above ground storage tank
air quality
asbestos/lead-based paint
baseline environmental assessment
brownfield redevelopment
building/infrastructure restoration
caisson/piles
coatings
concrete
construction materials services
corrosion
dewatering
drilling
due care analysis
earth retention system
environmental compliance
environmental site assessment
facility asset management
failure analyses
forensic engineering
foundation engineering
geodynamic/vibration
geophysical survey
geosynthetic
greyfield redevelopment
ground modification
hydrogeologic evaluation
industrial hygiene
indoor air quality/mold
instrumentation
masonry/stone
metals
nondestructive testing
pavement evaluation/design
property condition assessment
regulatory compliance
remediation
risk assessment
roof system management
sealants/waterproofing
settlement analysis
slope stability
storm water management
structural steel/welding
underground storage tank

SUBSURFACE EXPLORATION

CHAGRIN FALLS SALT DOME
CHAGRIN FALLS, OHIO

Prepared for:

Mr. Danny Bonham
c/o CT Consultants
8150 Sterling Court
Mentor, Ohio 44060

SME Project Number: 067725.00

September 12, 2013

Soil and Materials Engineers, Inc.

Important Information about Your
Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely on Your ASFE-Member Geotechnical Engineer for Additional Assistance

Membership in ASFE/The Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE THE GEOPROFESSIONAL BUSINESS ASSOCIATION

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

INTRODUCTION

This report presents the results of a subsurface exploration for the new salt storage facility to be located in Chagrin Falls, Ohio. Subsurface conditions were identified by a field exploration program consisting of six Standard Penetration Test (SPT) borings. Selected soil and bedrock samples were tested in the laboratory, and field and laboratory tests were interpreted. These interpretations led to recommendations for foundation design and site preparation for the salt storage building.

PROPOSED PROJECT

It is proposed to replace the existing salt dome with a new salt storage facility at the Chagrin Falls Service Department. The new structure will be located approximately 200 feet north of the existing salt dome. The building will be a wood framed building supported on a concrete foundation wall measuring 60 feet wide in its east-west direction by 100 feet long in its north-south direction. The interior of the building will be paved with asphalt. The structure will store 2000 tons of salt and provide access for dump trucks and loaders. The finished floor elevation for the floor will be near 859.0 to 860.0 ft. Loads on the framing are estimated to be less than 20 kips per support or less than 2,000 plf.

This describes our understanding of site conditions and the proposed project and is an important part of our engineering interpretation. If our understanding is incorrect or if the project is changed, we should be given the opportunity to review our recommendations.

SITE CONDITIONS

The Chagrin Falls Service Department is located at 240 Solon Road. The Chagrin River is approximately 350 feet west of Solon Road and at least 50 feet west of the proposed salt storage building. Site topography is relatively level in the building area. A drainage swale encroaches into the proposed construction area at the northwest building corner. Several stockpiles of fill and other materials cover portions of the proposed building footprint.

FIELD EXPLORATION

Subsurface conditions were studied by an exploration program consisting of six SPT borings, B-1, B-2, B-3, B-4, B-5, and B-7. Boring B-6, adjacent to the existing salt dome was not drilled due to the amount of fill encountered in boring B-7 which is also near the dome. The borings were drilled and sampled to depths of 11 to 21 feet and terminated in bedrock in the proposed building area or refusal on rubble fill near the existing salt dome. Approximate test locations are shown on the enclosed *Boring Location Plan.* SME staked the borings and CT Consultants surveyed the drilled locations and measured their surface elevations.

The borings were drilled and sampled in general accordance with ASTM Standards. A two inch O.D. split-barrel sampler was driven to obtain samples at selected intervals. The number of blows of a 140 pound hammer dropping 30 inches was recorded for each of three, six inch penetration intervals at each sample location. Where a penetration of less than six inches was

obtained for 50 hammer blows, the actual blow count and depth of penetration in inches for that interval was recorded.
Where groundwater was encountered during drilling its depth was recorded upon encounter, at the completion of each boring, and in some cases 24 hours after drilling. The borings were backfilled at the completion of field testing.

The results of this field exploration are presented on the enclosed boring logs.

LABORATORY TESTING

Samples were taken to our laboratory, where they were examined and classified by a geotechnical engineer in general accordance with ASTM Standards. Selected split-barrel samples were tested for their water contents as an indicator of soil consistency, strength, and compressibility. The results of these tests are included on the boring logs.

Bedrock samples were classified generally following guidelines presented in ASCE Manual 56 "Subsurface Investigation for Design and Construction of Foundations of Buildings," dated 1976. Because intact rock cores were not obtained, the rock classifications were based on judgment using split-barrel samples.

SUBSURFACE PROFILE

Geological references suggest that the site is in an area of alluvium and lacustrine deposits over shallow rock. The conditions encountered at the soil boring locations are generally consistent with this information with the exception that fill was encountered in five of the six borings.

The fill ranged in depth from 3½ feet in boring B-1 to 12½ feet in B-4 in the proposed building area. The fill was quite variable in composition consisting of clays, cinders, asphalt, rock, brick, and other materials.

Undisturbed soils in the building area ranged from medium dense, brown clayey sand to very stiff to hard, silty to lean clays. The deeper clay deposits are residual clays weathered back from the shale.

Bedrock consisting of shale and siltstone was encountered at depths of 9½ to 13 feet below the surface. The relative strength of the rock ranged from very soft to moderately hard.

Groundwater was encountered in all of the borings. Its depth ranged from 11 feet in boring B-1 to 14½ feet in B-4. Groundwater levels rose to with 7 to 13 feet of the ground surface 24 hours after drilling. The groundwater appears to be in the shale formation or near the shale/fill contact as encountered in B-4.

Subsurface conditions at other times and locations on the site may differ from those found at our test locations. If different conditions are encountered during construction, we should be contacted and given the opportunity to review our recommendations.

ENGINEERING INTERPRETATION

The fill encountered in the building area is not suitable for supporting the proposed pole structure foundations. Because the floor area of the building will be supporting 2000 tons of salt, and the variable depth of the fill, unacceptable differential settlement is likely to occur over the asphalt floor area. With the average depth of fill, including the "possible fill" noted on the boring logs, estimated to be less than 8 to 10 feet, it would be more economical to remove the fill and replace it with engineered/structural fill in lieu of a deep foundation system to support poles and floors.

CONCLUSIONS AND RECOMMENDATIONS

Site Preparation and Earth Fill Construction

The existing stockpiles should be removed from the building area. The existing fills should be excavated from the building area extending outside the building line a distance of at least 1 foot horizontally for each foot of fill removed (1H:1V oversize). The excavated material should be evaluated for its potential reuse as engineered fill. Contractors should be aware that the moisture content in some of the fill appears to be over optimum for proper compaction and that drying of the fill will be required before it is reused.

There was no fill encountered in boring B-2 at the northeast building corner while the greatest depth of fill, 12½ ft, occurred in B-4 at the southwest corner. We recommend that removal of the fill begin at the north wall line and proceed southward so that excessive over excavation of the site does not occur. Excavation should be done in the presence of a qualified soils technician to evaluate the fill materials including those noted as "possible fill" on the boring logs.

