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GEOTECHNICAL EXPLORATION
PROPOSED STORAGE BUILDING AT THE WASTEWATER TREATMENT PLANT
SUPERIOR, WISCONSIN
CITY OF SUPERIOR WWTP
GME PROJECT NO. D-2543

GME CONSULTANTS, INC.
CONSULTING ENGINEERS
360 Garfield Avenue / Duluth, MN 55802
(218) 722-4323 / Fax (218) 722-9722

June 5, 1998

Mr. Dan Romans
Administrator
City of Superior WWTP
51 East First Street
Superior, Wisconsin

GME Project No. D-2543

RE: Geotechnical exploration for the proposed storage building at the wastewater treatment plant in Superior, Wisconsin

Dear Mr. Romans:

We are pleased to submit the results of our subsurface exploration for this project. This report is the work product defined in our proposal dated January 30, 1998.

We appreciate the opportunity to work with you on this project. If you have questions about this report, please contact me at (218) 722-4323.

Sincerely,

GME CONSULTANTS, INC.

David L. Aspie, P.E.
Project Engineer

DLA:lkr

cc: Mr. Richard Anthony, P.E. - RMA Engineering Co.

WILLIAM C. KWASNY, P.E.
ERIC M. EDLUND

MARK D. MILLSOP
SANDRA J. FORREST

THOMAS PAUL VENEMA, P.E.
DAVID L. ASPIE, P.E.

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INTRODUCTION

Following your written acceptance of our proposal dated January 30, 1998, we have performed a subsurface exploration and geotechnical engineering review for this project. This report presents our findings, evaluations, and recommendations.

The City proposes construction of a storage building at the wastewater treatment plant site, which will be used to house vehicles and other equipment. The building will have a footprint of about 2,800 square feet. It has been planned for support on conventional spread footings, with cast-in-place concrete foundation walls and 4 foot high concrete knee walls. The building will have a gravel floor, near existing grade; a concrete slab or other pavement is not planned at this time. Because the building will not have an active ventilation system, a vapor barrier is proposed in the interior subgrade. The building will be heated in the winter to about 40° to 45°F.

The project Civil Engineer, Mr. Richard Anthony, P.E., of RMA Engineering Company, informed us that the column loads will be up to 40 kips under maximum snow loads, with wall loads of about 1 kip per lineal foot between columns.

The building will be constructed in a previously filled area. Mr. Anthony believes the fill was placed in the late 1970s, during the construction of the adjacent CSO#2 building and lagoon.

SCOPE OF WORK

As per our initial proposal and your authorization of additional testing, our work scope for this project was as follows:

1. Explore the subsurface conditions within the proposed building footprint by means of two Standard Penetration borings to 15 foot depth. Based on the results of the initial borings, we redrilled the second boring to 21 feet.
2. Perform pressuremeter testing in the additional boring to define the bearing capacity and settlement characteristics of the soils.
3. Prepare a geotechnical engineering report presenting the boring logs, a site plan showing the approximate boring locations, and our engineering opinions and recommendations regarding:
    - A. Soil correction to prepare the building pad for construction.
    - B. Appropriate foundation type.
    - C. Allowable soil bearing pressure for footing design, and estimated foundation settlements under the applied loads.
    - D. Building interior subgrade preparation.
    - E. Construction considerations related to foundations and earthwork.

EXPLORATION PROCEDURES

Mr. Anthony specified the number and locations of the initial two borings; we recommended the boring depths and the additional boring location. Our crew located the borings in the field by measuring distances from the scaled site plan provided. The approximate locations are shown on the Soil Boring Location Diagram in the Appendix.

Our crew shot surface elevations at the borings referenced to the top of the floor slab of the nearby CSO#2 screen building at the WWTP. Mr. Anthony informed us that the elevation of this benchmark is 609.0 feet NGVD.

We performed the field work on March 25 and April 27, 1998, with a CME 550 all-terrain drill rig. We drilled the borings using hollow stem augers fitted with a removable center plug. We sampled the soil in advance of the auger tip at 2 to 5 foot intervals of depth, in accordance with ASTM: D 1586, commonly referred to as the Standard Penetration Test. The N-value obtained from this test is an index of the relative density of cohesionless soils, and to a lesser extent, the consistency of cohesive and semi-cohesive soils.

The drill crew observed the boreholes for groundwater levels while drilling and after completion. They backfilled the borings with bentonite chips in accordance with NR141, Wisconsin Administrative Code; the borehole abandonment record is included in the Appendix.

