shaley, few pebbles

136.5-138.5ft <u>Shale</u>, gray, soft,
137.0-138.5ft brown, silty, fractured
138.5-147.0ft <u>Mudstone</u>, gray, soft, moist, fractured
147.0-165.0ft <u>Shale</u>, dark gray, firm, moist, highly fractured

Bottom of Hole-Elevation-423.2
-Depth-165.0ft

For Water Table information consult Section 4.1.3.

Water loss of 6-8 gal.

Hole backfilled with bentonite in soil and cement grout in rock

SOIL BORING NO. 46-A

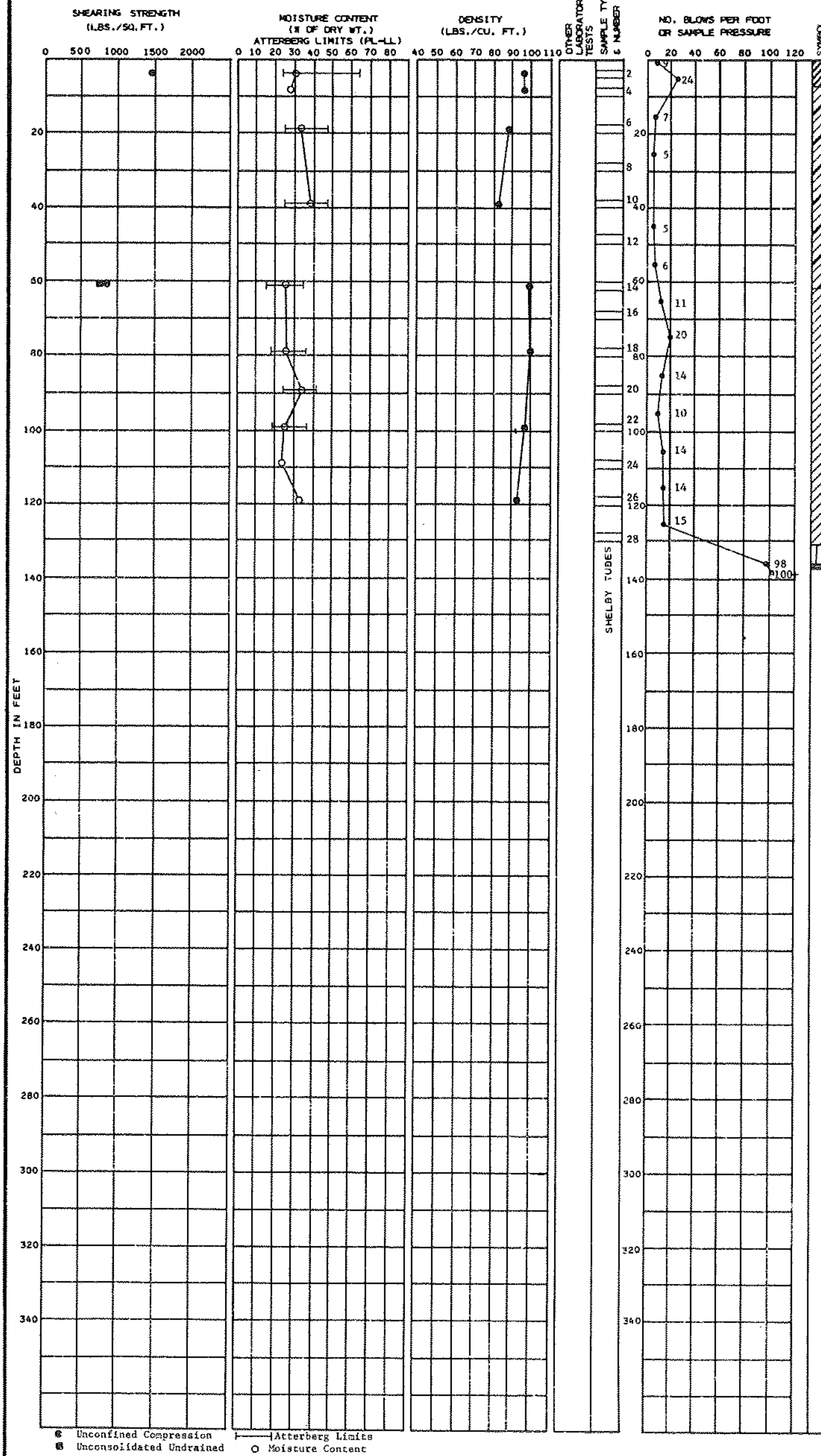
BECHTEL Belle River

LOCATION: N 3,950 E 12,584

GROUND ELEVATION: 587.5

DATE DRILLED: 1-14-74 1-23-74

SHEET 1 OF 1



DESCRIPTION

Stiff to very stiff, brown & gray, silty Clay (CH) trace sand, highly plastic

very stiff, brown, medium to high plasticity, silty Clay (CL-CH)

medium, gray, trace sand

soft to medium

soft, dark to very dark gray

Medium stiff, gray, silty Clay (CL) 35% coarse sand and fine gravel

firm, some fine sand

stiff, dark gray, little coarse sand and fine gravel

little fine sand, few pebbles

medium to stiff, little fine sand

soft to medium, dark gray, 20% fine to coarse sand and gravel

medium to stiff, gray, trace fine to coarse sand

fairly compact, gray, clayey Silt (ML), some fine sand

136.5-137.6ft Shale, gray, soft, clayey

Bottom of Hole-Elevation-449.9
-Depth-137.6ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and natural soil.

SOIL BORING NO. 48

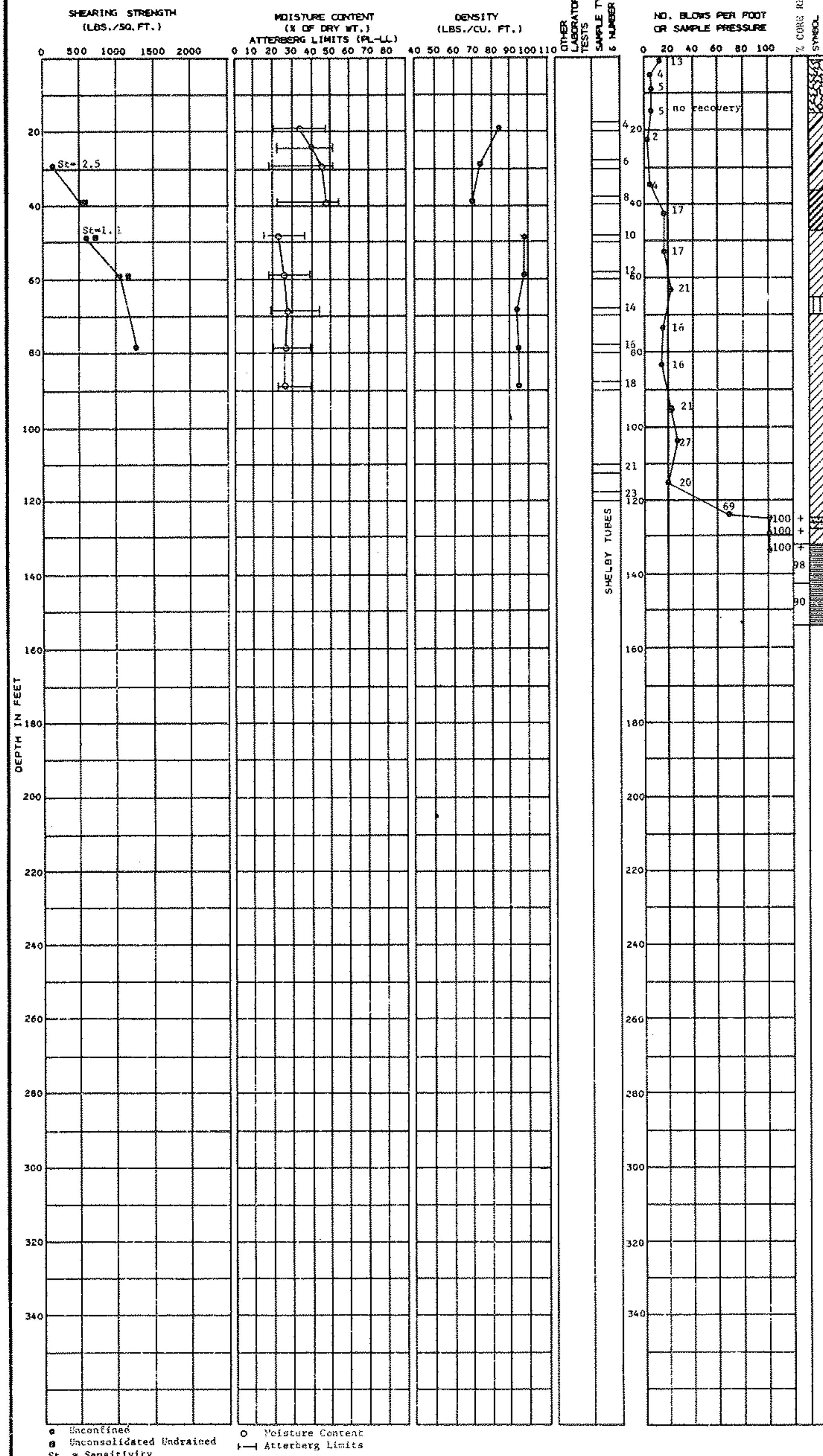
BECHTEL Belle River

LOCATION: N 2,951 E15,471

GROUND ELEVATION 581.8

DATE DRILLED: 12-19-73 1-8-74

SHEET 1 OF 1



DESCRIPTION

- cinders, fly ash Fill
- loose, gray, limestone Fill, some sand
- very soft, gray, silty Clay (CL-CH) top 16-20' possibly disturbed
  - highly plastic
- firm, highly plastic, gray, silty Clay (CH) some sand, trace pebbles
- firm, moderately plastic, gray, sandy, silty Clay (CL) 20 to 25% fine to coarse sand and 10-15% fine gravel
- fairly compact, fine sandy Silt (ML)
- plastic, gray, silty Clay (CL) some fine sand, trace fine gravel
  - 10-15% fine to coarse sand and fine gravel
  - 20-25% fine to coarse sand and 10% fine gravel
  - firm, gray, some fine sand, trace pebbles
  - plastic, gray, trace fine sand
  - hard, gray, very sandy, few pebbles
- compact, very fine Sand (SP) some silt
- very hard, gray, clayey fine Sand (SC)
- very hard, gray, sandy Clay (CL) (hardpan)
- 133.8-153.8ft Shale, gray, firm to soft, extremely fragmented and easily broken

Bottom of Hole-Elevation-428.05
-Depth-153.75ft

For Water Table information consult Section 4.1.3.

Water Level
At completion - 40.5'
Water Level
0800 33.5' 1-7-74

Bailed to 67.0'
1130 hours 67.91'
1400 " 66.33'
1600 " 66.08'
1800 " 65.25'
Water Level
0800 60.08' 1-8-74

Encountered gas at 98.0' while grouting casing at 98.0'. Extra precautions taken while grouting hole (slight pressure).

Hole backfilled with bentonite and natural soil in soil and cement grout in rock

SOIL BORING NO. 50

BECHTEL Belle River

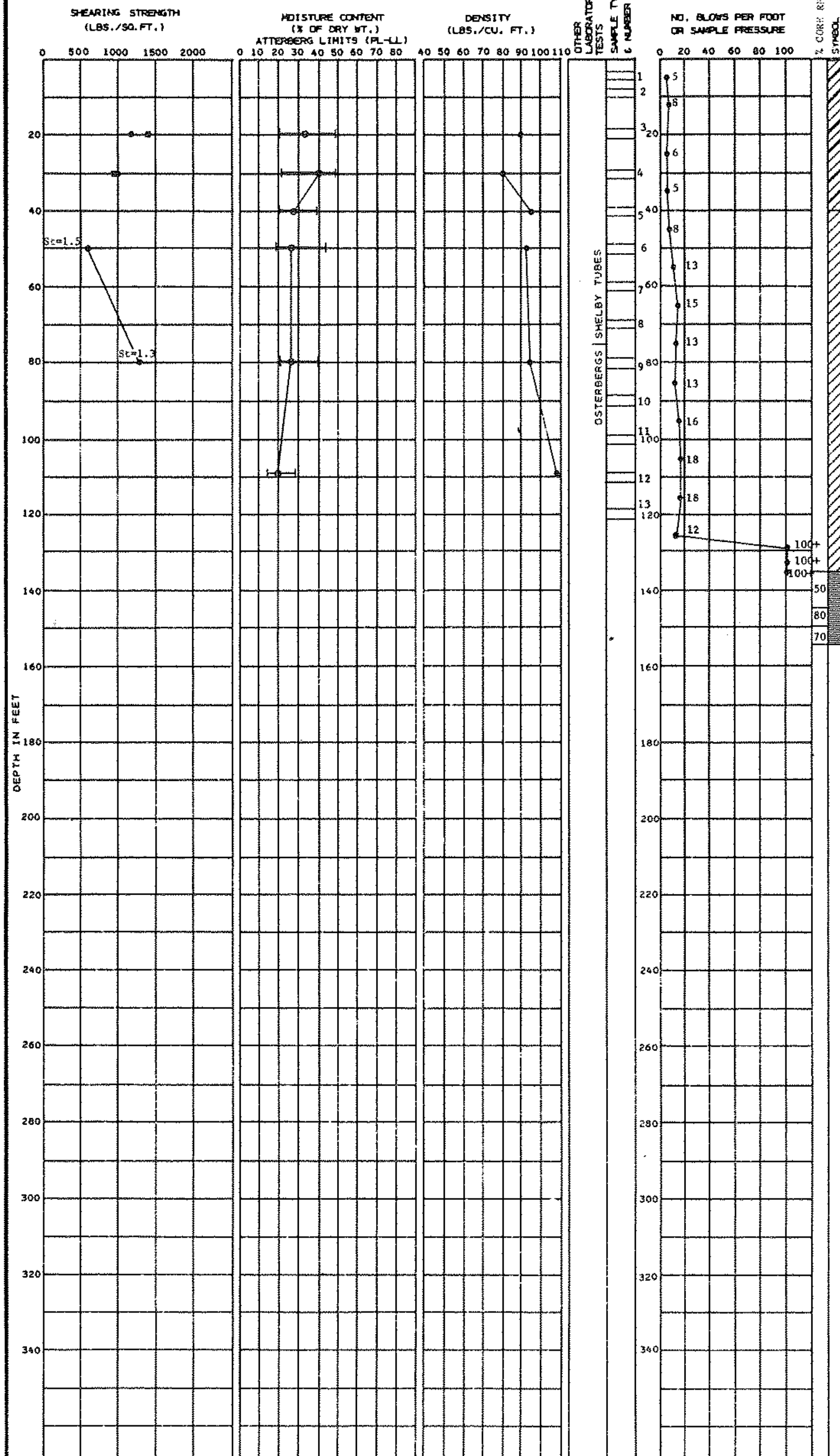
DUHN 10-73

LOCATION: N 2,052 E15,176

GROUND ELEVATION 580.6

DATE DRILLED: 12-21-73 1-7-74

SHEET 1 OF 1



DESCRIPTION

- cinder coal (fill)
- medium, brown, silty Clay (CL-CH) (possible fill)
- soft, brown, some peaty structure (possible fill or river sediments)
- plastic, brown & gray
- trace sand
- plastic, gray, trace sand and pebbles

firm, moderately plastic, gray, silty Clay (CL) 20-30% fine to coarse sand and fine gravel
- 15-20% fine to coarse sand
- 15% fine to coarse sand and fine gravel
- firm, gray, some fine sand, few pebbles
- very hard, gray, some pebbles, seams of fine sand (Hardpan)

135.0-154.9 ft Shale, gray, silty, highly hackly fractured, breaks easily. 137.8-140.3 ft local dip approximatel 30°, firm. 146.5-150.0 ft local dip approximately 30°, firm

Bottom of Hole-Elevation-425.7 -Depth-154.9 ft

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and natural soil in soil and cement grout in rock.

● Unconfined
■ Unconsolidated Undrained
St = Sensitivity

○ Moisture content
├─┤ Atterberg limits

SOIL BORING NO. 53

BECHTEL Belle River

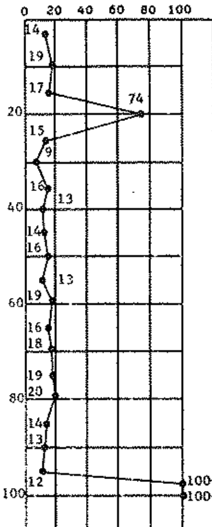
DUNN 10-73

LOCATION: N 2,645 E 15,506

GROUND ELEVATION: 547.9

DATE DRILLED: 3-29-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100	% CORE RECOVERY	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN				

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

DESCRIPTION

medium compact, gray, medium to coarse Sand (SW) coal

firm, brownish gray, silty, sandy Clay (CL) coarse sand seams

very compact, gray Silty Sand (SM) fine

soft, gray, silty Clay (CH)

firm, gray, clayey Silt(ML)

medium, gray, silty Clay (CL) some sand and gravel

— soft, trace sand and gravel

— soft, reddish, silty, sandy clay some gravel

very compact, gray Silty Sand (SM) fine, trace shale

97.5-100.0ft Shale, gray, soft

Bottom of Hole-Elevation-447.9
-Depth-100.0ft

Note: Hole drilled from drilling platform in 30.9ft of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and soil

SOIL BORING NO. 55

BECHTEL Belle River

DUNN 10-72

LOCATION: N 1,907 E 15,249

GROUND ELEVATION 543.3

DATE DRILLED: 3-20-74 3-26-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

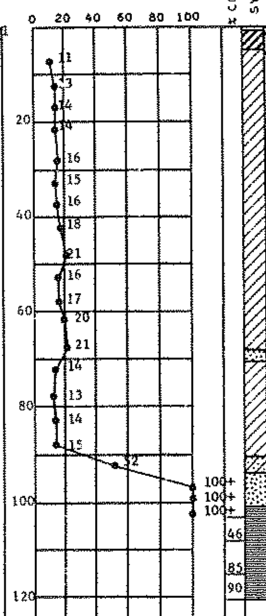
SAMPLE TYPE & NUMBER: OSTERBERG

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100

% CORE RECOVERY

SYMBOL

DEPTH IN FEET



DESCRIPTION

loose, brown, fine to medium sand (SW) and gravel

soft, brownish gray, silty clay (CH) some sand and gravel

medium, gray, silty clay (CL) some sand and gravel

compact, gray, fine sand (SP)

medium, gray, silty clay (CL) little sand

compact, gray, layers of fine sand and clayey sand (SC)

very compact, gray, fine to coarse sand (SW) trace gravel

101.7-120.2 ft. shale, dark gray, soft disintegrated, horizontal bedding in part, moist; fine to coarse, very gravelly & cobbles; firm from 119.9 to 120.2 ft.

Bottom of hole - Elevation - 428.1 - Depth - 120.2 ft.

NOTE: Hole drilled from drilling Platform in 30.7 ft. of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite in soil and cement in rock

SOIL BORING NO. 57

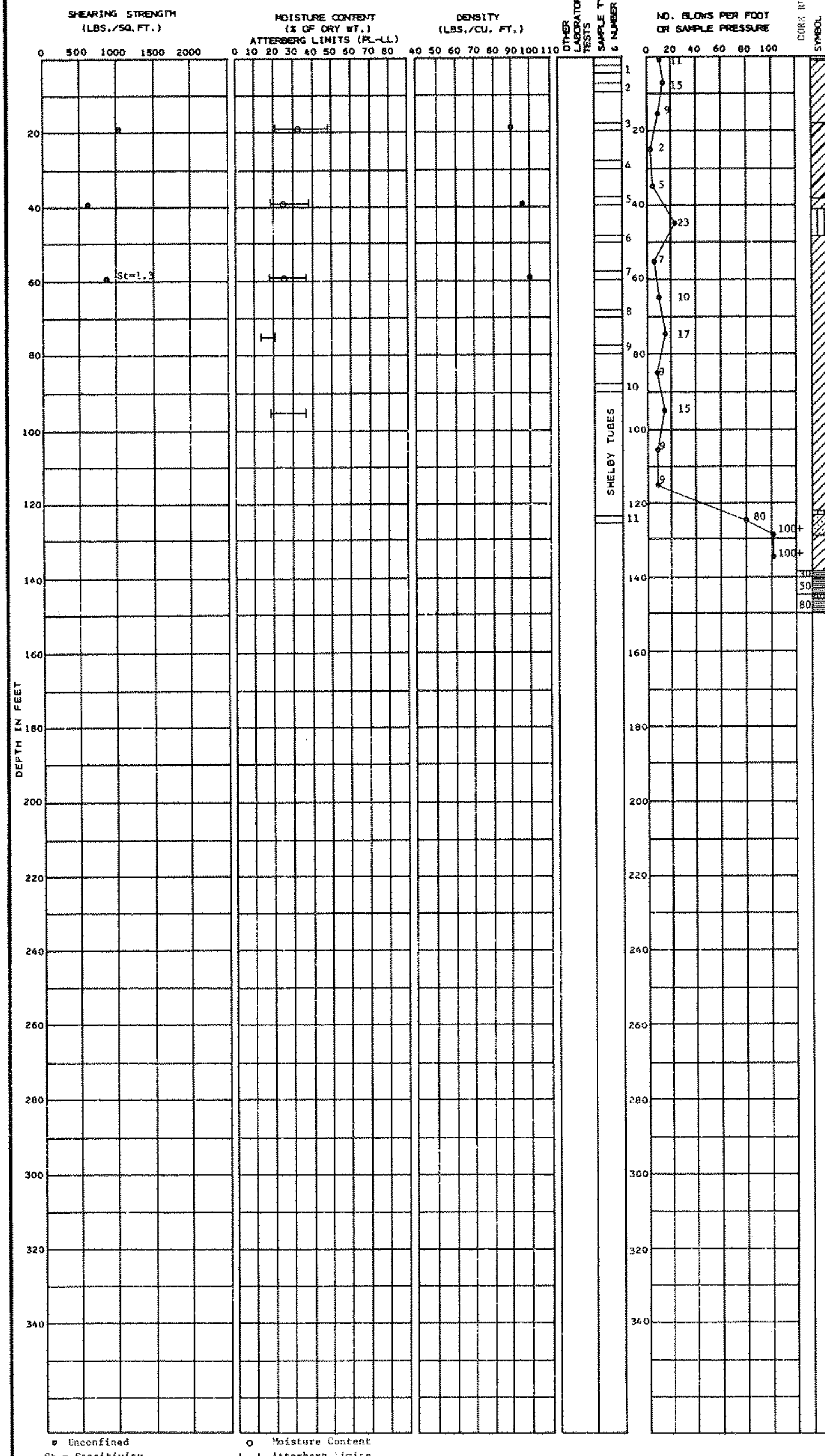
BECHTEL Belle River

LOCATION: N 2393 E15140

GROUND ELEVATION: 582.3

DATE DRILLED: 1-10-74 1-16-74

SHEET 1 OF 1



DESCRIPTION

- bottom ash Fill
- loose, brown, fine Sand (SP)
- plastic, brown & gray, silty Clay (CL) some sand
- plastic to firm, brown, trace fine sand
- soft, moderate to high plasticity, gray, silty Clay (CL-CH) trace fine sand
- firm, moderate plasticity, gray, silty Clay (CL) 20-25% fine to coarse sand and fine gravel
- compact, gray, fine sandy Silt (ML) trace clay
- plastic, gray, silty Clay (CL) some fine sand
- 20-25% fine to coarse sand and fine gravel
- plastic to firm, gray, sandy
- trace pebbles
- silty, trace fine sand
- 10% fine to coarse sand
- compact, gray, very fine sandy Silt (ML)
- compact, gray, very fine silty Sand (SC)
- very compact, clayey, trace pebbles
- very hard, gray, fine sandy silty Clay (CL) trace pebbles (hardpan)
- 138.0-140.5ft Mudstone, gray, moist, silty, highly weathered
- 140.5-145.0ft Shale, gray, moist, fractured
- 145.0-146.2ft Sandstone, moist, medium to fine grained, some shale
- 146.2-150.0ft Shale, gray, firm with seams of highly fractured shale

Bottom of Hole-Elevation-432.3
-Depth-150.0ft

For Water Table information consult Section 4.1.3.

Slight indication of gas at 124.5'. Water bubbling in casing.

Hole backfilled with Bentonite and Natural Soil in soil and Cement Grout in rock

SOIL BORING NO. 59

BECHTEL Belle River

LOCATION: N 5,283 E 14,042

GROUND ELEVATION 593.1

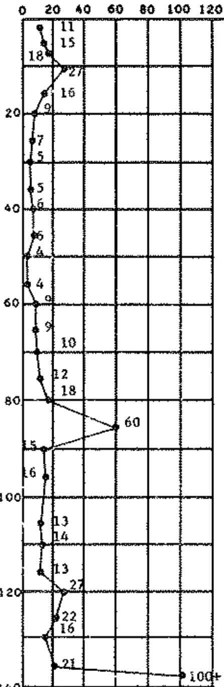
DATE DRILLED: 1-23-74 1-29-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) — MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) — DENSITY (LBS./CU. FT.) — OTHER LABORATORY TESTS — SAMPLE TYPE & NUMBER — NO. BLOWS PER FOOT OR SAMPLE PRESSURE — SYMBOL — DESCRIPTION

DEPTH IN FEET

NO UNDISTURBED SAMPLES TAKEN



DESCRIPTION

fill, cinders, clay, etc.

firm to stiff, brown, silty Clay (CL) trace fine sand

—plastic, gray

soft, gray silty Clay (CH)

plastic, gray silty Clay (CL) trace fine sand, few pebbles

—firm, sandy silty Clay (CL) few pebbles

—stiff, fine sandy silty

—plastic, silty Clay (CL), some fine sand

fairly compact, gray, clayey Silt (ML) trace Shale, pebbles

135.0-136.0ft Shale, gray, soft, weathered with sand seams

Bottom of Hole-Elevation-457.1
-Depth-136.0ft

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and natural soil.

SOIL BORING NO. 63

BECHTEL Belle River

LOCATION:* N 9,208.32 E 9,376.12

GROUND ELEVATION 587.6

DATE DRILLED: 2-28-74 3-7-74

SHEET 1 OF 1

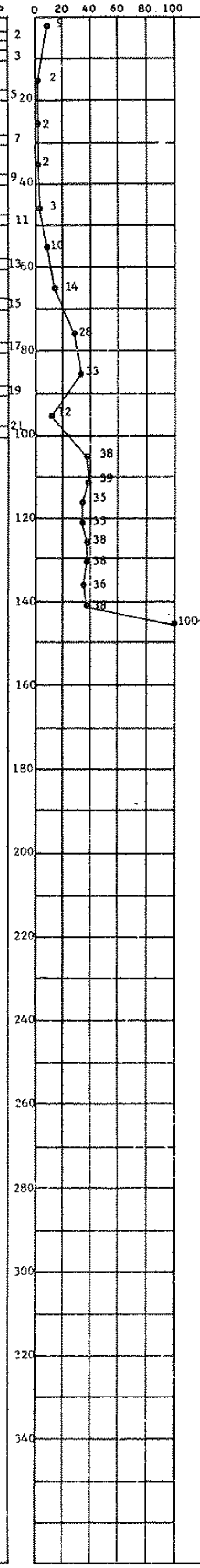
SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS | SAMPLE TYPE & NUMBER | NO. BLOWS PER FOOT OR SAMPLE PRESSURE | % CORE RECOVERY | SYMBOL | DESCRIPTION

DEPTH IN FEET



% CORE RECOVERY: 100 (143.5–156.5 ft.), 100 (156.5–166.5 ft.)

DESCRIPTION:

- sandy topsoil
- plastic, brown, sandy clay (CL)
- firm to stiff, silty clay, some fine sand
- plastic, gray, trace fine sand
- very soft to soft, gray, silty clay (CH)
- Lost approximately 25 gallons of water between 55.0 - 70.5 ft.
- plastic to firm, gray, silty clay (CL) some fine sand
- stiff, same, few pebbles
- soft to plastic
- medium compact, gray sand (SP) fine
- compact, gray sand (SW) very fine to medium, few pebbles
- medium compact, gray silt (ML) some fine sand
- 143.5-166.5 ft. shale, gray
  - 143.5-145.5 ft. soft, trace of clay and pebbles
  - 145.5-156.5 ft. soft, highly fractured
  - 155.5-166.5 ft. iuc` 'edded light and dark gray, firm, horizontal bedding, locally contorted, abundant quartz viens

Bottom of hole - Elevation - 421.2
- Depth - 166.5 ft.

* BENCH MARK ØBR - 3
16.5' of cement grout from 166.5' to 150.0'; 150.0' of 2" PVC blank casing from 150.0' to surface; casing cemented to surface and bench mark plate placed on top.
Benchmark Elev - 588.0

For Water Table information consult Section 4.1.3.

SOIL BORING NO. 65

BECHTEL Belle River

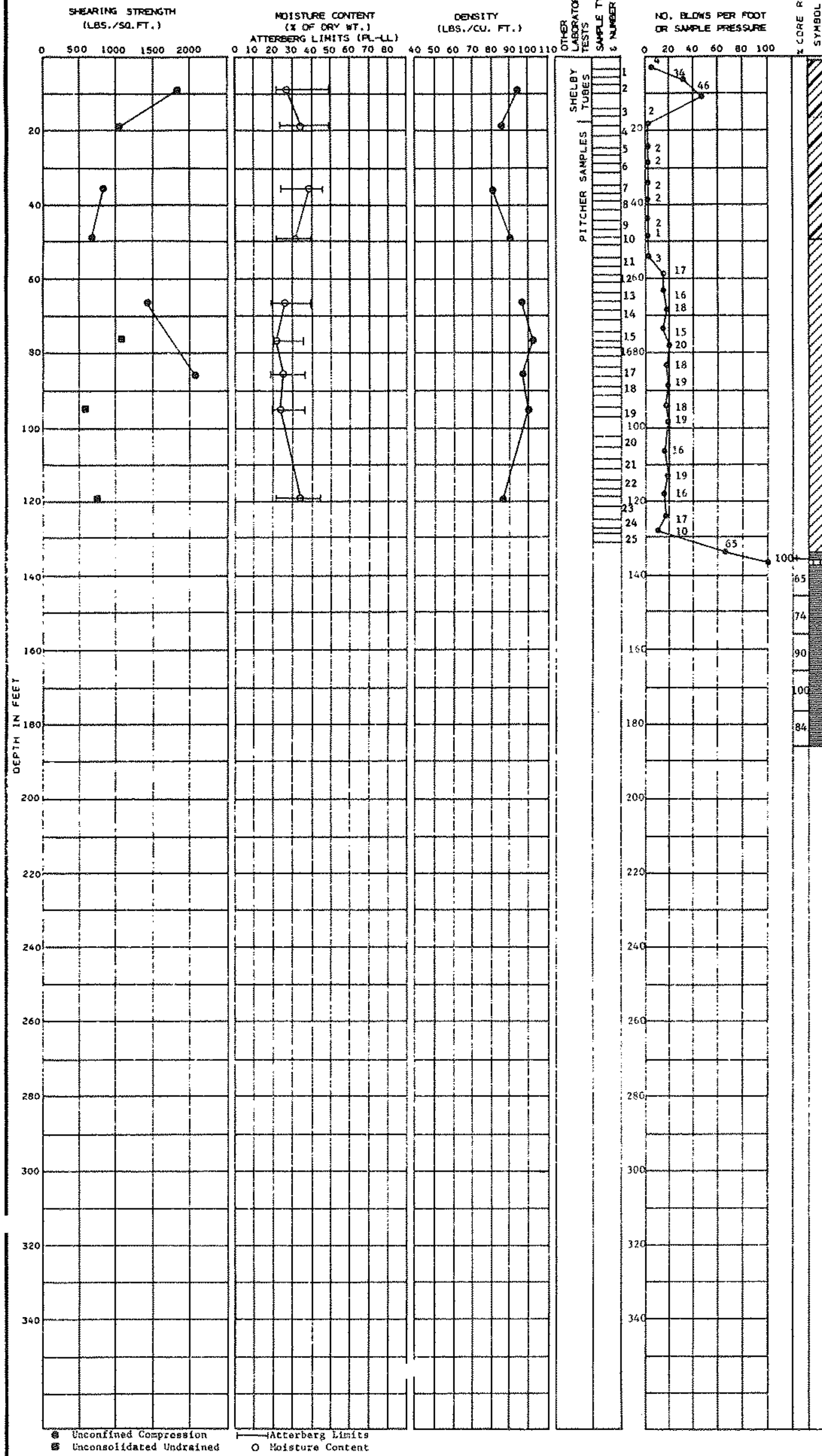
DUNN 10-72

LOCATION: N 3,800 E 12,060

GROUND ELEVATION 586.0

DATE DRILLED: 2-12-74 2-26-74

SHEET 1 OF 1



DESCRIPTION

- black, clayey topsoil
- soft, brown, silty Clay (CL-CH)
- very stiff, 5% gravel
- firm, gray

Firm, dark gray, silty Clay (CL) 20% fine to coarse sand
- plastic, trace to some fine sand
- small seam black silty sand, some gravel
- stiff, 30% fine to coarse sand and fine gravel
- dark gray
- 30% fine to coarse sand and fine gravel
- firm, dark gray, 15% coarse sand and fine gravel
- firm to stiff, gray, 10% fine to coarse sand and fine gravel
- soft to plastic, trace fine sand
- firm, some fine sand

134.0-136.8ft Shale, gray, soft, with some silt and sand seams

136.8-137.9ft Silt (ML), light gray

137.9-186.0ft Shale, dark gray, very soft to moderately soft, horizontal bedding. 137.9-176.0ft disintegrated to highly fractured. 150.0-152.7ft bedding dips 5°

176.0-186.0ft moderately hard

Bottom of Hole-Elevation-399.9 -Depth-186.0ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with QUIK-GEL and natural soil in soil and cement grout in rock.

SOIL BORING NO. 101

BECHTEL Belle River

LOCATION: N 4,435 E 12,350

GROUND ELEVATION: 589.7

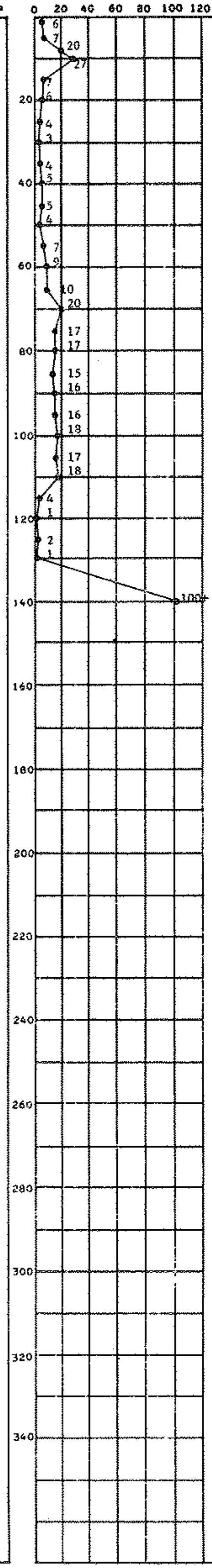
DATE DRILLED: 2-5-74 2-7-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	SYMBOL	DESCRIPTION
0 500 1000 1500 2000	0 10 20 30 40 50 60 70 80	40 50 60 70 80 90 100 110			0 20 40 60 80 100 120		

DEPTH IN FEET

NO UNDISTURBED SAMPLES TAKEN



DESCRIPTION

clay, wood, cinders, fill

plastic to firm, brown, silty Clay (CL) some gray pockets, trace fine sand

firm

plastic, gray

very soft to soft, gray, silty Clay (CH)

plastic, gray, silty Clay (CL) trace fine sand, few pebbles

— soft

compact, gray, silty Sand (SM) with some gravel

139.0-141.0ft Shale, gray, soft

Bottom of Hole-Elevation-448.7
-Depth-141.0ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and natural soil.