Clean earth fill free of organics should be moisture conditioned to within 2% of its optimum moisture content and placed in 10 inch loose lifts. Each lift should be compacted to 100% of its standard Proctor maximum dry density as determined by ASTM D698. Silt, shale, or slag should not be used as structural fill in the building area. Lean clay, sand, gravel, and crushed stone may be used as structural fill. Other materials not listed may be used as structural fill, but only with the approval of the geotechnical engineer of record.

Groundwater was encountered in the shale/siltstone bedrock that is well below the fill at most locations in the building area. Some use of sumps could be required at the southwest building corner where the fill is deeper. Contractors should be prepared to provide dewatering until fill is placed.

Foundations

Use shallow foundations to support poles/columns and frost walls. Footings should bear on medium stiff to stiff brown sandy lean clay, medium dense brown clayey sand, or structural fill, and should be proportioned for a maximum net soil bearing pressure of 2,000 psf for protection against frost-related heave. Embedment of footings in or surrounding unheated areas should be 3.5 ft.

Footings should be excavated to a level bearing surface. Bearing surfaces should be cleaned of mud and loose cuttings, and should be protected against water accumulation from rainfall, surface drainage, or excavation sidewall seepage prior to placing concrete.

Bearing soils should be protected from freezing if there is a delay in placing concrete during cold weather. Bearing surfaces should also be observed by the geotechnical engineer or a soils technician before concrete placement.

Final Subgrade Preparation for Floor Slab/Pavement Construction

Subgrade soils softened or otherwise disturbed during construction should either be disced and dried in place and recompacted to the specified density, or undercut and replaced. The top 12 inches of the floor slab subgrade should be uniformly compacted to at least 100% of the soil's standard Proctor maximum dry density.

MONITORING DURING CONSTRUCTION

Proofrolling and earthwork. Each lift of earth fill should be tested for density and moisture content after it is spread and compacted, to verify compliance with the earthwork specifications. If compaction is not being achieved, the technician should assist the contractor to make the adjustments to moisture conditioning and/or compaction procedures that are necessary to achieve the desired degree of compaction. The technician should prepare a daily report of compaction test results for the geotechnical engineer's review.

Spread footings and backhoe excavated piers. A soils technician working under the direct supervision of the project geotechnical engineer should be present during foundation construction, to verify compliance with the recommendations contained in this report. The technician's duties would include verifying that proper quality foundation bearing materials are reached and that the bearing surfaces are cleaned of excess water, mud, and loose soil prior to concrete placement. The technician would also verify the placement of reinforcement by comparison to the structural drawings and sample and test fresh concrete for compliance with the project specifications.

REMARKS

Our services were provided in general accordance with the standards for such professional services which prevailed among other qualified practitioners within the project area practicing under similar circumstances on projects of comparable scope, size, and complexity during the term of our agreement. Plan and specification review, and monitoring and testing during construction, are an extension of these professional services although they may not have been specifically addressed by the original agreement and are subject to the same standard of care. These extended services should be provided by SME to maintain continuity of the original intent of the recommendations and to reduce the possibility of conflicting interpretations or misinterpretations of the data presented in this report. SME accepts no responsibility for uses or interpretations of the data by the client, contractors, or other design professionals except as expressly described in this report or unless otherwise stated in writing.

SIGNATURES

REPORT PREPARED BY:

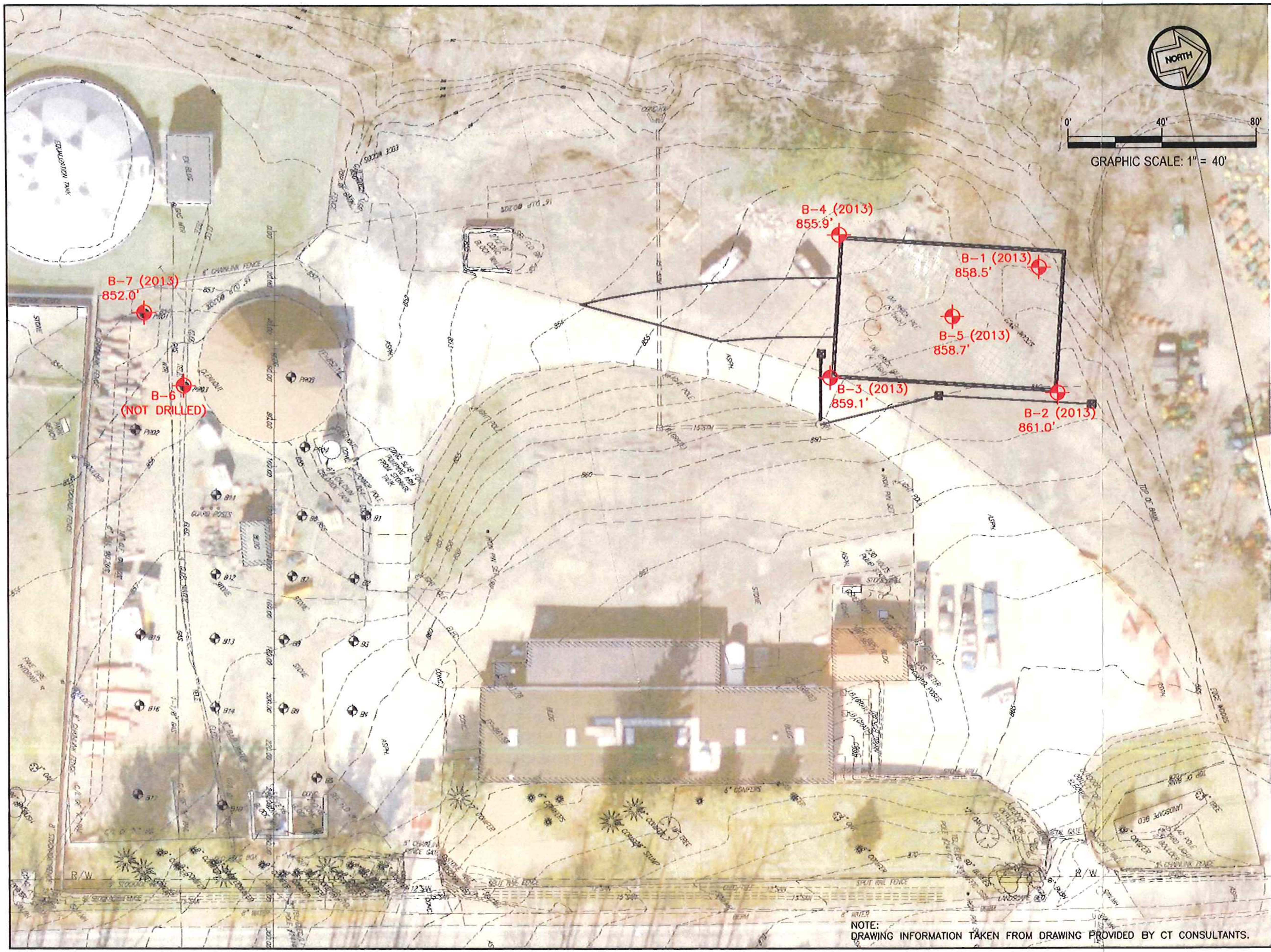
John E. Dingeldein, P.E.
Principal Consultant

STATE OF OHIO
JOHN E.
DINGELDEIN
E-049667
REGISTERED
PROFESSIONAL ENGINEER

REPORT REVIEWED BY:

Alan J. Esser, P.E.
Principal Consultant

STATE OF OHIO
ALAN JAMES
ESSER
E-40092
REGISTERED
PROFESSIONAL ENGINEER



NOTE:
DRAWING INFORMATION TAKEN FROM DRAWING PROVIDED BY CT CONSULTANTS.

