GEOTECHNICAL INVESTIGATION REPORT

PROPOSED SALT BARN
SHELBY TOWNSHIP, MACOMB COUNTY, MICHIGAN
MCDR PROJECT NO. 9048

MSG PROJECT NO. 401.2300893-TASK 2

AUGUST 28, 2024

PREPARED FOR:

MACOMB COUNTY DEPARTMENT OF RODS

117 SOUTH GROESBECK HIGHWAY
MOUNT CLEMENS, MI 48043

PREPARED BY:

THE MANNIK & SMITH GROUP, INC.

607 SHELBY STREET, SUITE 300
DETROIT, MICHIGAN 48226

August 28, 2024

Mr. Adam Newton, PE
Project Engineer
Macomb County Department of Roads
117 South Groesbeck Highway
Mount Clemens, Michigan 48043

Re: Geotechnical Investigation Report
Proposed Salt Barn
Shelby Township, Macomb County, Michigan
MCDR Job No. 9048
MSG Project Number: 401.2300893-Task 2

Dear Mr. Newton:

This report presents the results of our geotechnical field investigation, field and laboratory testing results, geotechnical analyses, and geotechnical recommendations and construction considerations for the proposed salt barn in Shelby Township, Macomb County, Michigan. Our investigation was completed in accordance with our Original Proposal No. 401.2400053 dated January 17, 2024.

We trust that this report addresses your project needs. We appreciate the opportunity to work with you on this very important project. Please contact us if you have any questions or if we can be of further assistance.

Sincerely,
The Mannik & Smith Group, Inc.

Lana AbuQtaish, PhD, PE
Geotechnical Engineer

Dr. Brahim Benhamida, PE
VP/Chief Geotechnical Engineer

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1.0 INTRODUCTION

1.1 General

The Mannik & Smith Group, Inc., (MSG) was retained by Macomb County Department of Roads (MCDR) to conduct a geotechnical investigation and to provide geotechnical engineering services to assist with the design and construction of the proposed Salt Barn in Shelby Township, Macomb County, Michigan. The site location is depicted in Figure 1-Site Location Map in Appendix A. This geotechnical investigation was performed in general accordance with MSG Original Proposal 401.2400053 dated January 17, 2024.

1.2 Project Information

As we understand, the overall proposed project consists of the design and construction of a Salt Barn Structure with a footprint area of 160 feet by 80 feet with no basement. The approximate interior height of the Salt Barn Building is 35 feet. Based on the current design concept provided to us via email on August 12, 2024, the proposed exterior walls are supported on 12 feet by 3 feet shallow foundation spaced at approximately 8 feet.

1.3 Site Conditions

The site of the proposed project is located at approximately 900 feet north of the intersection of Napi Drive and 23 Mile Road in Shelby Township, Macomb County. The site area consists of undeveloped open unpaved ground surface that is located south of an existing salt barn structure. Based on a recent Survey Data provided to us by MCDR, the site of the proposed structure is relatively flat with surface elevation ranging from approximately 634.0 to 636.0 feet.

2.0 SUBSURFACE INVESTIGATION

2.1 Field Exploration

The subsurface investigation consisted of performing seven (7) soil borings as indicated below in Table 2.1.1

Table 2.1.1: Summary of Drilled Soil Borings

Proposed Structure: Salt Barn Building	Soil Boring Number	Soil Boring Depth (ft)	Comments
Periphery Soil Borings	4	25	Or to refusal before 25 ft.
Central Soil Borings	3	35	Or to refusal before 35 ft.
Total Drilling Footage		**205**	

The approximate locations of the proposed soil borings were selected by MSG in coordination with MCDR's Project Manager based on Design concept of the Project's Structural Engineer. The boring locations were field marked by MSG personnel and surveyed by MCDR's Surveyor. These borings had to be field-adjusted away from existing underground utilities and overhead lines. The approximate as-drilled soil boring locations are shown in Figure 2 in Appendix A. Soil boring elevations were estimated from MCDR's recent survey data.

The drilling operations for this investigation were performed over 3 days on April 8, 9, and 1, 2024. Soil borings were advanced using a track-mounted Geoprobe 3230 DT and using 3¼-inch inner diameter hollow stem augers. Upon completion, the boreholes were backfilled to the surface with bentonite mixed with auger cuttings.

During drilling operations, Standard Penetration Test (SPT) was conducted in accordance with ASTM D1586 procedures and was completed at 2.5 feet intervals within the upper 10 feet, then every other 5 feet until depth termination. During the SPT testing, soil samples were obtained with a 2-inch outer diameter split spoon sampler driven 18 inches into the soil with blows of a 140-pound hammer falling 30 inches. The sampler is generally driven in three successive 6-inch increments with the blows for each 6-inch increment being recorded. The number of blows required to advance the sampler through 12 inches after an initial penetration of 6 inches is termed as the Standard Penetration Test resistance (N-value) and is presented graphically on individual Soil Boring Logs.

SPT sampling was conducted in accordance with ASTM D1586 and was completed at 2.5 feet intervals for the upper 10 feet and at 5 feet intervals thereafter. No rock coring was performed as part of the current geotechnical investigation.

Additionally, MSG collected thinned walled Shelby tubes from borings SB-05 and SB-07 at different depths in accordance with ASTM D1587.

Collected soil samples were labeled with the soil boring designation and a unique sample number. Split-spoon samples are designated as SS and Shelby tube samples are designated as ST. The soil samples were sealed in glass jars and in Shelby tubes in the field to protect the soil and maintain the soil's natural moisture content. All samples were transferred to MSG's laboratory for further analysis and testing.

Whenever possible, groundwater level observations were made during the drilling operations and are shown on the Soil Boring Logs. In addition, prior to backfilling, each open borehole was observed again for groundwater. During drilling, the depth at which free water was observed, where drill cuttings became saturated or where saturated samples were collected, was indicated as the groundwater level during drilling. It should be noted that seasonal variations and recent rainfall conditions may influence the groundwater table significantly.

2.2 Laboratory Testing

Each split-spoon recovered from the borings was examined and visually classified. This examination was performed to verify conditions identified within field boring logs, to select samples for further laboratory evaluation, and to perform visual-manual classification of samples not subject to further laboratory testing. During the examination process, the geotechnical engineer finalized the soil boring logs.

Representative soil samples were subjected to laboratory tests consisting of pocket penetrometer, Dry Unit Weight (ASTM D7263), Natural Moisture Content (ASTM D2216), Atterberg's Limits (ASTM D4318), One-Dimensional Consolidation (ASTM 2435), and Unconfined Compression Strength (ASTM D2166). A brief description of each test is provided in Laboratory Test Procedures in Appendix C.

All soil samples were classified in general accordance with the Unified Soil Classification System (USCS). The USCS group symbol determined from the visual-manual classification is shown in parentheses at the end of the sample description for each layer shown on the Soil Boring Logs.

The results of the soil classification and the laboratory test results are included on the soil boring logs and soil laboratory test data, which are presented in Appendices B and C, respectively.

3.0 SUBSURFACE CONDITIONS

3.1 Subsurface Classification

The following sections describe the subsurface conditions in terms of major soil strata for the purposes of geotechnical exploration. The soil boundaries indicated are inferred from non-continuous sampling and observations of the drilling operations and/or sampling resistance. The subsurface conditions discussed in the following sections and those shown on the boring logs represent an evaluation of the subsurface conditions based on interpretation of the field and laboratory data using normally accepted geotechnical engineering judgement and common engineering practice standards. The subsurface conditions described herein may vary beyond the boring locations and at different times of the year. A generalized soil profile of the subsurface conditions encountered across the site of the proposed development, beginning at the ground surface and extended downward is as follows:

Stratum 1 –Native Granular Soils (SP, SM, ML)
Native brown and gray granular soils were encountered at the ground surface at all soil borings. This stratum extended to depths ranging between approximately 6 feet to 13.5 feet below existing grades (El. 629.0 to El. 622.0). The density of this Stratum was very dense to medium dense.

Stratum 2 – Gray Silty Clay (CL)
Native gray silty clay was encountered underneath Stratum at all the soil. This cohesive layer extended to the explored planned depths at all drilled deep soil borings (El. 61104 to El. 605.0). The consistency of this stratum ranged from soft to hard.

3.2 Groundwater Observations

No groundwater was observed at any of the soil borings drilled during the current investigation. Water levels reported are accurate only for the time and date the borings were drilled. The borings were backfilled and sealed the same day that they were completed. Long term monitoring of the boreholes was not included as part of the scope of this subsurface investigation.

4.0 ANALYSES AND RECOMMENDATIONS

The following evaluations and recommendations are based on interpretations of field and laboratory data obtained during the geotechnical investigation, our geotechnical analyses, and MSG's experience with similar subsurface conditions and projects. Where comments are made on construction or regarding the proposed development, they are provided in order to highlight aspects of construction that could potentially affect the design of the project. Contractors bidding on or undertaking the work should make their own interpretations of the factual results of the investigation as it affects their construction methods, equipment capabilities, costs, schedule, sequencing and similar issues.

This report and evaluation reflects only the geotechnical aspects of the subsurface conditions at the site. Review and evaluation of environmental aspects of subsurface conditions is beyond the scope of this report

4.1 Structure Information

Based on the Geotechnical Investigation Specifications prepared by Advanced Storage Technology, Inc. (AST) provided to us by MCDR on August 12, 2024, we understand the following structural information for the proposed structure salt barn building:

- The footprint area of 160 feet by 80 feet with no basement.
- The approximate interior height of the Salt Barn Building is 35 feet.
- The current design concept calls for the proposed exterior walls be supported on 12 feet by 3 feet shallow foundation spaced at approximately 8 feet.

4.2 Foundation Recommendations for the proposed Structure

Based upon our review of the existing soil conditions in the planned foundation areas of the salt barn building, it is recommended that the shallow foundations bearing on **native granular soils overlying the native**

cohesive soils as described in Section 3.1 above be designed for an allowable soil bearing capacity of **2,000 psf**.

If during the construction operations, the upper layers consist of random backfill soils and not suitable to support the shallow foundation system, we recommend all the fill soils be removed and replaced with a well-compacted engineered fill.

It is highly recommended that **shallow foundations do not bear directly on random backfill soils and on high plasticity clays.** Removal of random backfill soils and/or high plasticity clay and replacement with a suitable material within 3 feet of the bearing elevation is recommended in all areas where these unsuitable soils are encountered. Replacement with lean concrete or suitable cohesive soil fill is preferred to limit water from accumulating in undercut areas. If granular fill material is used in undercuts, an underdrain system should be installed at the bottom of the undercut to limit water accumulation. We recommend MSG be retained to evaluate the foundation subgrades to determine the undercut locations and depths and perform the compaction testing of the engineered fill.

4.3 Settlement Analyses

As part of the current investigation, detailed settlement analyses were performed within the proposed shallow foundation areas using the geotechnical analysis/design parameters obtained from the laboratory consolidation testing conducted at our MSG's laboratory. The consolidation testing was performed on the relatively undisturbed Shelby tube soil samples collected during the field investigation. The consolidation testing results consisting of the compression index (Cc), recompression index (Cr), pre-consolidation pressure, and initial void ratio (e_0) are included in Appendix C – Soil Laboratory Testing Results.

Settlement generally consists of three separate components, immediate settlement, consolidation, and secondary settlement (or creep). In general, all soils will exhibit settlement as a result of a load applied on the soils. The magnitude of soil settlement depends on several factors, including soil type, structure, past loading history of the soil deposit, and moisture content. The predominant soil type encountered below the proposed shallow foundation areas consisted of granular soils (Stratum 1) underlain by cohesive clay soils (Stratum 2). Settlement of granular soils, if any, occurs rapidly, often during construction activities. For cohesive soils, consolidation settlement is the predominant mechanism of settlement. Consolidation settlement of clay is of greater concern than immediate settlement due to the potential magnitude and time dependent nature of consolidation.

The obtained consolidation parameters and coefficients were compared and verified with empirical relationships based on index properties. The empirical equations used in the estimation of Cc and Cr are based on our laboratory testing results of the natural moisture content and the Atterberg's limits and based on historical geotechnical data and our experience with Southeastern Michigan clay soils.

The compression index (Cc), recompression index (Cr), pre-consolidation pressure and initial void ratio (e_0) are used to assess the amount of consolidation settlement and the coefficient of consolidation is used to evaluate the time duration of the consolidation settlement.

Table 4.3.1 below summarizes the estimated soil parameters used in the settlement analyses for the proposed salt barn shallow foundations:

Table 4.3.1 Summary of Soil Settlement Parameters

Soil Description	Depth (feet)	Unit Weight (psf)	Initial Void Ratio e_0	Recompression Index, C_R	Compression Index, C_C	Pre-consolidation Pressure (ksf)
Medium Dense Sand (Stratum 1	1 to 6	130	-	0[1]	0[1]	-
Soft to hard Clay (Stratum 2)	6 to 30	125	0.823	0.058	0.333	3.5

1. Settlement of granular layers is assumed to be immediate with no long term settlement.

The results of the settlement analyses indicate consolidation settlement of the native underlying clay strata associated with an applied load of 2,000 psf will be on the order of 1 inch.

The differential settlement is expected to be ¾ of the total settlement.

The aforementioned recommended soil bearing capacity and the associated settlement evaluation are based on salt barn footing elevations with regards to existing and proposed preliminary site elevations. The required footing sizes are dependent on the anticipated applied loads in comparison to the above recommended allowable bearing capacity of the bearing soil. Exterior footing bottoms and footings in unheated areas should be no less than 42 inches below final exterior grade for protection against possible frost damage. This is the typical frost depth for Southeast Michigan; however, local building codes may vary and will govern the footing depth. Interior footings, which should not be subject to frost action, may bear at shallower depths, provided they are supported on native compact soil or engineered fill capable of supporting the design load.

Prior to the placement of reinforcing steel and concrete, an MSG geotechnical engineer or his/her designated representative should evaluate foundation excavations to verify that an adequate bearing material is present and that all debris, mud, loose, frozen or water-softened soils, and unsuitable soils are removed. All footings should bear in the undisturbed natural soils or in well-compacted engineered fill. In addition, MSG recommends that a DCP test or Housel Penetrometer Test, or similar field testing, be performed by the geotechnical engineer representative to assure a suitable bearing capacity for all foundations prior to concrete placement.

Where foundation subgrade undercutting and replacement is required, the undercuts should extend laterally at a slope of 1(Horizontal):2(Vertical) from the edge of the footing.

Foundations should be constructed as soon as is practical after foundation excavation activities. If the foundation excavations will be left open for an extended period of time, a thin mat of lean concrete should be placed over the bottom to minimize damage to the bearing surface from weather or construction activities. Water should not be allowed to pond in any excavation. Foundation concrete should not be placed on frozen or flooded subgrade.

The final grade adjacent to the structure exterior should be sloped at a minimum 2 percent grade away from the structure's foundations and structure's roof drains, if any, should be routed away from the foundation soils. Shallow groundwater was not encountered at the site. However, foundation drains will assist in ensuring the foundation subgrade soils are not adversely impacted by moisture changes that could result in differential settlement of the foundations. To prevent moisture against the exterior footings, a perforated matted edge drain may be used around the perimeter of the footings and placed at the base of the footings. The underdrain should be backfilled with free draining material. A waterproofing membrane with a protection layer should extend from the top to the base of the footings along the exterior edge where the concrete is in direct contact with the natural or backfilled material.

If a two-pour system is used for footings and slab, the cold joint at the interface of the exterior footings and slab on grade should be located at least 4 inches above the adjacent finish exterior grade. As an alternative, the use of a water stop between the two pours will minimize the moisture penetration through the cold joint and migration of water under the slab. A monolithic pour will eliminate the need of a water stop.

4.4 Slab-on-Grade

This section presents our geotechnical recommendations and construction considerations for a Slab-on-Grade foundation system if considered at the interior of the proposed salt barn structure.

Based on the existing subsurface conditions, it is recommended that soils be removed within 1 feet of the slab subgrade and replaced with engineered fill. The modulus for subgrade reaction for the native soils at the site is 150 pci and for a subgrade composed of well-compacted granular engineered fill is 200 pci. The final design thickness of the slab, the joint spacing and slab reinforcement should be determined by the structural engineer based on the above recommended subgrade modulus, the slab loading conditions and local building code requirements.

