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REPORT OF GEOTECHNICAL INVESTIGATION

2035 FISH HATCHERY ROAD
SOUTHEAST OF LEWISTOWN, MONTANA

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GEOTECHNICAL REPORT
2035 FISH HATCHERY ROAD
SOUTHEAST OF LEWISTOWN, MONTANA

1.0 EXECUTIVE SUMMARY

A geotechnical investigation was performed for the proposed hatchery house structure to be located at 2035 Fish Hatchery Road southeast of Lewistown, Montana. This investigation encountered surficial lean clay soils overlying severely weathered sandstone and claystone bedrock. The bedrock strata are extremely soft and more closely resemble soil for the purposes of design on this project. Based on the site conditions encountered, the limited depth of the investigation, and our experience, the seismic site class is D. The risk of seismically-induced liquefaction or soil settlement is considered low and does not warrant additional evaluation. The primary geotechnical concerns regarding this project are the presence of relatively soft, compressible fine-grained soils and shallow ground water which may impact this project depending on the final building configuration, which has not yet been determined.

In our opinion, the site is suitable for the use of conventional shallow foundation systems bearing on properly compacted native soils with recommended maximum allowable bearing pressures of 1,500 psf. The shallow ground water has the potential to rise from the elevations observed at the time of this study. This should be considered during the selection of the planned building configuration. If basement alternatives are considered, we would advise that the bury depth of the footings be raised slightly to account for potential ground water fluctuations.

A single boring was performed in the vicinity of the planned septic drain field for classification of the soil conditions present. This boring encountered similar conditions with severely weathered sandstone present at a depth of only 2.5 feet below existing grade. However, this material is nearly completely weathered and would likely classify as a very gravelly sandy loam or very gravelly sandy clay loam in accordance with the U.S. Department of Agriculture classification system.

2.0 INTRODUCTION

2.1 Purpose and Scope

This report presents the results of our geotechnical study for the proposed hatchery house to be located southeast of Lewistown, Montana, at 2035 Fish Hatchery Road. The purpose of the geotechnical study is to determine the general surface and subsurface conditions at the proposed site and to develop geotechnical engineering recommendations for support of the proposed structure. This report describes the field work and laboratory analyses conducted for this project, the surface and subsurface conditions encountered, and presents our recommendations for the proposed foundations.

Our field work included drilling four soil borings. Three were drilled in proximity to the proposed structure while the fourth was located to the west in the area for the proposed drain field construction. Samples were obtained from the borings and returned to our Great Falls laboratory for testing. Laboratory testing was performed on selected soil samples to determine engineering properties of the subsurface materials. The information obtained during our field investigations and laboratory analyses was used to develop recommendations for the design of the proposed foundation system.

2.2 Project Description

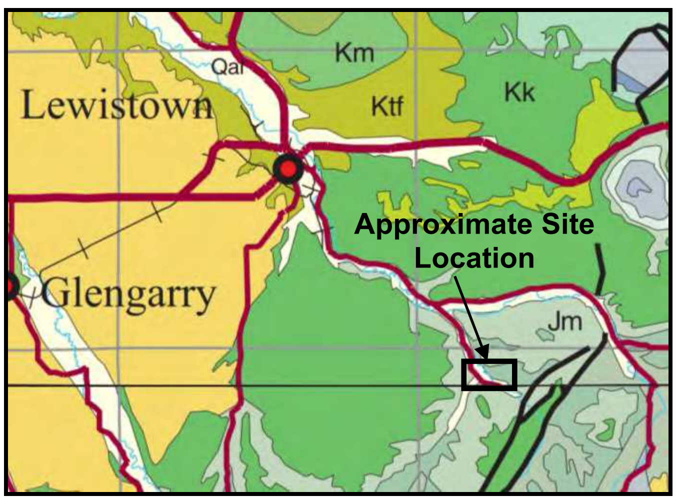
It is our understanding that the proposed project consists of, in part, a single-story, wood-framed structure being approximately 1,500 square feet in plan. The structure is proposed to be supported on conventional shallow foundations. At this time, the planned configuration for the structure has not been determined and options for potential basements, crawlspace, and conventional slab-on-grade construction are being evaluated. Structural loads had not been developed at the time of this report. However, for the purpose of our analysis, we have assumed that wall loads will be less than 2,500 pounds per lineal foot and column loads, if any, will be less than 25 kips.

