Geotechnical Engineering Report

Proposed Froedtert Clinic
Waukesha, Wisconsin
February 4, 2019
Terracon Project No. 58195002

Prepared for:
Froedtert & the Medical College of Wisconsin
Milwaukee, WI

Prepared by:
Terracon Consultants, Inc.
Franklin, Wisconsin

February 4, 2019

Froedtert & the Medical College of Wisconsin
9200 West Wisconsin Avenue
Milwaukee, WI 53226

Attn: Mr. Myles Multhauf, Project Manager
P: 414-805-9113
E: myles.multhauf@froedtert.com

Re: Geotechnical Engineering Report
Proposed Froedtert Clinic
SWC of W. St. Paul Avenue and Sunset Drive
Waukesha, Wisconsin
Terracon Project No. 58195002

Dear Mr. Multhauf:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P58195002 dated January 4, 2019. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, pavements and ponds for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Paul J. Koszarek, P.E.
Department Manager-Geotechnical Services

Paul A. Tarvin, P.E.
Regional Geotechnical Manager

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

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Proposed Froedtert Clinic
SWC of W. St. Paul Avenue and Sunset Drive
Waukesha, Wisconsin
Terracon Project No. 58195002
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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Froedtert Clinic to be located on the SWC of W. St. Paul Avenue and Sunset Drive in Waukesha, Wisconsin. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Dewatering considerations
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification per IBC
- Pavement design and construction
- Stormwater pond considerations

The geotechnical engineering Scope of Services for this project included the advancement of 10 test borings to depths ranging from approximately 15 to 22 feet below existing site grades. Several of the borings were terminated at shallower than planned depths on assumed cobbles or boulders.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at the SWC of W. St. Paul Avenue and Sunset Drive in Waukesha, Wisconsin. The site Latitude and Longitude is 42.98795 and -88.26828, respectively. See **Site Location**

Item	Description
Existing Improvements	Currently the site is mostly a vacant field with the exception of the eastern edge of the property where a paved frontage road is located. However, it should be noted that in the past, the site contained at least 4 residential homes and associated outbuildings. These houses are no longer present on the site. The extent of removal of the previous foundations, basement walls or slabs, nor the method used to backfill these structures, if any, is not known at this time.
Current Ground Cover	A majority of the site has bare soil with the exception of the asphalt paved frontage road running along the east side of the property.
Existing Topography	Slopes downward significantly from northwest to southeast. Elevations in the northwest portion of the site are near 825 feet, while the elevations within the southeast portion of the site are near 805 feet.
Geology	The bedrock elevation within the vicinity of this site is reported to be greater than 50 feet below existing grade, based on the Waukesha County Depth to Bedrock map published by Wisconsin Geological and Natural History Survey, 2004.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	A site plan showing the planned site layout and requested boring locations. Follow up information included the current topographic survey for the site and discussion regarding the planned finished floor elevation for the building
Project Description	It is understood that the project is planned to include a 5,000 square foot, single story slab on grade clinic located within the northeast corner of the site. Pavements will be constructed to the south and west of the new clinic. Two storm water ponds are planned along the east edge of the site, to the south of the main parking area. Future Expansion It is possible that in the future, the building may be expanded to the west.
Finished Floor Elevation	The finished floor elevation is yet to be determined at the time of this report. At this time, elevation 818 feet or 815 feet are being contemplated.
Maximum Loads	Maximum column loads are anticipated to be 250 kips Maximum wall loads are anticipated to be 6 kips/lf Maximum floor slab load is anticipated to be 150psf.

Item	Description
Grading/Slopes	Cuts on the order of 8 feet are anticipated along the western portion of the site. Within the building pad, it is anticipated that fills on the order of 4 to 7 feet will be required to attain a finished floor elevation of 718 feet.
Below-Grade Structures	Not Planned for this structure
Free-Standing Retaining Walls	Retaining walls may be required on portions of the west side of the site; however, the actual location, height and type of walls have not been finalized by the time of this report. Depending on the height of the new walls, additional soil borings and supplemental recommendations may be required.
Pavements	At grade pavements (assumed to be asphalt) will be constructed to the south and west of the new building. It is likely that cuts and fills will be on the order of 5 to 10 feet. We assume flexible (asphalt) pavement sections will be considered. Anticipated traffic is light-duty as follows (these values must be verified by the civil engineer prior to finalization of the pavement section): ■ Autos/light trucks: 100 vehicles per day ■ Light delivery and trash collection vehicles: 10 vehicles per week ■ Ambulances: 10 per day (5 trips/day) ■ Tractor-trailer trucks: <1 vehicle per week ■ Front End Loader used for snow removal (anticipated on non-frozen subgrades 2 weeks in November, December, March and 2 weeks in April)-January and February would be considered to have frozen subgrade soils. The pavement design period is 20 years.
Estimated Start of Construction	Spring/Summer 2019

GEOTECHNICAL CHARACTERIZATION

Based on the soil boring data within the planned building pad, the generalized soil profile below the upper pavement and topsoil consists generally of clayey soils over sandy soils. The clay soils were dark brown or brown and in a stiff to very stiff condition. These soils were typically observed within the upper 3.5 to 6 feet of the soil profile at borings B-2 and B-5. Below the clay at these borings or below the surficial topsoil or pavements at the remaining borings, the soils were typically observed to be clayey or silty sand with varying amounts of gravel. The sandy soils were typically observed to be loose to very dense with a majority of the sandy soils being loose to medium dense.

An exception was observed at boring B-3 where possible fill soils were observed in the upper 6 feet of the soil profile. These soils were underlain by sandy silt in a medium dense condition.

Sandy silt, in a medium dense condition, was also observed below the native silty sand materials at boring B-4.

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Topsoil**	11 to 15 inches
2	**Lean Clay**	Stiff to very stiff. Hand penetrometers vary from 1.0 tsf to 2.0 tsf.
3	**Sand/Silt/Silty Sand/Clayey Sand**	Very loose to very dense. Cobbles and boulders were observed at deeper depths. Mostly in a moist condition with the exception of borings B-2, B-7 through B-10 where wet sandy soils were observed below a depth of 6 to 15 feet.
4	**Existing Fill/Possible Fill**	Typically, granular, silty sand or clayey sand. At B-3, a trace of wood was observed in the sample from 3.5 to 5 feet below ground surface.

The geotechnical characterization forms the basis of our geotechnical calculations and evaluation of site preparation, foundation and pavement options. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results**, and are summarized below.