The subgrade of the slab-on-grade areas should be inspected and tested to assure proper preparation. The remediated slab subgrade shall be proof rolled as described in Section 4.5 to verify the effectiveness of the remediation measures. The subgrade soils should be protected against frost action if construction takes place during the winter. Frozen soils should be thawed, moisture conditioned and re-compacted or undercut and replaced prior to commencement of slab-on-grade construction. We recommend that the slabs-on-grade bear directly on a minimum of 6 inches of capillary resistant granular engineered fill (well graded granular material or engineered approved equivalent) compacted to 98 percent of Standard Proctor or 95 percent of the Modified Proctor maximum dry density within 2 percent of the optimum moisture content.

A waterproof membrane (vapor retarder) should be placed directly beneath the concrete building slab to minimize infiltration of water and delamination of the concrete floor slab. The moisture condition of the floor slab should be tested prior to placement of floor coverings to verify they are within tolerable limits for the floor coverings. Precautionary measures such as concrete mixture with low water-cement ratio of no more than 0.50 should be implemented to reduce the residual moisture in the slab. The vapor retarder should be sealed at all seams and pipe penetrations and connected to all footings. Water reducing admixtures may be used to obtain workability of the concrete. Sufficient time should be provided to moist cure the slabs for a minimum of 3 days or use other equivalent curing methods identified by the structural engineer.

In order to minimize the potential impacts caused by differential settlement, the slab-on-grade should be kept structurally separate from walls and columns and saw cut control joints should be provided at suitable intervals. A minimum of 6 inches of engineered fill should be placed between the slab bottom and the top of the footings below.

4.5 Site Preparation

The following are recommendations for the site soil preparation based on the geotechnical investigation performed for this project. These recommendations should be incorporated into the project specifications.

Before proceeding with construction, surface soils, vegetation, topsoil, root systems, refuse, asphalt, concrete including any existing abandoned buried foundations, and other deleterious materials should be stripped from the proposed construction areas. Depending on the time of year of construction and the Contractor's Means and Methods at controlling surface water, it may be possible that portions of the upper layers of site material including the surface soils and/or random backfill soils will be considered unsuitable and/or unstable and will be required to be stripped during site preparation activities.

The on-site soils are moisture sensitive and could become unstable if proper site water controls are not implemented and/or if they are subject to construction traffic. Every effort should be taken to minimize disturbance during compaction or over excavation and where possible, free standing water should be diverted away from the construction perimeter or pumped out using a sump to accommodate the proper compaction techniques.

Generally, areas exposed by stripping operations on which subgrade preparations are to be performed should be compacted in place to 98 percent of Standard Proctor or 95 percent of Modified Proctor within 2 percent of the optimum moisture content. If there are areas where the building floor slab will be located partially on a fill area and partially on a cut area, it is recommended that the depth of subgrade compaction in the cut area be increased to 18 inches, to provide uniform support of the rigid slab.

It is recommended that the prepared subgrade for pavement and slab-on-grade areas be proof rolled to detect any unstable areas. Proof rolling should be accomplished by making a minimum of two complete passes in each of two perpendicular directions with a fully-loaded tandem-axle dump truck, or other approved pneumatic-tired vehicle, with a minimum weight of 20 tons. If proof rolling reveals the presence of unstable areas within the subgrade, certain remedial measures will be required to stabilize the subgrade. Depending on the severity of distress encountered during proof rolling, undercutting of 12 to 18 inches below subgrade and backfilling with engineered fill as outlined in Section 4.6 may be performed. If an undercut and replacement of the top 12 to 18 inches fails to stabilize the subgrade, use of granular backfill with geogrid stabilization may be required.

The actual undercut depths and/or subgrade remediation measures required should be determined by the on-site Geotechnical Engineer or his/her designated representative.

During construction, if utilities are encountered within the project site, these should be removed and relocated or abandoned in place. If abandoned in place, it is recommended that the utility pipe be filled with cement grout to avoid potential collapse in the future. Should the utility lines be removed from the site, the resultant trench excavations should be backfilled with well-compacted granular material, placed and compacted in accordance with the recommendations of Section 4.6.

4.6 Fill Placement and Engineered Fill Requirements

All new fill should consist of inorganic soil that is free from all deleterious materials and construction debris. Fill materials should not be placed in a frozen condition or upon frozen subgrades. Proper drainage should be maintained during and after fill placement to prevent water from impacting compaction efforts or long-term fill integrity. Most on-site native granular and cohesive soils are suitable materials and they can be re-used as engineered fill.

Coarse crushed granular material is preferred as fill for replacement of undercut areas. For undercut areas, the coarse crushed granular material may consist of natural aggregate materials or geotechnical engineer approved equivalent. Typical lift thickness utilized for this material is 8 inches. The soil should be compacted to 98 percent of the Standard Proctor or 95 percent of Modified Proctor maximum dry density within 2 percent of the optimum moisture content. If coarse crushed granular material is used for fill in undercut areas, then underdrains shall be installed to limit water accumulation in the undercuts. As an alternative to imported granular fill, excavated soil material may be re-compacted back in place so long as the excavated soil material is determined to be suitable according to the project Geotechnical Engineer or his/her designated on-site representative. Undercuts backfilled with cohesive engineered fill material will not require an underdrain.

Coarse crushed granular material is recommended as fill for utility trench backfill and as aggregate base material for pavement and slab-on-grade areas. The granular material shall consist of natural aggregate materials. Typical lift thickness used for this material is 8 inches. In utility trenches, granular backfill material should extend at least two pipe diameters above the pipe's crown. Clay (on-site material determined to be suitable or import material) compacted to 98 percent of the Standard Proctor or 95 percent of Modified Proctor within 2 percent of the optimum moisture content can be used as a backfill for the balance of the trench excavation.

If a working platform for the new structure construction is needed, and prior to footing excavation, it is recommended that at least 6 inches of granular base material be placed and compacted to 98 percent of the Standard Proctor or 95 percent of Modified Proctor maximum dry density within 2 percent of the optimum moisture content.

The actual lift thickness suitable for fill placement is dependent upon the soil type, compaction equipment, and the compaction specification. In general, fill should be placed in 9-inch loose thickness lifts (8-inch compacted); assuming appropriately weighted and ballasted compaction equipment is used. In confined areas where hand operated compaction equipment is required, 4-inch and 6-inch loose thickness lifts should be used for hand operated vibratory plate compactors and hand operated vibratory drum rollers weighing at least 1,000 pounds, respectively. Sand fills should be compacted using smooth vibratory rollers. Clay fills should be compacted using a sheep foot compactor. The geotechnical engineer, as part of the construction monitoring, should review the equipment utilized for compaction to confirm suitability relative to the specified loose lift thickness. If necessary, the geotechnical engineer will recommend a revised lift thickness suitable to the equipment performing compaction.

A qualified geotechnical consultant should be retained to monitor all fill placement in order to assure that materials are placed according to their suitability and compaction requirements are achieved. In-place soil moisture/density testing should be performed during fill placement activities to assure proper fill compaction. A commonly used testing criterion is one test per 2,500 square feet per lift in areas to support proposed structures and one test per 5,000 square feet in parking lots, driveways, exterior slabs, etc., with a minimum of three tests per lift. Areas that do not achieve compaction requirements after initial placement should be re-compacted to meet project requirements.

4.7 Excavation and Slope

Familiarity with applicable local, state and federal safety regulations, including current OSHA excavation and trench safety is vital. Therefore, it should be a requisite for both the Owner and Contractor with the Contractor by and large being responsible for the safety of the site. Activities at the site, such as utilities or building demolition and site preparation, may require excavations at significant depths below the ground surface. Slope height, slope inclination, and excavation depth (including utility trench excavations) should in no case exceed those specified in local, state, or federal safety (OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926 Subpart P) regulations. Such regulations are strictly enforced and, if not followed, the Owner, Contractor, or earthwork or utility Subcontractors could be liable for substantial penalties.

The overburden soils encountered during our investigation were generally composed of dense to medium dense granular soil and soft to hard silty clay. Based upon the data obtained, we anticipate OSHA will classify site soils as **Type C Soil**, which will require a maximum temporary excavation slopes of 1(H):1(V). Flatter slopes will be required if seepage conditions occur during construction or if subsurface sand lenses are encountered. For permanent excavations and slopes, the grades should be no steeper than 3(H):1(V) without further geotechnical review of the finalized grading plan. If any excavation, including a utility trench, is extended to a depth of more than 20 feet, OSHA requires that a Professional Engineer design the side slopes of such excavations. However, we recommend that any excavation extending to a depth of more than 5 feet below existing grade be done under the supervision of a qualified engineer.

4.8 Site Seismic Classification

According to ASCE 7-10 Table 20.3-1, the proposed site is designated as "Site Class DE" based on medium stiff clay soil profile and expected shear wave velocity for the upper 30 feet of soil (the maximum depth the borings were advanced for this investigation) and assumed subsurface conditions to a depth of 100 feet.

4.9 Lateral Earth Pressure

Lateral earth pressures (horizontal stresses) are developed during soil displacements (strains). Lateral earth pressure for design is determined utilizing an earth pressure coefficient to relate horizontal stress to vertical stress. Three separate earth pressure coefficients are utilized to determine lateral earth pressure: at-rest; active; and passive. Active earth pressure addresses displacement of a vertical soil face away from the retained soil. Passive earth pressure addresses displacement against the retained soil. At-rest earth pressure addresses a negligible displacement scenario. Structures (retaining walls) that are restrained at the top and bottom such that negligible movement is allowed to occur should be designed using at-rest earth pressures. Structures (retaining walls) that are allowed to move laterally (at least 0.001 times the total height of the wall) such as retaining walls in loading docks, receiving areas or other unrestrained retaining walls necessary to accommodate site grade modifications should be designed using active earth pressures.

Applied horizontal stress can be determined by multiplying the appropriate earth pressure coefficient by the applied vertical stress. Earth pressure coefficients are a direct function of the internal friction of a soil. Laboratory testing to determine internal friction angles for soil was not performed. However, index laboratory and field data obtained can be utilized to approximate earth pressure coefficients based upon empirical relationships.

To minimize lateral earth pressures, MSG recommends the zone adjacent to any walls be backfilled with granular fill. To provide effective drainage, a zone of free-draining gravel (similar to AASHTO No. 57 stone) should be used directly adjacent to the walls with a minimum thickness of 18 inches. This granular zone should drain to weep holes or a pipe drainage system to prevent hydrostatic pressures from developing against the walls.

The type of backfill beyond the free-draining granular zone will govern the magnitude of the pressure to be used for structural design. Clean granular soil is recommended as the backfill material against retaining structures to minimize lateral earth pressures. Lateral earth pressure coefficients for granular and clay are provided in Table 4.8.1. The equivalent fluid pressure can be determined by multiplying the total unit weight by the appropriate pressure coefficient.

Table 4.8.1 Recommended Lateral Earth Parameters

Soil Parameters	Material	
	Clean Granular Soil	Clay Soil
Total Unit Weight (pcf)	125	125
Internal Friction Angle (°)	32	23
At-rest Pressure Coefficient, K_o	0.47	0.61
Active Pressure Coefficient, K_a	0.31	0.44
Passive Coefficient, K_p	3.25	2.28
Concrete/Soil Friction Coefficient	0.50	0.30

The coefficients of friction between concrete and soil subgrade were also provided in the table above. These friction coefficients can be used for evaluating the factor of safety against sliding of foundations. The recommended minimum safety factor against sliding is 1.5. Passive pressure resistance of the top 3.5 feet below final grade should generally be neglected in designing the retaining walls to resist sliding failure due to the freeze-thaw cycle that can significantly weaken soils and the potential for the material to be removed at a future date for installation of utilities or other construction-related activities.

Any additional lateral earth pressure due to surcharge loading conditions including, but not limited to, floor loads, column loads, sloping backfill, traffic loading, and construction loads, should be incorporated into the wall design.

MSG should be retained to perform other geotechnical evaluations for retaining walls, as necessary, including but not limited to bearing capacity, settlement, and global stability. A geotechnical evaluation of retaining walls is beyond the scope of this report.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Groundwater Control

The location of the level of groundwater is of importance in shallow foundations for a number of reasons. Most importantly, the bearing capacity of the soil is affected by the presence of a high water table, decreasing the bearing capacity. The project civil engineer is also responsible for designing the surface drainage improvements.

As discussed in Section 3.2 groundwater was not encountered in the borings drilled during the current geotechnical investigation. Typically, the groundwater elevation fluctuates and is higher during the winter and spring and lower in summer and early fall.

The amount and type of dewatering required during construction will depend on the weather, groundwater levels at the time of construction, and the effectiveness of the Contractor's techniques in preventing surface water runoff from entering open excavations and lowering the groundwater table. Given the nature of the soils encountered on-site, the Contractor should be prepared to address general water infiltration (i.e. pumping water from prepared sumps). The use of perimeter drains and/or sub-drains may be necessary on approval of the site civil design engineer.

6.0 GENERAL QUALIFICATIONS AND LIMITATIONS

The evaluations, conclusions and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the geotechnical investigation, results of our geotechnical analyses, our understanding of the project and our experience during previous work, with similar sites and subsurface conditions. Data used during this exploration included:

- Seven (7) exploratory borings performed during this investigation;
- Observations of the project site by our staff;
- Published historic soil and geologic data for the project area;
- Results of laboratory soil testing;
- Our discussion with the Project's Structural Engineer, and
- Results of the geotechnical analyses.

The subsurface conditions discussed in this report and those shown on the boring logs represent an estimate of the subsurface conditions based on interpretation of the boring data using normally accepted geotechnical engineering judgments. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates shown, they are not necessarily indicative of subsurface conditions at other locations or at other times. MSG is not responsible for independent conclusions, opinions or recommendations made by others based upon information presented in this report.

We strongly recommend the final project plans and specifications be reviewed by MSG's geotechnical engineer to confirm that the geotechnical aspects are generally consistent with the recommendations of this report. In particular, the specifications for excavation and foundation construction should be prepared and/or reviewed by MSG's Geotechnical Engineer of Record. In addition, we recommend site subgrade preparation, fill compaction activities, and foundation installation activities should be monitored by MSG's geotechnical engineer or his/her representative.

This report and evaluation reflects only the geotechnical aspects of the subsurface conditions at the site. Review and evaluation of environmental aspects of subsurface conditions are beyond the scope of this report.

APPENDIX A

SITE LOCATION MAP

SOIL BORING LOCATION MAP

2365 Haggerty Road South
Canton, Michigan 48188
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www.ManniksmithGroup.com

Figure 1: Site Location Map
Shelby Township, Salt Barn, Macomb County
MSG Project Number: 401.2300893.000

No Scale
Map Adapted from
Google Earth 2024 ®

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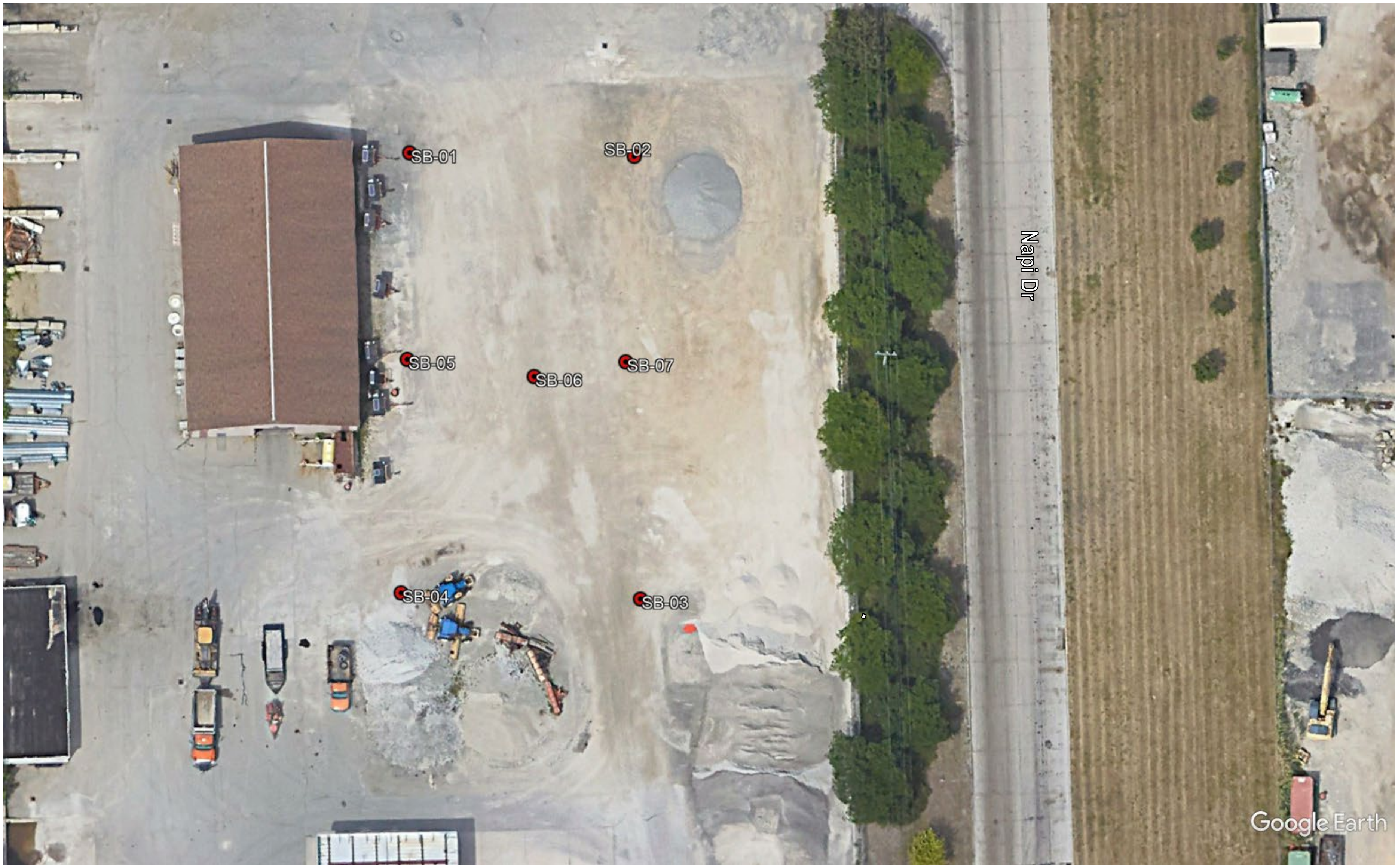

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Figure 2: Soil Boring Location Map
Shelby Township, Salt Barn, Macomb County
MSG Project Number: 401.2300893.000

No Scale
Map Adapted from
Google Earth 2024 ®

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APPENDIX B

SOIL BORING LOGS &
GENERALIZED SOIL PROFILE

Mannik Smith GROUP

GENERAL SOIL SAMPLE NOTES

Unless noted, all terms utilized herein refer to the Standard Definitions presented in ASTM D653.