Site development will most likely include landscaping and exterior concrete flatwork. If the assumed design values presented above vary from the actual project parameters, the recommendations presented in this report should be reevaluated.

3.0 SITE CONDITIONS

3.1 Geology and Physiography

The site is geologically quite complex due to its proximity to the Big Snowy mountain range. Areas directly along Big Spring Creek and Castle Creek, the confluence of which is located northwest of this site, are mapped as alluvium. These deposits are generally comprised of gravel, sand, silt, and clay associated with stream and river channels as well as floodplains. Areas not directly adjacent to these streams are mapped as bedrock of the Swift, Morrison, Rierdon, and Piper Formations. The Morrison Formation is part of the Livingston Group while the Swift, Rierdon, and Piper Formations are associated with the Ellis Group. This particular site appears to lie within the Swift Formation and is anticipated to consist of orangish brown, glauconitic, flaggy-bedded, fine-grained sandstone or sandy coquina with subordinate dark gray shale interbeds. The Morrison Formation is the next most common material mapped in the vicinity of this site with lesser amounts of the Rierdon and Piper formations present, mostly to the south and east. These formations are all generally comprised of mudstone or limestone materials. Areas to the north and west of this site encountered bedrock of the Kootenai Formation which are also consistent with more mudstone, siltstone, and limestone formations.



Geologic Map of Montana, Edition 1.0 (2007)
Montana Bureau of Mines & Geology

Based on the subsurface conditions encountered, the site falls under seismic Site Class D. The appropriate 2015 International Building Code (IBC) seismic design parameters for the site include site coefficients of 1.6 and 2.4 for F_a and F_v, respectively. The corresponding design spectral response accelerations at short periods (SD_s) and at 1-second period (SD_1) are 0.105g and 0.069g, respectively. These values represent two-thirds of the mapped response accelerations following correction for the appropriate site classification and assume the proposed construction to fall into risk category II. These values may warrant modification or verification by the structural if newer versions of the IBC will be utilized for design on this project. The likelihood of seismically-induced soil liquefaction or settlement for this project is low and does not warrant additional evaluation.

3.2 Surface Conditions

The proposed project site is located southeast of Lewistown, Montana, at 2035 Fish Hatchery Road. The triangular area is currently vegetated with native grasses. The southern edge of the parcel is separated from Fish Hatchery Road by a well-developed stand of trees. The northwest and northeast sides of the property are fenced. Just beyond the fence to the northwest is an existing gravel access road into the hatchery facility. An existing concrete canal system runs along the northeast side of the property beyond the fence. Based on background information and site observations, the site slopes downward toward the northeast at slopes ranging from 2 to 25 percent. The topography is best described as nearly level for the majority of the site with a strong downward slope along the northeast side towards the existing concrete canal.

It is our understanding that a pre-existing structure had been located in this general area and was completely removed long before our investigation. Historic aerial photographs of the area show the structure present on the property up until early 2012. It is reported that this previous structure incorporated a full depth basement and that fill may exist in this area to depths of approximately eight feet. The planned building location for this project is to be northeast of the original structure and is not anticipated to encounter fill materials. However, if the building location is changed, the potential fill should be evaluated to assess and potential impacts it may have on the new construction given the lack of information available regarding its placement.