Boring Number	Highest Approximate Depth to Groundwater while Drilling or after Drilling (feet) [1]	Elevation of Observed Water Level (feet) [1]
B-2	8.5	810
B-7	6	817
B-8	6	810
B-9	14	793
B-10	16	788

1. Below ground surface

Groundwater was not observed in the remaining borings while drilling, or for the short duration the borings could remain open. However, this does not necessarily mean the borings terminated above groundwater, or the water levels summarized above are stable groundwater levels. Due to the low permeability of the soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

In general, the borings encountered native soils directly under the topsoil or pavements, with the exception of borings B-3 and B-8. At these borings, possible fill and existing fills were observed. Boring B-3 is located within the planned building pad while boring B-8 is located in the proposed pavements. The existing fill soils were generally comprised of sandy soils, which in some cases contained wood. These existing fill or possible fill soils are not considered suitable for foundation support. However, the existing fills and possible fills, if prepared in accordance with the Site Preparation section, and the owner assumes the slight risk of experiencing greater than typical differential settlements, could also be used to support the new floor slab and pavements.

The existing fill soils should be suitable for construction of the pavements provided the owner is willing to assume the slight risk of experiencing greater than typical differential settlements due to the variable and undocumented nature of these soils. The existing fill soils are not considered suitable for foundation support. The native sandy soils are generally suitable for construction of the foundations once they have been recompacted after being excavated and dewatered. Additional recommendations have been provided in the **Site Preparation** section.

Water levels were observed as shallow as elevation 810 feet within the building pad. In order to maintain stability of the sandy soils, they should be dewatered so that the water levels are at least 2 feet lower than the lowest planned depth of excavation.

The **Shallow Foundations** section addresses support of the building foundations bearing on native loose to medium dense sand or engineered fill. The **Floor Slabs** section addresses slab-on-grade support of the building.

A flexible pavement system and a rigid pavement system are recommended for this site. The **Pavements** section addresses the design of pavement systems.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Site Preparation

It is not known if the former building foundations, slabs or walls were completely removed. Therefore, if there are remnants of the former buildings still below grade, then it is recommended that full removal of all foundations, walls and slabs be completed from within the planned building area. Existing foundations and/or walls may remain in place if the structure is not in conflict with new foundations or utilities, and if the top of the concrete is at least 2 feet below the planned bottom of slab or bottom of pavement section. Existing utilities that extended into the former buildings should be rerouted or abandoned in place using grout. Inspection of the soils underlying the former buildings by a representative of the geotechnical engineer should occur prior to backfilling the building.

Prior to placing fill, existing vegetation and root mat should be removed. Complete stripping of the topsoil should be performed in the proposed building and parking/driveway areas. The existing asphalt pavement and underlying base course materials, as well as the curbs, should be removed to expose the underlying soils.

Where feasible, the subgrade should be proof-rolled with an adequately loaded vehicle such as a 20-ton dump truck. The proof-rolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proof-roll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or modified by partial overexcavation and replacement with engineered fill as recommended by the geotechnical engineer. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted.

Existing Fill

As noted in **Geotechnical Characterization**, borings B-3 and B-8 encountered existing fill and possible fill to depths ranging from about 3.5 to 6 feet. A majority of the fill appears to have been placed in a controlled manner (exceptions include presence of wood), but we have no records to indicate the degree of control. Support of floor slabs and pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by following the recommendations contained in this report.

If the owner elects to construct the new floor slabs and pavements on the existing fill, the following protocol should be followed. Once the planned subgrade elevation has been reached the entire pavement area should be proof-rolled. Areas of soft, or otherwise unsuitable material should be undercut and replaced with either new structural fill or suitable, existing on site materials.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 10 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas. Earthen materials used for structural and general fill should meet the following material property requirements:

Soil Type [1]	USCS Classification	Acceptable Location for Placement	Maximum Lift Thickness (in.)
General [1]	SP (fines content < 5%)	All locations and elevations	6 to 9 [3]
	SP-SM (fines content between 5 and 12%)	All locations and elevations, except strict moisture control will be required during placement, particularly during the rainy season.	6 to 9 [2]
Limited	SM, SC (fines content >12%)	Limited to mass fill greater than 2 feet below final grade; strict moisture control will be required during placement.	6 to 9 [3]
Severely Limited	CH, CL, MH, ML	Not recommended for this site	n/a

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris.
2. Loose thickness when heavy compaction equipment is used in vibratory mode. Lift thickness should be decreased if static compaction is being used, typically to no more than 6 inches, and the required compaction must still be achieved. Use 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is required.
3. Static equipment should be used.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill
Minimum Compaction Requirements [1]	95 percent of the maximum modified Proctor dry density (ASTM D 1557).
Moisture Content [2]	Within ±3 percent of the optimum moisture content as determined by the modified Proctor test at the time of placement and compaction. Slightly higher or lower moisture contents may be acceptable for sand and silty sand soils.
Minimum Testing Frequency	One field density test per 2,000 square feet within the building and 5,000 square feet within the pavement area or fraction thereof per 1-foot lift.

Item	Structural Fill

1. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5% slope away from the building for at least 10 feet beyond the perimeter. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

After initial proofrolling and compaction, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become desiccated, saturated, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and re-compacted prior to floor slab and pavement construction.

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency stated in **Earthwork**.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer’s evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing pressure [1, 2]	3,000 psf (foundations bearing within structural fill)
Required Bearing Stratum [3]	Native medium dense sandy soils or newly placed and compacted engineered fill
Minimum Foundation Dimensions	Columns: 30 inches Continuous: 18 inches

Item	Description	
Minimum Embedment below Finished Grade [4]	Exterior footings in unheated areas: Exterior footings in heated areas: Interior footings in heated areas:	60 inches 48 inches 18 inches
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch	
Estimated Differential Settlement [2, 5]	About 2/3 of total settlement	

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in **Project Description**.
3. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork**.
4. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
5. Differential settlements are as measured over a span of 50 feet.