The drill crew preliminarily classified the recovered soil samples in the field. Representative portions of the samples were sealed in jars and returned to our laboratory for further examination and classification, based on the Unified Soil Classification System.

Included in the Appendix are logs of the borings which indicate the depths and identification of the various soil strata, the N-values, water level information, and pertinent information regarding the method of maintaining and advancing the drill holes. Charts illustrating the soil classification procedure, the descriptive terminology and the symbols used on the boring logs are also included.

Our drill crew noted an oily appearance and apparent petroleum odor in soil samples from borings 7 and 8. We notified you on March 25, 1998, and discussed your statutory duty to report the discovery to the State of Wisconsin. On March 26, you advised us that you would make the necessary notifications.

We will keep the soil samples obtained from the borings for a period of one month from the date of this report. We will then discard them, unless you contact us and direct us to do otherwise.

PRESSUREMETER TESTING

We performed pressuremeter testing in boring 8A, following ASTM: 4179. As a brief description, the pressuremeter test consists of inserting an expandable cylindrical probe to the selected test depth. The probe is expanded in-place by means of fluid and gas pressure. The Geotechnical Engineer conducting the test records data on the applied pressure versus volumetric displacement, to develop a curve analogous to a stress-strain curve. From this plot, we can then calculate the allowable bearing capacity and settlement characteristics of the soil.

SITE CONDITIONS

The site is located at the wastewater treatment plant on Avenue E, along the northeast side of East Second Street in Superior, Wisconsin. The new building will be northwest of the CSO#2 screen building. The plant consists of an operations building with other equipment buildings, treatment buildings and lagoons. The site is on the southwest shore of Superior Bay of Lake Superior, and is mostly within a filled area of the bay. The ground surface is relatively flat, with a difference in elevation of less than 1 foot between our three borings.

The principal naturally-occurring soil type in this area is glacio-lacustrine clay deposited during the retreat of the Superior ice lobe of the Wisconsinan Glaciation. Large portions of the area along the shore of Superior Bay have been overlain with man-placed fill.

SUBSURFACE CONDITIONS

Soil Conditions

The subsurface conditions encountered at the boring locations are shown on the logs in the Appendix. The soil conditions have been established at our three test boring locations only. Variations in the soil stratigraphy probably occur between and around the borings, the nature and extent of which would not become evident until exposed by construction excavation.

We found sand fill overlying naturally-occurring red clay. The fill extended to a depth of about 19 feet, and contained occasional silt and clay lenses; we also found a few small wood pieces in the fill. Possible petroleum contamination was encountered at 9 to 11 feet in the borings. The N-values ranged from 2 to 12; the sand was loose to medium dense in boring 7, and loose to very loose in boring 8. It is our opinion that the sand fill was not uniformly compacted when it was placed. It has not densified appreciably under its own weight since placement.

The red clay was firm, with an N-value of 6, unconfined compressive strength (by hand penetrometer) of 0.9 tsf, and natural moisture content of 44%. The clay is of high plasticity.

Groundwater Conditions

We observed free groundwater in the three borings at depths of 4.5 to 6.4 feet, corresponding to elevations 601.4 to 603.1 feet. The water level at this site is directly related to the prevailing water level in Lake Superior, and will fluctuate as the lake level varies. The long-term average lake elevation is about 602 feet.

ENGINEERING REVIEW AND RECOMMENDATIONS

Discussion

The engineering recommendations made in this report are based on our understanding of the project as described in the Introduction. The recommendations are valid solely for the project we described. In the event that any changes in the nature, size, location, elevation, or design of the building are planned, the opinions and recommendations contained in this report shall not be considered valid unless we review the plans, and modify or verify the recommendations in writing.

Based on our interpretation of the soil boring data, it is our opinion that the storage building can be supported on conventional spread footing foundations bearing on the existing sand fill after the fill bearing stratum is compacted. Our analysis of the pressuremeter test data indicates that the fill is suitable to support the lightly loaded building, with proper base preparation.

We recommend that shallow footings be used with adequate thermal insulation for frost protection. Deeper footings with no added insulation also could be used; however, this likely would require extensive dewatering due to the shallow groundwater conditions, to allow footing construction in dry conditions.

Site Preparation

Vegetation and organic topsoil should be removed from the building pad plus an 8-foot wide perimeter strip. Most of the required excavation may be less than 1/2 foot, although localized areas would have to be excavated deeper if other unsuitable soils are encountered during construction. The exposed sand subgrade should be surface compacted using a heavy, smooth drum vibratory roller to densify upper loose zones and soils disturbed during stripping.