SOIL BORING NO. 103

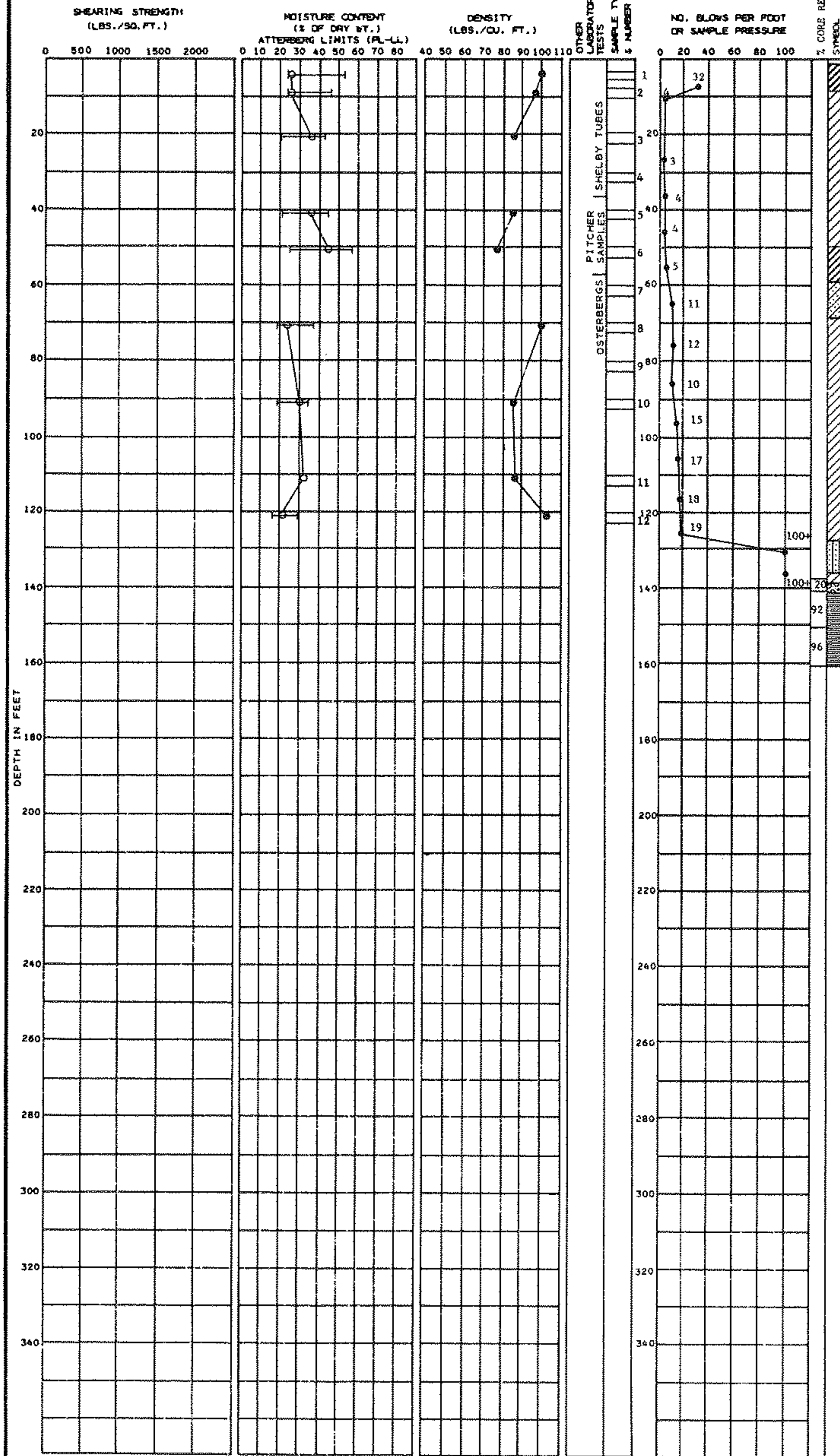
BECHTEL Belle River

LOCATION: N 5,000 E 11,000

GROUND ELEVATION 588.3

DATE DRILLED: 2-26-74 3-5-74

SHEET 1 OF 1



DESCRIPTION

- Black clayey topsoil
- Plastic, brown, sandy, gravelly clay (CH)
- very stiff to hard, silty clay, some fine sand, 5% gravel
- Very stiff, olive brown & grayish brown, silty Clay (CL) 5% gravel
- medium, gray, 5% fine to coarse sand
- medium, gray brown, 5% fine to coarse sand
- Medium, gray, silty Clay (CH) highly plastic
- Medium, gray, clayey sand (SC), trace gravel
- Stiff, gray, silty Clay (CL) 20% fine to coarse sand and fine gravel
- soft, gray, 10% fine to coarse sand
- 15% fine to coarse sand
- medium, dark gray, sandy, 35% fine to coarse sand
- Compact, gray, fine silty sand (SM) trace pebbles
- Hard, gray, silty clay (CL), some sand and shale chips
- 138.6-141.0 ft gravel (GP), dark gray shale and granitic cobbles
- 141.0-160.3 ft. shale, dark gray, soft to firm
  141.0-150.3 ft. disintegrated to fractured
  150.3-160.3 - fractured to intact

Bottom of hole - Elevation - 428.0
- Depth - 160.3 ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with quik-gel and natural soil in soil and cement in rock

I—I Atterberg Limits
O Moisture Content

SOIL BORING NO. 105

BECHTEL Belle River

LOCATION: S 6,450 E 13,140

GROUND ELEVATION 600.7

DATE DRILLED: 2-26-74 3-6-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

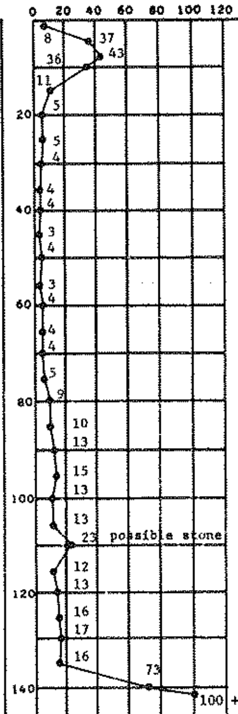
OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER

NO UNDISTURBED SAMPLES TAKEN

DEPTH IN FEET 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120



SYMBOL

DESCRIPTION

sandy topsoil

medium compact, brown, very fine to medium Sand (SW)

firm, brown, sandy Clay (CL)

stiff, silty clay, some fine sand with gray mottling

plastic, gray, trace very fine sand

soft, gray, silty Clay (CH) slight trace very fine sand

plastic, gray, silty Clay (CL) some very fine sand

plastic to firm, some fine sand

1.5' boulder

compact, gray, very fine Sand and Silt (SM)

142.0 - 142.67ft Shale, soft, gray, broken

Bottom of Hole-Elevation-458.03 -Depth-142.67ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and natural soil.

SOIL BORING NO. 109

BECHTEL Belle River

DUNN 14-S84

LOCATION: N 6,600 E 11,000

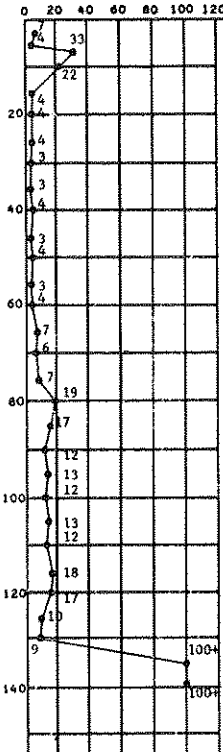
GROUND ELEVATION: 588.5

DATE DRILLED: 2-21-74 2-26-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN			Cinders, fill
							Plastic, brown & gray, silty clay (CL)
							Firm, some fine sand
							Stiff
							Very soft to soft, gray, silty clay (CH)
							Plastic, gray, silty clay (CL), some fine sand
							Firm, few pebbles
							Plastic to firm
							Soft to plastic
							Compact, gray silt (ML), some clay & very fine sand
							138.0-140.0 ft shale, gray, soft
							Bottom of hole - Elevation - 438.5 Depth - 140.0 ft
							No gain or loss of water
							For Water Table information consult Section 4.1.3.
							Hole backfilled with Quik-Gel and natural soil

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



SOIL BORING NO. 111

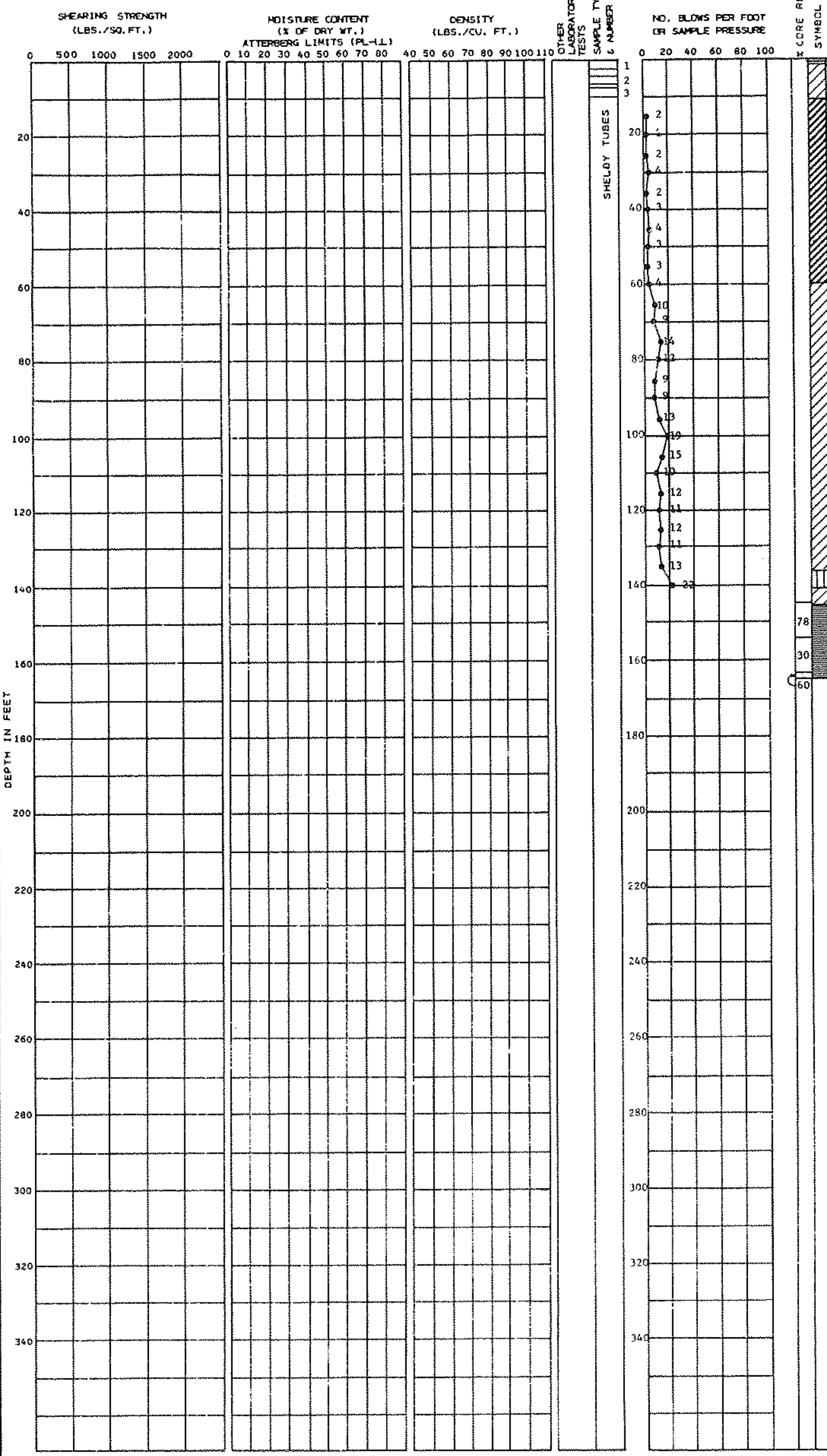
BECHTEL Belle River

LOCATION: N 6,800 E 9,360

GROUND ELEVATION 587.4

DATE DRILLED: 2-27-74 3-5-74

SHEET 1 OF 1



DESCRIPTION

cinders, fill

peaty topsoil

firm to stiff, brown and gray mottling, silty clay (CL) some fine sand

firm, gray

very soft to soft, gray, silty clay (CH)

plastic, gray, silty clay (CL) some fine sand

plastic to firm

plastic, trace fine sand

medium compact, gray silt (ML) trace clay

stiff, gray, silty clay (CL) with sand and shale chips

145.0-164.3 ft. Shale, gray to dark gray, soft to modĕrately soft
145.0-149.3 ft. fragmented
149.3-153.0 ft. fractured
153.0-164.3 ft. fragmented to fractured

Bottom of hole - Elevation - 423.15
- Depth - 164.25 ft.

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and natural soil in soil and cement grout in rock

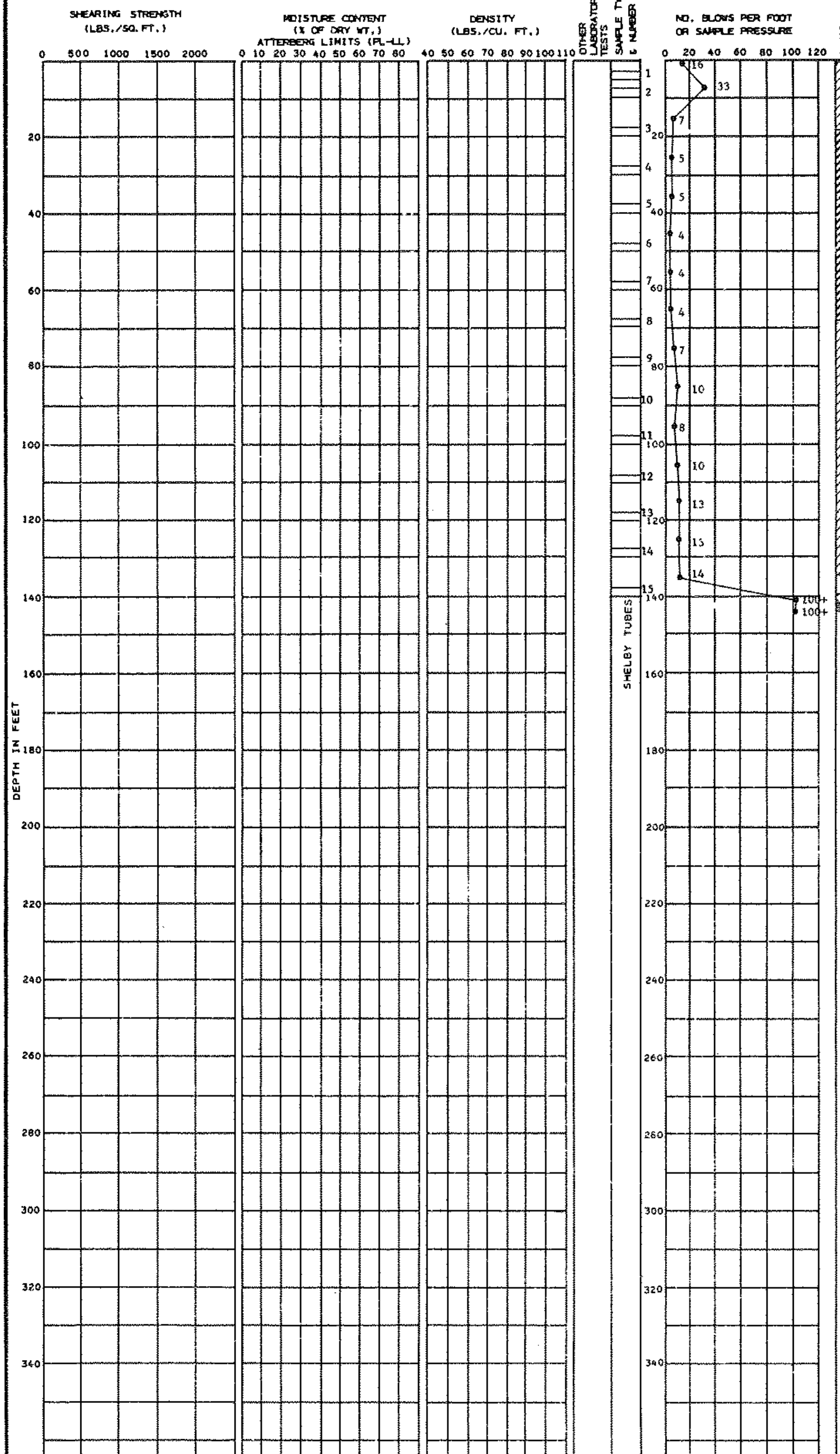
SOIL BORING NO. 113

BECHTEL Belle River

LOCATION: N 7,100 E13,060 GROUND ELEVATION 600.7

DATE DRILLED: 1-30-74 2-6-74

SHEET 1 OF 1



DESCRIPTION

sandy topsoil

stiff, brown, Clay (CL)

stiff, gray, silty sandy

soft, trace fine sand

very soft to soft, gray, silty Clay(CH)

plastic, gray, silty Clay (CL) some fine sand

compact, gray Silt (ML)

compact, gray, silty, very fine Sand (SM)

142.0-144.0ft Shale, gray, soft

Bottom of Hole-Elevation-456.7
-Depth-144.0ft

For Water Table information consult Section 4.1.3.

No Gain or Loss of Water

Hole Backfilled With Quick-Gel and Natural Soil

SOIL BORING NO. 115

BECHTEL Belle River

DUNN 10-79

LOCATION: N 7,270 E 9,360

GROUND ELEVATION: 585.5

DATE DRILLED: 2-5-74 2-12-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

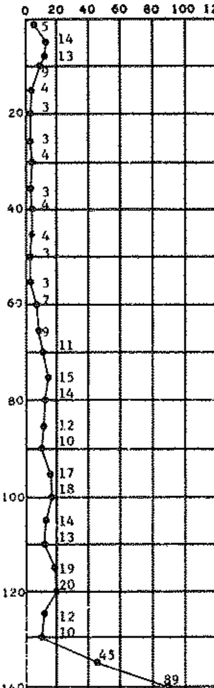
DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER

NO UNDISTURBED SAMPLES TAKEN

NO. BLOWS PER FOOT OR SAMPLE PRESSURE



SYMBOL

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

DESCRIPTION

clay, ash, gravel fill

stiff, brown, silty Clay (CL) some fine sand

firm, brown & gray, trace fine sand

plastic, gray, trace very fine sand

very soft to soft, gray, silty Clay (CH)

plastic, gray, silty Clay (CL) some fine sand

— firm

— plastic, trace fine sand

Sand (SP)

137.0-140.0ft Shale, gray, soft, interbedded with hard gray clay

Bottom of Hole-Elevation-445.5
-Depth-140.0ft

For Water Table information consult Section 4.1.3.

No Gain or Loss of Water

Hole Backfilled With Quick-Gel and Natural Soil

SOIL BORING NO. 117

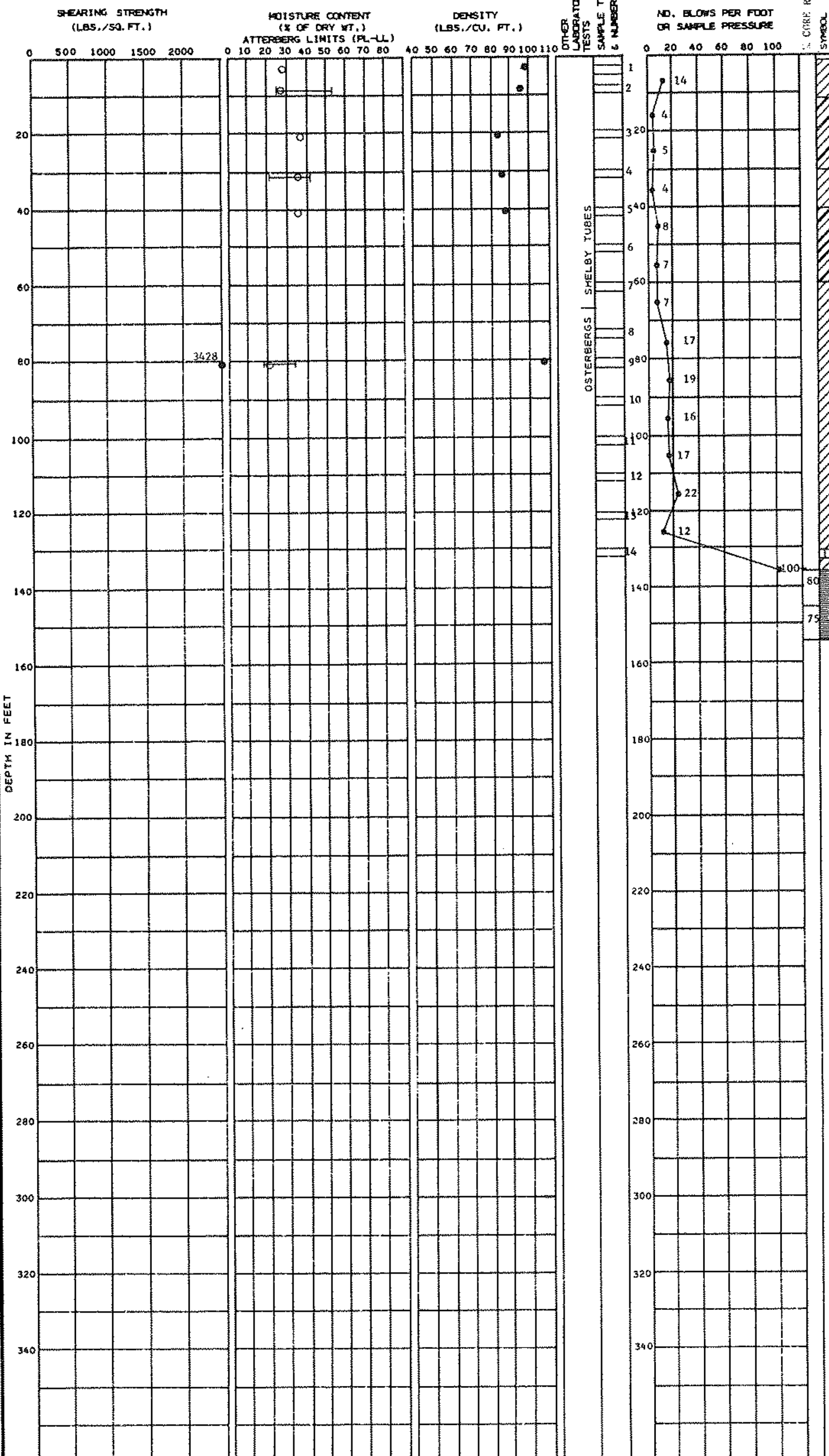
BECHTEL Belle River

LOCATION: N 7,510 E11,300

GROUND ELEVATION: 588.8

DATE DRILLED: 1-29-74 2-5-74

SHEET 1 OF 1



DESCRIPTION

- black, clayey, topsoil & cinder fill
- stiff to very stiff, dark grayish brown mottled light olive brown, silty Clay (CL) trace sand
  - very stiff, 10% coarse sand and fine gravel
- firm, dark gray, silty Clay (CL-CH) 5-10% coarse sand
- soft to firm, very dark grayish brown, silty Clay (CL) 5% coarse sand and gravel
- soft to firm, dark grayish brown, highly plastic, silty Clay (CH-CL)
- plastic to firm, gray, silty Clay (CL) some fine sand
  - stiff, grayish brown, sandy, 25% fine to coarse sand and gravel
  - slight trace of sand
- compact, gray, very fine sandy Silt(ML)
- stiff, gray, silty Clay (CL) some very fine sand
- 136.5-154.0ft Shale, dark gray. 136.5-139.0ft light gray, horizontal and contorted bedding

Bottom of Hole-Elevation-434.8
-Depth-154.0ft

No Gain or Loss of Water

For Water Table information consult Section 4.1.3.

Hole Backfilled With Bentonite and Natural Soil in Soil and Cement Grout in Rock

● Unconfined Compression

├──┤ Atterberg Limits

O Moisture Content

SOIL BORING NO. 119

BECHTEL Belle River

LOCATION: N 7,660 E 10,630

GROUND ELEVATION 587.9

DATE DRILLED: 2-14-74 2-19-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

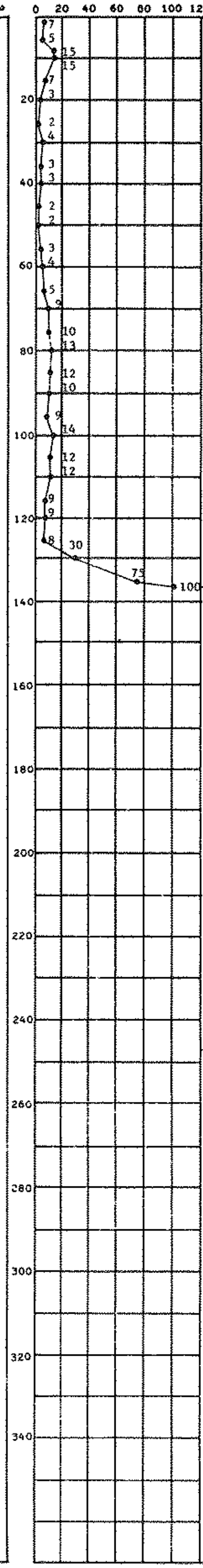
DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER: NO UNDISTURBED SAMPLES TAKEN

DEPTH IN FEET

NO. BLOWS PER FOOT OR SAMPLE PRESSURE



SYMBOL

DESCRIPTION

sandy topsoil

medium compact, brown, fine Sand (SP)

plastic, gray, silty Clay (CL) some fine sand

very soft to soft, gray, silty Clay (CH)

plastic, gray, silty Clay (CL) trace fine sand

medium compact, gray, clayey Silt (ML) trace fine sand

hard, gray, sandy Clay (CL) some pebbles

135.0-135.5ft Shale, gray, soft

Bottom of Hole-Elevation-452.4 -Depth-135.5ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with quik-gel and natural soil

SOIL BORING NO. 121

BECHTEL Belle River

LOCATION: N 8,017 E 4,999

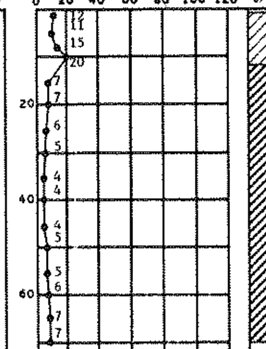
GROUND ELEVATION 588.9

DATE DRILLED: 3-25-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	SYMBOL	DESCRIPTION
0 500 1000 1500 2000	0 10 20 30 40 50 60 70 80	40 50 60 70 80 90 100 110		NO UNDISTURBED SAMPLES TAKEN	0 20 40 60 80 100 120		Gray, silty topsoil
							Medium, mottled brown & gray, silty sandy clay (CL), trace of pebbles
							Soft, gray, silty clay (CH), trace of sand
							Bottom of hole - Elevation - 518.9 - Depth - 70.0 ft
							No gain or loss of water
							For Water Table information consult Section 4.1.3.
							Hole backfilled with Quik-Gel and natural soil

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



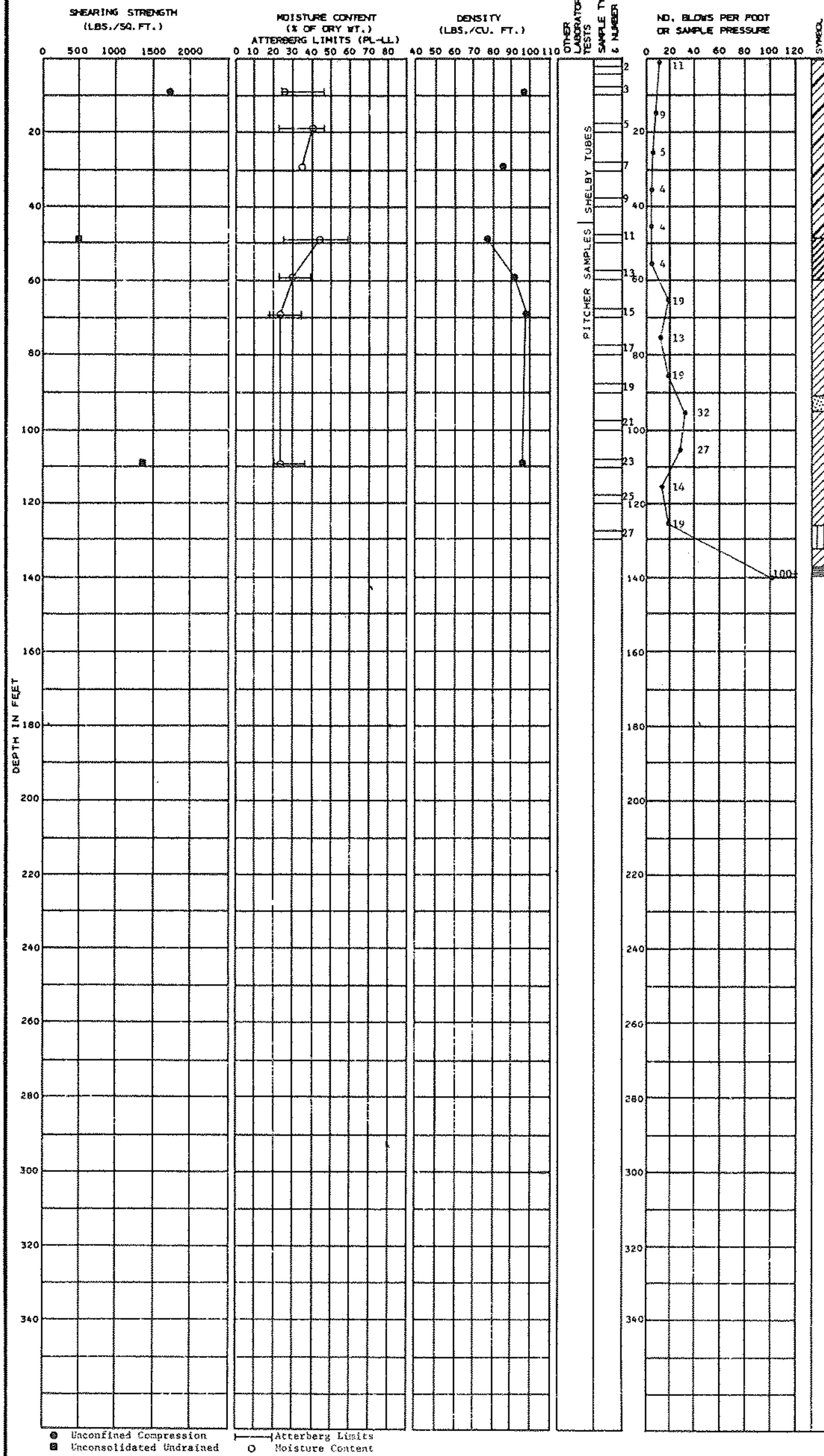
SOIL BORING NO. 123

BECHTEL Belle River

LOCATION: N 7,950 E 11,140   GROUND ELEVATION 588.8

DATE DRILLED: 2-1-74 2-6-74

SHEET 1 OF 1



DESCRIPTION

- sandy topsoil
- Very stiff, olive brown, silty Clay (CL-CH) some fine sand, trace gravel
  - stiff
  - very soft to soft, grayish brown
  - soft, grayish brown
  - soft, dark grayish brown, 5% fine to coarse sand
- Firm, gray, silty Clay (CH) 10% fine gravel and coarse sand
- Firm, gray, silty Clay (CL) 10% fine to coarse sand, few layers / lenses silty clay, 40% fine to medium sand
  - firm to stiff, dark gray, 15% fine to coarse sand and fine gravel
- compact, gray Sand (SP) trace gravel
- plastic to firm, gray, silty Clay (CL) trace fine sand
  - firm to stiff, dark gray, 20% fine to coarse sand and fine gravel
- loose, gray, clayey Silt (ML) trace fine sand
- hard, gray, sandy Clay (CL) few pebbles (hardpan)
- 137.0-140.0ft Shale, gray, soft

Bottom of Hole-Elevation-448.8ft
-Depth-140.0ft

For Water Table information consult Section 4.1.3.

No Gain or Loss of Water

Hole Backfilled With Quick-Gel and Natural Soil

● Unconfined Compression
■ Unconsolidated Undrained
├─┤ Atterberg Limits
○ Moisture Content

SOIL BORING NO. 126

BECHTEL Belle River

DUNN 16-72*

LOCATION: N 3,000 E 11,000

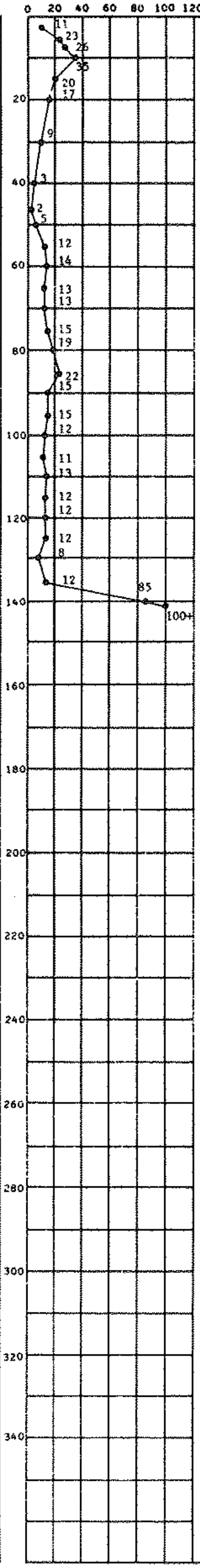
GROUND ELEVATION 589.5

DATE DRILLED: 2-7-74 2-13-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN			

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



DESCRIPTION

Sandy topsoil

Firm, brown, silty, clay fill, bricks cinders

Stiff, brown silty clay (CL) with some organic pockets

Very stiff, some fine sand

Firm, some gray mottling

Soft, gray, silty clay (CH)

Plastic, gray, silty clay (CL), some fine sand

Soft, trace of fine sand

Compact, gray silt (ML) with fine sand, trace of clay

Hard, gray, sandy clay (CL), few pebbles (hardpan)

141.0-141.5 ft. shale, gray, soft

Bottom of hole - Elevation -448.0
- Depth-141.5 ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and natural soil

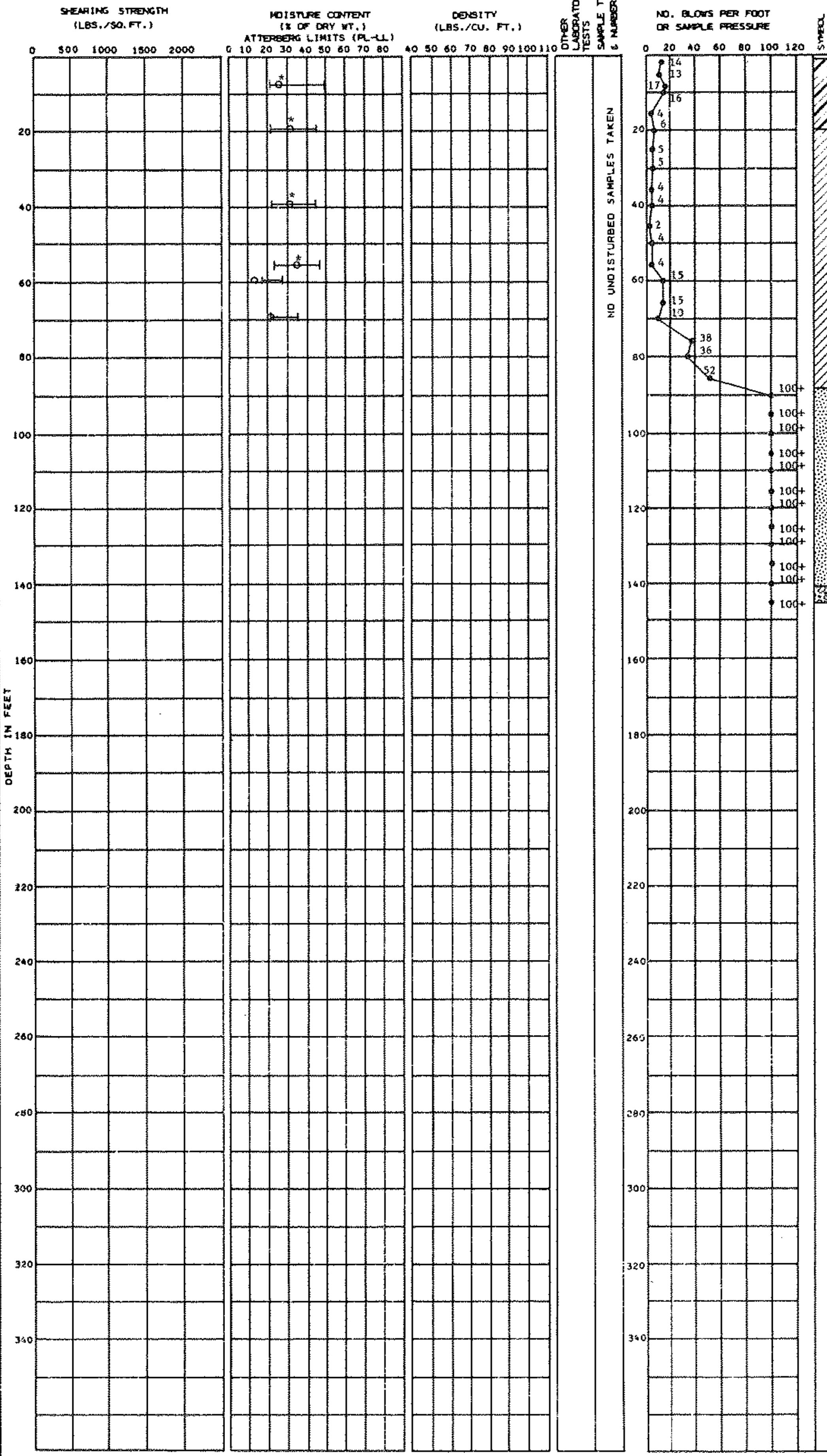
SOIL BORING NO. 128

BECHTEL Belle River

LOCATION: N 9,014 E 4,993 GROUND ELEVATION 595.3

DATE DRILLED: 3-26-74 3-28-74

SHEET 1 OF 1



DESCRIPTION

- gray, clayey topsoil
- medium to stiff, brown, silty Clay (CL-CH) some sand and gravel
- grayish brown, highly plastic
- medium, gray, no sand or gravel

medium, moderate to high plasticity, grayish brown, silty Clay (CL)

- low plasticity, dark gray, 25% fine to medium sand
- 15% fine to medium sand, low to medium plasticity

very compact, gray, fine to coarse Sand (SW) some gravel

very compact, gray, sands and fine to medium Gravel (GW) fragments of shale

Bottom of Hole-Elevation-450.3
-Depth-145.0ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and soil

o Water Content
|—| Atterburg Limits
* Water content taken from unsealed jar sample.