Standard Penetration Test (ASTM D1586): A 2.0-inch outside-diameter (O.D.), 1-3/8-inch inside-diameter (I.D.) split barrel sampler is driven into undisturbed soil by means of a 140-pound weight falling freely through a vertical distance of 30 inches. The sampler is normally driven three successive 6-inch increments. The total number of blows required for the final 12 inches of penetration is the Standard Penetration Resistance (N).

COHESIVE SOILS			COHESIONLESS SOILS	
Consistency	Approximate Range of N	Unconfined Compressive Strength (psf)	Density Classification	Approximate Range of N
Very Soft	0 – 1	Below 500	Very Loose	0 – 4
Soft	2 – 4	500 – 1,000	Loose	5 – 10
Medium Stiff	5 – 8	1,000 – 2,000	Medium Dense	11 – 30
Stiff	9 – 15	2,000 – 4,000	Dense	31 – 50
Very Stiff	16 – 30	4,000 – 8,000	Very Dense	Over 50
Hard	31 – 50	8,000 – 16,000		
Very Hard	Over 50	Over 16,000		

CLASSIFICATION

The major soil constituent is the principal noun, i.e. sand, silt, gravel. The second major soil constituent and other minor constituents are reported as follows:

Second Major Constituent (percent by weight)	Minor Constituents (percent by weight)
Trace – 1% to 11%	Trace – 1% to 11%
Adjective – 12% to 35% (clayey, silty, etc.)	Little – 12% to 22%
	Some – 23% to 33%
And – Over 35%	

PARTICLE SIZES

Boulders		- Greater than 12 inches (305 mm)
Cobbles		- 3 inches (76.2 mm) to 12 inches (305 mm)
Gravel:	Coarse	- ¾ inches (19.05 mm) to 3 inches (76.2 mm)
	Fine	- No.4 (4.75 mm) to ¾ inches (19.05 mm)
Sand:	Coarse	- No. 10 (2.00 mm) to No. 4 (4.75 mm)
	Medium	- No. 40 (0.425 mm) to No. 10 (2.00 mm)
	Fine	- No. 200 (0.074 mm) to No. 40 (0.425 mm)
Silt		- 0.005 mm to 0.074 mm
Clay		- Less than 0.005 mm

If clay content is sufficient so that clay dominates soil properties, clay becomes the principal noun with the other major soil constituent as modifier: i.e., silty clay. Other minor soil constituents may be included in accordance with the classification breakdown for cohesionless soils: i.e., silty clay, trace sand, little gravel.

If sand particle size is greater than 11% by weight of the total sample weight, the adjective (i.e., fine, medium or coarse) is added to the soil description for the sand portion of the sample, provided sand is the major or second major constituent.

SAMPLE DESIGNATIONS

AS	Auger Sample - directly from auger flight	ST	Shelby Tube Sample - 3-inch diameter unless otherwise noted
BS	Miscellaneous Samples - Bottle or Bag	PS	Piston Sample - 3-inch diameter unless otherwise noted
MC	Macro-Core Sample - 2.25-inch O.D., 1.75-inch I.D., 5 feet long polyethylene liner	RC	Rock Core - NX core unless otherwise noted
LB	Large-Bore (Micro-Core) Sample - 1-inch diameter, 2 feet long polyethylene liner	CS	CME Continuous Sample - 5 feet long, 3-inch diameter unless otherwise noted
SS	Split Spoon Sample - 1-inch or 2-inch O.D.	HA	Hand Auger
LS	Split Spoon (SS) Sampler with 3 feet long liner insert	DP	Drive Point
NR	No Recovery	CM	Coring Machine

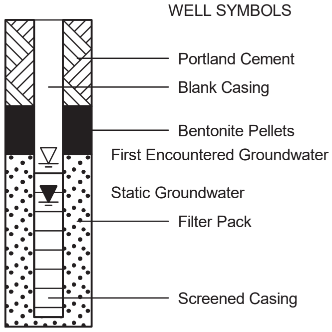
MAJOR DIVISIONS					TYPICAL NAMES
COARSE-GRAINED SOILS MORE THAN HALF IS COARSER THAN NO. 200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS WITH LESS THAN 15% FINES	GW		WELL-GRADED GRAVELS WITH OR WITHOUT SAND
			GP		POORLY-GRADED GRAVELS WITH OR WITHOUT SAND
		GRAVELS WITH 15% OR MORE FINES	GM		SILTY GRAVELS WITH OR WITHOUT SAND
			GC		CLAYEY GRAVELS WITH OR WITHOUT SAND
	SANDS MORE THAN HALF COARSE FRACTION IS FINER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LESS THAN 15% FINES	SW		WELL-GRADED SANDS WITH OR WITHOUT GRAVEL
			SP		POORLY-GRADED SANDS WITH OR WITHOUT GRAVEL
		SANDS WITH 15% OR MORE FINES	SM		SILTY SANDS WITH OR WITHOUT GRAVEL
			SC		CLAYEY SANDS WITH OR WITHOUT GRAVEL
FINE-GRAINED SOILS MORE THAN HALF IS FINER THAN NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT 50% OR LESS		ML		INORGANIC SILTS OF LOW TO MEDIUM PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			CL		INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			OL		ORGANIC SILTS OR CLAYS OF LOW TO MEDIUM PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%		MH		INORGANIC SILTS OF HIGH PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			CH		INORGANIC CLAYS OF HIGH PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			OH		ORGANIC SILTS OR CLAYS OF HIGH PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
HIGHLY ORGANIC SOILS			PT		PEAT AND OTHER HIGHLY ORGANIC SOILS

SYMBOLS KEY

SAMPLE TYPES

- Split Spoon sample, 1 inch or 2 inch outer-diameter.
- Shelby Tube sample - 3 inch diameter unless otherwise noted.

WELL SYMBOLS



OTHER MATERIAL SYMBOLS

- Topsoil
- Poorly Graded Sand with Clay
- Clayey Sand
- Sandy Silt
- Gravelly Silt
- Poorly Graded Gravelly Sand
- Well Graded Gravel with Clay
- Well Graded Gravel with Silt
- Well Graded Gravelly Sand
- Shale
- Shaly Dolomite
- Limestone

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BORING / WELL LOG KEY

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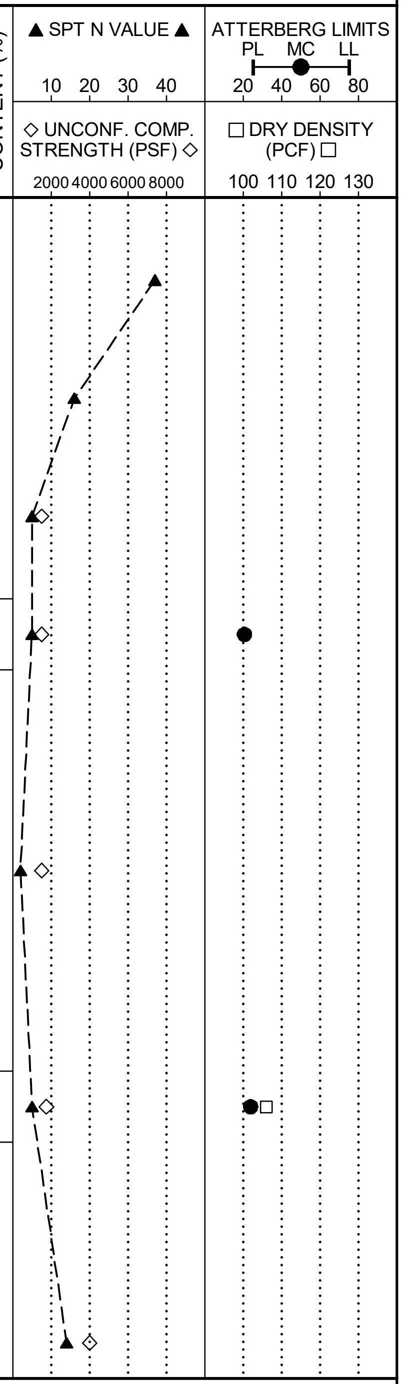
BORING ID: SB-01

CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/8/24 **COMPLETED** 4/8/24
BORING COORDINATES 430429.3 N;13488728.6 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 634.6 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 25.0 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)
		Dense to medium dense, brown, poorly graded SAND with gravel, trace silt, moist (SP)	0							
				SS 1	15-17-20	37	67			
			5	SS 2	5-6-10	16	44			
628.6		Medium stiff to stiff, gray, silty CLAY, trace sand, trace gravel, moist (CL)		SS 3	1-2-3	5	56		1500P	
			10	SS 4	1-2-3	5	44		1500P	21
			15	SS 5	0-0-2	2	50		1500P	
			20	SS 6	0-2-3	5	56	106	1800	24
609.6			25	SS 7	2-5-9	14	50		4000P	



Bottom of borehole at 25.0 feet.

LEGEND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

AASHTO R18

BORING ID: SB-02

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CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/8/24 **COMPLETED** 4/8/24
BORING COORDINATES 430432.8 N;13488802.5 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 634.4 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 25.0 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)
		Dense to medium dense, brown, poorly graded SAND, trace silt, trace gravel, moist (SP)	0							
				SS 1	17-18-21	39	61			
			5	SS 2	4-6-9	15	56			
628.4		Medium stiff to stiff, gray, silty CLAY, trace sand, trace gravel, damp (CL)		SS 3	2-2-3	5	56		1500P	
			10	SS 4	1-2-4	6	44		1500P	
			15	SS 5	0-1-2	3	39		2000P	34
			20	SS 6	0-2-3	5	67		2000P	
609.4			25	SS 7	2-6-8	14	50		4000P	

Bottom of borehole at 25.0 feet.

▲ SPT N VALUE ▲ (10 20 30 40); ◇ UNCONF. COMP. STRENGTH (PSF) ◇ (2000 4000 6000 8000); ATTERBERG LIMITS PL MC LL (20 40 60 80); □ DRY DENSITY (PCF) □ (100 110 120 130)

LEGEND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

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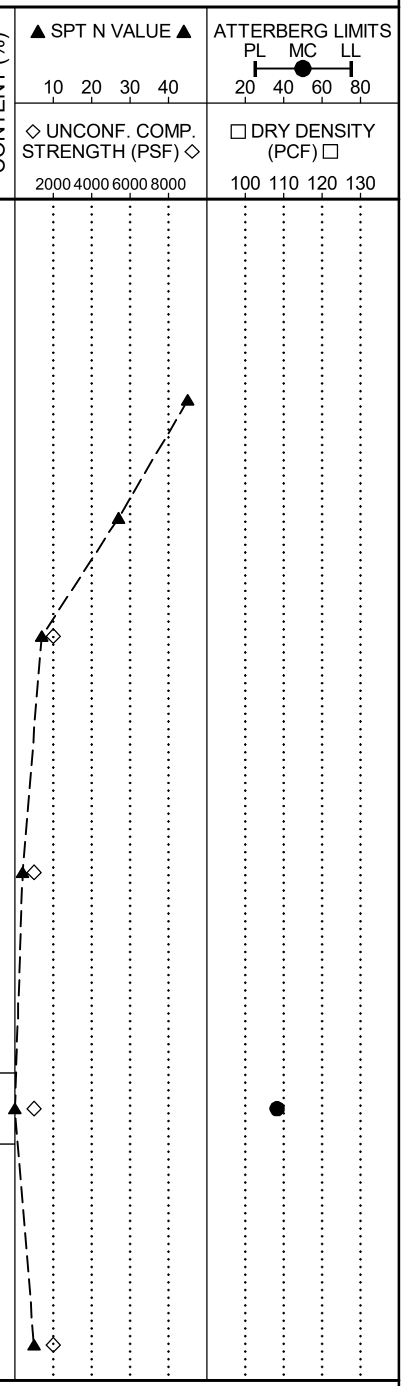
BORING ID: SB-03

CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/9/24 **COMPLETED** 4/9/24
BORING COORDINATES 430279.0 N;1348809.8 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 636.0 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 25.0 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)
	Very dense to dense, brown, poorly graded SAND with gravel, trace silt, damp (SP)	0	SS 1	50+		100			
		5	SS 2	10-20-25	45	50			
630.0	Medium dense, gray, silty SAND, trace gravel, damp (SM)		SS 3	8-12-15	27	44			
627.5	Medium stiff, gray, silty CLAY, trace sand, trace gravel, damp (CL)	10	SS 4	2-2-5	7	50		2000P	
		15	SS 5	1-1-1	2	61		1000P	
		20	SS 6	0-0-0	0	50		1000P	37
611.0		25	SS 7	0-2-3	5	67		2000P	



Bottom of borehole at 25.0 feet.

LEGAND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

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BORING ID: SB-04

The Mannik & Smith Group, Inc.
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CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/10/24 **COMPLETED** 4/10/24
BORING COORDINATES 430275.5 N;13488735.8 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 634.7 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 25.0 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)
	Very dense to dense, brown, poorly graded SAND with gravel, trace silt, damp (SP)	0	SS 1	50+		100			
		5	SS 2	15-17-22	39	56			
628.7	Medium dense, gray, silty SAND, trace gravel, damp (SM)		SS 3	9-12-14	26	67			
626.2	Loose, gray, sandy SILT, trace clay, trace gravel, damp (ML)		SS 4	2-3-5	8	50			
624.7	Soft to medium stiff, gray, silty CLAY, trace sand, trace gravel, damp (CL)	10							
		15	SS 5	1-1-2	3	56	88	850	34
		20	SS 6	0-0-1	1	44		1500^P	
609.7		25	SS 7	0-2-4	6	72		2000^P	16

▲ SPT N VALUE ▲ (10 20 30 40)
◇ UNCONF. COMP. STRENGTH (PSF) ◇ (2000 4000 6000 8000)
ATTERBERG LIMITS PL MC LL (20 40 60 80)
□ DRY DENSITY (PCF) □ (100 110 120 130)

Bottom of borehole at 25.0 feet.

