BLACKFEET HOSPITAL APARTMENTS

Geotechnical Engineering Report

Browning, Montana

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EXECUTIVE SUMMARY

Soil conditions on this project generally consist of glacial till classified as sandy lean clay with gravel or gravelly lean clay with sand. The glacial till extended beyond the deepest depths drilled. Based on the results of our field exploration and laboratory testing, we recommend the structure be constructed on conventional spread footings and have a slab-on-grade floor.

1.0 INTRODUCTION

1.1 Purpose and Scope

DOWL completed a geotechnical investigation for the proposed hospital apartments in Browning, Montana. The scope of geotechnical services consisted of reviewing existing geotechnical and geological information, field observations, subsurface exploration, laboratory testing, engineering analyses, and preparing this Geotechnical Report. The purpose of these services is to provide geotechnical related recommendations for project planning and design. DOWL conducted this referencing our proposal to HFG Architecture dated June 20, 2019.

1.2 Project Understanding

1.2.1 Existing Site Conditions

The proposed Blackfeet Hospital Apartments are proposed on knoll consisting of glacial till. The topography of the proposed structure is relatively flat but grades significantly to the west and north near the construction limits. Based on the survey performed by DOWL, the elevation varies from 4,406 to 4,409 feet across the proposed building site. Existing hospital single-family housing dwellings exists to the east and west of the proposed development.

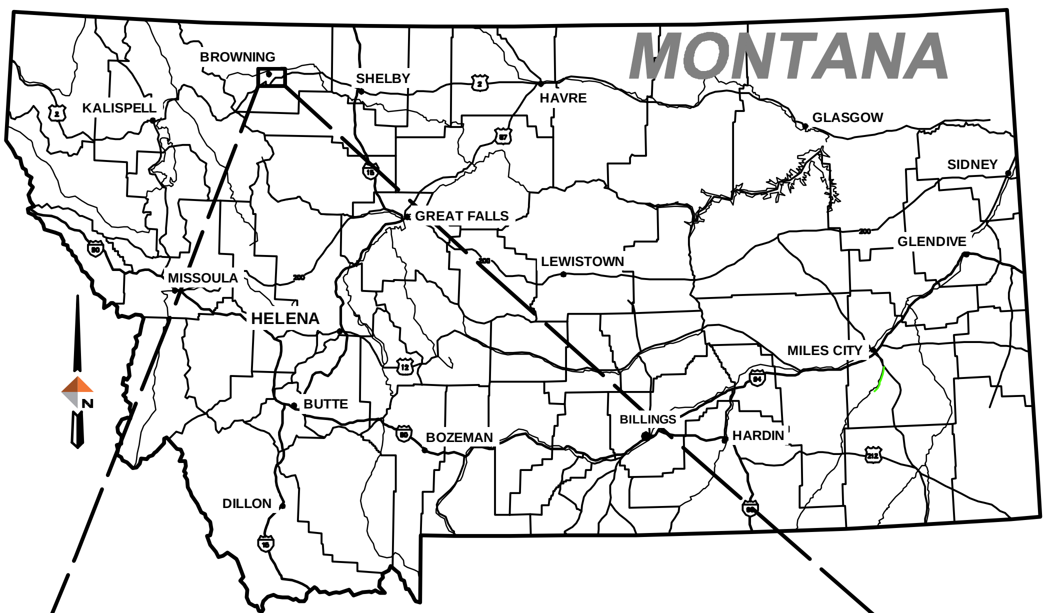
Existing overhead electrical bisects the proposed structure on an approximately north-south axis. Underground communication and water are also present. A gravel surface road exists long the eastern limits of the proposed development. During the geotechnical investigation, grass cuttings, waste debris and excess fill was being placed along the northern construction limits.

Photograph 1: Project Site Looking North

1.2.2 Proposed Construction

Based on preliminary concept drawings provided by HFG Architecture, development will consist of a two-two story, wood framed apartment building that has a footprint of about 230 feet long and about 80 feet wide. The building will contain about 17 one-bedroom apartments, two four-bedroom apartments, common area, lobby, mechanical room, and storage rooms. The building will not have a basement or below-grade space. Based on an e-mail from Professional Engineering Consultants, the maximum reactions will be 5 kips per lineal foot for continuous footings and 70 kips for column footings.

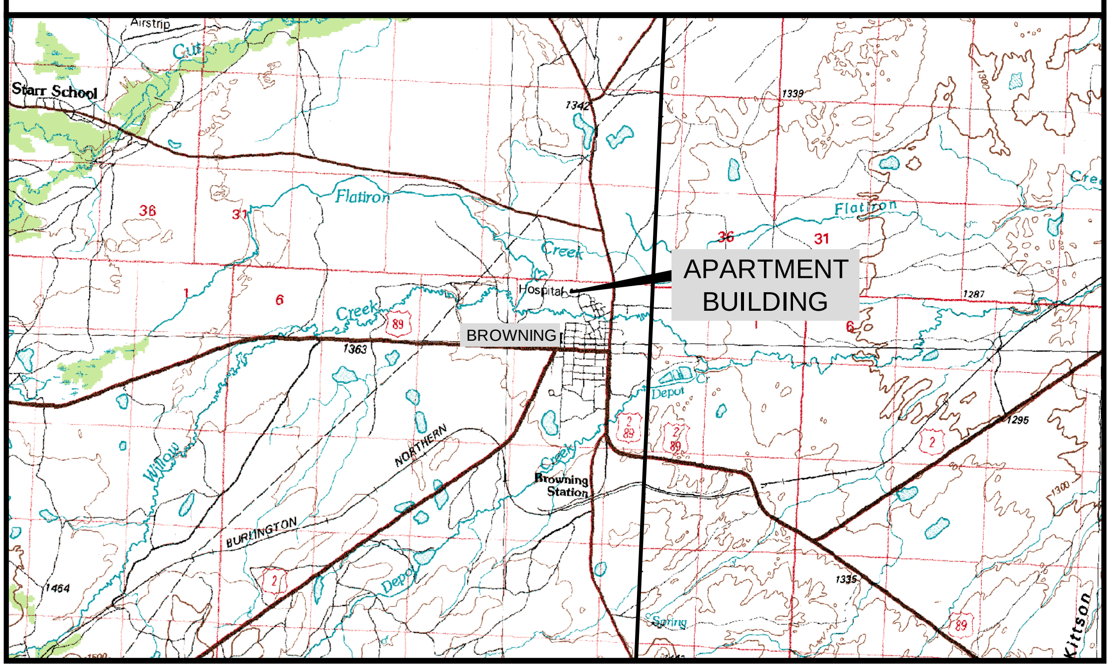
The building will have a parking lot on the east side that will have 20 to 25 parking stalls. Based on the site topography, we anticipate cuts and fills of about three feet will be necessary for site grading. We anticipate the building will connect to the existing water line on the north side of the site and to the existing sewer and franchise utilities. We expect buried utilities will extend from three to eight feet below the existing ground surface.



VICINITY MAP

NOT TO SCALE

BLACKFEET COMMUNITY HOSPITAL - NEW APARTMENT BUILDING



LOCATION MAP

2 0 2

SCALE IN MILES

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BLACKFEET COMMUNITY HOSPITAL
GEOTECHNICAL INVESTIGATION
VICINITY AND LOCATION MAP

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FIGURE 1

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2.0 INVESTIGATION

2.1 Field Investigation

DOWL performed fieldwork on June 27 and 28, 2019 which consisted of site observations and drilling eight (8) geotechnical borings. We present the boring locations on the Boring Location Map (Figure 2). Boland Drilling advanced the borings to depths ranging from 11.5 feet to 41.5 feet below the existing ground surface (see **Table 1**). DOWL surveyed the boring locations during the topographic survey relative to the project datum.

Table 1 Exploration Summary

Boring Number	Drill Depth (feet)	Surface Elevation (feet)	Northing (feet)	Easting (feet)	Location
B-1	41.5	4,406.5	24,251.6	365,733.8	Northwest Corner of Apartment
B-2	31.5	4,406.0	24,160.7	365,674.0	West Center Portion of Apartment
B-3	31.5	4,407.6	24,032.3	365,599.1	Southwest Corner of Apartment
B-4	36.5	4,405.4	24,162.9	365,782.9	Northeast Corner of Apartment
B-5	33.5	4,407.1	24,080.0	365,711.4	East Center Portion of Apartment
B-6	31.5	4,409.7	23,992.9	365,670.3	Southeast Corner of Apartment
B-7	11.5	4,405.7	24,241.1	365,879.4	Parking/Roadway Area
B-8	11.5	4,410.1	24,020.8	365,759.9	Parking/Roadway Area

Boland Construction drilled the borings under the direction of a DOWL geotechnical engineer using a Mobile B-59 truck-mounted drill rig equipped with 3.5-inch I.D. hollow stem augers. We conducted our field exploration referencing the following ASTM standards:

- ASTM D6151 Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling,
- ASTM D1586 Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils,
- ASTM D1587 Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils,
- ASTM D3550 Standard Practice for Thick Wall Ring-Lined, Split barrel, Drive Sampling of Soils,

We performed Standard Penetration Test (SPT) sampling using an automatic hammer. The resistance, or N-value, can be used to estimate the relative density of granular soils and the relative consistency of cohesive soils. We provide the field N-value or resistance data on the exploration logs.

We recorded the standard penetration test SPT N-values (in blows per foot on the boring logs for each soil sample. We have not corrected SPT values on the logs for hammer efficiency, sampler type, overburden stress, etc.

We provide exploration logs in Appendix A which include soil and groundwater conditions as well as SPT information. In Appendix C we present photographs of the site conditions and of the following samples obtained during drilling.

We based the soil descriptions shown on the boring logs on field and laboratory testing referencing ASTM Standards D2487 or D2488. The stratigraphic contacts shown on the individual borehole logs represent the approximate boundaries between soil types. The actual transitions may be more gradual or abrupt. The soil and groundwater conditions depicted are only for the specific dates and locations reported, and therefore, may not necessarily represent of other locations and times.

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GEOTECHNICAL INVESTIGATION
BORING LOCATION MAP

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FIGURE 2

2.2 Laboratory Testing

We transported samples to DOWL's laboratory for testing. DOWL selected representative field samples for laboratory testing after visual examination of the soil and consideration of the design criteria. DOWL performed tests for index and engineering soils properties in Billings, Montana and Lander, Wyoming. Energy Labs, of Billings, Montana, completed corrosion testing of select soil samples. Laboratory testing included:

Table 2 Laboratory Tests

Test	Purpose
Natural Moisture Content ASTM D 2216	Provides a measure of natural (in-situ) water content.
Atterberg Limits ASTM D 4318	Provides an indicator of the consistency and swell potential of fine-grained soils.
Particle-Size Distribution ASTM D 421	Provides a measure of grain sizes of the soils for classification and identification of physical characteristics.
Moisture-Density Relationship (Standard Proctor) ASTM D 698	Provides a measure of the relationship of water content to the density of soil during compaction.
California Bearing Ratio (CBR) ASTM D 1883	To determine the strength and stability of subgrade soil and base course.
Corrosion Tests (pH, Resistivity, and Soluble Sulfates)	To determine the potential for corrosive interaction of soils with concrete and metal.

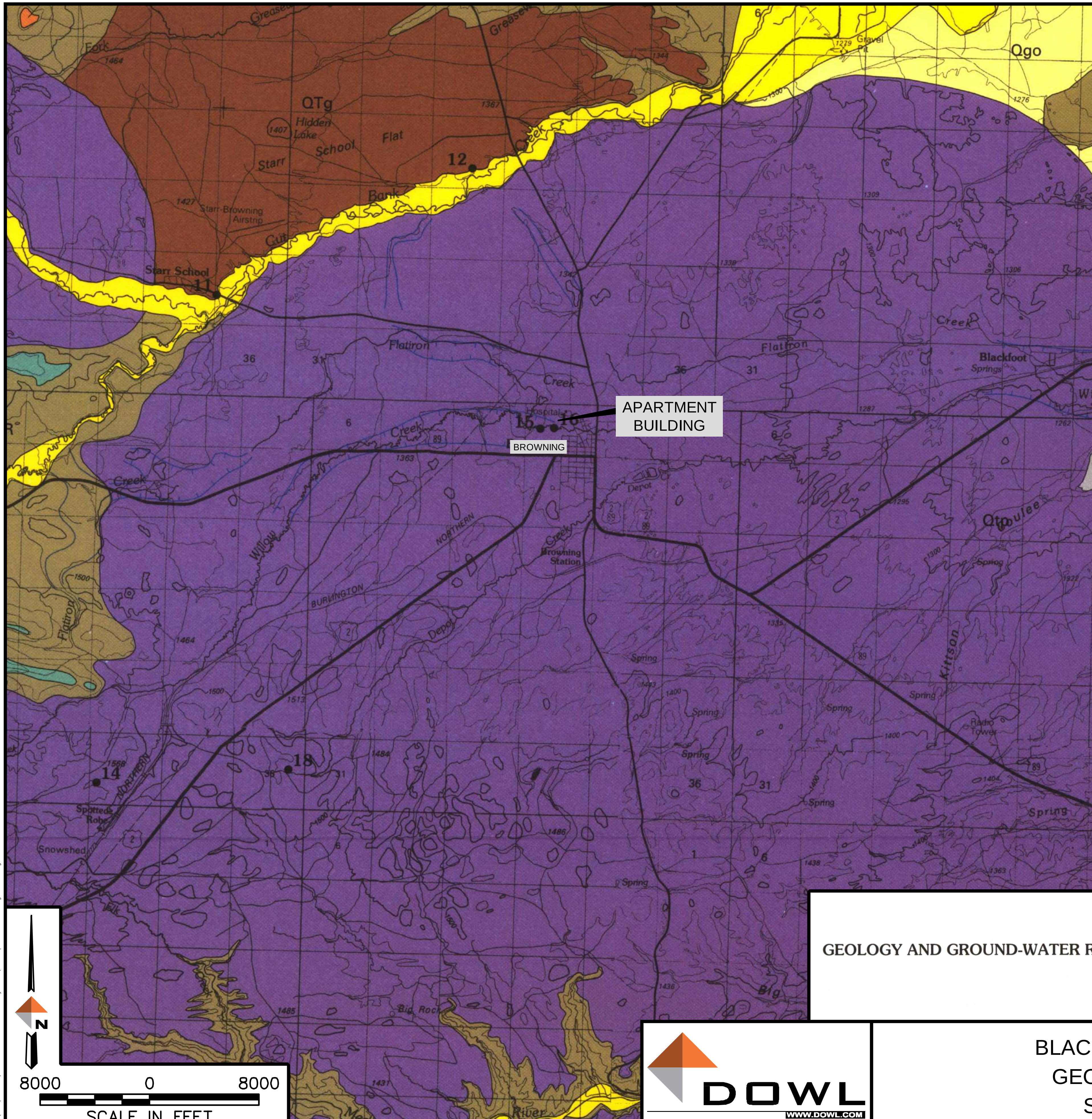
We performed laboratory tests referencing ASTM or other procedures standard to the industry. Appendix B includes laboratory test results on the summary table and in figures.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The proposed development is located within glacial till (Qtp) deposited by Piedmont Glaciers of the Pleistocene to Wisconsin glaciations (United States Geologic Survey – Geology and Ground-Water Resources of the Blackfeet Indian Reservation, NorthWestern, Montana by M.R. Cannon, 1996). A combination of alpine and continental glaciation produced terminal, recessional, and lateral moraines. These moraines consist of gravelly and clayey till with thickness being more than 50 feet thick in some areas. Younger glacial till deposited by the Laurentide ice sheet may also be present in the project area.

