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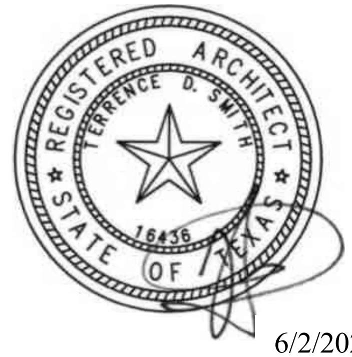

6/2/2021

ADDENDUM NO. 3

DATE: June 3, 2021

PROJECT: SMSD AG Barn

LOCATION: 1633 Staffordshire Rd. Stafford, Texas 77477.
PROJECT NO. N090120

DISTRIBUTION:
DELIVERED VIA: Download

NO. PAGES: see attached

PREPARED BY: Smith & Company Architects, Inc

This addendum form is a part of the Specifications for the New SMSD AG Barn project #N090120 for the Stafford Municipal School District Bid documents posted on May 14, 2021, for the subject project and modifies/add to them as noted below.

CHANGES TO PROJECT MANUAL

SPECIFICATIONS:

1. Add Specification Section 003132 Geotechnical Data (30 pages) dated June 2, 2021

END OF ADDENDUM NO. 3

DOCUMENT 003132 - GEOTECHNICAL DATA

1.1 GEOTECHNICAL DATA

A. This Document with its referenced attachments is part of the Procurement and Contracting Requirements for Project. They provide Owner's information for Bidders' convenience and are intended to supplement rather than serve in lieu of Bidders' own investigations. They are made available for Bidders' convenience and information. This Document and its attachments are not part of the Contract Documents.

B. Because subsurface conditions indicated by the soil borings are a sampling in relation to the entire construction area, and for other reasons, the Owner, the Architect, the Architect's consultants, and the firm reporting the subsurface conditions do not warranty the conditions below the depths of the borings or that the strata logged from the borings are necessarily typical of the entire site. Any party using the information described in the soil borings and geotechnical report shall accept full responsibility for its use.

C. A geotechnical investigation report for Project, prepared by Paradigm Consultants, Inc. dated December 2020, is available for viewing as appended to this Document.

1. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from the data.
2. Any party using information described in the geotechnical report shall make additional test borings and conduct other exploratory operations that may be required to determine the character of subsurface materials that may be encountered.

D. Related Requirements:

1. Document 002113 "Instructions to Bidders" for the Bidder's responsibilities for examination of Project site and existing conditions.
2. Document 003119 "Existing Condition Information" for information about existing conditions that is made available to bidders.
3. Document 003126 "Existing Hazardous Material Information" for hazardous materials reports that are made available to bidders.

END OF DOCUMENT 003132

Geotechnical Engineering Study
Stafford MSD AG Barn
Stafford Municipal School District
Stafford, Texas

Prepared For

Stafford Municipal School District
Stafford, Texas

Prepared By

Paradigm Consultants, Inc.
9980 W. Sam Houston Pkwy. South, Suite 500
Houston, Texas 77099
TBPE Reg. No. F-001478

December 2020

December 28, 2020
Paradigm Project No. 20-1064

PARADIGM

Paradigm Consultants, Inc.

9980 W. Sam Houston Pkwy S.
Suite 500
Houston, Texas 77099

Main: 713.686.6771
Dispatch: 713-686-6999
paradigmconsultants.com
TBPE Reg. No. F-001478

Stafford Municipal School District
c/o Mr. Victor C. Fleming
Program Manager
Lockwood, Andrews & Newnam, Inc.
2925 Briarpark Drive
Houston, Texas 77042

Geotechnical Engineering Study
Stafford MSD AG Barn
Stafford Municipal School District
Stafford, Texas

Mr. Fleming:

Paradigm Consultants, Inc. presents this report of our geotechnical study for the above referenced project. This study was authorized with PO Number 040923 dated October 28, 2020.

We appreciate the opportunity to work with you during the design phase of this project and look forward to the opportunity to provide construction materials testing and monitoring services during the construction phase. If we may be of further assistance, please call us at your convenience.

Sincerely,

Frank S. Ong, P.E.
Engineering Manager

STATE OF TEXAS
FRANK S. ONG
83982
LICENSED
PROFESSIONAL ENGINEER
12-28-2020

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Important Information about your Geotechnical Engineering Report

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INTRODUCTION

Paradigm Consultants, Inc. (Paradigm) presents this report of our geotechnical study the proposed Stafford MSD AG Barn located at Scanlin Road in Stafford, Texas. This study was authorized with PO Number 040923 dated October 28, 2020.

The objectives of this study were to develop design recommendations and construction considerations for the proposed foundation and paving. Our study included the following tasks:

- Drilling and sampling three soil borings at selected locations within the project limits to explore the subsurface stratigraphy and groundwater levels;

- Performing geotechnical laboratory tests to aid in soil classification and determination of engineering properties of the encountered soils;

- Analyzing field and laboratory test data to develop geotechnical engineering design recommendations and construction considerations;

- Preparing this report presenting our findings and recommendations.

FIELD EXPLORATION AND LABORATORY TESTING

Our field exploration included drilling and sampling three borings. The approximate boring locations are shown on Figure 1. The borings were located in the field using the proposed development plan and existing landmarks.

Drilling Operations

News Drilling, a subcontractor to Paradigm, drilled and sampled the soil borings on November 6, 2020 using truck-mounted drilling equipment. Paradigm's field representative was on-site to monitor drilling activities, direct the sampling efforts, and log the boreholes. Our field operations were performed in general accordance with ASTM International (ASTM D 1452). Our field operations were performed in general accordance with ASTM International (ASTM D 1452[1]).

Soil Sampling

Soil was sampled continuously at 2-ft intervals to 12-ft depth with additional samples taken at 5-ft interval to the completion depth of the boring. The sampling method is determined based on the anticipated soils.

Soils interpreted to be cohesive soils (clay) during field operations were sampled by hydraulically pushing a 3-in. diameter, thin-walled steel tube a distance of about 24 in. Our field sampling procedures were in general accordance with ASTM D 1587.[2] For each recovered sample, our representative extruded the sample in the field, visually classified the soil, and measured the penetration resistance using a pocket penetrometer. A representative portion of the recovered sample was wrapped in aluminum foil and placed into a plastic bag for transport to our laboratory.

