Applied
Geotechnical
Engineering
& Geologic Consulting

December 16, 2010
(Revised January 29, 2011)

Anderson Engineering of Minnesota, LLC
Attention: Gary Johnson, P.E.
13605 1st Avenue North, Suite 100
Plymouth, MN 55441

SUBJECT: Geotechnical Investigation
Proposed Administration, Maintenance and Vehicle Storage Buildings and Sanitary Sewer
Eagle Point National Cemetery
Eagle Point, Oregon

At your request, Applied Geotechnical Engineering and Geologic Consulting LLC (AGEGC) has conducted a geotechnical investigation for the proposed new buildings and sanitary sewer line at the Eagle Point National Cemetery in Eagle Point, Oregon. The approximate location of the site is shown on the Vicinity Map, Figure 1. The purpose of the investigation was to evaluate site conditions with respect to the proposed building development plans and develop guidelines and criteria for foundation design for the proposed buildings. Our investigation consisted of subsurface explorations, laboratory testing, and engineering analyses. This report summarizes our findings and presents our geotechnical recommendations for the proposed improvements.

PROJECT DESCRIPTION

We understand that a new vehicle storage building, a new maintenance building, and a new administration and public information building will be constructed on the southeastern portion of the Eagle Point National Cemetery. The approximate locations of the new buildings are shown on the Site Plan, Figure 2. We anticipate that foundations for the new buildings will consist of relatively-lightly loaded continuous spread footing foundations. Foundation loads have not been provided; however, we anticipate that all of the buildings will be relatively lightly loaded with column loads of less than 30 kips and continuous spread footing foundations of less than 5 kips/ft. We anticipate that both concrete slab-on-grade and post-and-beam floors may be used. Floors will be founded above adjacent final grades. A small retaining wall will be required as part of the development. We understand the retaining wall will be less than 10 ft high.

Site grading for this project will be relatively minor and include construction of the building pads for the new structures, parking areas, and concrete flatwork.

New paving for the project will include both asphaltic concrete (A.C.) pavements for the roadway and employee parking areas and concrete pavement for the new maintenance yard. Traffic for the new A.C. pavements will be typically lightly loaded and consist of passenger automobiles and small trucks. Traffic for the maintenance yard will include the equipment used for day-to-day operation of the cemetery which can include some relatively heavy tire loads from rubber-tired equipment. We also understand that some of the pavements will be underlain by underground storm water storage chambers. The intent of the chambers are to provide some storage and filtration during storm events. The chambers are open bottomed.

A new sanitary sewer may extend west past the new water reservoir on Riley Road and down to an existing subdivision downhill of the reservoir. The approximate alignment of the sewer is shown on the Site Plan, running from about the locations of boring B-4, boring B-2, boring B-16 and boring B-14.

SITE DESCRIPTION

The proposed building sites are currently occupied by the existing maintenance building, a gravel parking area, a trailer, and landscaping. Based on our experience with a previous expansion of the Eagle Point National Cemetery in the 1990's and our other experience in Eagle Point, the site is mantled with black clayey silt soil that is highly expansive and has a relatively low shear strength. Expansive clayey silt soils have significant changes in volume with a corresponding change in the natural moisture content and can cause severe damage to foundations and concrete flatwork. Based on historic and current site topographic maps, the majority of the northern portion of the proposed building areas has been graded, primarily with cut. The southern portion of the proposed building area is covered with scattered older oak trees, indicating this portion of the site has not been recently graded.

Portions of the proposed sanitary sewer alignment have been graded with significant fill. A disposal site for excavation spoils from the cemetery located on the northwestern side of the city's water reservoir has an estimated 10 to 15 ft of loose, uncompacted fill (at about the location marked boring B-2A on the Site Plan). The fill has been placed by end dumping the spoils over the existing fill slope. In addition, the relatively hummocky area along the western portion of the sewer alignment has also been graded with end dumped fill; however, in this area, the fill appears to be typically less than 5 ft thick. Outcrops of hard sandstone were not observed along the alignment; however, large fragments of hard sandstone were observed along Riley Road, probably excavated during installation of utilities along the road. On nearby projects, rock excavation methods (large trackhoes with rock buckets, rock saws, and hoe-rams) have been required to excavate the unweathered sandstone.

Significant groundwater seepage was observed by AGEGC in the ditch along Riley Road during our fieldwork in October 2010. In addition, vegetation indicative of shallow groundwater (including cattails) was observed on portions of the slope east of Riley Road, along the sanitary sewer alignment. The Medford Water Commission has an easement for a major, relatively old waterline located upslope of this area. There are limited irrigated areas upslope of the shallow groundwater areas. We also understand the cemetery's sewer drainfield is located to the northern end of where the seepage was observed by AGEGC.

SUBSURFACE EXPLORATIONS

General. On October 25 and 26, 2010, sixteen borings were completed for evaluation of subsurface conditions for this project including six borings (B-1 through B-4, B-14, and B-16) for the proposed sanitary sewer alignment, nine borings (borings B-5 through B-13) for the proposed building sites, and one boring (B-15) for an extension to the existing storm water sewer. Boring B-2A was not completed due to its location at an area of relatively thick non-structural fill (excavation spoils from the cemetery).