SOIL BORING NO. 130

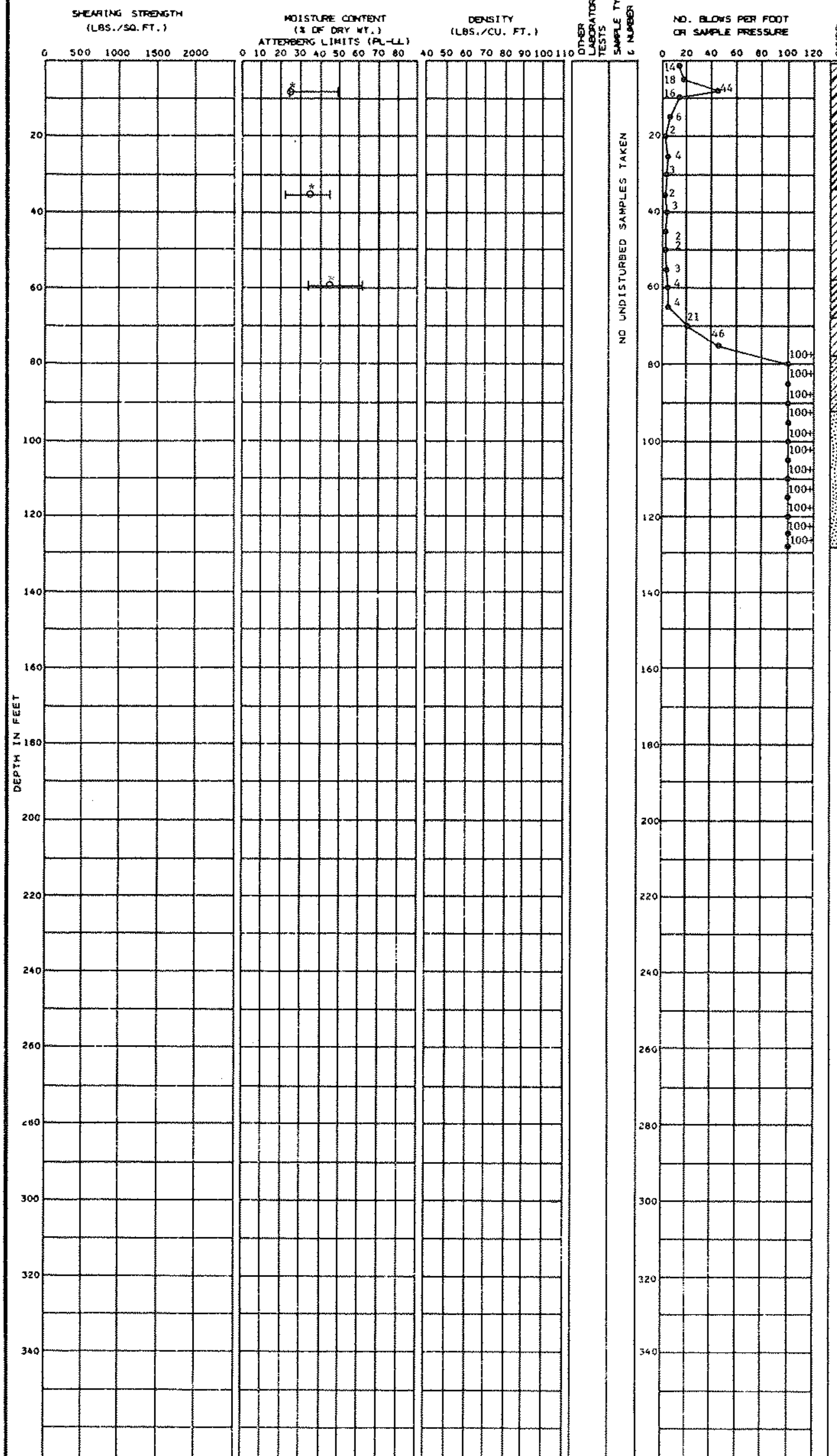
BECHTEL Belle River

LOCATION: N 10,050 E 4,995

GROUND ELEVATION 594.6

DATE DRILLED: 3-5-74 3-7-74

SHEET 1 OF 1



DESCRIPTION

- Clay topsoil
- Stiff, brown and gray, silty clay (CL-CH) some fine sand
- Hard
- Stiff, brown
- Plastic, gray, trace fine sand
- Very soft to soft, gray, silty clay (CH)
- Soft, moderate to high plasticity, gray, silty Clay (CL)
- Soft to firm, highly plastic, dark gray, silty Clay (CH) 5% fine sand
- Firm, gray, silty clay (CL), some fine sand
- Hard, very sandy
- Very compact, gray, clayey very fine sand (SC)
- Compact, gray, very fine sand (SP)
- Blowcount refusal possible boulder

Bottom of hole - Elevation - 456.1
- Depth - 128.5 ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and Natural Soil

o Water Content

├─┤ Atterburg Limits

* Water content taken from unsealed jar sample.

SOIL BORING NO. 134

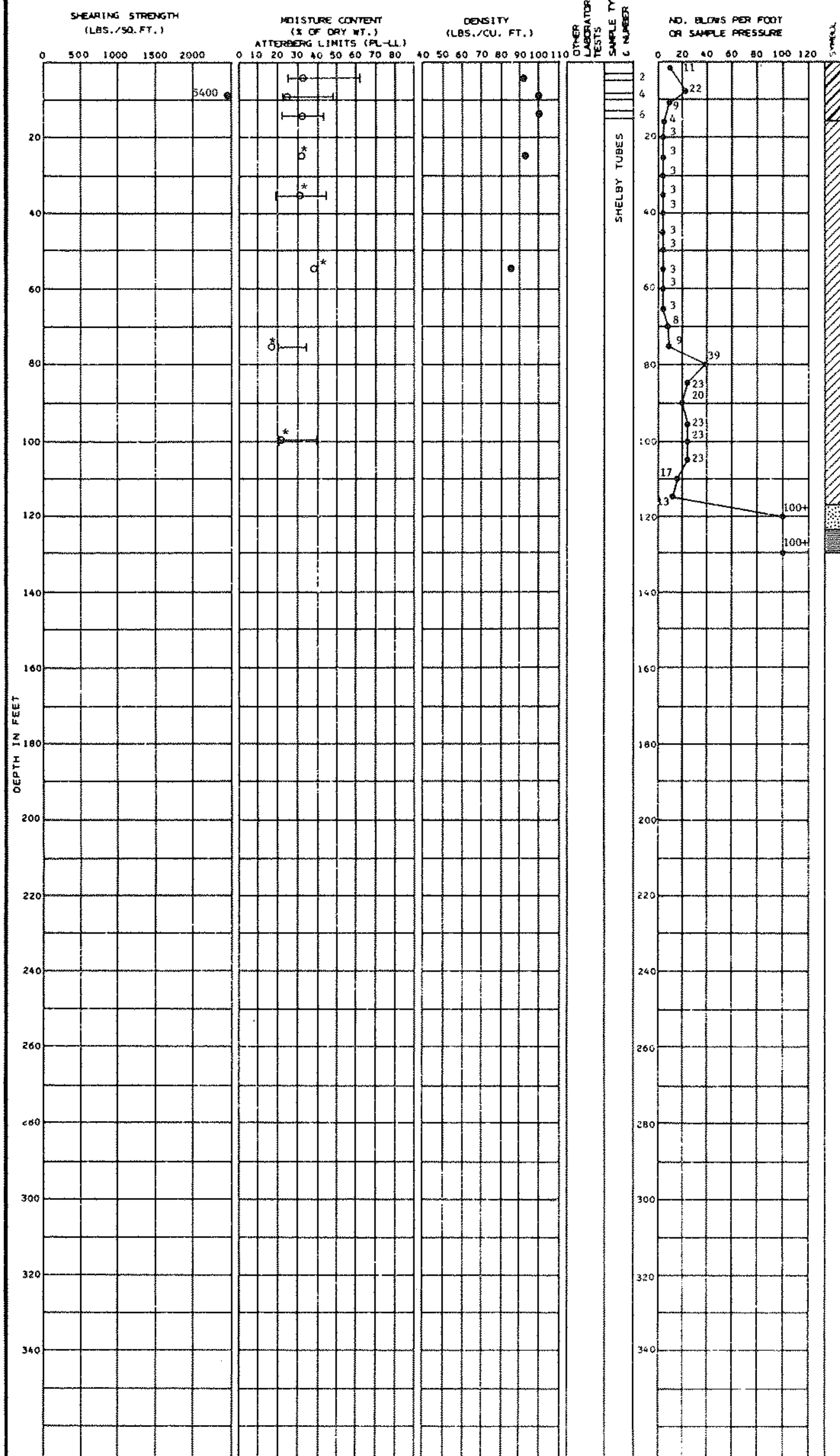
BECHTEL Belle River

LOCATION: N 10,050 E 7,000

GROUND ELEVATION 590.2

DATE DRILLED: 3-8-74 3-13-74

SHEET 1 OF 1



DESCRIPTION

Plastic, brown, silty clay (CL-CH) some fine sand

Stiff, brown and gray

Hard, mottled gray, 15% fine to coarse sand

Very soft to soft, moderately plastic, gray, silty Clay (CL)

10% fine to coarse sand

plastic, gray, some fine sand

low to moderate plasticity, 25% fine to coarse sand

very stiff, fine sandy

Firm, some fine sand

15% fine to coarse sand

Plastic, trace fine sand

Compact, gray, fine sand (SP)

124.0-130.0 ft shale, black, laminated, medium hard

Bottom of hole - Elevation - 460.2
- Depth - 130.0 ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and soil

● Unconfined Compression

O Moisture Content

|—| Atterburg Limits

* Water content taken from unsealed jar sample.

SOIL BORING NO. 136

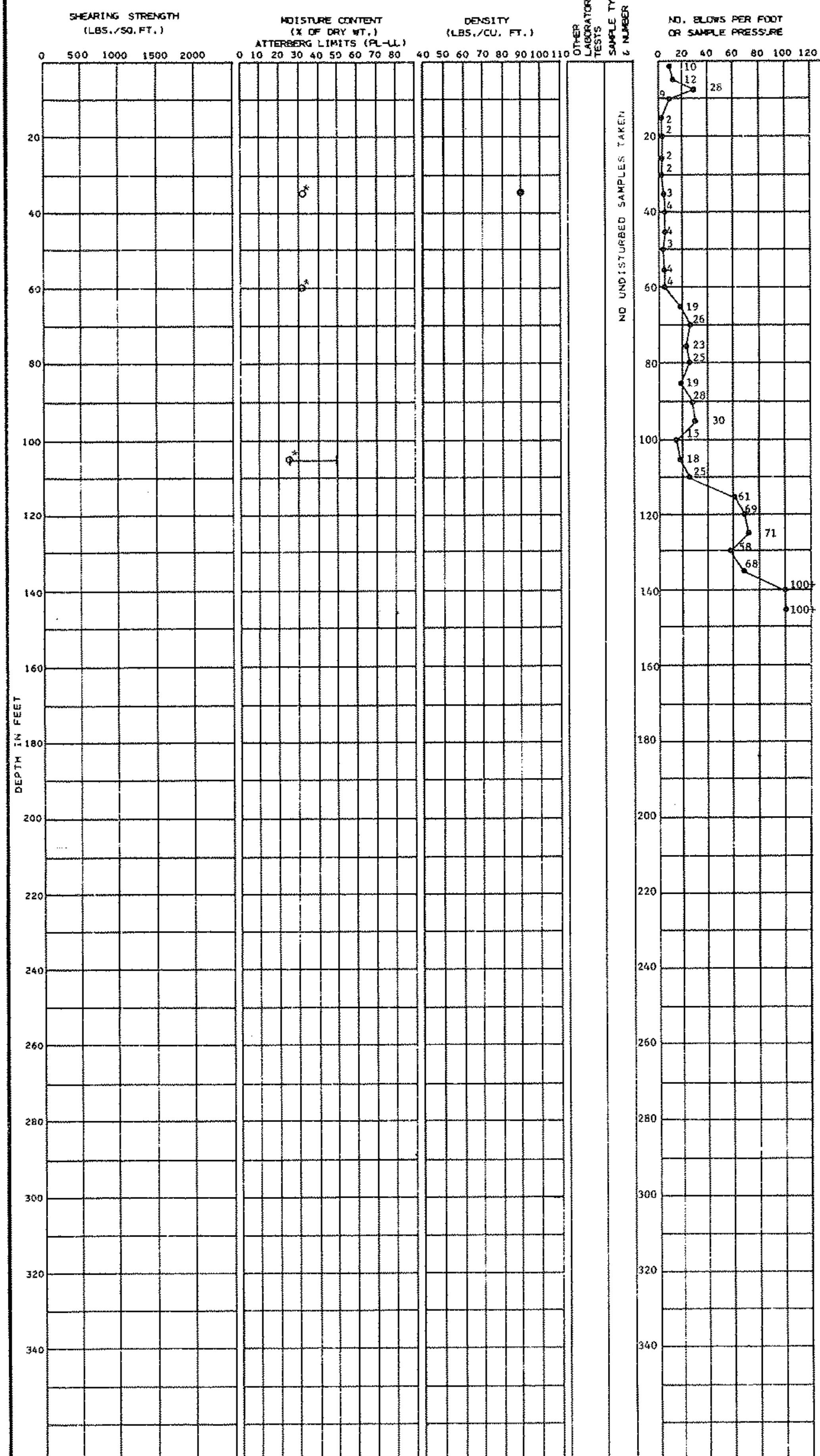
BECHTEL Belle River

LOCATION: 10,030 / 8,977

GROUND ELEVATION: 588.7

DATE DRILLED: 3-11-74 / 3-14-74

SHEET 1 OF 1



DESCRIPTION

peaty, sandy topsoil

firm, brown, silty Clay (CL-CH) some fine sand

stiff, sandy

plastic, gray, trace fine sand

very soft to soft, gray, silty Clay (CH)

soft to medium, moderate to high plasticity, gray, silty Clay (CL)

— firm, some fine sand

medium compact, gray, clayey silt (ML)

firm, gray, silty Clay (CL) some fine sand

— stiff

— plastic

— highly plastic

compact, gray, very fine Sand (SP) trace silt

compact, gray, very fine to medium Sand (SC) trace gravel

hard, gray, sandy, silty Clay (CL) few pebbles (Hardpan)

144.0-145.0ft Shale, gray, medium hard

Bottom of Hole-Elevation-443.7
-Depth-145.0ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and soil

o Water Content
|—| Atterburg Limits
* Water content taken from unsealed jar sample.

SOIL BORING NO. 138

BECHTEL Belle River

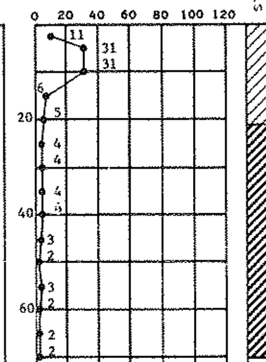
LOCATION: [illegible] 10,850 / [illegible] .003

GROUND ELEVATION: 592.0

DATE DRILLED: 3-19-74 / 3-20-74

SHEET 1 OF 1

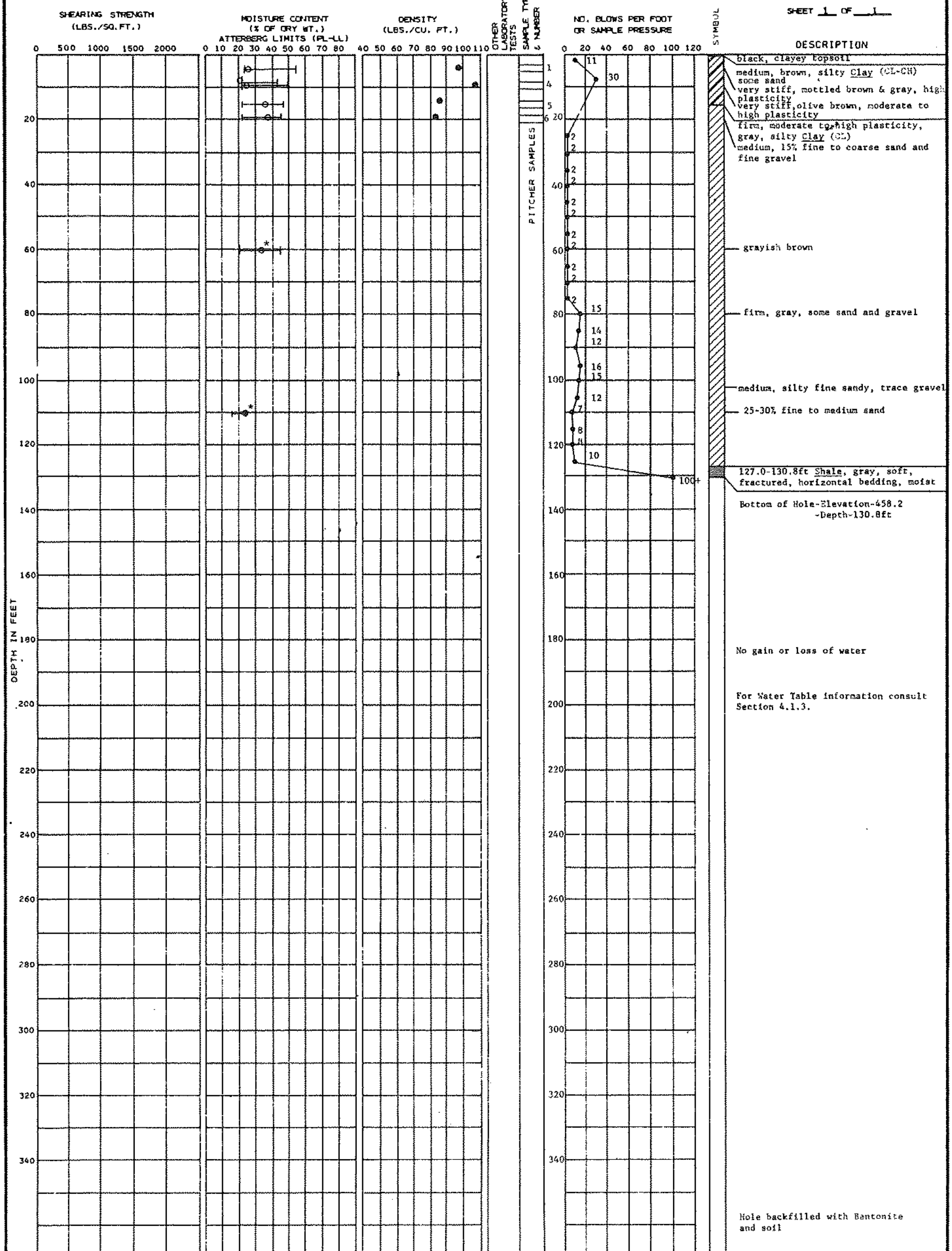
DEPTH IN FEET	SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120	SYMBOL	DESCRIPTION
0–21					NO UNDISTURBED SAMPLES TAKEN	11, 31, 31, 6, 5		plastic, brown, silty Clay (CL) trace sand; stiff, some fine sand; soft, gray
21–70.5						4, 4, 4, 4, 3, 2, 3, 2, 2, 2		very soft to soft, gray, silty Clay (CH)
70.5								Bottom of Hole-Elevation 521.5 -Depth-70.5ft
120								No gain or loss of water
135								For Water Table information consult Section 4.1.3.
360								Hole backfilled with Quik-Gel and soil



SOIL BORING NO. 140

BECHTEL Belle River

LOCATION: N 11,146 / E 7,995 — GROUND ELEVATION 589.0 — DATE DRILLED: 3-25-74 / 3-27-74 — SHEET 1 OF 1



o Moisture Content
⊢⊣ Atterburg Limits
* Water content taken from unsealed jar sample.

SOIL BORING NO. 142

BECHTEL Belle River

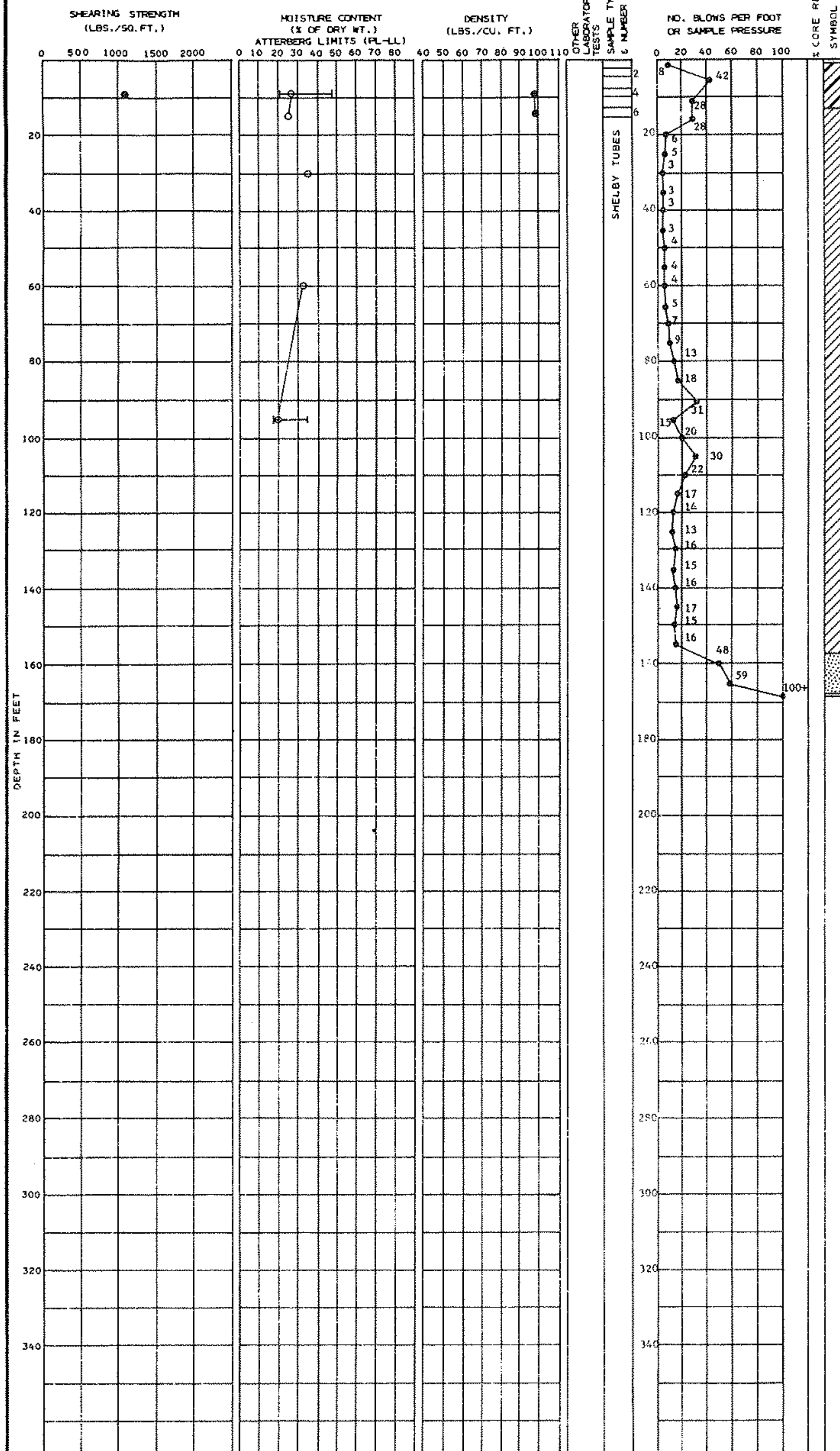
DUNN 10-724

LOCATION: N 12,000 E 5,000

GROUND ELEVATION 597.5

DATE DRILLED: 3-13-74 3-15-74

SHEET 1 OF 1



DESCRIPTION

topsoil

very stiff, gray-brown, silty Clay (CL-CH) some fine sand

brown, highly plastic, 20-25% fine to coarse sand and fine gravel

soft, gray, silty Clay (CL) slight trace very fine sand

5% fine to coarse sand

stiff, some fine sand, few stones

moderately plastic, 15% fine to coarse sand

very compact, gray sand (SW), medium to coarse, trace gravel

168.0-168.16 ft shale, soft, gray

Bottom of Hole - Elevation - 429.34
- Depth - 168.16 ft

Water lost in this hole - 25 gallons 57.0 ft

For Water Table information consult Section 4.1.3.

Hole backfilled with bentonite and natural soil

● Unconfined Compression

○ Moisture Content

├─┤ Atterburg Limits

SOIL BORING NO. 144

BECHTEL Belle River

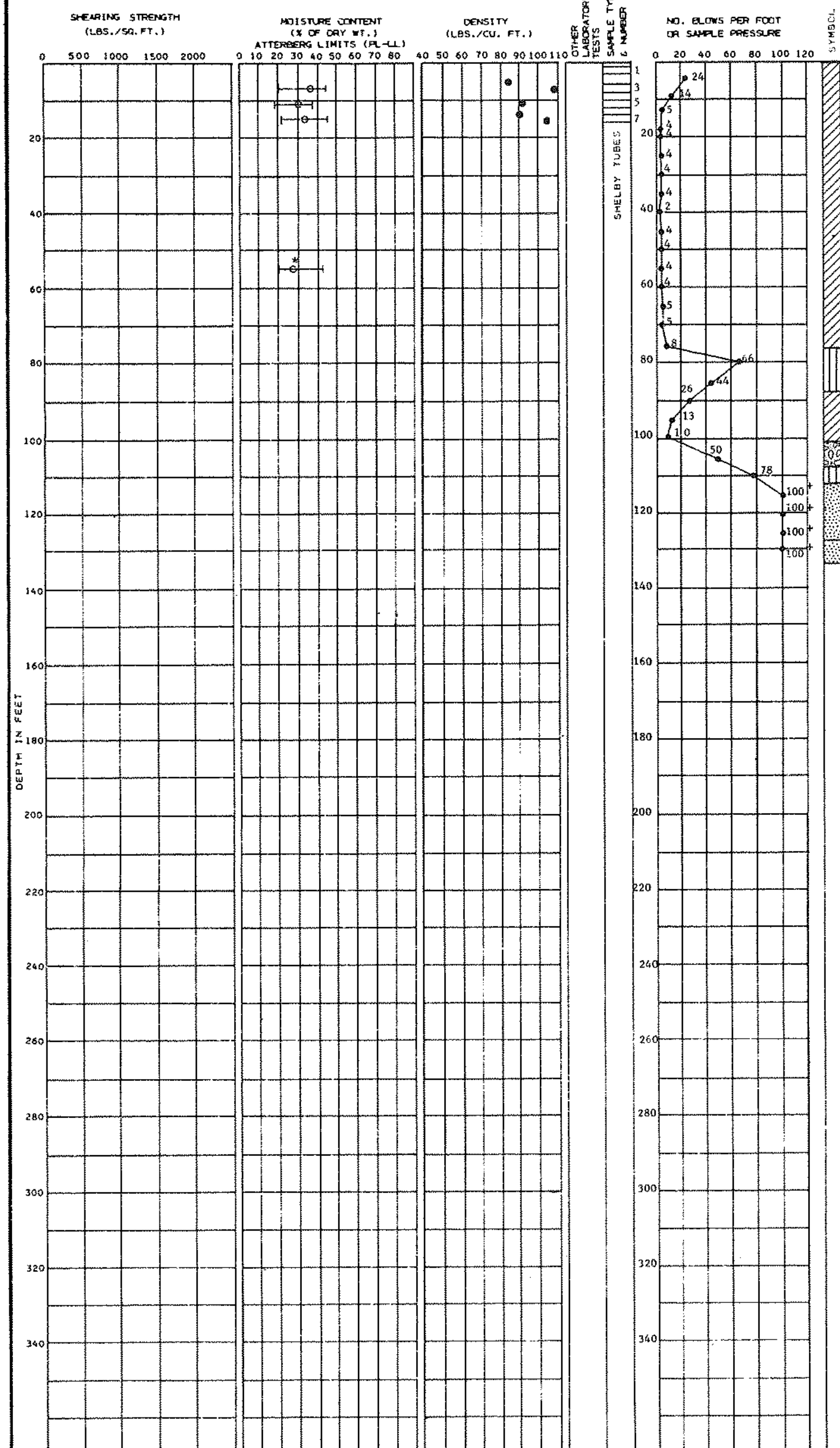
DUNN 10-72

LOCATION: N 12,000 E 7,000

GROUND ELEVATION 589.7

DATE DRILLED: 3-18-74 3-19-74

SHEET 1 OF 1



DESCRIPTION

topsoil
stiff, brown & gray, silty Clay (CL)
some fine sand
gray & brown, moderate plasticity, trace sand
40% fine to coarse sand & fine gravel
very soft to soft, brown, moderate to high plasticity, 5% fine to coarse sand

grayish brown

compact, gray Clayey fine Sand (ML)
trace pebbles

stiff, gray, fine sandy, silty Clay (CL)
plastic, trace fine sand
boulder

compact, gray, sandy Silty Gravel (GM)

compact, gray, clayey Silt (ML)

very compact, gray, very fine Sand (SP)

gravelly Sand (SW)
boulder

Bottom of Hole - Elevation - 455.7
- Depth - 134.0 ft.

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and soil

○ Moisture Content
├─┤ Atterburg Limits
* Water content taken from unsealed jar sample.

SOIL BORING NO. 146

BECHTEL elle i er

LOCATION: N 13,061 E 5,006

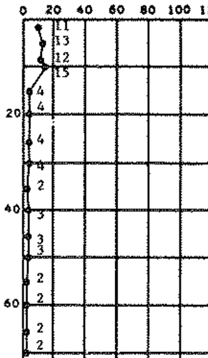
GROUND ELEVATION: 598.6

DATE DRILLED: 3-28-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN			

DEPTH IN FEET



DESCRIPTION

Black, clayey topsoil

Firm, brown & gray, silty, sandy clay (CL), trace of pebbles

Soft, gray, silty clay (CH), trace of sand

Bottom of hole - Elevation - 528.6
- Depth - 70.0 ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and natural soil

SOIL BORING NO. 148

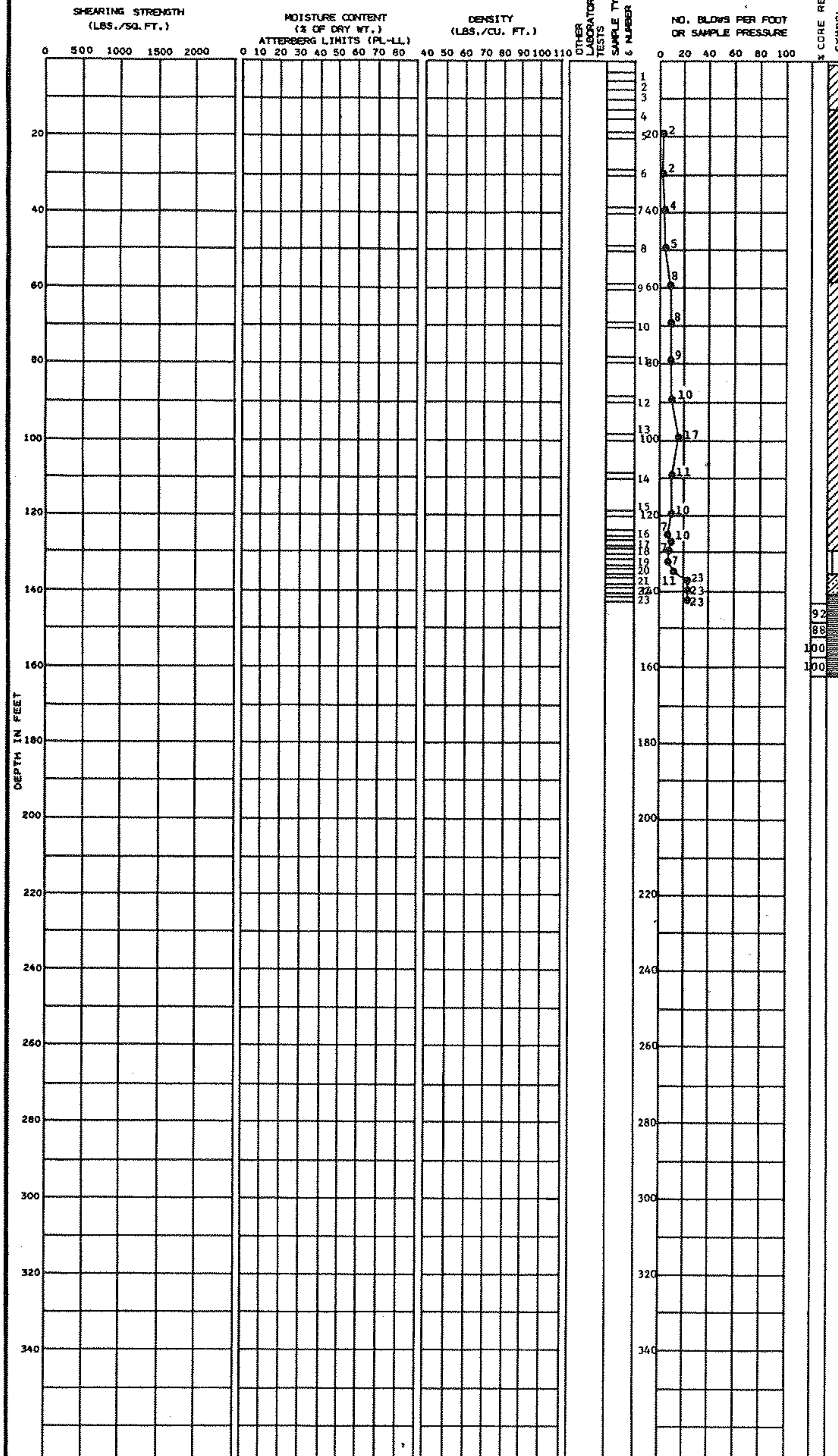
BECHTEL Belle River

LOCATION: N 7455 E 9535

GROUND ELEVATION 585.2

DATE DRILLED: 9/28/77 9/30/77

SHEET 1 OF 1



DESCRIPTION

0-0.7' Topsoil, dark brown, clayey

0.7-12.0' Silty Clay, dark brown, vary stiff, med. plasticity, moist, trace wood fragments, trace sand, trace fine gravel (CL)

12.0-58.0' Clay, med. gray, very soft, high plasticity, moist to wet, trace silt, trace sand, trace fine gravel (CH)

38.5'-58.0' Soft

58.0-129.8' Silty Clay, med. gray, med. stiff, med. plasticity, moist, little sand, trace fine to coarse gravel (CL)

98.5-108.5' Very stiff

108.5-118.5' Stiff

118.5-129.8' Trace sand

129.8-136.0' Clayey Silt, med. gray, med. stiff to stiff, wet, with occasional fine-grained sand seams (ML)

136.0-140.5' Clayey Sand, med. gray, med. dense, wet, fine-grained, scattered silt layers, trace fine to med. gravel (SC)

140.5' Top of Rock

140.5-162.0' Shale, med. gray, soft, weathered

144.0-158.7' Firm, scattered soft clay layers

156.0' Irregular bedding

158.7-162.0' Hard, dark gray, occasional soft clay layers

Bottom of Hole: Depth 162.0'
Elevation 423.2

Hole grouted from 162.0' to ground surface.

SOIL BORING NO. B-8

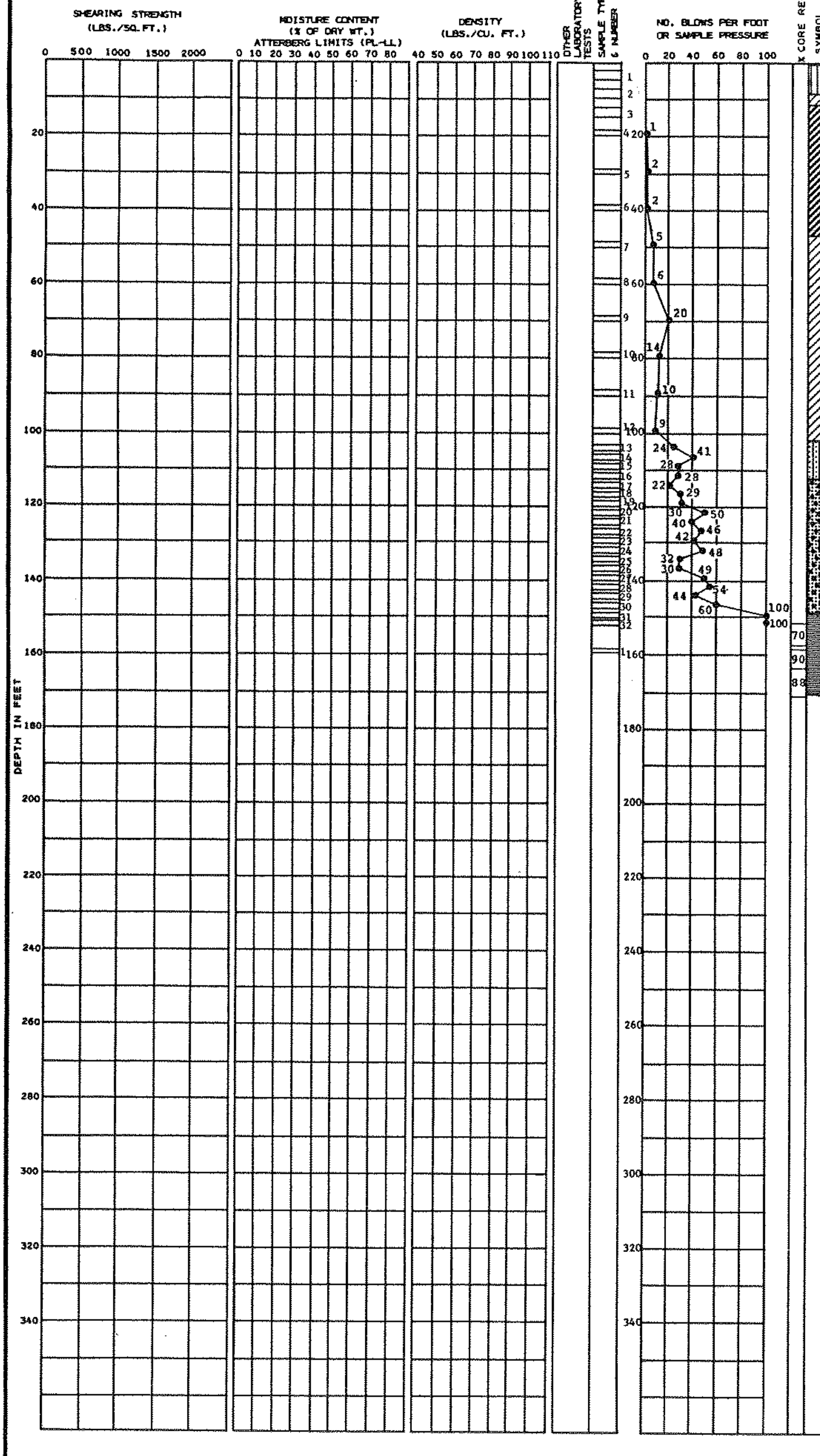
BECHTEL Belle River

LOCATION: N 7675 E 9100

GROUND ELEVATION: 585.6

DATE DRILLED: 8/8/77 – 8/11/77

SHEET 1 OF 1



DESCRIPTION

0-0.3' Topsoil, clayey silt, med. brown, dry

0.3-8.5' Clayey Silt, green brown and med. gray, mottled, slight plasticity, dry, trace wood fragments, trace fine gravel (ML)

8.5-11.5' Silty Clay, med. gray and brown, mottled, high plasticity, wet, trace silt, trace fine gravel (CL)

11.5-46.5' Clay, med. gray, very soft, very high plasticity, wet, trace silt, trace fine gravel (CH)

46.5-101.5' Silty Clay, med. gray, soft to med. stiff, med. plasticity, moist, little sand, trace fine to coarse gravel, occasional cobble(CL)
48.5-50.0' Seams of clayey sand and silt
68.5-78.5' Very stiff
78.5-88.5' Stiff
83.0-83.5' Cobble
88.5-101.5' Med. stiff

101.5-111.0' Silty Sand, med. gray and brown, med. dense, fine-to med.-grained, wet, with silt seams (SM)

111.0-150.5' Sand, med. gray and brown, med. dense, fine-to coarse-grained, wet, trace silt, trace fine to coarse gravel, very clean, occasional cobbles (SW-SP)
121.0-133.5' Fine-to med.-grained
128.5-133.5' Silty
133.5-148.5' Med.-to coarse-grained
143.0-148.5' Some fine to coarse gravel
148.5-150.5' Fine-to med.-grained

150.5' Top of Rock
150.5-171.0' Shale, med, gray to dark gray, soft to moderately hard
150.5-158.9' Soft, weathered, mechanically fractured
158.9-171.0' Moderately hard, occasional mechanical fractures at 45° angle, occasional soft shale seams
163.5-164.0' Fissile, core broken every 1/4"

Bottom of Hole: Depth 171.0'
Elevation 414.6

Hole caved in from 171.0' to 145.0'.