Water-Level Measurements

Drilling protocol includes dry augering from ground surface to the depth where water or borehole sidewall instability occurs. If neither water nor instability is encountered, dry-auger drilling techniques are used to the full depth of the boring. If water is encountered, the water level within the borehole is measured at 5-minute intervals for at least 15 minutes before drilling resumes using wet rotary methods.

Laboratory Testing

Paradigm performed geotechnical laboratory tests in general accordance with ASTM methods on selected soil samples to aid in soil classification and determine engineering properties. The test methods performed are presented in Table 1.

Table 1: Laboratory Test Methods

Test Name	Test Method
Moisture Content	ASTM D 2216[3]
Liquid and Plastic Limits and Plasticity Index	ASTM D 4318[4]
Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soil	ASTM D 2850[5]

Boring Logs

Paradigm's field representative logged each soil boring recording the drilling method, sampling method and interval, and penetration resistance. Details of the stratigraphic conditions encountered at each boring location were recorded on the field log in general accordance with ASTM D 5434.[6] Identification and descriptions of the soils were based on visual-manual procedures described in ASTM D 2488.[7]

The boring logs were developed using the stratigraphic and soil property data obtained during our field exploration and laboratory testing programs. Each log represents our interpretation of general soil and water conditions at the boring location. The boring logs include the type and interval depth for each sample, the corresponding penetration resistance, and the results of the index properties and strength testing. Soil classifications were based on the Unified Soil Classification System (ASTM D 2487[8]). The boring logs and a key to the terms and symbols used on the logs are included in Appendix.

When a penetration resistance value of 4.5 tsf is recorded and penetration resistance is used to determine soil consistency, Paradigm describes consistency as very stiff to hard. In the absence of unconfined compressive strength data, Paradigm does not expressly state that soil is hard consistency. In the absence of the appropriate field and/or laboratory test data at the interval depth, no estimate of consistency or density is noted.

Unified Soil Classification System. ASTM D 2487 classifies soil as either fine-grained or coarse-grained with the percentage of soil particles finer than the No. 200 sieve size used to differentiate between coarse-grained and fine-grained soil. Clay and silt are fine-grained soils and have 50% or more of their particles finer than the No. 200 sieve size. Gravel and sand are coarse-grained soils and have less than 50% of their particles finer than the No. 200 sieve size.

Clay has a plasticity index (PI) of 4 or greater and the plot of plasticity index versus liquid limit falls on or above the “A” line of the plasticity chart. Silt typically has a PI less than 4 and the plot of plasticity index versus liquid limit falls below the “A” line of the plasticity chart. For clay and silt, the descriptor “with sand” is used if 15% to 30% of the particles are sand size. If more than 30% of the particles within a clay or silt sample are sand size, the descriptor “sandy” is used. Fat clay has a liquid limit greater than or equal to 50, and lean clay has a liquid limit less than 50. Silty clay (CL-ML) has a PI between 4 and 7.

SURFACE AND SUBSURFACE CONDITIONS

General surface conditions were noted during our field exploration program. Subsurface conditions were evaluated by drilling three exploratory soil borings within the project site. Discussions of the site, subsurface and groundwater conditions encountered during our field exploration are presented in the following sections.

Surface Conditions

The site is generally level and covered with grass. Surface conditions at the boring locations and along the routes taken to access the boring locations were firm.

Subsurface Conditions

The subsurface soils, based on intercepted soils from three exploratory soil borings, consist of fill and fat clay within the 20-ft explored depth. Additional details of encountered soils with laboratory test results are presented on boring logs in Appendix.

Groundwater was not encountered during our field exploration. Short-term water level observations should not be interpreted to represent long-term conditions. Water levels vary seasonally and with climatic conditions.

Expansiveness of Soils Encountered. The clays within the anticipated zone of seasonal moisture change, the existing ground surface to a depth of 5 ft, have a very high swell/shrinkage potential (Holtz & Gibbs[9], Raman[10], and Chen[11]), as shown in Table 2. PIs for the tested clays within the upper 10-ft depth ranged from 41 to 56.

Table 2: Potential for Expansion

Expansion Potential	Plasticity Index Range	Liquid Limit Range
Low	**PI<18**	**----**
Medium	**15 ≤ PI ≤ 28**	**35 ≤ LL ≤ 50**
High	**25 ≤ PI ≤ 41**	**50 ≤ LL ≤ 70**
Very High	**PI > 35**	**LL > 70**

FOUNDATION RECOMMENDATIONS

The foundation system for the proposed structures must satisfy two independent engineering criteria with respect to foundation soils. First, the foundation system should be designed with an appropriate factor of safety against failure of the foundation soils. Second, the movement to the foundation system due to compression (consolidation) or expansion (swell) of the soils supporting the foundation system must be within tolerable limits for the structure.

Foundation Design

The field and laboratory data acquired indicate that competent soils were encountered within the 20-ft depth explored. Recommended foundation design parameters for a drilled pier foundation system are outlined in Table 3.

Table 3: Foundation Design Parameters

Parameter	Recommendation	Comments
Foundation Type	Drilled-and-Underreamed Pier	
Bearing Depth, ft	14	Below existing grade
Bearing Material	Clay	
Net Allowable Bearing Pressure*****, q_{all}		
Total Load, kips/ft^2	4.5	Includes factor of safety (F.S.) of 2
Dead Load plus Sustained Live Load, kips/ft^2	3.0	Includes factor of safety (F.S.) of 3
Lateral Resistance, $q_{lateral}$, kips/ft^2	0.8	Includes F.S. of 3; neglect upper 4 ft
Pier (Footing) Spacing	At least two underream or shaft diameters; whichever is greater	Measured center-to-center
Bell to Shaft Ratio	3:1	2:1 or Straight-sided if sloughing is encountered
Pier Reinforcement	Minimum of 0.5% to 1% of concrete area	Extend the full depth of shaft and underream

Notes: * May be increased 33% for transient loading conditions such as wind.

Uplift capacity of the shallow drilled pier should be limited to the weight of the foundation plus the weight of soil above the foundation. A factor of safety of 2 should be applied when calculating the uplift resistance.