The approximate locations of the explorations are shown on the Site Plan, Figure 2. The locations of the explorations were staked in the field by Anderson Engineering. The borings were completed using solid-stem auger drilling methods and an ATV-mounted drill rig provided and operated by Lawrence and Associates of Redding, California. The subsurface explorations were observed by a licensed geotechnical engineer/geologist from our firm who maintained a detailed log of the conditions and materials encountered. Representative soil samples were collected and stored in air-tight containers for transfer to our laboratory.

The boring logs are provided in Appendix A at the end of this report. The terms used to describe the soil and rock materials are provided in Tables 1A and 2A in Appendix A.

Building Sites. The borings completed for the buildings encountered a variable thickness of clayey silt soils at the ground surface, depending somewhat on grading completed for previous phases at the cemetery. The clayey silt ranges up to about 7 ft thick and is black at the ground surface and becomes dark gray with depth. The clayey silt is highly expansive (has a high shrink-swell potential) with expansive index between 60 and 100% (ASTM D 4829). Soils with a high shrink-swell potential have significant volume changes with corresponding changes in the soil's moisture content and can cause significant damage to foundations and concrete flatwork. The black clayey silt soil is typically medium stiff to stiff based on typical N-values of between 3 and 9 blows/ft; however, the relative stiffness can vary greatly depending on the natural moisture content at the time of sampling.

The surficial clayey silt soils are underlain by a medium stiff to hard silt soil based on N-values typically between 10 and 30 blows/ft but had SPT values as low as 3 bows/ft and greater than 50 blows/6 in., indicating the consistency of the soil is highly variable. The silt has a variable clay and sand content with local zones having relict rock structure and is non-expansive. The silt is moderately to severely weathered sandstone and siltstone. The building borings were terminated in the silt at depths of 8 to 10 ft below existing grades. Practical refusal of the drill rig was not encountered in any of the borings.

Sanitary Sewer Alignment. The proposed sanitary sewer alignment crosses sections of variable subsurface conditions. All of the borings encountered the surficial, highly expansive clayey black silt soils. In the vicinity of the staked location for boring B-2A, the surficial soils consist of end-dumped excavation spoils from the cemetery. Between boring locations B-2 and B-3, the majority of the alignment is mantled with up to about 4 ft of end-dumped fill.

The borings for the sanitary sewer alignment encountered between 2 and 4.5 of clayey silt soils. The clayey silt is underlain by medium stiff to hard silt that grades to very hard silt (weathered sandstone and siltstone). The material becomes less weathered and harder with depth. Borings B-2, B-3, and B-16 encountered practical refusal of the drill rig on relatively hard (RH-2 to RH-3) sandstone at depths of 8, 9 and 5 ft, respectively.

Perched groundwater was observed in the boreholes B-14 and B-16 at a depth of about 6 and 3 ft respectively. We anticipate that the groundwater is due to seepage from irrigation of landscaped areas and/or leakage from the Medford Water Commission's water line that crosses the site upslope of the two borings.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this investigation and our experience with similar projects, it is our opinion that the site, from a geotechnical standpoint, is suitable for the proposed improvements. In our opinion, the most important geotechnical considerations associated with the proposed buildings and new sewer are the presence of uncontrolled fill, expansive soils, locally shallow sandstone, and locally shallow (perched) groundwater.

In our opinion, structural loads of the proposed buildings can be supported by conventional spread footing foundations. Our conclusions and recommendations concerning site preparation, earthwork, and design and construction of foundations, and sewer installation are summarized below.

Site Preparation for Building Foundations. In our opinion, the existing fill and clayey silt soils are not suitable for support of the proposed buildings foundations. The unsuitable soils should be overexcavated from the buildings footprint to a distance at least 3 ft beyond the edge of the structures. We recommend that the clayey silt soils be overexcavated from the building pads to a depth of 2 ft below the foundations. Locally deeper overexcavation may be required to remove tree stumps, roots greater than 1 in, in diameter and pockets of old fill. The excavated clayey silt soils and existing fill soils are not suitable for use as structural fill and should be removed from the site.

Subgrade in areas of overexcavation must be protected from disturbance due to construction activities and climate (wetting, drying, and/or freezing). The subgrade should be evaluated by the project geotechnical engineer prior to placement of structural fill on the native subgrade.

We recommend that the overexcavation of unsuitable soils be completed using a trackhoe equipped with a smooth-lip bucket. The overexcavation of the unsuitable soils and placement of the structural fill should be completed as one continuous operation (the subgrade should not be allowed to dry during earthwork operations).

Concrete Flatwork. The existing fill soils and expansive clayey silt soils are not suitable for direct support of concrete flatwork without excessive differential movement of the concrete. The unsuitable soils should be overexcavated within a horizontal distance of 12 in. of all concrete flatwork and to a maximum depth of 2 ft below the bottom of concrete. The excavated clayey silt soils and existing fill soils are not suitable for use as structural fill and should be removed from the site.

Subgrade in areas of overexcavation must be protected from disturbance due to construction activities and climate (wetting, drying, and/or freezing). The subgrade should be evaluated by the project geotechnical engineer prior to placement of structural fill on the native subgrade.

We recommend that the overexcavation of unsuitable soils be completed using a trackhoe equipped with a smooth-lip bucket. The overexcavation of the unsuitable soils and placement of the structural fill should be completed as one continuous operation (the subgrade should not be allowed to dry during earthwork operations).

