AGEC

Applied GeoTech

GEOTECHNICAL INVESTIGATION

PROPOSED 1800 NORTH ROAD

APPROXIMATELY 850 WEST TO 1000 WEST

LOGAN, UTAH

PREPARED FOR:

CITY OF LOGAN
290 NORTH 100 WEST
LOGAN, UTAH 84321

ATTENTION: JUSTIN MAUGHAN

PROJECT NO. 1130124 **APRIL 16, 2013**

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EXECUTIVE SUMMARY

1. The natural subsurface materials encountered at the site consist of approximately 1 to 3 feet of topsoil and/or peat overlying lean and fat clay to depths of approximately 8 and 10½ feet below the ground surface in Borings B-1 and B-2, respectively. Interlayered clay and sand was encountered below the clay extending the full depth investigated, approximately 10½ feet below the ground surface in Boring B-1. Fill was encountered in the upper 1 foot in Boring B-1.

2. Subsurface water was measured at depths of approximately 2 and 1½ feet below the ground surface in Borings B-1 and B-2, respectively, based on measurements taken 12 days after the borings were drilled.

3. Four traffic conditions were assumed to calculate pavement thicknesses. The assumed traffic conditions are presented in the Proposed Construction section of this report and recommended pavement thicknesses for these traffic conditions are presented in the Pavement section of this report.

4. The natural soil below the topsoil and peat consists of clay with high moisture content. Construction access difficulties can be expected for rubber-tired construction equipment at the site. Placement of approximately 1½ to 2½ feet of granular fill may be needed where the subgrade consists of very moist to wet clay. A separation fabric may be placed between the natural soil and granular fill to facilitate construction.

5. Shallow groundwater conditions were encountered at the site at the time of our field investigation. Dewatering and shoring should be included in construction planning. Free-draining gravel should be used as fill below the original subsurface water level.

6. The natural soil or properly compacted bedding material is suitable to support the proposed sewer and water lines. Precautions should be taken during construction, excavation and dewatering to minimize the disturbance of the natural soil to remain below the proposed pipe.

7. The natural soil is not recommended for reuse as backfill above the pipe zone due to the clay content and shallow groundwater conditions. Imported backfill should be included in construction planning.

8. Geotechnical information related to subgrade preparation, excavation, pavement materials, compaction, and utility construction is included in the report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed 1800 North road to be constructed between approximately 850 West and 1000 West in Logan, Utah. The locations of the exploratory borings drilled along the proposed alignment are shown on Figure 1. The report presents the subsurface conditions encountered, laboratory test results and recommendations for the proposed pavement. The study was conducted in general accordance with our proposal dated February 15, 2013.

Field exploration was conducted to obtain information on the subsurface conditions. Samples obtained from the field investigation were tested in the laboratory to determine physical and engineering characteristics of the on-site soil. Information obtained from the field and laboratory was used to define the conditions at the site for our engineering analysis and to develop recommendations for the proposed pavement.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

SITE CONDITIONS

The site consists of a narrow strip of land extending in an east/west direction between the end of pavement at the Campbell Scientific building at approximately 815 West and 1000 West in Logan, Utah. The site extends through undeveloped fields or pasture. A small, unlined ditch extends along the south and west edges of the proposed roadway alignment. There was approximately 1 foot of water in the ditch at the time of our field investigation, flowing in an east to west direction. The eastern portion of the site within approximately 75 feet of the 1800 North end of pavement, has been raised approximately 2 feet above

the surrounding ground surface and likely consists of fill that was extended onto the site as part of the original construction of 1800 North. There are overhead power lines along the south and west edges of the roadway alignment. There are wire fences along the north and south edges of the roadway alignment.

Vegetation at the site consists of grass and weeds. Portions of the site contain wetlands as outlined in the Wetland Delineation report prepared for, and provided by, the City of Logan.

The ground surface at the site slopes gently down to the west.