Foundation Construction Considerations

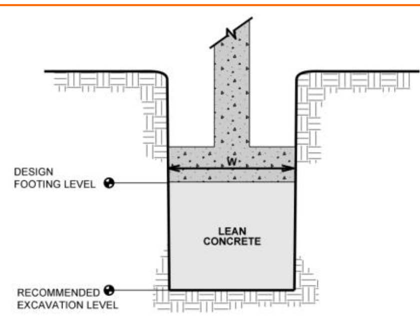
Based on the two finished floor elevations being considered for this project (818 feet or 815 feet), it is anticipated that the planned bottom of exterior footing would be 4 feet below the planned finished floor elevation. We recommend that the foundation excavations extend through the overlying clay soils to the native granular soils below. Therefore, based on the soil boring information, it should be anticipated that the following undercuts below bottom of footing may be necessary in order to expose suitable bearing soils:

Boring Number	Anticipated Undercut Depth Below Planned BOFE of 814 feet	Anticipated Undercut Depth Below Planned BOFE of 811 feet
B-1	0	0
B-2	1.5	0[1]
B-3	5	2
B-4	0[2]	0[2]
B-5	0	3.5

1. May require dewatering to lower water table to a depth of at least 2 feet below the planned bottom of footing
2. Anticipated that the asphalt and base course would be stripped and newly placed and compacted engineered fill placed up to bottom of footing grade

As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

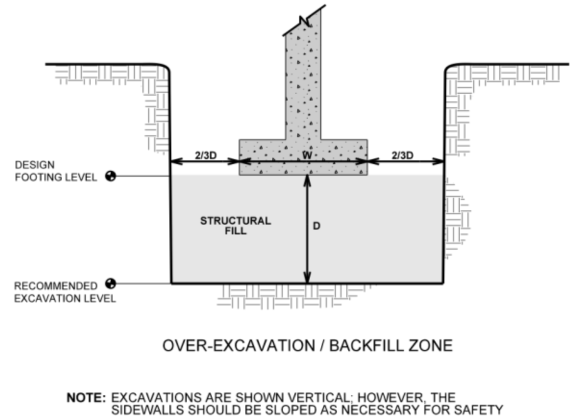
If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below.



LEAN CONCRETE BACKFILL

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with describe soil type placed, as recommended in the **Earthwork** section.



SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7-10 and the International Building Code (IBC). Based on the soil/bedrock properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Classification is D**. Subsurface explorations at this site were extended to a maximum depth of 22 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

FLOOR SLABS

Depending upon the finished floor elevation, unsuitable, weak, soft to medium stiff soils may be encountered at the floor slab subgrade level. These soils should be replaced with structural fill, so the floor slab is supported on at least 2 feet of compacted suitable natural soils or structural fill.

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support [1]	Minimum 6 inches of free-draining (less than 5% passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 92% of ASTM D 1557 [2, 3] Newly compacted engineered fill, or native sandy or clayey soils that have been prepared in accordance with the **Earthwork** section and tested/approved by Terracon
Estimated Modulus of Subgrade Reaction [2]	125 pci can be used at the top of the compacted granular leveling course (110 pci can be used for design without the compacted granular level course)

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.
3. Free-draining granular material should have less than 5% fines (material passing the No. 200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Settlement of floor slabs supported on existing fill materials cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, as noted in **Existing Fill** within **Earthwork**, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams and/or post-tensioned elements.

Floor Slab Construction Considerations

On most project sites, the site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed by utility excavations, construction traffic, desiccation, rainfall, etc. As a result, corrective action may be required prior to placement of the granular leveling course and concrete.

Terracon should review the condition of the floor slab subgrades immediately prior to placement of the granular leveling course and construction of the slabs. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by scarification/compaction or by removing the affected material and replacing it with engineered fill.

PAVEMENTS

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the **Earthwork** section.

Support characteristics of subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade, such as soils encountered on this project. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade.

Pavement Design Parameters

Design of pavements for the project is based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993).

The following design parameters are based on the Standards and were utilized for pavement thickness design.

Design Criteria	Value
Pavement Classification	Light Duty
Estimated Growth Factor Percentage	0
Calculated ESAL – Flexible	112,000
Calculated ESAL – Rigid	115,300

Local drainage characteristics of proposed pavements areas are considered to vary from poor to fair. For purposes of this design analysis, poor drainage characteristics are considered to control the design. These characteristics, coupled with the approximate duration of saturated subgrade conditions, result in a design drainage coefficient of 1.0 when applying the AASHTO criteria for design.

Pavement Thickness Design Parameters		
Input Parameter	**Flexible (asphalt)**	**Rigid (concrete)**
Reliability	85%	85%
Serviceability Loss	2.5	2.5
Standard Deviation	0.44	0.34
Asphalt Layer Coefficient	0.44	N/A
Aggregate Base Coefficient	0.14 (crushed limestone)	N/A
Concrete Elastic Modulus(Ec)	N/A	3,600,000 psi
Concrete Modulus of Rupture (S'c)	N/A	580 psi
Load Transfer Coefficient (J)	N/A	3.6 [1]

1. The Load Transfer Coefficient value provided is based on jointed plain concrete pavement with doweled longitudinal and expansion joints at a spacing interval no greater than 15 feet. Also, doweled into the concrete curb and gutter.

Pavement Section Thicknesses

The following tables provide options for AC and PCC Sections:

Asphaltic Concrete Design			
Layer	**Thickness (inches)**		
	Light Duty [1]	**Med. Duty**	**Heavy Duty**
AC [2]	4	n/a	n/a
Aggregate Base[3]	9	n/a	n/a

1. Surface course, WisDOT Specifications for No. 4 (12.5 mm) Hot Mix Asphalt (HMA)
2. Binder course, WisDOT Specifications for No. 3 (19.0 mm) HMA
3. The base course aggregate beneath the new pavement should conform to the 1-1/4-inch Dense Graded Base, Crushed Stone, listed in Section 305 of the WisDOT Standard Specifications (current edition). Crushed gravel would require 3 additional inches due the reduced structural number of this material.

Portland Cement Concrete Design			
Layer	Thickness (inches)		
	Light Duty [1]	Med. Duty [1]	Dumpster Pad [3]
PCC [2]	6	n/a	6
Aggregate base [3]	6	n/a	6

1. Portland cement concrete pavements are recommended for roadways and areas subjected to repeated truck traffic, truck turning areas, and trash container pads. Trash container pads should be large enough to support the container and the tipping axle of the trash collection vehicle.
2. The base course aggregate beneath the new pavement should conform to the 1-1/4-inch Dense Graded Base, Crushed Stone, listed in Section 305 of the WisDOT Standard Specifications (current edition).

A subgrade CBR of 3 was used for the AC pavement designs. This was based on the possibility of clay being present within the upper 3 feet of the soil profile. Clay was observed near the surface at borings B-6 and B-7. If it is possible and not cost prohibitive to remove any clay soils that are located within the top 3 feet and not allow clay soils to be placed as fill within the upper 3 feet of the subgrade, then a ½ inch of asphalt and 1 inch of base course could be removed from the recommended pavement section.