The soil under footings should be excavated to bottom of foundation elevation. The exposed sand fill should then be surface compacted with a heavy vibratory roller to at least 97% of the maximum Modified Proctor dry density (ASTM: D 1557).

Fill used to reach design subgrade elevation should consist of select granular material such as Wis/DOT 209 Grade 1 or 2. The fill should be placed in 8 to 10 inch loose lifts, and compacted to at least 95% of the maximum Modified Proctor dry density. Please refer to the notes in the Appendix concerning placement of compacted fill soils.

Foundation Recommendations

The building may be supported on conventional spread footing foundations, bearing on the densified sand fill at a depth of about 2 feet. The fill should be adequately surface compacted prior to footing construction, as described above. We recommend that adequate thermal insulation (vertical and horizontal) be installed outside the building to prevent frost penetration under the foundations.

The insulation should consist of a minimum 4 inch thickness of high quality extruded polystyrene board such as DOW 40 Brand High Load or CertiFoam 40. Beadboard should not be used for this purpose. The insulation should extend outward from the building a minimum distance of 8 feet, covered with a minimum of 1 foot of sand. The insulation should be placed nearly horizontal, with a slight slope to permit subsurface water drainage away from the building. The insulation also should be placed vertically against the exterior of the foundation wall, extending upward to the ground surface.

If there is a potential for the building to be unheated during the winter, the insulation should extend completely under the footings and 8 feet into the building interior.

Based on our pressuremeter data, we recommend that a maximum net allowable soil bearing pressure of 2,000 pounds per square foot be used for designing the footings supported on densified sand fill. This recommended soil bearing pressure would provide a theoretical factor of safety against bearing capacity failure in excess of 3.

The continuous strip footings under the bearing walls should be at least 24 inches wide; individual column footings should be at least 36 inches wide. The estimated total settlements for this design should be less than 1 inch, with differential settlement about half this amount, provided that the bearing soils are not frozen, wet, or disturbed at the time of construction. This settlement estimate is also predicated on any unsuitable fill found during excavation being removed and replaced with select compacted fill.

Foundation Backfill

The foundation excavations should be backfilled with the same type of granular fill used for the building pad. The backfill should be placed in 6 to 8 inch loose lifts, and uniformly compacted with manually-operated vibrating plate compactors to avoid damaging the foundation walls. The use of large vibrating equipment within 4 feet of the foundation walls should not be allowed. The backfill should be compacted to at least 95% of the maximum Modified Proctor dry density.

Interior Subgrade

The recommended site preparation should provide an adequate subgrade inside the building. However, the existing sand soils may rut considerably under traffic if a select gravel layer is not placed.

To provide an improved working surface, we recommend placing a minimum 10 inch thick lift of crushed aggregate base course, such as Wis/DOT 304.2.6 Gradation No. 3. The base course should be compacted to at least 95% of the maximum Modified Proctor dry density. The gravel layer thickness may have to be greater if large vehicles or heavy floor loads are to be applied.

Because of the shallow groundwater table and the lack of active ventilation in the building plans, you are concerned about excessive water vapor levels (humidity) in the building. We recommend that a vapor barrier covered be installed below the interior base course to retard (but not eliminate) the migration of water vapor upward into the building. The barrier should be covered with a minimum 3-inch sand cushion to reduce the potential for larger aggregate piercing the barrier.

The vapor barrier also may be designed to contain possible oil/gasoline spills from vehicles. The barrier would require an appropriate thickness and sealed seams, and should extend vertically upwards above the floor surface at the building walls.

CONSTRUCTION CONSIDERATIONS

Drainage and Groundwater

Good surface drainage should be maintained throughout the work so that water does not pond on the subgrade soils after rainfall or snow melt. For the recommended footing depths, groundwater infiltration into the excavations is not anticipated; water which enters the excavations from runoff or perched water infiltration should be promptly pumped out prior to fill placement and footing construction.

Environmental Considerations

At the storage building site, we recommend that the extent and magnitude of the apparent petroleum contamination be investigated in accordance with the requirements of the Wisconsin Department of Natural Resources. Soil and/or groundwater remediation may be needed prior to building construction. We would be pleased to assist the City in this investigation.

Winter Construction

If winter earthwork is contemplated, we recommend that special precautions be followed. Only unfrozen backfill should be used. Placement of fill and/or concrete must **not** be permitted on frozen soil, nor should the bearing soils under footings be allowed to freeze after concrete is placed, because excessive post-construction settlement could occur as the frozen soils thaw.