West of the site is1000 West which currently consists of a three-lane, asphaltic concrete-paved road, in good condition. UDOT is in the process of reconstructing 1000 West into a four-lane, Portland cement concrete-paved road. The existing portion of 1800 North, at the east end of the site, consists of a two-lane, asphaltic concrete-paved road in good condition. The areas to the north and south of the site consist of undeveloped pastures and wetland areas similar to the site.

FIELD STUDY

The field study was conducted on March 20, 2013. Two borings were drilled at the approximate locations indicated on Figure 1 using a truck-mounted drill rig. The borings extended approximately 10 feet below the ground surface. The borings were logged and soil samples obtained by a representative of AGEC. Logs of the subsurface conditions encountered in the borings are graphically shown on Figure 2.

SUBSURFACE CONDITIONS

The natural subsurface materials encountered at the site consist of approximately 1 to 3 feet of topsoil and/or peat overlying lean and fat clay to depths of approximately 8 and 10½ feet below the ground surface in Borings B-1 and B-2, respectively. Interlayered clay and sand was encountered below the clay extending the full depth investigated, approximately 10½ feet below the ground surface in Boring B-1. Fill was encountered in the upper 1 foot in Boring B-1.

A description of the various materials encountered in the borings follows:

Fill - The fill consists of clayey gravel with sand. It is moist to very moist and brown.

Topsoil - The topsoil consists of lean clay with sand. It is very moist, dark brown and contains roots and organics.

Peat - The peat is soft, very moist, dark brown to black and consists primarily of roots and organic material.

Fat Clay - The clay is stiff to soft, moist to wet and light brown to blue-gray.

Results of laboratory tests conducted on samples of the clay indicate natural moisture contents of 25 and 37 percent and natural dry densities of 99 and 83 pounds per cubic foot (pcf). The results of laboratory tests conducted on two samples of the clay also indicate 98 percent passing the No. 200 sieve. The results of the Atterberg limits laboratory tests indicate a liquid limit of 50 percent and a plasticity index of 33 percent for the clay sample obtained from a depth of approximately 4 feet in Boring B-1. The clay, at a depth of approximately 2 feet in Boring B-2, was found to have a liquid limit of 67 percent and a plasticity index of 42 percent.

Lean Clay and Silty Sand - The clay and sand is interlayered. It is soft, loose, wet and light blue-gray to gray.

Results of the laboratory tests are summarized on Table I and are included on the logs of the borings.

SUBSURFACE WATER

Subsurface water was measured at depths of approximately 2 and 1½ feet below the ground surface in Boringf B-1 and B-2, respectively, based on measurements conducted 12 days after drilling. Fluctuations in the water level will occur over time. The evaluation of water level fluctuations is beyond the scope of this report. Generally, the water levels are expected to be highest in the spring and summer and lowest in the fall and winter.

PROPOSED CONSTRUCTION

We understand that a new road will be constructed at the site. The road will have a length of approximately 750 feet. The proposed road is planned to extend across delineated wetlands at the site.

Logan City indicates that their master plan designates 1800 North as a Collector and projects 15,000 vehicles per day for two-way traffic. However, Logan City does not currently have specific traffic projections for 1800 North at this location. The following are four assumed traffic conditions for determining pavement thickness presented in the Pavement section of this report. The traffic conditions are assumed for a two-lane road and represent daily, two-way traffic.

Traffic Condition	Passenger Vehicles per day	Buses and Garbage Trucks per day	Delivery Vehicles per day	Semi-Tractor Trailer Trucks per day
I	2,000	4	10	50
II	3,000	7	60	160
III	8,000	18	160	400
IV	15,000	35	300	750

If the expected traffic is significantly different from what is described above, we should be notified to reevaluate the recommendations given. Additional traffic conditions and associated pavement thicknesses can also be provided as traffic data becomes available or as requested.