Because of the high clay content, the glacial till is commonly exhibiting poor hydraulic conductivity values. However, deposits of sand, gravel, cobbles and boulders allow for perched water tables. The groundwater recharge within these perched water tables may significantly decline with prolonged pumping.



DESCRIPTION OF MAP UNITS

	GEOLOGIC DESCRIPTION	EXTENT	WATER-BEARING CHARACTERISTICS
Qal	ALLUVIUM (HOLOCENE and PLEISTOCENE)—Unconsolidated gravel, sand, silt, and clay beneath flood plains of major streams. Includes some outwash gravel and sand from piedmont glaciers. Alluvium is thin beneath most flood plains but is thick in some fan deposits. Thick deposits are present at St. Mary, where alluvial fans from Divide and Wild Creeks filled the glacial channel now occupied by Upper and Lower St. Mary Lakes. Drill holes in the St. Mary area penetrated as much as 188 feet of alluvium and lake sediment without reaching bedrock (Alden, 1932)	Alluvial deposits are present in and adjacent to almost all stream channels in the reservation. In many valleys, however, gravel and sand deposits are thin and are restricted to narrow zones along the active stream channel and banks. These thin, narrow areas of alluvial deposits are not shown on the surficial geology map. Thicker and more extensive alluvial deposits are mapped in the St. Mary River, Milk River, South Fork Milk River, Cut Bank Creek, Two Medicine River, and Badger Creek valleys	Thick alluvial deposits are a dependable source of water for domestic and stock wells and generally yield from 10 to 50 gal/min. In the St. Mary area, thick alluvial deposits yield 100 gal/min or more to some wells. Irrigation wells with yields of 100 to 500 gal/min likely could be developed where alluvial gravel is recharged by streams
Qlt	LANDSLIDE DEPOSITS AND TILL (QUATERNARY)—Areas of landslides and glacial till with many rock outcrops. Much of this area formerly was covered by piedmont glaciers. Where present, till generally is a thin veneer overlying bedrock. Steeper slopes are mostly characterized by discontinuous landslide deposits and rock outcrops. Landslide deposits largely consist of rock debris or retransported surficial deposits	Mapped chiefly in the mountains and foothills near the southwestern and northwestern boundaries of the reservation. In the glaciated mountains and foothills around Dog Gun Lake, Mitten Lake, and Heart Butte (the mountain), and areas west of St. Mary River, landslide deposits are common	Glacial and landslide deposits in the mountains and foothills are recharged largely from melting snow and discharge water to small seeps and springs. In some areas, shallow wells drilled to the top of the bedrock will produce small yields to stock and domestic wells
Qtp	TILL DEPOSITED BY PIEDMONT GLACIERS (PLEISTOCENE--WISCONSIN STAGE)—Gravelly to clayey till in ground moraine and in terminal, recessional, and lateral moraines. Includes gravel deposits in narrow buried channels and meltwater channels. Thickness of till typically is from 1 to 15 feet, although in small areas thickness may be more than 50 feet. During the Wisconsin Stage of glaciation, moraines were formed by glaciers flowing eastward and northeastward from the high mountains onto the plains along the valleys of St. Mary River, Cut Bank Creek, Two Medicine River, and Birch Creek. Includes areas of landslide deposits on steep slopes east of St. Mary River and in upper Cut Bank Creek basin	Till deposited by piedmont glaciers covers much of the western and southern parts of the reservation. In the St. Mary River area, till deposited by the St. Mary Glacier extends from the valley of St. Mary River eastward to St. Mary Ridge and Duck Lake, and northward into Canada, where it was overlapped by younger till deposited by the Laurentide ice sheet (Qtc on sheet 1). Till deposited by the Two Medicine valley glacier mantles an area of more than 500 square miles, extending from East Glacier Park northeastward to Cut Bank Creek, southeastward to the town of Heart Butte, and as far east as the Two Medicine River in sec. 11, T. 31 N., R. 7 W.	Till generally is a poor aquifer because of its low permeability. However, in some areas gravel deposits between till units or underlying till are an important aquifer. Stock and domestic wells completed in these gravel units yield from 10 to 20 gal/min. Where buried channels of sand and gravel are present, yields greater than 100 gal/min have been obtained from public-supply wells. Yields to large-capacity wells may decline with prolonged pumping because of slow recharge through till to the gravel
Qlb	DISCONTINUOUS LAKE DEPOSITS (PLEISTOCENE)—Glacial lake deposits include laminated clay and silt, some stratified sand and gravel, and scattered granitic pebbles, cobbles, and boulders. More than 30 feet of silt deposited in glacial Lake Cut Bank is exposed in some coulees (Alden, 1932). In much of the area formerly occupied by glacial lakes, lake deposits are thin or have been removed by erosion	Glacial lakes once occupied parts of the St. Mary River and Milk River valleys and the Cut Bank Creek drainage basin. Spillway altitudes for the glacial lakes were about 4,550 feet for Lake St. Mary, about 4,010 feet for Lake Twin River (in Milk River valley) and about 3,900 feet for Lake Cut Bank (Horberg, 1954). Water that discharged from glacial Lake Twin River to glacial Lake Cut Bank carved a broad channel now named Big Rock Coulee	Stratified sand and gravel within the lake deposits reportedly yield 10 to 20 gal/min to a few wells; in many areas, the lake deposits are dry
Qgo	NONGLACIAL GRAVEL AND OUTWASH (PLEISTOCENE)—Chiefly coarse gravel and cobbles in sand matrix. Includes nonglacial fluvial terrace and pediment gravel deposits that were reworked by glacial meltwater. Also includes sand and gravel deposited as outwash from melting glaciers. Thickness of the sand and gravel locally is more than 38 feet	Gravel deposits that were reworked or were transported by glacial meltwater are mapped in the Squaw Flat area, northeast of Duck Lake, and near Meriwether, northeast of Blackfoot. Outwash sand and gravel deposited by glacial meltwater is mapped in the Badger Creek valley and north of the Two Medicine River near the old Mission (the Mission is in sec. 2, T. 31 N., R. 9 W.). Outwash sand and gravel also is mapped in several areas west of Cut Bank	Gravel deposits near Meriwether discharge ground water to pits that are used for watering stock. Most wells tapping saturated sand and gravel have adequate yields for stock and domestic use. A spring on the north side of Badger Creek in T. 30 N., R. 9 W. discharges about 30 gal/min
Qtc	TILL DEPOSITED BY CONTINENTAL ICE SHEETS (PLEISTOCENE)—Pebbly clay loam or loam till containing numerous granitic and metamorphic pebbles, cobbles, and boulders from Canada. The till is 15 to 70 feet thick in lower Birch Creek and Two Medicine River drainage basins and about 50 feet thick along the St. Mary River at the International Boundary. Includes till units deposited during the late Wisconsin and Illinoian glaciations	Till deposited by southward and southwestward moving ice of continental ice sheets is widespread near the northern and eastern boundaries of the reservation. Along the northern boundary, till mantles areas between the St. Mary and North Fork Milk Rivers, and along the lower Milk River. In the southeastern part of the reservation, till that mantles the bedrock surface between Alkali Lake and the mouth of Two Medicine River generally is overlain by lake sediments	The clayey or loamy till has low permeability and it yields little or no water to wells
Qd	DRIFT OF PRE-WISCONSIN MOUNTAIN GLACIERS (PLEISTOCENE AND POSSIBLY PLIOCENE)—Consists mostly of unsorted subrounded to subangular gravel, cobbles, and boulders with minor amounts of sand, silt, and clay. The drift includes multiple till beds in some locations (Richmond, 1986). In places, the drift is cemented by calcium carbonate	Drift of pre-Wisconsin mountain glaciers is mapped on Swiftcurrent Ridge, Sandy Ridge, St. Mary Ridge, Milk River Ridge, Cut Bank Ridge, and Two Medicine Ridge. Thickness of the drift is 200 feet or more on Swiftcurrent Ridge, 250 feet or more on St. Mary Ridge, and 150 feet or more on Milk River Ridge and Two Medicine Ridge (Alden, 1932)	Small springs discharge from drift on the ridges. Water-yielding potential to wells is unknown but probably would be small because of poor permeability of till
QTg	TERRACE AND PEDIMENT GRAVEL (PLEISTOCENE AND PLIOCENE)—Chiefly coarse gravel and rounded to sub-angular cobbles with some sand and silt. Gravel and cobbles are mostly quartzite and argillite clasts derived from mountains to the west. Includes some glacial outwash overlying pediment gravel near Fox Creek and Starr School. The deposits typically overlie planated erosional surfaces cut into bedrock. The terrace and pediment surfaces were mapped as number 3 benches by Alden (1932). Terrace and pediment gravel typically is from 5 to 40 feet thick	Gravel-capped terraces and pediments are mapped in the unglaciated parts of the Milk River and Cut Bank Creek drainage basins. The nearly flat areas known as Freezeout Flat, Starr School Flat, and Greasewood Flat are examples of gravel-capped pediments. Another large but unnamed pediment is in T. 34 N., R. 13 W. between Fox Creek and South Fork Milk River. Terrace and pediment gravel is buried beneath till, where glaciers overrode the western parts of Starr School Flat and Seville Flat. Buried gravel also is present in the Squaw Buttes area, east of Mission Lake	Gravel deposits near Fox Creek and Starr School are readily recharged by rainfall and snowmelt. Springs, with flows ranging from about 2 to 40 gal/min, discharge from the gravel aquifers. Wells with yields of 50 gal/min or more are likely from some wells completed in thick, saturated gravel beds
Tg2 / Tg1	OLDER GRAVEL (PLIOCENE)—Coarse gravel and rounded cobbles with sand and silt. Gravel and cobbles are mostly quartzite and argillite clasts derived from the mountains to the west. The sediments were deposited by braided streams on planated erosion surfaces and, as a result of topographic inversion, now are erosional remnants on high ridge tops and on broad northeastward sloping pediment surfaces. The highest and oldest gravel (Tg1) generally is from 5 to 20 feet thick and the second highest gravel (Tg2) is from 5 to 40 feet thick. The Tg1 and Tg2 gravel deposits are the deposits of the number 1 and 2 benches as mapped by Alden (1932)	Gravel deposits of the highest (Tg1) terrace or pediment remnants are present between the North Fork and South Fork Milk River, and on Houseman Hill, Landslide Butte, and Rocky Ridge. Gravel deposits of terrace level Tg2 are located on Milk River Ridge and Seville Flat	Gravel deposits on terraces and pediments are readily recharged by rainfall and snowmelt. Small springs and seeps discharge from gravel beds of the highest terraces (Tg1) and from gravel-filled coulees downslope from those terraces. Springs, with discharges ranging from 3 to 60 gal/min, flow from gravel aquifers of unit Tg2. The springs discharge primarily along contacts between gravel and the underlying Cretaceous bedrock. Wells tapping gravel aquifers of unit Tg2 typically yield from 15 to 30 gal/min
BR	BEDROCK, UNDIVIDED—Rock outcrops or bedrock with a thin cover of soil, colluvium, or residuum	Rock outcrops are numerous in the mountains and foothills, adjacent to incised rivers, and in the unglaciated north-central part of the reservation	In some areas, small springs discharge from soil and colluvium that overlies bedrock. See description of bedrock units (sheet 2) for water-yielding characteristics of bedrock aquifers

sec. 25, T. 29 N., R. 9 W.

[1]Colluvium not mapped on sheet 1.
[2]Spring discharges from Tertiary gravel (Tg2) in small gully below ma

Surficial geology

GEOLOGY AND GROUND-WATER RESOURCES OF THE BLACKFEET INDIAN RESERVATION, NORTHWESTERN MONTANA

By
M.R. Cannon
1996

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BLACKFEET COMMUNITY HOSPITAL
GEOTECHNICAL INVESTIGATION
SURFICIAL GEOLOGY MAP

PROJECT	4027.21815.01
DATE	07/10/2019

FIGURE 3

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3.2 Observed Soil Conditions

The generalized soil profile encountered at the proposed construction site consists of topsoil overlying glacial till classified as gravelly lean clay with sand. The glacial till extended beyond the depths explored. In Appendix A we present the exploration logs with lithology descriptions as well as other engineering properties. In the following paragraphs we provide a general description of the soil strata.

3.2.1 Topsoil

The topsoil ranged from 3 to 8 inches with an average thickness of approximately 4.5 inches.

3.2.2 Gravelly Lean Clay with Sand

Glacial till classified as gravelly lean clay with sand (CL) was encountered in all the borings underlying the topsoil. Interbedded layers of sand, gravel, cobbles, and possible boulders exist within the clay stratum. Uncorrected standard penetration test (SPT) N-values in the clay substrate ranged from seven (7) to greater than 50 blows per foot indicating a medium stiff to hard consistency. The color ranged from brown to dark brown to dark gray with multicolored clasts. Approximate in-situ moisture contents ranged from 3.9 to 13.9 percent with an average of approximately 10 percent. DOWL performed two (2) unconfined compressive strength with ranging from 5.36 to 6.61 kips per square foot (ksf). Dry unit weighs of the clay stratum ranged from 116.8 to 136.5 pound per cubic foot.