Concrete flatwork should not be structurally connected to the buildings foundations or any other structures.

Structural Fills. All fill placed for the building pads and concrete flatwork should consist of imported granular fill. The fill should be compacted to at least 95% of the maximum dry density as determined by ASTM D 698. As discussed above, the clayey silt soils are not suitable for use as structural fill.

Structural fill for mass grading of the buildings building pads and concrete flatwork should consist of imported hard, angular (crushed) rock up to about 4 in. in size. The crushed rock for mass grading should have less than 12% passing the no. 200 sieve (washed analyses). Structural fill for fine-grading of the buildings building pads and under concrete flatwork can consist of crushed rock up to about 1 in. in size, such a ¾-in.-minus crushed rock. The crushed rock for fine-grading of the building pad should have less than 10% passing the no. 200 sieve (washed analyses).

Pavement Sections. New paving for the project will include both A.C. and concrete pavements. We have assumed traffic for both will be minimal and that the design life of the pavement will be based on environmental considerations including the subgrade soils. The pavements will be locally underlain by underground storm water storage chambers. The pavement sections assume a 20-year design life, a substantial section of good subgrade soils (no expansive soils as subgrade), construction in conformance with current Oregon Department of Transportation specifications, and the storm water detention system installed in accordance with the manufacturer's recommendations.

For new sections of A.C. pavement, we recommend 4 in. of A.C. over 8 in. of ¾-in.-minus crushed rock base course for the roadway sections and 3 in. of A.C. over 8 in. of ¾-in.-minus crushed rock base course for the parking areas. We anticipate that an additional 12 in. of overexcavation will be required to remove the majority of expansive soils from the pavement areas. The overexcavated material can be replaced with additional imported crushed rock. The aggregate base should be compacted to at least 95% of the maximum dry density as determined by AASHTO T-99 using a moderate-sized smooth-drum vibratory compactor. The imported crushed rock should be durable, well-graded, and up to 4 in. in size. This section of imported crushed rock can also consist of the imported crushed rock section required for the storm water storage system.

For the new concrete pavement section for the maintenance yard, we recommend a minimum section of 6 in. of reinforced concrete (3,000 psi minimum) over 6 in. of ¾-in.-minus crushed rock, over 12 in. of 4-in.-minus crushed rock. As an alternative crushed rock section, the entire 18-in.-thick aggregate base rock section can consist of ¾-in.-minus crushed rock. The ¾-in.-minus crushed rock should be well-graded with less than 10% passing the No. 200 sieve. The aggregate base should be compacted to at least 95% of the maximum dry density as determined by AASHTO T-99 using a moderate-sized smooth-drum vibratory compactor. The concrete should be reinforced with a minimum of No. 4 deformed steel bars placed on 12 in. spacing in both directions. The reinforcement should be approximately 2 in. from the bottom of the slab.

For installation of the new pavement sections, the existing subgrade soils should be overexcavated to the design subgrade elevation using a trackhoe equipped with a smooth-lip bucket. Subgrade soils that are disturbed by construction equipment prior to placement of the new crushed rock base course should be removed and replaced with additional crushed rock base course. Construction traffic should not traffic the exposed subgrade until the new crushed rock section is placed.

The above A.C. and concrete pavement sections assume dry weather construction conditions. The exposed subgrade soils should be protected from significant wetting and/or drying during excavation of the existing subgrade soil, prior to placement of the base course crushed rock. In our opinion, when protected from disturbance due to construction activity or wetting/drying, the existing subgrade soils are suitable for support of the above pavement sections without additional compaction or preparation.

Prior to placement of the crushed rock aggregate base, the subgrade should be evaluated by the project geotechnical engineer. The evaluation may include proof-rolling of the subgrade with a fully loaded dump truck. Areas of soft subgrade should be overexcavated a minimum of 6 in. and replaced with compacted crushed rock aggregate base.

The new pavement should be designed to prevent ponding of surface water on the pavement to reduce the frequency of major maintenance of the pavement. Positive drainage of the pavement will also reduce the risk of saturation of the aggregate base crushed rock. Where practical, we recommend a minimum slope of the pavement of 2% to prevent surface ponding. In addition, we recommend that the pavement be sloped away from travel lanes where practical. Sheet flow on the pavement should be limited to less than 200 ft.

To provide a 20-year design life for the new pavements, routine maintenance for the pavement should include periodically sealing areas of pavement with significant cracks. The intent of the sealant is to reduce the amount of surface water draining into the subgrade soils. Surface water draining into the subgrade results in areas of soft/weak subgrade under the pavement. Crack sealants can be used in the wider pavement cracks to prevent the majority of surface water infiltration. The cracks should be cleaned prior to placement of any sealant.

Foundation Support Recommendations. Based on the results of our investigation and our understanding of the proposed buildings, it is our opinion that foundation support for the proposed buildings can be provided by conventional wall-type (continuous) spread footing foundations and column foundations founded on a 24-in.-thick layer of imported granular fill. Footings should be established at a minimum depth of 18 in. below the lowest adjacent finished grade for exterior footings. The width of footings should not be less than 16 in. for continuous wall footings and 24 in. for column footings. All footing excavations should be observed by a qualified geotechnical engineer prior to placement of steel rebar and concrete.