Sep 13, 2013 - 11:00am - preinesberger
\\Smefile\work in progress\067725.00\CAD\067725.00-1 Chagrin Falls Salt Storage Facility.dwg

No.	Revision Date

BORING LOCATION PLAN
CHAGRIN FALLS SALT STORAGE FACILITY
CHAGRIN FALLS, OHIO

Date	09/12/13
Drawn By	HRP
Designed By	JED
Scale	1" = 40'
Project	067725.00

sme
www.sme-usa.com

soil and materials engineers, inc.
michigan, ohio and indiana

BORING B-1

PAGE 1 OF 1

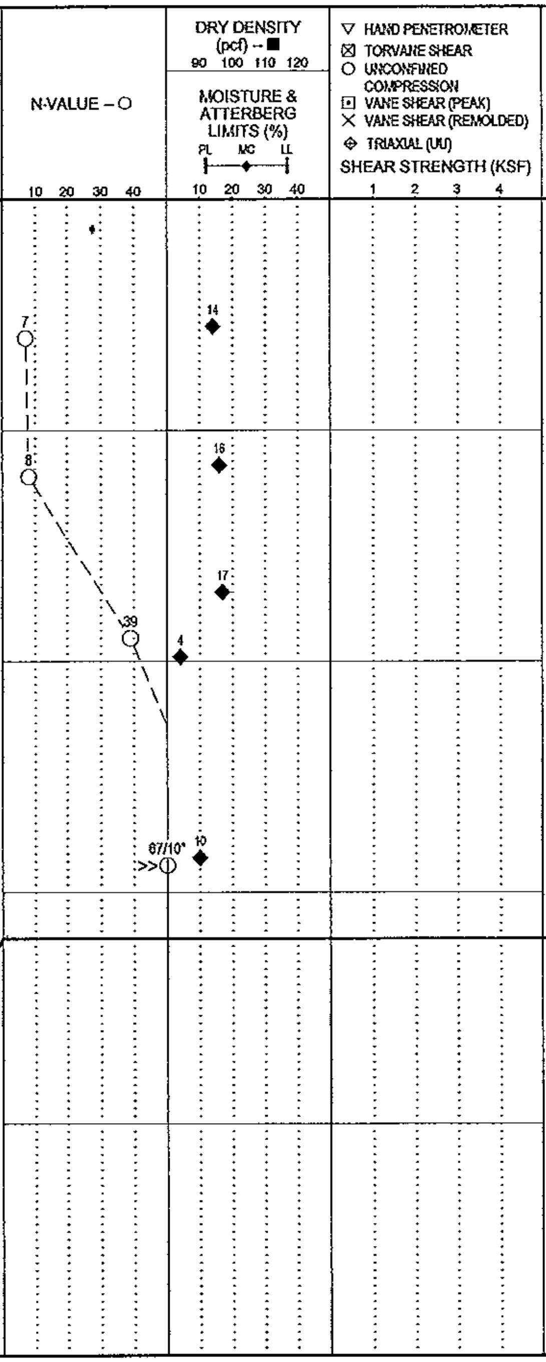
PROJECT NAME: Chagrin Falls Salt Storage Facility
PROJECT NUMBER: 067725.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Chagrin Falls, Ohio

DATE STARTED: 5/20/13
COMPLETED: 5/20/13
BORING METHOD: 3-1/4" I.D. Hollow-stem Augers
DRILLER: RH/BS
RIG NO.: 293-CME55CPT
LOGGED BY: SXM
CHECKED BY: JED

NORTHING: 642244.39 FT
EASTING: 2270929.82 FT
SURFACE ELEVATION: 858.47 FT

DEPTH (FEET)	PROFILE DESCRIPTION	ELEVATION (FEET)	SAMPLE TYPE/NO. INTERVAL	BLOWS PER SIX INCHES	REMARKS
3.5	POSSIBLE FILL: Brown sandy lean CLAY with gravel and rock fragments (CL)	855.0	SS1	5 4 3	
7.0	Medium stiff to stiff brown sandy lean CLAY with gravel (CL)	851.5	SS2	4 4 4	
9.9	Hard brown silty CLAY (weathered shale) (CL/ML)	848.6	SS3	5 17 22	
16.0	Medium to moderately hard gray SHALE	842.5	SS4 SS5	17 17 50/4" 50/0"	

Auger refusal at 16 feet
END OF BORING AT 16.0 FEET.



GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ DURING BORING:	11.0	847.5
▼ AT END OF BORING:	12.5	846.0
▽ 24 HRS AFTER BORING:	7.0	851.5
CAVE-IN OF BOREHOLE AT:	14.5	844.0
BACKFILL METHOD:		

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

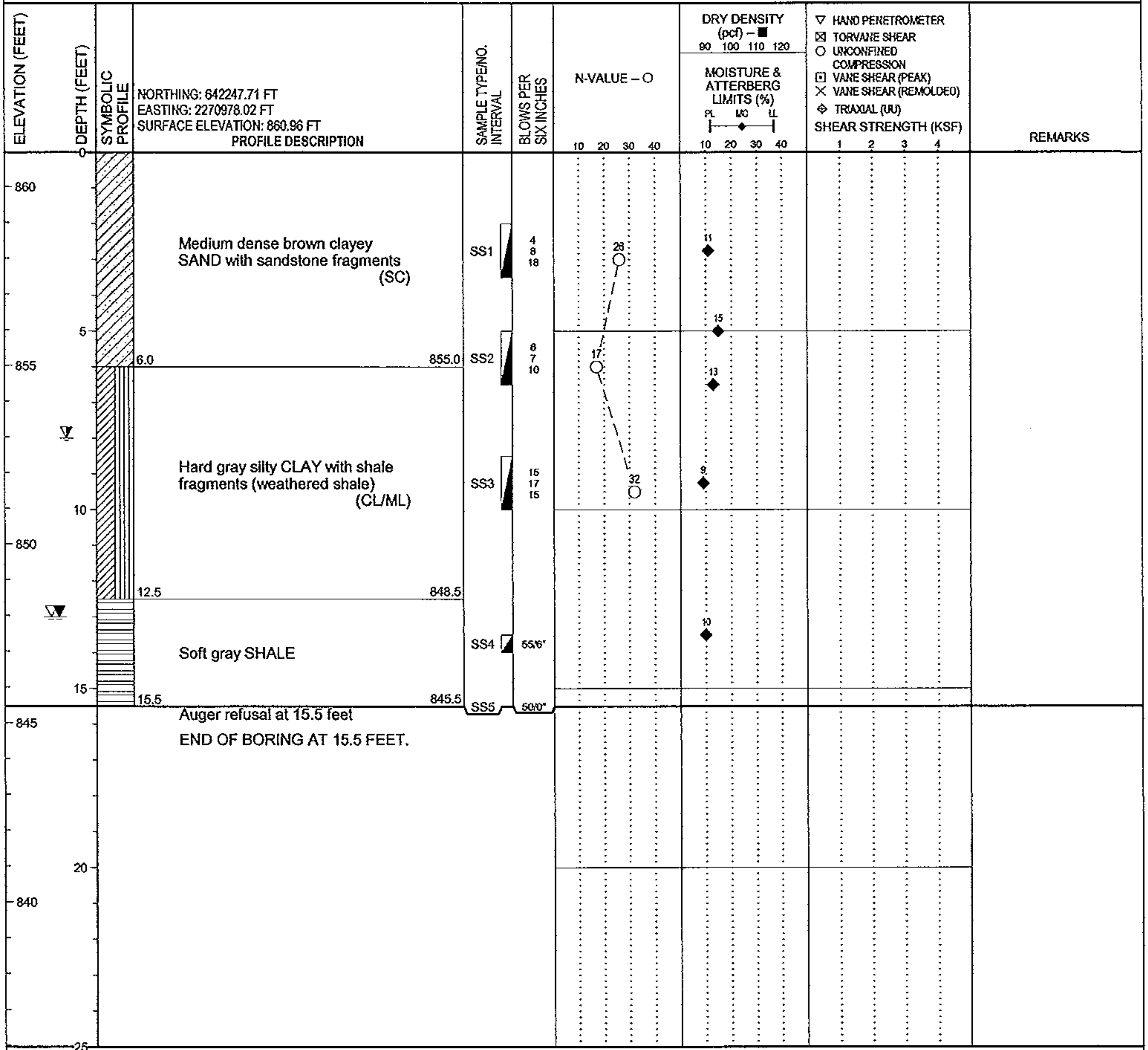
soil and materials engineers, inc.
michigan, ohio and indiana