3.3 Groundwater

We did encounter groundwater in three (3) of the eight (8) the borings during drilling. DOWL did not encounter groundwater during the drilling. However, we left Borings B-2, B-3, B-5, and B-6 open overnight to let the groundwater tables to fully stabilize and groundwater was encountered in B-5 and B-6. The observed groundwater tables may indicate a perched water table or a potentiometric surface.

Table 3
Depth to Groundwater Encountered During Geotechnical Investigation

Boring Number	Boring Surface Elevation (feet)	Depth to Groundwater During Drilling (feet)	Depth to Groundwater After Drilling (feet)	Approximate Elevation of Groundwater (feet)
B-1	4,406.5	Not Encountered	Not Encountered	
B-2	4,406.0	Not Encountered	Not Encountered	
B-3	4,407.6	Not Encountered	Not Encountered	
B-4	4,405.4	Not Encountered	27.1	4,378.3*
B-5	4,407.1	Not Encountered	9.9	4,395.5
B-6	4,409.7	Not Encountered	10.9	4,398.8
B-7	4,405.7	Not Encountered	Not Encountered	
B-8	4,410.1	Not Encountered	Not Encountered	

*Boring left open approximately 2 hours until backfilled

Fluctuations of groundwater can occur due to seasonal moisture conditions, irrigation practices, changes in land use, and many other factors. Groundwater conditions may vary from those encountered at the time of the field investigation depending upon the influence of these factors.

3.3.1 *Groundwater Information Center Research*

We researched the Montana Bureau of Mines and Geology's Groundwater Information Center (GWIC) website to estimate static water levels from existing near the project area. GWIC data is for informational purposes only and contains historical well logs, some of which may not be accurate. Based on the GWIC research, static groundwater levels range from approximately 4 to 50 feet below the existing ground surface with an average depth of approximately 18 feet.

3.4 Seismicity

3.4.1 *Design Accelerations*

DOWL utilized site soil and geologic data, our knowledge of local geology, the project location, the 2010 American Society of Civil Engineers 7 (ASCE 7) and the National Earthquake Hazards Reduction Program (NEHRP) to estimate Seismic Site Classification of "D" at the project site. We recommend seismic design reference the seismic parameters provided in table below based on the soil conditions and project location:

Table 4 Seismic Design Parameters

Period (seconds)	Modified Acceleration Coefficient for Site Class D (g)
0.0 (peak)	PGA_M = 0.297
0.2 (short	S_{DS} = 0.416
1.0 (long)	S_{MS} = 0.196

3.4.2 *Liquefaction*

Liquefaction is the partial or total loss of strength of soils that can occur during strong earthquake shaking of significant duration. Earthquake-induced liquefaction generally occurs only under particular conditions, including high groundwater table, strong earthquake ground shaking of long duration, and loose uniform sands. Typically, liquefaction occurs where the groundwater table is shallow (5 to 10 feet deep) and generally only at depths less than about 50 feet.

Due to the presence of cohesive soil and the depth of groundwater at this site, it is our opinion the risk of liquefaction is very low.

3.4.3 *Faulting*

Based on geologic mapping by the Montana Bureau of Mines and Geology (MBMG), the nearest Quaternary fault to the project is the South Fork Flathead Fault, located about 40 miles west of the project. It is our opinion the potential for fault rupture at this site is low.

4.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

4.1 Foundations

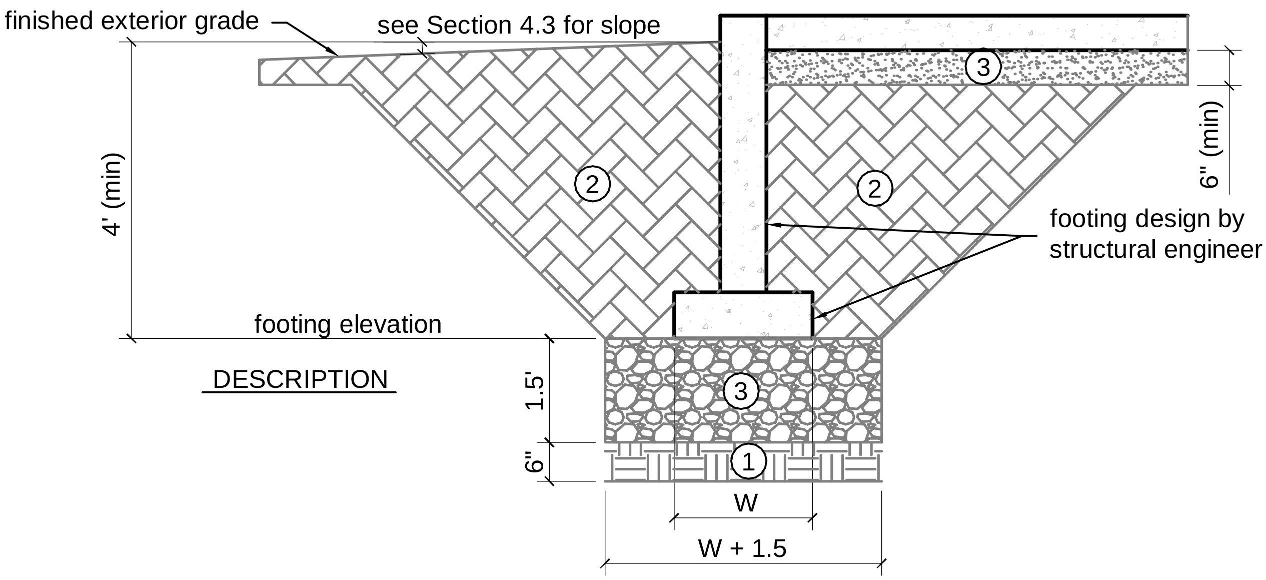
Based on the laboratory tests of the soil samples we obtained, the clay soil has the potential to collapse three to five percent; however, the soil samples were disturbed due to the presence of gravel in the clay. Glacial till is rarely collapsible, and it is our opinion the collapse observed in the laboratory tests is due to sample disturbance and is not representative of the soil at the site.

Based on our exploration, testing and experience, it is our opinion that structures at this site may be supported by a shallow foundation system utilizing conventional spread footings with subgrade.

4.1.1 Conventional Spread Footings

The building foundations may be founded on conventional spread footings according to the parameters shown in Figure 4.

Design uplift of shallow foundations from wind and seismic events using the weight of the foundation and soil above the footing. You can include soil resistance in the shape of a truncated pyramid above the foundation. The pyramid edges are defined by straight lines extending from the top of the footing on either side at a 2V:1H (vertical:horizontal) slope.



MATERIAL	DESCRIPTION
1	Subgrade prep - exposed soil
2	General fill - on-site soil
3	Structural fill

FOUNDATION DESIGN PARAMETERS	
Parameter	Value
Net Allowable Bearing Pressure	2,400 psf*
Coefficient of sliding friction	0.45

*An increase of 1/3 can be allowed for transient loads such as wind and seismic

MISCELLANEOUS NOTES

The building may be founded on conventional shallow spread footings if subgrade is prepared per the detail above. Subgrade preparations below foundations are critical to the proper performance of a shallow foundation on this site. If not properly prepared, settlements in excess of what we estimate may occur.

On-site clay may be used for foundation wall backfill except where structural fill is required below slabs, including non-frost susceptible fill below exterior slabs-on-grade. We estimate the total settlement will be less than 1" and differential settlement will be less than 1/2". Our settlement calculations are based on a 5.5 foot square footing and a load of 70 kips.

B:\27\21815-01\50Design\GEO\Blackfeet Community Hospital Figure 4.dwg PLOT DATE 2019-7-31 14:32 SAVED DATE 2019-07-31 14:25 USER: drussell

DOWL
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BLACKFEET COMMUNITY HOSPITAL
GEOTECHNICAL INVESTIGATION
CONVENTIONAL SPREAD FOOTINGS

PROJECT	4027.21815.01
DATE	07\29\2019

FIGURE 4

4.2 Slabs-on-Grade

The on-site clay soil encountered near the ground surface are suitable for the support of the new fill and lightly loaded concrete slab-on-grade construction. We recommend placing at least six inches of aggregate base course below the floor slabs. Based on correlations to our field and laboratory test results, we recommend concrete slab design utilize a modulus of subgrade reaction (K) of 150 pci with at least six inches of structural fill over the native clay soil. Subgrade areas that become soft, loose, wet, or disturbed or that cannot be re-compacted to structural fill requirements discussed in Section 4.6.5, must be over-excavated to firm undisturbed soil and replaced with granular structural fill prior to placing the free-draining gravel.

To reduce the effects of some differential movement, separate floor slabs from bearing walls and columns with expansion joints, which allow unrestrained vertical movement. Use floor slab control joints to reduce damage due to shrinkage cracking. The structural engineer should design slab thickness and reinforcement based the intended use of the slab.

Exterior slabs are susceptible to frost action which can generate substantial frost heave at certain times of the year. The potential for frost heave may not be acceptable at entries, bays or other critical areas adjacent to the building that will be exposed to weather. One approach to provide partial frost protection would be to place and compact a minimum of 32 inches of aggregate base course beneath the slab. Alternatively, if partial frost protection is unacceptable, over-excavate and replace the native soil with aggregate base course to the anticipated frost depth (48 inches).

If the floor coverings are sensitive to moisture, place a vapor retarder below the slab, underlain by 4 inches of clean drain gravel. A choker layer such as fine-concrete aggregate (ASTM C 33 sand) may be used to prevent clean drain gravel from puncturing the vapor barrier.

4.3 Drainage

Drainage is critical to the long-term performance of the structure. In the following sections we provide recommendations for surface and subsurface drainage.

4.3.1 Surface Drainage

To reduce the potential for movement due to an increase in the moisture content of subgrade soil, we strongly encourage the implementation of the following recommendations.

- Per the 2018 IBC, slope the ground surface within 10 feet of the structure downward a minimum of 5% away from the structure as shown in the detail below. Slope the ground surface beyond 10' of structures downward at least 2 percent away from the structure.
- Apron slabs and pavement may be used to further reduce infiltration adjacent to structures. Aprons should consist of asphalt or Portland cement concrete pavement that is placed directly adjacent to the foundation stemwalls. An elastomeric sealant should also be considered between aprons and foundation stemwalls to further reduce the potential for moisture to infiltrate the area directly adjacent to foundations. Slope apron slabs and pavement a minimum of 2%, downward, away from the building.
- Install eve gutters, downspouts, and extensions such that they dispose of water a minimum of 10 feet away from the structure.
- Limit irrigation within 5 feet of the building to drip systems. Periodically inspect and flush irrigation systems to detect potential leaks and avoid saturation of foundation backfill.

- Seal cracks in sidewalks, exterior slabs, and foundation walls. Maintain sealant between adjacent slabs and between slabs and adjacent walls.
- Remove or repair landscaping, curbs or other barriers that impair drainage.
- Do not burry rain gutter discharge pipes because they can leak, which often goes undetected. Seepage problems can also be caused by clogging, crushing, and poor grading of the pipes.
- Do not construct infiltration basins adjacent to or up gradient of the structures. If detention is required by statute, infiltration basins should be located down gradient and at least 30 feet from foundations.

4.4 Lateral Earth Pressures

4.4.1 Equivalent Fluid Pressures

Design below-grade walls for building, landscape, and retaining walls and any structure retaining soil to resist both lateral earth pressures from the retained soil adjacent to the structure, as well as hydrostatic pressures from retaining water (if undrained, not recommended). Also, lateral surcharge loads from equipment, slopes, or vehicles adjacent to the walls must be accounted for in structural wall design. We provide recommended lateral earth pressures for below-grade wall design are provided below.

Table 5: Lateral Earth Pressures

Lateral Earth Pressure Case	Equivalent Fluid Pressure
Structural Fill	
At-rest (no wall movement)	37 pcf
Active (wall moves away from soil mass)	62 pcf
Passive (wall moves into soil mass)	400 pcf
Native (clay) soil	
At-rest (no wall movement)	45 pcf
Active (wall moves away from soil mass)	73 pcf
Passive (wall moves into soil mass)	300 pcf

- The above equivalent fluid pressures assume fully drained conditions and no hydrostatic forces acting on the wall.
- Construct below grade walls, retaining walls, or other retaining structures with adequate drainage and water proofing systems as specified by the Architect and Structural Engineer to reduce the potential for instability, leakage or seepage.
- The retaining wall must move away from or toward the soil to develop active and passive resistance, respectively. For walls that cannot tolerate movement, structurally design walls utilizing at-rest equivalent earth pressures.
- We based the above equivalent fluid pressures on the assumption that the surface of backfill adjacent to walls slopes down and away from the wall a minimum of 5 percent for 10 feet to provide drainage.
- Lateral surcharge pressures due to equipment, slopes, storage loads, etc. are not included in the above lateral earth pressure recommendations. Use the lateral earth pressures coefficient of 0.5, acting over the entire below-grade wall height to estimate the lateral

surcharge loads from equipment, adjacent foundations and slopes behind and above walls.

4.4.2 *Seismic Earth Pressure*

We recommend using the Mononobe-Okabe approach to determine the additional earth pressures due to earthquakes. For the assumed unit weight of the retained structural fill at this project 138 pcf and the design peak horizontal ground acceleration 0.149g, estimate the equivalent additional fluid (active) earth pressure acting on the wall is: 51 pcf. We calculated this value using ½ the peak ground acceleration in the horizonal direction.

4.4.3 *Coefficient of Friction*

We recommend using a coefficient of friction of 0.45 between cast-in-place concrete and structural fill. And 0.3 between cast-in-pace concrete and the native clayey soil. The friction value may be combined with the passive pressure to resist horizontal loads.

4.5 Pavement Design

The primary purpose of a pavement section to distribute concentrated wheel loads to the subgrade in a manner such that the subgrade is not over-stressed. Performance of the pavement section is a function of subgrade strength and traffic loading. For purposes of designing a pavement section, subgrade soil is represented by a soil support value for flexible pavements (asphaltic concrete) or by a modulus of subgrade reaction value for rigid pavements (Portland cement concrete). Subgrade strength decreases when the moisture content of the subgrade increases. Therefore, proper drainage, both surface and subsurface, is essential for long-term pavement performance.