A bell-to-shaft ratio of 3:1 may be considered. If a 3:1 bell-to-shaft ratio in the pier excavation is not possible due to the presence of slickensided material at a location during construction, a reduced bell-to-shaft ratio or straight-sided shaft with a design bell diameter will be required.

Foundation Installation

Installation considerations include test pier, water conditions, reinforcing and concrete placement, and monitoring. These topics are discussed in the following sections.

Test Pier. We recommend test piers be drilled to verify the construction feasibility of drilled-and-underreamed piers, as planned. Test piers provide beneficial information for the contractor about cleaning, sloughing, and water conditions. Installation of underreamed piers may proceed provided the bearing surface is clean before concrete placement. If test piers are drilled, at least two piers should be installed across the site. The geotechnical engineer or his qualified representative should observe test pier installation.

Test piers should be drilled with the largest diameter shaft and bell with the largest bell to shaft ratio proposed for the project. The piers should extend to the recommended bearing elevation. Piers should be located within the footprint of the building but should not be located at working pier locations. Test piers may be backfilled with concrete, cement-stabilized sand, or flowable fill. Cement stabilized sand should meet a specification similar to Item 400 of TxDOT *Standard Specifications for Construction of Highways, Streets and Bridges.*[12] Flowable fill should meet a specification similar to Item 434 of *Specifications for the Construction of Roads and Bridges within Harris County*.[13] Excavated soil should not be used to backfill test piers. For planning purposes, test piers should remain open for 2 hr to evaluate sidewall stability. Production drilling may proceed immediately after test pier installation provided no difficulty is encountered during test pier installation.

Water Conditions. Based upon the observations during the field exploration, seepage into drilled-and-underreamed piers is not anticipated during the excavation. If water in excess of about 2 in. accumulates at the bottom of the excavation, the water should be pumped out before concrete placement. Water levels vary seasonally and with climatic conditions. Therefore, the contractor should verify that groundwater will not adversely affect pier installation prior to foundation construction.

Reinforcing and Concrete Placement. Reinforcing steel should be clean and free of any bond-inhibiting coating or mud. Reinforcing steel should be properly positioned and supported to assure the design concrete cover around the reinforcing steel is achieved. Before concrete placement, the bottom of each excavation should be cleaned. If water in excess of about 2 in. accumulates at the bottom of the excavation, the water should be pumped out before concrete placement.

Concrete should be placed in pier excavations within 2 hr after excavation to reduce the potential for soil sloughing and/or perched water seepage from the excavation walls. If sloughing soils are encountered in the excavation, it may be necessary to place reinforcing steel and concrete immediately after completion of excavation. Concrete should conform to applicable requirements of ACI 301,[14] ACI 318,[15] and ASTM C 94/C 94M.[16] The concrete slump should be 5 in. ± 1 in. Concrete should be placed with a tremie to direct the concrete toward the bottom of the foundation excavation. The concrete should not be allowed to ricochet off the walls of the excavation or the reinforcing steel. Pier design and placement should comply with the requirements of ACI 318, ACI 336.3R[17] and ACI 336.1.[18]

Monitoring. Depth to competent bearing soils is based on conditions encountered at the boring locations. Significant variations can occur over short horizontal distances from the boring locations. Our representative should be present during foundation construction to verify that the proper bearing stratum has been reached, the pier dimensions are as designed, the reinforcing steel is as specified, and that the excavation is clean and dry before reinforcing and concrete placement.

Foundation Performance

The recommended depth of the pier foundation system is predicated on existing and anticipated soil and water conditions. It is generally acknowledged that the depth of seasonal moisture change or “active zone” in the Houston and surrounding areas is about 10 ft below grade. That is, the moisture content of the soils to that depth undergo moisture fluctuations caused by climatic conditions often characterized by cycles of dry then wet weather. In addition, geotechnical engineers have documented that factors other than climate can exert an influence to much greater depths. Instances of trees affecting subgrade moisture as far as 15 to 20-ft below the ground surface have been reported. The recommended bearing depth of the pier foundations will provide protection of the piers from significant influence by seasonal moisture change but will not necessarily provide protection from non-climatic factors. Discussions of climatic and non-climatic factors affecting foundation performance as well as site specific factors are presented in the Slab Performance section of this report.

FLOOR SLAB SYSTEM

The in-situ clays encountered during our field exploration program generally have a high to very high shrink/swell potential with soil moisture changes. A range of options from structurally-isolated floor slab to slab-on-grade may be considered for floor slab design. The selection of a specific option depends on risk of movement and consequential damage to the structure.

Structurally Isolated Floor Slab

The use of a structurally isolated floor slab with crawl space or void form is the most effective method to avoid the effects of moisture-related soil movement. A structurally supported floor should be selected if equipment installed on the first floor or if building elements or finishes on the first floor will be sensitive to movement. If the potential for slab movement must be eliminated, we recommend the structural slab. Void forms should be used to provide at least 6-in. void beneath the slab and grade beam to accommodate swelling movement of the subgrade soils. The building subgrade for a structurally isolated floor slab, if selected, should be prepared to provide a level and firm surface for placement of the collapsible void forms.

Slab-on Grade

To reduce potential movements of a slab-on-grade, we recommend at least 4-ft thick buffer of select fill or lime treated on-site excavated clay soils be prepared beneath the slab. Recommendations for subgrade preparation, select fill soils, and moisture conditioning of natural soils are presented in the *Site Development Considerations* section of this report.

The near-surface soils consist of sands/silts fill underlain by high plasticity clays. These sands/silts are sensitive to moisture conditions and may create a perched water condition. In addition, these surficial sands/silts may provide a pathway for water to travel underneath the slab resulting in swelling of the subsoils. It is recommended that surficial sands/silts fill be removed and replaced with select fill.

Grade Beams. Grade beams can be used to transfer loads to the drilled piers and to stiffen the floor slab. The depth of exterior and interior grade beams can be varied according to the structural requirements of the floor slab. We recommend the depth of the exterior grade beams be at least 2.5-ft below the lowest adjacent grade. We do not recommend the use of void boxes below grade beams because of the potential to collect free water within the void space.