3.3 Subsurface Conditions

3.3.1 Soils

The subsurface soil conditions appear to be relatively consistent based on our exploratory drilling and soil sampling. In general, the subsurface soil conditions encountered within the borings consist of approximately 2.5 to 9.0 feet of surficial lean clay soils containing varying amounts of sand. The lean clay is underlain in all borings by very soft sandstone and claystone bedrock which extends to depths of at least 17.0 feet, the maximum depth investigated.

The subsurface soils are described in detail on the enclosed boring logs and are summarized below. The stratification lines shown on the logs represent approximate boundaries between soil types, and the actual in situ transition may be gradual vertically or discontinuous laterally.

LEAN CLAY

The lean clay is present in all four borings and ranges in thickness from 6.0 to 9.0 feet beneath the building site. The surficial clay is much thinner, approximately 2.5 feet, in the area of the planned septic drain field. The lean clay is considered very soft to firm as indicated by penetration resistance values which ranged from 2 to 7 blows per foot (bpf) and averaged 5 bpf. This material is moderately compressible and slightly expansive as indicated by the consolidation-swell test results shown on Figures 14 and 15. Three samples of the material contained between 0.5 and 5.4 percent gravel, between 20.5 and 30.1 percent sand, and between 69.4 and 78.9 percent Fines (silt and clay). Three additional samples exhibited liquid limits ranging from 30 to 41 percent and plasticity indices ranging from 14 to 20 percent. Two unconfined compressive strength specimens resulted in undrained shear strengths of 704 and 1,312 pounds per square foot (psf), respectively. The natural moisture contents varied from 16 to 23 percent and averaged 20 percent.

WEATHERED BEDROCK
Severely weathered sandstone and claystone bedrock was encountered in all four borings at depths of 2.5 to 9.0 feet and extends to depths of at least 17.0 feet. The rock is considered completely weathered and very soft as indicated by penetration resistance values which ranged from 3 to 34 bpf and averaged 13 bpf. The natural moisture contents varied from 10 to 27 percent and averaged 16 percent.

3.3.2 Ground Water

Ground water was encountered in all four borings at depths ranging from 6.6 to 9.8 feet below the ground surface. Based on the estimated ground surface elevations, this equates to water level elevations ranging from 4,168.7 to 4,170.0 feet. Water levels were measured shortly after the completion of drilling to allow time for water levels to stabilize. The presence or absence of observed ground water may be directly related to the time of the subsurface investigation. Numerous factors contribute to seasonal ground water occurrences and fluctuations, and the evaluation of such factors is beyond the scope of this report.

4.0 ENGINEERING ANALYSIS

4.1 Introduction

The primary geotechnical concerns regarding this project are the presence of relatively soft, compressible fine-grained soils and shallow ground water which may impact this project depending on the final building configuration, which has not yet been determined.

4.2 Site Grading and Excavations

The ground surface at the proposed site is relatively flat over the majority of the site with a strong downward slope at the northeast edge of the building site to the existing concrete canal system. Slopes are estimated to be between 2 and 25 percent based on the topographic information provided to us. Based on our field work, foundation and utility excavations are anticipated to encounter surficial lean clay soils overlying severely weathered sandstone bedrock. The bedrock will be easily excavatable with conventional equipment and will act more like a soil than rock due to its severe weathering. Based on the borings, ground water should be expected in foundation or utility excavations extending to elevation 4,170 or below. Occasional pockets of trapped or perched ground water associated with recent precipitation events may be encountered above this elevation. Furthermore, ground water levels may fluctuate seasonally, and the magnitude of such fluctuations has not been evaluated.

4.3 Conventional Shallow Foundations

Considering the subsurface conditions encountered and the nature of the proposed construction, the structure can be supported on conventional shallow foundation systems bearing on properly compacted native soils. If, during construction, the native soils cannot be compacted to the specified limits outlined in Section 5 of this report, the use of a reinforcing geotextile and structural fill may be needed to ensure proper bearing. The ability to compact the native soils will be largely controlled by the depth of the footings and the selected building configuration. Foundations nearing the ground water table are more likely to encounter excessive soil moisture and non-compactible clay soil.