Pavement design procedures are based upon strength properties of the subgrade soil and pavement materials, along with the design traffic conditions (especially truck traffic).

4.5.1 *Traffic*

We based our pavement design on the estimated traffic breakdown and calculated equivalent single axle loads (ESALs) as shown in the table below assuming an annual growth rate of two percent. If future projects are planned that will impact general traffic routes, contact DOWL to revise our recommendations as necessary.

Table 6: Traffic Loading

Vehicle Description	ADT (Design Lane)	Axle Load (kips)*
Passenger Car	100	2S 2S
Pickup Truck/Van	100	2S 4S
School Bus	0	6S 14S
Delivery Truck	2	6S 12S
Garbage Truck	1	20S 35T
Dump Truck	0	20S 48T
Semi-Tractor Trailer	0	12S 34T 34T
Calculated 18 kip ESALs	38,670 (flexible) 42,100 (rigid)	

*S-Single, T-Tandem

4.5.2 *Design Parameters*

We used the pavement design parameters shown in the table below.

Table 7: Pavement Design Parameters

Pavement Design Parameter	Design Value	Source
Design life	20 years	MDT Pavement Design Manual
Initial serviceability	4.2	MDT Pavement Design Manual
Terminal serviceability	2.5	MDT Pavement Design Manual
Reliability	85%	Typical Value
Drainage coefficient	1.0	MDT Pavement Design Manual
Flexible Pavement		
Standard Deviation	0.45	MDT Pavement Design Manual
Asphalt layer coefficient	0.41	MDT Pavement Design Manual
Base layer coefficient	0.14	MDT Pavement Design Manual
SubBase layer coefficient	0.10	MDT Pavement Design Manual
Subgrade resilient modulus	6,500 psi	CBR value
Rigid Pavement		
Design life	20 years	MDT Pavement Design Manual
Standard Deviation	0.35	AASHTO 1993
PCC Modulus of Rupture	600 psi	MDT Pavement Design Manual
Elastic Modulus	4,300,000 psi	4,000 psi concrete strength
Modulus of subgrade reaction, k	110 pci	CBR value
JPCP Load Transfer, J	4.2	AASHTO 1993

4.5.3 *Flexible Pavement*

Based on our design calculations, anticipated traffic, and the field conditions, we recommend the asphalt pavement section shown below.

3.5 inches asphalt
7.0 inches aggregate base course

4.5.4 *Rigid Pavement*

Based on our design calculations, anticipated traffic, and the field conditions, we recommend the concrete pavement section shown below.

6.0 inches Portland cement concrete
4.0 inches aggregate base course

We recommend the concrete section in areas where trucks will turn such as dumpster aprons. Provide sawed or hand-formed joints should at spacings not greater than 15 feet on centers. Construct the joints should be at least one-fourth of the slab thickness. Provide expansion joints at the end of each construction sequence and between the concrete slab and adjacent structures.

4.5.5 *Construction Considerations*

- Remove unsuitable material including soft and/or organic soil encountered. Overexcavate soil to a depth of 12 inches below the pavement surfacing materials
- Base Course shall meet the requirements for Type A Crushed Base Course in Section 701, Aggregates, in Montana Standard Specifications for Road and Bridge Construction.
- Asphalt shall meet the requirements in Section 401, Plant Mix Surfacing, in the Montana Standard Specifications for Road and Bridge Construction.
- Compact asphaltic concrete to at least 92% of its theoretical maximum Rice density (ASTM D 2041).
- Portland cement pavement shall meet the requirements in Section 501, Portland Cement Concrete Pavement, in Montana Standard Specifications for Road and Bridge Construction.
- Compact all pavement materials (and subgrade) in accordance with the table in Section 4.6.5.
- Once the subgrade is scarified, moisture conditioned, and recompacted, it should be proofrolled using a loaded dump truck or water truck. Proofrolling should be observed by a DOWL representative and soft areas should be repaired at our discretion.
- Subexcavate any unstable areas and replace with moisture conditioned and compacted aggregate base.
- Place and compact structural fill in level lifts, not more than 8-inches in loose thickness, up to planned grade.
- Grade pavement such that surface water drains into the curb or storm drains at a minimum 2 percent slope.

4.5.6 *Maintenance*

- The pavement's life will be dependent on achieving adequate drainage throughout the section and especially at the subgrade.
- Surface and subgrade, crushed surfacing, and asphalt surfaces shall slope at no less than 2 percent to an appropriate stormwater disposal system or other appropriate location that does not impact adjacent buildings of properties.
- Seal cracks and perform surface maintenance on all pavement surfaces every 3 to 5 years to reduce the potential for surface water infiltration in to the underlying pavement subgrade.
- Water that ponds at the pavement subgrade surface can induce heaving during freeze-thaw process, which can readily damage pavement.
- Never allow inverted crowns at the subgrade or pavement surfaces without center concrete gutters designed to have asphalt overlap.

4.6 Earthwork

4.6.1 *Subgrade Preparation*

- Soil containing vegetation and organics (topsoil) extended approximately 3 to 8 inches below the existing ground surface in the locations explored. Remove soil containing vegetation and organics below planned improvements or structures.

- Scarify, moisture condition, and compact subgrade soil as specified in the table in Section 4.6.5.
- Grade the exposed subgrade surfaces so that they are free of mounds and depressions which could prevent uniform compaction. If unexpected fills or obstructions are encountered during site clearing or excavation, remove such features, and clean the excavation prior to placing backfill and/or construction.
- The site soil is moisture sensitive and susceptible to disturbance when moist or wet and may be expected to pump or rut under construction traffic. Soil disturbance negatively impacts the soil's performance. Disturbed soil is not allowed below any structure or pavement, and especially at footing or slab subgrades.
- Moisture condition and compact disturbed soil or fill placed to achieve site grades to general structural fill requirements in Section 8 on this sheet. This may require considerable moisture conditioning and soil processing due to the clayey nature of the on-site soil.
- Remove pumping or rutting subgrade areas to depths between 12 and 18 inches or as directed by DOWL.
- Replace overexcavations with granular structural fill. DOWL's geotechnical engineer shall review and approve the exposed subgrade.
- Once prepared and approved by the DOWL, it is the contractor's sole responsibility to protect subgrades from degradation.

4.6.2 Excavation

Based on the materials encountered in the soil borings, conventional earthmoving equipment should be capable of excavating the site soils.

4.6.3 Temporary Slopes

Excavations must conform to OSHA Standards for Excavations, 29 CFR Part 1926.652 Appendix B to Subpart P. Based on field observations and laboratory tests, the soil at the site are classifiy as OSHA Type B. OSHA requires that Type B soil excavation slope angles not to exceed 1H:1V (horizontal to vertical). The nature and extent of subsurface variations and groundwater conditions between the boring locations may not become evident until construction. Evaluate soil conditions at the time of construction by the contractor’s responsible person to ensure compliance to OSHA requirements. Temporary excavation slopes may be required for soil improvement excavations and utility trenches. Conduct excavations and shoring in accordance with OSHA standards. Do not allow surcharges within a horizontal distance equal to half the excavation depth. Construction vibrations can cause excavations to slough or cave. Ultimately, the contractor is solely responsible for site safety and excavation configurations.

Plan excavations to allow for water collection points and utilizing conventional sumps and pumps to remove nuisance or precipitation. If site soil excavations are not immediately backfilled, they may degrade when exposed to runoff and require overexcavation and replacement with structural fill. We recommend construction activities, particularly earthwork, be performed as rapidly as possible and/or during drier conditions to reduce the potential for remedial earthwork.

4.6.4 Structural Fill

Fill placed within the planned building footprint shall be considered structural fill. The on-site lean clay is not suitable for use below foundation, floor slabs, or exterior concrete flatwork; however, the on-site clay is suitable for use as fill below pavements, exterior foundation wall backfill, utility trenches and landscaped areas.

Table 8: Fill Specifications

Soil/Fill Product	Allowable Use	Material Specifications
Non-Structural Fill (Landscape Fill)	Any area that will not have structures (typically landscape areas)	• Soil classified as GM, GW, SM, SW, SC, CL, CH or ML according to the USCS. • Soil may not contain particles larger than 8 inches in median diameter. • Soil must be reasonably free from deleterious substances such as wood, metal, plastic, waste, etc. • Approved by Landscape Architect.
General Fill	• Site grading outside the building footprint. • Utility backfill areas • Non-structural fill • Foundation wall backfill	• Soil classified as GP, GM, GW, GC, SP, SM, SW, SC, CL, or ML according to the USCS. • Site soil free of vegetation, organics and debris meets these requirements. • Soil may not contain particles larger than 4 inches in diameter. • Soil must contain less than 3% (by weight) of organics, vegetation, wood, metal, plastic, or other deleterious substances.
Structural Fill	• General fill • Over-excavations • Soil improvements • Retaining Wall backfill	• Soil classified as GP, GM, GW, SP, SM, or SP with at least 30 percent retained on a number 4 sieve and less than 15 percent passing a number 200 sieve. • Soil may not contain particles larger than 2 inches in diameter. • Soil must contain less than 3% (by weight) of organics, vegetation, wood, metal, plastic, or other deleterious substances.
Unsatisfactory Soil	NONE	• Soil classified as MH, OH, CH, OL or PT may not be used at the project site • Any soil type not maintaining moisture contents within 5% of optimum during compaction is unsatisfactory soil that must be moisture conditioned prior to disposal and replacement • Any soil containing more than 3% (by weight) of organics, vegetation, wood, metal, plastic or other deleterious substances.

4.6.5 Compaction Requirements

Place fill material in lifts not exceeding 8 inches in uncompacted thickness. Moisture condition and compact fill according to the table below.

Table 9: Compaction Specifications

Application	Moisture Content (% of optimum)	Minimum Compaction
Subgrade	±4	95% ASTM D698
Below Foundations	±4	98% ASTM D698
Below Slabs-On-Grade	±4	97% ASTM D698
Base and Subbase Courses	±4	98% ASTM D698
Utility Trenches	±4	95% ASTM D698
Site Grading Fill	±4	95% ASTM D698
Foundation Backfill	±4	95% ASTM D698

4.6.6 Testing and Observations

We recommend the following compaction testing frequencies:

- **Structural Fill below Footing and Subgrade** - 1 compaction test every 50 linear feet (lf) of footing trench or 2 tests per wall line, whichever results in the greater number of tests, per each 1-foot lift of fill.
- **Foundation/Retaining Wall Backfill** - 1 compaction test every 100 lf of wall or 2 tests per wall line (interior and exterior sides), whichever results in the greater number of tests, per each 1' lift of backfill.
- **Interior and Exterior Slab Subgrade** - 1 compaction test every 1,000 square feet (sf) of slab area or 2 tests per slab area, whichever results in the greater number of tests, per 1-foot lift of fill.
- **Pavements** - 1 compaction test every 2,500 sf of pavement area on each subgrade, subbase, and base course layer as applicable, per each 1-foot lift of backfill.
- **Trenches** - 1 compaction test every 150 linear feet or 2 per trench, whichever results in the greater number of tests, per each 1-foot lift of backfill

To verify that construction conforms to the intent of the specifications, we recommend that DOWL be retained to observe and record the following:

- site preparation including grubbing, stripping, excavating and proofrolling,
- removal of topsoil and root zone beneath slabs and pavements,
- interior and exterior slab subgrades,
- excavations and subexcavations prior to placing bakcfill/fill materials or prior to construction of footings and slabs, and
- approve additional excavation, replacement or stabilization if unsuitable soil is identified by the geotechnical engineer during excavation or proofrolling operations.

4.6.7 Cold Weather Construction

Do not place concrete, pavement or fill on frozen soil. Do not use frozen soil as fill or backfill. Remove frozen soil, snow, and/or ice from the subgrade or fill soil prior to continuing with construction. Limit winter excavations to areas small enough to be refilled to finished floor grade or higher on the same day. A DOWL representative must monitor fill placed during freezing conditions to reduce the potential for placing frozen material.

4.6.8 Wet Weather/Soil Construction

- Ideally perform earthwork construction during dry weather conditions.
- The site clay is susceptible to pumping or rutting from heavy loads such as rubber-tired equipment or vehicles any time of the year.
- If possible, do not perform earthwork immediately after rainfall or until soil can dry sufficiently to allow construction traffic without disturbing the subgrade.
- If the subgrade soil becomes wet, it may be necessary to complete earthwork with track-mounted equipment that reduces vehicular pressure applied to the soil if construction commences in wet areas or before soil can dry.

4.6.9 Geosynthetics

Geosynthetic fabrics are applicable when constructing on soft or wet soil, for foundations soil improvement applications, as separation fabrics between drainage aggregate, below the construction access road and at the base of soft-spot over-excavations. Where required, apply geosynthetics directly on approved subgrades, taut, free of wrinkles, and over-lapped at least 12 inches. Consult DOWL to review geosynthetic applications or other subgrade improvement alternatives. Geogrid is required to help support any area that exhibits unusually high groundwater, soft pumping, or rutting conditions. Geotextile fabric placed at the bottom of the footing excavation must meet the requirements for separation/stabilization geotextile in Section 716, Geotextiles, of the Montana Department of Transportation *Standard Specifications for Road and Bridge Construction.*

4.7 Soil Chemistry and Corrosion

Based on the results shown in the table below, concrete in contact with the on-site soil classifies as exposure class S0 according to ACI 318 table 19.3.1.1. Special concrete protections are not required against sulfate related corrosion. Details can be found in the above ACI reference and in the Portland Cement Association publication "Design and Control of Concrete Mixtures."

According to Corrosion/Degradation of Soil Reinforcement for Mechanically Stabilized Earth Walls (FHWA, 2009) the soil at the site is “very corrosive” to steel. Based on that publication and the tests above, we estimate a corrosion rate of 1.2 ounce per square foot per year.