Construction Safety

All excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches." This document states that excavation safety is the sole responsibility of the contractor. Reference to this OSHA requirement should be included in the job specifications.

The responsibility to provide safe working conditions on the site, for earthwork, building construction, or any associated operations, is not borne in any manner by GME Consultants, Inc.

Field Observation and Testing

We recommend that a Geotechnical Engineer be retained to provide observation and testing of the subgrade and foundation base soils and fill compaction. We recommend that the testing consist of, but not be limited to, hand augering and Dynamic Cone Penetrometer (DCP) tests.

A representative number of field density tests should be taken by the nuclear or sand cone method in the densified existing fill and in new compacted fill, to aid in judging their suitability. The proposed fill soils should be submitted to a laboratory for gradation tests and Modified Proctor compaction tests.

We would be pleased to provide the necessary field observation, monitoring, and testing services.

GENERAL QUALIFICATIONS

We determined the soil and groundwater conditions for this project at three locations. The conditions which we describe and discuss in this report are pertinent only at the boring locations and under the environment at the time of our field exploration. Variations in the subsurface conditions were encountered, and it is probable that additional variations exist that would not become apparent until construction is started. This is especially possible in the existing fill. No warranty, express or implied, is presented in this report with respect to the soil and groundwater conditions at this site.

Since there are no records of inspection or testing during placement of the existing fill, it is possible that unsuitable materials are buried within the fill. It is important that the City recognize this fact, and that we cannot provide any guarantee or warranty regarding the uniformity of the fill soil.

STANDARD OF CARE

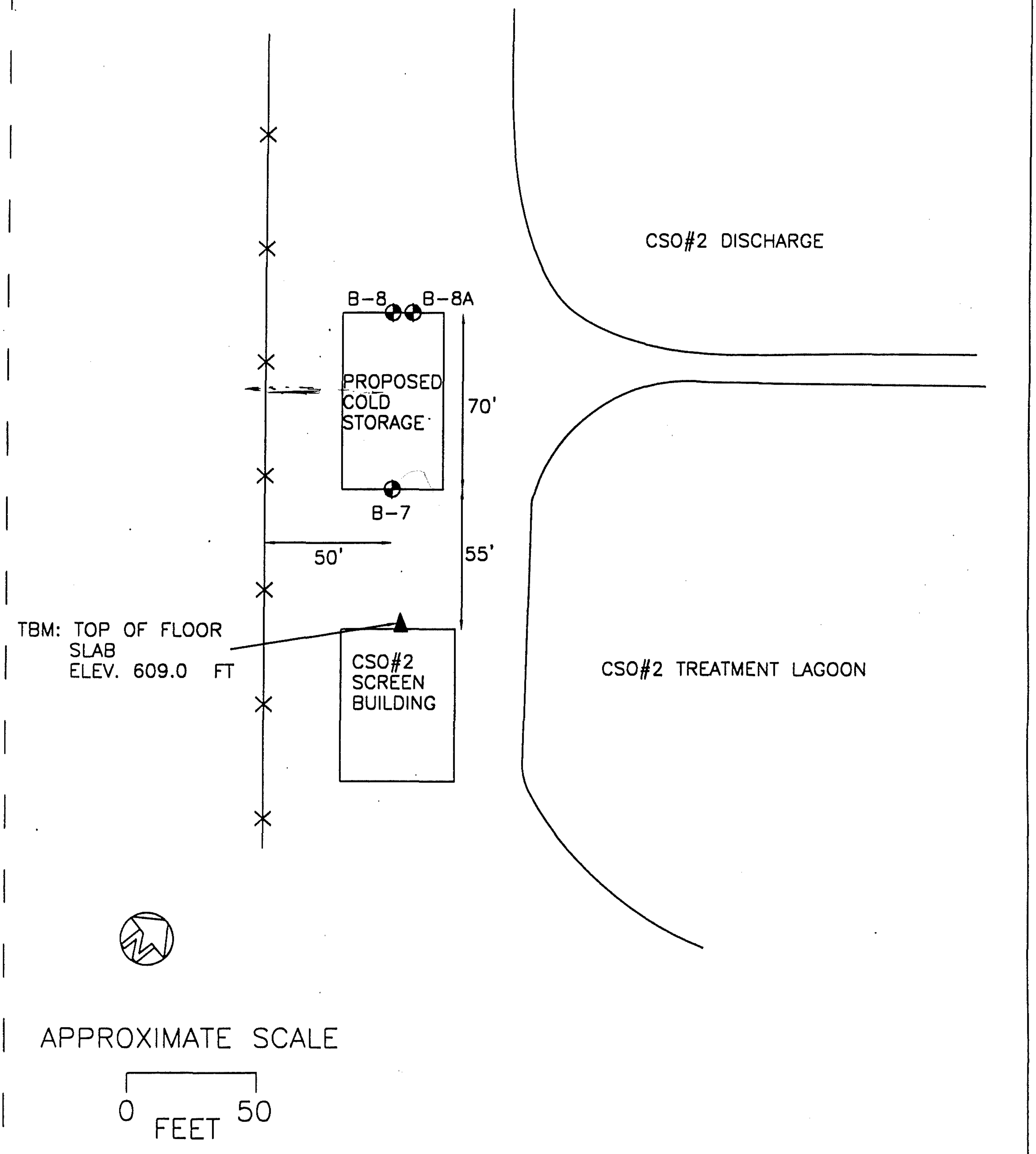
The opinions and recommendations contained in this report represent our professional judgement. The geotechnical engineering services performed for this project have been conducted in a manner consistent with that level of skill and care ordinarily exercised by other members of the profession currently practicing in this area under similar budgetary and time constraints. No other warranty, express or implied, is made.