Hole grouted from 145.0' to ground surface.

SOIL BORING NO. B-9

BECHTEL Belle River

LOCATION: N 7500 / E 9388.7

GROUND ELEVATION: 585.3

DATE DRILLED: 7/21/77 – 7/25/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.): 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL): 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.): 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS | SAMPLE TYPE & NUMBER | NO. BLOWS PER FOOT OR SAMPLE PRESSURE: 0 20 40 60 80 100 | % CORE RECOVERY | SYMBOL | DESCRIPTION

DEPTH IN FEET: 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

Sample No.	Blows per foot / % core recovery
1	16
2	23
3	16
4	8
5	2
6	2
7	2
8	2
9	3
10	13
11	17
12	8
13	11
14	17
15	21
16	12
17	6
18	19
19	23
20	47
21	27
22	87
23	37
Core 1	84, 100 (% core recovery)

DESCRIPTION

0-1.0' Clayey Silt, topsoil, light gray to dark brown, med. dense, dry, with wood fragments (ML)

1.0-6.0' Silty Clay, med. brown and light gray, mottled, very stiff, med. plasticity, moist, trace sand (CL)

6.0-11.0' Clay, med. brown, very stiff, med. plasticity, moist, trace silt, trace sand (CL-CH)

7.5-11.0' Light gray, med. stiff, high plasticity

11.0-54.0' Clay, light gray, very soft, very high plasticity, wet (CH)

54.0-131.0' Silty Clay, med. gray, stiff, high plasticity, moist, trace sand, trace cobble (CL)

63.5-73.5' Very stiff

73.5-83.5' Med. stiff

83.5-93.5' Stiff, trace fine to coarse gravel

93.5-113.5' Very stiff

100.5-123.5' Med. plasticity, little sand

113.5-126.0' Stiff

123.5-124.0' Fine-grained clayey sand seam

126.0-131.0' Very stiff

126.5-127.0' Fine-grained silty sand seam

131.0-138.0' Silty Sand, med. gray, dense, wet, fine-grained (SM)

Cobble on top of rock

138.0' Top of Rock

138.0-160.0' Shale, dark gray, soft to firm, fissile mechanically fractured in areas

138.0-141.4' Soft, weathered

141.4-160.0' Hard, fissil

Bottom of Hole: Depth 160.0'
Elevation 425.3

Hole grouted from 160.0' to ground surface.

SOIL BORING NO. B-12

BECHTEL Belle River

LOCATION: N 13,000 E 7,000

GROUND ELEVATION: 590.6

DATE DRILLED: 3-27-74 3-28-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN	9, 20, 20, 13, 9, 7, 5, 4, 3, 2, 2, 2, 2, 2, 2		black, clayey topsoil medium, brown, silty Clay (CL) trace of sand and gravel — gray, silty soft, gray, sandy, silty Clay (CH) — no sand Bottom of Hole-Elevation-520.1 -Depth-70.5ft No gain or loss of water For Water Table information consult Section 4.1.3. Hole backfilled with Bentonite and soil

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

SOIL BORING NO. 150

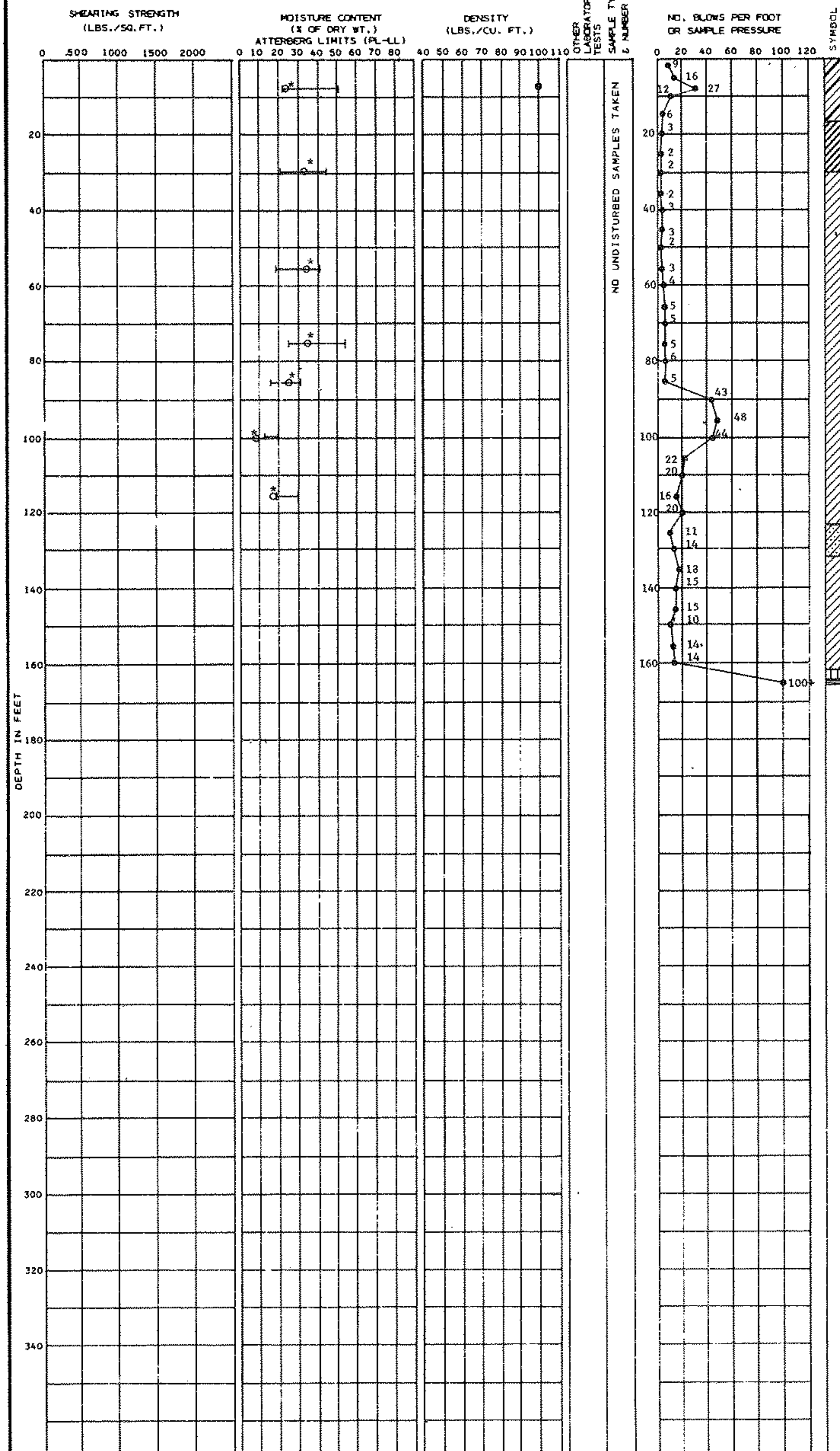
BECHTEL Belle River

LOCATION: N 13,785 E 5,006

GROUND ELEVATION: 599.0

DATE DRILLED: 3-7-74 3-14-74

SHEET 1 OF 1



DESCRIPTION

firm, brown, leached Clay (CL-CH) trace fibers and topsoil
stiff, brown and gray, silty clay, trace fine sand, few pebbles
soft to plastic, gray, some fine sand

very soft to soft, gray, silty Clay (CH)

soft, moderately plastic, grayish brown, silty Clay (CL) 10% fine to coarse sand

5% fine to coarse sand

soft to plastic, gray, some fine sand
highly plastic

25% fine to coarse sand
very stiff, very sandy clay, few pebbles

low plasticity, clayey silt (CL-ML)
lense, 15% fine to medium sand
firm to stiff, silty, some fine sand

10% fine sand, low plasticity

medium compact, gray, Clayey Sand (SC) fine to medium

plastic to firm, gray, silty Clay (CL) some fine sand

clayey Silt (ML)
164.0-165.0ft Shale, gray, soft

Bottom of Hole-Elevation-434.0
-Depth-165.0ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and soil

o Moisture Content
├─┤ Atterburg Limits
* Water content taken from unsealed jar sample.

SOIL BORING NO. 154

BECHTEL Belle River

DUNN 14-73

LOCATION: N 14,000 E 8,000

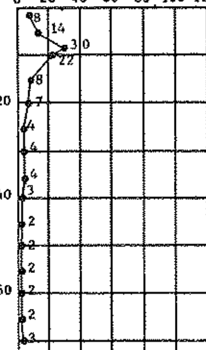
GROUND ELEVATION 591.5

DATE DRILLED: 4-5-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN			topsoil firm to stiff, brown, silty clay (CL) — very stiff, trace gravel — plastic to firm, gray soft, gray, silty clay (CH) Bottom of Hole - Elevation - 521.5 - Depth - 70.0 ft. No gain or loss of water For Water Table information consult Section 4.1.3. Hole backfilled with Quik-Gel and soil

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



SOIL BORING NO. 157

BECHTEL Belle River

DUNN 16-72

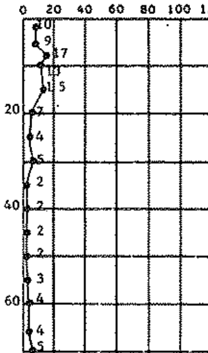
LOCATION: N 14,000 E 9,950

GROUND ELEVATION 591.3

DATE DRILLED: 4-3-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL–LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN			gray silt (ML)
							loose to medium compact, brown to gray, silty sand (SM) fine to medium
							firm, gray, silty clay (CL)
							soft, gray, silty clay (CH)
							Bottom of Hole - Elevation - 521.3 - Depth - 70.0 ft.
							No gain or loss of water
							For Water Table information consult Section 4.1.3.
							Hole backfilled with Quik-Gel in soil



DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

SOIL BORING NO. 159

BECHTEL Belle River

DUNN 10-72F

LOCATION: N 15,000 / E 8,000

GROUND ELEVATION: 591.4

DATE DRILLED: 4-8-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	% CORE RECOVERY	SYMBOL	DESCRIPTION
0 500 1000 1500 2000	0 10 20 30 40 50 60 70 80	40 50 60 70 80 90 100 110		NO UNDISTURBED SAMPLES TAKEN	0 20 40 60 80 100			

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

No. blows per foot (top to bottom): 8, 12, 13, 15, 7, 4, 2, 2, 3, 2, 2, 2, 3, 3, 4, 2, 5, 7, 8, 7, 11, 11, 9, 6, 12, 24, 21, 41, 48

DESCRIPTION

- plastic, gray, silty Clay (CL-CH)
- firm, gray and brown, trace fine sand
- plastic, gray, some fine sand

medium, grayish brown, moderately to highly plastic, silty Clay (CL)
- very soft to soft, gray
- moderately plastic
- 5% fine to medium sand
- soft to plastic, trace fine sand
- highly plastic
- plastic, some fine sand
- 10% fine to coarse sand
- firm, few sand seams
- very stiff, sandy, few pebbles

medium compact, gravelly Sand (SW) seams of fine sand

Bottom of Hole-Elevation-453.4
-Depth-138.0ft

Unable to keep this boring open below 138.0' due to gravel.

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and Natural Soil.

O Moisture Content

├─┤ Atterburg Limits

* Water content taken from unsealed jar sample.

SOIL BORING NO. 163

BECHTEL Belle River

LOCATION: N 14,830 E 9,938

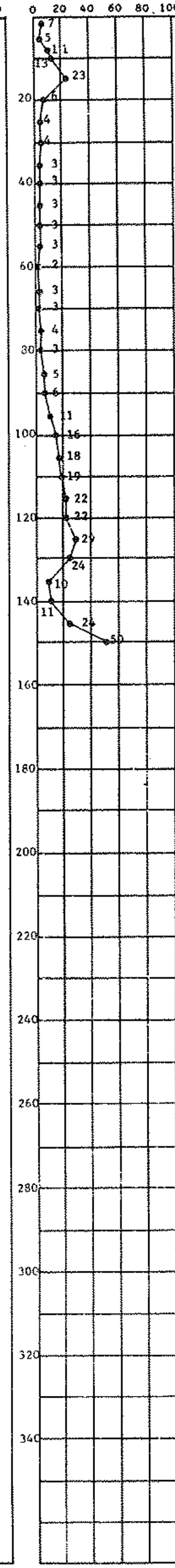
GROUND ELEVATION 594.3

DATE DRILLED: 3-26-74 3-27-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100	% CORE RECOVERY	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN				

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



DESCRIPTION

Loose to medium compact, brown, fine to medium sand (SW) trace fine gravel

Stiff, gray, silty clay (CL)
— medium, some sand

soft, gray, silty clay (CH)

Medium, gray, sandy, silty clay (CL) some gravel

— firm, trace of sand and gravel

— medium, silty

medium compact, gray, silty sand (SM) fine

compact, gray, fine to medium gravel (GW) with fine to coarse sand

156.0 - 156.5 ft. shale

Bottom of Hole - Elevation - 437.8
- Depth - 156.5 ft.

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Bentonite and soil

SOIL BORING NO. 165

BECHTEL Belle River

LOCATION: N 3,525 E 12,533 | GROUND ELEVATION 590.8 | DATE DRILLED: 3-5-74 3-7-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

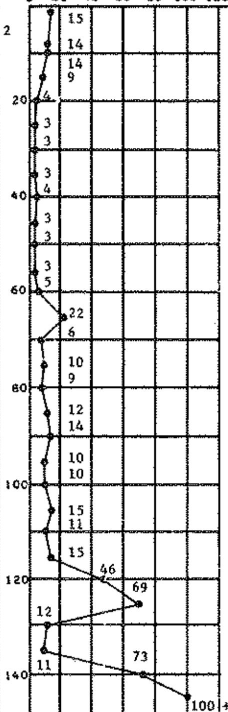
MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER: SHELBY TUBES

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120



SYMBOL

DEPTH IN FEET

DESCRIPTION

cinders, fill

stiff, brown and gray, silty Clay (CL) some fine sand

firm, gray, trace fine sand

▽ 4-25-74 Elevation of water-578.3 Depth of water-10.0 ft.

Very soft to soft, gray, silty clay (CH)

plastic, gray, silty Clay (CL) some fine sand

compact, dark gray, Clayey Sand (SC) few pebbles

plastic to firm, gray, silty Clay (CL) some fine sand

compact, gray, very fine Sand (SP)

plastic, gray, silty Clay (CL) trace fine sand

compact, gray, clayey Silt (ML)

143.5 - 144.0ft Shale, soft, gray

Bottom of Hole-Elevation-446.8 -Depth-144.0ft

No gain or loss of water

Piezometer Installation:
3 feet of 2 inch pvc blank casing from 144.0 to 141.0 feet, 4 feet of #80 screen from 141.0 to 137.0 feet, 141.3 feet of 2 inch pvc casing from 137.0 to 4.3 feet above ground surface, backfilled with sand around screen, annulus backfilled with bentonite and soil to ground surface.

For Water Table information consult Section 4.1.3.

SOIL BORING NO. 181

BECHTEL Belle River

LOCATION: N 3,556 / E 9,564

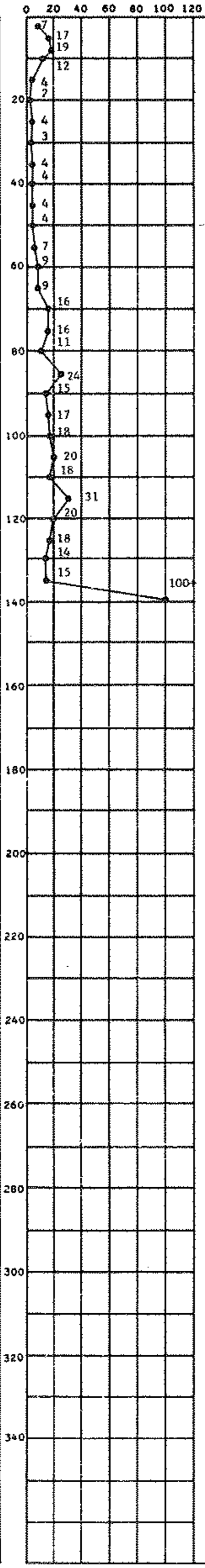
GROUND ELEVATION: 586.1

DATE DRILLED: 3-15-74 / 3-19-74

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100 120	SYMBOL	DESCRIPTION
				NO UNDISTURBED SAMPLES TAKEN			

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



DESCRIPTION

topsoil

Stiff, brown, silty clay (CL), trace fine sand, some gray mottling

Very soft to soft gray, silty clay (CH)

Plastic, gray, silty clay (CL), some fine sand

Plastic to firm, some fine sand, few pebbles

138.5-139.92 ft shale, gray, soft

Bottom of hole - Elevation - 446.18
" - Depth - 139.92 ft

No gain or loss of water

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and soil

SOIL BORING NO. 184

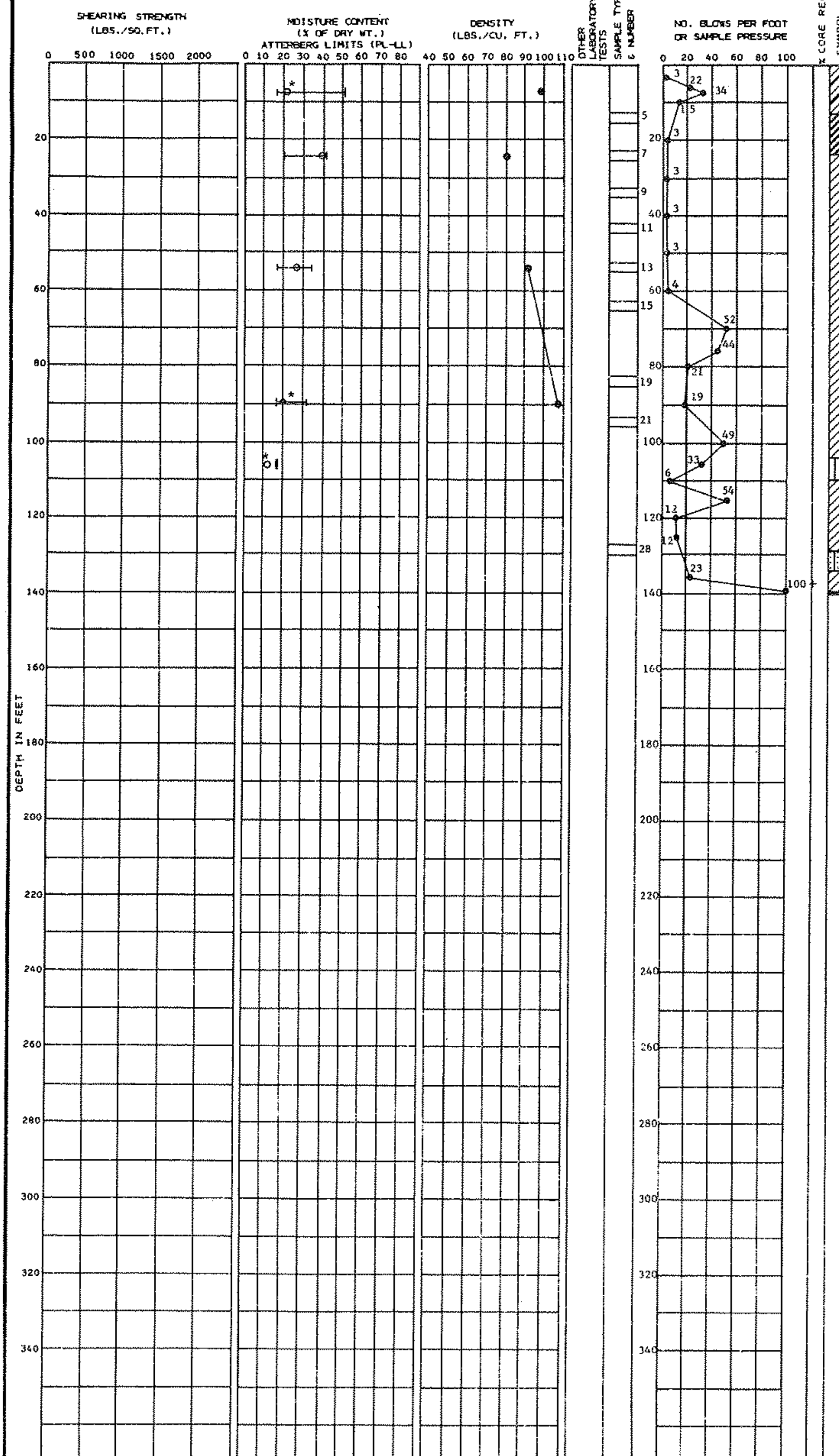
BECHTEL Belle River

LOCATION: N 5,500 E 9,797

GROUND ELEVATION: 586.8

DATE DRILLED: 2-26-74 2-27-74

SHEET 1 OF 1



DESCRIPTION

Very soft, brown & gray, silty, sandy Clay (CL-CH)
- stiff, brown, silty, some fine sand
- gray mottling
- plastic, gray, some fine sand

Very soft to soft, gray, silty Clay (CH)

Soft, moderate to high plasticity, gray, silty Clay (CL)
- soft to firm, 20% fine to coarse sand
- stiff, sandy, with silt & sand lenses
- firm to stiff, few pebbles
- moderate plasticity, 20% fine to coarse sand

Compact, gray Silt (ML) trace of clay & 20% fine sand, nonplastic

Hard, gray, sandy Clay (CL) some pebbles
- plastic to firm, silty, some fine sand

Compact, gray, very fine Silty Sand (SM)

Very hard, gray, sandy Clay (CL) some pebbles
- 139.0-139.3 Shale, gray, soft

Bottom of Hole - Elevation - 447.5
- Depth - 139.3 ft

No gain or loss of water.

For Water Table information consult Section 4.1.3.

Hole backfilled with Quik-Gel and natural soil.

O Moisture Content
├──┤ Atterburg Limits
* Water content taken from unsealed jar sample.

SOIL BORING NO. 186

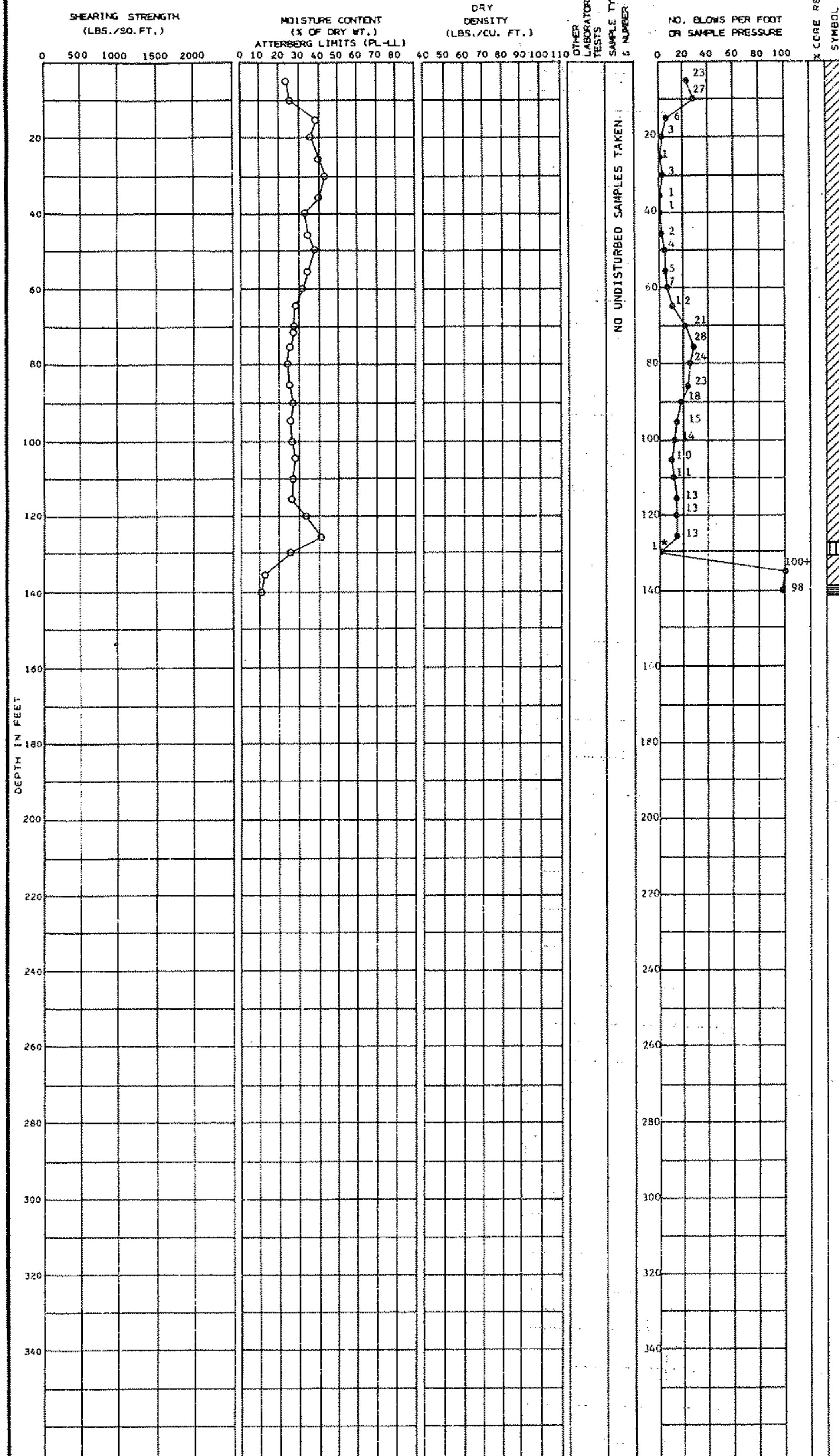
BECHTEL Belle River

LOCATION: N 3500 E 11741

GROUND ELEVATION: 585.2

DATE DRILLED: 8/6/75 8/8/75

SHEET 1 OF 1



DESCRIPTION

Medium stiff, mottled brown & gray, slightly moist, silty Clay (CL) trace shale fragments
- brown
- very soft, gray, moist
- trace very fine sand and pebbles
- very slight trace sand
- trace sand
- medium stiff
- stiff, trace sand and very fine gravel
- hard, trace to little sand and very fine gravel
- stiff
- less very fine gravel
- medium stiff

Very soft, moist, gray Silt (ML)

Medium stiff, gray, moist, silty Clay (CL) trace sand
- very hard, slightly moist, trace to little sand

138-140.5 ft. Shale, gray, highly weathered

Bottom of Hole - Elevation - 444.7
- Depth - 140.5 ft.

Boring grouted with cement at completion.

* Possibly caused by unbalanced hydrostatic head.

For Water Table information consult Section 4.1.3.

SOIL BORING NO. 191

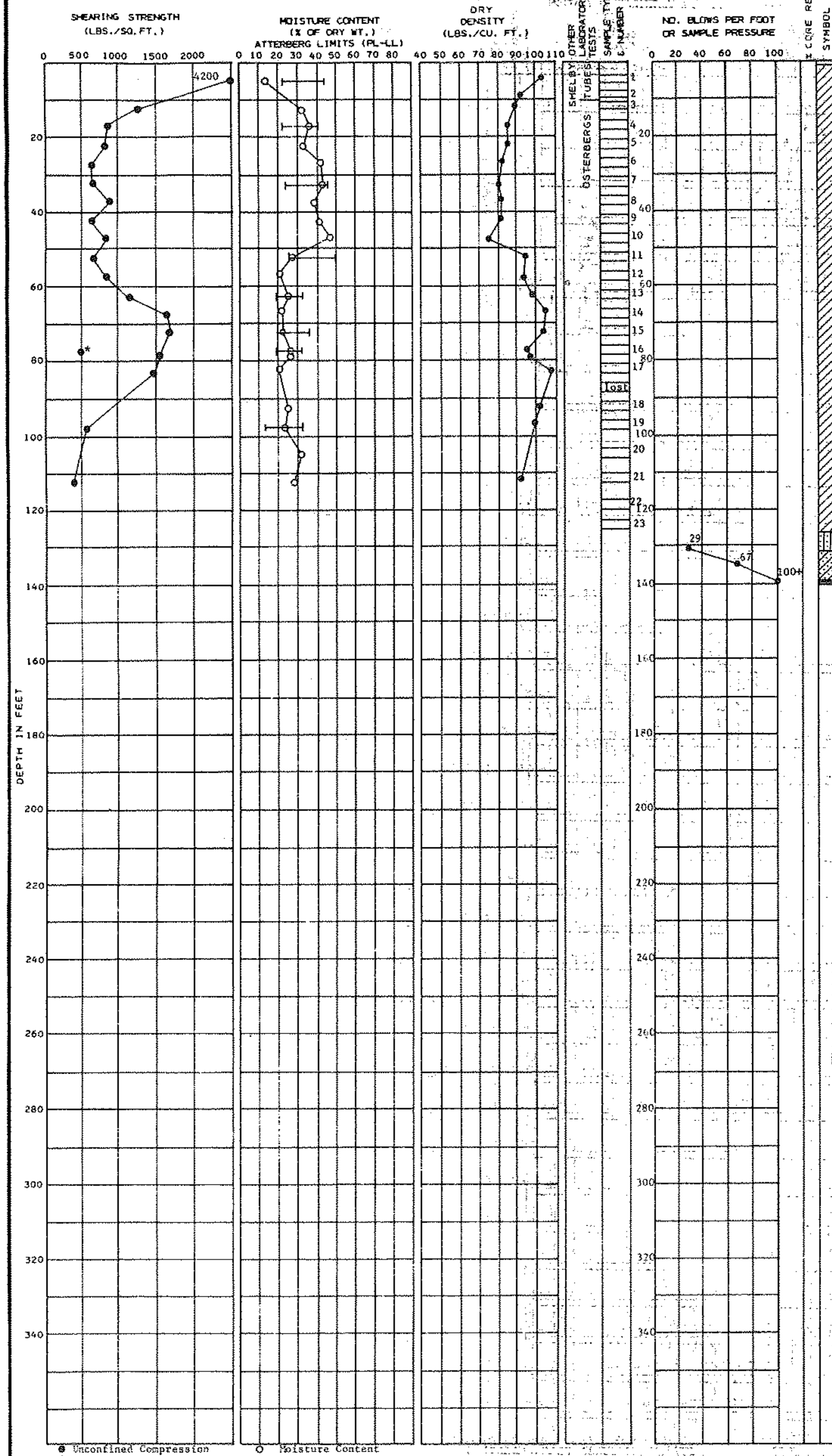
BECHTEL BELLE RIVER

LOCATION: N 3558 E 11701

GROUND ELEVATION 585.2

DATE DRILLED: 8/11/75 8/14/75

SHEET 1 OF 1



DESCRIPTION

Topsoil

Stiff, mottled brown & gray, slightly moist, silty Clay (CL) trace sand

gray, trace sand

medium stiff

soft

slightly stiffer, trace sand

medium stiff, moist, trace to little sand and fine gravel

trace sand and very fine gravel, possible sand or silt seams

more fine gravel

Medium dense, gray, fine to medium Silty Sand (SM)

Very dense, gray, medium coarse Clayey Sand (SC) trace gravel

139.5-140 ft, Shale, gray, very hard, weathered

Bottom of Hole - Elevation - 445.2
- Depth - 140.0 ft.

Boring grouted with cement at completion.

For Water Table information consult Section 4.1.3.

⊗ Unconfined Compression
* Sample contained sand seams.

○ Moisture Content
|—| Atterberg Limits

SOIL BORING NO. 193

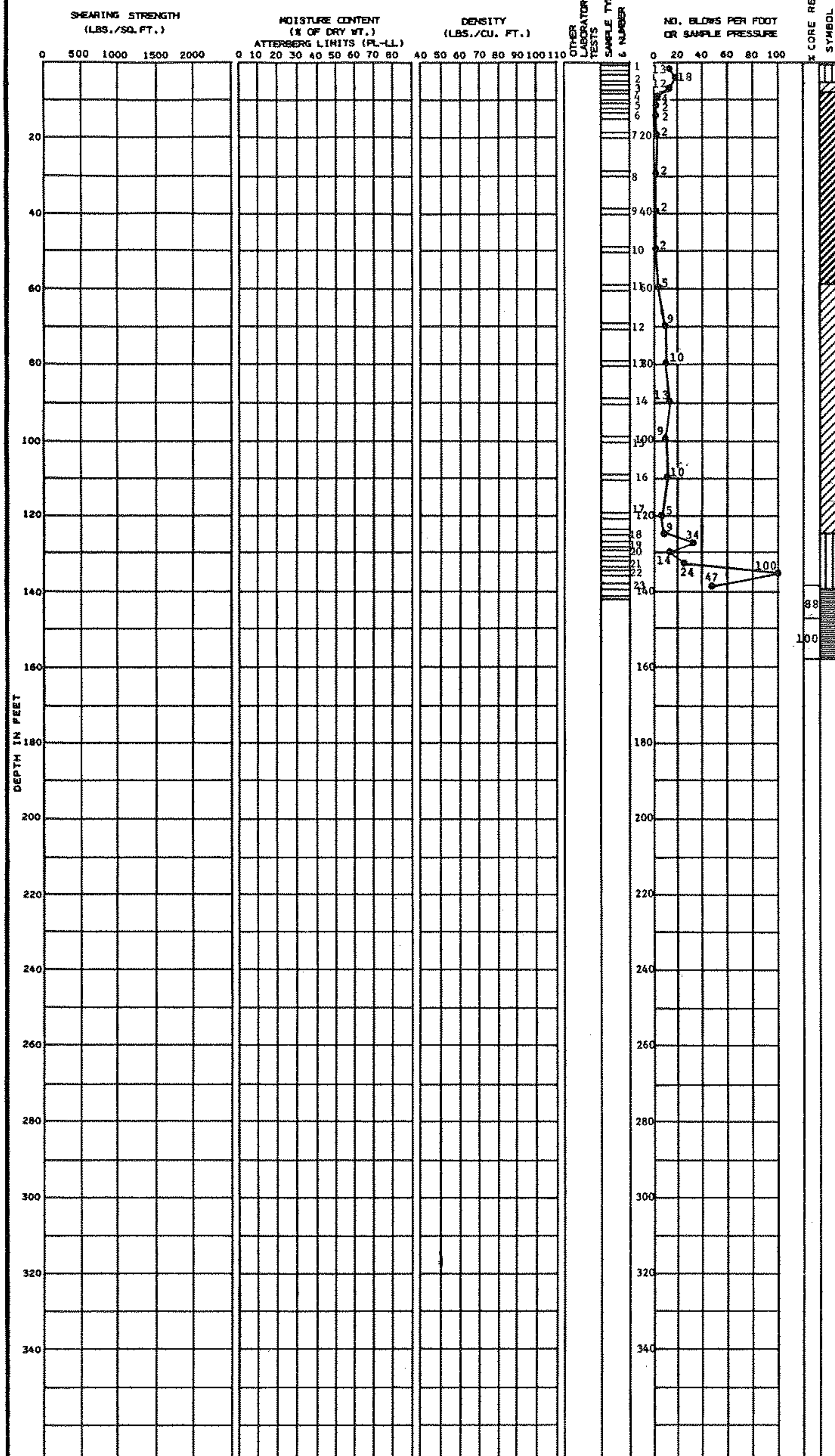
BECHTEL BELLE RIVER

LOCATION: N 7800 E 9400

GROUND ELEVATION 585.1

DATE DRILLED: 8/17/77 8/22/77

SHEET 1 OF 1



DESCRIPTION

0-0.5' Topsoil, silty, dark brown, roots

0.5-5.5' Clayey Silt, brown and med. gray, mottled, med. dense, slight plasticity, dry, trace fine to med. gravel (ML)

5.5-8.0' Silty Clay, med. gray, stiff, med. plasticity, moist, trace sand, trace fine gravel (CL)

8.0-58.5' Clay, med. gray, very soft, high plasticity, wet, trace silt, trace fine sand (CH)

58.5-125.5' Silty Clay, med. gray, soft, med. plasticity, moist, trace to little sand, trace fine gravel(CL)
58.5-88.5' Little sand
68.5-88.5' Med. Stiff

88.5-98.5' Stiff
88.5-118.5' Trace sand

98.5-125.5' Med. stiff

105.5-106.0' Small cobbles

118.5-125.5' Occasional fine-grained sand seams

125.5-138.8' Clayey Silt, med. gray, med. dense to dense, moist, with fine-grained sand seams (ML)
127.5-128.3' Fine gravel
134.5-136.3' Boulder
138.1-138.8' Boulder

138.8' Top of Rock
138.8-157.5' Shale, dark gray, soft, friable, slightly fissile, occasional mechanically fractured
149.8-157.5' Harder, scattered, thin black shale stringers

Bottom of Hole: Depth 157.5'
Elevation 427.6

Hole grouted from 157.5' to ground surface.