Table 10: Soil Chemistry Test Results

Sample Location	Soluble Sulfate (%)	Resistivity (ohm-cm)	pH
Boring B-1 at 35.0 to 36.5 feet	0.0392	417	7.5
Boring B-4 at 12.5 to 14.0 feet	0.0514	407	7.8

5.0 GEOTECHNICAL DESIGN CONTINUITY

Geotechnical design continuity will be an important aspect of the successful completion of this project. In our opinion, geotechnical continuity can occur in three stages in the planning, design and construction project aspects. Specifically, we recommend DOWL maintain the geotechnical design continuity in the following aspects:

- **Plan and Specification Review:** We recommend you retain DOWL to review final design and construction plans and specifications to verify our geotechnical recommendations are incorporated into construction documents as well as to provide additional recommendations based on the final design concepts. These efforts can help provide document continuity and reduce the potential for errors as the project concepts evolve.
- **Geotechnical Design Confirmation:** The potential soil variation may have a significant impact on foundation construction. As such, we recommend you retain DOWL to provide geotechnical engineering oversight during site grading and foundation excavation to observe the potential variability in the soil conditions and provide consultation regarding potential impacts on foundation construction.
- **Construction Observation and Testing:** We recommend you retain DOWL to provide observation and testing during site preparation, grading, structural fill placement and backfilling to verify compliance with the recommendations presented in this report. Having DOWL provide inspection and oversight during this process will reduce the potential for an unforeseen construction error which may ultimately impact the project. If we are not retained to perform the recommended services, we cannot be responsible for related construction errors or omissions.

6.0 LIMITATIONS

DOWL based the conclusions and recommendations presented in this report, based on the assumption that site conditions are not substantially different than those exposed by the explorations. If during construction, subsurface conditions are different from those encountered in the explorations, advise DOWL at once to review those conditions and reconsider recommendations if necessary. The geotechnical recommendations provided herein are based on the premise that an adequate program of tests and observations will be conducted during construction in order to document compliance with DOWL's recommendations and to confirm conditions exposed during subgrade preparations.

If there is a substantial lapse of time between submission of this report and the start of work at the site, and especially if conditions have changed due to natural causes or construction operations at or near the site, contact DOWL to review this report and to evaluate the applicability of the conclusions and recommendations presented herin.

DOWL prepared this report for HFG Architecture and their Consultants use on this project. DOWL recommends you make this report available to prospective contractors for information and factual data only, but not as a warranty of subsurface conditions. DOWL prepared this report, including engineering analyses, recommendations, figures, and design details specifically for the Blackfeet Hospital Apartments. These recommendations are not applicable to other construction sites. Do not separate the figures from the text for independent use.

Any conclusions made by a construction contractor or bidder relating to construction means, methods, techniques, sequences, or costs based upon the information provided in this report are not the responsibility of HFG Architecture or DOWL.

7.0 REFERENCES

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APPENDIX A: EXPLORATION LOGS

SOIL CLASSIFICATION/LEGEND

Unified Soil Classification System

Criteria for Assigning Group Symbols and Names			Soil Classification Generalized Group Descriptions	
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS Less than 5% fines	GW	Well-graded gravels
			GP	Poorly-graded gravels
		GRAVELS w/ FINES More than 12% fines	GM	Gravel and silt mixtures
			GC	Gravel & clay mixtures
	SANDS 50% or more of coarse faction passes No. 4 sieve	CLEAN SANDS Less than 5% fines	SW	Well-graded sands
			SP	Poorly-graded sands
		SANDS with FINES More than 12% fines	SM	Sand and silt mixtures
			SC	Sand and clay mixtures
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	SILTS & CLAYS Liquid limit less than 50	INORGANIC	CL	Low-plasticity clays
			ML	Non-plastic and low-plasticity silts
		ORGANIC	OL	Non-plastic and low plasticity organic clays Non-plastic and low-plasticity organic silts
	SILTS & CLAYS Liquid limit greater than 50	INORGANIC	CH	High-plasticity clays
			MH	High-plasticity silts
		ORGANIC	OH	High-plasticity organic clays High-plasticity organic soils
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color and has an organic odor		PT	peat

Component Definitions By Gradation

Component	Size Range
Boulders	Greater than 12-in.
Cobbles	3-in. to 12-in.
Gravel	3-in. to No. 4 (4.75 mm)
Coarse gravel	3-in. to ¾-in.
Fine gravel	¾-in. to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (.075 mm)
Coarse sand	No. 4 (4.75 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.425 mm)
Fine sand	No. 40 (0.425 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

Silt and Clay Descriptions

Description	Typical Unified Designation
Silt	ML (non-plastic)
Clayey Silt	CL-ML (low plasticity)
Silty Clay, Lean Clay	CL
Clay, Fat Clay	CH
Plastic Silt	MH
Organic Soils	OL, OH, Pt

Relative Density or Consistency Utilizing Standard Penetration Test Values

Cohesionless Soils[a]			Cohesive Soils[b]		
Density[c]	N blows/ft[c]	Relative Density (%)	Consistency	N blows/ft[c]	Undrained Shear Strength[d] (psf)
Very loose	0 to 4	0 - 15	Very soft	0 to 2	<250
Loose	5 to 10	15 - 35	Soft	3 to 4	250 - 500
Med. Dense	11 to 29	35 - 65	Medium Stiff	5 to 8	500 – 1,000
Dense	30 to 49	65 - 85	Stiff	9 to 15	1,000 – 2,000
Very Dense	Over 50	>85	Very Stiff	16 to 30	2,000 – 4,000
			Hard	Over 30	>4,000

(a) Soils consisting of gravel, sand and silt, either separately or in combination, possessing no characteristics of plasticity and exhibiting drained behavior.
(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.
(c) Undrained shear strength = ½ unconfined compressive strength.
(d) Qp - Denotes pocket penetrometer field measurement (tons per square foot) approximation to unconfined compressive strength.

Descriptive Terminology Denoting Components Proportions

Descriptive Terms	Range of Proportion
Trace or Scattered	0 - 5%
Few	5 - 10%
Some or Adjective[a]	15 - 30%
And	30 - 50%

(a)Use gravelly, sandy or silty as appropriate.

Samples

- **Split Spoon Sampler (2.0" OD)**
- **Ring Sampler (3.0" OD)***
  *Indicates increased blow counts due to sampler size.
- **Shelby Tube Sampler (3.0" OD)**
- **Bulk Sample (auger cuttings)**
- **Core Barrel**

Unless otherwise noted, drive samples advanced with 140-lb. hammer and 30-in. drop.

Groundwater Elevation

- ▼ Water Elevation Noted During Drilling
- ▽ Water Elevation Recorded After Drilling Complete

Soil Moisture

Dry	Absence of moisture, dusty, dry to the touch
Slightly Moist	Minor existence of moisture, not dusty, but still dry to the touch
Moist	Damp but no visible water
Very Moist	Zones of visible moisture and usually above the water table
Wet	Visible free water, usually soil is below water table

LOG OF BOREHOLE B-1

CLIENT: HFG Architecture	PROJECT: Blackfeet Hospital Apartments
BORING LOCATION: Northwest Corner of Apartment - See Figure 2	SITE: Browning, Montana

Surface Elevation: 4406.5

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	M.C. / N VALUE	ADDITIONAL DATA/ REMARKS
0	5-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics		3 5 5	10	1	5/18 28%		
0.4	Sandy Lean CLAY; stiff, moist, brown, fine to coarse grained sand	4406.1						
1.6	Gravelly Lean CLAY with Sand and Cobbles; stiff, brown to dark brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible boulders	4404.9	5 6 9	15	2	1/18 6%		
3.5		4403						
	Grades very stiff at 5.0 feet		7 12 12	24	3	18/18 100%		Lab #33813 Natural Moisture=7.4%
7		4399.5						
	Grades hard at 7.5 feet		12 16 18	34	4	12/18 67%		Moderately rough drilling at 7.5 feet
10.0	Sandy Lean CLAY with Gravel, CL; very stiff, slightly moist to moist, brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible cobbles and boulders	4396.5	8 14 16	30	5	17/18 94%		Lab #33814 Natural Moisture=8.9%
10.5		4396						
	Grades hard at 12.5 feet		5* 7* 8*	15*	6	18/18 100%		*Conversion of Dames and Moore blow counts to SPT equivalent blow counts
14		4392.5						
14.5	Gravelly Lean CLAY with Sand and Cobbles; hard, slightly moist to moist, brown to light grayish brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible boulders	4392	14 18 17	35	7	17/18 94%		Lab #312 USCS=CL Fines=54.6% Sand/Gravel=45.4% Liquid Limit=28 Plasticity Index=12 Natural Moisture=13.9%
17.5		4389						
			19 27 28	55	8	16/18 89%	55	Lab #33815 Natural Moisture=3.9%
21		4385.5						
23.0	Sandy Lean CLAY with Gravel and Cobbles, CL; very stiff, moist to slightly moist, dark gray	4383.5						

Column headings also include: GRAPHIC LOG; SAMPLES: BULK, DRIVEN/PUSH; TESTS: POCKET PENETROMETER, TSF; PL — LL (10, 20, 30, 40); N VALUE □ BLOWS/FT (9.8, 19.6, 29.4, 39.2).

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CLIENT: HFG Architecture

PROJECT: Blackfeet Hospital Apartments

BORING LOCATION: Northwest Corner of Apartment - See Figure 2

SITE: Browning, Montana

Surface Elevation: 4406.5

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	ADDITIONAL DATA/ REMARKS
24.5	with multicolored clasts, rounded to subrounded, fine to coarse grained sand	4382	4 8 11	19	9	12/18 67%		
28		4378.5						
31.5		4375	3* 6* 8*	14*	10	18/18 100%		Lab #313 USC=CL Fines=50.6% Sand/Gravel=49.4% Liquid Limit=25 Plasticity Index=11 Natural Moisture=10.5% Dry Unit Weight=130.0 pcf Unconfined=5.36 ksf Undrained Shr Str=2.68 ksf *Conversion of Dames and Moore blow counts to SPT equivalent blow counts
35		4371.5	3 6 11	17	11	18/18 100%	1.5	
38.5		4368	4 9 12	21	12	18/18 100%		Lab #33816 Natural Moisture=9.4%
41.5	Boring terminated at 41.5 feet No groundwater observed. Boring backfill approximately 4 hours after drilling	4365						
42								
45.5								

TESTS chart: M.C. ●; PL 10 20 30 40 LL; N VALUE □ BLOWS/FT 9.8 19.6 29.4 39.2

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LOG OF BOREHOLE B-2

Project No.: 4027.21815.01	LOG OF BOREHOLE B-2	Sheet 1 of 2

CLIENT: HFG Architecture	PROJECT: Blackfeet Hospital Apartments
BORING LOCATION: West Center Portion of Apartment - See Figure 2	SITE: Browning, Montana

Surface Elevation: 4406.0

MATERIAL DESCRIPTION

Depth (ft.)	Material Description	Elevation (ft.)
0	3-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics	
0.3	Sandy Lean CLAY; stiff, moist, light brownish gray, fine to coarse grained sand	4405.7
2.4	Gravelly Lean CLAY with Sand, CL; stiff, moist, brown to dark brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand	4403.6
	Grades very stiff at 5.0 feet	
	Grades stiff at 7.5 feet	

Depth scale (ft.): 0, 3.5, 7, 10.5, 14, 17.5, 21
Elevation scale (ft.): 4403, 4399.5, 4396, 4392.5, 4389, 4385.5, 4382

SAMPLES / TESTS

Number	Driven/Push	Blows per 6"	N Blows/ft	In. Recovered / In. Driven	Additional Data / Remarks
1	Driven	4, 5, 5	10	14/18 78%	
2	Driven	4, 4, 5	9	14/18 78%	
3	Driven	4, 8, 13	21	14/18 78%	Lab #33817 Natural Moisture=8.6%
4	Driven	5*, 6*, 5*	11*	14/18 78%	Lab #314 USCS=CL Fines=52.9% Sand/Gravel=47.1% Liquid Limit=31 Plasticity Index=15 Natural Moisture=9.5% Dry Unit Weight=116.8 pcf Consolidation Cc=0.18 Swell Coeff Cs=0.01 Collapse=5.3%
5	Driven	2, 4, 5	9	18/18 100%	
6	Push			3/24 13%	
7	Driven	10, 13, 17	30	14/18 78%	Lab #33818 Natural Moisture=10.1%
8	Driven	2*, 4*, 6*	10*	18/18 100%	Lab #315 USCS=CL Fines=50.1% Sand/Gravel=49.9% Liquid Limit=31 Plasticity Index=16 Natural Moisture=11.9%

Tests chart: M.C. (●); PL ├──┤ LL: 10, 20, 30, 40; N VALUE □ BLOWS/FT: 9.8, 19.6, 29.4, 39.2

*Conversion of Dames and Moore blow counts to SPT

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CLIENT	PROJECT
HFG Architecture	Blackfeet Hospital Apartments
BORING LOCATION	SITE
West Center Portion of Apartment - See Figure 2	Browning, Montana

Surface Elevation: 4406.0

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	ADDITIONAL DATA/ REMARKS
24.5							equivalent blow counts
25.5	Lean CLAY with Gravel; very stiff, slightly moist to moist, dark gray with multicolored clasts, rounded to subrounded	4380.5	4 6 10	16	9	8/18 44%	
		4378.5					
28							
	Grades stiff at 30.0 feet	4375	2* 4* 6*	10*	10	18/18 100%	*Conversion of Dames and Moore blow counts to SPT equivalent blow counts
31.5	Boring terminated at 31.5 feet No groundwater observed, borehole left open approximately 20 hours, no groundwater observed	4374.5					
35							
38.5							
42							
45.5							

Column headers also include: GRAPHIC LOG; SAMPLES: BULK, DRIVEN/PUSH; TESTS: POCKET PENE-TROMETER, TSF; M.C. ●; PL 10 20 30 40 LL; N VALUE □ BLOWS/FT 9.8 19.6 29.4 39.2

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Project No.: 4027.21815.01	LOG OF BOREHOLE B-3	Sheet 1 of 2

CLIENT	PROJECT
HFG Architecture	Blackfeet Hospital Apartments
BORING LOCATION	SITE
Southwest Corner of Apartment - See Figure 2	Browning, Montana