Finished Grade Conditions. Slab-on-grade construction should proceed as soon as possible after completion of the building pads to prevent changes in the density and moisture conditions of the building pad soils. If construction is delayed and the fill soils are exposed to inclement weather or traffic, recompaction or moisture adjustment of the pad to at least 6-in. depth may be needed to return the soils to the specified density and moisture range. Alternately, protection of the fill soils with plastic sheeting or the placement of a protective fill layer may be considered. The plastic sheeting or protective fill layer must be removed before slab construction. The final lift should be moisture adjusted and recompacted before the floor slab is placed. Construction should not proceed on dry or saturated subgrade.

Vapor Retarder. ACI 302.1R, Guide for Concrete Floor and Slab Construction[19] recommends that a vapor retarder with a permeance of less than 0.3 US perms (ASTM E 96[20]). The thickness of the vapor retarder should not be less than 10 mils, placed under the concrete floor slab on ground to reduce the transmission of water vapor from the supporting soil through the concrete slab. The vapor retarder should function as a slip-sheet to reduce subgrade drag friction. Local practice is to place the concrete floor directly on the vapor retarder. The vapor retarder should be installed according to ASTM E 1643[21]. Water that collects within the building pad area after the vapor retarder is placed should be removed before concrete placement.

Utility Bedding and Backfill. Cement-stabilized sand is a preferred bedding material for utilities within the limits of the building and paving. Cement stabilized sand should meet the requirements of Item 400.3 of the TxDOT Specifications (Cement Stabilized Backfill[22]), or equivalent. Backfill for utility trenches within and for a distance of 10 ft from the building footprint should be select structural fill or cement-stabilized sand. Material and placement criteria for structural fill were presented in the *Building Pad Preparation* section. A testing frequency of one in-place density and moisture test for each 75 linear feet of utility trench or a minimum of two tests per lift should be included in the project specifications.

A bentonite seal should be placed within utility trenches where the trenches exit the building footprint. The seals should be located within 5-ft of the building and should be at least 2-ft in length; bentonite should not be placed under grade beams. The bentonite seal will prevent water infiltration into the utility bedding and backfill.

Slab Performance

Throughout much of the State, buildings supported on pier foundations use a slab-on-grade supported on a constructed building pad of relatively low-plasticity fill. This system is widely used and generally provides Owners with years, if not a lifetime, of acceptable performance. Nevertheless, a slab-on-grade presents a risk of poor long-term building performance.

The practice of most geotechnical engineers is to provide at least two options for the floor slab system: 1) a structural slab elevated above the site grade and supported by a deeper foundation system, and 2) a slab-on-grade. These two systems will not provide comparable assurance of performance. The structural slab relies on support by the foundations, typically piers that are placed at a sufficient depth to greatly reduce the risk of movement due to most causes of moisture fluctuation. A slab-on-grade, however, is susceptible to the inherent instability of the supporting clay subgrade, including any clay fill that will shrink or swell with any moisture fluctuation whether it occurs during or following construction.

Thus, the selection of the floor slab system should be made by the Owner with the counsel of the design and construction team to adequately advise the Owner of the risks each system presents and the relative costs. Owners select the least expensive system only to discover later that the performance of the system does not meet their expectations. This discussion is intended to assist the Owner in that decision.

Design methods for slab-on-grade construction consider only climatic factors and are based on average climatic conditions being present before construction and throughout the structure life. Maintaining balanced soil moisture conditions in the subgrade throughout the structure life reduces the potential for differential movements. Early in the life of the structure, the performance of a slab-on-grade will be affected by the soil moisture conditions at the time of construction, and they may be different than the conditions that existed during the geotechnical study. The conditions will be affected by the weather before and during construction, construction techniques, and site preparation including drainage. Steps should be taken to reduce moisture content fluctuations within the near-surface soils. Positive drainage to carry runoff away from the structure will minimize excess migration into the soils. Following construction, Owner influences begin to control soil moisture and the potential for soil movement. Rainfall, drainage, irrigation, or unintended water sources such as broken or leaking irrigation or utility lines can disrupt the post-construction moisture conditions and cause soils to swell. Landscaping, particularly trees, and dry weather can cause shrinkage of the clays and settlement.

The amount of movement considered acceptable to many Owners is less than that tolerated by the structural members. Movements often result in cracks in brick or masonry veneer or walls; cracks in drywall; separation of the joints in trim; cracks in tile floors, walls, and countertops; and distortion to windows and doors making them difficult to open and close. While these consequences of movement are annoying and may be unsightly, they do not necessarily indicate unacceptable structural performance or failure. Movements sufficient to cause those types of distress should be anticipated if a slab-on-grade floor slab is constructed on active clay soils.

Climatic Factors. Average annual climatic conditions are documented in the area, but these conditions occur in cycles of dry weather followed by wet weather. Such cycles coupled with the time of construction have a significant influence on the long-term performance of the structure. If construction proceeds during or immediately after a dry period, the soils within the upper 5 ft to 10-ft depth are expected to be dry. When moisture is introduced, such as, through infiltration of rainfall along the slab edges, the dry soils likely will swell. Conversely, if construction proceeds after a wet period, the soils likely are wet and have experienced some swell. Although additional swell may occur, the amount of swell likely will be less than that experienced by dry soils. Shrinkage of wet soils likely will occur during dry periods.

Non-Climatic Factors. Factors unrelated to climate may result in soil movements that may be greater than those resulting only from climatic influences. The presence of many non-climatic factors is generally beyond the direct influence of the design team and is often manifested during the structure life. Non-climatic factors that affect the moisture content of the site soils include the presence of trees (existing and recently removed) and landscaping, inadequate drainage or altered drainage during the structure life, and the availability of moisture from unplanned sources such as roof drains, air conditioning drains, or below-grade utility or irrigation system leaks. Design methods cannot account for movements resulting from these non-climatic factors. Since the slab performance is related to soil properties, climatic factors, non-climatic factors, and the interaction between factors that may occur during the structure life, the actual amount of movement that can be expected over the life of the structure cannot be quantified. Non-climatic factors and their potential effects on structure performance are discussed in the following paragraphs.

Drainage. Improper drainage can have significant negative effects on the performance, especially if the structure were constructed during or immediately after a dry period. The following are general notes concerning proper drainage considerations:

- Positive drainage away from the structure must be designed, constructed, and maintained throughout the structure life.