WISCONSIN
DAVID L.
ASPIE
E-30188
DULUTH,
MINNESOTA
PROFESSIONAL ENGINEER

Prepared by:
David L. Aspie, P.E.
Project Engineer

Reviewed by: William C. Kwasny
William C. Kwasny, P.E.
President/Principal Engineer

DLA:WCK:lkr



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360 Garfield Avenue
Duluth, Minnesota 55802
(218)722-4323

SOIL BORING LOCATION DIAGRAM
PROPOSED COLD STORAGE
SUPERIOR WWTP
SUPERIOR, WISCONSIN

JRY	DLA	5/98	GME PROJECT NO. D-2543

APPENDIX

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SL : SS with Liner
SS : Split Spoon — 1⅜" I.D., 2" O.D., unless otherwise noted
ST : Shelby Tube — 2" O.D., unless otherwise noted
PA : Power Auger
DB : Diamond Bit — NX: BX: AX
AS : Auger Sample
JS : Jar Sample
VS : Vane Shear
OS : Osterberg Sampler — 3" Shelby Tube
HS : Hollow Stem Auger
WS : Wash Sample
FT : Fish Trail
RB : Rock Bit
BS : Bulk Sample
PM : Pressuremeter test — in situ

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL : Water Level
WCI : Wet Cave In
DCI : Dry Cave In
WS : While Sampling
WD : While Drilling
BCR : Before Casing Removal
ACR : After Casing Removal
AB : After Boring

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In previous soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible in even several days observation, and additional evidence of ground water elevations must be sought.

GRADATION DESCRIPTION & TERMINOLOGY

Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are described as: clays or clayey silts if they are cohesive, and silts if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their strength or consistency, and their plasticity.

Major Component Of Sample	**Size Range**	**Descriptive Term(s) (Of Components Also Present in Sample)**	**Percent of Dry Weight**
Boulders	Over 8 in. (200mm)	Trace	1 — 9
Cobbles	8 in. to 3 in. (200mm to 75mm)	Little	10 — 19
Gravel	3 in. to #4 sieve (75mm to 2mm)	Some	20 — 34
Sand	#4 to #200 sieve (2mm to .074mm)	And	35 — 50
Silt	Passing #200 sieve (0.074mm to 0.005mm)		
Clay	Smaller than 0.005mm		

CONSISTENCY OF COHESIVE SOILS:

Unconfined Comp. Strength, Qu, tsf	**Consistency**
< 0.25	Very Soft
0.25 — 0.49	Soft
0.50 — 0.99	Medium (Firm)
1.00 — 1.99	Stiff
2.00 — 3.99	Very Stiff
4.00 — 8.00	Hard
> 8.00	Very Hard

RELATIVE DENSITY OF GRANULAR SOILS:

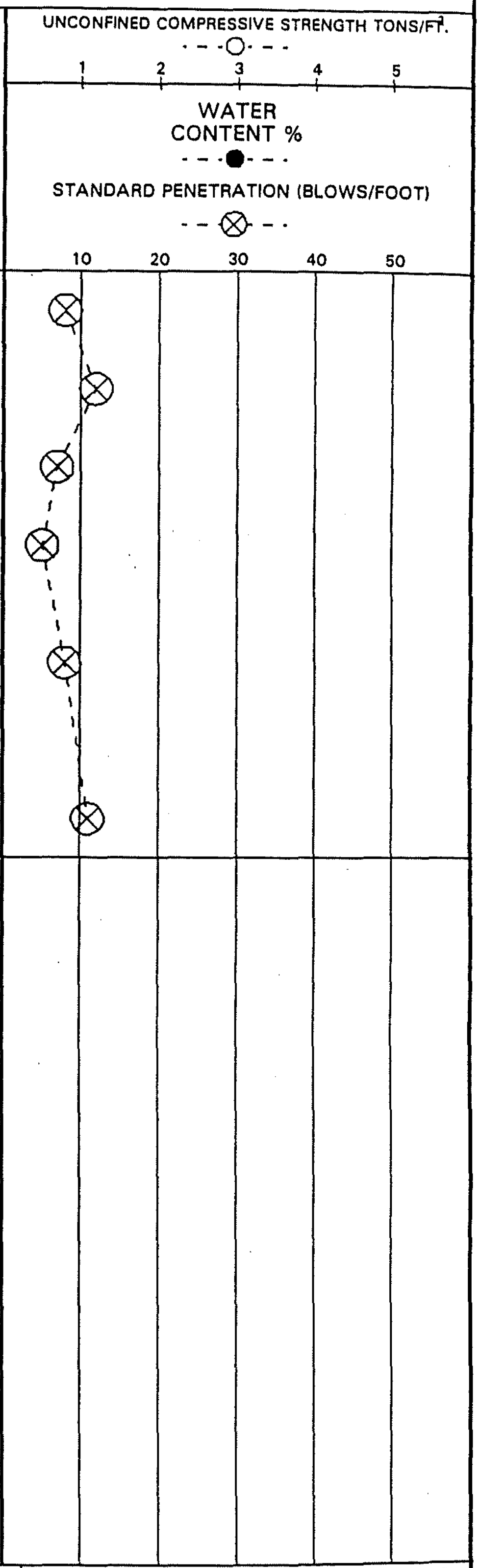
N — Blows/ft.	**Relative Density**
0 — 3	Very Loose
4 — 9	Loose
10 — 29	Medium Dense
30 — 49	Dense
50 — 80	Very Dense
80 +	Extremely Dense

LOG OF BORING B- 7

PROJECT Proposed Cold Storage Building	SITE Superior, Wisconsin
CLIENT City of Superior WWTP	ARCHITECT-ENGINEER

SURFACE ELEVATION 608.4

DEPTH, FEET	SAMPLE NUMBER AND TYPE	WATER LEVEL	STRATA CHANGE, FEET	DESCRIPTION OF MATERIAL	SPECIAL TEST RESULTS	N-VALUE (BLOWS/FT.)
	1SS			Brown fine SAND, silt lenses, scattered roots at 0.2 feet and 4 to 6 feet, trace wood at 6.4, oily sand 9 to 11 feet - loose to medium dense - moist to wet - (SP) (FILL)		8
	2SS					12
5	3SS					7
	4SS	▽ ▼				5
10	5SS					8
	6SS					11
15			15.0			
				End of boring at 15 feet Hollow stem auger used full depth Borehole backfilled with bentonite chips		



WATER LEVEL OBSERVATIONS

W.L. ▽ 6.4 feet while drilling
W.L. ▼ 8 feet after casing removal
W.L.

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(218) 722-4323

BORING STARTED	3/25/98		
BORING COMPLETED	3/25/98		
RIG	CME 550	DRILLER	TEA
DRAWN	TGL	APPROVED	DLA
JOB #	D-2543	SHEET	1 of 1