Based on our experience, the one-dimensional consolidation result, and the theory of elasticity, foundations designed using the bearing pressures provided in this report are not anticipated to realize total vertical movements exceeding ¾-inch when supported on properly prepared and compacted soils. Differential settlement within the limits of the structure should be on the order of one-half this magnitude.

The lateral resistance of spread footings is controlled by a combination of sliding resistance between the footing and the foundation material at the base of the footing and the passive earth pressure against the side of the footing in the direction of movement. Design parameters are given in the recommendations section of this report.

4.4 Foundation Walls

Foundation walls associated with crawlspace or basement alternatives will be subjected to horizontal loading due to lateral earth pressures. The lateral earth pressures are a function of the natural and backfill soil types and acceptable wall movements, which affect soil strain to mobilize the shear strength of the soil. More soil movement is required to develop greater internal shear strength and lower the lateral pressure on the wall. To fully mobilize strength and reduce lateral pressures, soil strain and allowable wall rotation must be greater for clay soils than for cohesionless, granular soils.

The lowest lateral earth pressure against walls for a given soil type is the active condition and develops when wall movements occur. Passive earth pressures are developed when the wall is forced into the soil, such as at the base of a wall on the side opposite the retained earth side. When no soil strain is allowed by the wall, this is the "at-rest" condition, which creates pressures having magnitudes between the passive and active conditions.

The distribution of the lateral earth pressures on the structure depends on soil type and wall movements or deflections. In most cases, a triangular pressure distribution is satisfactory for design and is usually represented as an equivalent fluid unit weight. Design parameters are given in the recommendations section of this report.

4.5 Floor Slabs and Exterior Flatwork

The natural on-site soils, exclusive of topsoil, are suitable to support lightly to moderately loaded, slab-on-grade construction. A leveling course of granular fill directly beneath the slab is recommended to provide a structural cushion, a capillary-break from the subgrade, and a drainage medium. Construction typically utilizes six inches of compacted granular fill beneath slabs; however, the requirements may vary locally.

Based on the laboratory testing performed, the lean clay soils are considered only marginally expansive and are not anticipated to have any significant detrimental impact on the use of slab-on-grade construction. Some potential vertical movement related to expansion is possible; however, we do not anticipate slab displacements to exceed ½-inch. We have included recommendations for interior improvements to help minimize the impact associated with such movements.

4.6 Drain Field Conditions

A single boring performed within the limits of the planned drain field encountered approximately 2.5 feet of surficial topsoil and lean clay overlying severely weathered sandstone bedrock. The sandstone is very soft and should be treated more like a soil based on the degree of weathering. The surficial lean clay is considered to classify as clay under the U.S. Department of Agriculture (USDA) classification system typically utilized during septic design. The underlying weathered sandstone is considered a very gravelly sandy loam or very gravelly sandy clay loam using this system. The weathered rock is expected to have adequate infiltration properties for use in septic design; however, no on-site infiltration testing was performed as part of our scope of work. Furthermore, ground water was encountered at a depth of approximately 6.6 feet at this location and could impact the final drain field design for the project.

5.0 RECOMMENDATIONS

5.1 Site Grading and Excavations

1. All topsoil and organic material should be removed from the proposed building and pavement areas and any areas to receive site grading fill. For planning purposes, a stripping thickness of 6 to 9 inches should be adequate to remove the majority of organic material. Tree roots may be encountered below this depth due to the surrounding trees. While occasional tree roots are not likely to be detrimental, excessive root growth can impact the structure and should be evaluated during construction to assess if additional stripping depth may be warranted.