- Landscaping systems must maintain the positive drainage away from the structure and not permit water to impound adjacent to the structure.

- Downspouts from roof drainage systems and air conditioning unit drains should be designed to discharge water away from, and preferably 10-ft or more from, the foundation.

- Drainage through drainpipes to the storm sewer is preferred for all roof drains.

- Splash blocks are not effective in draining water away from the foundation and should not be used.

- Water drains should be tied to the storm sewer and not be allowed to drain along the boundary of the building with discharge at the foundation.

Unplanned Water Sources. Following the effects of landscaping and improper drainage, unplanned water releases such as from poorly constructed or broken below-grade utility lines, pool leaks, irrigation system leaks, or other unintended or unanticipated water sources are the most prevalent causes of poor foundation and slab-on-grade performance. The sources may be particularly problematic because they often go unnoticed for weeks or months causing significant movement of the soils and significant distress to the structure. Again, design methods do not account for soils movements resulting from these non-climatic factors.

Summary. Based on our experience, a slab-on-grade is selected for well over 95% of light loaded structures. Few problems may develop when subgrade moisture conditions are affected only by climatic factors. However, where non-climatic factors over which the design team has little or no control are allowed to influence the subgrade moisture variations, the result is frequently unsatisfactory foundation performance. Therefore, the selection of a slab-on-grade carries a substantially greater risk than a structurally-isolated floor slab. The Owner should understand that with the selection of a slab-on-grade, they must accept the associated risks and consequences.

PAVEMENT RECOMMENDATIONS

We understand that the pavement for the parking lot will be concrete paving. Design, material requirements, and maintenance considerations for the pavement and subgrade preparation are discussed in the following section.

Design Considerations

ACI 330R[23] was used as the basis for rigid pavement recommendations. The recommended concrete thicknesses have performed satisfactorily under similar use conditions and have an anticipated life of 15 to 20 years provided the paving sections are based on a properly prepared and stabilized subgrade as outlined in Subgrade Preparation.

Rigid Paving Section

Paving should consist of 5-in. thick hydraulic cement concrete paving for vehicle parking areas only, 6-in. thick concrete paving for passenger vehicle driveways, and 7-in. thick concrete paving for entrance, access to dumpster pads, and truck traffic areas. The pavement subgrade be stabilized with lime-fly ash to an 8-in. depth. Subgrade stabilizations are presented in the *Site Development Considerations* section of this report.

Concrete Mixture. The concrete paving mixture should be proportioned to achieve a compressive strength of at least 3500 lb/in.^{2} at 28 days or a minimum flexural strength of 500 lb/in.^{2} in third-point loading (ASTM C 78[24]) at 7 days.

Joints. Although the ACI 330R addresses design and construction of joints to control cracking and facilitate construction, the Guide does not consider the possible effects of joint layout on subgrade performance. The following are some general notes regarding joint placement:

- Spacing between joints should comply with Table 3.5 below from ACI 330R:

Pavement thickness, in.	Maximum spacing, ft
4, 4.5	10
5, 5.5	12.5
6 or greater	15

  Note that joint spacing should not exceed 15 ft;

- Avoid doweled expansion joint with winged retention plate on pavements less than 8 in. thick;

- Panels between joints should be square, or nearly so, with the ratio of length to width no greater than 1.5;

- Isolation or doweled joints should be installed between the building or penetrations such as inlets or manholes and adjoining pavement;

- Isolation joints should be installed at junctions of pavement with walks, curbs, or other obstructions where independence of movement is needed;

- Install a joint at any change in direction;

- Joints should be installed perpendicular to tangent along curve in pavement, preferably at point of smallest diameter;

- Reinforce re-entrant corners with three #3 diagonal or corner bars;

- Do not allow joints intersections to form a “T”;

- Avoid, if possible, longitudinal joints in or near wheel paths, particularly where heavy vehicles are expected; and

- Avoid positioning joints where water flows along the joint since joint sealant is not 100% effective in sealing moisture infiltration. Water intrusion at joints is frequently a major contributor to subgrade damage and loss of subgrade support.

Distributed Steel Reinforcement and Dowels. Local practice is to use distributed steel reinforcement in hydraulic cement concrete pavements to control opening of intermediate cracks that develop between joints in response to shrinkage, temperature differentials, uneven subgrade support, or load-related stresses. The function of the distributed steel is to hold together the crack's fracture faces.

ACI 330R addresses distributed steel reinforcement and provides an equation to determine the required area of distributed steel. Plain smooth dowels are recommended to provide load transfer across contraction joints while permitting the joints to move. ACI 330R contains recommendations for dowel size, length, and spacing. Avoid locating a dowel closer than three times the pavement thickness from a joint parallel to the dowel.

Maintenance. During the paving life, maintenance to seal surface cracks and reseal joints within concrete paving should be performed to achieve the desired paving life. Adequate drainage should be provided to prevent or retard influx of surface water from areas surrounding the paving. Water penetration into the pavement subgrade leads to paving degradation.

Subgrade Stabilization

The appropriateness of stabilizer and application rate for the subgrade, preferably, should be determined at the time of construction. However, based on the conditions encountered in our borings, a mixture of lime and fly ash appears to be the better choice for stabilization. Texas Department of Transportation (TxDOT) Specifications, Item 265,[25] should be used as procedural guide for placing, mixing, and compacting the stabilizer and the soils. A commercially available blend of 40% quicklime and 70% fly ash known as TRU-BLN® can be considered. Application rate of 48 lb/yd^2 to 8-in. depth is expected to be appropriate for stabilization. The type and amount of stabilizer needed for stabilization will depend on the characteristics of the material used to raise grade and should be determined at the time of construction.

Stabilized soils should be compacted to at least 95% of the maximum dry density determined by standard effort (ASTM D 698[26]). The moisture content should be within a range of optimum to 3% wet of the optimum moisture content.

CONSTRUCTION OBSERVATION

As dictated by common practice, our geotechnical engineering analysis and recommendations are based on the information on the subsurface conditions obtained from small diameter, widely-spaced borings and our judgment based on our education and experience. Because the borings indicate subsurface conditions only at the specific locations and time and only to the depths penetrated, they do not necessarily reflect strata variations that may exist between boring locations. Therefore, the validity of the recommendations in this report is based in part on assumptions about the stratigraphy made by the geotechnical engineer. Because variations may not be evident until construction begins, Paradigm should be retained to observe foundation installation and perform construction materials monitoring and test, particularly earthwork construction, during the construction phase of the project.