LEGAND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

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BORING ID: SB-05

CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/10/24 **COMPLETED** 4/10/24
BORING COORDINATES 430352.1 N;13488725.2 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 635.1 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 29.9 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)
	Dense to medium dense, brown, poorly graded SAND with gravel, trace silt, damp (SP)	0							
			SS 1	10-20-25	45	56			
		5	SS 2	5-10-13	23	67			
629.1	Soft to medium stiff to stiff, gray, silty CLAY, trace sand, trace gravel, moist (CL)		SS 3	7-4-4	8	44		2000P	
		10	ST 1			88	106	800	22
		15	SS 4	2-3-2	5	44		1500P	24
		20	SS 5	0-0-4	4	39		2000P	
		25	SS 6	1-2-5	7	67		1500P	

▲ SPT N VALUE ▲ 10 20 30 40
◇ UNCONF. COMP. STRENGTH (PSF) ◇ 2000 4000 6000 8000
ATTERBERG LIMITS PL MC LL 20 40 60 80
□ DRY DENSITY (PCF) □ 100 110 120 130

LEGEND:
WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A
D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

AASHTO R18

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BORING ID: SB-05

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CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/10/24 **COMPLETED** 4/10/24
BORING COORDINATES 430352.1 N;13488725.2 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 635.1 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 29.9 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)	▲ SPT N VALUE ▲ 10 20 30 40 / ◇ UNCONF. COMP. STRENGTH (PSF) ◇ 2000 4000 6000 8000	ATTERBERG LIMITS PL MC LL 20 40 60 80 / □ DRY DENSITY (PCF) □ 100 110 120 130
		Soft to medium stiff to stiff, gray, silty CLAY, trace sand, trace gravel, moist (CL) *(continued)*	25									
606.6		Hard, gray, silty CLAY, trace sand, trace gravel (CL) (HARDPAN)		SS 7	20-20-50+	70	59		9000+[P]		>>	
605.1		Refusal at 29.9 feet. Bottom of borehole at 29.9 feet.										

LEGEND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

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BORING ID: SB-06

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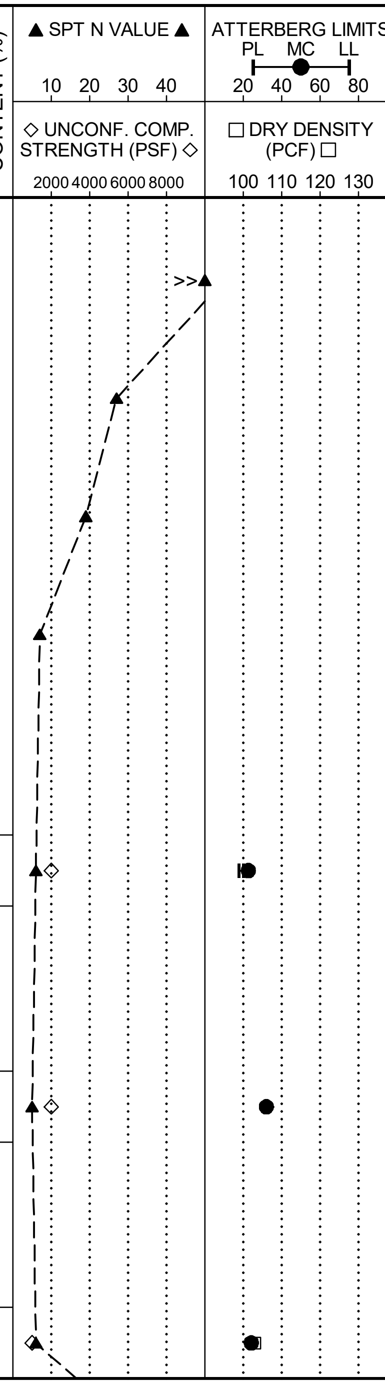
CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/8/24 **COMPLETED** 4/8/24
BORING COORDINATES 430354.1 N;13488769.2 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 635.6 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 29.9 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)
	Very dense to medium dense, brown, poorly graded SAND with gravel, trace clay, trace silt, damp (SP)	0	SS 1	42-30-25	55	67			
		5	SS 2	9-13-14	27	56			
629.6	Medium dense to loose, gray, sandy SILT, damp (ML)		SS 3	7-9-10	19	67			
		10	SS 4	2-3-4	7	50			
622.1	Medium stiff, gray, silty CLAY, trace gravel, trace sand, damp (CL)	15	SS 5	1-3-3	6	72		2000P	23
		20	SS 6	0-2-3	5	78		2000P	32
		25	SS 7	0-2-4	6	56	103	1000	24



LEGEND:
WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A
D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

AASHTO R18

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BORING ID: SB-06

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CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/8/24 **COMPLETED** 4/8/24
BORING COORDINATES 430354.1 N;13488769.2 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 635.6 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 29.9 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)	▲ SPT N VALUE ▲ 10 20 30 40 / ◇ UNCONF. COMP. STRENGTH (PSF) ◇ 2000 4000 6000 8000	ATTERBERG LIMITS PL MC LL 20 40 60 80 / □ DRY DENSITY (PCF) □ 100 110 120 130
		Medium stiff, gray, silty CLAY, trace gravel, trace sand, damp (CL) *(continued)*	25									
607.1		No recovery		SS 8	20-26-50+	76	0				>>▲	
605.6		Refusal at 29.9 feet. Bottom of borehole at 29.9 feet.										

LEGEND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

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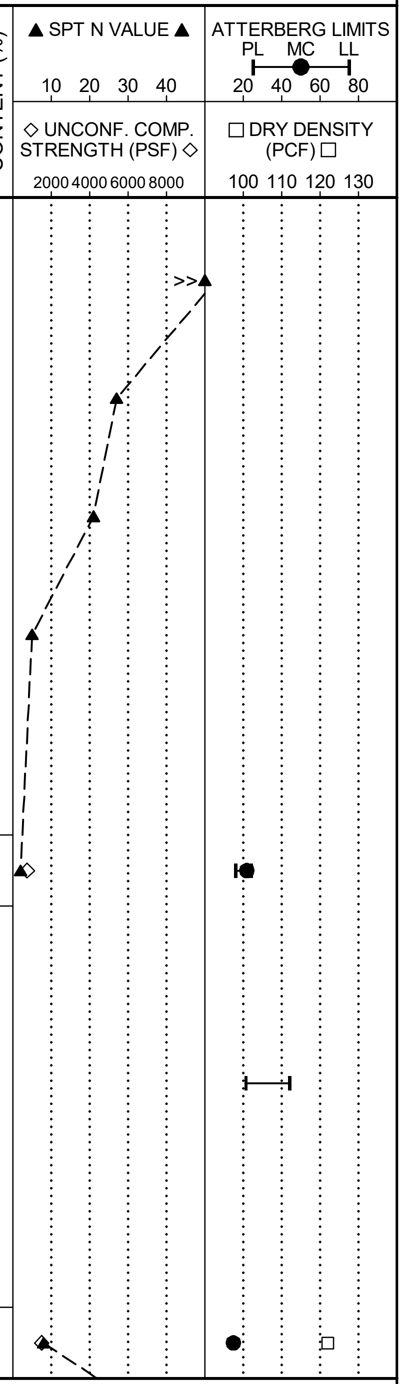
BORING ID: SB-07

CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/9/24 **COMPLETED** 4/9/24
BORING COORDINATES 430356.2 N;13488813.1 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 636.0 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 29.0 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)
	Very dense to medium dense, brown, poorly graded SAND with gravel, trace clay, trace silt, damp (SP)	0	SS 1	35-28-25	53	44			
		5	SS 2	9-12-15	27	56			
630.0	Medium dense to loose, gray, silty SAND, trace gravel, damp (SM)		SS 3	7-10-11	21	56			
		10	SS 4	1-2-3	5	78			
622.5	Soft to medium stiff, gray, silty CLAY, trace sand, trace gravel, damp (CL)	15	SS 5	1-1-1	2	67		800T	22
		20	ST 1			75			
		25	SS 6	1-4-4	8	72	122	1500	15



LEGEND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

AASHTO R18

(Continued Next Page)

The Mannik & Smith Group, Inc.
2365 Haggerty Road South, Canton, MI 48188
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BORING ID: SB-07

CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County
DATE STARTED 4/9/24 **COMPLETED** 4/9/24
BORING COORDINATES 430356.2 N;13488813.1 E FT
DRILLING METHOD 3.25" Hollow Stem Auger
GROUND ELEVATION 636.0 FT
DRILLING CONTRACTOR MSG
TOTAL DEPTH 29.0 FT **BACKFILL** Soil Cuttings & Bentonite
DRILL RIG 3230DT **HAMMER TYPE** Automatic
LOGGED BY RD **CHECKED BY** BBH
DRILLER RS
REMARKS N/A

ELEVATION (FEET)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (FEET)	SAMPLE TYPE NUMBER	BLOW COUNTS	SPT N VALUE	RECOVERY % (RQD)	DRY DENSITY (PCF)	UNCONF. COMP. STRENGTH (PSF)	MOISTURE CONTENT (%)	▲ SPT N VALUE ▲ 10 20 30 40 / ◇ UNCONF. COMP. STRENGTH (PSF) ◇ 2000 4000 6000 8000	ATTERBERG LIMITS PL MC LL 20 40 60 80 / □ DRY DENSITY (PCF) □ 100 110 120 130
		Soft to medium stiff, gray, silty CLAY, trace sand, trace gravel, damp (CL) *(continued)*	25									
607.5												
607.0		Hard, gray, silty CLAY, trace sand, trace gravel, damp (CL) (HARDPAN)		SS 7	45-50/1	50+	100		9000+P	13	>>	
		Refusal at 29.0 feet. Bottom of borehole at 29.0 feet.										

LEGEND:

WATER LEVEL AT TIME OF DRILLING N/A
WATER LEVEL AT END OF DRILLING N/A
WATER LEVEL AFTER DRILLING N/A

D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST

AASHTO R18

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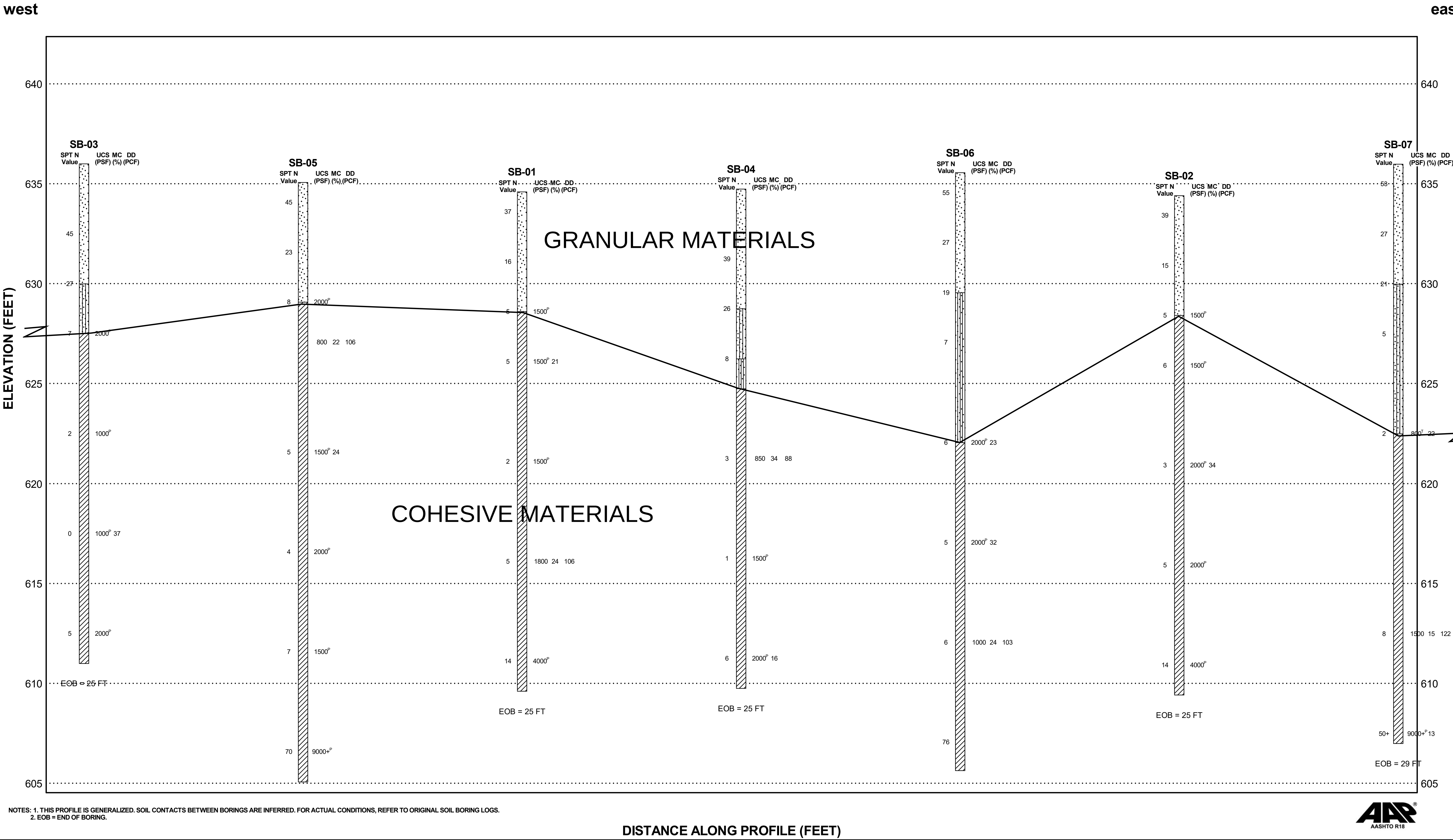
GENERALIZED SOIL PROFILE
Shepherd Road

CLIENT Macomb County Department of Roads
PROJECT NUMBER 401.2300893.000
PROJECT NAME Shelby Township Salt Barn
PROJECT LOCATION Shelby Township, Macomb County

LEGEND:
Poorly-graded SAND
CLAY
Silty SAND
Sandy SILT

= WATER LEVEL AT TIME OF DRILLING
= WATER LEVEL AT END OF DRILLING
= WATER LEVEL AFTER DRILLING
D = UCS TEST PERFORMED ON DISTURBED SAMPLE
P = POCKET PENETROMETER TEST
T = TORVANE SHEAR TEST



NOTES: 1. THIS PROFILE IS GENERALIZED. SOIL CONTACTS BETWEEN BORINGS ARE INFERRED. FOR ACTUAL CONDITIONS, REFER TO ORIGINAL SOIL BORING LOGS.
2. EOB = END OF BORING.

AASHTO R18

SOIL PROFILE - BBH - GINT STD US LAB.GDT - 8/28/24 10:31 - W:\PROJECTS\2023\800-999\2300893\ADMIN\02_SALT BARN\04_SOIL BORING LOGS & LOG PLAN SHEETS\401.2300893.GPJ

APPENDIX C

SOIL LABORATORY TEST DATA

LABORATORY TEST PROCEDURES

A brief description of the most common laboratory tests performed at the Geotechnical Engineering Laboratory at the Mannik Smith Group is provided in the following sections.

DESCRIPTION OF SOILS (VISUAL-MANUAL PROCEDURE) (ASTM D2488)
The visual classification of soil samples are performed in accordance with ASTM D2488 standard. Our engineers use this test method to describe each soil sample using visual examination and simple manual tests. Visual classification helps grouping similar soil samples so that only a minimum number of laboratory tests are required for positive soil classification.

POCKET PENETROMETER
In the pocket penetrometer test, the unconfined compressive strength of a cohesive soil sample is estimated by measuring the resistance of the sample to the penetration of a small, calibrated spring-loaded cylinder. The maximum capacity of the penetrometer is 4.5 tons per square foot.

NATURAL MOISTURE CONTENT (ASTM D2216)
Natural moisture content represents the ratio of the weight of water in a given amount of soil to the weight of solid particles. Natural moisture content is expressed as a percentage (%). In this test method the water content is measured in the laboratory by noting the weight loss after drying the soil at specific temperature for 24 hours.

ATTERBERG LIMITS (ASTM D4318)
The Atterberg Limits test is performed in accordance with ASTM D4318. Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) of the soil sample are determined using this test method. The Liquid Limit is the moisture content at which the soil begins to behave as a liquid material and starts to flow. The Plastic Limit is the moisture content at which the soil changes from plastic to semi-solid stage. The Plasticity Index (PI = LL - PL) is the range of moisture content at which the soil is in a plastic stage. Typically, a soil's potential for volume change increases with increase of plasticity indices.

PARTICLE SIZE ANALYSIS (ASTM D421, D422 and D1140)
These tests are performed to determine the partial soil particle size distribution. The soil sample is prepared according to ASTM D421 test method. The amount of material finer than the openings on the No. 200 sieve (0.075 mm) is determined by wash sieve method according to ASTM D1140. The hydrometer test is used to determine particle size distribution of material finer than 0.075 mm according to ASTM D422 test method.