SOIL BORING NO. B-1

BECHTEL Belle River

LOCATION: N 7600 E 9200

GROUND ELEVATION: 585.0

DATE DRILLED: 8/23/77 8/25/77

SHEET 1 OF 1

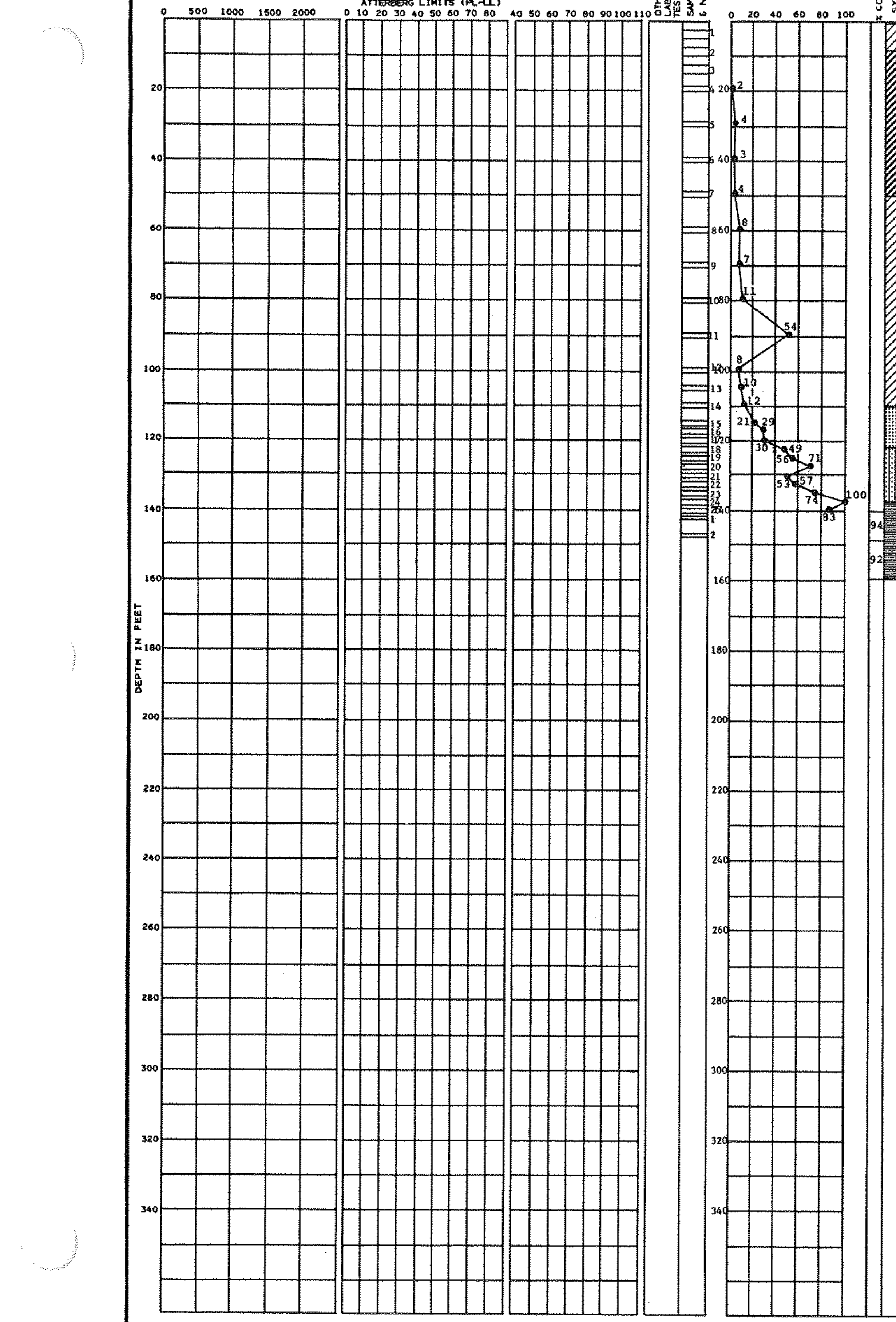
SHEARING STRENGTH (LBS./SQ. FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS | SAMPLE TYPE & NUMBER | NO. BLOWS PER FOOT OR SAMPLE PRESSURE | % CORE RECOVERY | SYMBOL

DEPTH IN FEET



DESCRIPTION

0-0.5' Topsoil, silty, dark brown, dry

0.5-8.0' Silty Clay, brown and gray, mottled, slight to med. plasticity, moist, trace roots, trace fine to coarse gravel (CL)

8.0-49.5' Clay, med. gray, very soft to soft, high plasticity, wet, trace silt, trace fine gravel (CH)

49.5-109.5' Silty Clay, med. gray, med. stiff, med. plasticity, moist, little sand, trace fine gravel (CL)

78.5-88.5' Stiff

88.5-98.5' Hard

109.5-121.0' Sand, med. gray, med. dense, wet, fine-to med.-grained, trace silt (SP)

121.0-136.5' Silty Sand, med. gray, dense to very dense, moist, fine-grained, trace fine gravel, scattered thin silt seams (SM)

135.5-136.5' Med. gray silt with thin fine-grained sand seams

Cobble on top of rock

136.5' Top of Rock

136.5-158.5' Shale, dark gray, soft, silty, fractures easily, air slakes readily

145.0-148.6' Moderately hard with occasional soft silty layers

148.5-158.5' Hard, massive

150.9-153.5' Very fine-grained, hard, irregularly bedded sandy layers interbedded with shale

156.6-157.5' Soft

Bottom of Hole: Depth 158.5'
Elevation 426.5

Hole grouted from 158.5' to ground surface.

SOIL BORING NO. B-2

BECHTEL Belle River

LOCATION:	N 7850, E 9200
GROUND ELEVATION	585.5
DATE DRILLED:	8/2/77 – 8/4/77
SHEET	1 OF 1

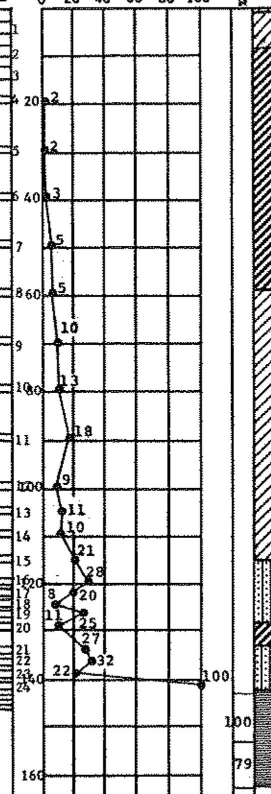
SHEARING STRENGTH (LBS./SQ.FT.) — 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) — 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) — 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS | SAMPLE TYPE & NUMBER | NO. BLOWS PER FOOT OR SAMPLE PRESSURE (0 20 40 60 80 100) | % CORE RECOVERY | SYMBOL

DEPTH IN FEET



DESCRIPTION

0-1.0' Topsoil, clayey silt, dark brown to light brown, dry, wood fragments and roots (ML)

1.0-8.5' (?) Silty Clay, med. brown, med. plasticity, moist, trace fine to coarse gravel (CL)

8.5-58.5' Clay, med. gray, very soft, very high plasticity, wet, trace silt, trace fine angular gravel (CH)

46.5-58.5' Soft

58.5-114.5' Silty Clay, med. gray, soft to med. stiff, high plasticity, moist to wet, trace to little fine sand, trace fine to coarse gravel(CL)

78.5-88.5' Stiff

88.5-98.5' Very stiff

98.5-114.5' Stiff to med. stiff
103.5 Less sand, occasional 1/4" pits of red clay
104.0' 1/2" light gray, fine-grained, sand pit
113.5' Trace silt, trace sand

114.5-128.5' Silty Sand, med. gray, med. dense, moist to wet, fine-grained, with thin seams of silt and clay(SM)
123.5-125.0' Loose

128.5-133.3' Clay, med. gray, stiff, high plasticity, wet, trace silt, trace fine gravel, occasional pits of red clay (CH)

133.3-142.0' Silty Sand, med. gray, med. dense to dense, moist to wet, fine-grained, occasional silt and clay seams (SM)
141.7-142.0' Coarse sand seam

142.0' Top of Rock
142.0-162.5' Shale, dark gray, soft, massive, friable
155.0-162.5' Hard
159.0-160.5' Core mechanically fractured

Bottom of Hole: Depth 162.5'
Elevation 423.0

Hole grouted from 162.5' to ground surface.

SOIL BORING NO. B-4

BECHTEL Belle River

LOCATION: N 7600 E 9400

GROUND ELEVATION 584.8

DATE DRILLED: 7/26/77 8/1/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ. FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100

% CORE RECOVERY

SYMBOL

DEPTH IN FEET

Sample No.	Blows per foot
1	14
2	17
3	13
4	4
5	2
6	2
7	3
8	3
9	5
10	12
11	11
12	10
13	15
14	19
15	11
16	9
17	8
18	14
19	9
20	37
21	25
22	26
23	45

% Core Recovery
65
100
94

DESCRIPTION

0-1.0' Silty Clay, topsoil, dark brown to green brown, stiff, slight plasticity, moist, trace sand, with roots and wood fragments (CL)

1.0-6.0' Clayey Silt, light brown to gray, med. dense, dry, trace sand, trace fine gravel (ML)

6.0-8.5' Clay, dark brown, stiff, med. plasticity, moist, trace silt (CL)

8.5-54.0' Clay, med. gray, soft to very soft, very high plasticity, wet, trace fine angular gravel (CH)

54.0-127.5' Silty Clay, med. gray, stiff, med. plasticity, moist, trace sand, trace fine to coarse gravel (CL)

73.5-75.0' Med. stiff

93.5-103.5' Very stiff

103.5-113.5 Stiff

113.5-126.0' Med. stiff

123.5-124.4' Clay seam, high plasticity

124.4-125.0' Silty sand seam, fine-grained, wet

126.0-127.5' Stiff, some sand

127.5-137.8' Silt and Sand, med. gray, med. dense to dense, wet, sand fine-grained (ML and SM)

137.8' Top of Rock

137.8-160.0' Shale, dark blue gray to black, soft, fissile, dry

142.6-144.2' and 154.5-160.0' Core completely fractured into 1/4" or less pieces

150.5-153.0' Core fractured into 1/4" to 4" pieces

Bottom of Hole: Depth 160.0'
Elevation 424.8

Hole grouted from 160.0' to ground surface.

SOIL BORING NO. B-5

BECHTEL Belle River

LOCATION: N 7650 E 9550

GROUND ELEVATION: 585.7

DATE DRILLED: 8/25/77 8/31/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) — MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) — DENSITY (LBS./CU. FT.) — OTHER LABORATORY TESTS — SAMPLE TYPE & NUMBER — NO. BLOWS PER FOOT OR SAMPLE PRESSURE — % CORE RECOVERY — SYMBOL — DEPTH IN FEET

DESCRIPTION

0-0.3' Topsoil, dark brown, silty, dry

0.3-7.0' Clayey Silt, brown and gray, mottled, med. dense, none to slight plasticity, dry, abundant wood fragments, trace fine gravel (ML)

7.0-8.5' Silty Clay, med. gray, med. stiff, med. plasticity, moist, trace sand, trace fine gravel (CL)

8.5-56.0' Clay, med. gray, very soft, high plasticity, moist to wet, trace silt, trace sand, trace fine gravel (CH)

11.0-56.0' Wet

48.5-56.0' Soft

56.0-141.0' Silty Clay, med. gray, med. stiff, med. plasticity, moist, little sand, trace fine gravel (CL)

68.5-78.5' Very stiff

78.5-88.5' Trace sand

88.5-118.5' Little sand

98.5-108.5' Very stiff

108.5-136.0' Stiff

123.5-125.0' Scattered, fine-grained sand seams

130.5-133.5' Scattered silt and fine-grained sand seams

133.5-136.0' Silt with silty clay seams, wet

136.0-138.5' Dense, fine-grained silty sand, wet, trace med. gravel

138.5-141.0' Very stiff clayey silt with fine-grained sand seams, wet

141.0' Top of Rock

141.0-163.5' Shale, med. gray, soft to firm, massive to slightly fissile, occasional interbeds of soft clay, shale air slakes rapidly, core mechanically fractured.

150.0-158.8' Hard, with very thin sandy interbeds

Bottom of Hole: Depth 163.5' Elevation 422.2

Hole grouted from 163.5' to ground surface.

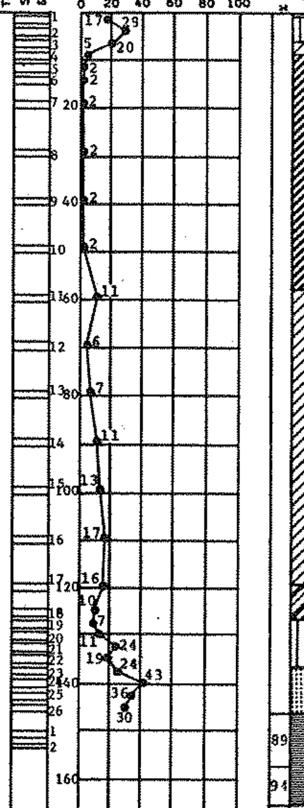
SOIL BORING NO. B-6

BECHTEL Belle River

LOCATION: N 8180 E 9550 | GROUND ELEVATION: 585.3 | DATE DRILLED: 8/12/77 8/17/77 | SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100	% CORE RECOVERY	SYMBOL	DESCRIPTION

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340



DESCRIPTION

0-0.5' Topsoil, silty dark brown

0.5-6.0' Clayey Silt, light gray and med. brown, mottled, med. dense, slight plasticity, dry, trace fine gravel, roots (ML)

6.0-8.5' Silty Clay, med. brown, very stiff, med. plasticity, very stiff, med. plasticity, moist, trace fine gravel (CL)

8.5-57.0' Clay, med. gray, soft to very soft, high plasticity, wet, trace silt (CH)

48.5' Trace fine to med. gravel

57.0-118.5' Silty Clay, med. gray, stiff, med. plasticity, moist, trace to little sand, trace fine gravel (CL)
68.5-88.5' Med. stiff

78.5-118.5' Little fine sand

108.5-118.5' Very stiff

118.5-125.5' Clay, med. gray, very stiff, med. plasticity, moist, trace silt (CL-CH)
123.5-125.5' Med. stiff

125.5-135.5' Clayey Silt, med. gray, loose to med. dense, wet, trace sand occasional fine to med.-grained sand seams (ML)
128.5-131.0' Sandy silt
131.0-132.0' Fine-grained silty sand seam

135.5-145.0' Sand, gray and brown, med. dense to dense, wet, fine-to med. grained, trace silt (SP)
143.5-144.5' Clayey sand

145.0' Top of Rock
145.0-164.0' Shale, green-gray, hard, occasional irregular bedding with very fine black coal stringers, predominately massive
148.7-149.3' Very fine-grained, hard, irregularly bedded sandy layers inter-bedded with shale
162.7-164.0' Soft dark gray, dry, friable

Bottom of Hole: Depth 164.0'
Elevation 421.3
Hole grouted from 164.0' to ground surface.

SOIL BORING NO. B-13

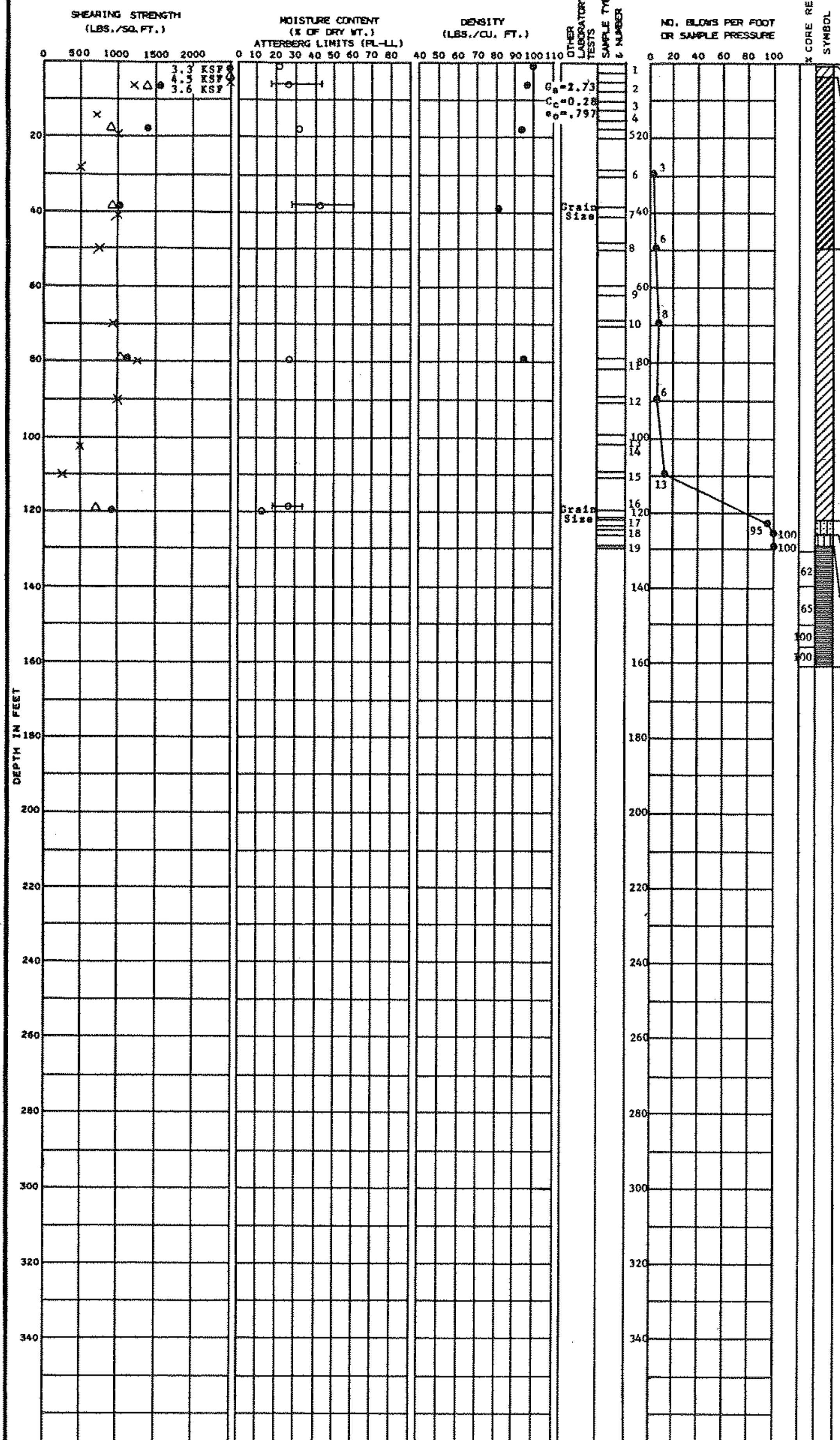
BECHTEL Belle River

LOCATION: N 5270 E 15660

GROUND ELEVATION 580.0

DATE DRILLED: 9/7/77 9/14/77

SHEET 1 OF 1



DESCRIPTION

0-0.5' Topsoil, dark brown, dry

0.5-3.0' Silty Clay, med. brown, gray and black, mottled, slight to med. plasticity, moist, trace fine gravel (CL)

3.0-48.5' Clay, med. gray, very soft, high plasticity, moist to wet, trace silt (CH)

48.5-120.5' Silty Clay, dark gray, med. stiff, med. plasticity, moist, little sand, trace fine to med. gravel (CL)

108.5-120.5' Stiff, trace sand

118.5'-120.4' Seams of silt, clayey sand, and silty sand

120.5-124.6' Silty Sand, med. gray, very dense, moist, fine to med.-grained, trace fine gravel, occasional silt seams (SM)

124.6-128.0' Clayey Silt, med. gray, very dense, dry, trace fine gravel (ML)

128.0' Top of Rock

128.0-159.5' Shale, dark grey, soft, weathered, fragments as abstracted from core barrel

151.3' Slightly harder with soft lenses, splits easily

155.0' Moderately hard core broken every 1"-2"

Bottom of Hole: Depth 159.5'
Elevation 420.5

Hole grouted from 159.5' to ground surface.

Discovered gas in hole when removing casing.

Symbol	Meaning	Symbol	Meaning
△	Torvane	G_s	Specific Gravity
O	Unconsolidated Undrained	C_c	Compression Index
●	Unconfined Compression	e_o	Initial Void Ratio
├─┤	Atterberg Limits	X	Pocket Penetrometer

SOIL BORING NO. B-17

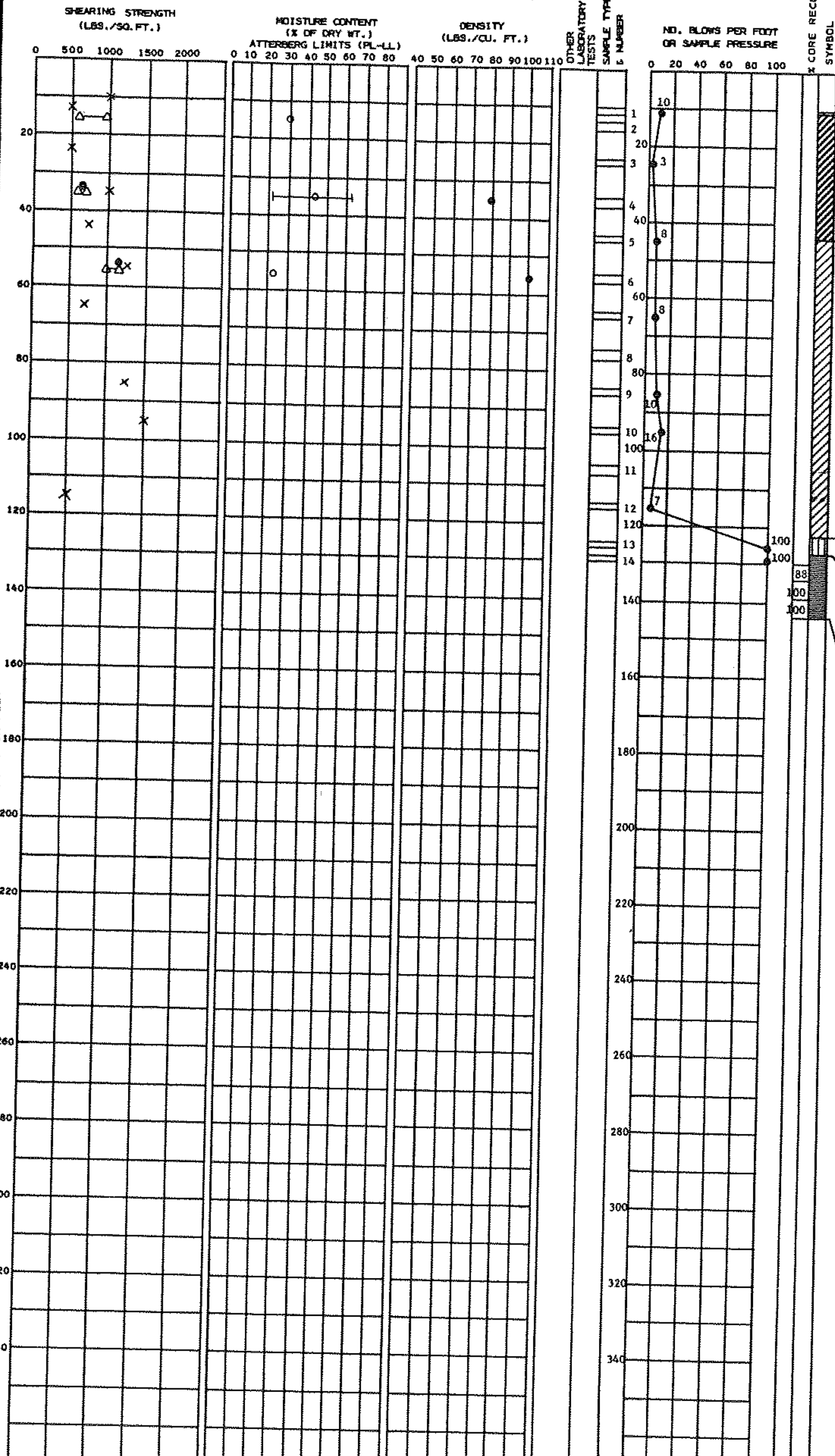
BECHTEL Belle River

LOCATION: N 5163 E 15744

GROUND ELEVATION: 577.5 (Top of Water)

DATE DRILLED: 9/21/77 9/27/77

SHEET 1 OF 1



DESCRIPTION
0-10.0' Water
10.0-10.3' Sandy Clay, dark gray to black, very soft, wet, trace fine to coarse gravel (CL)
10.3-43.5' Clay, gray-brown, med. stiff, high plasticity, moist to wet, trace silt (CH) 18.0-43.5' Very soft
43.5-122.0' Silty Clay, med. gray, med. stiff, med. plasticity, moist, trace to little sand, trace fine gravel (CL) 93.5-113.5' Very stiff, trace sand 113.5-122.0' Med. stiff, trace silt, trace sand
122.0-127.0' Silt, light gray, very dense, dry, with fine sand (ML)
127.0' Top of Rock 127.0-144.0' Shale, med. gray, soft, weathered 131.7-144.0' Moderately hard with soft clay interbeds 139.0-144.0' Occasional soft clay layers
Bottom of Hole: Depth 144.0' Elevation 433.5 Hole grouted from 127.0' to ground surface.

△ Torvane
⊢ Atterberg Limits
● Unconfined Compression
○ Unconsolidated Undrained
× Pocket Penetrometer

SOIL BORING NO. B-22

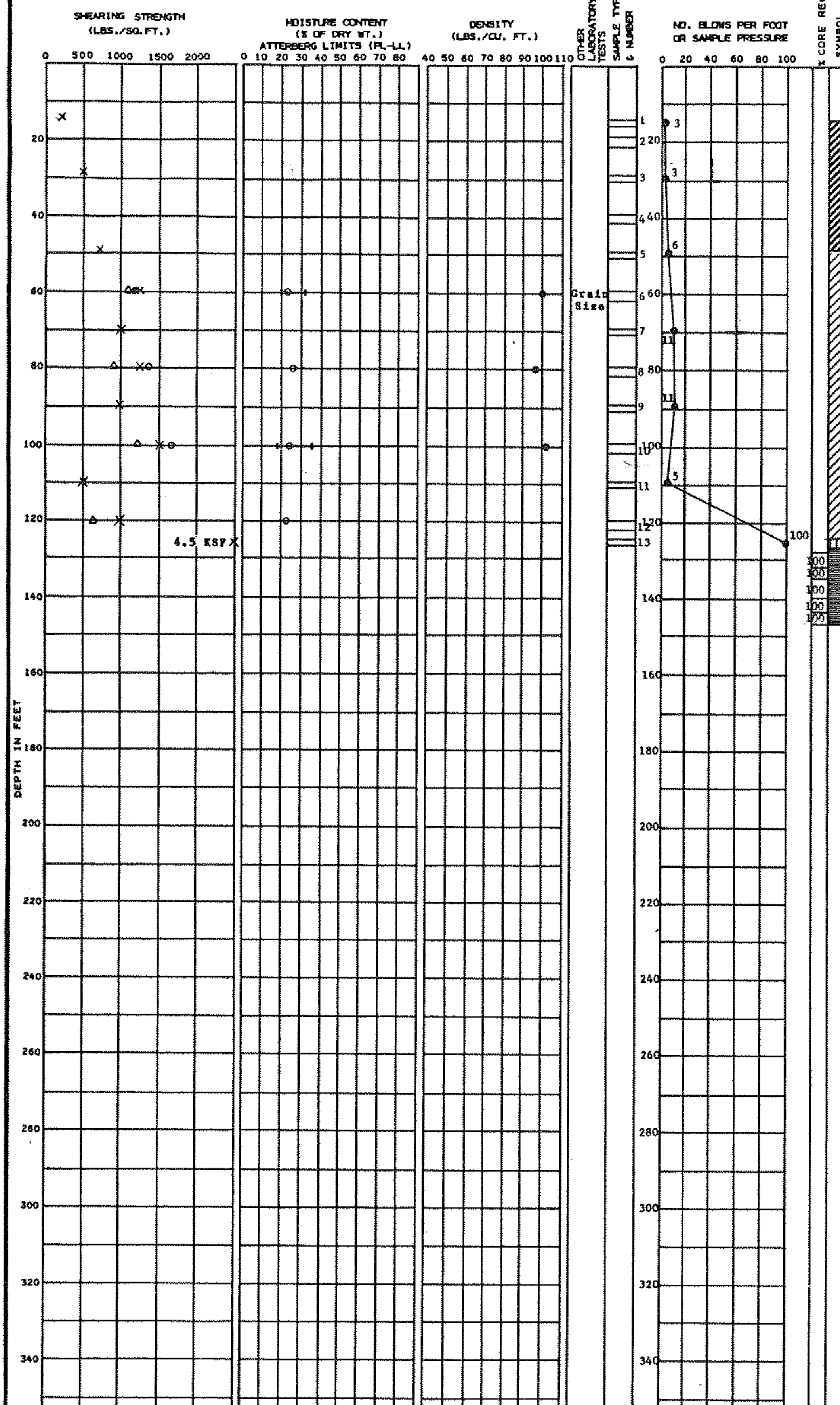
BECHTEL Belle River

LOCATION: N 5364 E 15750

GROUND ELEVATION: 577.5 (Top of Water)

DATE DRILLED: 9/15/77 9/21/77

SHEET 1 OF 1



DESCRIPTION

0-14.0' Water

14.0-47.5' Clay, light gray-brown, very soft, high plasticity, wet, trace silt (CH)

47.5-123.0' Silty Clay, med. gray, med. stiff, med. plasticity, moist, trace sand, trace fine gravel (CL)

68.5-108.5' Stiff

100.3' Gray, sandy

108.5-123.0' Soft
118.5'-121.2' Layers of clay, silt, clayey sand, and silty sand

123.0-126.5' Silt with fine-grained sand seams, med. gray, very dense, trace fine gravel (ML)

126.5' Top of Rock
126.5-146.4' Shale, dark gray, very soft, weathered
128.8-132.5' Soft
132.5-146.4' Moderately hard with interbeds of soft clay, core breaks easily

Bottom of Hole: Depth 146.4'
Elevation 431.1

Hole grouted from 146.4' to ground surface.

△ Torvane
○ Unconsolidated Undrained
● Unconfined Compression
├─┤ Atterberg Limits
× Pocket Penetrometer

SOIL BORING NO. B-23

BECHTEL Belle River

LOCATION: N 7113 E 11039

GROUND ELEVATION: 588.5

DATE DRILLED: 9/1/77 9/1/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

SAMPLE TYPE & NUMBER

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100

% CORE RECOVERY

SYMBOL

DEPTH IN FEET: 0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

Sample	Blows per foot
1	12
2	7
3	28
4	13
5	8
6	4
7	4
8	4

DESCRIPTION

0-0.8' Topsoil, dk. brown, dry

0.8-4.0' Clayey Silt, yellow to med. brown, med. dense, dry, trace sand, trace fine to coarse gravel, roots (ML)

4.0-17.0' Silty Clay, dk. brown and gray, mottled, med. stiff to very stiff, med. plasticity, moist, trace sand, trace fine to coarse gravel (CL)
9.0' Med. brown
13.5' Med. gray

17.0-30.0' Clay, med. gray, soft, high plasticity, moist to wet, trace silt, trace sand, trace fine gravel (CH)

Bottom of Hole: Depth 30.0'
Elevation 558.5

Hole backfilled with cuttings.

SOIL BORING NO. B-24

BECHTEL Belle River

LOCATION: N 6921 / E 11501

GROUND ELEVATION: 587.5

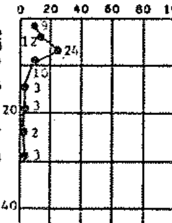
DATE DRILLED: 9/1/77 / 9/1/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	% CORE RECOVERY	SYMBOL	DESCRIPTION
0 500 1000 1500 2000	0 10 20 30 40 50 60 70 80	40 50 60 70 80 90 100 110			0 20 40 60 80 100			

DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

Sample numbers: 1, 2, 3, 4, 5, 6, 7, 8



DESCRIPTION

0-0.7' Topsoil, dk. brown, dry

0.7-4.5' Silty Sand, tan and yellow, mottled, loose, damp, fine-grained (SM)

4.5-9.0' Silty Clay, brown and gray, mottled, stiff to very stiff, med. plasticity, moist, trace sand, trace fine to coarse gravel (CL)

9.0-30.0' Clay, med. gray, very soft, high plasticity, moist to wet, trace sand, trace fine gravel, trace silt (CH)

Bottom of Hole: Depth 30.0'
Elevation 557.5

Hole backfilled with cuttings.

SOIL BORING NO. B-26

BECHTEL Belle River

LOCATION: N 6730 E 11963

GROUND ELEVATION: 588.1

DATE DRILLED: 9/1/77 – 9/1/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.)	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL)	DENSITY (LBS./CU. FT.)	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE	% CORE RECOVERY	SYMBOL	DESCRIPTION
				1	11			0-0.7' Topsoil, dr. brown, dry
				2	7			0.7-4.0' Silty Sand, tan and gold, mottled, med. dense, dry, fine-grained, roots (SM)
				3	21			
				4	10			
				5	3			4.0-13.5' Silty Clay, gray and brown, mottled, med. stiff to very stiff, med. plasticity, moist, trace sand, trace fine gravel (CL)
								6.0' Green brown
				6	3			13.5-30.0' Clay, med. gray, soft, high plasticity, moist to wet, trace silt, trace fine gravel (CH)
				7	3			
				8	3			

Bottom of Hole: Depth 30.0'
Elevation 558.1

Hole backfilled with cuttings.

DEPTH IN FEET: 0–340

SOIL BORING NO. B-28

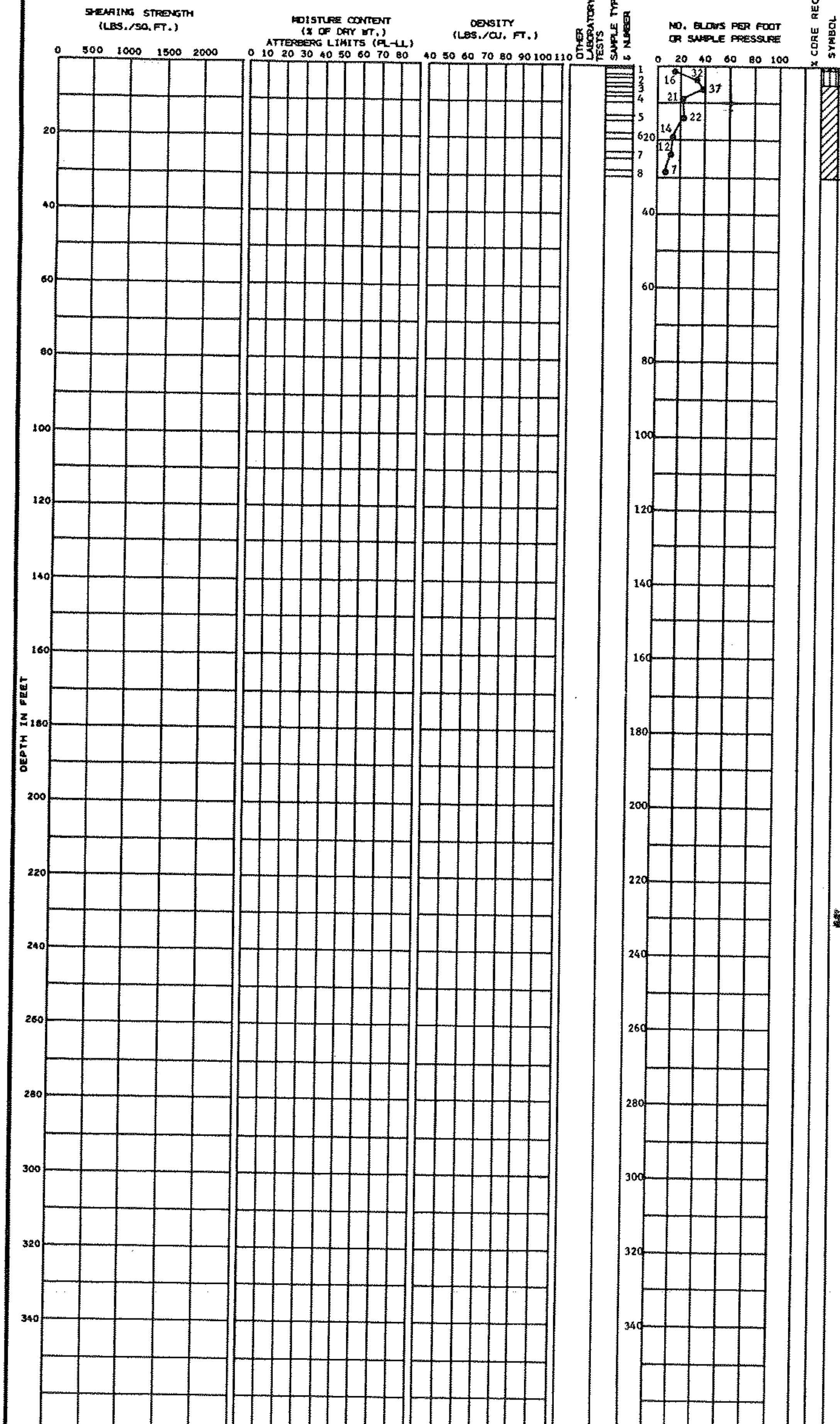
BECHTEL Belle River

LOCATION: N 6539 E 12425

GROUND ELEVATION 588.2

DATE DRILLED: 9/2/77 9/2/77

SHEET 1 OF 1



DESCRIPTION

0-1.0' Topsoil, dk. brown, silty, fine to med. gravel, dry (GM)

1.0-5.0' Clayey Silt, dk. brown, med. dense to dense, dry, trace sand, trace fine gravel (ML)

5.0-30.0' Silty Clay, dk. brown, hard to very stiff, dry, med. plasticity, trace sand, trace fine to med. gravel (CL)

13.5' Moist, dipping parting in sample, med. brown with med. gray filling, with roots

19.0-28.5' Med. grey, stiff

23.5' green-brown and grey, mottled

28.5-30.0' Med. gray, med. stiff

Bottom of Hole: Depth 30.0'
Elevation 558.2

Hole backfilled with cuttings.