Our involvement enables Paradigm's geotechnical engineer or his/her representative to monitor the foundation and earthwork activities and be available to personally evaluate unanticipated conditions, conduct additional tests, if necessary, and to provide alternative recommendations where appropriate. Therefore, our recommendations on issues such as final bearing elevation, depth of undercutting unsuitable materials, and appropriateness of subgrade stabilization agent and quantity should be considered preliminary until actual subsurface conditions are revealed during construction.

SITE DEVELOPMENT CONSIDERRATIONS

To plan the construction, initial earthwork will include stripping, site drainage, proofrolling, moisture conditioning, and select fill placement and testing. Redevelopment of previously developed site often uncovers unknown below-grade elements during new construction. Elements that should be addressed before new construction include existing foundations and utilities. Recommendations for site preparation are presented in the following sections.

Stripping

The exposed soils within and 5 ft beyond the proposed building and paving areas should be stripped of vegetation, topsoil, debris, and other deleterious materials. For planning purposes, we recommend a stripping depth of at least 6 in. Stripped soils should not be used as select fill but may be suitable for landscaping purposes.

Site Drainage

Based on our experience with similar projects, drainage should be established early in the site development and maintained as the site grades change. Drainage could be critical if construction begins following or during a period of wet weather.

Proofrolling

Proofrolling is a method to evaluate the performance of the surface soils within 12 in. to 18 in. under load application. Proofrolling should be performed using a heavy rubber-tired vehicle such as loaded dump truck, a large maintainer or pneumatic equipment weighing about 20 tons. Proofrolling operations should be observed by our representative to delineate areas that require remediation. Remediation typically involves removing and replacing the soft areas; disking, drying and recompacting the soils; or treating the soils with a chemical additive.

Existing Foundations

Complete removal of former foundations often is not undertaken for new development. Excavations for foundation removal if needed may require backfilling under controlled compaction conditions. Large excavations may be backfilled with select fill. Fill should be placed in 8-in. thick maximum loose lifts, with each lift compacted to at least 95% of the maximum dry density determined by standard effort (ASTM D 698[27]). Isolated excavations may be more economically backfilled with controlled low-strength material (CLSM) or flowable fill. If CLSM is used, the mixture should be proportioned to produce the desired strength at the time of excavation.

Existing Utilities

Paradigm recommends that any former utilities including water service, sewer service, and electrical service should be removed in their entirety if located within the footprint of the new building. Removal should include the pipes, bedding, and backfill. It is likely that sand was used as bedding and backfill for on-site utility excavations. Sand bedding and backfill should not remain within the footprint of the proposed building since the presence of sand will increase risks for water intrusion and resulting movements of a grade-supported floor. If utilities are located within the surface paving areas, the utilities may be abandoned in place. We recommend that the lines be grouted as part of the abandonment process.

Existing Fill Materials

Any on-site fill soils should have records of successful compaction tests that confirm the use of the fill and record of passing density tests. These tests should have been performed on all the lifts. In the event that no compaction tests results are available, the fill materials must be removed, processed and re-compacted in accordance with our fill placement recommendations. Excavations should be extended at least 5 ft beyond the building and pavement area.

Moisture Conditioning

The building pad subgrade should be moisture conditioned and recompacted prior to placement select fill pad. Moisture conditioning should be performed to bring the *in-situ* moisture content of the subgrade to within 0 to 3% wet of optimum moisture content. Moisture conditioning of the subgrade (8 in.) can be accomplished by controlled sprinkling of water on the natural lean clay soils and compacting to at least 95 percent of the maximum dry density, as determined by ASTM D 698 (Standard Proctor) prior to placement of successive lifts. Maintaining constant moisture content within the *in-situ* soils both pre- and post-construction is important to the successful performance of the slab-on-grade foundation.

Select Fill

Select fill for the building pad should consist of lean clay or sandy lean clay, free of roots, organics, and deleterious materials. The select fill should have at least 50% passing the No. 200 sieve and have a PI between 12 and 20, with a liquid limit less than 35. Representative samples of the fill materials should be tested to confirm their material characteristics.

Select fill should be placed in maximum 8-in. thick loose lifts and compacted to 95% of the maximum dry density (ASTM D 698). Over-compaction should be avoided. The moisture contents for select fill should be within 1% dry to 3% wet of the optimum moisture content. Fill placement greater than one 6-in. thick compacted lift should be tested and documented by the geotechnical engineer or an experienced soils technician. A testing frequency of one in-place density and moisture test for each 2,500 ft^2 or less per lift of fill should be considered, with a minimum of two tests per lift.

LIMITATIONS

Opinions, conclusions, and recommendations presented in this geotechnical engineering report are based on the data obtained from the field and laboratory programs, our interpretation of the data, and information received from our client and construction professionals associated with the project. If changes in the nature, design, or location of the project are made, the opinions, conclusions, and recommendations contained in this report are not valid unless the changes are reviewed by Paradigm and the recommendations included within this report are modified or verified in writing by Paradigm. If subsurface conditions different from those described are noted during construction, recommendations in this report must be reevaluated.

The scope of our services did not include environmental assessment, compliance with applicable laws, geologic faults, and wetlands. Our scope did not include the investigation, detection, or design related to the presence of any biological pollutants. The term “biological pollutants” include, and is not limited to, mold, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms.

Design Review

Paradigm should review the design drawings and specifications before being released for construction. Our review will confirm that the geotechnical recommendations and construction criteria presented in this report have been correctly interpreted and implemented. Paradigm is not responsible for any claims, damages, or liability associated with non-compliance with or misinterpretation of the recommendations and construction criteria presented in our geotechnical report. Design review is not within the scope of services authorized in this study. We would be pleased to submit a budget for this activity.

Standard of Care

This study was performed in a manner consistent with the level of care and skill ordinarily exercised by reputable geotechnical engineers practicing contemporaneously in the local area. No warranty or guarantee, express or implied, is made or intended.