A modulus of subgrade reaction of 125 pci was used for the PCC pavement designs. The values were empirically derived based upon our experience with the described subgrade soils and our understanding of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in **Earthwork**.

The estimated pavement sections provided in this report are minimums for the assumed design criteria, and as such, periodic maintenance should be expected. Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e. concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles. A maintenance program including surface sealing, joint cleaning and sealing, and timely repair of cracks and deteriorated areas will increase the pavement's service life. As an option, thicker sections could be constructed to decrease future maintenance.

Concrete for rigid pavements should have a minimum 28-day compressive strength of 4,000 psi and be placed with a maximum slump of 4 inches. Although not required for structural support, a minimum 6-inch thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are edge drains connected to the storm water collection system, longitudinal subdrains, or other suitable outlet and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Dishing in parking lots surfaced with ACC is usually observed in frequently-used parking stalls (such as near the front of buildings) and occurs under the wheel footprint in these stalls. The use of higher-grade asphaltic cement, or surfacing these areas with PCC, should be considered. The dishing is exacerbated by factors such as irrigated islands or planter areas, sheet surface drainage to the front of structures, and placing the ACC directly on a compacted clay subgrade.

Rigid PCC pavements will perform better than ACC in areas where short-radii turning, and braking are expected (i.e. entrance/exit aprons) due to better resistance to rutting and shoving. In addition, PCC pavement will perform better in areas subject to large or sustained loads. An adequate number of longitudinal and transverse control joints should be placed in the rigid pavement in accordance with ACI and/or AASHTO requirements. Expansion (isolation) joints must be full depth and should only be used to isolate fixed objects abutting or within the paved area.

Pavement Drainage

The pavement sections provided above are based on no significant increase in the moisture content of the subgrade soils. Paved areas should be sloped to provide rapid drainage of surface water and to drain water away from the pavement edges. Water should not be allowed to accumulate on or adjacent to the pavement, since this could saturate and soften the subgrade soils and subsequently accelerate pavement deterioration. Periodic maintenance of the pavements will be required. Cracks should be sealed, and areas exhibiting distress should be repaired promptly to help prevent further deterioration.

We recommend pavement subgrades be crowned at least 2 percent, to promote the flow of water toward subdrains or a suitable daylight. Pavement edges should include a designed curb and gutter system to facilitate the collection of runoff or incorporate edge drains.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install below pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

STORM WATER MANAGEMENT

Storm water management facilities are governed by the Wisconsin Department of Natural Resources Conservation Practice Standard 1002 (Site Evaluation for Storm Water Infiltration). For this project, the subsurface soils at the site were variable, consisting of Clay and Loamy Sand. However, based on the colorization and mottling of the soils, the seasonal high groundwater level in the pond area was only 1 to 2 feet below existing grade. Based on this, the infiltration requirement is exempt per NR 151.12(5)(c)5.e. and NR 151.12(5)(c)5.i. The following sections outline our recommendations for the proposed storm water management facility planned for this development.

Based on the presence of granular soils within the planned pond area and infiltration not being feasible due to the close proximity of the seasonal high groundwater level to the existing ground surface, it is recommended that the ponds be constructed with a clay liner and used as a wet pond. To build the pond liner, a minimum 2-foot thick layer of engineered clay fill should be constructed. The on-site lean clays should be suitable for use as a clay liner. Clay fill materials used for liner construction should be processed to be free of clods greater than about 1 inch in size and placed in horizontal lifts of 9 inches or less in loose thickness. Each lift should be compacted to at least 95% of the standard Proctor dry density (ASTM D698), or the minimum degree required to achieve the specified maximum permeability recommended below. The liner material should be uniformly moisture conditioned at the time of compaction within 0 to +4% of the optimum moisture content as determined by the standard Proctor test. The pond side slopes should be no steeper than 3H:1V.

The completed earthen liner should be protected from desiccation and cracking prior to filling the pond. If the liner becomes dry, desiccated, or cracked prior to filling or during the life of the pond, the clay liner should be scarified, moisture conditioned, and recompacted.

The clay liner should typically have a coefficient of permeability of less than or equal to $1x10^{-7}$ cm/sec. On-site or imported clay fill materials used for liner construction should have a liquid limit of 45 or less and a plasticity index of at least 15. We recommend that potential import materials be evaluated by conducting laboratory permeability tests prior to bringing the material on-site. The existing site soils are anticipated to meet the above-mentioned criteria, although some moisture conditioning will be required.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet) [1]	Planned Location
3	14 to 22 feet	Building Pad
2	20[2]	Ponds
2	15 to 20	Pavements (anticipating up to 11 feet of cut)
2	20	Future Building Expansion
1	14	Pavement (SWC)

1. Below ground surface.
2. Continuous Sampling

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±20 feet) and approximate elevations were obtained by interpolation from the topographic survey provided to Terracon on 1-28-19 and dated 12-11-18. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advanced the borings with a track-mounted ATV-mounted rotary drill rig using continuous flight augers (hollow stem). At boring locations B-1 to B-8, four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter until boring termination. At borings B-9 and B-10, samples were obtained continuously. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, were indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with bentonite chips after their completion. Pavements were patched with cold-mix asphalt and/or pre-mixed concrete, as appropriate.

The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a geotechnical engineer. Our exploration team prepares field boring logs as part of the drilling operations. These field logs include visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil and rock strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

The laboratory testing program included examination of soil samples by an engineer. Based on the texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