Surface Elevation: 4407.6

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	ADDITIONAL DATA/ REMARKS
0	4-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics	4406.5					
0.3	Sandy Lean CLAY; moist, brown to light gray, fine to coarse grained sand	4407.3					
2.0	Sandy Lean CLAY with Gravel; stiff, moist, brown to light gray with multicolored clasts, rounded to subrounded, fine to coarse grained sand	4405.6	5 5 5	10	1	18/18 100%	
3.5		4403					
4.5	Gravelly Lean CLAY with Sand and Cobbles, CL; stiff, moist to slightly moist, brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible boulders	4403.1	5 6 7	13	2	12/18 67%	Lab #317 USCS=CL Fines=59.7% Sand/Gravel=40.3% Liquid Limit=30 Plasticity Index=12 Natural Moisture=10.7%
7	Grades very stiff at 7.5 feet	4399.5	10 9 14	23	3	12/18 67%	Lab #33819 Natural Moisture=9.3%
10.5		4396	6 12 12	24	4	18/18 100%	
	Grades hard at 12.5 feet		6 10 26	36	5	12/18 67%	
14		4392.5	7 18 18	36	6	18/18 100%	
17.0	Lean Clay with Sand; stiff, moist, dark gray with multicolored sand, fine to coarse grained sand, possible cobbles	4390.6					
17.5		4389					
21			3 5 8	13	7	5/18 28%	
22.0	Lean CLAY with Gravel; very stiff, moist, dark gray with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible cobbles	4385.6 / 4385.5					

TESTS: M.C. ●; PL 10 20 30 40 LL; N VALUE □ BLOWS/FT 9.8 19.6 29.4 39.2

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LOG OF BOREHOLE B-3

CLIENT: HFG Architecture	PROJECT: Blackfeet Hospital Apartments
BORING LOCATION: Southwest Corner of Apartment - See Figure 2	SITE: Browning, Montana

Surface Elevation: 4407.6

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BULK	DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	M.C. (PL–LL 10 20 30 40) / N VALUE BLOWS/FT (9.8 19.6 29.4 39.2)	ADDITIONAL DATA/ REMARKS
24.5											
		4382		■	6 8 11	19	8	18/18 100%		● □	Lab #33820 Natural Moisture=8.9%
28		4378.5									
				■	7 10 12	22	9	14/18 78%		□	Lab #33821 Natural Moisture=11.0%
31.5	31.5 — 4376.1										

Boring terminated at 31.5 feet

No groundwater observed during drilling, borehole left open approximately 20 hours, no groundwater observed

Depth scale: 35, 38.5, 42, 45.5

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LOG OF BOREHOLE B-4

Project No.: 4027.21815.01

CLIENT	PROJECT
HFG Architecture	Blackfeet Hospital Apartments
BORING LOCATION	**SITE**
Northeast Corner of Apartment - See Figure 2	Browning, Montana

Surface Elevation: 4405.4

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)
0	5-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics	4405.4
0.4	Sandy Lean CLAY; medium stiff, very moist to moist, brown to reddish brown with multicolored sand, fine to coarse grained sand, trace rounded to subrounded gravel	4405
2.2	Gravelly Lean CLAY with Sand and Cobbles, CL; stiff, moist, light brown to brown to dark brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible boulders	4403.2
7.5	Grades very stiff at 7.5 feet	
15.0	Grades medium stiff at 15.0 feet	
19.0	Lean CLAY with Gravel; stiff, moist, dark gray with brown mottling and multicolored clasts, rounded to subangular, trace sand	4386.4

Depth scale: 0, 3.5, 7, 10.5, 14, 17.5, 21. Elevation scale: 4403, 4399.5, 4396, 4392.5, 4389, 4385.5, 4382.

SAMPLES: BULK	DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	ADDITIONAL DATA/ REMARKS
	Driven	1, 3, 3	6	1	13/18 72%		
	Driven	7, 6, 6	12	2	12/18 67%		
	Driven	2, 4, 5	9	3	18/18 100%	2	Lab #33822 Natural Moisture=12.4%
	Driven	4, 7, 9	16	4	14/18 78%	2	Lab #318 USCS=CL Fines=56.4% Sand/Gravel=43.6% Liquid Limit=30 Plasticity Index=14 Natural Moisture=11.4%
	Push	7*, 11*, 11*	22*	5	14/18 78%		*Conversion of Dames and Moore blow counts to SPT equivalent blow counts
	Driven	9, 15, 6	21	6	18/18 100%		
	Driven	2, 4, 4	8	7	16/18 89%	2	Lab #33823 Natural Moisture=12.1%
	Push	3*, 8*, 7*	15*	8	18/18 100%		Lab #33840 Unconfined=6.61 ksf Undrained Shr Str=3.31 ksf Natural Moisture=10.1% Dry Unit Weight=128.1 pcf

TESTS: M.C. ● ; PL ├──┤ LL (10, 20, 30, 40); N VALUE □ BLOWS/FT (9.8, 19.6, 29.4, 39.2)

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LOG OF BOREHOLE B-4

Project No.: 4027.21815.01

CLIENT: HFG Architecture	PROJECT: Blackfeet Hospital Apartments
BORING LOCATION: Northeast Corner of Apartment - See Figure 2	SITE: Browning, Montana

Surface Elevation: 4405.4

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BULK	DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	ADDITIONAL DATA/ REMARKS
24.5	Grades very stiff at 25.0 feet			X	4, 10, 11	21	9	14/18 78%	2	Lab #33824 Natural Moisture=11.5%
	Groundwater observed at 27.1 feet approximately two hours after drilling	4378.5								
28										
	Wet zones at 30.0 feet	4375		X	2, 3, 4	7	10	18/18 100%	0.5	
	Grades medium stiff at 30.0 feet									
31.5										
		4371.5								
35	Grades stiff at 35.0 feet			X	3, 3, 8	11	11	14/18 78%	0.75	
36.5	Boring terminated at 36.5 feet	4368.9								
	Groundwater observed at 27.1 feet approximately 2 hours after drilling. Boring backfilled 2 hours after drilling.									
38.5										
42										
45.5										

TESTS: M.C. ●; PL 10 20 30 40 LL; N VALUE □ BLOWS/FT 9.8 19.6 29.4 39.2

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LOG OF BOREHOLE B-5

CLIENT: HFG Architecture

PROJECT: Blackfeet Hospital Apartments

BORING LOCATION: East Center Portion of Apartment - See Figure 2

SITE: Browning, Montana

Surface Elevation: 4407.1

Depth (ft.)	Material Description	Elevation (ft.)	Blows per 6"	N Blows/ft	Sample Number	In. Recovered / In. Driven	Pocket Penetrometer, TSF	Additional Data/Remarks
0	6-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics	4406.5	3, 2, 3	5	1	10/18 56%		
0.5	Sandy Lean CLAY; medium stiff, moist, olive brown, fine to coarse grained sand	4406.6						
2.1	Gravelly Lean CLAY with Sand, CL; stiff, moist, brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible cobbles	4405	4, 6, 5	11	2	17/18 94%		Lab #33825 Natural Moisture=11.1%
3.5		4403						
			2*, 3*, 6*	9*	3	8/18 44%		*Conversion of Dames and Moore blow counts to SPT equivalent blow counts
7		4399.5	4, 6, 9	15	4	12/18 67%		Lab #321 USCS=CL Fines=56.9% Sand/Gravel=43.1% Liquid Limit=27 Plasticity Index=12 Natural Moisture=10.6% Consolidation Cc=0.18 Swell Coeff. Cs=0.01 Collapse=3.5%
10.5	Groundwater observed at 9.9 feet approximately 20 hours after drilling. Grades very stiff at 10.0 feet	4396	5, 10, 11	21	5	12/18 67%		
	Grades stiff at 12.5 feet		5, 6, 9	15	6	18/18 100%		Lab #33826 Natural Moisture=11.6%
14		4392.5						
15.0	Clayey GRAVEL with Sand, GC; very stiff, moist, brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible cobbles	4392.1	3*, 8*, 13*	21*	7	17/18 94%	4	Lab #322 USCS=CL Fines=44.2% Sand=24.2% Gravel=31.6 Liquid Limit=30 Plasticity Index=13 Natural Moisture=12.2% Dry Unit Weight=124.0 pcf
17.5		4389						
20.0	Gravelly Lean CLAY with Sand, CL; very stiff, moist, brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible cobbles	4387.1	6, 9, 14	23	8	13/18 72%		Smoother drilling at 20.0 feet; Lab #33827 Natural Moisture=10.9%
21		4385.5						

Tests: M.C. ●; PL — LL (10, 20, 30, 40); N VALUE □ BLOWS/FT (9.8, 19.6, 29.4, 39.2)

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LOG OF BOREHOLE B-5

CLIENT: HFG Architecture

PROJECT: Blackfeet Hospital Apartments

BORING LOCATION: East Center Portion of Apartment - See Figure 2

SITE: Browning, Montana

Surface Elevation: 4407.1

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	M.C.	ADDITIONAL DATA/ REMARKS
25.0	Lean CLAY with Gravel; very stiff, moist to slightly moist, dark gray with multicolored clasts, rounded to subrounded (4382.1)	4382	27 12 11	23	9	3/18 17%			
		4378.5			10	4/24 17%			
		4375	4 10 14	24	11	18/18 100%	2	●	Lab #33828 Natural Moisture=11.1%
33.5	Boring terminated at 33.5 feet (4373.6)								

Depth scale: 24.5, 28, 31.5, 35, 38.5, 42, 45.5

Tests: M.C. ●; PL 10 20 30 40 LL; N VALUE □ BLOWS/FT 9.8 19.6 29.4 39.2

Boring terminated at 33.5 feet

Groundwater not observed during drilling.

Groundwater observed at 9.9 feet approximately 20 hours after drilling

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Project No.: 4027.21815.01	LOG OF BOREHOLE B-6	Sheet 1 of 2

CLIENT: HFG Architecture	PROJECT: Blackfeet Hospital Apartments
BORING LOCATION: Southeast Corner of Apartment - See Figure 2	SITE: Browning, Montana

Surface Elevation: 4409.7

MATERIAL DESCRIPTION

Depth (ft.)	Material Description	Elevation (ft.)
0	8-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics	
0.7	Sandy Lean CLAY; medium stiff, moist, light brown, fine to coarse grained sand	4409
1.9	Gravelly Lean CLAY with Sand and Cobbles, CL; stiff, moist to slightly moist, brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible boulders	4407.8
5.0	Grades very stiff at 5.0 feet	
10.9	Groundwater observed at 10.9 feet approximately 24 hours after drilling	
12.5	Grades stiff at 12.5 feet	
15.0	Grades very stiff at 15.0 feet	
20.0	Grades hard at 20.0 feet	

Depth scale (ft.): 0, 3.5, 7, 10.5, 14, 17.5, 21

Elevation scale (ft.): 4406.5, 4403, 4399.5, 4396, 4392.5, 4389

SAMPLES AND TESTS

Sample Number	Type	Blows per 6"	N Blows/ft	In. Recovered / In. Driven	Pocket Penetrometer, TSF	N Value (Blows/ft)	Additional Data/Remarks
1	Driven/Push	2, 2, 3	5	12/18, 67%			
2	Driven/Push	5, 5, 5	10	12/18, 67%			
3	Driven/Push	4, 8, 15	23	7/18, 39%			
4	Push			12/24, 50%			Lab #323 USCS=CL Fines=50.7% Sand/Gravel=49.3% Liquid Limit=28 Plasticity Index=14 Natural Moisture=9.5% Dry Unit Weight=120.2 pcf
5	Driven/Push	8, 10, 12	22	18/18, 100%			Moderately rough drilling at 11.0 feet
6	Driven/Push	5, 7, 6	13	18/18, 100%			
7	Driven/Push	4, 13, 14	27	18/18, 100%	4		Lab #33829 Natural Moisture=11.2%
8	Driven/Push	9, 24, 37	61	18/18, 100%		61	Lab #33830 Natural Moisture=10.4%

Tests chart: M.C. (●); PL — LL (10, 20, 30, 40); N VALUE □ BLOWS/FT (9.8, 19.6, 29.4, 39.2)

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LOG OF BOREHOLE B-6

CLIENT: HFG Architecture	PROJECT: Blackfeet Hospital Apartments
BORING LOCATION: Southeast Corner of Apartment - See Figure 2	SITE: Browning, Montana

Surface Elevation: 4409.7

DEPTH (FT.)	MATERIAL DESCRIPTION	GRAPHIC LOG	ELEVATION (FT.)	BULK	DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	M.C. / PL–LL (10 20 30 40); N VALUE □ BLOWS/FT (9.8 19.6 29.4 39.2)	ADDITIONAL DATA/ REMARKS
24.5	Possible cobble or boulder at 24.5 feet				■	50/ 6"	50	9	1/6 17%		50 □→	
25.0	Lean CLAY with Gravel; very stiff, moist to slightly moist, dark gray with multicolored clasts, rounded to subrounded, trace fine to coarse grained sand		4384.7									
28			4382									
					■	6 9 12	21	10	18/18 100%	4	● □	Lab #33831 Natural Moisture=9.8%
31.5	Boring terminated at 31.5 feet No groundwater observed during drilling. Groundwater observed at 10.9 feet approximately 24 hours after drilling		4378.5 / 4378.2									
35												
38.5												
42												
45.5												

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DRILL CO.	Boland	DRILL RIG	B-59
DRILLER	C. Tigert	HAMMER	Auto
LOGGED BY	D. Barrick	APPROVED BY	D. Russell

LOG OF BOREHOLE B-7

Project No.: 4027.21815.01 | Sheet 1 of 1

CLIENT	PROJECT
HFG Architecture	Blackfeet Hospital Apartments
BORING LOCATION: Paved Driveway - See Figure 2	SITE: Browning, Montana

Surface Elevation: 4405.7

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	ADDITIONAL DATA/ REMARKS
0	3-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics		4 4 4	8	1	14/18 78%	
0.3	Sandy Lean CLAY; medium stiff, moist, brown, fine to coarse grained sand	4405.4					Lab #33793 USCS=CL Fines=66.3% Sand=27.1% Gravel=6.6% Liquid Limit=30 Plasticity Index=16 Natural Moisture=8.7% Standard Proctor=116.5 pcf Optimum Moisture=12.1% CBR=6.6
1.3	Gravelly Lean CLAY with Sand and Cobbles, CL; medium stiff, moist, brown to dark brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible boulders	4404.4 / 4403	4 4 4	8	2	7/18 39%	
3.5							
	Grades stiff at 5.0 feet	4399.5	3 3 7	10	3	18/18 100%	
7	Grades hard at 7.5 feet		7 15 17	32	4	8/18 44%	
		4396	6 16 18	34	5	8/18 44%	
10.5							
11.5	Boring terminated at 11.5 feet No groundwater observed	4394.2					
14							
17.5							
21							