STANDARD PROCTOR COMPACTION TEST (ASTM D698)
The Standard Proctor compaction test is used to determine maximum dry density and optimum moisture content of the soil sample. In this test, the soil is compacted in the Proctor mold in three lifts of equal volume using a standard effort by the free falling of a 5.5 lb rammer from 12 inches above soil surface. The test procedure is repeated on samples at several different moisture contents and a parabolic graph showing the relationship between moisture content and dry density of the soil is established. The maximum dry unit weight of the compacted sample and the respective moisture content is reported as maximum dry density and optimum moisture content of the soil sample.

MODIFIED PROCTOR COMPACTION TEST (ASTM D1557)
Modified Proctor compaction is similar to the Standard Proctor test. In this test, the soil is compacted in the Proctor mold in five lifts of equal volume using a standard effort by the free falling of a 10 lb rammer from 18 inches above the soil surface. The maximum dry unit weight of the compacted sample and the respective moisture content is reported as maximum dry density and optimum moisture content of the soil sample.

LABORATORY CALIFORNIA BEARING RATIO (ASTM D1883)
The CBR value is the ratio of forces required for 0.1-inch penetration of a 2-inch diameter circular plunger at the rate of 0.05 inch/min into a compacted soil sample compared to the same penetration in a certain standard crushed stone.

LOSS ON IGNITION TEST (LOI) (ASTM D2974)
LOI tests are performed on peat or suspected organic soils. An oven-dried sample is ignited in a furnace at 440°C (Method C) or 750°C (Method D). The ash content of the soil sample is determined as a percentage of the weight of the oven-dried sample. The organic content is the loss of weight due to ignition and reported as a percentage of the weight of the oven-dried sample.

ONE-DIMENSIONAL CONSOLIDATION TEST (ASTM D2435)
The consolidation test data is used to estimate the magnitude and rate of both differential and total settlement of a structure. A one-dimensional consolidation test is performed in a consolidation ring that does not allow lateral displacement of the sample. The sample is subjected to various vertical loading and unloading cycles. The deformation of the sample due to loading and unloading is recorded and used for the plotting a void ratio-applied pressure graph. The pre-consolidation pressure for the soil can also be determined from this test.

UNCONFINED COMPRESSION TEST ON ROCK SAMPLES (ASTM D7012)

In the unconfined compression test, the unconfined compressive strength (q_u) of a rock sample is estimated by measuring the resistance of the sample in compression when an axial loading is applied to the cylindrical specimen (with a height to diameter ratio of approximately 2) to reach the failure condition.

UNCONFINED COMPRESSION TEST ON SOIL SAMPLES (ASTM D2166)

In the unconfined compression test, the unconfined compressive strength (q_u) of a cohesive soil sample is estimated by measuring the resistance of the sample in compression when an axial loading is applied to the cylindrical specimen (with a height to diameter ratio of 2 to 2.5) to reach the failure condition or 15 percent (%) of axial deformation, whichever is secured first.

UNCONSOLIDATED-UNDRAINED (UU) TRIAXIAL COMPRESSION TEST (ASTM D2850)

Triaxial Shear tests are used to determine the shear strength of soil samples under various loading conditions. The test is performed on a relatively undisturbed sample extruded from a Shelby tube. In this test method, fluid flow is not permitted into or out of the soil specimen as the load is applied (undrained condition), therefore pore pressure builds up in the sample. The compressive strength of a soil is determined in terms of the total stress. The various confining pressures help determining the shear strength of the soil at different depths.

CONSOLIDATED-UNDRAINED (CU) TRIAXIAL COMPRESSION TEST (ASTM D4767)

The shear characteristics of cohesive samples (collected from relatively undisturbed sample extruded from a Shelby tube) are measured in this test under undrained conditions. This test represents field conditions where fully consolidated soils under one set of stresses are subjected to a sudden change in stress without sufficient time for further consolidation (undrained condition). The data from this test is used to analyze the shear strength parameters of the soil at different depths. The compressive strength of a soil is reported in terms of the effective stress.

WATER SOLUBLE SULFATE, RESISTIVITY AND PH

To evaluate the corrosion potential of the site, MSG performs sulfates (Ohio DOT Supplement 1122), resistivity (ASTM G187), and pH tests (ASTM D4972) on select soil samples.

SPECIFIC GRAVITY (ASTM D854)

Specific gravity is defined as the ratio of the unit weight of soil solids only to unit weight of water at a specific temperature. MSG performs specific gravity tests for soils according to ASTM D854 test procedure.

PERMEABILITY (ASTM D2434 and ASTM D5084)

This test method covers laboratory measurements of the hydraulic conductivity (the coefficient of permeability) of water-saturated granular and cohesive materials. MSG performs multiple methods for permeability tests according to ASTM D2434 and ASTM D5084.

DIRECT SHEAR TEST (ASTM D3080)

The direct shear tests are performed to determine the maximum and residual shear strength. A horizontal load is applied at a constant rate of strain. The soil sample is placed in a box where the lower half of the box is mounted on rollers and is pushed forward at a uniform rate by a motorized apparatus. The upper half of the box bears against a steel proving ring, the deformation of which is shown on a dial gauge indicating the shear force. The various information that can be obtained from the results includes the maximum (peak) shear strength and the ultimate (residual) shear strength.

SUMMARY OF LABORATORY RESULTS

The Mannik & Smith Group, Inc.
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AASHTO R18

CLIENT Macomb County Department of Roads

PROJECT NAME Shelby Township Salt Barn

PROJECT NUMBER 401.2300893.000

PROJECT LOCATION Shelby Township, Macomb County

Boring No. / Sample No.	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Bulk Density (pcf)	Satur-ation (%)	Specific Gravity
SB-01 / SS-1	1.0				19	0	SP				
SB-01 / SS-4	8.5							20.6			
SB-01 / SS-6	18.5							23.8	130.8		
SB-02 / SS-5	13.5							34.2			
SB-03 / SS-6	18.5							36.5			
SB-04 / SS-5	13.5							34.0	118.2		
SB-04 / SS-7	23.5							15.9			
SB-05 / ST-1	8.0							22.2	129.5		
SB-05 / SS-4	13.5	23	16	7				24.5			
SB-06 / SS-2	3.5				9.525	0	SP				
SB-06 / SS-5	13.5	20	18	2				22.7			
SB-06 / SS-6	18.5							32.0			
SB-06 / SS-7	23.5							24.2	127.3		
SB-07 / SS-5	13.5	24	16	8				21.8			
SB-07 / ST-1	18.0	44	21	23							
SB-07 / SS-6	23.5							14.8	140.0		
SB-07 / SS-7	28.5							13.5			

ATTERBERG LIMITS' RESULTS

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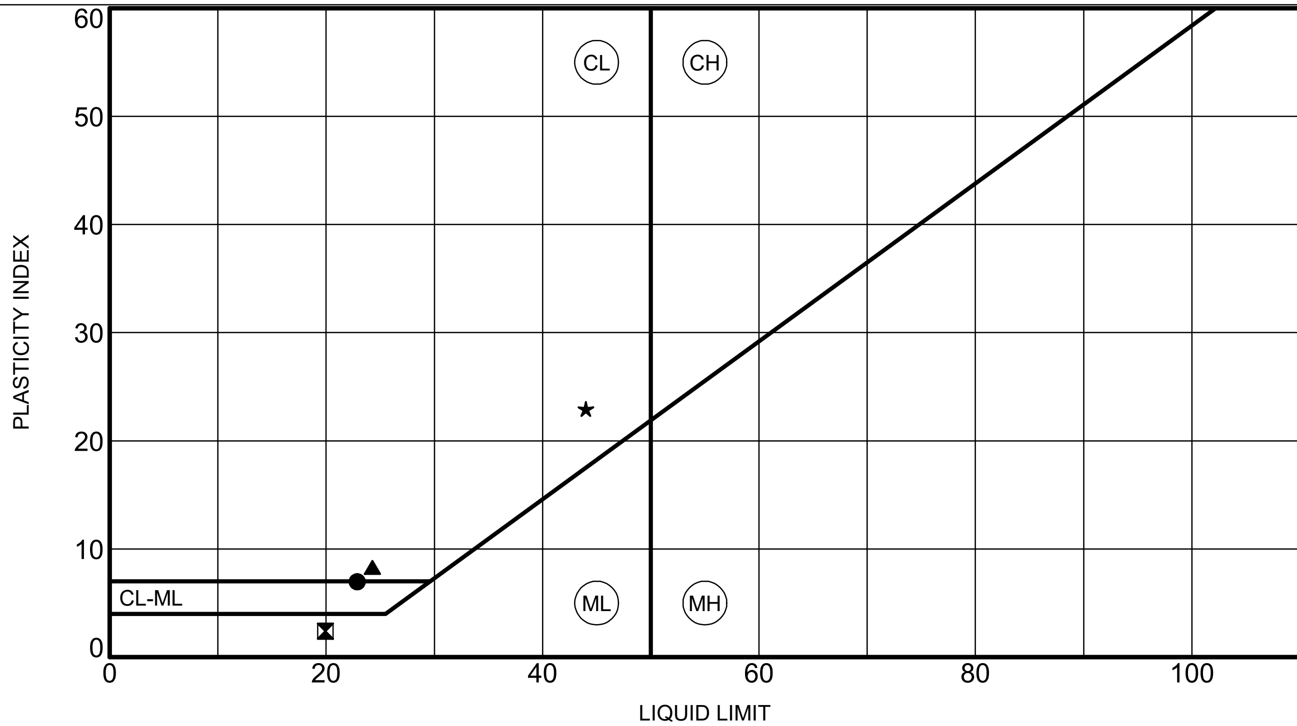
AASHTO R18

CLIENT Macomb County Department of Roads

PROJECT NAME Shelby Township Salt Barn

PROJECT NUMBER 401.2300893.000

PROJECT LOCATION Shelby Township, Macomb County



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**SB-05 / SS-4**	**13.5**	**23**	**16**	**7**		
⧗	**SB-06 / SS-5**	**13.5**	**20**	**18**	**2**		
▲	**SB-07 / SS-5**	**13.5**	**24**	**16**	**8**		
★	**SB-07 / ST-1**	**18.0**	**44**	**21**	**23**		

GRAIN SIZE DISTRIBUTION

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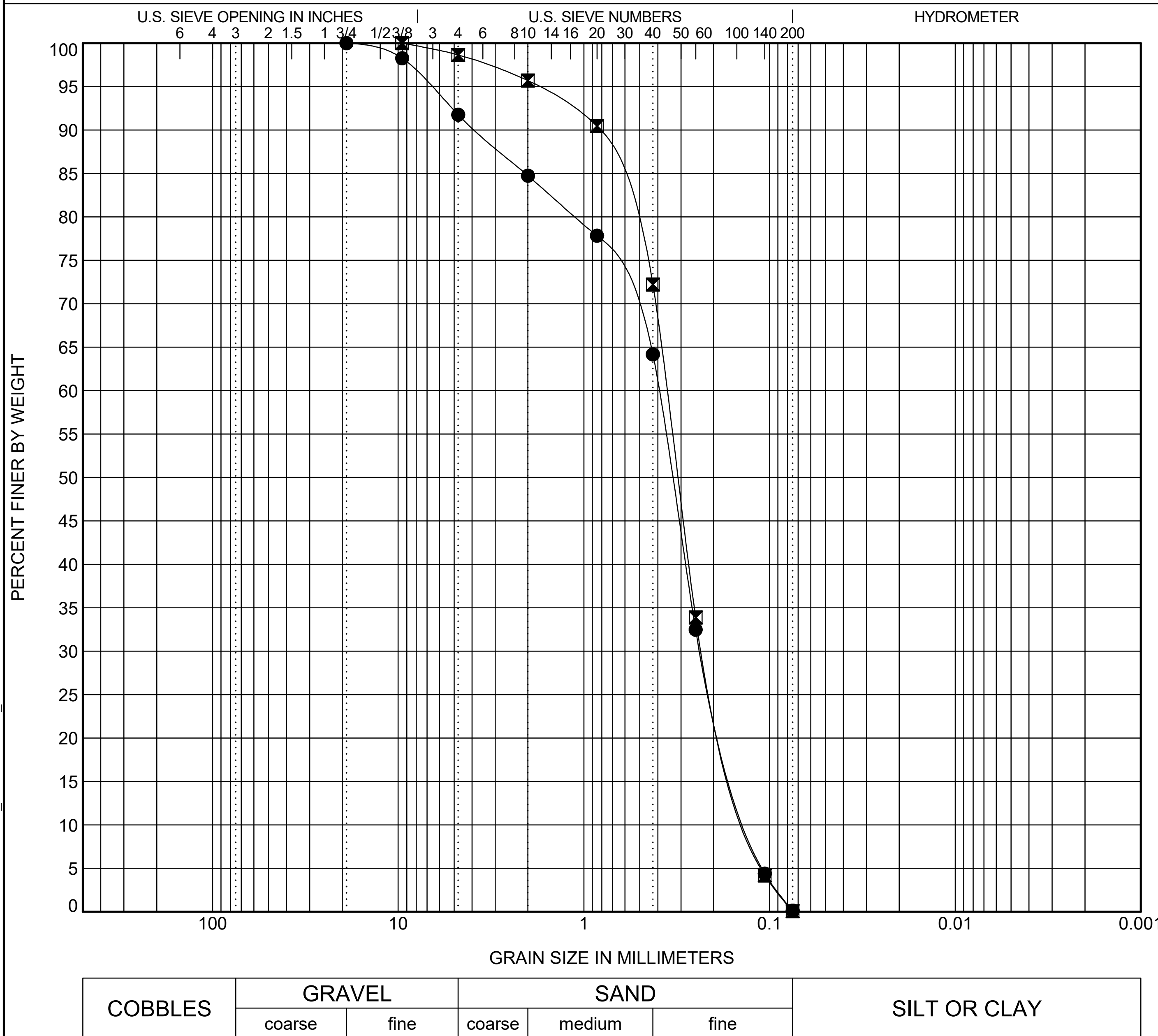
AASHTO R18

CLIENT Macomb County Department of Roads **PROJECT NAME** Shelby Township Salt Barn

PROJECT NUMBER 401.2300893.000 **PROJECT LOCATION** Shelby Township, Macomb County



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● SB-01 / SS-1	1.0	**POORLY GRADED SAND (SP)**				**1.08**	**3.15**
⊠ SB-06 / SS-2	3.5	**POORLY GRADED SAND (SP)**				**1.11**	**2.86**

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB-01 / SS-1	1.0	**19**	**0.396**	**0.232**	**0.126**	**8.2**	**91.6**	**0.1**	
⊠ SB-06 / SS-2	3.5	**9.525**	**0.359**	**0.223**	**0.125**	**1.4**	**98.6**	**0.1**	