SITE LOCATION

Proposed Froedtert Clinic ■ Waukesha, Wisconsin

February 4, 2019 ■ Terracon Project No. 58195002

Terracon GeoReport

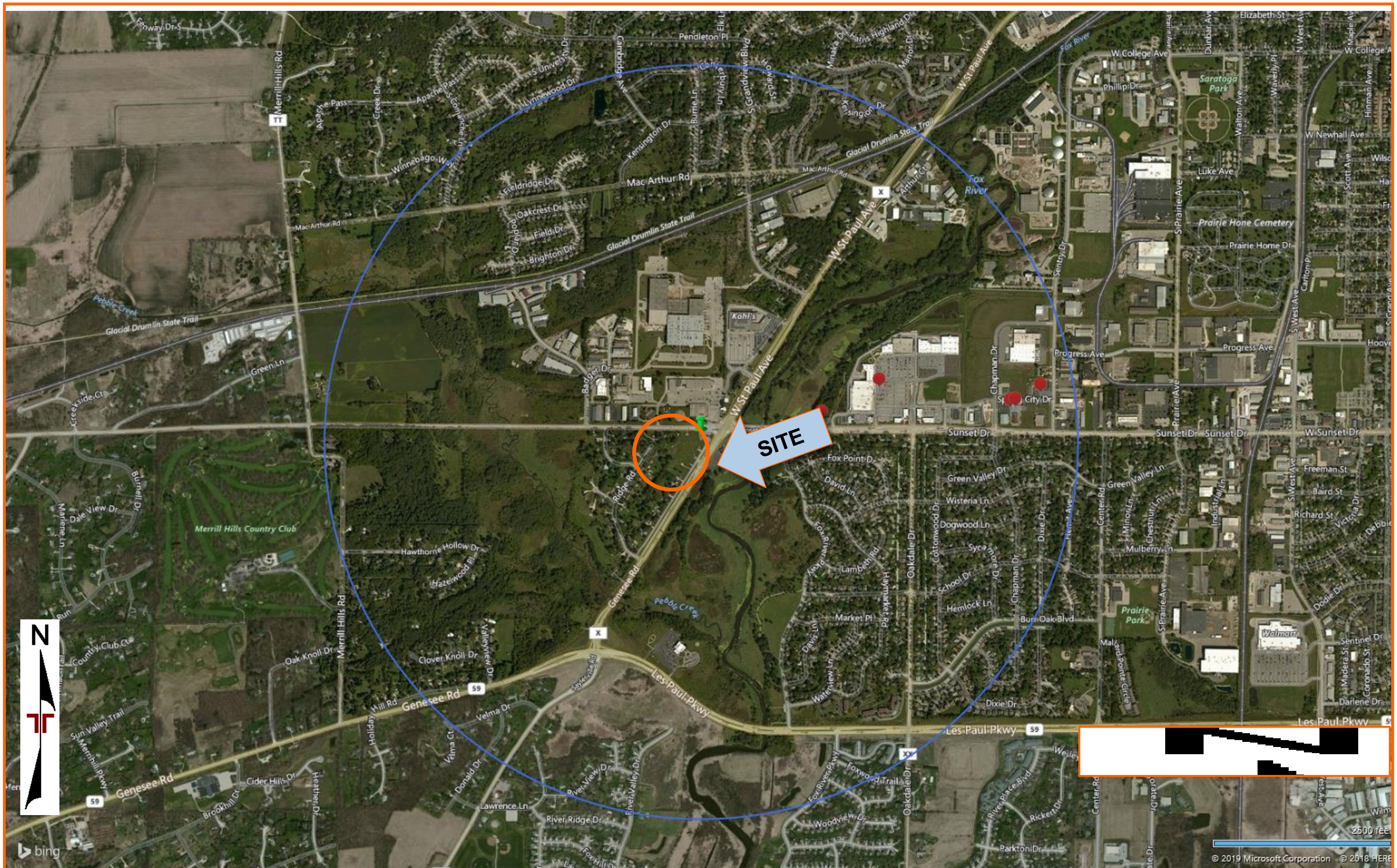


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Proposed Froedtert Clinic ■ Waukesha, Wisconsin
February 4, 2019 ■ Terracon Project No. 58195002

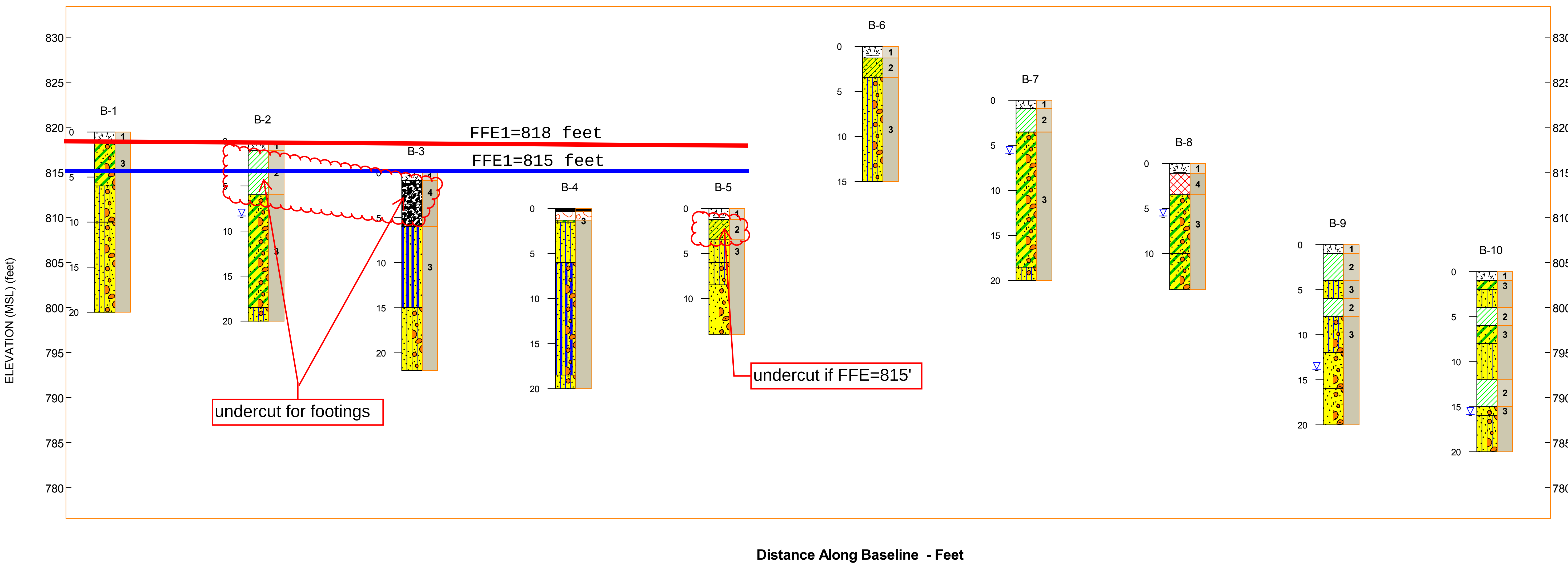
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