SOIL BORING NO. B-30

BECHTEL Belle River

LOCATION: N 6348
E 12890

GROUND ELEVATION: 600.0

DATE DRILLED: 9/1/77
9/1/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000

MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80

DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110

OTHER LABORATORY TESTS

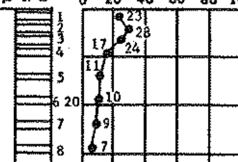
SAMPLE TYPE & NUMBER

NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100

% CORE RECOVERY

SYMBOL

DEPTH IN FEET



DESCRIPTION

0-1.0' Topsoil, dk. brown, silty, dry, sandy fill with coarse gravel

1.0-6.0' Clayey Silt, green brown, med. dense, dry, trace sand (ML)

6.0-30.0' Silty Clay, green brown, very stiff, slight plasticity, moist, trace sand, trace fine gravel (CL)
13.5' Med. gray, stiff to med. stiff, med. plasticity
28.5-30.0' Med. to high plasticity

Bottom of Hole: Depth 30.0'
Elevation 570.0

Hole backfilled with cuttings.

SOIL BORING NO. B-32

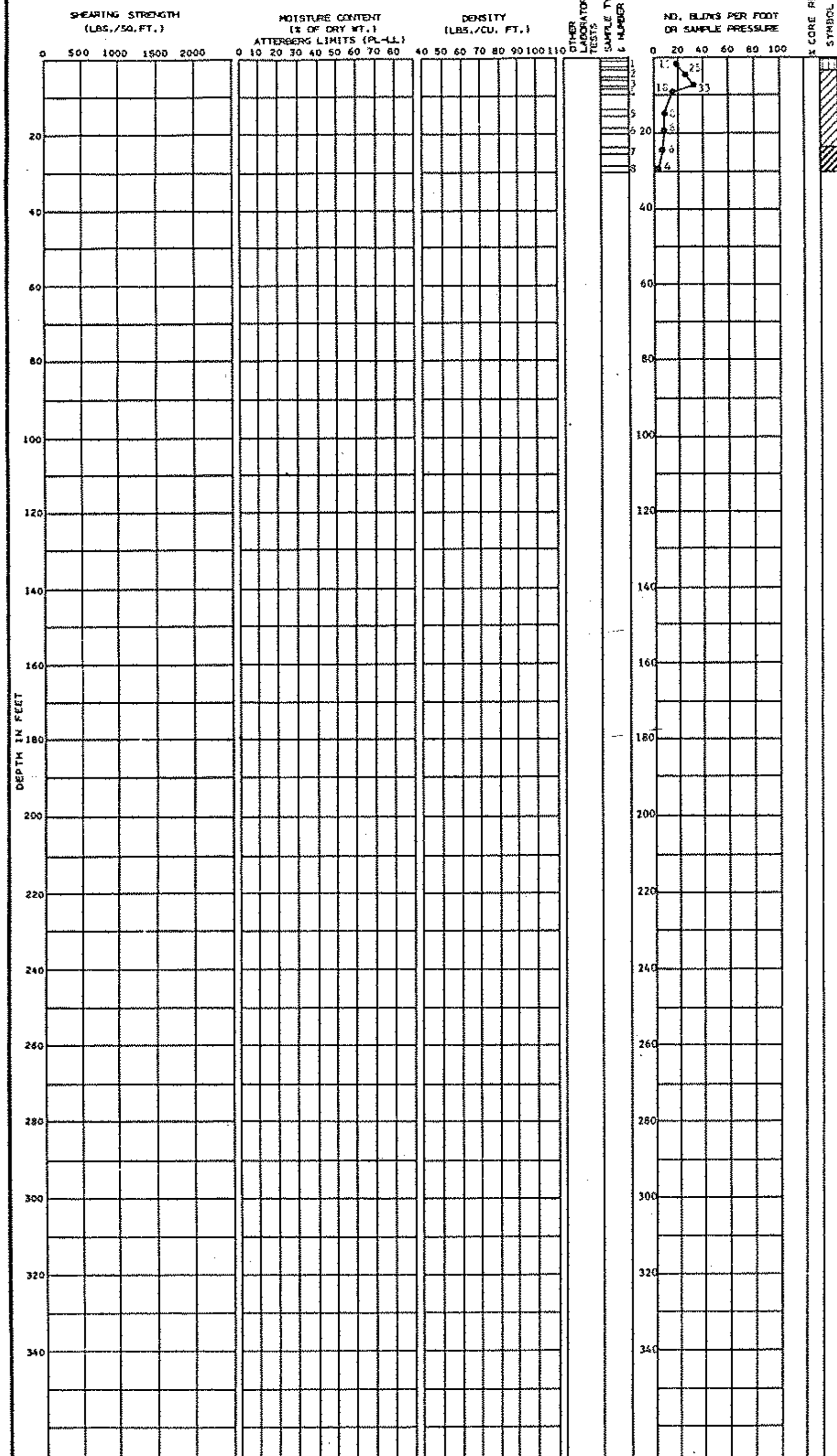
BECHTEL Belle River

LOCATION: N 6156 E 13349

GROUND ELEVATION: 598.8

DATE DRILLED: 9/2/77 9/2/77

SHEET 1 OF 1



DESCRIPTION

0-0.3' Topsoil, dk. brown, dry

0.3-3.5' Clayey Silt, light brown and gray, mottled, med. dense, none to slight plasticity, dry, trace sand, trace fine to coarse gravel (ML)

3.5-23.5' Silty Clay, med. brown and gray, lightly mottled, very stiff to hard, med. plasticity, moist, trace sand, trace fine gravel (CL)
13.5-23.5' Med. gray, med. stiff

23.5-30.0' Clay, med. gray, soft to very soft, high plasticity, moist, trace silt (CH)

Bottom of Hole: Depth 30.0'
Elevation 568.8

Hole backfilled with cuttings.

SOIL BORING NO. B-34

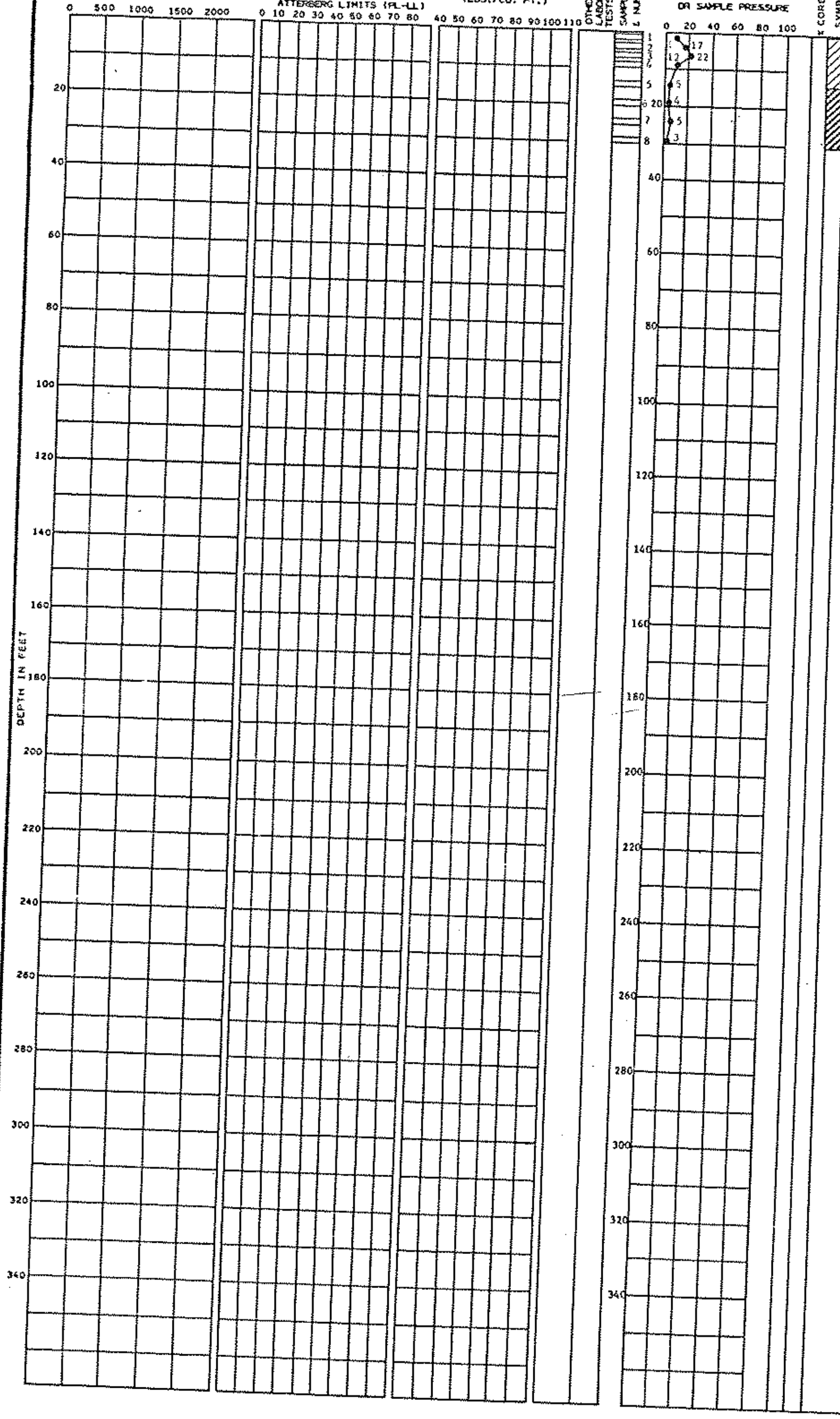
BECHTEL Belle River

LOCATION: N 52?5 / E 1?211

GROUND ELEVATION: 591.5

DATE DRILLED: 9/2/77 / 9/2/77

SHEET 1 OF 1



DESCRIPTION

0-0.4' Topsoil, dk. brown, dry

0.4-14.0' Silty Clay, dk. brown and gray, mottled, very stiff to med. stiff, slight plasticity, moist, trace sand, trace fine gravel (CL)
3.5-5.0' Scattered stringers of calcium carbonate
8.5-14.0' Med. brown

14.0-30.0' Clay, med. gray, soft to very soft, high plasticity, moist, trace silt (CH)

Bottom of Hole: Depth 30.0'
Elevation 561.5

Hole backfilled with cuttings.

SOIL BORING NO. B-36

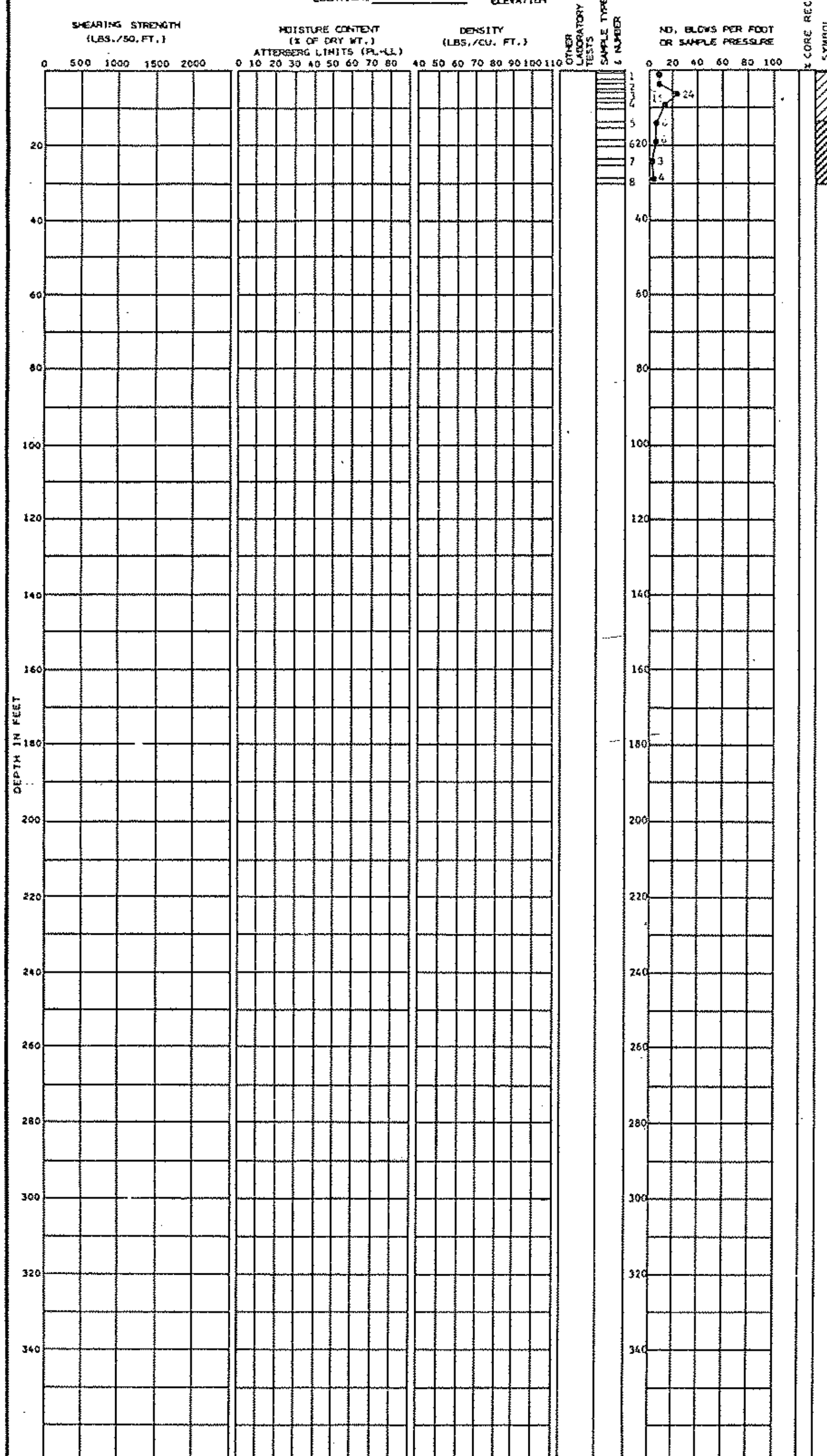
BECHTEL Belle River

LOCATION: N 5774 E 14272

GROUND ELEVATION 591.2

DATE DRILLED: 9/6/77 9/6/77

SHEET 1 OF 1



DESCRIPTION

0-0.3' Topsoil, dk. brown, moist

0.3-13.5' Silty Clay, med. brown and gray, mottled, med. stiff, med. plasticity, trace sand, trace fine gravel (CL)

6.0-8.5' Med. brown, very stiff

8.5-13.5' Med. brown, stiff

13.5-30.0' Clay, med. gray, med. stiff, high plasticity, moist, trace silt (CH)

23.5-28.5' Very soft, moist to wet

28.5-30.0' Soft

Bottom of Hole: Depth 30.0'
Elevation 561.2

Hole backfilled with cuttings.

SOIL BORING NO. B-38

BECHTEL Belle River

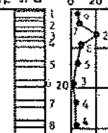
LOCATION: N 5582 E 14735

GROUND ELEVATION 590.2

DATE DRILLED: 9/6/77 9/6/77

SHEET 1 OF 1

SHEARING STRENGTH (LBS./SQ.FT.) 0 500 1000 1500 2000	MOISTURE CONTENT (% OF DRY WT.) ATTERBERG LIMITS (PL-LL) 0 10 20 30 40 50 60 70 80	DENSITY (LBS./CU. FT.) 40 50 60 70 80 90 100 110	OTHER LABORATORY TESTS	SAMPLE TYPE & NUMBER	NO. BLOWS PER FOOT OR SAMPLE PRESSURE 0 20 40 60 80 100	% CORE RECOVERY	SYMBOL	DESCRIPTION
								0-0.4' Topsoil, dk. brown, dry
								0.4-13.5' Silty Clay, med. brown, med. stiff to very stiff, med. plasticity, moist, trace sand, trace fine gravel (CL)
								13.5-30.0' Clay, med. gray, soft to very soft, high plasticity, moist to wet, trace silt (CH)
								Bottom of Hole: Depth 30.0' Elevation 560.2
								Hole backfilled with cuttings.



DEPTH IN FEET: 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340

SOIL BORING NO. B-40

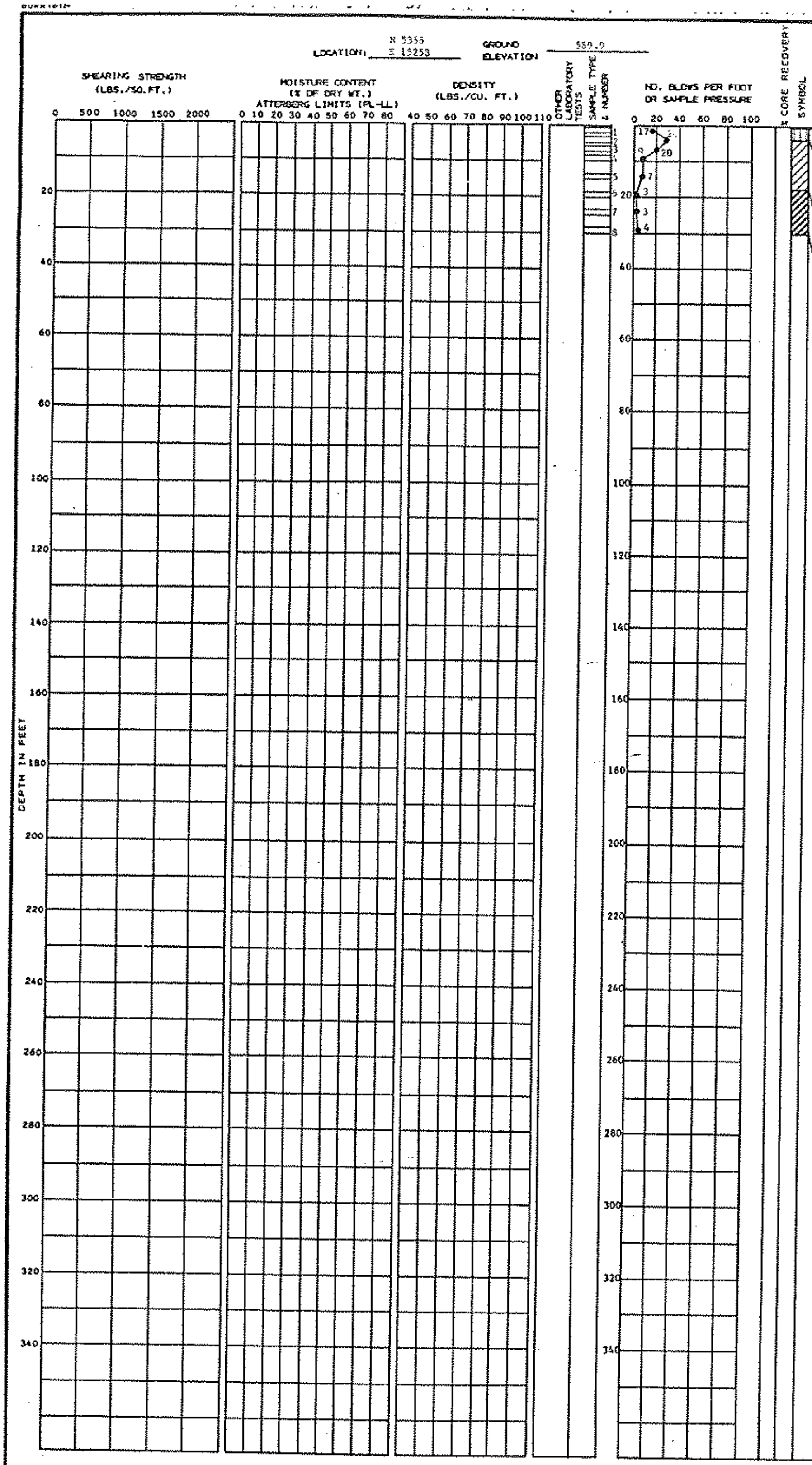
BECHTEL Belle River

LOCATION: N 5356 / E 15253

GROUND ELEVATION: 559.9

DATE DRILLED: 9/6/77 / 9/6/77

SHEET 1 OF 1



DESCRIPTION

0-0.3' Topsoil, dk. brown, dry

0.3-4.0' Clayey Silt, light brown, med. dense, dry, trace sand, trace fine to coarse gravel (ML)

4.0-18.5' Silty Clay, med. brown and gray, mottled, very stiff, med. plasticity, moist, trace sand, trace fine gravel (CL)

8.5-18.5' Med. stiff

18.5-30.0' Clay, med. gray, very soft, high plasticity, moist to wet, trace silt (CH)

28.5-30.0' Soft

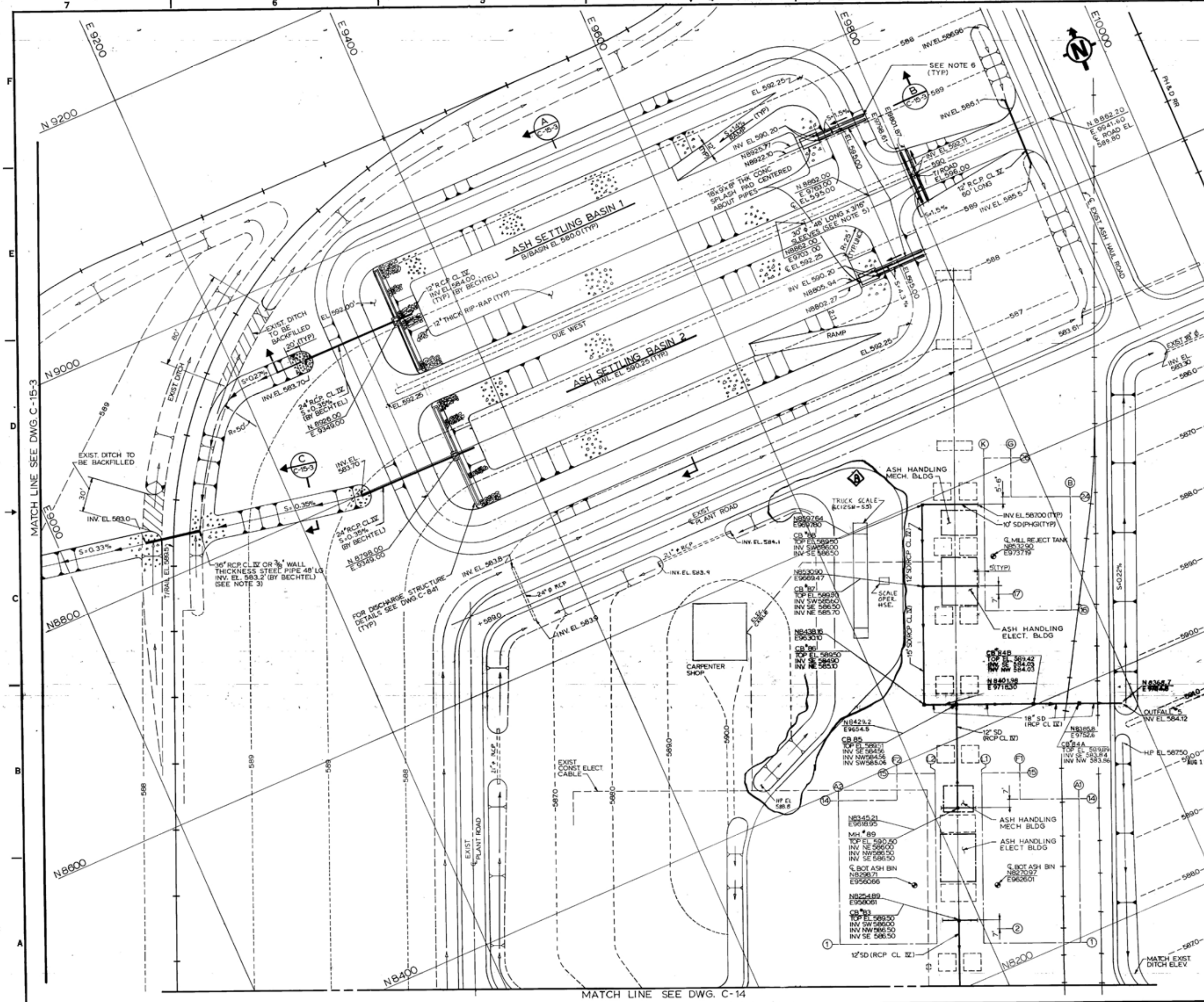
Bottom of Hole: Depth 30.0'
Elevation 559.9

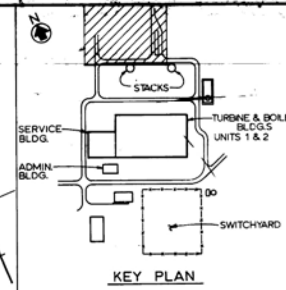
Hole backfilled with cuttings.

SOIL BORING NO. -3-42

BECHTEL Belle River

Appendix L
Technical Specifications, Design and As Built Documents





KEY PLAN

NOTES

1. FOR GENERAL NOTES LEGEND AND REFERENCE DWGS SEE DWG C-13.
2. EXIST OUTFALL ELEVATIONS SHALL BE VERIFIED IN THE FIELD PRIOR TO START OF CONSTRUCTION OF DRAINAGE SYSTEM.
3. 36" CULVERT SHALL BE INSTALLED UNDER RAILROAD BY TUNNELING AND/OR JACKING IN ACCORDANCE WITH AREA SPECIFICATIONS.
4. ASH SETTLING BASIN AND DISCHARGE CHANNEL SHALL BE IN ACCORDANCE WITH CP-204
5. FOR 24" ASH INLET PIPE DETAILS TO THE ASH BASINS, SEE DWG M-0320-7. 30" φ SLEEVES SHALL BE PROVIDED BY BECHTEL AND INSTALLED BY THE CP-204 CONTRACTOR.
6. AFTER INSTALLATION OF THE 24" ASH INLET PIPES, REMOVABLE BULKHEADS SHALL BE PROVIDED AT BOTH SLEEVE ENDS

6C1258-15-1
LATEST REVISION B

AUG 12 1988

NO.	DATE	REVISIONS	BY	CHK'D	DESIGN SUPV.	ENGR.	PROJ. ENGR.
B	7/12/88	ADD TRUCK SCALE REVISE DITCH	EJP	JRD	PWC		AKX
A	12/21/88	REVISED CB, ROAD NOTES TO SHOW AS BUILT, ADD TRACKS	EJP	J.T.H.		JRD	
7	4/2/83	ADDED SPLASH PADS	MPM				
6	7/11/83	INCORP FCN C-337 & REMV'D MATCH LINE CALLOUT	MPM	g.D.	g.D.		

DESIGNED: J. HARTMANN — DRAWN: M.P. MILLS — DATE: 4-18-78

BECHTEL ANN ARBOR — JOB No. 10539 — BECHTEL DRAWING No. C-15-1 — REV B

THE DETROIT EDISON CO.
BELLE RIVER POWER PLANT
UNIT 1&2

TITLE: YARD PIPING & DUCT BANK PLAN-SH-5

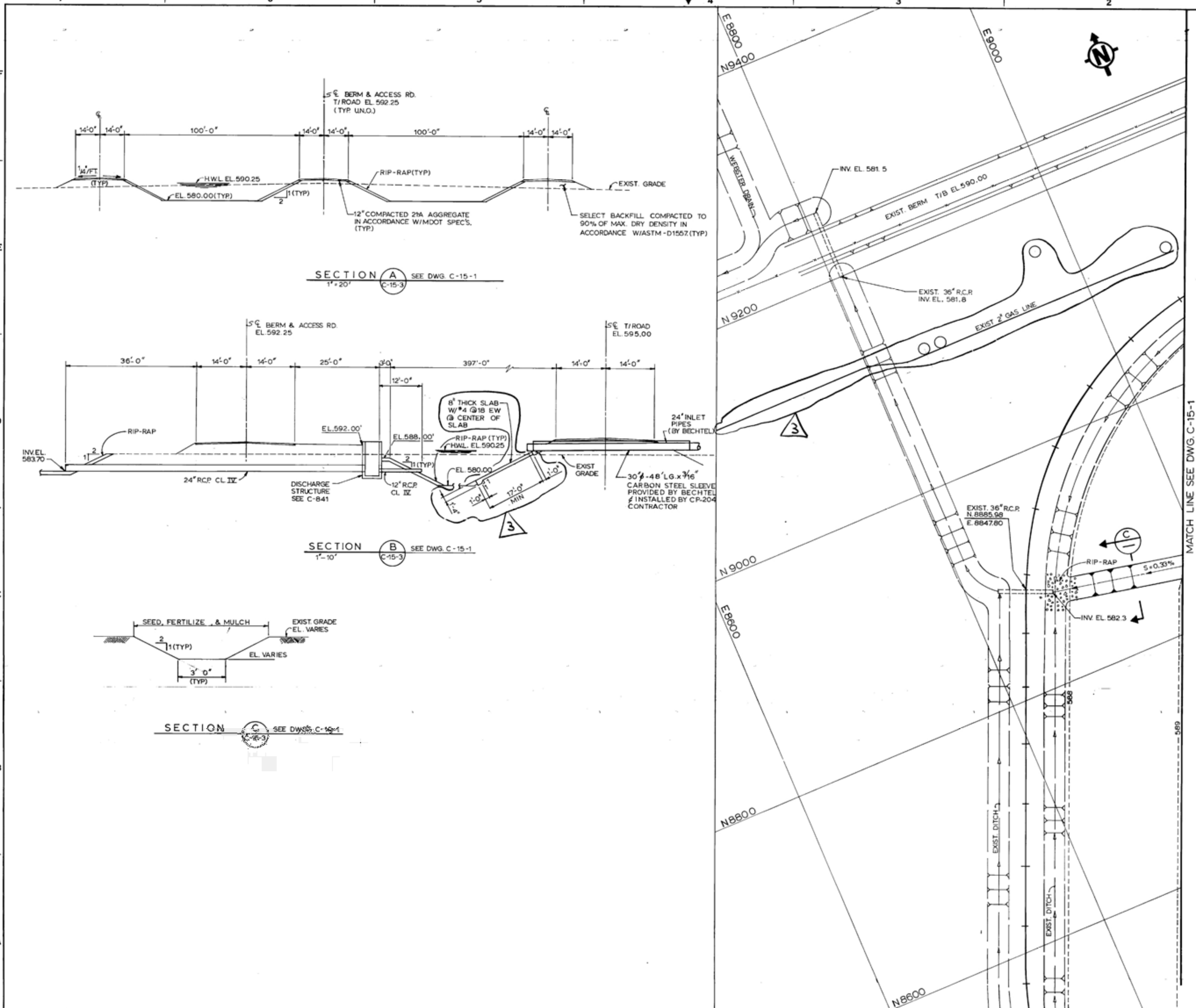
USE DIMENSIONS ONLY DO NOT SCALE — SCALE 1" = 30'

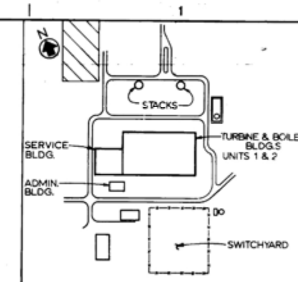
YARD PIPING & DUCTBANK PL SH 5

DETROIT EDISON DRAWING NUMBER 6C1258-15-1

FEB 15 1984

30 x 42 SIZE





KEY PLAN

NOTES

1. FOR GENERAL NOTES & REFERENCE DRAWINGS SEE DWG. C-13 & C-15-1
2. RIP-RAP STONE SHALL BE SOUND, DURABLE ROCK, FREE FROM CRACKS, SEAMS AND ORGANIC MATERIAL. THE STONE SHALL HAVE A MINIMUM SPECIFIC GRAVITY OF 2.6
   GRADATION AS FOLLOWS:

SIEVE SIZE	9"	8"	7"	5"	3"
% PASSING	100	80-100	50-90	20-50	5-10

6C1258-15-3
LATEST REVISION 3

No.	DATE	REVISIONS	BY	CHK'D	DESIGN SUPV.	ENGR.	PROJ. ENGR.
3	[illegible]	ADDED SPLASH PAD & GAS LINE	MPM	[illegible]	FS	FS	AA
2	[illegible]	INCORP. DCN #1 & ADDED 30" ϕ SLEEVE	[illegible]	MPM	G.D.	FS	[illegible]
1	[illegible]	ISSUED FOR CONST	MPM	RLS	G.D.	[illegible]	AA
0	[illegible]	ISSUED FOR BIDS FOR CP-204	EK	RLS	G.D.	FS	AA

DESIGNED: G. DEUKMAJI — DRAWN: L. KRANICK — DATE: 10-20-81 — CHIEF ENGR.:

BECHTEL ANN ARBOR — JOB No. 10539 — BECHTEL DRAWING No. C-15-3 — REV 3

THE DETROIT EDISON CO.
BELLE RIVER POWER PLANT
UNIT 1&2

TITLE
ASH SETTLING SYSTEM PLAN SECTIONS & DETAILS

APERT CD TITLE: ASH SETT SYST PLN SECT & DETLS
USE DIMENSIONS ONLY — DO NOT SCALE
SCALE 1" = 30'

DETROIT EDISON DRAWING NUMBER
6C1258-15-3

RDMS INDEXED 1 FEB [illegible] 30X42 SIZE

Bechtel Associates Professional Corporation
Ann Arbor, Michigan

TECHNICAL SPECIFICATION

FOR

CONSTRUCTION

OF

ASH SETTLING BASINS, WASTE STORAGE BASINS, AND FUEL OIL TANK DIKE

FOR

THE DETROIT EDISON COMPANY

BELLE RIVER POWER PLANT

UNITS 1 AND 2

No.	DATE	REVISIONS	BY	CH'K	APPR
0	12/17/81	Issued for Bids	G.D.	[illegible]	[illegible]

ORIGIN		
BECHTEL	BELLE RIVER POWER PLANT UNITS 1 AND 2 THE DETROIT EDISON COMPANY	JOB No. 10539-201 CP-204 REV. 0 SHEET i OF ii

TECHNICAL SPECIFICATION

FOR

CONSTRUCTION

OF

ASH SETTLING BASINS, WASTE STORAGE BASINS,

AND FUEL OIL TANK DIKE

CONTENTS

APPENDIXES

TECHNICAL SPECIFICATION

FOR

CONSTRUCTION

OF

ASH SETTLING BASINS, WASTE STORAGE BASINS,

AND FUEL OIL TANK DIKE

1. SCOPE

A. WORK INCLUDED

1) General

The work includes construction of two ash settling basins, two boiler blowdown surge basins, the oily waste basin, the chemical cleaning waste basin, and the fuel oil storage tank dike. It includes, but is not limited to, the following:

a) All earthwork for excavation and backfill for the two ash settling basins, the ash settling basin dikes, and the ash settling basin ramps

b) All earthwork for construction of the ash settling basin discharge ditch and modifications to existing ditches around the ash settling basins

c) Furnishing and installing one 12 inch culvert under the ash settling basin access ramp

d) Furnishing, spreading, and compacting aggregates and riprap for the ash settling basins

e) All earthwork for grading and dike construction for the existing fuel oil storage tank

f) Excavation for two boiler blowdown surge basins, oily waste basin, and chemical cleaning waste basin

g) Furnishing and constructing the membrane liner and pipe penetration boots for the boiler blowdown, oily waste, and chemical waste basins

2) Dewatering During Construction

Work includes designing the dewatering system, and furnishing all plant, labor, materials, tools and equipment, and performing all operations and incidentals necessary to control the water level to accomplish all construction to be performed in the dry. The work includes, but is not limited to, the following:

a) Control of all surface and ground water, whether caused by rain, ice, snow, or by act of the Contractor

b) Mobilization, supply, installation, operation, maintenance, and final dismantling and removal from the site of the dewatering system

3) Grading, Excavating, and Backfill

Work includes furnishing all labor, materials, tools and equipment, services and transportation, and performing all operations and incidentals necessary for grading, excavating, and backfilling as specified herein and as shown on design drawings including, but not limited to, the following:

a) Removal of obstructions

b) Disposal of unsuitable materials

c) Required horizontal and vertical layout and staking from established survey control points

d) Construction of required construction access and haul roads

4) Furnishing and Placing Membrane Liner and Pipe Penetrations

Work includes furnishing all plant, labor, materials, tools and equipment, and performing all operations and incidentals necessary to membrane line and seal pipe penetrations for the following basins:

a) Chemical cleaning waste basin

b) Two boiler blowdown surge basins

c) Oily waste basin

B. WORK NOT INCLUDED

The following work is not included as a part of this contract:

1) Surveying to establish horizontal and vertical control points

2) Constructing the ash settling system discharge structures (by Bechtel)

3) Furnishing and constructing inlet and discharge piping to the ash settling basins

4) Any piping or culverts not specified in Section 1.A.1.c even though they appear on the design drawings

5) Any work involving foundations or erection of the fuel oil tank

6) Any earthwork not related to the ash settling basins, waste basins, and fuel oil dike

7) Fuel oil piping, penetrations through the dike, and pipe supports

8) Wastewater piping to the waste storage ponds

C. SUBMITTAL REQUIREMENTS

1) Standard Forms

a) Engineering and quality verification document requirements are summarized on Form G-321-E (engineering) and Form G-321-V (quality verification), as applicable, and are augmented by detailed requirements in this specification.