UNCONFINED COMPRESSION TEST

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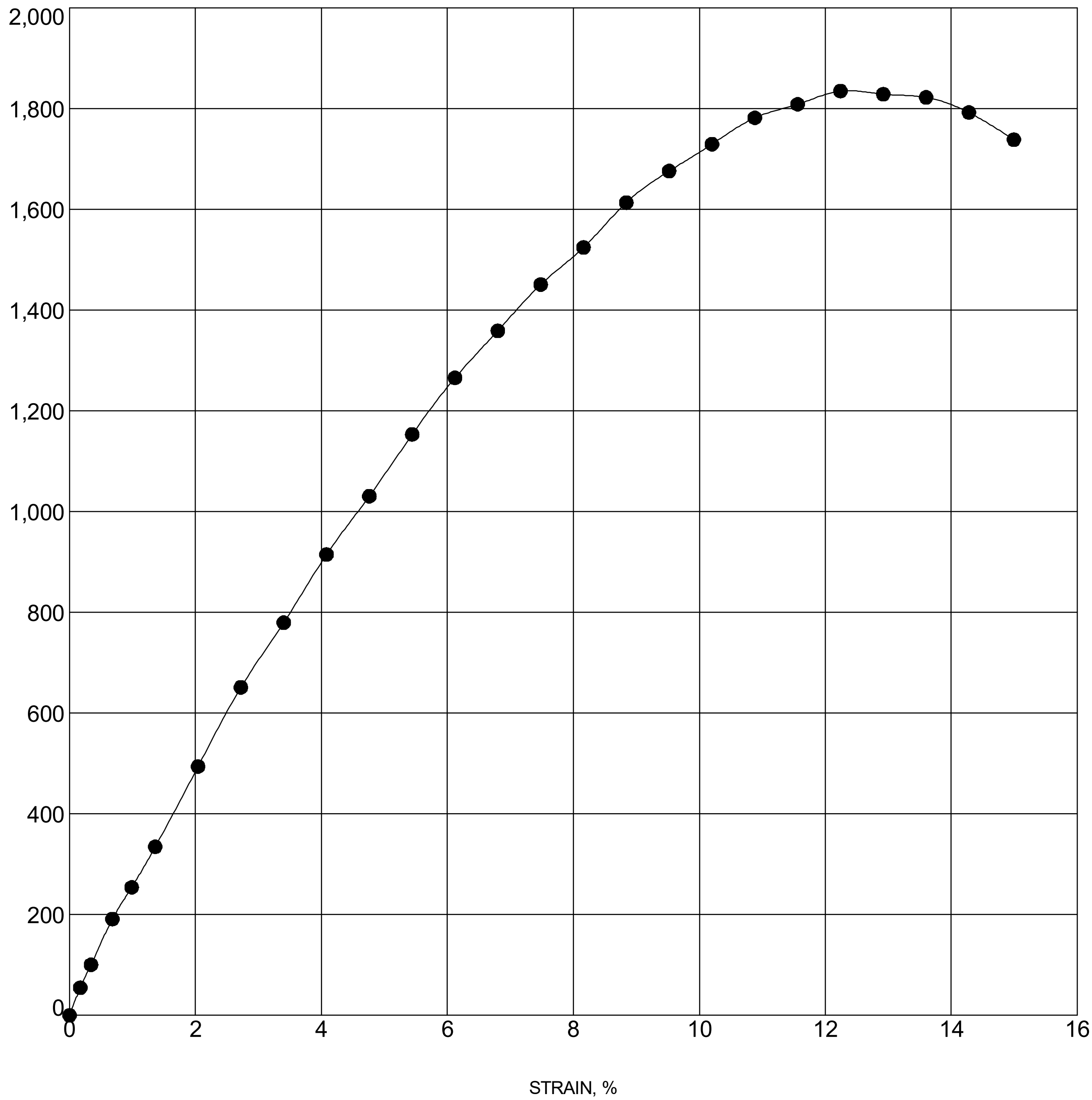
AASHTO R18

CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County



	Specimen Identification		Classification	UCS (psf)	γ_d	MC%
●	**SB-01 / SS-6**	**18.5**		**1835**	**106**	**24**

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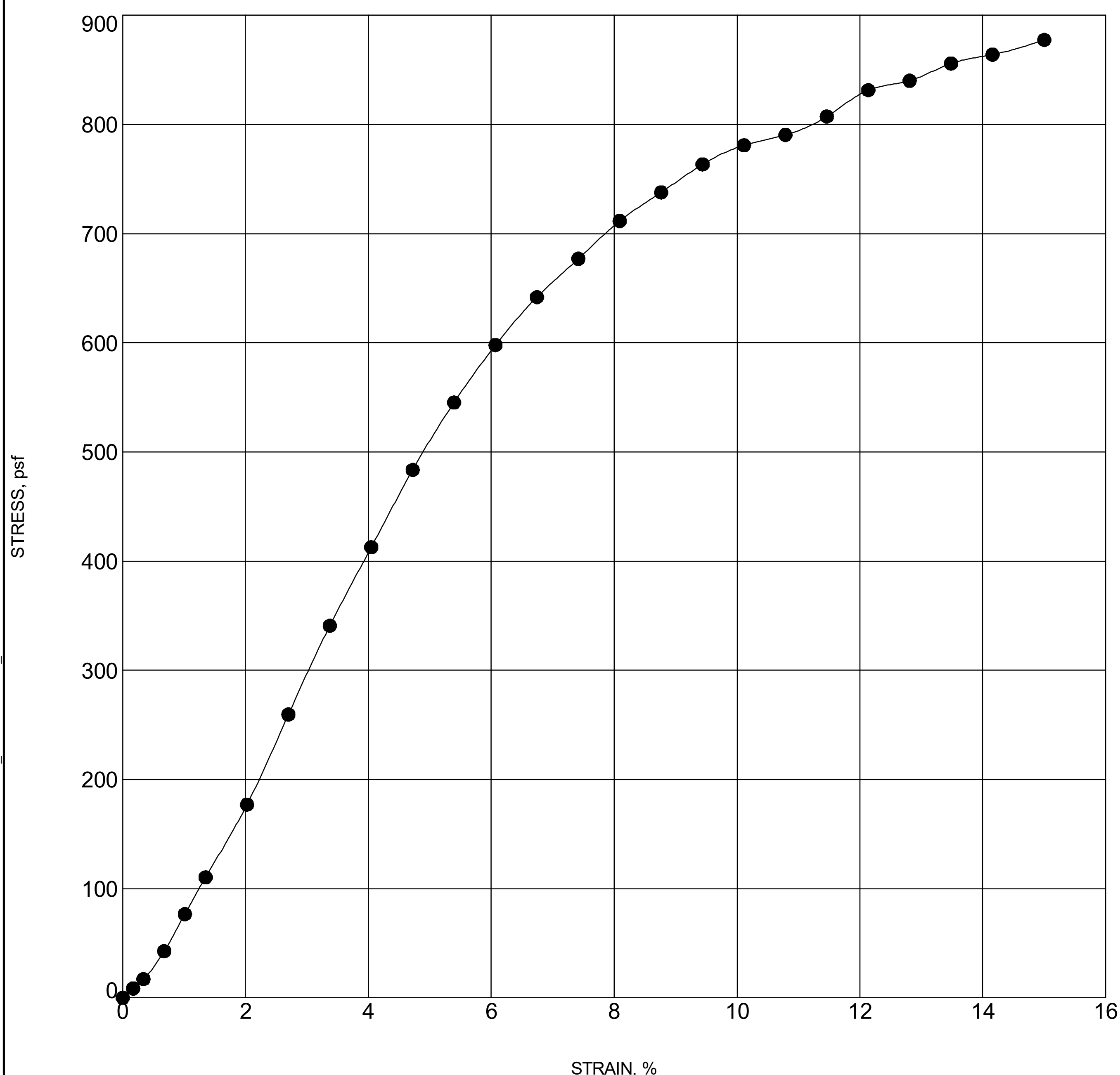
UNCONFINED COMPRESSION TEST

AASHTO R18

CLIENT Macomb County Department of Roads **PROJECT NAME** Shelby Township Salt Barn

PROJECT NUMBER 401.2300893.000 **PROJECT LOCATION** Shelby Township, Macomb County



	Specimen Identification		Classification	UCS (psf)	γ_d	MC%
●	**SB-04 / SS-5**	**13.5**		**878**	**88**	**34**

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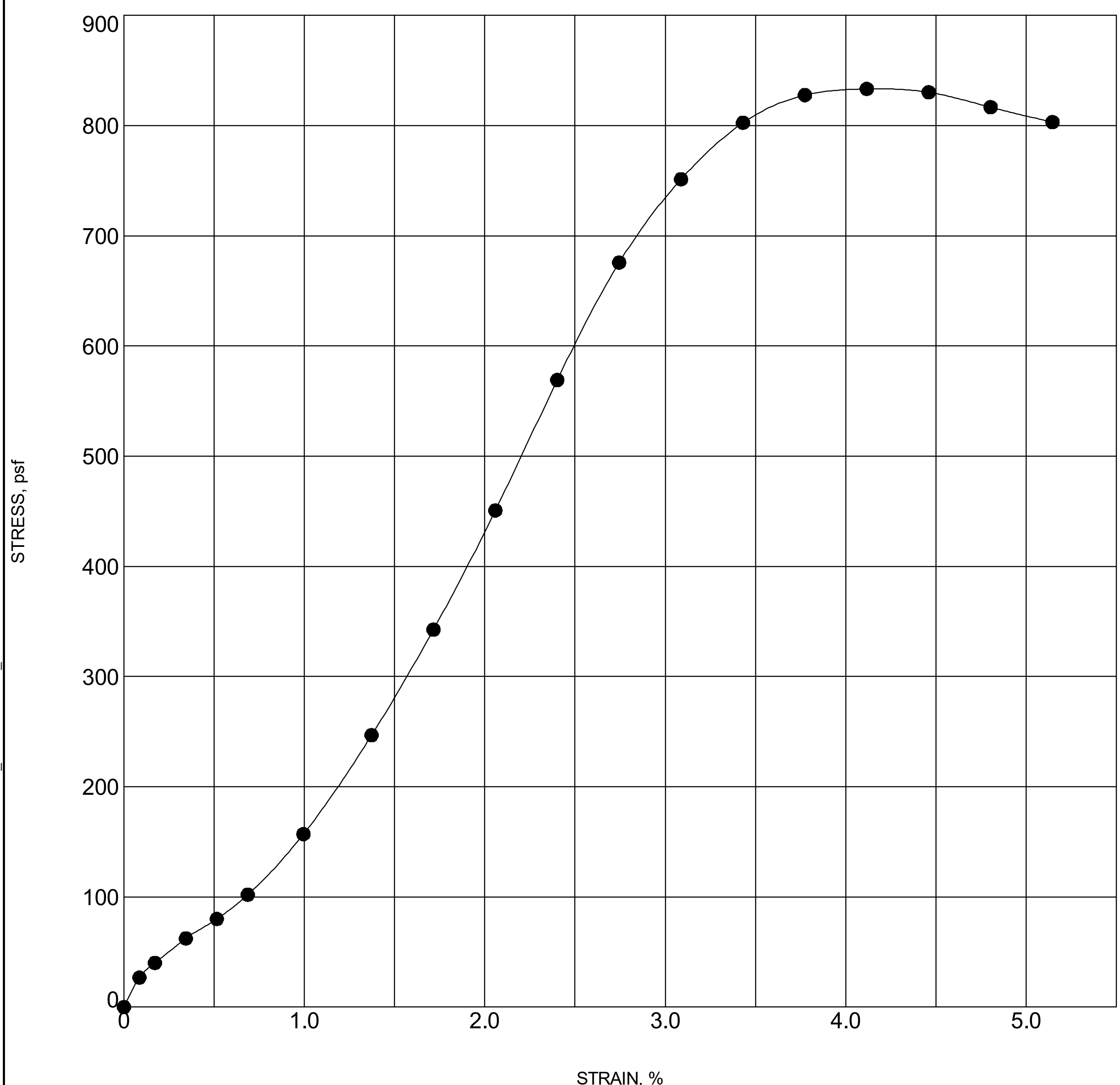
UNCONFINED COMPRESSION TEST

AASHTO R18

CLIENT Macomb County Department of Roads
PROJECT NAME Shelby Township Salt Barn
PROJECT NUMBER 401.2300893.000
PROJECT LOCATION Shelby Township, Macomb County



	Specimen Identification		Classification	UCS (psf)	γ_d	MC%
●	**SB-05 / ST-1**	**8.0**		**833**	**106**	**22**

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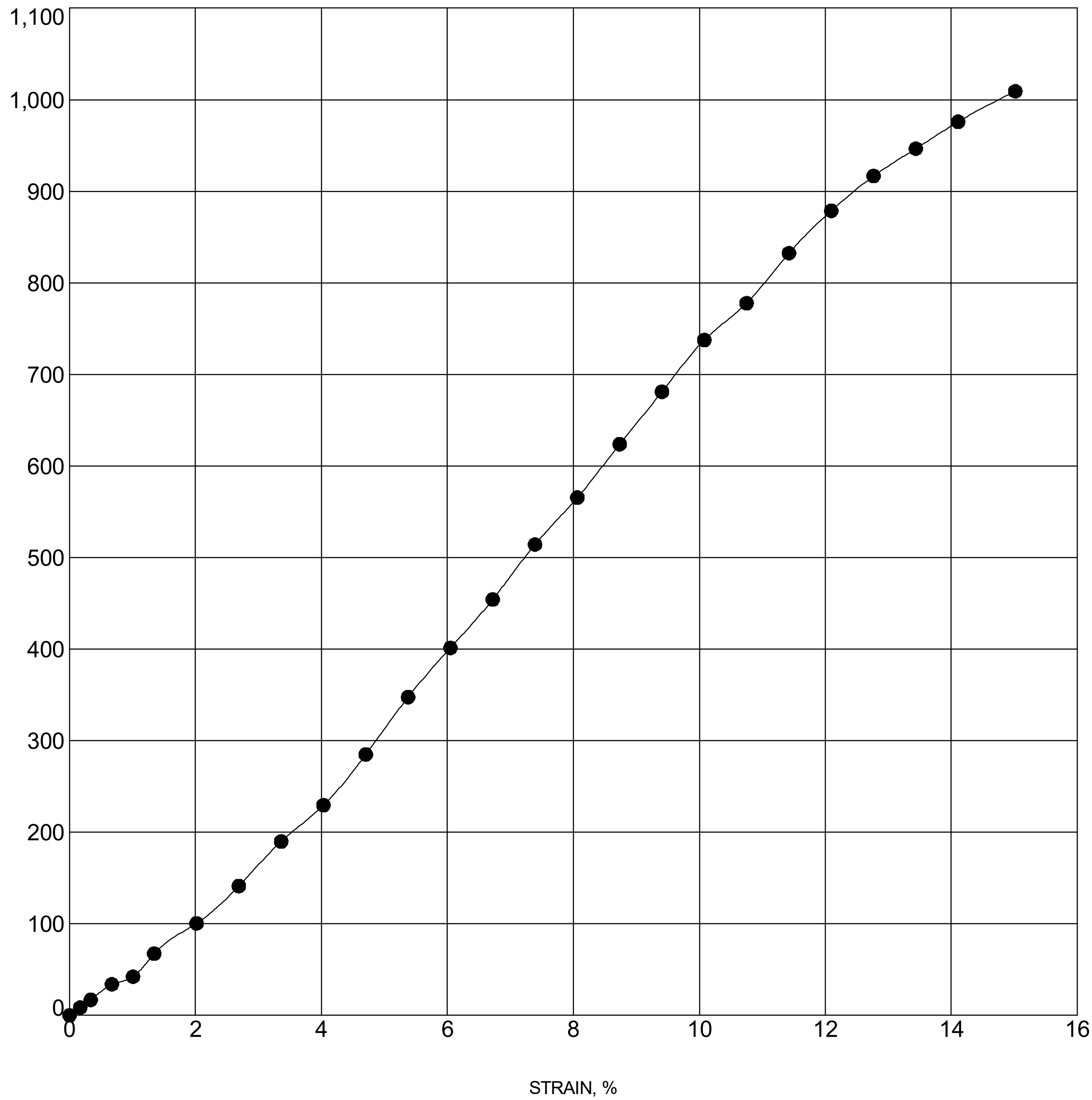
UNCONFINED COMPRESSION TEST

AASHTO R18

CLIENT Macomb County Department of Roads **PROJECT NAME** Shelby Township Salt Barn

PROJECT NUMBER 401.2300893.000 **PROJECT LOCATION** Shelby Township, Macomb County



	Specimen Identification		Classification	UCS (psf)	γ_d	MC%
●	**SB-06 / SS-7**	**23.5**		**1009**	**103**	**24**