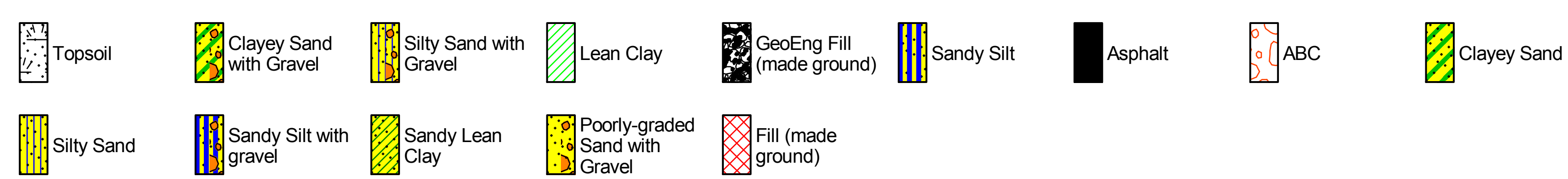
MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

GEOTECHNICAL MODEL
Proposed Froedtert Clinic ■ Waukesha, wi
1/31/2019 ■ Terracon Project No. 58195002

Terracon GeoReport





Model Layer	Termed	General Description
1	**Topsoil**	Typically 11 to 15 inches
2	**Lean Clay**	Typically stiff to very stiff. Hand penetrometers vary from 1.0 tsf to 2.0 tsf.
3	**Sand/Silt/Silty Sand/Clayey Sand**	Typically very loose to very dense. Cobbles and boulders were observed at deeper depths. Mostly in a moist condition with the exception of borings B-2, B-7 through B-10 where wet sandy soils were observed below a depth of 6 to 15 feet.
4	**Existing Fill/Possible Fill**	Typically granular, silty sand or clayey sand. At B-3, a trace of wood was observed in the sample from 3.5 to 5 feet below ground surface.

NOTES:
See boring logs for more detailed conditions specific to each boring.
GeoModel provided for illustration purposes only. Actual subsurface conditions between borings will vary.

Layering shown on this figure has been developed by the geotechnical engineer for purposes of characterization of subsurface conditions as required for the subsequent geotechnical engineering for this project.

LEGEND
- First Water Observation
- Second Water Observation
- Final Water Observation

BORING LOG NO. B-1

PROJECT: Proposed Froedtert Clinic

CLIENT: Froedtert Memorial Lutheran Hospital Milwaukee, WI

SITE: West St. Paul Avenue & Sunset Drive Waukesha, WI

LOCATION See Exploration Plan

Latitude: 42.9882° Longitude: -88.2684°

Surface Elev.: 819.5 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	1.0	**TOPSOIL**, (12" thick)	818.5
3	6.0	**CLAYEY SAND WITH GRAVEL (SC)**, trace silt, fine to medium grained, brown, very moist, very loose to loose	813.5
3	10.0	**SILTY SAND WITH GRAVEL (SM)**, trace clay, fine to medium grained, brown, moist, medium dense	809.5
3	20.0	**SILTY SAND WITH GRAVEL (SM)**, trace cobbles/boulders, fine to medium grained, brown and gray, moist, very dense	799.5
		Boring Terminated at 20 Feet	

SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
X	6	2-2-2 N=4	1.5 (HP)	12
X	6	3-3-2 N=5		10
X		4-5-5 N=10		
X		4-9-14 N=23		8
X		22-50/5" N=50/5"		7
X		20-50/2" N= 50/2"		7

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed.

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-2

PROJECT: Proposed Froedtert Clinic

CLIENT: Froedtert Memorial Lutheran Hospital Milwaukee, WI

SITE: West St. Paul Avenue & Sunset Drive Waukesha, WI

LOCATION See Exploration Plan

Latitude: 42.9881° Longitude: -88.2686°

Surface Elev.: 818.5 (Ft.)

GRAPHIC LOG	MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
	1	1.1	**TOPSOIL**, (13" thick)	817.5							
	2		**LEAN CLAY (CL)**, trace sand and gravel, dark brown, very stiff				X	10	1-3-3 N=6	2.0 (HP)	18
					5		X	4	2-3-4 N=7		15
		6.0		812.5							
	3		**CLAYEY SAND WITH GRAVEL (SC)**, trace silt, fine to medium grained, brown, very moist to wet, medium dense				X	1	7-8-5 N=13		14
						▽					
					10		X	8	1-4-2 N=6		11
							X	1	50/2" N= 50/2"		11
					15						
		18.5		800							
	3		**SILTY SAND WITH GRAVEL (SM)**, trace cobbles and boulders, fine to medium grained, brown, moist, very dense				X	1	50/1" N= 50/1"		7
		20.0		798.5	20						
			Boring Terminated at 20 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 8.5' while drilling.*

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-3

PROJECT: Proposed Froedtert Clinic

**CLIENT: Froedtert Memorial Lutheran Hospital
Milwaukee, WI**

**SITE: West St. Paul Avenue & Sunset Drive
Waukesha, WI**

LOCATION See Exploration Plan

Latitude: 42.988° Longitude: -88.2683°

Surface Elev.: 815 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	0.9	**TOPSOIL**, (11" thick)	814
4	3.5	**SILTY SAND**, fine to medium grained, brown, moist, very loose, POSSIBLE FILL	811.5
4	6.0	**SILTY SAND WITH GRAVEL**, trace wood, fine to medium grained, brown, loose, POSSIBLE FILL	809
3	15.0	**SANDY SILT (ML)**, trace gravel and clay, light brown, moist, medium dense, Trace cobbles at 13.5 feet.	800
3	22.0	**SILTY SAND WITH GRAVEL (SM)**, trace cobbles, fine to medium grained, gray, moist, very dense	793

Auger Refusal on probable cobbles and boulders at 22 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
1-2.5		X	14	2-1-1 N=2		12
3.5-5		X	12	5-3-3 N=6		12
6-7.5		X	6	4-11-14 N=25		9
8.5-10		X	10	4-7-7 N=14		9
13.5-15		X	2	13-6-5 N=11		9
18.5		X	1	50/4" N=50/4"		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

Auger refusal at 22 feet on probable cobbles and boulders.

WATER LEVEL OBSERVATIONS

No water observed.

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-4

PROJECT: Proposed Froedtert Clinic

**CLIENT: Froedtert Memorial Lutheran Hospital
Milwaukee, WI**

**SITE: West St. Paul Avenue & Sunset Drive
Waukesha, WI**

LOCATION See Exploration Plan

Latitude: 42.9881° Longitude: -88.268°

Surface Elev.: 811 (Ft.)