2. All fill and backfill should be non-expansive, free of organics and debris and should be approved by the project geotechnical engineer. The on-site soils, exclusive of topsoil, are considered suitable for use as backfill and general site grading fill on this project. All fill should be placed in uniform lifts not exceeding 8 inches in thickness. All materials compacted using hand compaction methods or small walk-behind units should utilize a maximum lift thickness of 6 inches to ensure adequate compaction throughout the lift. All fill and backfill shall be moisture conditioned to near the optimum moisture content and compacted to the following percentages of the maximum dry density determined by a standard proctor test which is outlined by ASTM D698 or equivalent (e.g. ASTM D4253-D4254).

   a) Below Foundations or Spread Footings 95%
   b) Below Slab-on-Grade Construction.. 95%
   c) Foundation Wall Backfill 95%
   d) General Landscaping or Nonstructural Areas............................ 92%

   For your consideration, verification of compaction requires laboratory proctor tests to be performed on a representative sample of the soil prior to construction. These tests can require up to one week to complete (depending on laboratory backlog) and this should be considered when coordinating the construction schedule to ensure that delays in construction or additional testing expense is not required due to laboratory processing times or rush processing fees.

3. The need for imported structural fill materials is not anticipated for this project; however, if during construction subgrade moistures preclude proper compaction of the bearing layer, a reinforcing geotextile and limited structural fill depth may be warranted to ensure proper foundation support. If needed, imported structural fill should be non-expansive, free of organics and debris, and conform to the material requirements outlined in Section 02234 of the Montana Public Works Standard Specifications (MPWSS). All gradations outlined in this standard are acceptable for use on this project; however, conventional proctor methods (outlined in ASTM D698)

shall not be used for any materials containing less than 70 percent passing the ¾-inch sieve. Conventional proctor methods are not suitable for these types of materials, and the field compaction value must be determined using a relative density test outlined in ASTM D4253-4254.

4. Develop and maintain site grades which will rapidly drain surface and roof runoff away from foundation and subgrade soils; both during and after construction. The final site grading shall conform to the grading plan, prepared by others to satisfy the minimum requirements of the applicable building codes.

5. At a minimum, downspouts from roof drains should discharge at least six feet away from the foundation or beyond the limits of foundation backfill, whichever is greater. All downspout discharge areas should be properly graded away from the structure to promote drainage and prevent ponding.

6. Irrigation around the perimeter of individual structures should be minimized. Landscaping around foundation walls should consider plant varieties that do not require significant irrigation such as drought-resistant species.

7. It is the responsibility of the Contractor to provide safe working conditions in connection with underground excavations. Temporary construction excavations greater than four feet in depth, which workers will enter, will be governed by OSHA guidelines given in 29 CFR, Part 1926. For planning purposes, subsoils encountered in the borings are considered Type B for the native clays and Type C for the weathered bedrock. The soil conditions on site can change due to changes in soil moisture or disturbances to the site prior to construction. Thus, the contractor is responsible to provide an OSHA knowledgeable individual during all excavation activities to regularly assess the soil conditions and ensure that all necessary safety precautions are implemented and followed.

5.2 Conventional Shallow Foundations

The design and construction criteria below should be observed for a spread footing foundation system. The construction details should be considered when preparing the project documents.

8. Both interior and exterior footings should bear on properly compacted native soils and should be designed for a maximum allowable soil bearing pressure not to exceed 1,500 pounds per square foot (psf) provided settlements as outlined in the Engineering Analysis are acceptable.

   If during construction subgrade moistures preclude proper compaction of the bearing layer and the requirements of Item 2a cannot be satisfied, a reinforcing geotextile and limited structural fill depth may be warranted to ensure proper foundation support. If encountered during construction, our geotechnical engineers should be involved to assess the subgrade soil and provide additional recommendations for modifications for structural fill inclusion.

9. Soils disturbed below the planned depths of footing excavations should either be re-compacted or be replaced with suitable compacted backfill approved by the geotechnical engineer.

10. Footings shall be sized to satisfy the minimum requirements of the applicable building codes while not exceeding the maximum allowable bearing pressure provided in Item 8 above.