BORING B-2

PAGE 1 OF 1

PROJECT NAME: Chagrin Falls Salt Storage Facility
PROJECT NUMBER: 067725.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Chagrin Falls, Ohio

DATE STARTED: 5/21/13
COMPLETED: 5/21/13
BORING METHOD: 3-1/4" I.D. Hollow-stem Augers
DRILLER: RH/BS
RIG NO.: 293-CME55CPT
LOGGED BY: SXM
CHECKED BY: JED



Depth (ft)	Elev. (ft)	Profile Description	Sample	Blows per six inches	N-Value	Moisture (%)
0.0–6.0	855.0	Medium dense brown clayey SAND with sandstone fragments (SC)	SS1	4 8 18	26	11
			SS2	6 7 10	17	15 13
6.0–12.5	848.5	Hard gray silty CLAY with shale fragments (weathered shale) (CL/ML)	SS3	15 17 15	32	9
12.5–15.5	845.5	Soft gray SHALE	SS4	55/6"		10
			SS5	50/0"		

Auger refusal at 15.5 feet
END OF BORING AT 15.5 FEET.

GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ DURING BORING:	13.0	848.0
▼ AT END OF BORING:	13.0	848.0
▽ 3 HRS AFTER BORING:	8.0	853.0
CAVE-IN OF BOREHOLE AT:	14.5	846.5
BACKFILL METHOD:		

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

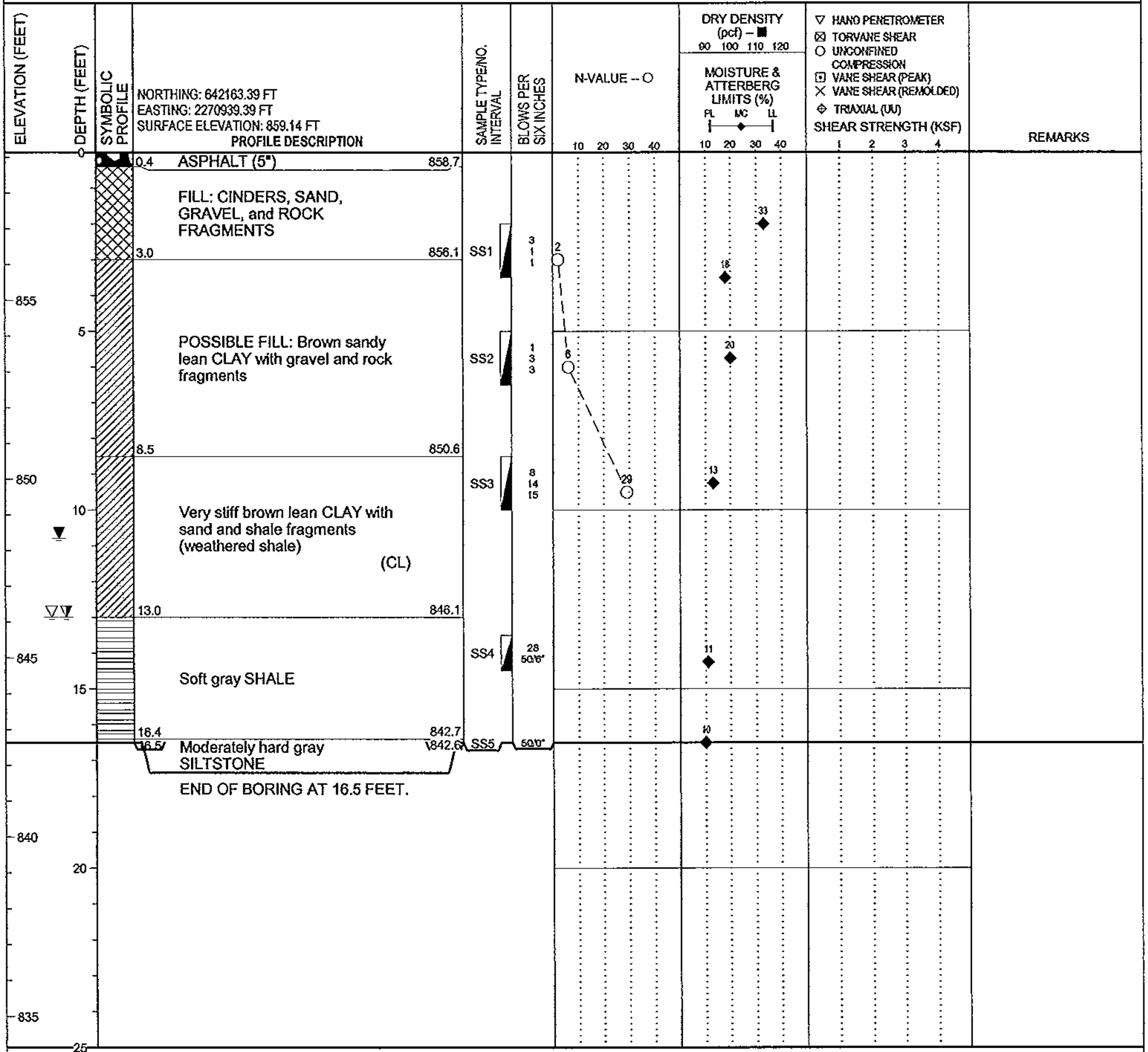
067725.00.GPJ 9/12/13

soil and materials engineers, inc.
michigan, ohio and indiana

BORING B-3

PAGE 1 OF 1

PROJECT NAME: Chagrin Falls Salt Storage Facility
PROJECT NUMBER: 067725.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Chagrin Falls, Ohio
DATE STARTED: 5/20/13
COMPLETED: 5/20/13
BORING METHOD: 3-1/4" I.D. Hollow-stem Augers
DRILLER: RH/BS
RIG NO.: 293-CME55CPT
LOGGED BY: SXM
CHECKED BY: JED