MODEL LAYER	DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)
	0.3	**ASPHALT**, (3.5" thick)	810.5
	1.3	**AGGREGATE BASE COURSE**, (13.5" thick)	809.5
3	1.5	**CLAYEY SAND (SC)**, fine to medium grained, dark brown, moist, loose	809.5
3	6.0	**SILTY SAND (SM)**, fine to medium grained, dark brown, moist, loose to medium dense	805
3	18.5	**SANDY SILT WITH GRAVEL (ML)**, trace clay, light brown, medium dense	792.5
3	20.0	**SILTY SAND WITH GRAVEL (SM)**, fine to medium grained, brown, moist, medium dense	791
		Boring Terminated at 20 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
1-2.5		X	12	4-4-5 N=9		10
3.5-5		X	10	6-8-12 N=20		7
6-7.5		X	4	9-11-11 N=22		8
8.5-10		X	12	5-8-12 N=20		9
13.5-15		X	4	7-6-7 N=13		10
18.5-20		X	10	7-6-7 N=13		10

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed.

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-5

PROJECT: Proposed Froedtert Clinic

CLIENT: Froedtert Memorial Lutheran Hospital Milwaukee, WI

SITE: West St. Paul Avenue & Sunset Drive Waukesha, WI

LOCATION See Exploration Plan

Latitude: 42.9879° Longitude: -88.2682°

Surface Elev.: 811 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	SAMPLE DEPTH (Ft.)	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
1	1.2	**TOPSOIL**, (14" thick)	810					
2	3.5	**SANDY LEAN CLAY (CL)**, trace gravel, dark brown, stiff	807.5		8	2-2-1 N=3	1.0 (HP)	18
3	6.0	**SILTY SAND (SM)**, fine to medium grained, brown, moist, very loose	805		12	2-2-2 N=4		11
3	8.5	**SILTY SAND WITH GRAVEL (SM)**, fine to medium grained, brown, moist, dense	802.5		4	8-16-22 N=38		4
3	14.0	**SAND WITH GRAVEL (SP)**, trace silt, medium grained, brown, moist, dense to very dense	797		12	15-15-20 N=35		5
						50/1" N=50/1"		

Auger Refusal on probable cobbles and boulders at 14 Feet

Depth scale: 5, 10

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

Auger Refusal at 14 feet on probable cobbles and boulders.

WATER LEVEL OBSERVATIONS

No water observed.

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-6

PROJECT: Proposed Froedtert Clinic

CLIENT: Froedtert Memorial Lutheran Hospital Milwaukee, WI

SITE: West St. Paul Avenue & Sunset Drive Waukesha, WI

LOCATION See Exploration Plan

Latitude: 42.988° Longitude: -88.2694°

Surface Elev.: 829 (Ft.)

MODEL LAYER	DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
1	1.3	**TOPSOIL**, (15" thick)	827.5							
2		**SANDY LEAN CLAY (CL)**, trace gravel, dark brown, medium stiff				X	10	2-3-6 N=9		15
	3.5		825.5							
3		**SILTY SAND WITH GRAVEL (SM)**, trace cobbles, fine to medium grained, moist, medium dense				X	2	12-12-11 N=23		10
				5						
						X	2	12-5-15 N=20		
						X		18-50/3" N=18-50/3"		
				10						
						X		29-30-50/1" N=30-50/1"		
	15.0		814	15						
		Auger Refusal on probable cobbles and boulders at 15 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:
Auger refusal at 15 feet on probable cobbles and boulders.

WATER LEVEL OBSERVATIONS

No water observed.

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-7

PROJECT: Proposed Froedtert Clinic

CLIENT: Froedtert Memorial Lutheran Hospital
Milwaukee, WI

SITE: West St. Paul Avenue & Sunset Drive
Waukesha, WI

LOCATION See Exploration Plan

Latitude: 42.9879° Longitude: -88.2691°

Surface Elev.: 823 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	0.9	**TOPSOIL**, (11" thick)	822
2	3.5	**LEAN CLAY (CL)**, trace sand and gravel, dark brown, stiff	819.5
3	18.5	**CLAYEY SAND WITH GRAVEL (SC)**, trace silt, trace cobbles, fine to medium grained, brown, very moist to wet, very dense to medium dense	804.5
3	20.0	**SILTY SAND WITH GRAVEL (SM)**, trace cobbles and boulders, fine to medium grained, brown, moist, very dense	803
		Boring Terminated at 20 Feet	

DEPTH (Ft.) (approx.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
1–2.5		X	8	2-2-7 N=9		16
3.5–5		X	8	2-10-50/1" N=10-50/1"		9
6	▽					
6–7.5		X	14	2-2-3 N=5		10
8.5–10		X	10	6-8-10 N=18		10
13.5		X		50/2" N= 50/2"		7
18.5–20		X	6	18-30-50/2" N= 30-50/2"		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 6' while drilling.*

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-8

PROJECT: Proposed Froedtert Clinic

**CLIENT: Froedtert Memorial Lutheran Hospital
Milwaukee, WI**

**SITE: West St. Paul Avenue & Sunset Drive
Waukesha, WI**

LOCATION See Exploration Plan

Latitude: 42.9873° Longitude: -88.2697°

Surface Elev.: 816 (Ft.)

GRAPHIC LOG	MODEL LAYER	DEPTH / DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
	1	**TOPSOIL**, (13" thick) — 1.1	815							
	4	**FILL - CLAYEY SAND WITH GRAVEL**, fine to medium grained, dark brown, moist, medium dense				X	4	8-8-4 N=12		10
		3.5	812.5							
	3	**CLAYEY SAND WITH GRAVEL (SC)**, fine to medium grained, brown with rust mottling, very moist to wet, medium dense to loose				X	10	7-8-8 N=16		8
				5	▽	X	10	11-3-4 N=7		10
						X	6	3-10-16 N=26		13
		10.0	806	10						
	3	**CLAYEY SAND WITH GRAVEL (SC)**, trace cobbles and boulders, fine to medium grained, brown with rust mottling, wet								
		14.0	802			X		50/3" N= 50/3"		
		Auger Refusal on probable cobbles and boulders at 14 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:
Auger Refusal at 14 feet on probable cobbles and boulders.