Report Reproduction

Paradigm’s report was prepared exclusively for the Stafford Municipal School District and its project team for use in preparing design and construction documents. This report shall not be reproduced or used for any other purpose without Paradigm’s express written authorization.

If included in construction documents, the report should be provided in its entirety with the caveat that it is included as a construction reference. Specific project requirements including options selected from this report must be obtained from the design drawings and specifications.

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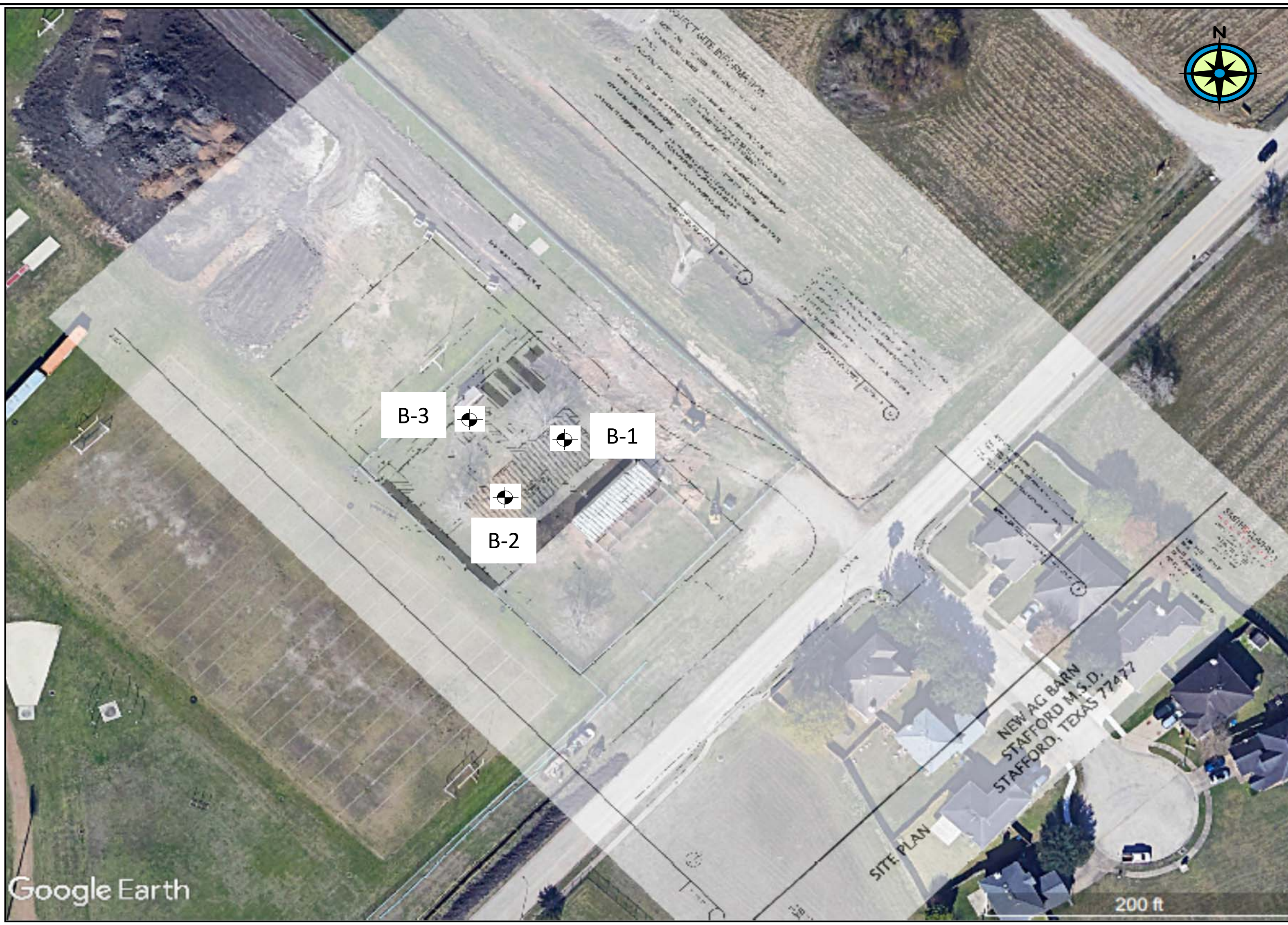

Reference: Base map provided by Google Earth
Note: Boring locations are approximate
Legend: ⊕ Boring location

STAFFORD MSD AG BARN STAFFORD MUNICIPAL SCHOOL DISTRICT STAFFORD, TEXAS	**Paradigm Consultants, Inc.** 9980 West Sam Houston Parkway South, Suite 500 Houston, Texas 77099
STAFFORD MUNICIPAL SCHOOL DISTRICT STAFFORD, TEXAS	PROJECT NO. 20-1064 FIGURE 1 PLAN OF BORINGS

Appendix

SOIL BORING LOGS

LOG OF BORINGS

Project: AG Barn Building
1625 Staffordshire Road
Stafford, Texas
Client: Stafford Municipal School District
Houston, Texas

Project No.: 20-1064
Boring Number: 1
Surface Elevation:
Drilled: 11/5/20 - 11/6/20
Sheet 1 of 1

Drilling Method(s):
Dry-auger drilling: 0 ft to 20 ft

Borehole Water Levels:
First encountered — No water encountered

Depth, ft	Penetration Resistance, P, tsf / Standard Penetration Test N, blows/ft or blows/interval	Moisture Content, %	Finer than No. 200 sieve, %	Liquid Limit LL	Plastic Limit PL	Plasticity Index PI	Dry Density, lb/ft³	Undrained Shear Strength, c_u, lb/ft²	Failure Strain, %	Confining Pressure, lb/in²	Comment	Description of Stratum
0	P = 0	4.1		NP	NP	NP						FILL: Tan and gray silty sand with clay layer.
2	P = 4.5	19.7										FAT CLAY (CH): Very stiff to hard, dark gray.
4	P = 4.5+	23.3										
6	P = 3.5	24.2		75	19	56						- with calcareous nodules and ferrous stains, 6 to 12 ft.
8	P = 4.5	21.8										- becoming reddish brown and gray, 8 to 12 ft.
10	P = 4.0	21.7					106	3040	4.12		Slickensided	
13	P = 4.0	25.1					100	1030	1.18		Slickensided	
18	P = 4.0	26.8										
20												Borehole terminated at 20-ft depth