TESTS: M.C. ●; PL 10 20 30 40 LL; N VALUE □ BLOWS/FT 9.8 19.6 29.4 39.2

DOWL
222 N. 32nd Street, Suite 700
Billings, Montana 59101
Telephone: (406) 656-6399
www.dowl.com

STARTED	6/28/2019	FINISHED	6/28/2019
DRILL CO.	Boland	DRILL RIG	B-59
DRILLER	C. Tigert	HAMMER	Auto
LOGGED BY	D. Barrick	APPROVED BY	D. Russell

LOG OF BOREHOLE B-8

Project No.: 4027.21815.01

CLIENT	PROJECT
HFG Architecture	Blackfeet Hospital Apartments
BORING LOCATION	**SITE**
Paved Driveway - See Figure 2	Browning, Montana

Surface Elevation: 4410.1

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	ADDITIONAL DATA/ REMARKS
0	3-inches +/- Topsoil, Sandy Lean CLAY; very moist, black, organics		2 4 3	7	1	13/18 72%		
0.3	Sandy Lean CLAY; medium stiff, moist, brown, fine to coarse grained sand	4409.8						
2.0	Gravelly Lean CLAY with Sand and Cobbles, CL; stiff, moist, brown to dark brown with multicolored clasts, rounded to subrounded, fine to coarse grained sand, possible boulders	4408.1	3 5 5	10	2	12/18 67%	2.5	Lab #33794 USCS=CL Fines=62.2% Sand=26.7% Gravel=11.1% Liquid Limit=28 Plasticity Index=14 Natural Moisture=10.7% Standard Proctor=123.9 pcf Optimum Moisture=11.0%
3.5		4406.5						
			4 4 5	9	3	18/18 100%	2.0	
7		4403						
	Grades very stiff at 7.5 feet		10 9 11	20	4	8/18 44%		
	Possible cobble or boulder at 10.0 feet		50/ 5.5"	50	5	0/5.5 0%		
10.5	Boring terminated at 10.5 feet	4399.6						
	No groundwater observed							

TESTS: M.C. (●); PL — LL scale 10, 20, 30, 40; N VALUE □ BLOWS/FT 9.8, 19.6, 29.4, 39.2; 50

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STARTED	6/28/2019	FINISHED	6/28/2019
DRILL CO.	Boland	DRILL RIG	B-59
DRILLER	C. Tigert	HAMMER	Auto
LOGGED BY	D. Barrick	APPROVED BY	D. Russell

APPENDIX B: LABORATORY TESTING

Blackfeet Hospital Community Apartments - 4027.21815.01

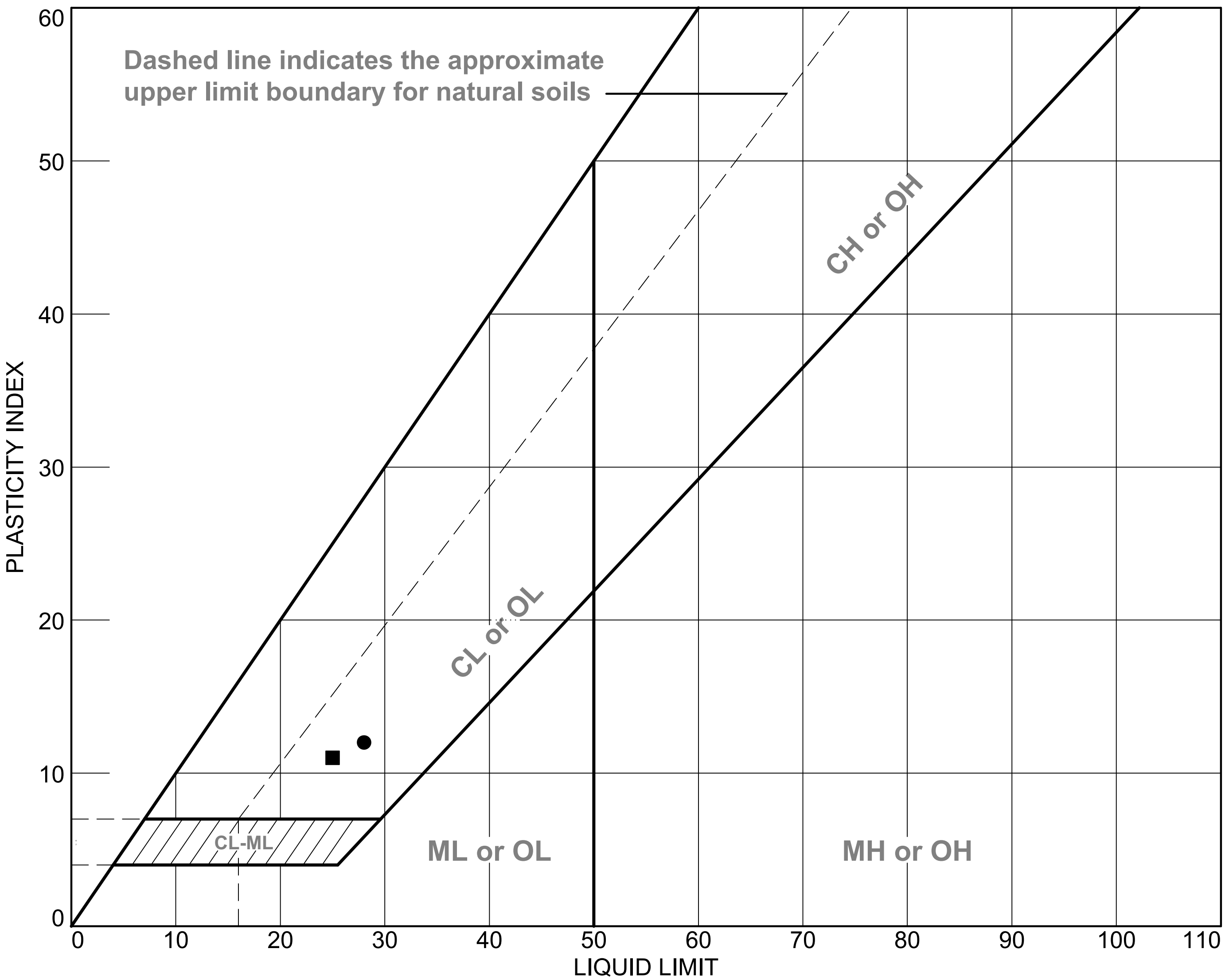
LAB NUMBER	LOCATION	SAMPLE TYPE	DEPTH RANGE (FEET)	CLASSIFICATION SYMBOL	**FINES** SMALLER THAN #200 (0.075 mm)	**SAND & GRAVEL** #200 to # 3" (0.075 - 76.2 mm)	**SAND** #200 to # 4 (0.075 - 4.76 mm)	**GRAVEL** #4 to 3" (4.76 -76.2 mm)	LIQUID LIMIT - %	PLASTICITY INDEX - %	MAXIMUM DRY UNIT WEIGHT (ASTM D698)-PCF	OPTIMUM MOISTURE CONTENT - %	CONSOLIDATION - Pc - KSF	CONSOLIDATION -Cc	CONSOLIDATION - Cs	COLLAPSE - %	UNCONFINED STRENGTH - qu KSF	UNCONFINED COHESION - qu/2 - KSF	DRY UNIT WEIGHT - PCF	NATURAL MOISTURE - %	CALIFORNIA BEARING RATIO (CBR)	RESISTIVITY (Ohm-Cm) SATURATED	pH	WATER SOLUBLE SO4 - %
33813	B-1	SPT	5.0 to 6.5																	7.4				
33814	B-1	SPT	10.0 to 11.5																	8.9				
312	B-1	Dames & Moore	12.5 to 14.0	CL	54.6	45.4			28	12			2.0	0.18	0.01	5.3			116.8	13.9				
33815	B-1	SPT	20.0 to 21.5																	3.9				
313	B-1	SPT	30.0 to 31.5	CL	50.6	49.4			25	11							5.36	2.68	136.5	10.5				
B19070472-001	B-1	SPT	35.0 to 36.5										.									417	7.5	0.0392
33816	B-1	SPT	40.0 to 41.5																	9.4				
33817	B-2	SPT	5.0 to 6.5																	8.6				
314	B-2	Dames & Moore	7.5 to 9.0	CL	52.9	47.1														9.5				
33818	B-2	SPT	14.5 to 16.0																	10.1				
315	B-2	Dames & Moore	20.0 to 21.5	CL	50	50			31	16										11.9				
317	B-3	SPT	5.0 to 6.5																	10.7				
33819	B-3	SPT	7.5 to 9.0																	9.3				
33820	B-3	SPT	25.0 to 26.5																	8.9				
33821	B-3	SPT	30.0 to 31.5																	11.0				
33822	B-4	SPT	5.0 to 6.5																	12.4				
318	B-4	SPT	7.5 to 9.0	CL	56.4	43.6			30	14										11.4				
B-19070472-002	B-4	SPT	12.5 to 14.0																			407	7.8	0.0514
33823	B-4	SPT	15.0 to 16.5														6.61	3.31	128.1	12.1				
33824	B-4	SPT	25.0 to 26.5																	11.5				
33825	B-5	SPT	2.5 to 4.0																	11.1				
321	B-5	Dames & Moore	6.0 to 6.5	CL	56.9	43.1			27	12			2.0	0.18	0.01					10.6				
33826	B-5	SPT	12.5 to 14.0																	11.6				
322	B-5	Dames & Moore	15.0 to 16.5	CL	44.2		24.2	31.6	30	13									124.0	12.2				
33827	B-5	SPT	20.0 to 21.5																	10.9				
33828	B-5	SPT	32.0 to 33.5																	11.1				
323	B-6	Shelby	7.5 to 9.5	CL	50.7	49.3			28	14									120.2	9.5				

Materials Testing Laboratory
Montana: Billings, Butte
Wyoming: Lander

Blackfeet Hospital Community Apartments - 4027.21815.01

LAB NUMBER	LOCATION	SAMPLE TYPE	DEPTH RANGE (FEET)	CLASSIFICATION SYMBOL	**FINES** SMALLER THAN #200 (0.075 mm)	**SAND & GRAVEL** #200 to # 3" (0.075 - 76.2 mm)	**SAND** #200 to # 4 (0.075 - 4.76 mm)	**GRAVEL** #4 to 3" (4.76 -76.2 mm)	LIQUID LIMIT - %	PLASTICITY INDEX - %	MAXIMUM DRY UNIT WEIGHT (ASTM D698)-PCF	OPTIMUM MOISTURE CONTENT - %	CONSOLIDATION - Pc - KSF	CONSOLIDATION -Cc	CONSOLIDATION - Cs	COLLAPSE - %	UNCONFINED STRENGTH - qu KSF	UNCONFINED COHESION - qu/2 - KSF	DRY UNIT WEIGHT - PCF	NATURAL MOISTURE - %	CALIFORNIA BEARING RATIO (CBR)	RESISTIVITY (Ohm-Cm) SATURATED	pH	WATER SOLUBLE SO4 - %
33829	B-6	SPT	15.0 to 16.5																	11.2				
33830	B-6	SPT	20.0 to 21.5																	10.4				
33831	B-6	SPT	30.0 to 31.5																	9.8				
33793	B-7	Bulk	2.0 to 9.5	CL	66.3		27.1	6.6	30	16	116.5	12.1								8.7	6.6			
33794	B-8	Bulk	2.0 to 9.5	CL	62.2		26.7	11	28	14	123.9	11.0								10.7				

LIQUID AND PLASTIC LIMITS TEST REPORT



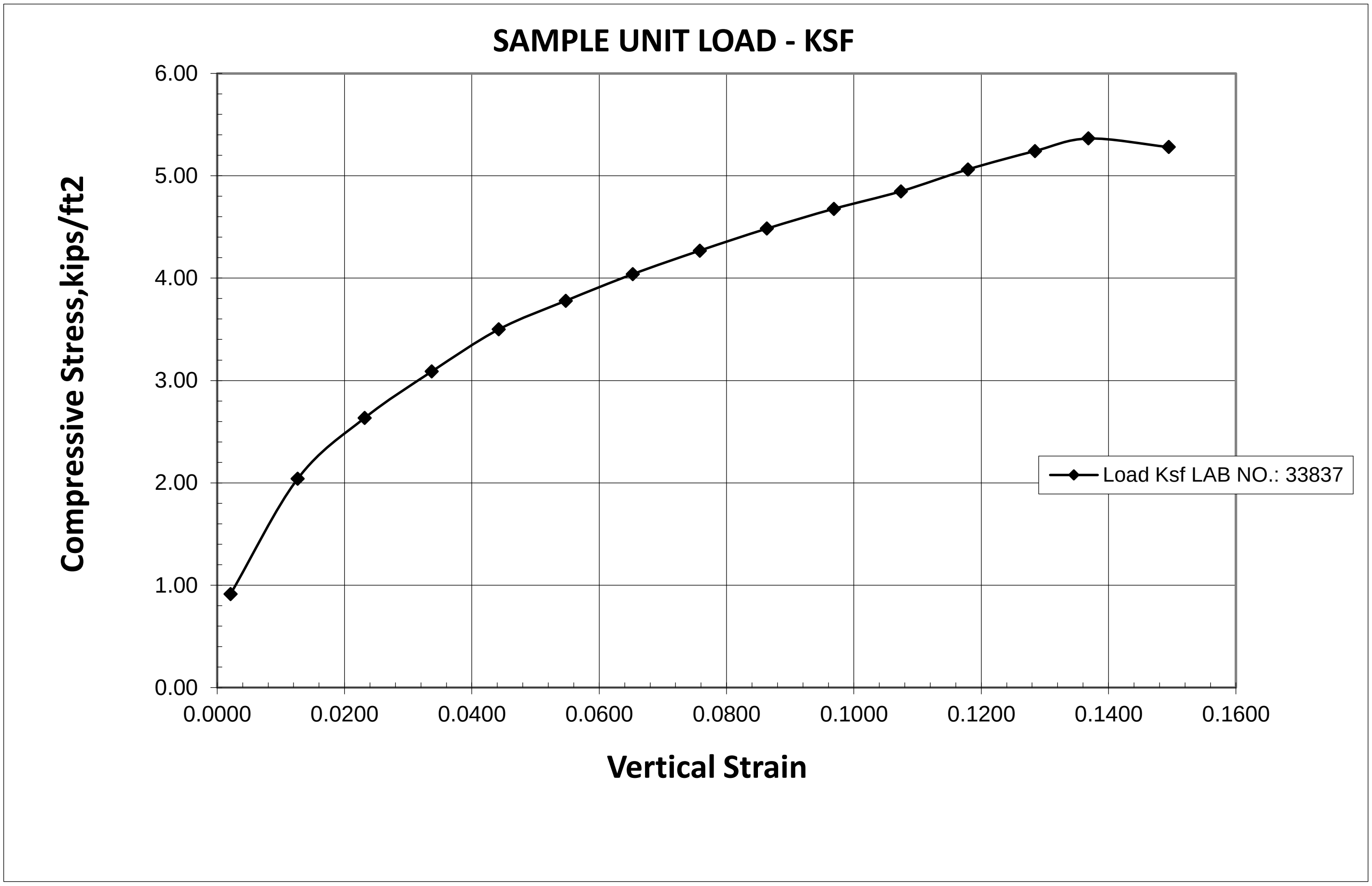
SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	BH-1, 12.5-14		12.5	13.9	16	28	12	CL
■	BH-1, 30-31.5		30	10.5	14	25	11	CL