11. Exterior footings and footings beneath unheated areas should be placed at least 48 inches below finished exterior grade for frost protection. For consideration, conventional full-depth basement foundations which bear 8 to 9 feet below grade are more likely to encounter ground water which can complicate construction. We are not aware of any ground water issues with the previous structure; however, the depth of footings for this structure are also unknown. The use of a partial basement with shallower footing depths would be advisable to alleviate significant ground water concerns.

12. Lateral loads are resisted by sliding friction between the footing base and the supporting soil and by lateral pressure against the footings opposing movement. For design purposes, a friction coefficient of 0.25 and a lateral resistance pressure of 150 psf per foot of depth are appropriate footings bearing on and backfilled with properly compacted native lean clay soils.

13. A representative of the project geotechnical engineer should be retained to observe all footing excavations and backfill phases prior to the placement of concrete formwork to verify that subgrade preparation conforms to the recommendations outlined above and that the subgrade can support the design bearing pressure.

5.3 Foundation Walls

The design and construction criteria presented below should be observed for foundation walls associated with either crawlspace or basement foundation systems. The construction details should be considered when preparing the project documents.

14. Crawlspace or basement walls which are laterally supported and can be expected to undergo only a slight amount of deflection should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 60 pcf for backfill consisting of properly compacted native lean clays.

15. If a crawlspace configuration is utilized, fill should be placed and compacted on the interior of the crawlspace to an elevation equal to the top of the exterior footings. This fill is intended to provide lateral support to the wall during exterior backfill and help reduce the potential for water accumulation in the crawlspace of exterior sources.

16. Backfill should be selected, placed, and compacted per Item 2 above. Care should be taken not to over-compact the backfill since this could cause excessive lateral pressure on the walls. Only hand-operated compaction equipment should be used within 5 feet of foundation walls.

17. Exterior footing drains are required by the applicable building codes for all structures incorporating a usable below-grade space such as a basement or crawlspace. Drains should consist of a minimum 3-inch diameter, geotextile-wrapped, flexible, slotted pipe (ADS) or perforated, SDR 35, 4-inch diameter, PVC drain tile in poorly-graded gravel with geotextile placed at or below exterior footing grade. Drains shall be covered by at least 12 inches of free-draining, open-graded, granular material. The open-graded granular material should be enveloped in a geotextile to prevent the migration of fines. Use of a single piece of geotextile with a full-width lap at the top is preferred; however, two separate pieces of fabric may be used provided a minimum overlap distance of 12 inches is maintained at all joints. Drains should be sloped to an interior sump or surface discharge location determined by others. A typical perimeter foundation drain is shown on Construction Standard No. 02801-06C.

18. Foundation walls for basement or crawlspace systems in which the footing elevation is no deeper than five feet below existing grades should de damp-proofed in accordance with the applicable sections of the International Building Code (IBC).

19. Basement foundation walls associated with a basement in which the footings bears more than five feet below existing grade should be water-proofed in accordance with the applicable sections of the International Building Code (IBC) due to the potential for ground water exposure associated with seasonal fluctuation.

5.4 Floor Slabs and Exterior Flatwork

20. For normally loaded, slab-on-grade construction, a minimum 6-inch cushion course consisting of free-draining, crushed gravel should be placed beneath the slabs and compacted to the requirements of Item 2 above.

21. Cushion course materials utilized beneath slab-on-grade applications should conform to the requirements outlined in Section 02235 of the Montana Public Works Standard Specifications (MPWSS). All gradation outlined in this specification are

acceptable for this application. Prior to placing the cushion course, the upper six inches of subgrade should be compacted per Item 2.

22. Concrete floor slabs should be designed using a modulus of vertical subgrade reaction no greater than 150 pci when designed and constructed as recommended above.

23. *Geotechnically*, an underslab vapor barrier is not required for surface slab applications. However, a vapor barrier is advised when a basement foundation bearing more than five feet below existing grade is used for this project. When utilized, a minimum 10-mil vapor barrier is recommended unless otherwise specified by the architect and/or structural engineer.