NORTHING: 642163.39 FT
EASTING: 2270939.39 FT
SURFACE ELEVATION: 859.14 FT

DEPTH (FEET)	PROFILE DESCRIPTION	ELEVATION (FEET)
0.4	ASPHALT (5")	858.7
3.0	FILL: CINDERS, SAND, GRAVEL, and ROCK FRAGMENTS	856.1
8.5	POSSIBLE FILL: Brown sandy lean CLAY with gravel and rock fragments	850.6
13.0	Very stiff brown lean CLAY with sand and shale fragments (weathered shale) (CL)	846.1
16.4	Soft gray SHALE	842.7
16.5	Moderately hard gray SILTSTONE	842.6

END OF BORING AT 16.5 FEET.

SAMPLE TYPE/NO.	BLOWS PER SIX INCHES	N-VALUE
SS1	3 1 1	2
SS2	1 3 3	6
SS3	8 14 15	29
SS4	28 50/6"	
SS5	50/0"	

GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ DURING BORING:	13.0	846.1
▼ AT END OF BORING:	10.8	848.3
▼ 24 HRS AFTER BORING:	13.0	846.1
CAVE-IN OF BOREHOLE AT:	14.5	844.6
BACKFILL METHOD:		

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

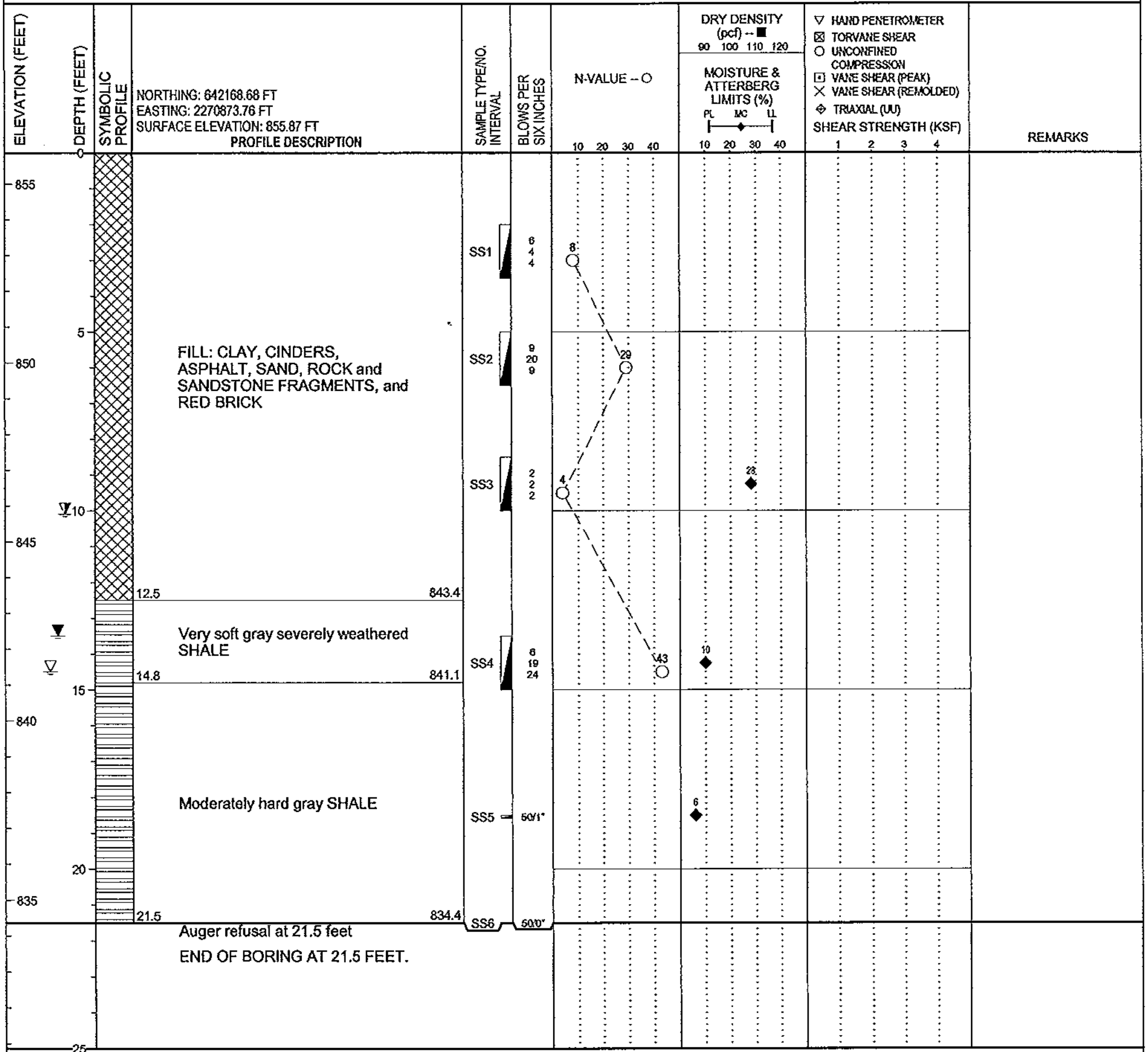
soil and materials engineers, inc.
michigan, ohio and indiana

BORING B-4

PAGE 1 OF 1

PROJECT NAME: Chagrin Falls Salt Storage Facility
PROJECT NUMBER: 067725.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Chagrin Falls, Ohio

DATE STARTED: 5/20/13
COMPLETED: 5/20/13
BORING METHOD: 3-1/4" I.D. Hollow-stem Augers
DRILLER: RH/BS
RIG NO.: 293-CME55CPT
LOGGED BY: SXM
CHECKED BY: JED



NORTHING: 642168.68 FT
EASTING: 2270873.76 FT
SURFACE ELEVATION: 855.87 FT

0 – 12.5	843.4	FILL: CLAY, CINDERS, ASPHALT, SAND, ROCK and SANDSTONE FRAGMENTS, and RED BRICK		
12.5 – 14.8	841.1	Very soft gray severely weathered SHALE		
14.8 – 21.5	834.4	Moderately hard gray SHALE		

Auger refusal at 21.5 feet

END OF BORING AT 21.5 FEET.