Remarks:

03GEOTECH1 20-1064 BORING LOG.GPJ 11/13/20

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LOG OF BORINGS

Project: AG Barn Building
1625 Staffordshire Road
Stafford, Texas
Client: Stafford Municipal School District
Houston, Texas

Project No.: 20-1064
Boring Number: 2
Surface Elevation:
Drilled: 11/5/20 - 11/6/20
Sheet 1 of 1

Drilling Method(s):
Dry-auger drilling: 0 ft to 20 ft

Borehole Water Levels:
First encountered — No water encountered

Soil Symbol	Depth, ft	Penetration Resistance, P, tsf / Standard Penetration Test N, blows/ft or blows/interval	Moisture Content, %	Finer than No. 200 sieve, %	Liquid Limit LL	Plastic Limit PL	Plasticity Index PI	Dry Density, lb/ft³	Undrained Shear Strength, c_u, lb/ft²	Failure Strain, %	Confining Pressure, lb/in²	Comment	DESCRIPTION OF STRATUM
	0	P = 0	7.7										FILL: Brown silty sand with clay layer.
	2	P = 2.0	25.7		62	21	41						FAT CLAY (CH): Very stiff, dark gray.
	4	P = 2.0	27.3										
	6	P = 2.0	26.1										
	8	P = 2.5	30.8										
	10	P = 2.0	30.6		66	22	44						
	13	P = 3.5	24.6					101	2160	3.99		Multiple Shear, Vertical Fracture	
	18	P = 3.0	28.2										
	20												Borehole terminated at 20-ft depth

Remarks:

03GEOTECH1 20-1064 BORING LOG.GPJ 11/13/20

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LOG OF BORINGS

Project: AG Barn Building
1625 Staffordshire Road
Stafford, Texas
Client: Stafford Municipal School District
Houston, Texas

Project No.: 20-1064
Boring Number: 3
Surface Elevation:
Drilled: 11/5/20 - 11/6/20
Sheet 1 of 1

Drilling Method(s):
Dry-auger drilling: 0 ft to 5 ft

Borehole Water Levels:
First encountered — No water encountered

Soil Symbol	FIELD DATA			LABORATORY DATA										Comment	DESCRIPTION OF STRATUM
	Depth, ft	Sample Interval, Sampler Type	Penetration Resistance, P, tsf / Standard Penetration Test N, blows/ft or blows/interval	Moisture Content, %	Finer than No. 200 sieve, %	ATTERBERG LIMITS: Liquid Limit LL	Plastic Limit PL	Plasticity Index PI	Dry Density, lb/ft^3	Undrained Shear Strength, c_u, lb/ft²	Failure Strain, %	Confining Pressure, lb/in²			
	0–2		P = 0	5.3		NP	NP	NP							FILL: Tan and dark brown silty sand.
	2–4		P = 1.5	32.6		79	26	53							FAT CLAY (CL): Stiff, tan and dark brown.
	4–5		P = 1.5	28.8											

Borehole terminated at 5-ft depth

Remarks:

03GEOTECH1 20-1064 BORING LOG.GPJ 11/13/20

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KEY TO BORING LOG TERMS AND SYMBOLS

MATERIAL SYMBOLS

- Fat Clay (CH)
- Lean Clay (CL)
- Sandy Lean Clay (CL)
- Silty Clay (CL-ML)
- Silt (ML)
- Sandy Silt (ML)
- Elastic Silt (MH)
- Organic Clay or Silt (OH) High Plasticity
- Organic Clay or Silt (OL) Low Plasticity
- Peat (PT)
- Well Graded Sand (SW)
- Poorly Graded Sand (SP)
- Silty Sand (SM)
- Clayey Sand (SC)
- Well Graded Gravel (GW)
- Poorly Graded Gravel (GP)
- Silty Gravel (GM)
- Clayey Gravel (GC)
- Fill
- Asphalt
- Base
- Concrete

SAMPLER SYMBOLS

- Auger
- Thin-walled tube
- Split barrel
- Core
- No recovery

STANDARD PENETRATION TEST (SPT)

N = 25	The sampler was seated 6 in. with blows from a 140-lb hammer then 25 blows were required to advance the sampler through the two 6-in. intervals of the test. The "N" value is the sum of the blows needed to penetrate the final 12 in.
12, 26, 50/3"	The sampler was seated 6 in. by 12 blows from a 140-lb hammer then 76 blows were required to advance the sampler a distance of 9 in. Full penetration of 12 in. below the seating interval could not be achieved before the 50 blow limit was recorded in one interval.
50/4"	Sampler was driven 4 in. of the 6-in. seating interval by blows of a 140-lb hammer before the 50 blow limit was reached.

WATER SYMBOLS

- ▽ Depth where water was first encountered during drilling
- ▼ Depth where water was encountered within the open borehole after completion of drilling (see log for elapsed time)
- ▼ Depth where water was encountered within the open borehole 24 hours after completion of drilling

DESCRIPTIVE TERMS

Fine-Grained

(Major portion passing No. 200 sieve)
Silt and Clay

Consistency	Undrained Shear Strength, ksf	SPT "N" Value
Very soft	Less than 0.25	Less than 2
Soft	0.25 to 0.50	2 to 4
Firm	0.50 to 1.00	4 to 8
Stiff	1.00 to 2.00	9 to 15
Very stiff	2.00 to 4.00	15 to 30
Hard	Greater than 4.00	Greater than 31

Coarse-Grained

(Major portion retained on No. 200 sieve)
Gravel and Sand

Description	Relative Density	SPT "N" Value
Very loose	0 to 15%	Less than 4
Loose	15% to 35%	4 to 10
Medium dense	35% to 65%	10 to 30
Dense	65% to 85%	30 to 50
Very dense	85% to 100%	Greater than 50

PCI's geotechnical engineer reviewed and compiled the field and laboratory data to develop each boring log. Each log represents our interpretation of general soil and water conditions at the boring location. Strata lines on the log may be transitional and are approximate in nature. Water levels refer only to those conditions observed at the time and location indicated.