We understand that sewer and water utilities will also be constructed in the roadway alignment. The excavation depth for the pipe installation is expected to be approximately 8 feet for the sewer and 5 feet for the water utility.

PAVEMENT RECOMMENDATIONS

Based on the subsurface conditions encountered, laboratory test results and the assumed traffic for the road, the following recommendations are given:

A. Site Grading

1. Subgrade Preparation

   Prior to placing grading fill or base course, topsoil, organics, debris, inadequately compacted fill and other deleterious material should be removed. The subgrade should be cut to the undisturbed natural soil. Care should be

taken to minimize disturbance of the subgrade. Consideration should be given to using excavation equipment with a smooth cutting blade. Disturbed areas of the subgrade should be removed and replaced with granular fill consisting predominantly of gravel and containing less than 15 percent passing the No. 200 sieve.

The existing natural soil at the site consists of clay with a high moisture content. The clay may result in access difficulties for rubber-tired construction equipment. It may be necessary to place approximately 1½ to 2½ feet of granular borrow above the subgrade in areas of construction traffic to provide access and a working service for construction of the pavement. A separation fabric may be used between the granular fill and natural clay subgrade.

2. Excavation

Excavation at the site can be accomplished with tracked excavation equipment. If excavation extends below the subsurface water level, the excavation should be dewatered. Free-draining gravel should be used as fill below the original subsurface water level.

3. Compaction

Fill and utility-trench backfill placed to support proposed roads should be compacted to at least 90 percent of the maximum dry density as determined by ASTM D 1557. Base course should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D 1557. Fill consisting of free-draining gravel placed to support the proposed road should be placed in lifts and densified using vibratory compaction equipment.

To facilitate the compaction process, the fill, granular borrow and base course should be compacted at a moisture content within 2 percent of the optimum moisture content.

Fill and pavement materials should be frequently tested for compaction during construction.

4. Materials

The natural soil is not recommended for use as fill to support the proposed road due to the shallow depth of water and the clay content of the soil.

Granular borrow, base course and pavement materials should meet the requirements of the applicable jurisdiction for gradation and quality.

5. Drainage

The collection and diversion of drainage away from the pavement surface is important to the satisfactory performance of the pavement section. Proper drainage should be provided.

B. Pavement

1. Subgrade Support

The near surface soil consists of clay. We have used a CBR value of 2 percent in our analysis based on the results of field dynamic cone penetrometer (DCP) tests and the type of soil encountered in the borings. Results of the DCP tests are included at the end of this report.

2. Pavement Thickness

Based on the subsurface conditions encountered, laboratory test results, a design life of 20 years for flexible and 30 years for rigid pavement and

methods presented by the Utah Department of Transportation, the following pavement sections are calculated:

	Rigid Pavement	Flexible Pavement		
Traffic Condition *	Portland Cement Concrete Thickness (inches)	Asphaltic Concrete Thickness (inches)	Base Course Thickness (inches)	Granular Borrow Thickness (inches)
I	8	-	6	-
		5½	6	24
		5½	26	-
II	9	-	7	-
		6½	7	28
		6½	29	-
III	10½	-	8	-
		7½	8	31
		7½	33	-
IV	11½	-	8	-
		8½	8	32
		8½	34	-

*See the "Proposed Construction" section for a description of proposed traffic.

When the upper soil is very moist to wet it may be necessary to place granular borrow to provide access and facilitate pavement construction as discussed in the "Subgrade Preparation" section of the report.

3. Pavement Materials and Construction

a. Flexible Pavement (Asphaltic Concrete)

The pavement materials should meet the Utah Department of Transportation specifications for gradation and quality. Other

materials may be considered for use in the pavement section. The use of other materials may result in the need for different pavement material thicknesses.

b. Rigid Pavement (Portland Cement Concrete)

The pavement thicknesses assume that the pavement will have aggregate interlock joints and that a concrete shoulder or curb will be provided.