SS1	6 4 4	8	
SS2	9 20 9	29	
SS3	2 2 2	4	28
SS4	6 19 24	43	10
SS5	50/1"		6
SS6	50/0"		

GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ DURING BORING:	14.5	841.4
▼ AT END OF BORING:	13.5	842.4
▽ 24 HRS AFTER BORING:	10.1	845.8
CAVE-IN OF BOREHOLE AT:	18.0	837.9
BACKFILL METHOD:		

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

soil and materials engineers, inc.
michigan, ohio and indiana

BORING B-5

PAGE 1 OF 1

PROJECT NAME: Chagrin Falls Salt Storage Facility

PROJECT NUMBER: 067725.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Chagrin Falls, Ohio

DATE STARTED: 5/21/13

COMPLETED: 5/21/13

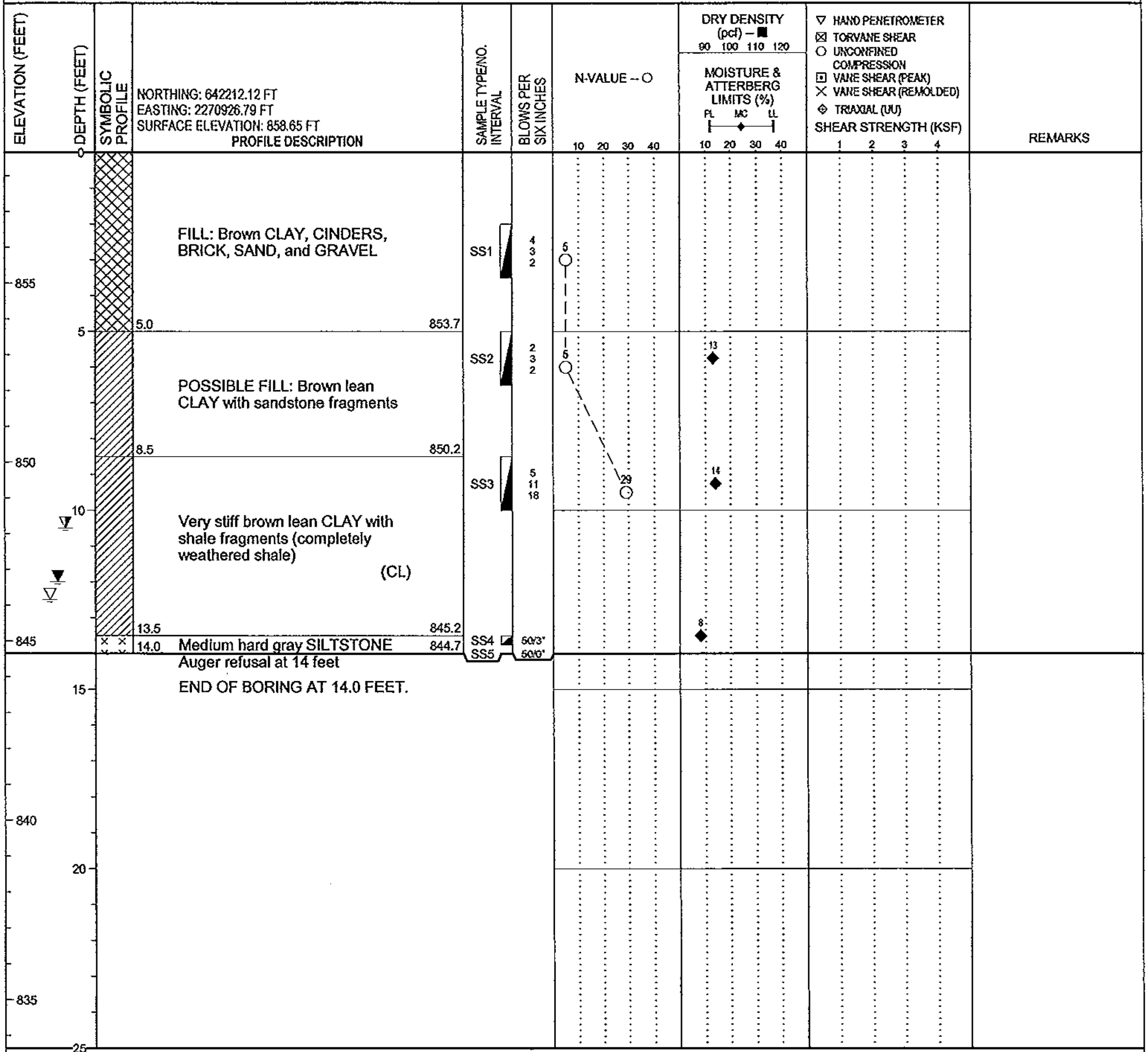
BORING METHOD: 3-1/4" I.D. Hollow-stem Augers

DRILLER: RH/BS

RIG NO.: 293-CME55CPT

LOGGED BY: SXM

CHECKED BY: JED



FILL: Brown CLAY, CINDERS, BRICK, SAND, and GRAVEL

POSSIBLE FILL: Brown lean CLAY with sandstone fragments

Very stiff brown lean CLAY with shale fragments (completely weathered shale) (CL)

Medium hard gray SILTSTONE

Auger refusal at 14 feet

END OF BORING AT 14.0 FEET.

GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ DURING BORING:	12.5	846.2
▼ AT END OF BORING:	12.0	846.7
▽ 2 HRS AFTER BORING:	10.5	848.2
CAVE-IN OF BOREHOLE AT:	12.8	845.9
BACKFILL METHOD:		