WATER LEVEL OBSERVATIONS

▽ *Water observed at 6' while drilling.*

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-9

PROJECT: Proposed Froedtert Clinic

CLIENT: Froedtert Memorial Lutheran Hospital
Milwaukee, WI

SITE: West St. Paul Avenue & Sunset Drive
Waukesha, WI

LOCATION See Exploration Plan

Latitude: 42.9875° Longitude: -88.2685°

Surface Elev.: 807 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
1	1.0	**TOPSOIL**, (12" thick)	806			14	2-2-2 N=4		17
2	4.0	**LEAN CLAY (CL)**, trace sand and gravel, dark brown with rust mottling, stiff	803			16	2-2-1 N=3	1.0 (HP)	21
3	6.0	**SILTY SAND (SM)**, fine to medium grained, brown, moist, very loose	801	5		16	1-3-4 N=7		11
2	8.0	**LEAN CLAY (CL)**, brown with gray mottling	799			6	4-7-13 N=20	2.0 (HP)	16
3	12.0	**SILTY SAND WITH GRAVEL (SM)**, trace cobbles, light brown, moist	795	10		6	22-20-50/3" N= 20-50/3"		4
						10	21-22-22 N=44		4
3	16.0	**SAND WITH GRAVEL (SP)**, medium to coarse grained, brown with rust mottling, moist to wet, medium dense to very dense	791		▽ (14')	10	8-9-16 N=25		4
				15		8	8-10-11 N=21		14
3	20.0	**SAND WITH GRAVEL (SP)**, fine to medium grained, brown, wet, very dense	787			4	50/3" N= 50/3"		19
						8	10-50/4" N=10-50/4"		19
		Boring Terminated at 20 Feet		20					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 14' while drilling.*

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

BORING LOG NO. B-10

PROJECT: Proposed Froedtert Clinic

CLIENT: Froedtert Memorial Lutheran Hospital Milwaukee, WI

SITE: West St. Paul Avenue & Sunset Drive Waukesha, WI

LOCATION See Exploration Plan

Latitude: 42.9872° Longitude: -88.2687°

Surface Elev.: 804 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)
1	1.0	**TOPSOIL**, (12" thick)	803		X	14	4-2-4 N=6		12
3	2.0	**CLAYEY SAND (SC)**, fine grained, dark brown, moist, very loose	802						
3	4.0	**SILTY SAND (SM)**, trace clay, fine to medium grained, dark brown with rust mottling, very moist, very loose	800		X	16	3-1-1 N=2		13
2	6.0	**LEAN CLAY (CL)**, trace sand, dark brown with rust mottling, medium stiff	798		X	16	2-1-2 N=3		18
3	8.0	**CLAYEY SAND (SC)**, trace silt, fine to medium grained, gray with rust mottling, moist, medium dense	796		X	18	4-7-7 N=14		13
3	12.0	**SILTY SAND (SM)**, brown with rust mottling, loose to medium dense	792		X X	10 16	2-1-6 N=7 2-6-9 N=15		10 10
2	15.0	**LEAN CLAY (CL)**, light brown, stiff	789		X X	18 14	6-5-7 N=12 3-14-50/4" N=14-50/4"	1.5 (HP) 2.0 (HP)	21 25
3	16.0	**SAND WITH GRAVEL (SP)**, trace cobbles, medium grained, moist, very dense, Trace wet silt laminations.	788	▽					
3	20.0	**SILTY SAND WITH GRAVEL (SM)**, brown, very moist to wet, dense	784		X X	14 12	11-17-22 N=39 15-17-14 N=31		6 8
		Boring Terminated at 20 Feet							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
2 1/4" HSA

Abandonment Method:
Boring backfilled with bentonite upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 16' while drilling.*

Terracon
9856 S 57th St
Franklin, WI

Boring Started: 01-11-2019	Boring Completed: 01-11-2019
Drill Rig: 7866DT	Driller: MS/PTS
Project No.: 58195002	

SUPPORTING INFORMATION

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING		WATER LEVEL		FIELD TESTS	
Auger	Split Spoon	Water Initially Encountered		(HP)	Hand Penetrometer
Shelby Tube	Macro Core	Water Level After a Specified Period of Time		(T)	Torvane
Ring Sampler	Rock Core	Water Level After a Specified Period of Time		(b/f)	Standard Penetration Test (blows per foot)
Grab Sample	No Recovery	Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.		(PID)	Photo-Ionization Detector
				(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

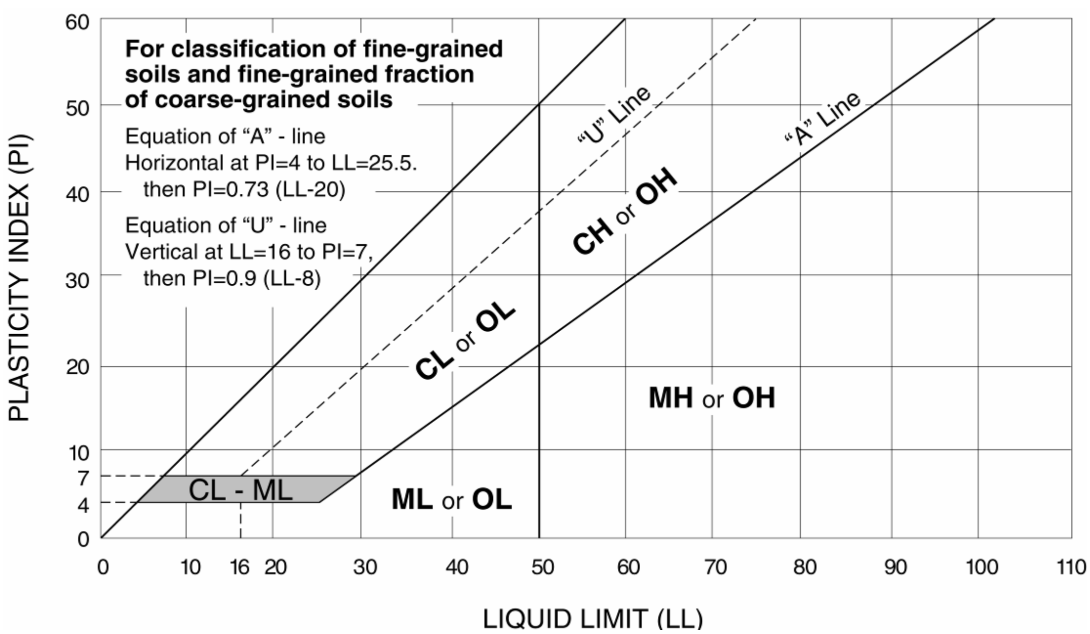
Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	**Group Name** [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	$PI > 7$ and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			$PI < 4$ or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay
[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains $\geq$ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains $\geq$ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains $\geq$ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] $PI \geq 4$ and plots on or above "A" line.
[O] $PI < 4$ or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Terracon