For foundations founded on crushed rock fill, we estimate that the total, long-term settlement of spread footings designed in accordance with the above recommendations and imposing a real bearing pressure of up to 2,000 psf will be less than ¼ in. for continuous wall foundation and column loads.

For design purposes, the real bearing value refers to the total of dead load plus frequently and/or permanently applied live loads, and can be increased by one-third for the total of all loads; dead, live, and wind or seismic.

Lateral Earth Pressures. Design lateral earth pressures for embedded walls depend on the type of construction, i.e., the ability of the wall to yield and whether the wall is drained. Possible conditions are: 1) a wall which is laterally supported at its base and top and therefore is unable to yield, and 2) a conventional cantilevered retaining wall that yields by tilting about its base. For design purposes, cantilevered retaining walls are typically assumed to be yielding.

For drained conditions and yielding retaining wall conditions, the new cemetery retaining walls can be designed based on an equivalent fluid pressure of 35 pcf. These design criteria assume the wall will be backfilled within 2 ft of the back of the wall with relatively clean (less than 10% passing the No. 200 sieve – washed analysis) granular fill. A non-woven geotextile (minimum 5 oz weight) should be placed between any drain material and any soil classified as sand or finer. The backfill should be placed in horizontal lifts not to exceed 12 in. (loose) and compacted to about 93% of the maximum dry density as determined by ASTM D 698. Overcompaction of the backfill should be avoided, and heavy compactors and large pieces of construction equipment should not operate within 10 ft of embedded walls. Compaction within 10 ft of the walls should be accomplished using hand-operated compactors.

Lateral Load Resistance. Horizontal shear forces on spread footing foundations (building and retaining wall foundations) can be resisted by frictional forces developed between the base of spread footings and the underlying soil. The total frictional resistance between the footing and the soil is the normal force times the coefficient of friction between the soil and the base of the footing. We recommend an ultimate value of 0.4 for the coefficient of friction; the normal force is the sum of the vertical forces (dead load plus real live load). If additional lateral resistance is required, passive earth resistance against embedded footings or walls can be computed using a pressure based on an equivalent fluid with a unit weight of 300 pcf. This design passive earth pressure is appropriate only if granular structural fill is to be used for the backfill around footings.

Slab-on-Grade Floor Support and Drainage. To provide uniform floor support, all slab-on-grade floors should be underlain by a minimum 24-in.-thick granular base course placed as structural fill. To provide a vapor break under the floor slab, the upper 8 in. of the granular base should consist of angular crushed rock up to 1 in. in size with not more than about 2% passing the No. 200 sieve (washed analysis).

Crushed rock of ¾- to ¼-in. gradation is suitable for this purpose. Typically, a small dozer is used to spread and level the rock prior to placement of steel reinforcement for the slab-on-grade. The base course material should be installed in at least three lifts and compacted until well-keyed, using a minimum of four passes with a moderate-sized, smooth-drum vibratory roller. To facilitate compaction of the granular base and limit contamination from construction activities prior to placing the concrete slab, the upper 2 in. of the open-graded base course material is typically replaced with ¾-in.-minus crushed rock having less than 5% passing the No. 200 sieve (washed analysis).

In moisture-sensitive floor areas, such as those to be covered with vinyl flooring or carpet, or where moisture-sensitive material may be stored directly on the concrete floor slab, we recommend installation of a vapor-retarding membrane beneath the slab-on-grade floor. Vapor-retarding membranes should be installed in accordance with the manufacturer's recommendations.

Seismic Considerations. The foundations for the new buildings will be founded on compacted fill on very stiff subgrade soils at relatively shallow depths (weathered sandstone at less than 20 ft). In our opinion, the subsurface conditions at this site may be classified as a Site Class C for seismic design purposes.

Based on the results of our investigation, the location of the site, and the nature of the underlying soil/rock, we anticipate that the potential for earthquake-induced fault displacement, subsidence, liquefaction-induced settlement and/or lateral displacement, or seiches at this site is low.

Rock Excavation. We understand that excavations of up to 15 ft deep may be required for installation of the sanitary sewer west of the building sites; however, we understand the majority of the sewer will be installed at depths of less than 8 ft. In our opinion, the risk of encountering hard sandstone rock that can't be excavated with a large trackhoe with rock bucket is low.

Utility Trenches. All utility trench excavations should be backfilled with relatively clean, granular material, such as sand, sandy gravel, or crushed rock of up to 2-in. maximum size and having less than 5% passing the No. 200 sieve (washed analysis). In our opinion, ¾-in.-minus crushed rock would be suitable for this purpose. The granular backfill material should be compacted to at least 95% of the maximum dry density as determined by ASTM D 698 in the upper 5 ft of the trench and to at least 90% of this density below a depth of 5 ft.

The sanitary sewer line should be installed below the loose, non-structural fill observed during our fieldwork. This includes around the locations marked B-2A on the site plan (the cemetery's excavation spoils disposal area) and boring B-3. On grades steeper than 5%, the sanitary sewer should also be installed so the base of the excavation is located below the surficial clayey silt soils (at depths of greater than 4 ft). The intent of the deeper installation is to reduce the risk of soil creep causing stresses in the pipe which may result in pulling the pipe apart.