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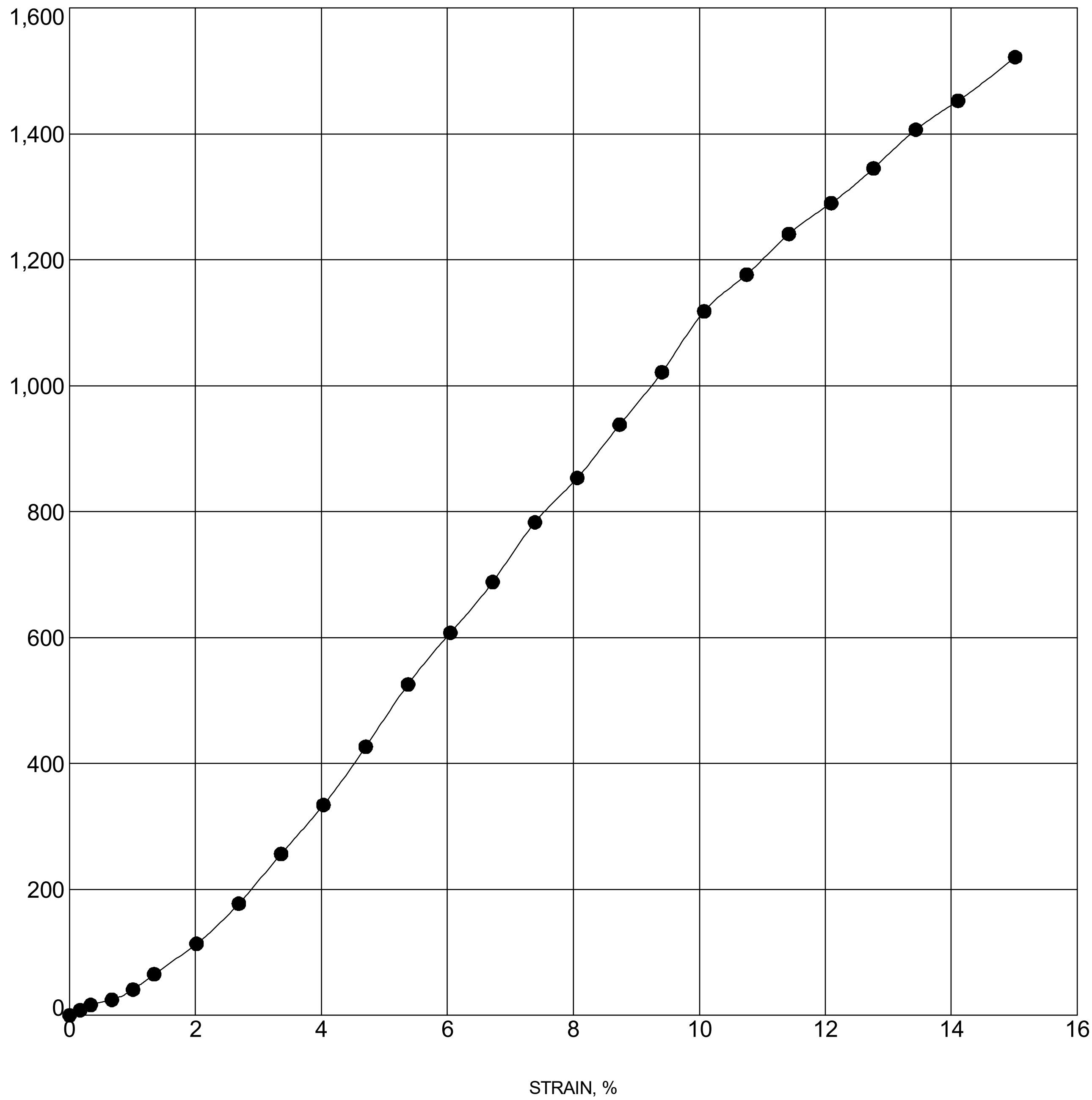
UNCONFINED COMPRESSION TEST

AASHTO R18

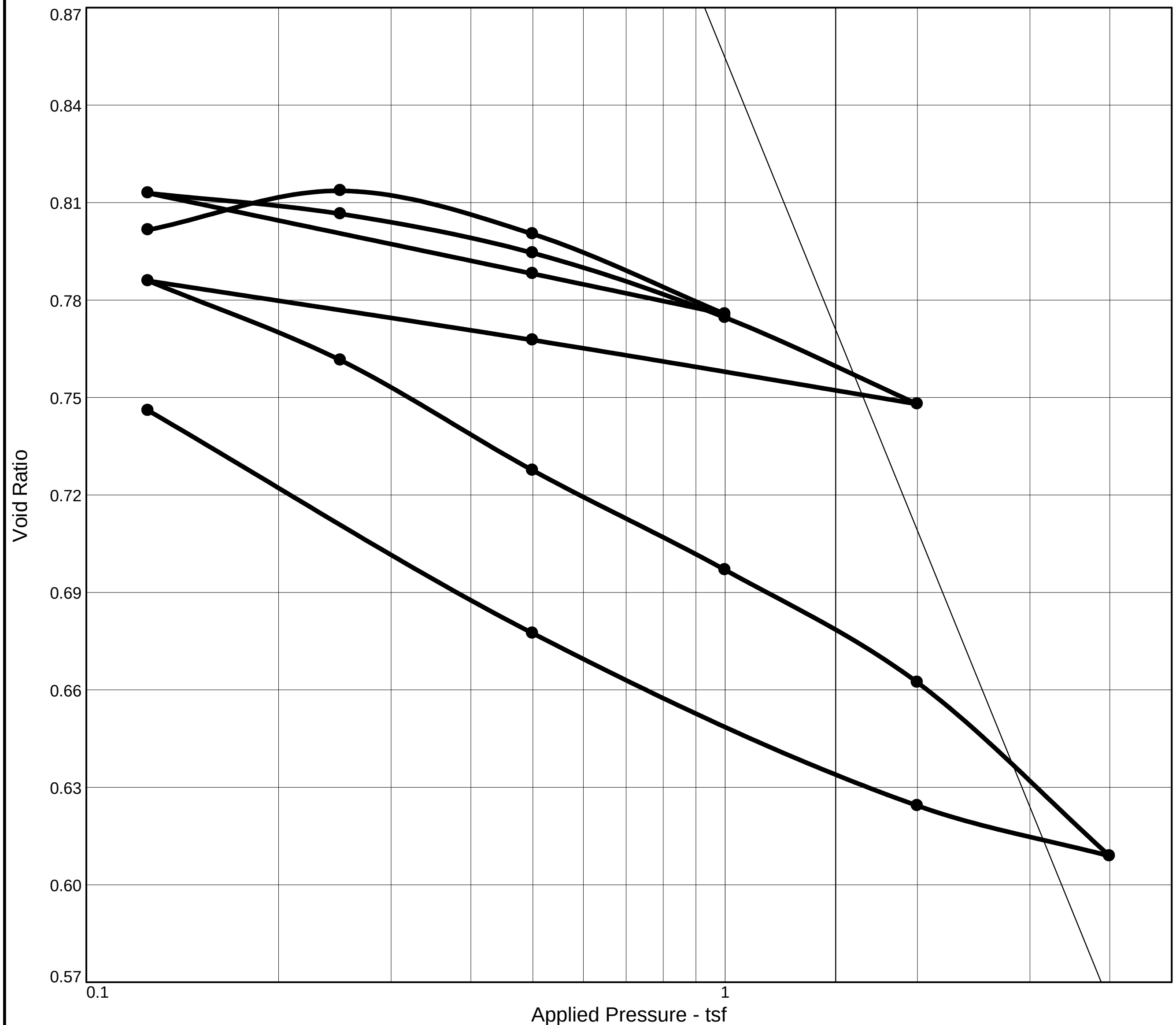
CLIENT Macomb County Department of Roads **PROJECT NAME** Shelby Township Salt Barn

PROJECT NUMBER 401.2300893.000 **PROJECT LOCATION** Shelby Township, Macomb County



	Specimen Identification		Classification	UCS (psf)	γ_d	MC%
●	**SB-07 / SS-6**	**23.5**		**1521**	**122**	**15**

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
95.4 %	29.1 %	92.4	44	23	2.70		1.5	0.48	0.08			0.823

MATERIAL DESCRIPTION	USCS	AASHTO
Lean Clay	CL	A-7-6(25)

Project No. 401.2300893 **Client:** Macomb County Department of Roads

Project: Shelby Township Salt Barn

Location: SB-07 **Depth:** 18.0-20.0' **Sample Number:** ST-1

Mannik Smith GROUP

Remarks:

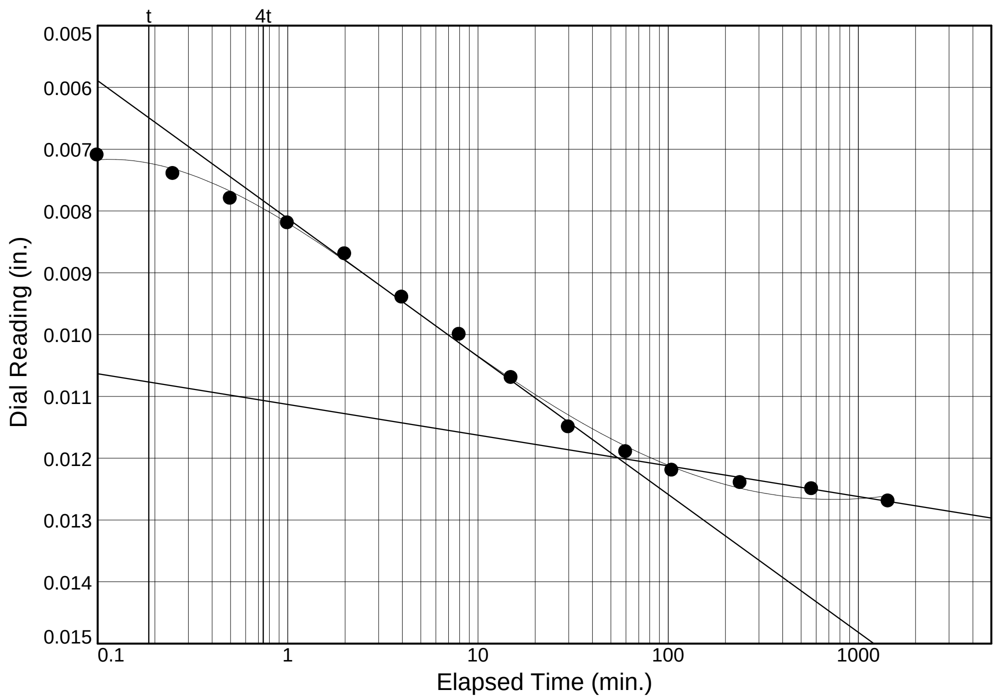
Figure

Tested By: MJG **Checked By:** Michael Gerdeman

Dial Reading vs. Time

Project No.: 401.2300893
Project: Shelby Township Salt Barn

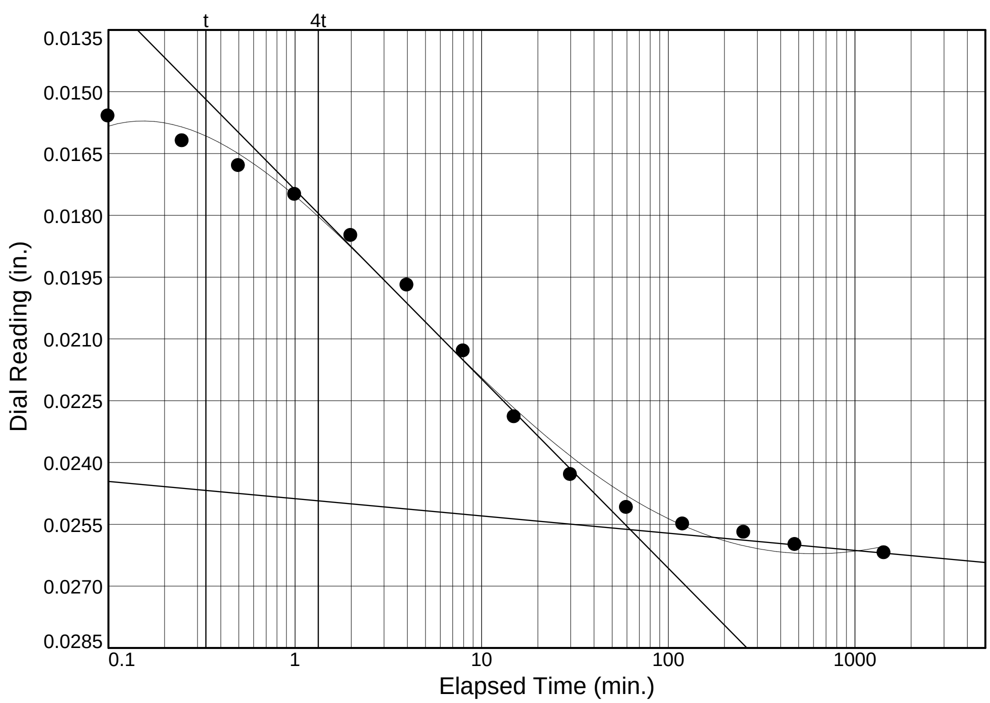
Location: SB-07 Depth: 18.0-20.0' Sample Number: ST-1



Load No.= 3
Load= 0.50 tsf
D_0 = 0.0065
D_{50} = 0.0092
D_{100} = 0.0120
T_{50} = 3.16 min.

C_v @ T_{50}
0.153 ft.^{2}/day

C_α = 0.001



Load No.= 4
Load= 1.00 tsf
D_0 = 0.0141
D_{50} = 0.0199
D_{100} = 0.0256
T_{50} = 3.50 min.

C_v @ T_{50}
0.135 ft.^{2}/day

C_α = 0.001

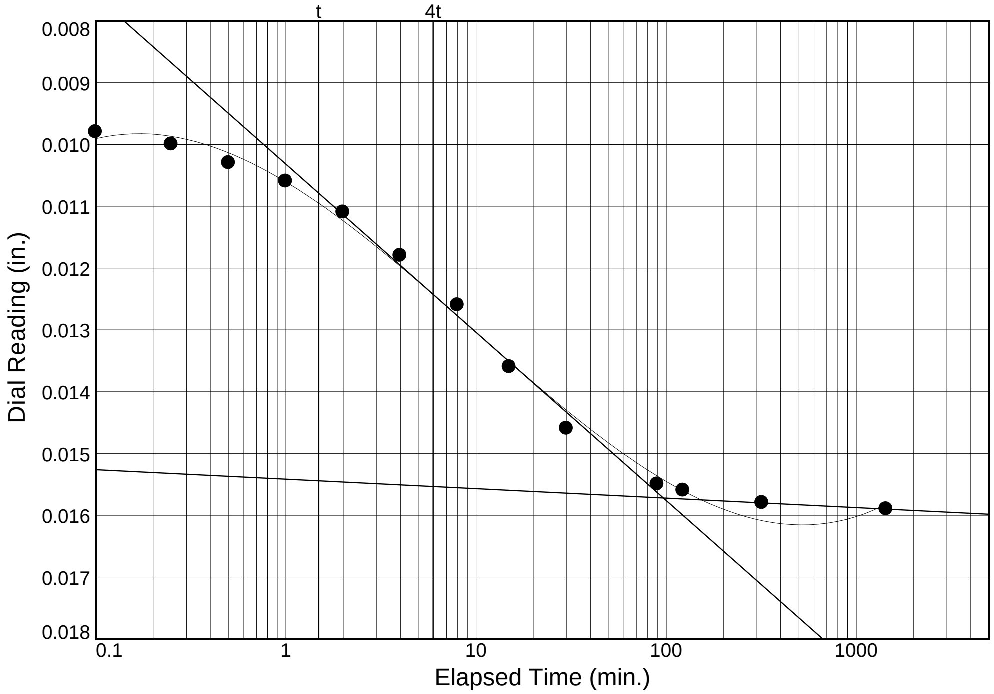
Figure

Mannik and Smith Group, Inc.

Dial Reading vs. Time

Project No.: 401.2300893
Project: Shelby Township Salt Barn

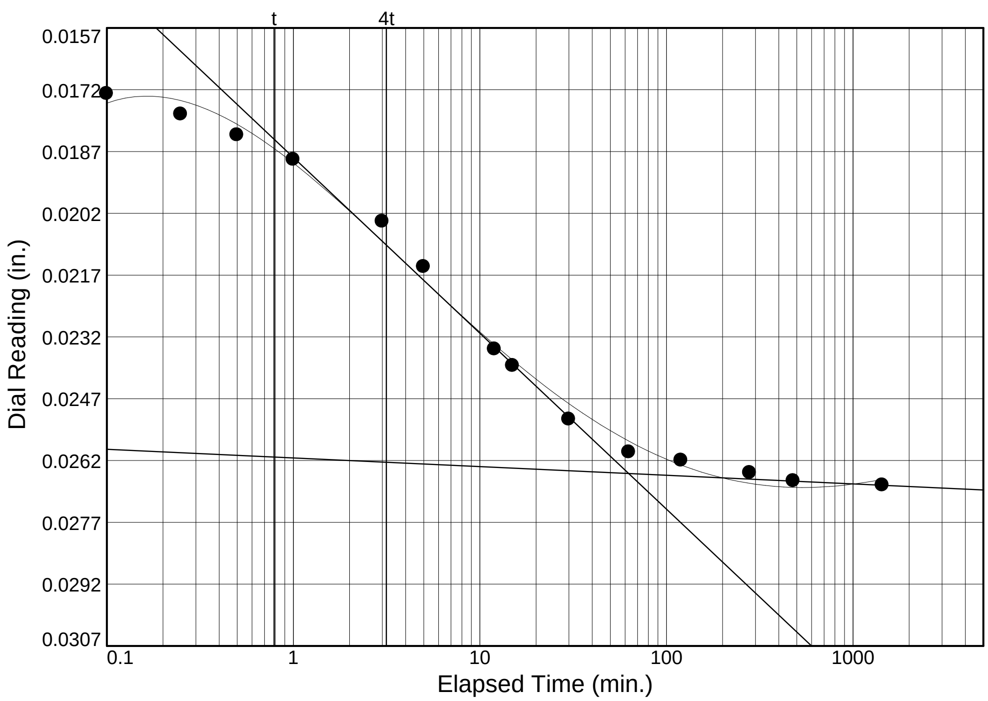
Location: SB-07 Depth: 18.0-20.0' Sample Number: ST-1



Load No.= 8
Load= 0.50 tsf
D_0 = 0.0095
D_{50} = 0.0126
D_{100} = 0.0157
T_{50} = 6.87 min.