Pavement materials should meet the Utah Department of Transportation Specifications. The pavement thicknesses indicated above assume that the concrete will have a 28 day compressive strength of 4,000 psi. Concrete should be air entrained with approximately 6 percent air. Maximum allowable slump will depend on the method of placement but should not exceed 4 inches.

4. Jointing

Joints for concrete pavement should be laid out in a square or rectangular pattern. Joint spacings should not exceed 30 times the thickness of the slab. The joint spacings indicated should accommodate the contraction of the concrete and under these conditions steel reinforcing will not be required. The depth of joints should be approximately one-fourth of the slab thickness.

C. Settlement

We understand that the final road surface will be approximately 3 feet above original grade. We estimate that settlement of the subgrade clay due to this raise in grade could result in 1 to 2 inches of settlement. Consideration may be given to installing settlement plates or other settlement monitoring systems on the natural subgrade surface below the roadway embankment. Settlement monitoring systems should not

be installed above or within close proximity to utility trench areas. After the roadway embankment is constructed, settlement can then be monitored for a period of time to determine an appropriate time to re-grade and construct the flexible or rigid pavement.

UTILITY RECOMMENDATIONS

Based on the subsurface conditions encountered, laboratory test results and the proposed construction, the following recommendations are given:

A. Pipe Support

The undisturbed natural soil or properly compacted bedding material is suitable to support the proposed sewer and water pipe.

1. Settlement

   Settlement of the proposed sewer line will be a function of the disturbance of the soil beneath the pipe. Disturbance may result from excavation, dewatering and construction activities. Care should be taken to minimize disturbance of the soils below the proposed pipe so that settlement can be maintained within tolerable limits. Disturbed material should be removed and replaced with properly compacted bedding material.

2. Pipe Bedding

   Pipe bedding requirements will depend on the type of pipe selected and the design criteria for the pipe based on the manufacturer's recommendations. Bedding materials should be placed on undisturbed natural soil. If the bearing

soil is disturbed, it should be removed and replaced with compacted bedding material. Pipe bedding should meet the criteria given by the pipe manufacturer.

Due to the shallow free water level, free-draining gravel should be placed in the base of the excavations to facilitate dewatering and for ease of construction. The gravel should meet the specifications for bedding material and should have less than 5 percent passing the No. 200 sieve. Free-draining gravel or bedding material should be mechanically densified prior to pipe placement. A filter fabric or properly sized fill should be provided between the natural soil and free-draining gravel to prevent particle migration into the gravel.

B. Uplift Resistance

Uplift for the pipe and manholes may be of concern where the pipe or manhole extends below the subsurface water level and is empty. Resistance to these uplift pressures is typically provided by compacted backfill above the pipe or manhole. The uplift resistance from the compacted backfill may be determined using the following soil unit weights:

Soil Conditions	Unit Weight, pcf
Natural Clay Above Water Table	95
Natural Clay Below Water Table	35
Imported Gravel Above Water Table	120
Imported Gravel Below Water Table	60

These values are ultimate values and appropriate safety factors should be applied.

C. Excavation

We anticipate that excavation for the proposed sewer and water lines will generally extend to depths of up to approximately 8 feet and 5 feet below the ground surface, respectively.

We an ticipate that excavation can be accomplished with tracked excavation equipment.

1. Shoring

Care should be taken to maintain the stability of excavations during construction. Proper side slopes or shoring should be provided for safety of workers and to support adjacent facilities. Flattening of slopes may not be practical within the construction easement. We anticipate that shoring will be required. Shoring and trench boxes should be designed to restrain the soil mass along with the surcharge from construction equipment and other loads.

Active lateral loads may be calculated using an equivalent fluid weight of 50 and 40 pcf above the water table and 25 and 20 pcf plus the hydrostatic pressure below the water table for cohesive and granular soils, respectively. The lateral load calculation should include the effect of seepage forces, sloping backfill, surcharge and other loading conditions that are not included in the values given above. An appropriate factor of safety should be used in design for the shoring system and trench boxes.