Check dams should be installed in utility trenches installed with gradients of greater than 5%, on slopes of greater than 10%, or in areas with significant groundwater seepage. In this regard, we recommend seepage dams be installed on a 100-ft-spacing between borings B-1 and B-14. Seepage dams should consist of concrete section approximately 18 in. wide installed perpendicular to the trench. The dams should extend from the bottom of the trench to within 12 in. of the ground surface. The intent of the dam is to reduce groundwater seepage along trenches which can result in excessive pore water pressures in lower sections of the trench and at manholes.

Trench excavation safety is the responsibility of the pipeline contractor; however, we anticipate that areas of the deeper trench (sections typically greater than 4 ft deep) will need shoring or benching for safe working conditions. Areas with groundwater seepage and/or uncontrolled fill will likely need the entire depth shored and/or trenched.

Utility trenches deeper than about 6 ft will likely encounter perched groundwater, especially adjacent to Riley Road. Along Riley Road and upslope from Riley Road, groundwater may be encountered at even less than 6 ft deep. Where encountered, we anticipate that groundwater can be controlled by a system of sumps placed in the utility trenches or by installing the utilities starting at the downhill end and allowing gravity drainage from the trench, or a combination of the two drainage methods.

Construction Observation Services. In our opinion, construction operations dealing with earthwork and foundations should be observed by a qualified geotechnical engineer. Due to previous work at the site, including mass grading, subsurface conditions can vary from those typically encountered in undisturbed, native ground. Construction engineering for the geotechnical engineer of record should include overexcavation of unsuitable soils for building pads, placement and compaction of structural fill, and foundation subgrade. AGEGC would be pleased to provide these services. If we do not have the opportunity to confirm our interpretations, assumptions, and analyses during construction, we cannot be responsible for the application of our recommendations to subsurface conditions that are different from those described in this report.

LIMITATIONS

This report has been prepared to aid in the evaluation of this site and to assist the project engineers in the engineering design for the proposed Eagle Point National Cemetery improvements. The scope is limited to the specific improvements and locations described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the design and construction of the proposed cemetery improvements. In the event that any changes in the design and location of the cemetery improvements, as outlined in this report, are planned, we should be given the opportunity to review the changes and to modify or reaffirm the conclusions and recommendations of this report in writing.

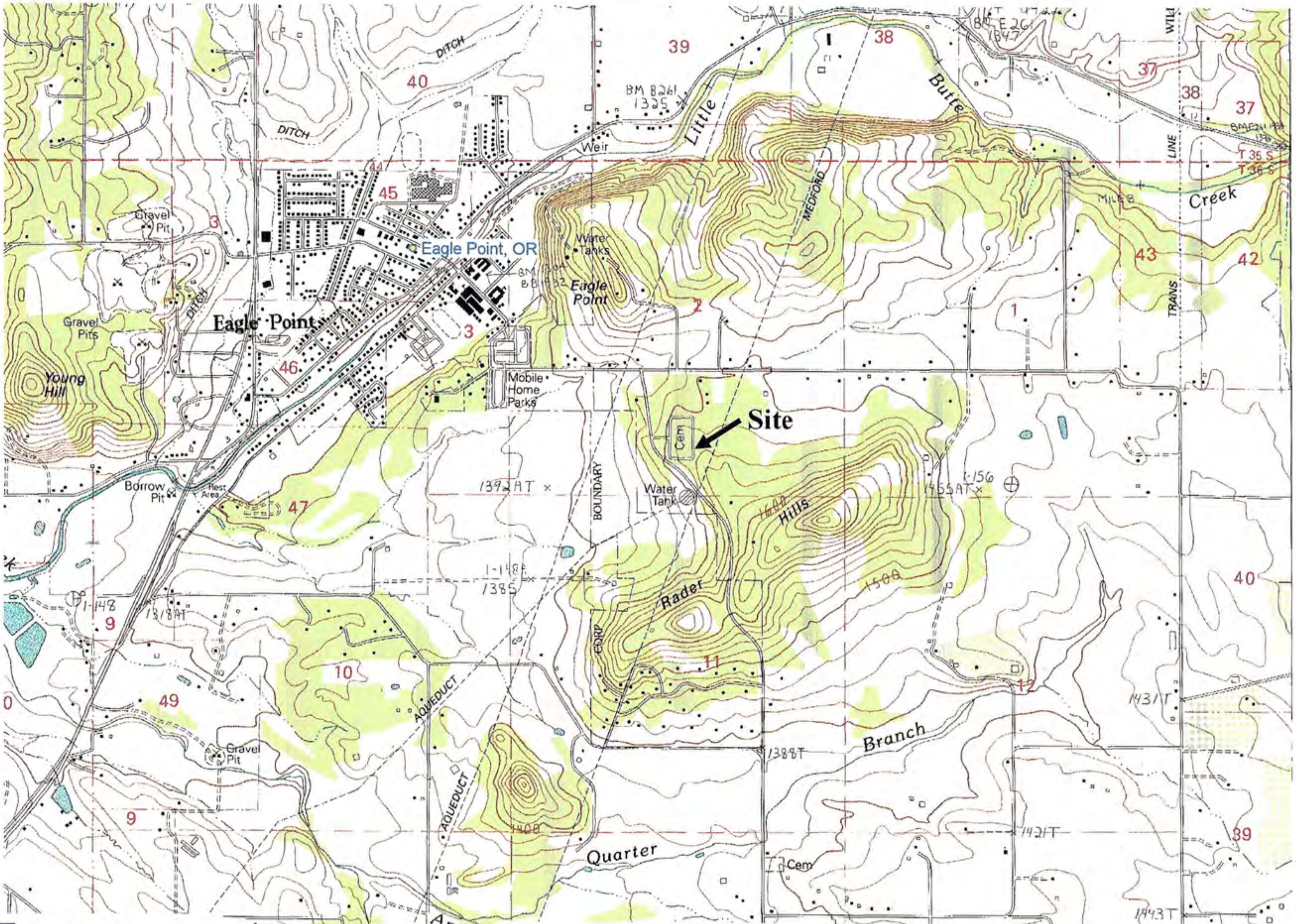
The conclusions and recommendations submitted in this report are based on the data obtained from the subsurface explorations completed at the locations discussed in this report and from other sources of information discussed in this report. In the performance of subsurface investigations, specific information is obtained at specific locations at specific times. However, it is acknowledged that variations in soil, rock, and groundwater conditions exist between exploration locations. This report does not reflect any variations which may occur between these explorations. The nature and extent of variation may not become evident until construction. If, during construction, subsurface conditions different from those encountered in the explorations are observed or encountered, we should be advised at once so that we can observe and review these conditions and reconsider our recommendations where necessary.