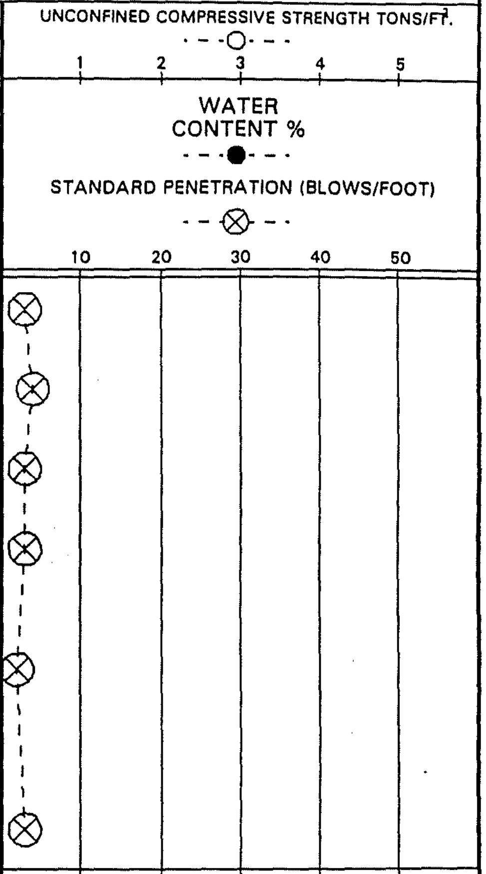
The stratification lines represent approximate boundaries between soil types; insitu the transition may be gradual.

LOG OF BORING B- 8

PROJECT Proposed Cold Storage Building	SITE Superior, Wisconsin
CLIENT City of Superior WWTP	ARCHITECT-ENGINEER

SURFACE ELEVATION 607.6

DEPTH, FEET	SAMPLE NUMBER AND TYPE	WATER LEVEL	STRATA CHANGE, FEET	DESCRIPTION OF MATERIAL	SPECIAL TEST RESULTS	N-VALUE (BLOWS/FT.)
	1SS		0.2	Brown fine SILTY SAND, roots, grass - very loose - moist - (SM) (Topsoil)		3
	2SS			Brown fine to medium SAND, scattered silt lenses, trace wood 4 to 6 feet and 13 to 15 feet, oily sand 9 to 11 feet, sandy clay lens at 13.4 feet - very loose to loose - moist to wet - (SP) (FILL)		4
5	3SS					3
	4SS	▽ ▼				3
10	5SS					2
	6SS					3
15			15.0	End of boring at 15 feet Hollow stem auger used full depth Borehole backfilled with bentonite chips		



WATER LEVEL OBSERVATIONS

W.L. ▽ 6.3 feet while drilling

W.L. ▼ 7 feet after casing removal

W.L.

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BORING STARTED	3/25/98		
BORING COMPLETED	3/25/98		
RIG	CME 550	DRILLER	TEA
DRAWN	TGL	APPROVED	DLA
JOB #	D-2543	SHEET	1 of 1

The stratification lines represent approximate boundaries between soil types; insitu the transition may be gradual.