2. Unretained Excavation Slopes

Temporary, unretained excavation slopes in the existing fill and natural sand may be constructed at 1½ horizontal to 1 vertical or flatter. Temporary unretained excavation slopes in the natural clay may be constructed at 1 horizontal to 1 vertical or flatter. The excavation slopes indicated above

assume that the excavations will be properly dewatered. If water is allowed to flow into the excavation, slopes will need to be significantly flatter. It is the responsibility of the contractor to provide appropriate slopes to assure safe working conditions and stability of adjacent areas. Additional evaluation of excavation slopes by a qualified engineer may be required during the construction process.

3. Excavation Dewatering

Water levels were measured at depths ranging from 1½ to 2 feet below the ground surface. Artesian conditions exist at the site. Based on the water levels measured and our understanding of the depth of the proposed sewer line, we anticipate that the water will need to be lowered up to approximately 7 feet to facilitate construction.

Interlayered sand and clay was encountered at a depth of approximately 8 feet in boring B-1. Sand layers may be encountered at various depths along the alignment. Care should be taken to prevent sand from flowing into the excavation which could significantly reduce the stability of the excavation and disturb relatively large areas.

The quantity of water produced from the excavation dewatering is difficult to predict due to variations of in-situ soil conditions and will depend on the depth and size of the area dewatered, the free-water level, soil type and shoring systems or water cut-off systems used. Assuming the water level is lowered on the order of 7 feet and an excavation 50 feet long, the quantity of water produced is estimated on the order of 5 and 50 gallons per minute. Initial pumping rates will be higher than long-term pumping rates. The actual quantity of water required to dewater the excavation may vary significantly

due to variations in the subsurface conditions and the length of time which dewatering is conducted. Consideration may be given to conducting a pump test to better estimate pumping rates for excavation dewatering.

Dewatering may impact surrounding areas resulting in ground subsidence and loss of water in shallow wells. The potential impacts should be considered in planning of the dewatering system.

D. Backfill

1. Material

The natural soil is not recommended for use as utility-trench backfill due to the shallow depth of water and the clay content of the soil. Due to the shallow free water level, free-draining gravel should be used as backfill. The gravel should have less than 5 percent passing the No. 200 sieve.

2. Compaction

Backfill should be compacted to at least 90 percent of the maximum dry density as determined by ASTM D 1557.

To facilitate the compaction process, the fill should be compacted at a moisture content within 2 percent of the optimum moisture content.

Free-draining gravel should be placed in lifts and densified with vibratory compaction equipment.

3. Observation and Testing

We recommend frequent observation and testing as backfill is placed and compacted.

E. Manhole Design Considerations

Manholes may bear on the undisturbed natural soil or on properly compacted bedding material extending down to the undisturbed natural soil using a net allowable bearing pressure of 1,200 psf. The weight of the backfill above the base of the manhole may be neglected when sizing footings. Settlement of the manholes will be a function of disturbance of the bearing soils. If disturbance is kept to a minimum, we anticipate that settlement will be less than ½ inch.

F. Water Soluble Sulfates

Based on our experience in the area, we consider the natural soil at the site to have a negligible sulfate attack potential on concrete. Sulfate resistant cement is not needed for concrete placed in contact with the natural soil. Other conditions may dictate the type of cement to be used in concrete for the project.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the borings drilled at the approximate locations indicated on Figure 1 and the data obtained from laboratory and field testing. Variations in the subsurface conditions may not become evident until additional excavation or exploration is conducted. If the subsurface soil conditions or water level is found to be significantly different from what is described above, we should be notified to reevaluate the recommendations given.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