2. MOBILIZATION AND DEMOBILIZATION

A. MOBILIZATION

1) The Contractor shall mobilize at the jobsite all plant, equipment, materials, supplies, and personnel necessary to perform the work as required. The Contractor shall assemble such plant and equipment at the site in adequate time for satisfactory performance of the work.

B. DEMOBILIZATION

1) After acceptance of the work, the Contractor shall demobilize and remove from the site all its construction plant, equipment, materials, personnel, and temporary buildings. All debris and waste material shall be removed and the site shall be left in a condition in compliance with the design drawings, specifications, and as approved by Bechtel.

3. CODES AND STANDARDS

A. GENERAL

1) Unless otherwise specified or shown, all material, procedures, and work shall be in accordance with the following codes and standard specifications to the extent indicated by reference herein. The date of issue or revision indicated shall apply.

2) However, should codes or standards be revised after issue of this specification, the Contractor has the option of notifying Bechtel that it will adopt the subsequent issue, addendum, or case ruling and will proceed with the changes only after receiving written Bechtel approval.

B. QUALITY STANDARDS

1) The Contractor shall control quality of items and services to meet the requirements of this specification and applicable codes and standards.

C. ABBREVIATIONS

Abbreviations, when used in this specification, shall have the following meanings:

1) ASTM - American Society for Testing and Materials

2) AWWA - American Water Works Association

3) MDNR - Michigan Department of Natural Resources

4) MDOT - Michigan Department of Transportation

5) FTM - Federal Test Method

D. APPLICABLE CODES AND STANDARDS

Sponsor	Number	Subject
ASTM	D 1556-64(74)	Tests for Density of Soil in Place by Sand-Cone Method
ASTM	D 1557-78	Tests for Moisture Density Relations of Soils Using 10-lb (4.5 kg) Rammer and 18-in. (457 mm) Drop
ASTM	D 2167-66(72)	Tests for Density of Soil in Place by the Rubber-Balloon Method
ASTM	D 2922-71,(76)	Tests for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM	D 3017-72	Test for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM	D 751	Thickness, Tensile Strength, Tongue Tear, and Hydrostatic Resistance
ASTM	D 2136	Cold Bend
ASTM	D 412	Tensile Strength, Elongation, and Heat Aging
ASTM	D 1149	Ozone Resistance

ASTM	D 471	Oil Resistance and Water Absorption
ASTM	D 746	Brittleness
ASTM	D 413	Ply Adhesion
ASTM	D 1203	Volatility
ASTM	D 1204	Dimensional Stability
FTM	101B2031	Puncture Resistance

4. SURVEYING

A. The Contractor shall be responsible for all surveying required to perform its work from baselines and survey reference points established by Bechtel.

B. The Contractor shall preserve all stakes, monuments, and benchmarks and shall replace and reset all disturbed markers as required.

5. DEWATERING DURING CONSTRUCTION

A. TECHNICAL PROVISIONS

1) Dewatering operations shall ensure that the sides and base of excavated slopes remain stable, and that the excavation bottom provides a satisfactory base for foundation concreting as determined by Bechtel.

2) The Contractor shall provide such standby dewatering equipment as deemed necessary by Bechtel to preclude any dewatering system service interruption during the construction period.

3) The Contractor shall dispose of all water, surface and subsurface, in a manner that will not endanger public health, property, any work under construction, and any work completed, and in accordance with applicable environmental regulations of the MDNR.

6. GRADING, EXCAVATING, AND BACKFILL

A. EXCAVATION

1) Excavation shall consist of the removal of material from designated areas as indicated on the drawings and as directed by Bechtel, regardless of the character of the materials encountered. Excavation shall conform to the elevations and grades shown or indicated on the drawings with allowable tolerances of 0.25 foot.

2) Select materials shall include all materials not defined as waste and all materials suitable for use in compacted fills. Select materials, evaluated in the soil report

after testing as suitable, shall be utilized in compacted fills as specified herein.

3) Classification of all materials shall be determined in the field by Bechtel.

4) When excavating, the Contractor shall furnish, place, and maintain such sheeting and shoring as required to support the sides of excavations, regardless of the time the trench or hole is open, unless banks are sloped to the angle of repose. When the Contractor slopes the sides of excavations so that sheeting, shoring, and bracing are not necessary, additional excavation and backfill required because of such flattening of slopes shall be done at the Contractor's expense.

5) Existing structures and utilities shall be protected and supported as directed by Bechtel where adjacent excavation is likely to cause damage or settlement. Water courses that are interrupted shall be restored to their intended use or suitable diversions constructed by the Contractor as directed by Bechtel. All active sewers, water and gas lines, electric power, light or telephone conduits or cables, and any other active utility lines not shown on the drawings that are encountered during excavation shall be immediately reported to Bechtel.

B. FILL AND COMPACTION

1) All approved fill within work limits shall be brought to required grades by compacting with rolling or vibratory equipment sufficient to do the work in accordance with requirements of the drawings and specifications. The Contractor shall maintain all compaction equipment in first class operating condition.

2) After a layer of fill material has been placed and spread, it shall be harrowed, if required, to break up any surface crust and to blend the fill materials. If one pass of the harrow does not accomplish breaking up and blending of the materials, additional passes of the harrow may be required, but in no case will more than three passes of the harrow on any one layer be required for this purpose. Fill shall be compacted in layers not exceeding 8 inches. When moisture content and condition of the layer is satisfactory, each layer shall be compacted to 90% of the maximum dry density determined in accordance with ASTM D 1557.

3) The densities attained shall be determined by field density tests and/or by extraction of undisturbed core samples from the completed fill for moisture and density determinations. Test results shall be the basis upon which satisfactory completion of the work shall be judged. The tests shall be by Bechtel. If one test fails, then two additional tests shall be made within

10 feet. If one of the two additional tests fail, that area shall be reworked.

4) No fill shall be placed on a frozen surface nor shall any ice or frozen earth be incorporated in embankments.

C. DISPOSAL AND TRANSPORTATION OF MATERIALS

1) Excess excavated materials shall be hauled to areas as directed by Bechtel and/or as shown on the drawings.

2) In transporting materials, the Contractor shall take all necessary precautions to avoid spillage from trucks onto access roads or the highway. Any material which drops from the vehicle when the material is being carried over roads or highways shall be removed immediately by and at the expense of the Contractor. If local ordinances prescribe additional measures for trucking over the highway, conformance with such measures is required.

7. EROSION AND SEDIMENTATION CONTROL

A. GENERAL

1) The Contractor shall be responsible for establishing and implementing an erosion and sedimentation control plan. The plan shall comply with the Standards and Specifications for Soil Erosion and Sediment Control as adopted by the St. Clair Soil Conservation District on May 29, 1974, and shall be submitted to Bechtel for review prior to starting work. The drainage system will be monitored and maintained on a continuing basis by the Contractor to ensure effective control and proper performance.

2) Disturbed areas not surfaced with aggregate material and ditch slopes surrounding such areas shall be constructed as indicated and in accordance with the specification for seeding and mulching as specified in Appendix E.

3) The topsoil stockpile and earth disposal areas shall be constructed with maximum side slopes of two horizontal units to one vertical unit. The topsoil stockpile and earth disposal areas shall receive seeding and mulching as specified in Appendix E.

B. APPLICATION

1) Vegetative Protection for Soil Stabilization

a) Vegetative measures shall be applied on all unprotected permanent slopes and ditching as soon as they are prepared.

b) Soil preparation shall be as specified in Appendix E.

2) Slope Stabilization

a) Unprotected sloped areas shall be planted as specified in Appendix E.

3) Soil stockpiles shall be located such that they will not interfere with existing water sheds. Soil stockpiles in heights exceeding 10 feet will require bench terracing graded longitudinally to a 2% slope to carry surface water runoff to collection points, from where it will be conveyed by slope pipes to the base of the stockpile.

8. FURNISHING AND PLACING MEMBRANE LINER AND PIPE PENETRATIONS

A. MATERIALS

1) Materials shall be first quality products designed and manufactured specifically for purposes of this work, and which have been satisfactorily demonstrated by prior use to be suitable and durable for such purposes.

2) The plastic lining shall consist of widths of calendered plastic sheeting fabricated into large sections by means of special factory-sealed seams to fit the jobsite.

a) Physical Characteristics

The materials shall be manufactured from resins specifically compounded for use in hydraulic facilities and in accordance with these specifications. Certification test results showing that the sheeting meets the specification shall be supplied in accordance with Appendixes B, C, and F.

b) Splicing Materials

Splicing material shall be supplied by the lining material manufacturer and installed in accordance with manufacturer's written instructions. The Contractor shall be responsible for proper splicing of all materials in the field.

c) Lining material for the chemical waste and boiler blowdown surge basins shall be chlorosulfonated polyethylene reinforced membrane lining (hypalon by Watersaver Company, Inc. or approved equal) with the following properties:

Property	Test Method	Requirement
Thickness	ASTM D 751	36 mils (nominal)
Scrim	-	10 x 10 - 1,000 D
Tensile strength	ASTM D 412	1,500 psi (min)
Elongation at break	ASTM D 412	300% (min)

Property	Test Method	Requirement
Water absorption	ASTM D 471 (7 days at 70F) (7 days at 150F)	 2% (wt) max 5% (wt) max
Cold bend	ASTM D 2136	-45F, no cracks
Brittleness temperature	ASTM D 746	-45F, no failures
Ozone resistance	ASTM D 1149	No effect
Heat aging Tensile strength Elongation at break	ASTM D 412	 1,500 psi (min) 150% (min)
Puncture resistance	FTM 101B2031	180 lb
Tongue tear	ASTM D 751	80 lb
Seam strength	ASTM D 751	To exceed that of parent material
Seam continuity	Air lance	100% bonded

d) Lining material for the oily waste basin shall be chlorinated polyethylene reinforced membrane lining (CPER by Watersaver Company, Inc. or approved equal) with the following properties:

Property	Test Method	Requirement
Thickness	ASTM D 751	36 mils (nominal)
Scrim	-	10 x 10 - 1,000 D polyester
Tensile strength	ASTM D 751	200 lb
Tongue tear	ASTM D 751	80 lb
Puncture resistance	FTM 101B2031	180 lb
Dimensional stability	ASTM D 1204	± 3% (max)
Cold bend	ASTM D 2136	-25F
Ozone resistance	ASTM D 1149	Pass
Oil resistance (max % wt gain)	ASTM D 471	35%
Ply adhesion	ASTM D 413	16 lb (min)

Property	Test Method	Requirement
Volatile loss	ASTM D 1203	0.2
Mullens burst	ASTM D 751	375 psi

3) Fabrication

a) Individual calender widths materials shall be factory fabricated into large panels. Lap joints with a minimum width of 1/2 inch shall be used. Factory made splices shall have a strength of 80% of the specified sheet strength. Panels shall be as large as can be conveniently handled on the jobsite. The panels shall be fabricated as shown on the shop drawings. After fabrication, the lining shall be folded in both directions and packaged for minimum handling in the field. Packaging shall be substantial enough to prevent damage to the contents.

B. SURFACE PREPARATION

1) The surface to receive the liner shall be smooth and free of sharp objects that could puncture the lining. All vegetation shall be removed. All holes and hollow areas shall be filled in and compacted. Before beginning application of the lining material, the surface shall be examined and found satisfactory for installation. Surfaces receiving liner shall be sterilized in accordance with manufacturer's recommendations.

C. PLACING OF LINING MATERIALS

1) The lining material shall be placed over the prepared surfaces to be lined in such a manner as to ensure minimum handling. The lining shall be closely fitted and sealed around inlets, outlets, and other projections through the lining. Any portion of lining damaged during installation shall be removed or repaired by using an additional piece of lining as specified hereinafter. Vents shall be provided at each corner and at 50 foot intervals.

a) Lap joints shall be used to seal factory-fabricated panels together in the field. Lap joints shall be formed by lapping the edges of panels a minimum of 2 inches. Contact surfaces of the panels shall be wiped clean to remove all dirt, dust, or other foreign materials. Sufficient cold-applied bonding adhesive as recommended by the manufacturer shall be applied to the contact surfaces in the joint area, and the two surfaces pressed together immediately. Any wrinkles shall be smoothed out. Field made splices shall have a strength of 80% of the specified sheet strength.

b) All curing compounds and coatings shall be completely removed from the joint area. Adhering the plastic to concrete shall be made using an adhesive as recommended by the manufacturer.

c) Any necessary repairs shall be patched with the lining material and cold applied bonding adhesive. The bonding adhesive shall be applied to the contact surfaces of both the patch and lining to be repaired and the two surfaces pressed together immediately. Any wrinkles shall be smoothed out.

d) All joints, on completion of the work, shall be tightly bonded. Any lining surface damaged due to scuffing, penetration by foreign objects, or from rough subgrade shall, as directed by Bechtel, be replaced or covered and sealed with an additional layer of liner of the proper size.

D. PROTECTION AFTER CONSTRUCTION

1) Immediately following lining installation, the lining shall be covered with a 12 inch minimum depth of water. Care should be taken to eliminate traffic which may cause damage to the lining material. The Contractor shall be responsible for any damage to the lining material during its operations.

E. QUALITY ASSURANCE

1) The Contractor shall at its expense provide a technical representative of the sheeting manufacturer at the jobsite to ensure compliance with manufacturer's directions. The technical representative shall be present when liner installation is started and may make periodic checkbacks, if required. The representative shall instruct and observe the work, reporting unsatisfactory conditions or recommendations for improvement in procedures to the Contractor. The manufacturer's representative is not directly responsible for the quality of the work involved; such responsibility will be solely that of the Contractor.

++ End of Specification 10539-201-CP-204 ++

TECHNICAL SPECIFICATION

FOR

FIELD AND LABORATORY SOIL TESTING

CONTENTS

APPENDIXES

TECHNICAL SPECIFICATION

FOR

FIELD AND LABORATORY SOIL TESTING

1. SCOPE

A. ITEMS INCLUDED

1) Conducting field soil tests

2) Conducting laboratory soil tests

3) Conducting static plate bearing tests

4) Providing an experienced soil engineer and soil engineering technicians to supervise and conduct field tests as required to complete the testing work

5) Keeping records of field and laboratory tests, recording pertinent field observations, and submitting complete reports

6) Reporting nonconforming tests

7) Operating jobsite laboratory and equipment

B. RELATED ITEMS NOT INCLUDED

1) Foundation engineering

2. QUALITY STANDARDS

A. GENERAL

1) A Bechtel field soil engineer shall control the quality of items and services to meet the requirements of this specification, applicable codes and standards, and other contract documents, unless otherwise required by project engineering.

2) Within the scope of this specification the term "Bechtel" shall denote "Bechtel Construction".

B. REFERENCED CODES AND STANDARDS

Sponsor	Number	Subject
ASTM	C 117-76	Material Finer than No. 200 Sieve
ASTM	C 136-76	Sieve or Screen Analysis
ASTM	D 1556-64(74)	Density of Soil in Place by the Sand-Cone Method

ASTM	D 1557-78	Moisture Density Relations for Soils Using 10 lb. Rammer and 18 Inch Drop
ASTM	D 1195-64(77)	Repetitive Static Plate Load Tests
ASTM	D 1196-64(77)	Nonrepetitive Static Plate Load Tests
ASTM	D 2049-1969	Relative Density of Cohesionless Soils
ASTM	D 2167-66(77)	Density of Soil In-Place by the Rubber Balloon Method
ASTM	D 2216-71	Laboratory Determination of Moisture Content of Soil
ASTM	D 2922-78	Density of Soil and Soil Aggregate In-Place by Nuclear Methods (Shallow Depth)
ASTM	D 3017-78	Moisture Content of Soil and Soil Aggregate In-Place by Nuclear Methods (Shallow Depth)
ASTM	D 854-58(72)	Specific Gravity of Soils
MDSH	July 76	Michigan Department of State Highways, Standard Specifications for Highway Construction

3. SUBMITTALS

A. STANDARD FORMS

1) Engineering document requirements are summarized on Form G-321-E (Appendix XII) and are augmented by detailed requirements in this specification.

B. SUBMITTAL REQUIREMENTS

1) Daily raw test data

2) Daily test reports

4. INSPECTION AND TESTING

A. FIELD INSPECTION

1) The work is subject to inspection and supervision by Bechtel.

B. TESTING

1) All testing shall be performed in accordance with the procedures referenced herein, or with those procedures accepted in writing by project engineering prior to the commencement of work.

5. MATERIAL REQUIREMENTS

Backfill material used shall conform to the applicable contract documents.

6. COMPACTION CRITERIA

Compaction criteria used shall conform to the applicable contract documents.

7. TESTING REQUIREMENTS

A. Concurrent with construction, samples shall be taken of the borrow or imported material. These shall be tested for moisture content, gradation, and other control or record tests in accordance with this specification.

B. Concurrent with construction, field density control tests shall be performed in accordance with ASTM D 1556, ASTM D 2922, or ASTM D 2167 on backfill materials after compaction. The following frequencies are established as guidelines. Actual testing frequency for remote areas and the areas listed below shall be determined by Bechtel as required to monitor the Contractor's work for conformance to the contract documents.

1) Structural backfill placed with hand-operated equipment: one test per 10-200 cubic yards of compacted backfill, as determined by Bechtel (includes fill adjacent to pulverizers and other equipment foundations shown on drawings).

2) Structural backfill placed with self-propelled or towed equipment: one test per 500 cubic yards of compacted backfill

3) Nonstructural fill (in areas not supporting or adjacent to structures) placed with hand-operated equipment: one test per 200 cubic yards of compacted fill

4) Nonstructural fill (in areas not supporting or adjacent to structures) placed with self-propelled or towed equipment: one test per 1,000 cubic yards of compacted fill

C. Concurrent with construction, laboratory compaction tests shall be performed in accordance with ASTM D 1557 or ASTM D 2049. The laboratory compaction tests shall be made on the same material being used for density testing every 20 density tests. The "zero air voids curve" shall be presented with each compaction test made in accordance with ASTM D 1557. Gradation, moisture content, and Atterberg limit tests shall be made with each relative density and compaction test, as applicable.

The moisture-density points for the ASTM D 1557 test shall be presented on the test result form. Compaction curves shall cover the moisture content range used in backfill operations. Compaction curves shall be performed so the curve need not be extended to densities higher than those achieved in the laboratory.

In performing relative density tests (ASTM D 2049), both the wet and dry methods of determining the maximum density shall be performed and recorded. The maximum of these two values shall be used as the maximum density.

D. One-point compaction tests shall be used to aid in determining the compaction curve appropriate for determining the percent of maximum density for clays and silts, as per ASTM D 1557. The one-point tests shall be made at the field moisture content. One-point compaction test results should conform to within ±1 lb/ft of the compaction curve selected. If the one-point result does not conform to the available curves, then it shall be redone or a new compaction test shall be made. Each one-point compaction test shall be reported with the density test results.

A gradation analysis shall be made for each density test on materials applicable to ASTM D 2049 to allow selection of appropriate relative density test values by comparison of the gradation analysis with that performed on the relative density test sample.

E. Concurrent with construction, gradation and moisture content tests shall be performed in accordance with ASTM C 117, C 136, and D 2216, on structural backfill materials at the minimum frequency of one test per 1,000 cubic yards of compacted backfill and fill or as directed by Bechtel. Gradation tests shall be performed to check the 3", 2", 1", #4, #40, #100, and #200 sieve sizes.

F. Concurrent with construction, field plate bearing tests may be performed in accordance with ASTM D 1195 and 1196, or as modified by Bechtel, on structural backfill material. The tests will be made when required by project engineering. Plate bearing tests shall be performed with a 1 foot square plate 1 foot below the compacted surface.

G. When nuclear testing devices are used, daily volumetric density and moisture tests shall be made adjacent to the nuclear tests for each area being backfilled. Personnel using nuclear devices must have attended training sessions given by the manufacturer or have equivalent training as approved by Bechtel.

H. Compaction control testing may include an evaluation of each type of compactor for each material type by determining the percent compaction obtainable for various lift thicknesses and equipment passes. Where possible, this evaluation should be accomplished during initial backfill operations. The procedure for conducting tests shall be provided by Bechtel on a case-by-case basis.

I. The field soils engineer shall perform surveillance inspection of backfill operations. Daily reports shall include observation of such items as the material type, equipment, equipment passes, and lift thickness.

J. Calculations required to perform tests included in this specification shall be checked by personnel independent from the person performing the test. The checker shall be capable of performing the test being checked. Calculations for all these tests shall be maintained in a permanent record. Forms listed below shall be used to document these calculations.

Test Type	Appendix Number
Gradation Tests	I
Density Tests	
- Volumetric Methods	II
- Nuclear Gage Method	III
Compaction Tests	IV
Moisture Content Tests	V
Specific Gravity	VI
Atterberg Limits	VII
Relative Density	VIII

K. Compaction tests results shall be presented on the attached form (Appendix IX). Gradation tests shall be presented on the attached form (Appendix X).

L. Reports

1) Copies of all raw test result data (Sections 7.J. and 7.K.) collected shall be submitted to the onsite geotech representative on a daily basis.

2) Legible reports of each days testing shall be submitted to project engineering and the onsite geotech representative within seven calendar days in accordance with Section 7.K. This submittal shall also include the Compacted Fill Density Test Report (Appendix XI). The

type of density testing device used shall be noted on the Compacted Fill Density Test Report.

+ + End of Specification 10539-201-C13C, Rev 0 + +

SIEVE ANALYSIS

PROJECT ____________
FILE NO. ____________
TEST NO. ____________
AREA/BLDG. ____________
TESTED BY: ____________
DATE: ____________
CHECKED BY: ____________
DATE: ____________

SOIL SAMPLE:
VISUAL CLASSIFICATION AND DESCRIPTION ____________
COORDINATES ____________
BORING NO. ________ DEPTH ________
SAMPLE NO. ____________
SPECIFIC GRAVITY, Gs, ____________

WATER CONTENT:
SPECIMEN LOCATION ____________
CONTAINER NO. ____________
WT. CONTAINER, WET SOIL ____________
WT. CONTAINER, DRY SOIL ____________
WT. WATER ____________
WT. DRY SOIL ____________
WATER CONTENT in % ____________

DRY SIEVE ☐
WASH SIEVE ☐
COMBINED ☐

TOTAL SAMPLE

U. S. STANDARD SIEVE NO.	SIEVE OPENING IN MM.	ACCUMULATIVE WT. OF SOIL RETAINED	ACCUMULATIVE PERCENT RETAINED	TOTAL SAMPLE PERCENT FINER BY WT.
2"	50.8			
1"	25.4			
3/4"	19.1			
1/2"	12.7			
4	4.76			
TOTAL SAMPLE DRY WEIGHT –				

SPLIT SAMPLE

		ACCUMULATIVE WT. OF SOIL RETAINED	ACCUMULATIVE PERCENT RETAINED	SPLIT SAMPLE PERCENT FINER BY WT.	TOTAL SAMPLE PERCENT FINER BY WT.
4	4.76			100	
10	2.00				
20	0.840				
40	0.420				
60	0.250				
100	0.149				
200	0.074				
270	0.053				
PAN					
SPLIT SAMPLE DRY WEIGHT –					

DENSITY OF SOIL IN PLACE TEST REPORT
VOLUMEASURE METHOD

REA & WORK PERFORMED:______________ DATE:__________ PAGE_____OF_____

		IN PLACE-DENSITY						MOISTURE CONTENT						DENSITY COMPUTATION				
TEST NO	LOCATION AND ELEVATION	INITIAL READING C.F. (1)	FINAL READING C.F. (2)	VOL. OF HOLE (2)-(1) C.F. (3)	WT. OF SAMPLE & TARE LBS. (4)	WT. OF TARE LBS. (5)	WT. OF SAMPLE (4)-(5) LBS. (6)	WT. OF WET SAMPLE & TARE GMS. (7)	WT. OF DRY SAMPLE & TARE GMS. (8)	WT. OF WATER IN SAMPLE (7)-(8) GM. (9)	TARE WT. & NO. GMS. (10)	WT. OF DRY SAMPLE (8)-(10) GMS. (11)	MOISTURE CONT. (9)÷(11) % (12)	WET DENSITY (6) LBS. / (3) C.F. (13)	DRY DENSITY (14) LBS / 1.00+MOIST.CONT.CF (14)	MAX. DRY DENSITY T-99□MICH.CONE□ T-180□AVE.DEN□ (15)	PERCENT COMP. (14)/(15) X 100 (16)	REMARKS
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

APPENDIX II

ENL CONTRACTOR:______________

SUB.CONTRACTOR:______________

WEATHER:______________

SPEC. & DRAWING NO.______________

DEVIATION: □YES □NO (SEE REMARKS)

CORRECTIVE ACTION:______________

SOURCE & TYPE OF MATERIAL:______________

METHOD OF COMPACTION:______________

NUMBER OF PASSES:______________

BECHTEL INSPECTOR:______________

Appendix III

Method of Test

TROXLER

BECHTEL POWER CORP.

DENSITY OF SOIL IN PLACE

Location & Remarks	Elevation	Probe Depth	Moisture Count	Moisture Count Ratio	Moisture p.c.f.	Percent Moisture Troxler	Percent Moisture Control Ck	Density Count	Density Count Ratio	Wet Density p.c.f.	Dry Density Troxler p.c.f.	Dry Density Control Ck. p.c.f.	Percent Compaction

APPENDIX III

CONTROL DATA
T180 ☐ T99 ☐ Mich Cone ☐
Avg. of Control Tests ☐
Optimum Moisture ______ %
Maximum Density ______ p.c.f.

TROXLER No. ______

STANDARD COUNT		
Density	Moisture	Time:

Sketch of Test Locations

PROJECT ______

Contractor ______

Source of Material ______

Type of Material ______

Weather & Temp. ______

Bechtel ______

Other ______

Inspector ______ Date ______

Checked By ______ Date ______

COMPACTION TEST DATA SHEET

FILE NO.	TEST NO.	AREA/BLDG.
BORING NO.	SAMPLE NO.	DEPTH
PROJECT		COORDINATES

☐ 1	STANDARD PROCTOR 5½ pound hammer 12" drop 3 layers 25 blows/layer	☐ 2	MODIFIED PROCTOR 10 pound hammer 18" drop 5 layers 25 blows/layer	☐ 3	OTHER	MAXIMUM SIZE % PASSING #200 SIEVE VOL. cyl. cu. ft.

COMPACTION DATA

Run No.	1	2	3	4	5	6	7	8
Cylinder No.								
Wt. of sample and cylinder								
Wt. of cylinder								
Wet wt. of sample								
Unit wet weight								
Water content, % dry weight								
Unit dry weight								

WATER CONTENT DATA

Dish No.								
Wet weight sample and dish								
Dry weight sample and dish								
Wt. of water								
Wt. of dish								
Dry weight of sample								
Water content, % dry weight								

COMPACTION CURVE

DRY WT - LBS/CU. FT.

WATER CONTENT – % DRY WT.

SUMMARY

Opt. water content, %	
Max. dry density, lbs/cu ft.	
Corr. density, lbs/cu ft.	
Water content at zero air voids, %	
Void Ratio, (e)	

TESTED BY:	DATE:	COMPUTED BY:	DATE:	CHECKED BY:	DATE:

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WATER CONTENT DETERMINATIONS

PROJECT ____________________

FILE NO. __________ TEST NO. __________

AREA/BLDG. ____________________

BORING NO. ____________________

APPENDIX V

SAMPLE NO.	DEPTH (ft.)	COORDINATES	WEIGHT OF WET SAMPLE + CONTAINER	WEIGHT OF DRY SAMPLE + CONTAINER	WEIGHT OF WATER	CONTAINER NO./ WEIGHT	WEIGHT OF DRY SAMPLE	WATER CONTENT %

TESTED BY: DATE: CHECKED BY: DATE:

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BECHTEL

SPECIFIC GRAVITY TEST

SOIL SAMPLE:

VISUAL CLASSIFICATION AND DESCRIPTION ____________

COORDINATES ____________

BORING NO. ________ SAMPLE DEPTH ________

SAMPLE NO. ____________

PROJECT ____________

FILE NO. ____________

TEST NO. ____________

AREA/BLDG. ____________

DETERMINATION NO.	1	2	3	4
BOTTLE NO.				
WT. BOTTLE + WATER + SOIL, W_1, IN g				
TEMPERATURE, T, IN °C				
WT. BOTTLE + WATER, W_2, IN g				
EVAPORATING DISH NO.				
WT. DISH + DRY SOIL IN g				
WT. DISH IN g				
WT. SOIL, W_s, IN g				
SPECIFIC GRAVITY OF WATER AT T, G_T				
SPECIFIC GRAVITY OF SOIL, G_s				

REMARKS

$$G_s = \frac{G_T \, W_s}{W_s - W_1 + W_2} \quad ; \qquad G_s \_\_\_\_\_\_\_\_$$

TESTED BY: ________ DATE: ________ CHECKED BY: ________ DATE: ________

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ATTERBERG LIMITS

SOIL SAMPLE:

VISUAL DESCRIPTION ______________________

____

BORING NO. __________ DEPTH __________

SAMPLE NO. ______________________

SPECIFIC GRAVITY ______________________

PROJECT ______________________

FILE NO. ______________________

TEST NO. ______________________

AREA/BLDG. ______________________

COORDINATES ______________________

PLASTIC LIMIT

DETERMINATION NO.	1	2	3
CONTAINER NO.			
WT. CONTAINER & WET SOIL IN g			
WT. CONTAINER & DRY SOIL IN g			
WT. WATER IN g			
WT. CONTAINER IN g			
WT. DRY SOIL IN g			
WATER CONTENT IN %			

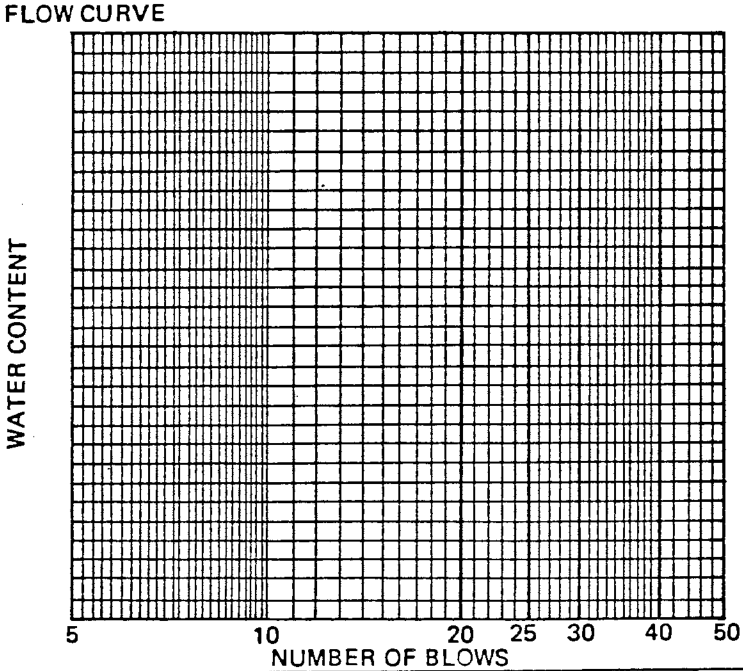
NATURAL WATER CONTENT

1	2	3

LIQUID LIMIT

DETERMINATION NO.						
NO. OF BLOWS						
CONTAINER NO.						
WT. CONTAINER & WET SOIL IN g						
WT. CONTAINER & DRY SOIL IN g						
WT. WATER IN g						
WT. CONTAINER IN g						
WT. DRY SOIL IN g						
WATER CONTENT IN %						

FLOW CURVE



RESULTS SUMMARY

NATURAL WATER CONTENT, w, __________

LIQUID LIMIT, LL __________

PLASTIC LIMIT, PL __________

PLASTICITY INDEX, PI __________

REMARKS

TESTED BY:	DATE:	CHECKED BY:	DATE:

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RELATIVE DENSITY DETERMINATIONS

PROJECT ____________ FILE NO. ____________ SAMPLE NO. ____________

SAMPLE DEPTH ____________ TEST NO. ____________ AREA/BLDG. ____________

COORDINATES ____________

MINIMUM DENSITY DETERMINATION (0% RELATIVE DENSITY)			
Test No.			
Wt. soil + mold lbs.			
Wt. mold lbs.			
Wt. soil (W_s) lbs.			
Volume of mold (V_c) cu.ft.			
Minimum Dens. $= \frac{W_s}{V_c}$ pcf			

RELATIVE DENSITY COMPUTATION			
Test No.			
① In-place density pcf			
② Max. lab. density pcf			
③ Min. lab. density pcf			
④ ① − ③			
⑤ ④ x ②			
⑥ ② − ③			
⑦ ① x ⑥			
Relative Density % $= \frac{⑤}{⑦} \times 100$			

MAXIMUM DENSITY DETERMINATION (100% RELATIVE DENSITY)			
	DRY METHOD		WET METHOD
Test No.			
Left gage read. inches			
Right gage read. inches			
Avg. gage read. R_f			
Initial gage read. R_i			
Area of sample surface sq.ft. A			
Calib. vol. of mold cu.ft. V_c			
Soil vol. $= V_c - \frac{R_i - R_f}{12} \times A$ V_s			
Wt. dry soil + mold lbs.			
Wt. mold lbs.			
Wt. dry soil lbs. W_s			
Maximum Density $\frac{W_s}{V_s}$ pcf			

Mold No. ________ Surcharge base plate no. ________

surcharge base pl. thick. ____________ in.

Straightedge thickness ____________ in.

Left dial read. ________ ________ ________

Right dial read. ________ ________ ________

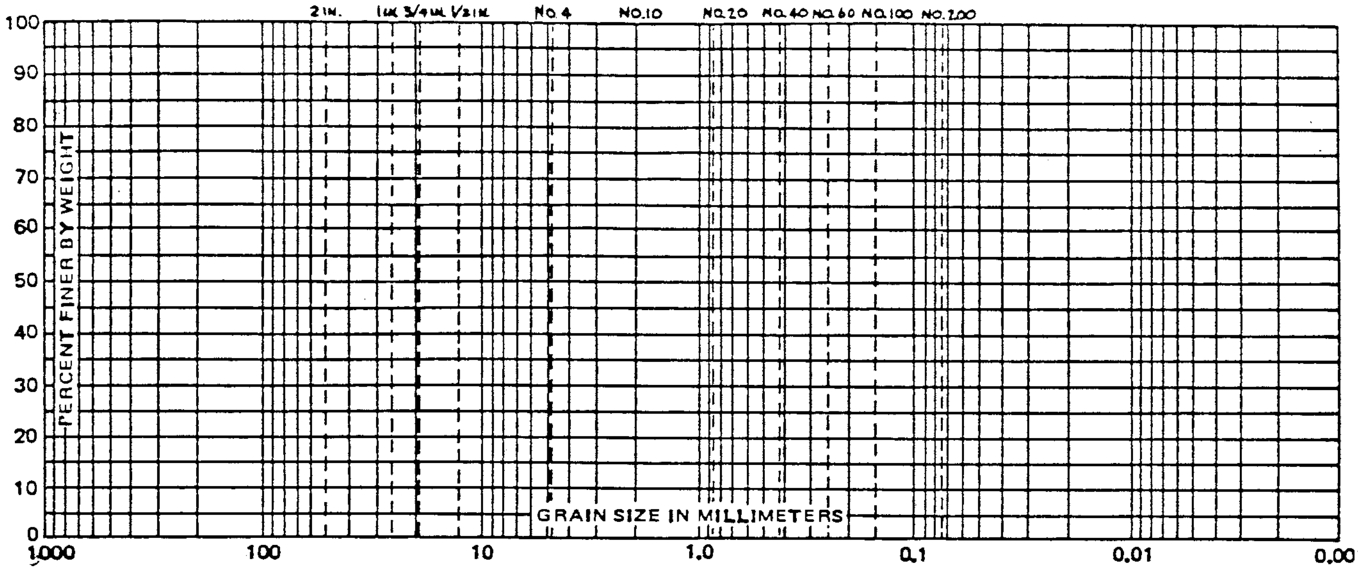
R_i = Avg. dial gage read. + surcharge base pl. thick. - st. edge thick.

R_i = ____________ in.