24. To minimize impacts to the interior finishes of the structure associated with potential expansive slab displacements, interior, non-bearing partition walls resting on floor slabs can be provided with slip joints so that potential slab movements cannot be transmitted to the upper structure. Slip joint construction consisting of fastening studs to the upper joists with lateral restraint at the bottom is preferred. A typical detail is shown on Construction Standard 02801-08.

5.5 Continuing Services

Three additional elements of geotechnical engineering service are important to the successful completion of this project.

25. Consultation between the geotechnical engineer and the design professionals during the design phases is highly recommended. This is important to ensure that the intentions of our recommendations are incorporated into the design, and that any changes in the design concept consider the geotechnical limitations dictated by the on-site subsurface soil and ground water conditions.

26. Observation, monitoring, and testing during construction is required to document the successful completion of all earthwork and foundation phases. A geotechnical engineer from our firm should be retained to observe the excavation, earthwork, and foundation phases of the work to determine that subsurface conditions are compatible with those used in the analysis and design.

27. During site grading, placement of all fill and backfill should be observed and tested to confirm that the specified density has been achieved. We recommend that the Owner maintain control of the construction quality control by retaining the services of an AASHTO accredited construction materials testing laboratory. TD&H Engineering operates a fully AASHTO accredited testing laboratory from our Great Falls office location and we are available to provide construction inspection services

as well as materials testing of compacted soils and the placement of Portland cement concrete for this project. In the absence of project specific testing frequencies, TD&H recommends the following minimum testing frequencies be used:

Compaction Testing

Beneath Column Footings	1 Test per Footing per Lift
Beneath Wall Footings	1 Test per 25 LF of Wall per Lift
Beneath Slabs	1 Test per 500 SF per Lift
Foundation Backfill	1 Test per 25 LF of Wall per Lift

LF = Lineal Feet SF = Square Feet

6.0 SUMMARY OF FIELD AND LABORATORY STUDIES

6.1 Field Explorations

The field exploration program was conducted on May 1, 2020. A total of four borings were drilled to depths ranging from 16.5 to 17.0 feet at the approximate locations shown on Figure 1 to observe subsurface soil and ground water conditions. The borings were advanced through the subsurface soils using a track-mounted Geoprobe 6610X drill rig equipped with 6-inch hollowstem augers which is owned and operated by TD&H Engineering. The subsurface exploration and sampling methods used are indicated on the attached boring logs. The borings were drilled by Mr. Craig Nadeau, PE and logged by Mr. Bill Colenso, EI of TD&H Engineering. The location of the borings were determined using field measurements to existing surface features. Elevations were subsequently estimated from existing topographic data provided by the architect for our use.

Samples of the subsurface materials were taken using 1⅜-inch I.D. split spoon samplers. The samplers were driven 18 inches, when possible, into the various strata using a 140-pound drop hammer falling 30 inches onto the drill rods. For each sample, the number of blows required to advance the sampler each successive six-inch increment was recorded, and the total number of blows required to advance the sampler the final 12 inches is termed the penetration resistance ("N-value"). This test is known as the Standard Penetration Test (SPT) described by ASTM D1586. When the sampler is driven more than 18 inches, the number of blows required to advance the sampler the second and third six-inch increments are used to determine the N-value. Penetration resistance values indicate the relative density of granular soils and the relative consistency of fine-grained soils. Samples were also obtained by hydraulically pushing a 3-inch I.D., thin-walled Shelby tube sampler into the subsoils. Logs of all soil borings, which include soil descriptions, sample depths, and penetration resistance values, are presented on the Figures 2 through 5.

Measurements to determine the presence and depth of ground water were made in the borings by lowering an electronic water sounder through the open boring shortly after the completion of drilling. The depths of the water levels measured, if encountered, and the date of measurement are shown on the boring logs.