Please contact AGEGC if you have any questions or require additional information.

Sincerely,
Applied Geotechnical Engineering and Geologic Consulting LLC

Robin L. Warren, P.E., G.E., R.G.
Principal

Renewal: June 2012



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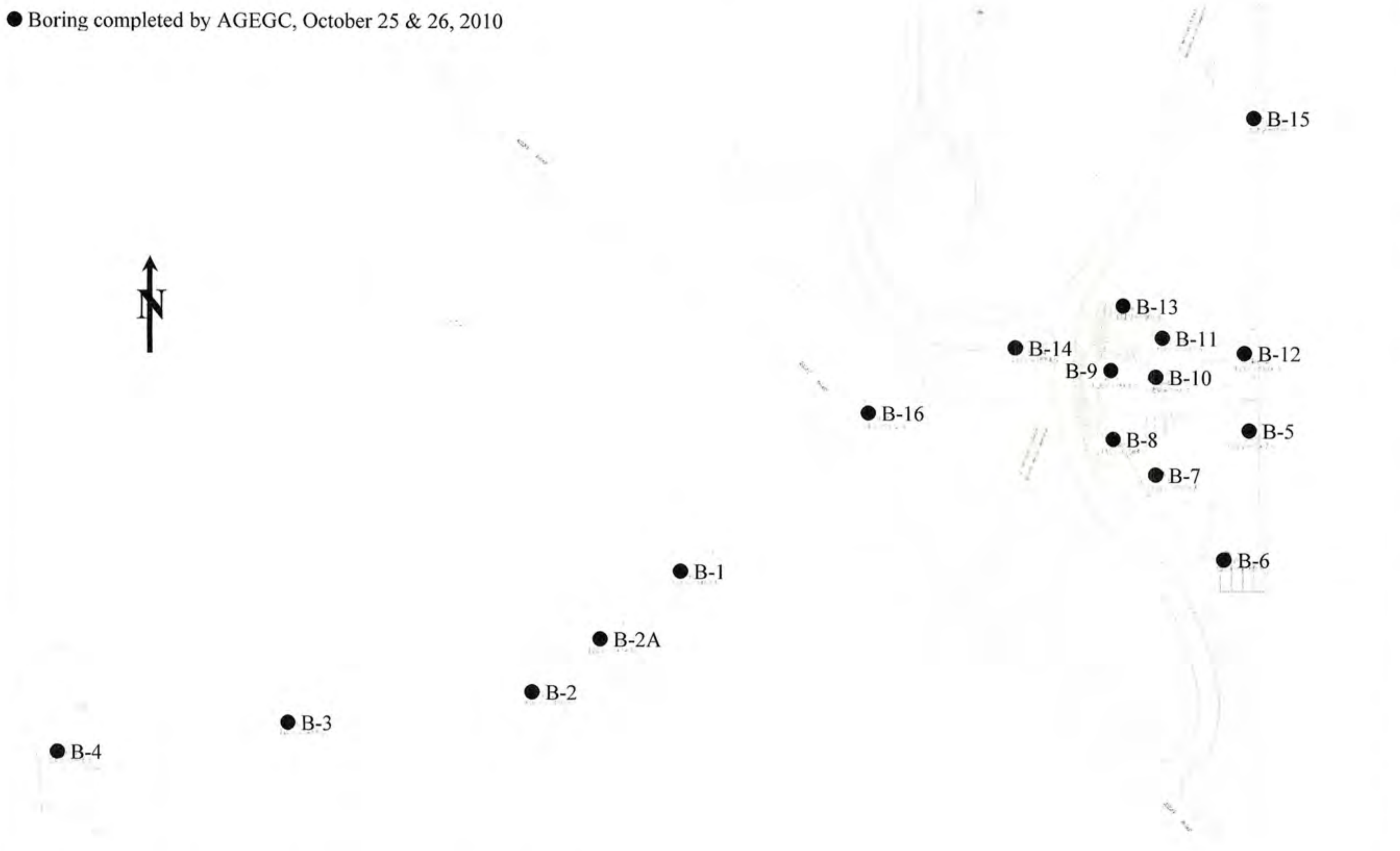
Vicinity Map
Figure 1

Project No. 3268
Eagle Point National Cemetery
Administration Building
Eagle Point, Oregon
January 2011



Site Map provided by Anderson Engineering of Minnesota,LLC

Applied Geotechnical Engineering & Geologic Consulting

Figure 2
Site Plan

Project No. 3268
Eagle Point Cemetery
Administration Building
Eagle Point, Oregon
January 2011

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

General. Subsurface materials and conditions for the proposed cemetery improvements were investigated on October 25 and 26, 2010, with sixteen borings. The locations of the borings were staked prior to our fieldwork by Anderson Engineering. The approximate locations of the borings are shown on the Site Plan, Figure 2.