TESTED BY: ____________ DATE: ____________

CHECKED BY: ____________ DATE: ____________

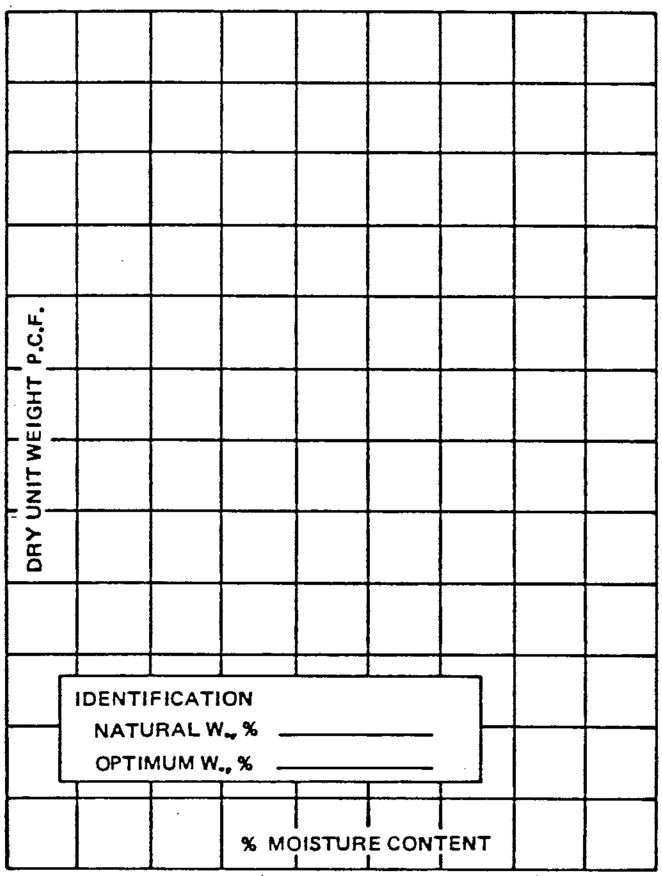
GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

COMPACTION



ATTERBERG LIMITS

IDENTIFICATION ____________
LIQUID LIMIT ____________
PLASTIC LIMIT ____________

COMPACTION METHOD

ASTM TEST:

MOLD HEIGHT ______", MOLD DIAM. ______"
NO. LAYERS- ______, BLOWS/LAYER ______
HAMMER WT. ______ LBS, DROP HT. ______"

REMARKS

TESTED BY: ____________ DATE: ____________

CHECKED BY: ____________ DATE: ____________

COMPACTION – GRADATION TESTS

PROJECT ____________
FILE NO. ____________ TEST NO. ____________
AREA/BLDG. ____________
BORING NO. ____________
SAMPLE NO. ____________ DEPTH ____________
COORDINATES ____________

BECHTEL

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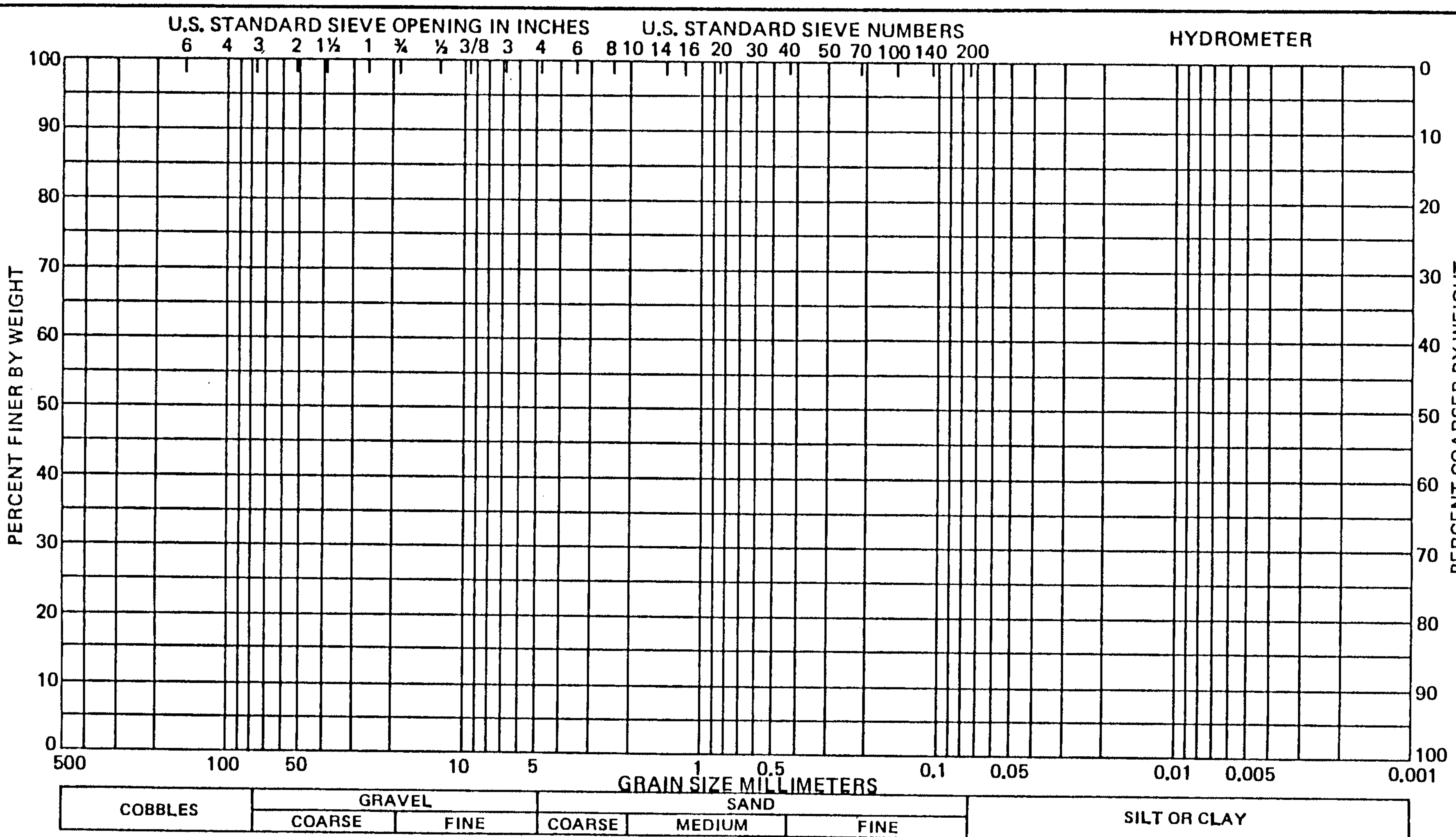
GRADATION CURVES



SAMPLE NO.	ELEV. OR DEPTH	COORDINATES	CLASSIFICATION	NAT.W%	LL	PL	PI

PROJECT

FILE NO. TEST NO.

AREA/BLDG.

BORING NO.

TESTED BY: DATE:

CHECKED BY: DATE:

BECHTEL

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APPENDIX XI

COMPACTED FILL DENSITY TEST REPORT

3. ________ QC ACCEPTANCE ________ DATE
________ CONTROL NO. ________ FILE NO.

1. PROJECT NO. ________ 2. DATE ________ PAGE ____ OF ____

4. SPEC. NO. ________ 5. DRAWING NO. ________ 6. TESTED WEEK OF ________

7. DATE TAKEN	8. TEST NO.	9. TEST-ED BY	10. LOCATION	11. ELEV. OF TEST	12. DEPTH BELOW FINAL GRADE (FT.)	13. IN PLACE WET DENSITY (LB./C.F.)	14. MOISTURE CONTENT (%)	15. IN PLACE DRY DENSITY (LB./C.F.)	16. SOIL CLASSIFICATION	17. MAX. LAB. DRY DENSITY (LB./C.F.)	18. PERCENT COMPACTION	19. REMARKS

20. PREPARED BY (Signature) ________ DATE ________ 21. RESPONSIBLE ENGINEER ________ DATE ________

ENGINEERING DOCUMENT REQUIREMENTS

1 DOCUMENT CATEGORY NUMBER	2. SPECIFICATION PARAGRAPH REFERENCE	3 DOCUMENT DESCRIPTION	4 PERMISSION TO PROCEED REQUIRED		5 SUBMITTAL SCHEDULE	6 QUANTITY REQUIRED		7 KIND OF COPIES	8 REMARKS
			YES	NO		INITIAL	FINAL		
30.0	7.I and 7.L.1)	Raw test data		X	NA		1	R	To onsite geotech representative
31.0	7.L.2)	Test reports		X	NA		1	R	
32.0	4.B.1	Testing Procedures	X		NA		1	R	

9. FORWARD COPIES TO:
Bechtel Associates Professional Corporation
P.O. Box 1000
Ann Arbor, Michigan 48106

SPECIAL INSTRUCTIONS

Attn: Mr. M.T. Fravel
Project Engineer
Contract: 10539-201-C13C

BECHTEL
G-321-E

10. BELLE RIVER POWER PLANT UNITS 1 AND 2
THE DETROIT EDISON COMPANY

11. JOB NO. 10539-201

12. SPEC NUMBER C13C

ENGINEERING DOCUMENT REQUIREMENTS

SHEET 1 OF 4

REV. 0

ENGINEERING DOCUMENT REQUIREMENTS

1. Document Category Number	2. Specification Paragraph Reference	3. Document Description	4. Permission to Proceed Required: Yes	No	5. Submittal Schedule	6. Quantity Required: Initial	Final	7. Kind of Copies	8. Remarks
30.0	7.A.1	Erosion and Sedimentation Control Plan	X			1	1		Prior to start of work
1.3	8.A.3.a	Shop Drawings	X			1	1		Prior to start of work

9. FORWARD COPIES TO:

SPECIAL INSTRUCTIONS

Bechtel Associates Professional Corporation
P.O. Box 1000
Ann Arbor, MI 48106

Attn: Mr. M.T. Fravel
Project Engineer
Job: 10539-201

BECHTEL

G-321-E

10. BELLE RIVER POWER PLANT UNITS 1 AND 2
THE DETROIT EDISON COMPANY

ENGINEERING DOCUMENT REQUIREMENTS

11. JOB NO. 10539-201

12. SPEC NUMBER CP-204

SHEET 2 OF 4

REV. 0

ENGINEERING
DOCUMENT CATEGORY DEFINITIONS
G-321-E — SUP A

(E) Engineering Documents. This term comprises procedures, drawings, specifications, QA plans, prototype qualification test reports, and other similar documents that require Bechtel permission to proceed prior to fabrication, or prior to use of the document on the design, fabrication, installation, or other work progress. The term is also applied to price lists, and instructions for erection/installation, operation, maintenance, and site storage and handling.

A. DEFINITIONS OF TERMS

(Note: Standard abbreviated titles follow the category definitions).

Supplier — This is a comprehensive term and includes seller, vendor, contractor, subcontractor, subsupplier, etc.

Original — The initial document of which copies are made, i.e., handwritten copy, typed copy, printed matter, tracings or drawings and photographs.

Reproducible — A master copy which can be legibly duplicated by either microreproduction, diazo or electrostatic process. Diazo sepias may be submitted, only if they meet and satisfy Bechtel microfilming requirements.

Microfilm — Film containing an image reduced in size from the original and capable of being enlarged to a clear reproduction of the original.

Permission to Proceed Required — Bechtel review required prior to use of documents in the design, fabrication, installation, or other work processes.

Initial — The first submittal of a document in accordance with the schedule mutually agreed to by Bechtel and the supplier.

Final — The submittal that reflects the required resolution of review comments or the complete submittal required. Drawings submitted as final shall show Bechtel's job title, job number, procurement document number, line, equipment, tag or code number and the manufacturer's serial number(s).

B. SUBMITTAL

In column 5, Bechtel Engineering to place the following codes where applicable:

F — Before Fabrication
S — Before Shipment
I — Before Installation
P — Before Final Payment
W — With Shipment
D — Before Design

or

Expressed in calendar days after notice of award.

In column 7, Bechtel Engineering to place the following letter as applicable:

M — Microfilm
R — Reproducible
O — Original

In column 8, supplier to indicate its schedule if different than shown, and agreed with by Bechtel.

C. DISTRIBUTION

Items and/or documents required to be provided by the G-321-E shall be forwarded to the Bechtel Engineering designated under entry No. 9, "Forward Copies To:"

D. DOCUMENT CATEGORY NUMBERS & ABBREVIATED DESCRIPTIONS

Engineering Documents are identified and defined as follows:

1.0 DRAWINGS (DWG)

- 1.1 Outline Dimensions, Services, Foundations and Mounting Details (OUTLINE DIM, SERVICES & FDN/MTG DETS) — Drawings providing external envelope, including lugs, centerline(s), location and size for electrical cable, conduit, fluid, and other service connections, isometics and details related to foundations and mountings.
- 1.2 Assembly Drawings (ASSEMBLY DWGS) — Detailed drawings indicating sufficient information to facilitate assembly of the component parts of an equipment item.
- 1.3 Shop Detail Drawings (SHOP DET DWGS) — Drawings which provide sufficient detail to facilitate fabrication, manufacture, or installation. This includes pipe spool drawings, internal piping and wiring details, cross-section details and structural and architectural details.
- 1.4 Wiring Diagrams (WIRING DIAGS) — Drawings which show schematic diagrams, equipment internal wiring diagrams, and interconnection wiring diagrams for electrical items.
- 1.5 Control Logic Diagrams (CONT LOGIC DIAGS) — Drawings which show paths which input signals must follow to accomplish the required responses.
- 1.6 Piping and Instrumentation Diagrams (P&IDs) — Drawings which show piping system scheme and control elements.

2.0 PARTS LIST AND COST — Sectional view with identified parts and recommended spare parts for one year's operation or specified with unit cost.

3.0 COMPLETED BECHTEL DATA SHEETS (COMP DATA SHT) — Information provided by a supplier on data sheets furnished by Bechtel.

4.0 INSTRUCTIONS

4.1 Erection/Installation (EREC/INSTL) – Detailed written procedures, instructions, and drawings required to erect or install material or equipment.

4.2 Operating – Detailed written instructions describing how an item or system should be operated.

4.3 Maintenance – Detailed written instructions required to disassemble, reassemble and maintain items or systems in an operating condition.

4.4 Site Storage and Handling (SITE STOR & HDLG) – Detailed written instructions which define the requirements and time period for lubrication, rotation, heating, lifting or other handling requirements to prevent damage or deterioration during storage and handling at jobsite. This includes return shipping instructions.

5.0 SCHEDULES: ENGINEERING AND FABRICATION/ERECTION (SCHED) (ENGRG & FAB EREC) – Bar charts or critical path method diagrams which detail the chronological sequence of activities.

6.0 QUALITY ASSURANCE MANUAL/PROCEDURES (QA MNL/PROC) – The document(s) which describe(s) the planned and systematic measures that are used to assure that structures, systems, and components will meet the requirements of the procurement documents.

7.0 SEISMIC DATA REPORT – The analytical or test data which provides data and demonstrates suitability of material, component or system in relation to the conditions imposed by the stated seismic criteria.

8.0 ANALYSIS AND DESIGN REPORT (ANAL & DSGN RPRT) – The analytical data (stress, electrical loading, fluid dynamics, etc.) which demonstrates that an item satisfies specified requirements.

9.0 ACOUSTIC DATA REPORT (ACST DATA RPRT) – The noise, sound and other acoustic vibration data required by the procurement document.

10.0 SAMPLES

10.1 Typical Quality Verification Documents (TYP QUAL VERIF DOC) – A representative data package which will be submitted for the items furnished as required in the procurement documents.

10.2 Typical Material Used (TYP MAT USED) – A representative example of the material to be used.

11.0 MATERIAL DESCRIPTION (MAT DESCRT) – The technical data describing a material which a supplier proposes to use. This usually applies to architectural items, e.g., metal siding, decking, doors, paints, coatings.

12.0 WELDING PROCEDURES AND QUALIFICATIONS (WLDG PROC & QUALF) – The welding procedure, specification and supporting qualification records required for welding, hard facing, overlay, brazing and soldering.

13.0 MATERIAL CONTROL PROCEDURES (MATERIAL CONT PROC) – The procedures for controlling issuance, handling, storage and traceability of materials such as weld rod.

14.0 REPAIR PROCEDURES (REPAIR PROC) – The procedures for controlling material removal and replacement by welding, brazing, etc., subsequent thermal treatments, and final acceptance inspection.

15.0 CLEANING AND COATING PROCEDURES (CLNG & CTG PROC) – The procedures for removal of dirt, grease or other surface contamination and preparation and application of protective coatings.

16.0 HEAT TREATMENT PROCEDURES (HEAT TR PROC) – The procedures for controlling temperature and time at temperature as a function of thickness, furnace atmosphere, cooling rate and method, etc.

19.0 UT – ULTRASONIC EXAMINATION PROCEDURES (UT PROC) – Procedures for detection of presence and certain characteristics of discontinuities and inclusions in materials by the use of high frequency acoustic energy.

20.0 RT – RADIOGRAPHIC EXAMINATION PROCEDURES (RT PROC) – Procedures for detection of presence and certain characteristics of discontinuities and inclusions in materials by x-ray or gamma ray exposure of photographic film.

21.0 MT – MAGNETIC PARTICLE EXAMINATION PROCEDURES (MT PROC) – Procedures for detection of surface (or near surface) discontinuities in magnetic materials by distortion of an applied magnetic field.

22.0 PT – LIQUID PENETRANT EXAMINATION PROCEDURES (PT PROC) – Procedures for detection of surface discontinuities in materials by application of a penetrating liquid in conjunction with suitable developing techniques.

23.0 EDDY CURRENT EXAMINATION PROCEDURES (EDDY CUR EXAM PROC) – Procedures for detection of discontinuities in material by distortion of an applied electromagnetic field.

24.0 PRESSURE TEST – HYDRO, AIR, LEAK, BUBBLE OR VACUUM TEST PROCEDURE (PRESS TEST – HYDRO, AIR, BUBBLE – VAC TEST PROC) – Procedures for performing hydrostatic or pneumatic structural integrity and leakage tests.

25.0 INSPECTION PROCEDURE (INSPECTION PROC) – Organized process followed for the purpose of determining that specified requirements (dimensions, properties, performance results, etc.) are met.

26.0 PERFORMANCE TEST PROCEDURES (PRFM TEST PROC) – Tests performed to demonstrate that functional design and operational parameters are met.

26.1 Mechanical Tests (MECH TEST) – e.g., pump performance data, valve stroking, load, temperature rise, calibration, environmental, etc.

26.2 Electrical Tests (ELEC TEST) – e.g., impulse, overload, continuity, voltage, temperature rise, calibration, saturation, loss, etc.

27.0 PROTOTYPE TEST REPORT (PROTO TYP TEST REPORT) – Report of a test which is performed on a standard or typical example of equipment or item, and is not required for each item produced in order to substantiate the acceptability of equal items. This may include tests which result in damage to the item(s) tested.

28.0 PERSONNEL QUALIFICATION PROCEDURES (PERSONL QUAL PROC) – Procedures for qualifying welders, inspectors and other special process personnel.

29.0 SUPPLIER SHIPPING PREPARATION PROCEDURE (SPLR SHPNG PREP PROC) – The procedure used by a supplier to prepare finished materials or equipment for shipment from its facility to the jobsite.

30.0 Erosion and Sedimentation Control Plan

31.0 (OPEN)

32.0 (OPEN)

QUALITY VERIFICATION DOCUMENT REQUIREMENTS

1. DOCUMENT CATEGORY NUMBER	2. SPECIFICATION PARAGRAPH REFERENCE	3. DOCUMENT DESCRIPTION	4. BECHTEL RELEASE	5. FIELD RECEIPT INSPECTION CHECK-IN	6. REMARKS	7. DOC SUPPLIER PAGE COUNT
33	1.A.1.d	Aggregate Gradation Analysis Reports			Prior to material delivery as shown on the drawings	
17.4	8.A.2.a	Liner Material Certification			Prior to placement of liner	

8. SUPPLIER'S ORDER NO.
9. SUPPLIER'S PART NO.
10. SUPPLIER'S PART NAME
11. QUANTITY

12. BECHTEL'S REQ OR P.O. NO.
13. BECHTEL'S LINE/EQUIP TAG OR CODE NO.
14. BECHTEL'S PART NAME
15.

16. SUPPLIER'S CONFORMANCE STATEMENT
WE CERTIFY THAT THE WORK AND REQUIRED DOCUMENTS MEET THE REQUIREMENTS OF THE PROCURING DOCUMENTS.
AUTHORIZED SUPPLIER SIGNATURE — TITLE — DATE

17. SUPPLIER QUALITY REPRESENTATIVE AT PLANT
WORK WAS RELEASED BASED ON SATISFACTORY COMPLETION OF QUALITY SURVEILLANCE AND REVIEW OF DOCUMENTATION.
☐ WITH AUTHORIZED DEVIATIONS NOTED IN COLUMN 6
☐ NO DEVIATIONS
SIGNATURE OF SQR — DATE

18. RECEIVING INSPECTION AT THE FIELD
THIS FORM AND THE QUALITY VERIFICATION DOCUMENTS REFERENCED HEREON HAVE BEEN RECEIVED AND THEIR RELATIONSHIP TO THE HARDWARE ITEMS VERIFIED.
SIGNATURE OF BECHTEL FIELD INSPECTOR — DATE

19. FORWARD COPIES TO:
Bechtel Power Corporation
P.O. Box 167
St. Clair, MI 48079

SPECIAL INSTRUCTIONS
Attn: Mr. W.L. Pons, Project Supt.
Job 10539-201

BECHTEL
G-321-V

20. BELLE RIVER POWER PLANT UNITS 1 AND 2
THE DETROIT EDISON COMPANY

21. JOB NO. 10539-201
22. SPEC NO. CP-204

QUALITY VERIFICATION DOCUMENT REQUIREMENTS

SHEET 1 OF 3 — REV. 0

23. CONTROL NO. ______ FILE NO. ______

SFP-20213
ED-62 REV. 3A (4-77)

INSTRUCTIONS FOR THE PREPARATION OF FORM G-321-V (QUALITY VERIFICATION DOCUMENT REQUIREMENTS)

A. PURPOSE: The G-321-V is initially prepared by Bechtel Engineering and completed by the supplier when providing Quality Verification Documents to Bechtel in support of the work. The G-321-V is a multi-purpose form to:

(1) Transmit quality verification documents from the supplier.
(2) Provide a Certificate of Conformance from the supplier.
(3) Evidence SQR release of documentation and/or work.
(4) Provide evidence of a Field Inspection check of the quality verification documentation received at the installation site.

B. GENERAL INFORMATION: Instructions for filling out the G-321-V form is found in Section "E". Category numbers and abbreviated descriptions of the information to be used are found in Section "F". Detailed quality verification document definitions are found in G-321-V Supplement A.

C. DISTRIBUTION: Quality verification documents required to be provided by the G-321-V form shall be forwarded to the group(s) and destination(s) designated under entry #19, "Forward copies to".

D. DEFINITIONS OF TERMS: (Also see Document Category Definitions G-321-SUP A).
Supplier — This is a seller, vendor, contractor, subcontractor, sub-supplier, etc.
Reproducible — A master copy which can be legibly duplicated by either microreproduction, diazo or electrostatic process. Diazo sepias may be submitted only if they meet and satisfy Bechtel microfilming requirements.
Microfilm — Film containing an image reduced in size from the original, and capable of being enlarged to a clear reproduction of the original.
Drawings submitted as final show title, job number, purchase order number, line, equipment, tag or code number and the manufacturer's serial number(s).

E. BECHTEL ENTRY INSTRUCTIONS:

Entry No.	Information Required
1.	Enter Document Category Number.
2.	Enter Specification Paragraph Reference.
3.	Enter Abbreviated Description Corresponding to the Document Category Number.
4.	SQR to Complete Upon Release and Sign On Line 17.
5.	Bechtel Field Inspection at the jobsite to Complete Check-in and Sign on Line 18.
6.	Enter "Remarks" as appropriate. When a deviation has occurred, reference the deviation(s) and Authorization Document(s) in this column, and include the authorization document(s) in the verification package.
17.	Upon inspection and verification with the Supplier Quality Verification Document Package and Associated Deviations, if any, and checking appropriate block, SQR or Authorized Representative signs and dates release.
18.	Upon receipt of the Quality Verification Documentation Package at the jobsite, the Field Inspector will review the documents and the appropriate hardware. If found to be satisfactory, he signs and dates the check-in statement, routes hardware to storage and files the form.
19.	Enter name and address to whom items or documents are to be forwarded.
20.	Project may pre-print or type Project and Client Identification.
21.	Project may pre-print Bechtel Job Number.
22.	Enter Specification Number/Number of Sheets to the G-321-V and the Revision.
23.	Following SQR Check, the G-321-V is identified and filed in the Jobsite Files, available for eventual turnover to the Client when required.

SUPPLIER ENTRY INSTRUCTIONS:

Entry No.	Information Required
7.	Enter number of pages of Quality Verification Document being submitted, corresponding to the units being released. Sign Entry 16.
8-9-10.	Enter information required.
11.	Enter the quantity of units covered by the Quality Verification Documents being submitted. For each Item No. (Entry 12) being released, provide a separate copy of this completed form and the supporting Quality Verification Documents.
12-13-14	Enter information required.
15.	Open — This space to be identified and used for traceability. If or when appropriate enter identification numbers, serial numbers, Heat numbers, etc.
16.	Supplier — Signature of an employee of the supplier identified in his QA Manual or by suppliers letter as authorized to sign such documents.
19.	Upon Inspection Release the completed Quality Verification Documents are forwarded to the address(es) shown. A completed copy of Form G-321-V shall accompany the hardware with an additional copy forwarded to the Field Inspector at the site.

F. DOCUMENT CATEGORY NUMBERS & ABBREVIATED DESCRIPTIONS:

Quality-Verification Documents are identified as follows and defined in G-321-V-Supplement A.

- 12.0 WELDING VERIFICATION DOCUMENTS (WELD & QUALF VERIF DOC)
- 14.0 MAJOR REPAIR VERIFICATION REPORTS (MAJ REPAIR VERIF RPRT)
- 15.0 CLEANING AND COATING VERIFICATION REPORTS (CLNG & CTG VERIF RPRT)
- 16.0 HEAT TREAT REPORTS (HEAT TRT VERIF RPRT)
- 17.0 MATERIAL PROPERTY REPORTS (MAT TEST RPRT)
  - 17.1 MTR Material Test Reports (MAT TEST RPRT)
  - 17.2 Impact Test Data (IMP TEST DATA)
  - 17.3 Ferrite Data (FERRITE DATA)
  - 17.4 Material Certificate of Compliance (MAT CERT OF COMPL)
  - 17.5 Electrical Property Reports (ELEC PROP RPRT)
- 18.0 CODE COMPLIANCE (CODE COMPL)
- 19.0 UT — Ultrasonic Examination and Verification Reports (UT — REPORT)
- 20.0 RT — Radiographic Examination and Verification Reports (RT — REPORT)
- 21.0 MT — Magnetic Partical Examination and Verification Reports (MT — REPORT)
- 22.0 PT — Liquid Penetrant Examination and Verification Reports (PT — REPORT)
- 23.0 Eddy Current Examination and Verification Reports (EDDY CUR EXAM & VERIF REPORT)
- 24.0 Pressure Test — Hydro, Air, Leak, Bubble or Vacuum Test and Verification Reports (PRESS TST) (HYDRO, AIR, BUBBLE — VAC TEST & VERIF REPORT)
- 25.0 Inspection and Verification Reports (INSP & VERIF RPRT)
- 26.0 Performance Test and Verification Reports (PRFM TEST REPORT)
  - 26.1 Mechanical Test (MECH TEST)
  - 26.2 Electrical Test (ELEC TEST)
- 27.0 Prototype Test Report (PROTO TYP TEST REPORT)

QUALITY VERIFICATION DOCUMENT CATEGORY DEFINITIONS G-321-V – SUP A

(V) - Quality Verification Documents. This term comprises material test reports, heat treatment charts, welding records, NDE results, performance test reports, and similar document(s), which demonstrate or certify conformance to the technical or inspection requirements of the procurement documents.

12.0 WELDING QUALIFICATION VERIFICATION REPORTS – A verification report of welds performed including the identification of the qualified weld(s), and certification that the weld(s) were qualified.

13.0 MATERIAL VERIFICATION REPORTS – Reports relative to material which confirm, substantiate or assure that an activity or condition has been implemented in conformance with code and material specifications imposed by the procurement documents.

14.0 MAJOR REPAIR VERIFICATION REPORTS – Verification reports may include weld repair locations (maps), material test reports for filler metal, pre- and post-weld heat treatment records, NDE records, etc. The resolution of whether a repair is major or not is a Bechtel responsibilitv.

15.0 CLEANING AND COATING VERIFICATION REPORTS – Verification reports include certification of visual examination for surface preparation, surface profile, materials, etc., humiditv data, temperature data and coating thickness data as required by the procurement documents.

16.0 HEAT TREAT REPORTS – Verification reports normally include furnace charts or similar records which identify and certify the item(s) treated, the procedure used, furnace atmosphere, time at temperature, cooling rate, etc.

17.0 MATERIAL PROPERTY REPORTS

17.1 MTR (Material Test Reports) – These reports include all chemical, physical, mechanical, and electrical property test data required by the material specification and applicable codes. This is applicable to cement, concrete, metals, cable jacket materials, rebar, rebar splices, etc.

17.2 Impact Test Data – Results of Charpy or drop weight tests including specimen configuration, test temperature and fracture data.

17.3 Ferrite Data – Report of the ferrite percentage for stainless steel materials used, including castings & welding filler metals as deposited.

17.4 Material Certificate of Compliance – Verification document which certifies conformance to the requirements of the applicable material specification.

17.5 Electrical Property Reports – Report of electrical characteristics, e.g., dielectric, impedance, resistance, flame tests, corona, etc.

18.0 CODE COMPLIANCE – Verifying documents (such as data Forms U-1, N-2, State, etc.), which are prepared by the manufacturer or installer and certified by the Authorized Code Inspector.

19.0 UT – ULTRASONIC EXAMINATION AND VERIFICATION REPORTS – Examination results of presence and certain characteristics of discontinuities and inclusions in material by the use of hiah frequency acoustic energy.

20.0 RT – RADIOGRAPHIC EXAMINATION AND VERIFICATION REPORTS – Examination results of presence and certain characteristics of discontinuities and inclusions in materials by x-ray or gamma-ray exposure of photoaraphic film.

21.0 MT – MAGNETIC PARTICLE EXAMINATION AND VERIFICATION REPORTS – Examination results of surface (or near surface) discontinuities in magnetic materials by distortion of an applied magnetic field.

22.0 PT – LIQUID PENETRANT EXAMINATION AND VERIFICATION REPORTS – Examination results of surface discontinuities in materials by application of a penetrating liquid in conjunction with suitable developing techniques.

23.0 EDDY CURRENT EXAMINATION AND VERIFICATION REPORTS – Examination results of discontinuities in material by distortion of an applied electromagnetic field.

24.0 PRESSURE TEST – HYDRO, AIR, LEAK, BUBBLE OR VACUUM TEST AND VERIFICATION REPORTS – Results of hydrostatic or pneumatic structural integrity and leakage tests.

25.0 INSPECTION AND VERIFICATION REPORTS – Documented findings resulting from an inspection.

26.0 PERFORMANCE TEST AND VERIFICATION REPORTS – Report of test results.

26.1 Mechanical Tests, e.g., pump, performance data, valve stroking, load, temperature rise, calibration, environment, etc.

26.2 Electrical Tests, e.g., load, impulse, overload, continuity, voltage, temperature rise, calibration, saturation, loss, etc.

27.0 PROTOTYPE TEST REPORT – Report of the test which is performed on a standard or typical example of equipment, material or item, and is not required for each item produced in order to substantiate the acceptability of equal items. This normally includes tests which mav, or could be expected to, result in damaae to the item(s) tested.

33.0 Aggregate Gradation Analysis Reports

34.0 (OPEN)

35.0 (OPEN)

QUALITY VERIFICATION DOCUMENT CATEGORY DEFINITIONS G-321-V – SUP A

(V) - Quality Verification Documents. This term comprises material test reports, heat treatment charts, welding records, NDE results, performance test reports, and similar document(s), which demonstrate or certify conformance to the technical or inspection requirements of the procurement documents.

12.0 WELDING QUALIFICATION VERIFICATION REPORTS – A verification report of welds performed including the identification of the qualified weld(s), and certification that the weld(s) were qualified.

13.0 MATERIAL VERIFICATION REPORTS – Reports relative to material which confirm, substantiate or assure that an activity or condition has been implemented in conformance with code and material specifications imposed by the procurement documents.

14.0 MAJOR REPAIR VERIFICATION REPORTS – Verification reports may include weld repair locations (maps), material test reports for filler metal, pre- and post-weld heat treatment records, NDE records, etc. The resolution of whether a repair is major or not is a Bechtel responsibility.

15.0 CLEANING AND COATING VERIFICATION REPORTS – Verification reports include certification of visual examination for surface preparation, surface profile, materials, etc., humidity data, temperature data and coating thickness data as required by the procurement documents.

16.0 HEAT TREAT REPORTS – Verification reports normally include furnace charts or similar records which identify and certify the item(s) treated, the procedure used, furnace atmosphere, time at temperature, cooling rate, etc.

17.0 MATERIAL PROPERTY REPORTS

17.1 MTR (Material Test Reports) – These reports include all chemical, physical, mechanical, and electrical property test data required by the material specification and applicable codes. This is applicable to cement, concrete, metals, cable jacket materials, rebar, rebar splices, etc.

17.2 Impact Test Data – Results of Charpy or drop weight tests including specimen configuration, test temperature and fracture data.

17.3 Ferrite Data – Report of the ferrite percentage for stainless steel materials used, including castings & welding filler metals as deposited.

17.4 Material Certificate of Compliance – Verification document which certifies conformance to the requirements of the applicable material specification.

17.5 Electrical Property Reports – Report of electrical characteristics, e.g., dielectric, impedance, resistance, flame tests, corona, etc.

18.0 CODE COMPLIANCE – Verifying documents (such as data Forms U-1, N-2, State, etc.), which are prepared by the manufacturer or installer and certified by the Authorized Code Inspector.

19.0 UT – ULTRASONIC EXAMINATION AND VERIFICATION REPORTS – Examination results of presence and certain characteristics of discontinuities and inclusions in material by the use of high frequency acoustic energy.

20.0 RT – RADIOGRAPHIC EXAMINATION AND VERIFICATION REPORTS – Examination results of presence and certain characteristics of discontinuities and inclusions in materials by x-ray or gamma-ray exposure of photographic film.

21.0 MT – MAGNETIC PARTICLE EXAMINATION AND VERIFICATION REPORTS – Examination results of surface (or near surface) discontinuities in magnetic materials by distortion of an applied magnetic field.

22.0 PT – LIQUID PENETRANT EXAMINATION AND VERIFICATION REPORTS – Examination results of surface discontinuities in materials by application of a penetrating liquid in conjunction with suitable developing techniques.

23.0 EDDY CURRENT EXAMINATION AND VERIFICATION REPORTS – Examination results of discontinuities in material by distortion of an applied electromagnetic field.

24.0 PRESSURE TEST – HYDRO, AIR, LEAK, BUBBLE OR VACUUM TEST AND VERIFICATION REPORTS – Results of hydrostatic or pneumatic structural integrity and leakage tests.

25.0 INSPECTION AND VERIFICATION REPORTS – Documented findings resulting from an inspection.

26.0 PERFORMANCE TEST AND VERIFICATION REPORTS – Report of test results.

26.1 Mechanical Tests, e.g., pump, performance data, valve stroking, load, temperature rise, calibration, environment, etc.

26.2 Electrical Tests, e.g., load, impulse, overload, continuity, voltage, temperature rise, calibration, saturation, loss, etc.

27.0 PROTOTYPE TEST REPORT – Report of the test which is performed on a standard or typical example of equipment, material or item, and is not required for each item produced in order to substantiate the acceptability of equal items. This normally includes tests which may, or could be expected to, result in damage to the item(s) tested.

33.0 (OPEN)

34.0 (OPEN)

35.0 (OPEN)

TECHNICAL SPECIFICATION

FOR

SEEDING AND MULCHING

1. SCOPE OF WORK

   A. Furnish all labor, materials, equipment, facilities, transportation, services, and supervision required for preparation of seed beds and placing of all seed, soil supplements, and mulch on disturbed areas, to include ditches, within the work limits indicated that are not surfaced with aggregate.

2. LOCATION OF WORK

   A. All disturbed areas

3. APPLICABLE PUBLICATIONS

   A. The following publication and the documents referenced therein are hereby made a part of this specification.

      1) State of Michigan Department of Transportation Standard Specifications for Construction, 1979

4. MATERIALS

   A. FERTILIZER

      1) Fertilizer shall be chemical fertilizer for grass seeding (12-12-12 grade) specified in Section 8.21.10 of the State of Michigan Department of Transportation Specifications.

         a) Chemical analysis of the fertilizers shall be clearly shown upon each container and the contents of each container shall be guaranteed to be the compound stated in such analysis.

   B. SEEDS

      1) All seed shall conform to the State of Michigan Department of Transportation Specifications as detailed in Section 8.21.09.

   C. MULCH

      1) Mulch shall consist of straw, hay, and marsh hay and shall be held in place by a spray coating of asphalt emulsion (designation SS-1s).

5. PREPARATION FOR SEEDING

A. The areas to be seeded shall be prepared in accordance with Section 6.52.03 of the State of Michigan Department of Transportation Specifications. Topsoil will be required as directed by Bechtel.

B. Fertilizer shall be applied to the soil at the rate of 800 pounds per acre and may be spread in combination with the seed when a hydraulic seeder is used.

6. SEEDING

A. Class 1 shall be sown at the rate of 80 pounds per acre.

7. MULCHING

A. Mulch shall be placed over slope areas after seeding has been performed. It shall be placed uniformly at the rate of 2 tons per acre. Mulch shall be anchored by the use of an asphalt emulsion (designation SS-1s).

WASTE CHARACTERISTICS

Membrane liner for each respective basin shall be designed for the following characteristics:

Boiler Blowdown Surge Basin

pH	9-9.5
TDS, ppm	0.3-5
TSS, ppm	0.1-100
Fe (total), ppm	0.01-30
Cu, ppm	0
NH_3, ppm	0.3-2
Oil and grease, ppm	<15

Chemical Cleaning Waste Basin

pH	<6
TDS, ppm	3,000-5,000
TSS, ppm	100
Fe (total), ppm	500-1,000
Cu, ppm	0
Oil and grease, ppm	<15

Oily Waste Basin

pH	6-8
TDS, ppm	50-150
TSS, ppm	5-150
Oil and grease, ppm	25 avg. 50 max.