LOG OF BORING B-8A

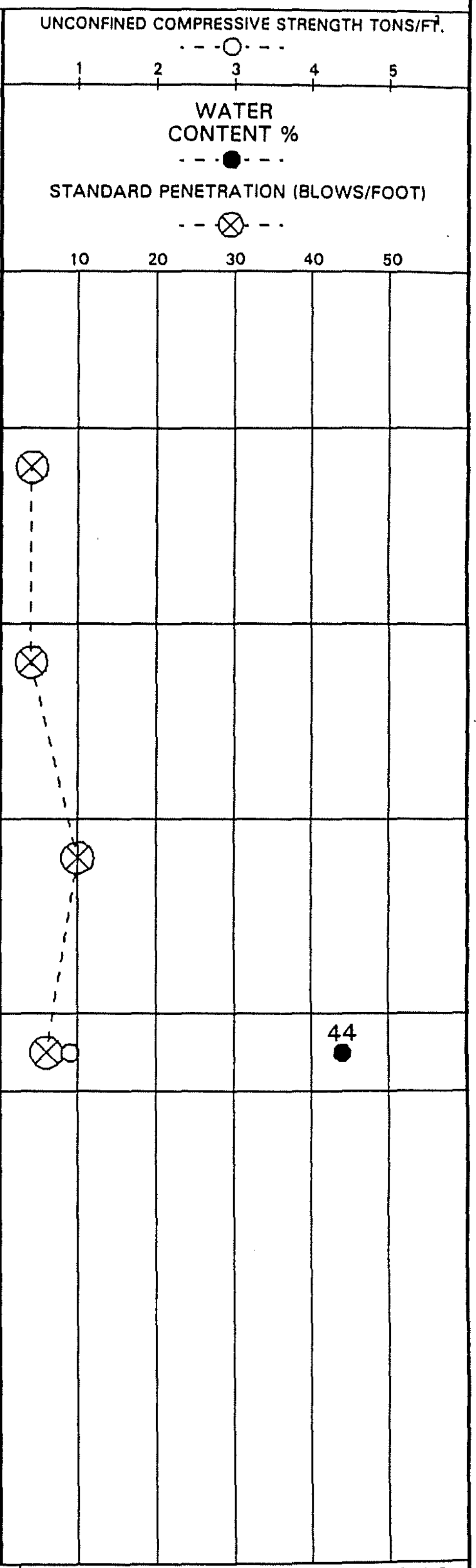
PROJECT
Proposed Cold Storage Building

SITE
Superior, Wisconsin

CLIENT
City of Superior WWTP

ARCHITECT-ENGINEER

DEPTH, FEET	SAMPLE NUMBER AND TYPE	WATER LEVEL	STRATA CHANGE, FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 607.6	SPECIAL TEST RESULTS	N-VALUE (BLOWS/FT.)
			4.0	Not sampled		
5	1SS	▽	9.0	Brown fine SAND, trace silt, coal, small wood pieces - loose - moist to wet - (SP) (FILL)		4
10	2SS		14.0	Black fine SAND, trace silt, moderate creosote odor - loose - wet - (SP) (FILL)		4
15	3SS		19.0	Brown fine SAND, trace silt - medium dense - wet - (SP) (FILL)		10
20	4SS		21.0	Red brown CLAY, scattered thin silt lenses, trace sand - firm - (CH)		6
				End of boring at 21 feet Hollow stem auger used full depth Borehole backfilled with bentonite chips		



WATER LEVEL OBSERVATIONS

W.L. ▽ 4.5 feet while drilling
W.L.
W.L.

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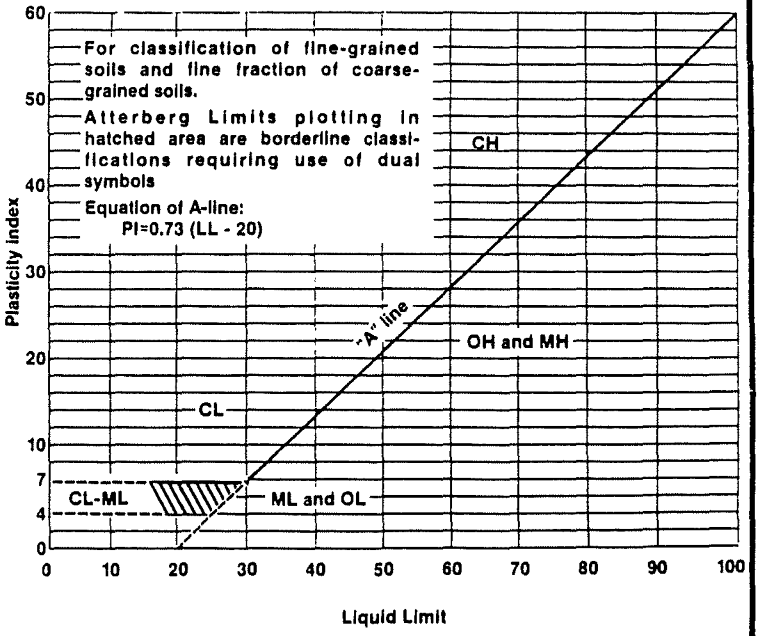
BORING STARTED	4/27/98		
BORING COMPLETED	4/27/98		
RIG	CME 550	DRILLER	TEA
DRAWN	TGL	APPROVED	DLA
JOB #	D-2543	SHEET	1 of 1

The stratification lines represent approximate boundaries between soil types; insitu the transition may be gradual.

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

(ASTM: D 2487 and 2488)

Major divisions			Group symbols		Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravels (More than half of corase fraction larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	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 per cent .... GW, GP, SW, SP More than 12 per cent .... GM, GC, SM, SC 5 to 12 per cent .... *Borderline* cases requiring dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} X D_{60}}$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM	d	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 *are borderline* cases requiring use of dual symbols
				u				
			GC		Clayey gravels, gravel-sand-clay mixtures		Atterberg limits below "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} X D_{60}}$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	d	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 *are borderline* cases requiring use of dual symbols.
				u				
			SC		Clayey sands, sand-clay mixtures		Atterberg limits below "A" line or P.I. greater than 7	
Fine-grained soils More than half of material is *smaller* than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity			
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
Highl organic soils			Pt		Peat and other highly organic soil			

For classification of fine-grained soils and fine fraction of coarse-grained soils.

Atterberg Limits plotting in hatched area are borderline classifications requiring use of dual symbols

Equation of A-line:
PI=0.73 (LL - 20)

Plasticity Chart