6.2 Laboratory Testing

Samples obtained during the field exploration were returned to our materials laboratory where they were observed and visually classified in general accordance with ASTM D2487, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the engineering and physical properties of the soils in general accordance with ASTM or other approved procedures.

Tests Conducted:	To determine:
Natural Moisture Content	Representative moisture content of soil at the time of sampling.
Grain-Size Distribution	Particle size distribution of soil constituents describing the percentages of clay/silt, sand and gravel.
Atterberg Limits	A method of describing the effect of varying water content on the consistency and behavior of fine-grained soils.
Consolidation	Measurements of the percent compression experienced under various loading conditions. For use in settlement analysis and foundation design.
Constant Volume Swell	Determination of the maximum uplift force exerted by a soil specimen during inundation by gradual increases in the applied resisting force to maintain a fixed samples height.
UU Shear Strength (Field)	The undrained, unconfined shear strength (s_u) of cohesive soils as determined in the field by either a pocket penetrometer or a hand torvane.
Unconfined Compression	Undrained shear strength properties of cohesive soils determined in the laboratory by axial compression.

The laboratory testing program for this project consisted of 24 moisture-visual analyses, 3 sieve (grain-size distribution) analyses, and 3 Atterberg Limits analyses. The results of the water content analyses are presented on the boring logs, Figures 2 through 5. The grain-size distribution curves and Atterberg limits are presented on Figures 6 through 11. In addition, one consolidation test, one constant volume swell test, and two unconfined compression tests were performed. The results are presented on Figures 12 through 15. Unconfined compressive strengths (q_u) were determined in the field using a pocket penetrometer. The results are shown on the boring logs at the depths the samples were tested.

7.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The findings, analyses, and recommendations contained in this report reflect our professional opinion regarding potential impacts the subsurface conditions may have on the proposed project and are based on site conditions encountered. Our analysis assumes that the results of the exploratory borings are representative of the subsurface conditions throughout the site, that is, that the subsurface conditions everywhere are not significantly different from those disclosed by the subsurface study. Unanticipated soil conditions are commonly encountered and cannot be fully determined by a limited number of soil borings and laboratory analyses. Such unexpected conditions frequently require that some additional expenditures be made to obtain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

The recommendations contained within this report are based on the subsurface conditions observed in the borings and are subject to change pending observation of the actual subsurface conditions encountered during construction. TD&H cannot assume responsibility or liability for the recommendations provided if we are not provided the opportunity to perform limited construction inspection and confirm the engineering assumptions made during our analysis. A representative of TD&H should be retained to observe all construction activities associated with subgrade preparation, foundations, and other geotechnical aspects of the project to ensure the conditions encountered are consistent with our assumptions. Unforeseen conditions or undisclosed changes to the project parameters or site conditions may warrant modification to the project recommendations.

Long delays between the geotechnical investigation and the start of construction increase the potential for changes to the site and subsurface conditions which could impact the applicability of the recommendations provided. If site conditions have changed because of natural causes or construction operations at or adjacent to the site, TD&H should be retained to review the contents of this report to determine the applicability of the conclusions and recommendations provide considering the time lapse or changed conditions.

Misinterpretation of the geotechnical information by other design team members is possible and can result in costly issues during construction and with the final product. Our geotechnical engineers are available upon request to review those portions of the plans and specifications which pertain to earthwork and foundations to determine if they are consistent with our recommendations and to suggest necessary modifications as warranted. This service was not included in the original scope of the project and will require additional fees for the time required for specification and plan document review and comment. In addition, TD&H should be involved throughout the construction process to observe construction, particularly the placement and compaction of all fill, preparation of all foundations, and all other geotechnical aspects. Retaining the geotechnical engineer who prepared your geotechnical report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

This report was prepared for the exclusive use of the owner and architect and/or engineer in the design of the subject facility. It should be made available to prospective contractors and/or the contractor for information on factual data only and not as a warranty of subsurface conditions such as those interpreted from the boring logs and presented in discussions of subsurface conditions included in this report.

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