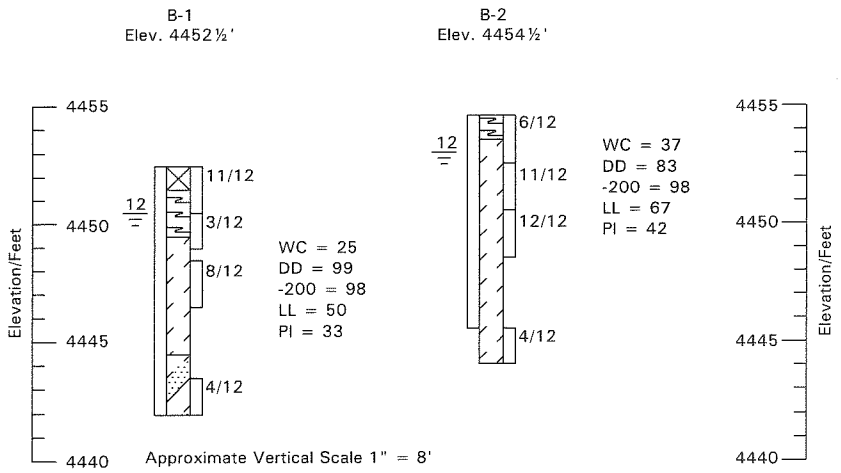
Jesse S. Elsmore, P.E.

Douglas R Hawkes by r.s.

Reviewed by DRH, P.E., P.G.

JSE/rs

1130124	AGEC Applied GeoTech	Locations of Exploratory Borings	Figure 1



LEGEND:

Fill; clayey gravel with sand, very moist, brown, roots.

Topsoil; peat or lean clay with sand, major roots and organics, very moist, dark brown to black.

Fat Clay (CH); medium stiff to stiff, wet, blue-gray to gray to brown.

Interlayered Lean Clay and Silty Sand (CL/SM); soft, loose, wet, light blue-gray, gray.

10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound automatic hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates slotted 1½ inch PVC pipe installed in the boring to the depth shown.

12 Indicates the depth to free water and the number of days after drilling the measurement was taken.

NOTES:

1. Borings were drilled on March 20, 2013 with 8-inch diameter hollowstem auger.
2. Locations of borings were measured approximately by pacing from features shown on the site plan provided.
3. Elevations of borings were estimated based on location relative to contour elevations provided on the Wetlands Delineation report.
4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level may occur with time.
7. WC = Water Content (%);
   DD = Dry Density (pcf);
   -200 = Percent Passing No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%).

1130124	AGEC Applied GeoTech	Logs, Legend and Notes of Exploratory Borings	Figure 2

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1130124

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (%)	SAMPLE CLASSIFICATION
BORING	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
B-1	4	25	99		2	98	50	33			Fat Clay (CH)
B-2	2	37	83		2	98	67	42			Fat Clay (CH)

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DCP TEST DATA

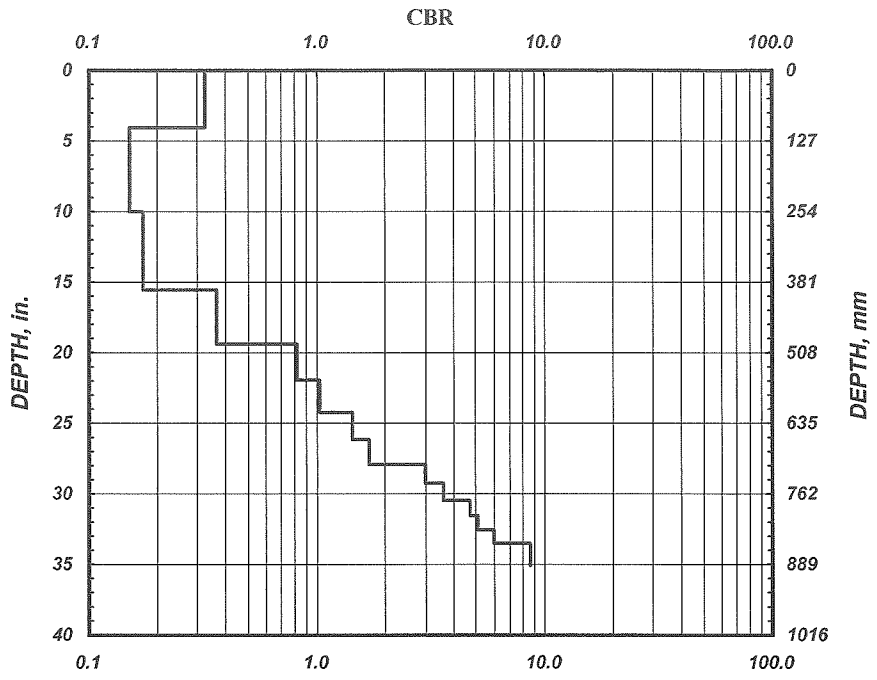
Project: 1130124 - Logan 1800 North **Date:** 20-Mar-13