Borings. The borings were drilled using solid-stem auger techniques with an ATV-mounted drill rig provided and operated by Lawrence and Associates of Redding, California. All field operations were observed by a licensed geotechnical engineer provided by our firm, who maintained a detailed log of the materials and conditions encountered in the borings and directed the sampling operations.

Soil samples were obtained from the borings at 4-ft-intervals (the drill rod lengths). The soil samples were obtained using a standard split-spoon sampler. The Standard Penetration Test was conducted at the time of sampling. This test consists of driving a standard split-spoon sampler into the soil a distance of 18 in. using a 140-lb hammer dropped 30 in. The number of blows required to drive the sampler the last 12 in. is known as the Standard Penetration Resistance or N-value. The N-values provide a measure of the relative density of granular soils, such as sand, and the relative consistency, or stiffness, of cohesive soils, such as silt. The soil samples obtained from the split-spoon sampler were carefully examined in the field and representative portions were saved in airtight containers for further examination and physical testing in our laboratory.

Logs of the borings are provided at the end of Appendix A. Each log presents a descriptive summary of the materials and conditions encountered in the boring. The interval and type of samples taken during the drilling operation are shown to the right of the descriptive summary. The N-values from the SPT are also shown. The terms used to describe the materials encountered in the borings are defined in Tables 1A and 2A.

BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-1	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–3.5		Medium stiff, black clayey SILT; gray below 1 ft.
X	12		3.5–8 (5)		Medium stiff, brown SILT; trace clay and fine sand.
X	18/33/50 for 4in		8–9.3		Hard, brown SILT; trace clay, relict sandstone structure.

Depth scale: 5, 10, 15, 20, 25, 30, 35

Completion Notes:
Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 26, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-2	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–3		Medium stiff, black clayey SILT; gray below 1 ft, scattered rounded and subrounded basalt cobble.
	39/50 for 3 in.		3–8		Very stiff to hard, dark brown SILT; trace clay, relict sandstone structure.
	50 for 2 in.				

Depth scale: 5, 10, 15, 20, 25, 30, 35

Completion Notes:

Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 26, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-3	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–4.5		Medium stiff, black clayey SILT; gray below 1 ft.
X	26		5		Medium stiff, brown SILT; trace clay and fine sand, relict sandstone structure.
X	11/50 for 6in.				Hard, brown SILT; trace clay, relict sandstone structure.
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes: Undefined	Site: Eagle Point National Cemetery Eagle Point, Oregon
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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 26, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-4	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
					Medium stiff, black clayey SILT.
					Medium stiff, brown SILT; some clay to clayey, relict siltstone structure.
	69		5		
	21/27/50 for 6in.				Soft (RH-1) SILTSTONE; consistency of a hard soil.
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:
Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client: Anderson Eng.	Boring Number: B-5	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–2		Medium stiff, black clayey SILT.
			2–4		Medium stiff, brown SILT; some clay to clayey.
X	31		5		Very stiff, brown SILT; trace clay.
X	22		9.5		
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:
Undefined

Site:
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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-6	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
					Medium stiff, black clayey SILT.
					Medium stiff, brown clayey SILT.
					Medium stiff, brown SILT; trace clay.
	16/36/50at5"		5		
					Hard brown SILT; trace clay and fine sand, relict sandstone structure.
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:

Undefined

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Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-7	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–2		FILL: medium dense brown silty GRAVEL; 3 in. asphaltic concrete at ground surface.
			2–5		Medium stiff, gray clayey SILT.
X	9		5		
			5–8		Medium stiff, brown SILT; trace clay and fine sand.
X	52		8–9.5		Very stiff, dark brown SILT; trace clay, relict sandstone structure.

Depth scale: 5, 10, 15, 20, 25, 30, 35

Completion Notes:

Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-8	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0		Medium stiff, black clayey SILT; gray below 1 ft.
X	23		5		Very stiff to hard, dark brown SILT; trace clay, relict sandstone structure.
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:

Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-9	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0		Medium stiff, black clayey SILT; gray below 1 ft.
X	32		5		Very stiff to hard, brown SILT; trace clay, some sand to sandy, relict sandstone structure.
X	42				
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:

Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-10	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–6.5		Medium stiff, black clayey SILT; becomes gray below 1 ft, possible fill to 6.5 ft.
X	3		5		
			6.5–10		Medium stiff, brown SILT; trace to some clay.
X	6				
			10–13.5		Very stiff to hard, brown SILT; trace to some fine sand, trace clay.
X	42				

Depth scale: 5, 10, 15, 20, 25, 30, 35

Completion Notes:

Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-11	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0		Medium stiff, black clayey SILT.
					Medium stiff, brown SILT; trace clay, some fine sand.
					Medium stiff, brown clayey SILT; moderately expansive.
X	9		5		
					Very stiff to hard, reddish brown SILT; trace clay, trace sand, relict sandstone structure.
X	68				
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:

Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-12	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–1		Medium stiff, black clayey SILT.
X	10		1–6 (5)		Medium stiff, gray clayey SILT; moderately expansive.
X	38		6–9.5		Very stiff to hard, light gray SILT; trace clay, trace sand.
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:

Undefined

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-13	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–1		Medium stiff, black clayey SILT.
			1–4		Medium stiff, brown SILT; some clay to clayey.
X	28		5		Very stiff to hard, brown SILT; trace clay.
X	32				
			10		
			15		
			20		
			25		
			30		
			35		

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client: Anderson Eng.	Boring Number: B-14	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–7		FILL: Soft to medium stiff, black clayey SILT; gray below 1 ft.
X	4		5		
			7–8		Medium stiff, gray clayey SILT.
X	24		8–9.5		Very stiff to hard, brown SILT; trace clay, some sand, relict sandstone structure.
			10		
			15		
			20		
			25		
			30		
			35		

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	BORING LOG		
	Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
	Client Anderson Eng.	Boring Number: B-15	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–1		Medium stiff, black clayey SILT.
			1–3		Medium stiff, gray clayey SILT.
X	42		3–6		Very stiff, reddish-brown SILT; trace clay, relict siltstone structure.
X	49		6–9		Hard, dark gray clayey SILT; weathered claystone.
			9–9.5		Hard, gray mottled brown SILT; trace clay and fine sand, relict sandstone structure.

Depth scale: 5, 10, 15, 20, 25, 30, 35

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BORING LOG

Drill Rig: ATV	Date Drilled: Oct 25, 2010	Logged By:
Client Anderson Eng.	Boring Number: B-16	Robin Warren, PE

Sample	Blow Counts	Moisture %	Depth Feet	Lithology	Description
			0–3		Soft to medium stiff, black clayey SILT; gray below 1 ft, scattered angular sandstone cobble and small boulder at the ground surface.
			3–5		Medium stiff, brown SILT; trace to some fine sand.
			5		Medium hard, brown SANDSTONE; practical refusal of drill rig on sandstone.
			10		
			15		
			20		
			25		
			30		
			35		

Completion Notes:

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TABLE 1A: SOIL DESCRIPTION TERMINOLOGY

Coarse-Grained Soils (Sand Size and Larger)

Relative Density	Standard Penetration Resistance (N-Values)
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-Value)	Torvane Undrained Shear Strength, tsf	Field Identification
Very Soft	2	Less than 0.125	• Easily penetrated by fist.
Soft	2-4	0.125-0.25	• Easily penetrated by thumb.
Medium Stiff	5-8	0.25-0.50	• Penetrated by thumb with moderate effort.
Stiff	9-15	0.50-1.0	• Readily indented by thumb but penetrated only with great effort.
Very Stiff	16-30	1.0-2.0	• Readily indented by thumbnail.
Hard	Over 30	Over 2.0	• Indented with difficulty by thumbnail.

Grain Shape

Term	Description
Angular	Corners and edges sharp.
Subangular	Corners worn off, angles not worn off
Subrounded	Corners and angles worn off, flat surfaces remain.
Rounded	Worn to almost spherical shape.

Grain Size Classification

Boulders	6 to 36 inches
Cobbles	3 to 6 inches
Gravel	¼-¾ inch (fine)
	¾-3 inches (coarse)
Sand	No. 200-No. 40 sieve (fine)
	No. 40-No. 10 sieve (medium)
	No. 10-No. 4 sieve (coarse)
Silt/Clay	Pass No. 200 sieve

Modifier for Subclassification

Adjective	Percentage of Other Material in Total Sample
Clean	0 – 1.5
Trace	1.5 - 10
Some	10 - 30
Sandy, Silty, or Clayey	30 - 50

TABLE 2A: ROCK DESCRIPTION TERMINOLOGY

Scale of Rock Hardness (After Panama Canal Company, 1959)

RH-1	Soft	Slightly harder than very hard over-burden, rock-like character, but crumbles or breaks easily by hand.
RH-1	Medium Soft	Cannot be crumbled between fingers but can be easily picked with light blows of the geology hammer.
RH-2	Medium Hard	Can be picked with moderate blows of geology hammer. Can be cut with knife.
RH-3	Hard	Cannot be picked with geology hammer but can be chipped with moderate blows of the hammer.
RH-4	Very Hard	Chips can be broken off only with heavy blows of the geology hammer.

Terms Used to Describe the Degree of Weathering

Descriptive Term	Defining Characteristics
Fresh	Rock is unstained. May be fractured but discontinuities are not stained.
Slight	Rock is unstained. Discontinuities show some staining on their surface but discoloration does not penetrate rock mass.
Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.
High	Individual rock fragments are thoroughly stained and can be crushed with pressure hammer. Discontinuous surfaces are thoroughly stained and may be crumbly.
Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.

Thickness of Bedding

Massive	Beds are 3 feet thick or greater.
Thick Bedding	Beds from 1 to 3 feet thick.
Medium Bedded	Beds from 4 inch to 1 feet thick.
Thin Bedded	Beds less than 4 inch thick.