C_v @ T_{50}
0.070 ft.^{2}/day

C_α = 0.000



Load No.= 9
Load= 1.00 tsf
D_0 = 0.0163
D_{50} = 0.0214
D_{100} = 0.0265
T_{50} = 3.97 min.

C_v @ T_{50}
0.119 ft.^{2}/day

C_α = 0.000

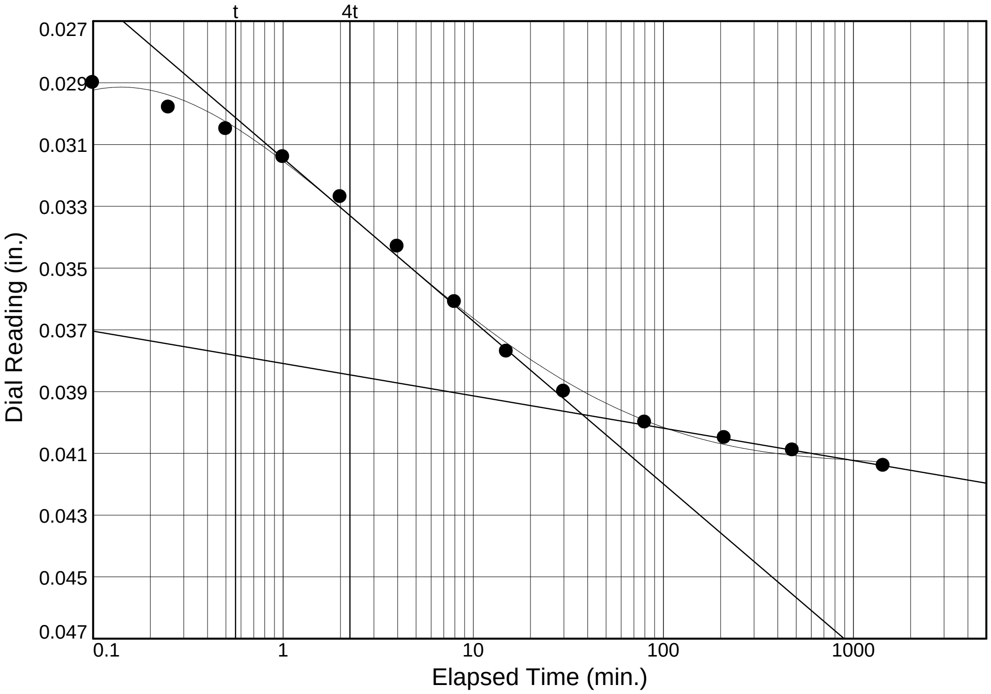
Figure

Mannik and Smith Group, Inc.

Dial Reading vs. Time

Project No.: 401.2300893
Project: Shelby Township Salt Barn

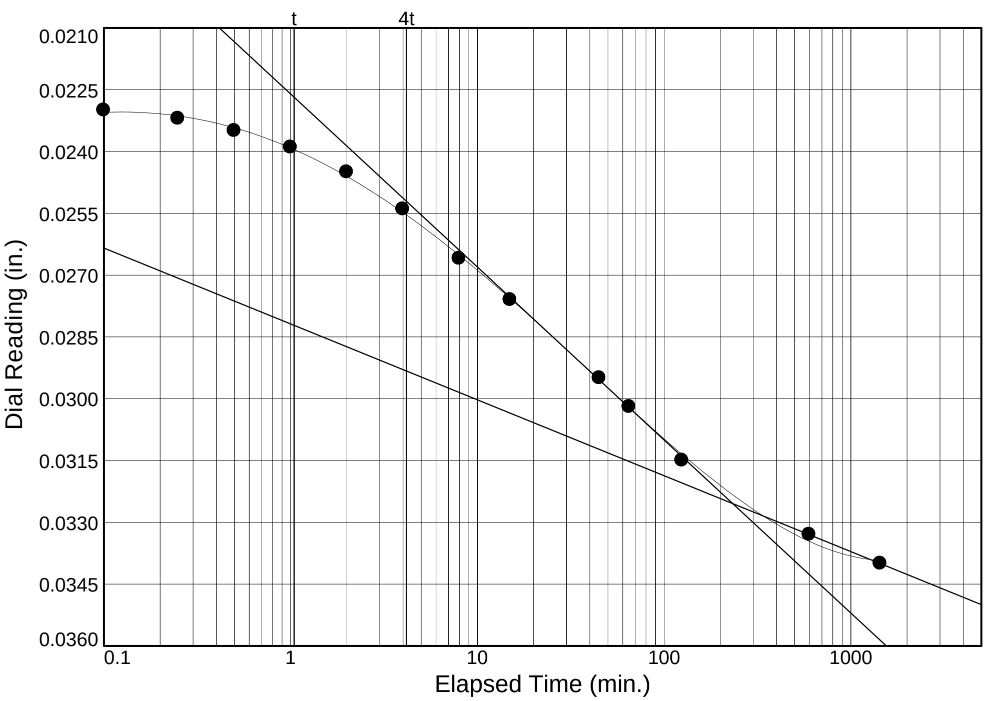
Location: SB-07 Depth: 18.0-20.0' Sample Number: ST-1



Load No.= 10
Load= 2.00 tsf
D_0 = 0.0276
D_{50} = 0.0337
D_{100} = 0.0397
T_{50} = 2.64 min.

C_v @ T_{50}
0.174 ft.^{2}/day

C_α = 0.002



Load No.= 13
Load= 0.25 tsf
D_0 = 0.0224
D_{50} = 0.0275
D_{100} = 0.0325
T_{50} = 14.00 min.

C_v @ T_{50}
0.033 ft.^{2}/day

C_α = 0.003

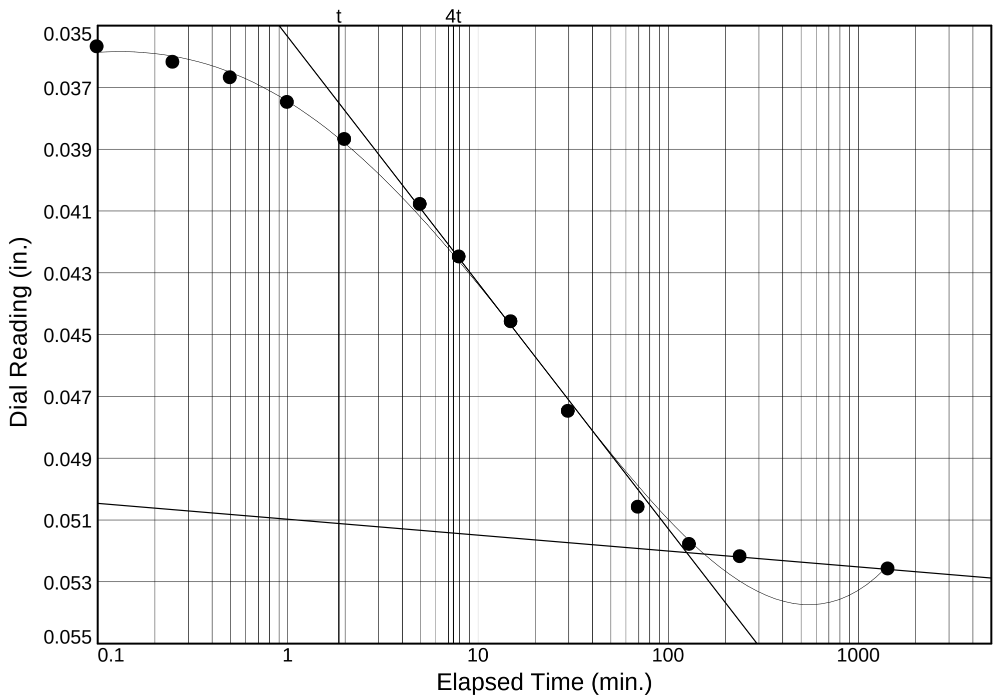
Figure

Mannik and Smith Group, Inc.

Dial Reading vs. Time

Project No.: 401.2300893
Project: Shelby Township Salt Barn

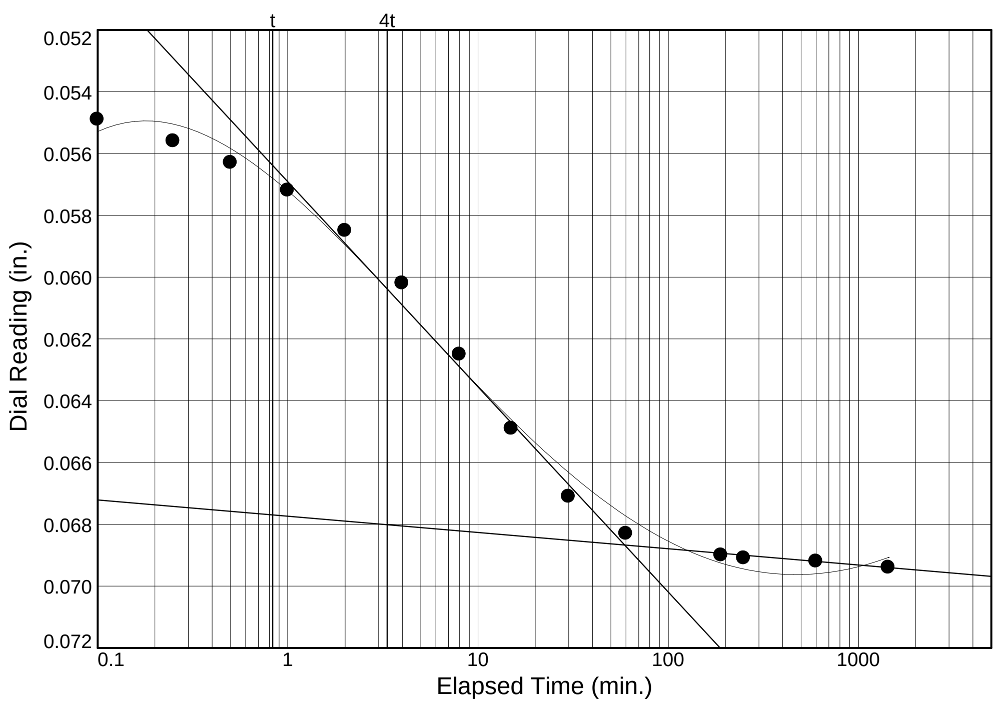
Location: SB-07 Depth: 18.0-20.0' Sample Number: ST-1



Load No.= 14
Load= 0.50 tsf
D_0 = 0.0349
D_{50} = 0.0435
D_{100} = 0.0521
T_{50} = 10.31 min.

C_v @ T_{50}
0.044 ft.^{2}/day

C_α = 0.001



Load No.= 15
Load= 1.00 tsf
D_0 = 0.0532
D_{50} = 0.0609
D_{100} = 0.0687
T_{50} = 4.05 min.

C_v @ T_{50}
0.107 ft.^{2}/day

C_α = 0.001

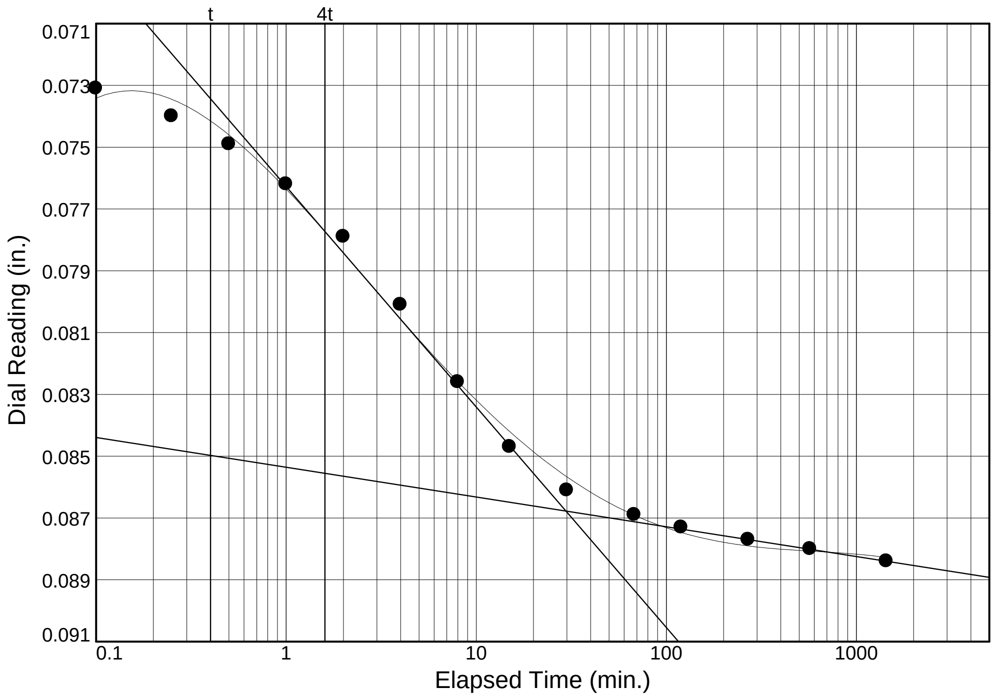
Figure

Mannik and Smith Group, Inc.

Dial Reading vs. Time

Project No.: 401.2300893
Project: Shelby Township Salt Barn

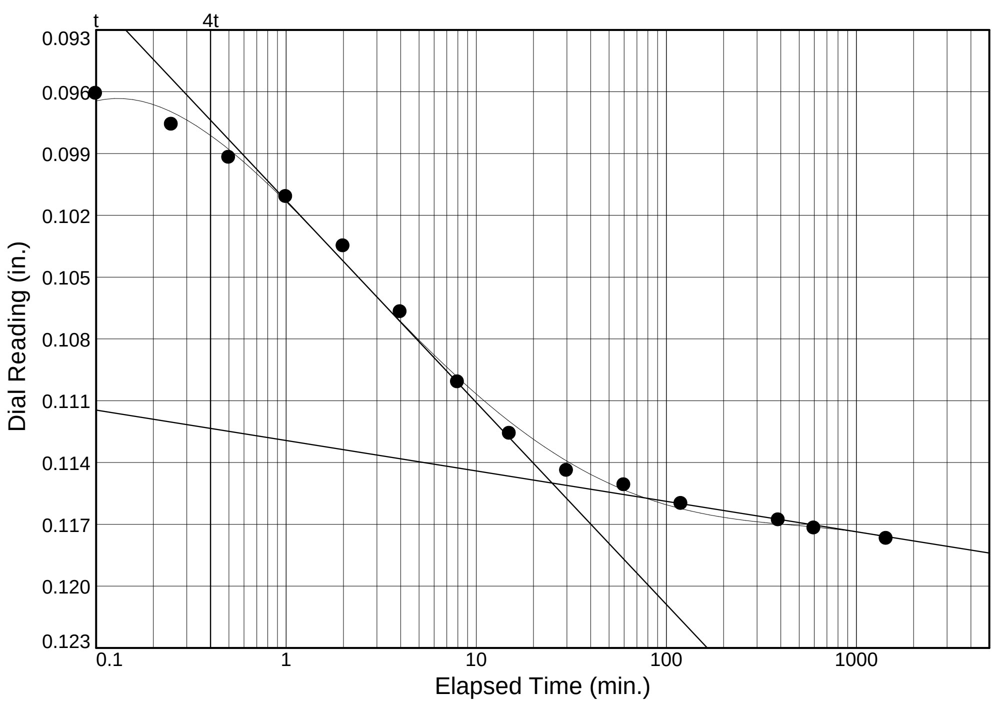
Location: SB-07 Depth: 18.0-20.0' Sample Number: ST-1



Load No.= 16
Load= 2.00 tsf
D_0 = 0.0706
D_{50} = 0.0787
D_{100} = 0.0868
T_{50} = 2.17 min.

C_v @ T_{50}
0.193 $ft.^2$/day

C_α = 0.002



Load No.= 17
Load= 4.00 tsf
D_0 = 0.0948
D_{50} = 0.1049
D_{100} = 0.1150
T_{50} = 2.33 min.

C_v @ T_{50}
0.170 $ft.^2$/day

C_α = 0.003

Figure

Mannik and Smith Group, Inc.