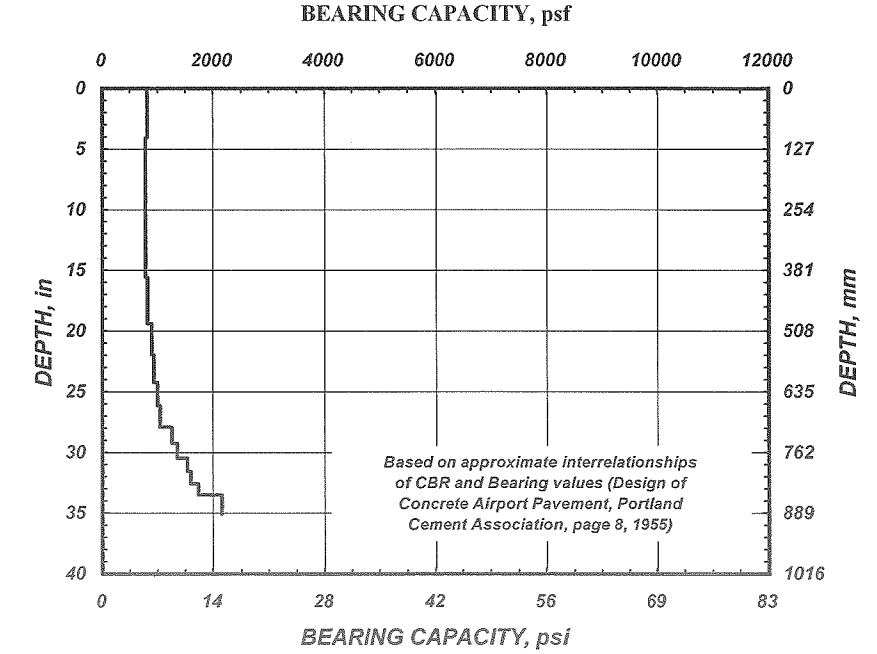
Location: 5' East of B-1 @ ground surface **Soil Type(s):** Low plasticity Clay with CBR<10

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ◉ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
1	103	1
1	254	1
1	395	1
1	492	1
1	557	1
1	615	1
1	664	1
1	709	1
1	743	1
1	774	1
1	801	1
1	827	1
1	851	1
1	871	1
1	891	1





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DCP TEST DATA

Project: 1130124 - Logan 1800 North Date: 20-Mar-13

Location: 3' East of B-2 @ ground surface Soil Type(s): High Plasticity Clay

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ◉ CH
- ○ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
1	110	1
1	175	1
1	227	1
1	273	1
1	315	1
1	352	1
1	381	1
1	408	1
1	431	1
1	453	1
1	474	1
1	495	1
1	515	1
1	535	1
1	555	1
1	575	1
1	616	1
1	656	1
1	691	1
1	721	1
1	748	1
1	777	1
1	805	1
1	819	1