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

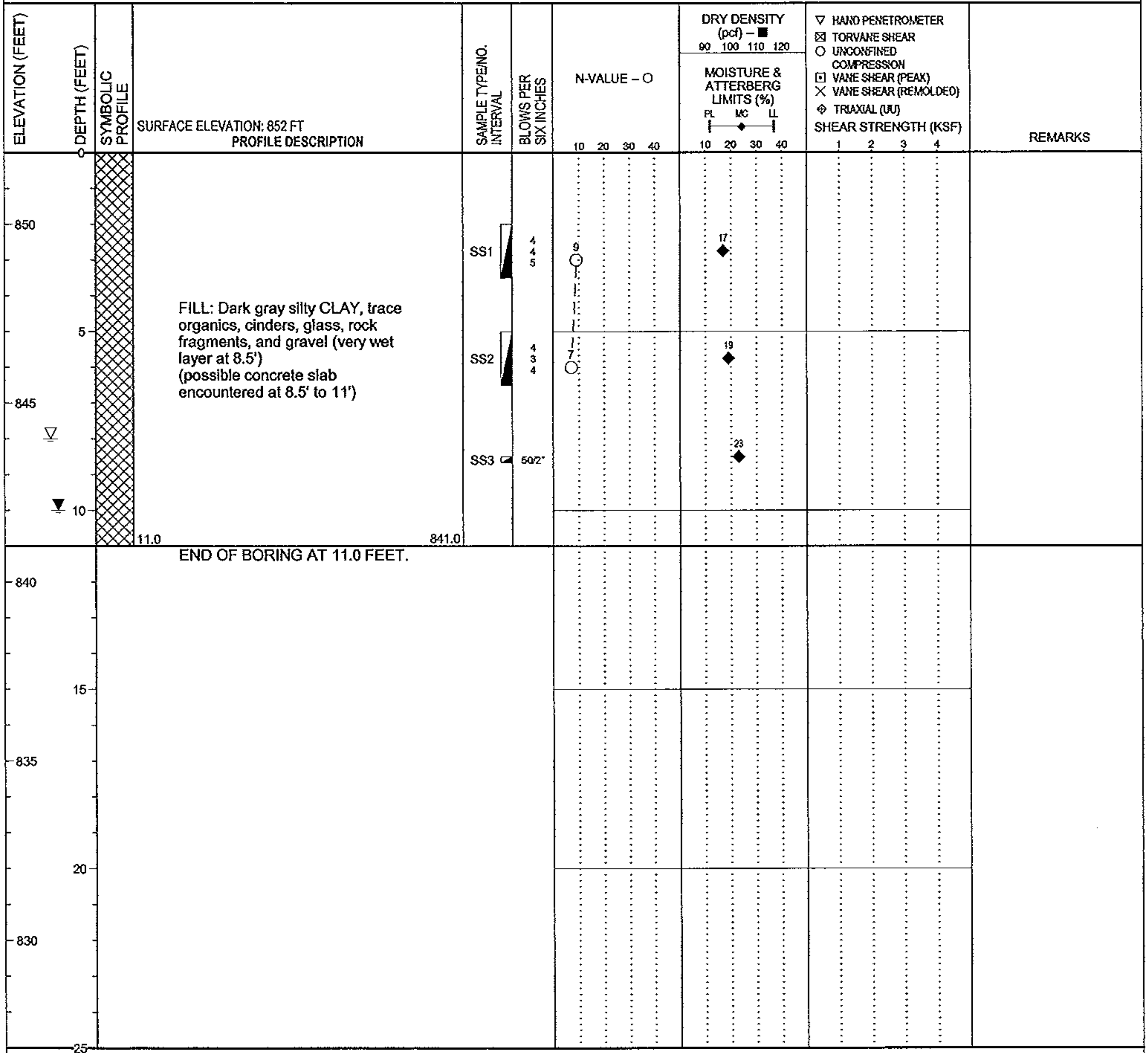
067725.00.GPJ 9/13/13

soil and materials engineers, inc.
michigan, ohio and indiana

BORING B-7

PAGE 1 OF 1

PROJECT NAME: Chagrin Falls Salt Storage Facility
PROJECT NUMBER: 067725.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Chagrin Falls, Ohio
DATE STARTED: 5/21/13
COMPLETED: 5/21/13
BORING METHOD: 3-1/4" I.D. Hollow-stem Augers
DRILLER: RH/BS
RIG NO.: 293-CME55CPT
LOGGED BY: SXM
CHECKED BY: JED



FILL: Dark gray silty CLAY, trace organics, cinders, glass, rock fragments, and gravel (very wet layer at 8.5')
(possible concrete slab encountered at 8.5' to 11')

Sample Type/No.	Blows per Six Inches	N-Value	MC (%)
SS1	4 4 5	9	17
SS2	4 3 4	7	19
SS3	50/2"		23

END OF BORING AT 11.0 FEET.

GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ DURING BORING:	8.0	844.0
▼ AT END OF BORING:	10.0	842.0

BACKFILL METHOD:

NOTES: 1. The indicated stratification lines are approximate. In situ, the transition between materials may be gradual.

BORING LOG TERMINOLOGY

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOIL (more than 50% of material is larger than No. 200 sieve size.)			
	Clean Gravel (Less than 5% fines)		
GRAVEL More than 50% of coarse fraction larger than No. 4 sieve size	▨	GW	Well-graded gravel; gravel-sand mixtures, little or no fines
	▨	GP	Poorly-graded gravel; gravel-sand mixtures, little or no fines
	Gravel with fines (More than 12% fines)		
	▨	GM	Silty gravel; gravel-sand-silt mixtures
	▨	GC	Clayey gravel; gravel-sand-clay mixtures
	Clean Sand (Less than 5% fines)		
SAND 50% or more of coarse fraction smaller than No. 4 sieve size	▨	SW	Well-graded sand; sand-gravel mixtures, little or no fines
	▨	SP	Poorly graded sand; sand-gravel mixtures, little or no fines
	Sand with fines (More than 12% fines)		
	▨	SM	Silty sand; sand-silt-gravel mixtures
	▨	SC	Clayey sand; sand-clay-gravel mixtures
FINE-GRAINED SOIL (50% or more of material is smaller than No. 200 sieve size)			
SILT AND CLAY Liquid limit less than 50%	▨	ML	Inorganic silt; sandy silt or gravelly silt with slight plasticity
	▨	CL	Inorganic clay of low plasticity; lean clay, sandy clay, gravelly clay
	▨	OL	Organic silt and organic clay of low plasticity
SILT AND CLAY Liquid limit 50% or greater	▨	MH	Inorganic silt of high plasticity, elastic silt
	▨	CH	Inorganic clay of high plasticity, fat clay
	▨	OH	Organic silt and organic clay of high plasticity
HIGHLY ORGANIC SOIL	▨	PT	Peat and other highly organic soil

OTHER MATERIAL SYMBOLS

■ Topsoil	□ Void	▨ Sandstone
▨ Asphalt	▨ Glacial Till	▨ Siltstone
▨ Base	■ Coal	▨ Limestone
▨ Concrete	▤ Shale	▨ Fill

LABORATORY CLASSIFICATION CRITERIA

GW	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with PI greater than 7	
SW	$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for SW	
SM	Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
SC	Atterberg limits above "A" line with PI greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent....................................GW, GP, SW, SP
More than 12 percent.................................GM, GC, SM, SC
5 to 12 percent..........................Cases requiring dual symbols

- SP-SM or SW-SM (SAND with Silt or SAND with Silt and Gravel)
- SP-SC or SW-SC (SAND with Clay or SAND with Clay and Gravel)
- GP-GM or GW-GM (GRAVEL with Silt or GRAVEL with Silt and Sand)
- GP-GC or GW-GC (GRAVEL with Clay or GRAVEL with Clay and Sand)

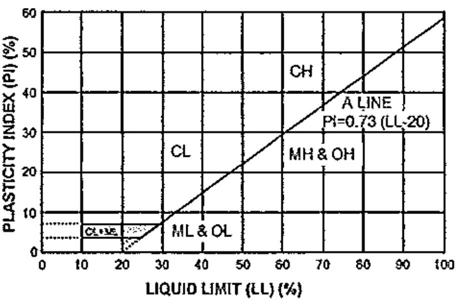
If the fines are CL-ML:

- SC-SM (SILTY CLAYEY SAND or SILTY CLAYEY SAND with Gravel)
- SM-SC (CLAYEY SILTY SAND or CLAYEY SILTY SAND with Gravel)
- GC-GM (SILTY CLAYEY GRAVEL or SILTY CLAYEY GRAVEL with Sand)
- GM-GC (CLAYEY SILTY GRAVEL or CLAYEY SILTY GRAVEL with Sand)

PARTICLE SIZES

Boulders		- Greater than 12 inches
Cobbles		- 3 inches to 12 inches
Gravel-	Coarse	- 3/4 inches to 3 inches
	Fine	- No. 4 to 3/4 inches
Sand-	Coarse	- No. 10 to No. 4
	Medium	- No. 40 to No. 10
	Fine	- No. 200 to No. 40
Silt and Clay		- Less than (0.0074 mm)

PLASTICITY CHART



VISUAL MANUAL PROCEDURE

When laboratory tests are not performed to confirm the classification of soils exhibiting borderline classifications, the two possible classifications would be separated with a slash, as follows:

For soils where it is difficult to distinguish if it is a coarse or fine-grained soil:

- SC/CL (CLAYEY SAND to Sandy LEAN CLAY)
- SM/ML (SILTY SAND to Sandy SILT)
- GC/CL (CLAYEY GRAVEL to Gravelly LEAN CLAY)
- GM/ML (SILTY GRAVEL to Gravelly SILT)

For soils where it is difficult to distinguish if it is sand or gravel, poorly or well-graded sand or gravel; silt or clay; or plastic or non-plastic silt or clay:

- SP/GP or SW/GW (SAND with Gravel to GRAVEL with Sand)
- SC/GC (CLAYEY SAND with Gravel to CLAYEY GRAVEL with Sand)
- SM/GM (SILTY SAND with Gravel to SILTY GRAVEL with Sand)
- SW/SP (SAND or SAND with Gravel)
- GP/GW (GRAVEL or GRAVEL with Sand)
- SC/SM (CLAYEY to SILTY SAND)
- GM/GC (SILTY to CLAYEY GRAVEL)
- CL/ML (SILTY CLAY)
- ML/CL (CLAYEY SILT)
- CH/MH (FAT CLAY to ELASTIC SILT)
- CL/CH (LEAN to FAT CLAY)
- MH/ML (ELASTIC SILT to SILT)
- OL/OH (ORGANIC SILT or ORGANIC CLAY)

DRILLING AND SAMPLING ABBREVIATIONS

2ST – Shelby Tube – 2" O.D.
3ST – Shelby Tube – 3" O.D.
AS – Auger Sample
GS – Grab Sample
LS – Liner Sample
NR – No Recovery
PM – Pressure Meter
RC – Rock Core diamond bit. NX size, except where noted
SB – Split Barrel Sample 1-3/8" I.D., 2" O.D., except where noted
VS – Vane Shear
WS – Wash Sample

OTHER ABBREVIATIONS

WOH – Weight of Hammer
WOR – Weight of Rods
SP – Soil Probe
PID – Photo Ionization Device
FID – Flame Ionization Device

DEPOSITIONAL FEATURES

Parting – as much as 1/16 inch thick
Seam – 1/16 inch to 1/2 inch thick
Layer – 1/2 inch to 12 inches thick
Stratum – greater than 12 inches thick
Pocket – deposit of limited lateral extent
Lens – lenticular deposit
Hardpan/Till – an unstratified, consolidated or cemented mixture of clay, silt, sand and/or gravel, the size/shape of the constituents vary widely
Lacustrine – soil deposited by lake water
Mottled – soil irregularly marked with spots of different colors that vary in number and size
Varved – alternating partings or seams of silt and/or clay
Occasional – one or less per foot of thickness
Frequent – more than one per foot of thickness
Interbedded – strata of soil or beds of rock lying between or alternating with other strata of a different nature

CLASSIFICATION TERMINOLOGY AND CORRELATIONS

Cohesionless Soils

Relative Density	N-Value (Blows per foot)
Very Loose	0 to 4
Loose	4 to 10
Medium Dense	10 to 30
Dense	30 to 50
Very Dense	50 to 80
Extremely Dense	Over 80

Cohesive Soils

Consistency	N-Value (Blows per foot)	Undrained Shear Strength (kips/ft^2)
Very Soft	0 - 2	0.25 or less
Soft	2 - 4	0.25 to 0.50
Medium	4 - 8	0.50 to 1.0
Stiff	8 - 15	1.0 to 2.0
Very Stiff	15 - 30	2.0 to 4.0
Hard	> 30	4.0 or greater

Standard Penetration 'N-Value' = Blows per foot of a 140-pound hammer falling 30 inches on a 2-inch O.D. split barrel sampler, except where noted.

soil and materials engineers, inc.

GEOTECHNICAL NOTES

Drilling and Sampling Symbols

SS – Split-Spoon 1-3/8" I.D., 2" O.D. except where noted
LS – Liner Sample
AS – Power Auger Sample
2ST – Shelby Tube – 2" O.D.
3ST – Shelby Tube – 3" O.D.
PS – Piston Sample – 3" diameter
WS – Wash Sample
HA – Hand Auger Sample
BS – Bag or Bottle Sample
CS – Continuous Sample

NR – No Recovery
RC – Rock Core with diamond bit. NQ size, except where noted
RB – Rock Bit
VS – Vane Shear
PM – Pressuremeter
WOH – Weight of Hammer

SP – Soil Probe
PID – Photo Ionization Device
FID – Flame Ionization Device

Standard Penetration 'N' – Blows per foot of a 140-pound hammer falling 30 inches on a 2-inch O.D. split spoon, except where noted.

Particle Sizes

Boulders - Greater than 12 inches (305 mm)
Cobbles - 3 inches (76.2 mm) to 12 inches (305 mm)
Gravel-Coarse - 3/4 inches (19.05 mm) to 3 inches (76.2mm)
Fine - No. 4 (4.75 mm) to 3/4 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)

Depositional Features

Parting - as much as 1/16 inch (1.6 mm) thick
Seam - 1/16 inch (1.6 mm) to 1/2 inch (12.7 mm) thick
Layer - 1/2 inch (12.7 mm) to 12 (305 mm) inches thick
Stratum - greater than 12 inches (305 mm) thick
Pocket - small, erratic deposit of limited lateral extent
Lens - lenticular deposit
Varved - alternating seams or layers of silt and/or clay and sometimes fine sand
Occasional - one or less per foot (305 mm) of thickness
Frequent - more than one per foot (305 mm) of thickness
Interbedded - applied to strata of soil or beds of rock lying between or alternating with other strata of a different nature

Groundwater levels indicated on the boring log are the levels measured in the boring at the times indicated. The accurate determination of groundwater levels may not be possible with short term observations, especially in low permeability soils. The groundwater levels shown may fluctuate throughout the year with variation in precipitation, evaporation and runoff.

Classification

Cohesionless Soils (Blows per foot or 0.3 m)

Very Loose : 0 to 4
Loose : 5 to 9
Medium Dense : 10 to 29
Dense : 30 to 49
Very Dense : 50 to 80
Extremely Dense : Over 80

Cohesive Soils

Consistency	Shear Strength
Very Soft :	0.25 kips/ft^2 (12.0 kPa) or less
Soft :	0.25 to 0.49 kips/ft^2 (12.0 to 23.8 kPa)
Medium :	0.50 to 0.99 kips/ft^2 (23.9 to 47.7 kPa)
Stiff :	1.00 to 1.99 kips/ft^2 (47.8 to 95.6 kPa)
Very Stiff :	2.00 to 3.99 kips/ft^2 (95.7 to 191.3 kPa)
Hard :	4.00 kips/ft^2 (191.4 kPa) or greater

Soil Constituents

Trace : Less than 5%
Trace to Some : 5% to 12%
Some : 12% to 25%
Use Descriptor : 25% to 50%
(i.e., Silty, Clayey, etc.)

Soil description

If clay content sufficiently dominates soil properties, then clay becomes the primary noun with the other major soil constituent as modifier: i.e. silty clay. Other minor soil constituents may be added according to estimates of soil constituents present, i.e., silty clay, trace to some sand, trace gravel.