DOWL

Client: HFG Architecture
Project: Blackfeet Hospital Apartments

Project No.: 4027.21815.01 **Figure**

UNCONFINED COMPRESSION TEST



TYPE OF BREAK	GRADATION		ATTERBERG LIMITS	
	SIEVE	% PASSING	LIQUID LIMIT	25
			PLASTIC LIMIT	14
			PLASTIC INDEX	11
			CLASSIFICATION	
			USCS	CL
			AASHTO	
			DESCRIPTION	
% MOISTURE 10.3 %			Sandy Lean CLAY with Gravel	
WET UNIT WT. 150.6 PCF				
DRY UNIT WT. 136.5 PCF			SPECIFIC GRAVITY	
U.C. STRENGTH, qu 5.36 KSF				
COHESION (qu/2) 2.68 KSF				

PROJECT:	Blackfeet Hospital	LAB NO.:	33837
PROJECT NO.:	4027.21815.01	SAMPLED BY:	DOWL
LOCATION:	B-1	DATE SAMPLED:	6/28/2019
DEPTH:	30-31.5	DATE TESTED:	7/26/2019
RATIO:	2.00		

DOWL

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: DOWL
Project: Blackfeet Hospital Housing
Report Date: 07/10/19

Lab ID: B19070472-001
Client Sample ID: Boving B-1 [35.0-36.5]
Collection Date: 06/28/19 12:00
DateReceived: 07/03/19
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
WATER EXTRACTABLE CONSTITUENTS							
Sulfate, 1:2	392	mg/kg		1		E300.0	07/09/19 10:04 / mrc
SATURATED PASTE EXTRACT							
Resistivity, Sat. Paste	417	ohm-cm		1		Calculation	07/10/19 09:30 / srm
pH, sat. paste	7.5	s.u.		0.1		ASA10-3	07/10/19 09:30 / srm

Lab ID: B19070472-002
Client Sample ID: Boving B-4 [12.5-14.0]
Collection Date: 06/28/19 13:00
DateReceived: 07/03/19
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
WATER EXTRACTABLE CONSTITUENTS							
Sulfate, 1:2	514	mg/kg		1		E300.0	07/09/19 10:51 / mrc
SATURATED PASTE EXTRACT							
Resistivity, Sat. Paste	407	ohm-cm		1		Calculation	07/10/19 09:30 / srm
pH, sat. paste	7.8	s.u.		0.1		ASA10-3	07/10/19 09:30 / srm

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: DOWL **Work Order:** B19070472 **Report Date:** 07/10/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA10-3									Batch: 134867
Lab ID: B19070472-001A DUP	Sample Duplicate				Run: MISC-SOIL_190710A				07/10/19 09:30
pH, sat. paste	7.50	s.u.	0.10				0.0	10	
Lab ID: LCS-1907100930	Laboratory Control Sample				Run: MISC-SOIL_190710A				07/10/19 09:30
pH, sat. paste	7.40	s.u.	0.10	99	90	110			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: DOWL **Work Order:** B19070472 **Report Date:** 07/10/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: Calculation								Batch: R323717	
Lab ID: B19070472-001A DUP	Sample Duplicate				Run: MISC-SOIL_190710A			07/10/19 09:30	
Resistivity, Sat. Paste	426	ohm-cm	1.0		70	130	2.1	30	
Lab ID: LCS-1907100930	Laboratory Control Sample				Run: MISC-SOIL_190710A			07/10/19 09:30	
Resistivity, Sat. Paste	245	ohm-cm	1.0	101	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: DOWL **Work Order:** B19070472 **Report Date:** 07/10/19

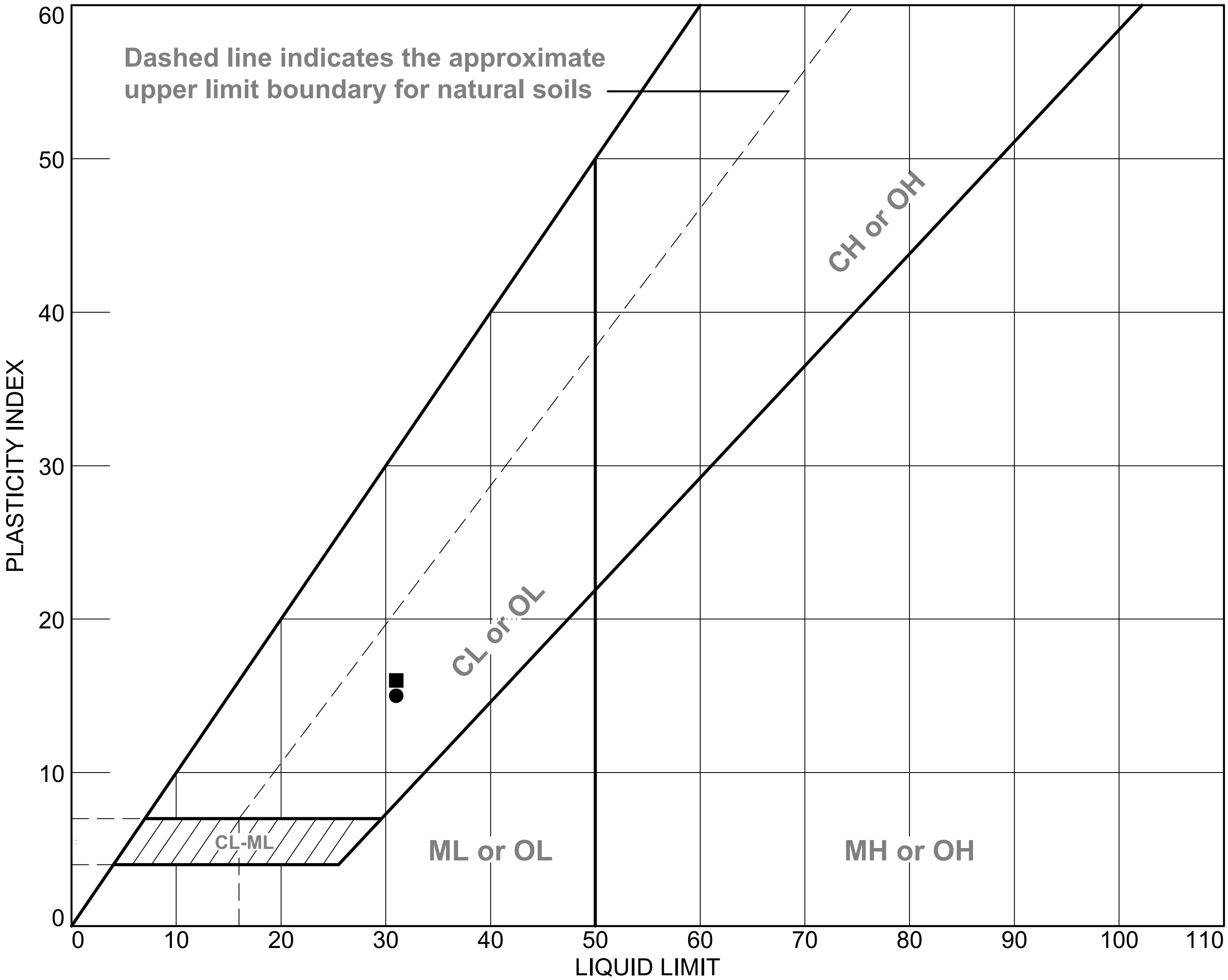
Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E300.0									Batch: 134802
Lab ID: LCS-134802	Laboratory Control Sample				Run: IC METROHM 2_190708A				07/09/19 09:17
Sulfate, 1:2	616	mg/kg	1.0	100	70	130			
Lab ID: B19070472-001AMS	Sample Matrix Spike				Run: IC METROHM 2_190708A				07/09/19 10:19
Sulfate, 1:2	804	mg/kg	1.0	98	70	130			
Lab ID: B19070472-001A DUP	Sample Duplicate				Run: IC METROHM 2_190708A				07/09/19 10:35
Sulfate, 1:2	373	mg/kg	1.0				4.8	30	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	BH-2, 7.5-9		7.5	9.5	16	31	15	CL
■	BH-2, 20-21.5		20	11.9	15	31	16	CL

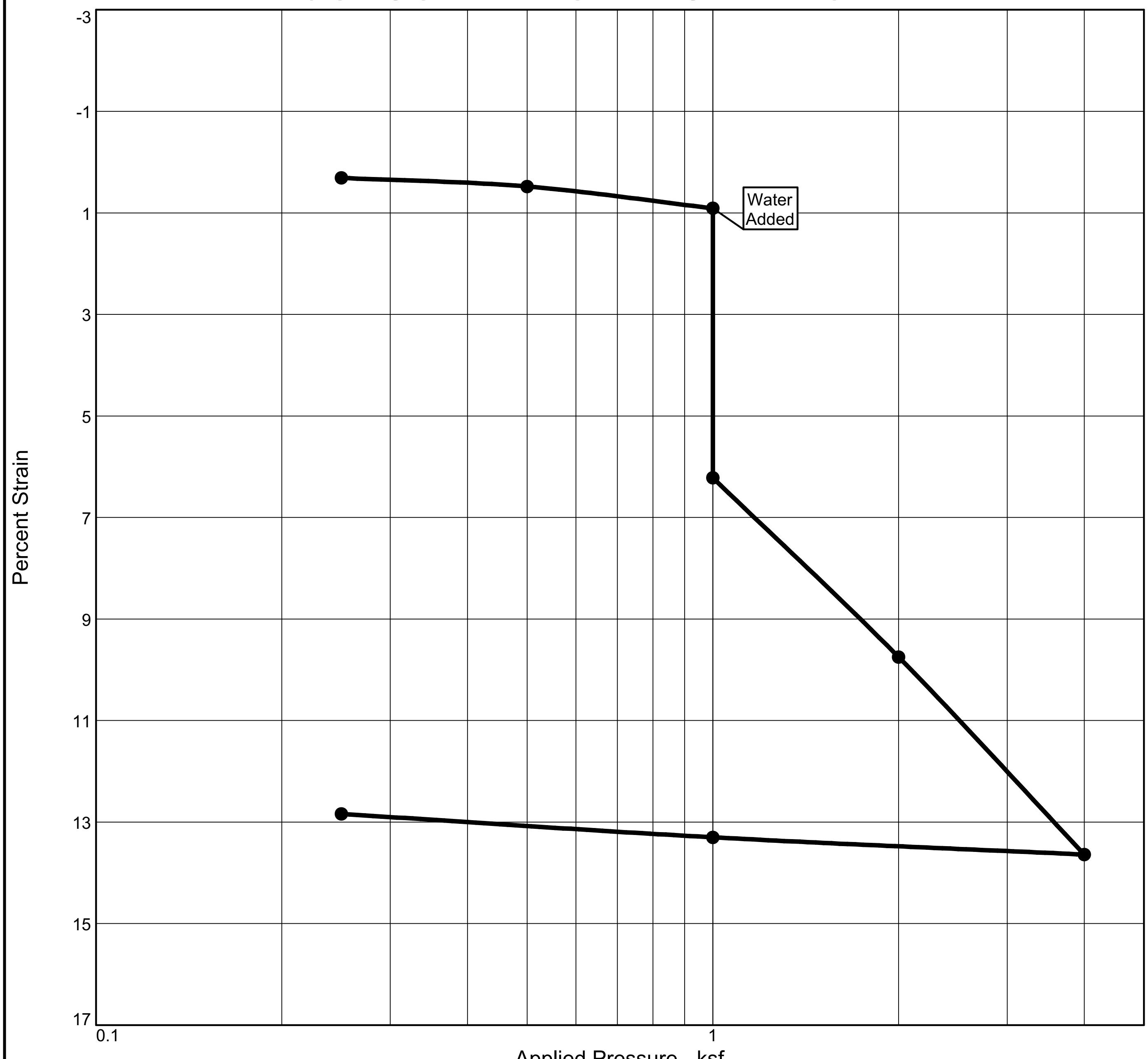
DOWL

Client: HFG Architecture

Project: Blackfeet Hospital Apartments

Project No.: 4027.21815.01 **Figure**

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_s	Swell Press. (ksf)	Clpse. %	e_o
Sat.	Moist.											
60.6 %	9.5 %	116.9	31	15	2.65	0.96	2.0	0.18	0.01		5.3	0.415

MATERIAL DESCRIPTION	USCS	AASHTO
Gravelly Lean CLAY with Sand	CL	

Project No. 4027.21815.01 **Client:** HFG Architecture

Project: Blackfeet Hospital Apartments

Source of Sample: BH-2, 7.5-9 **Depth:** 7.5

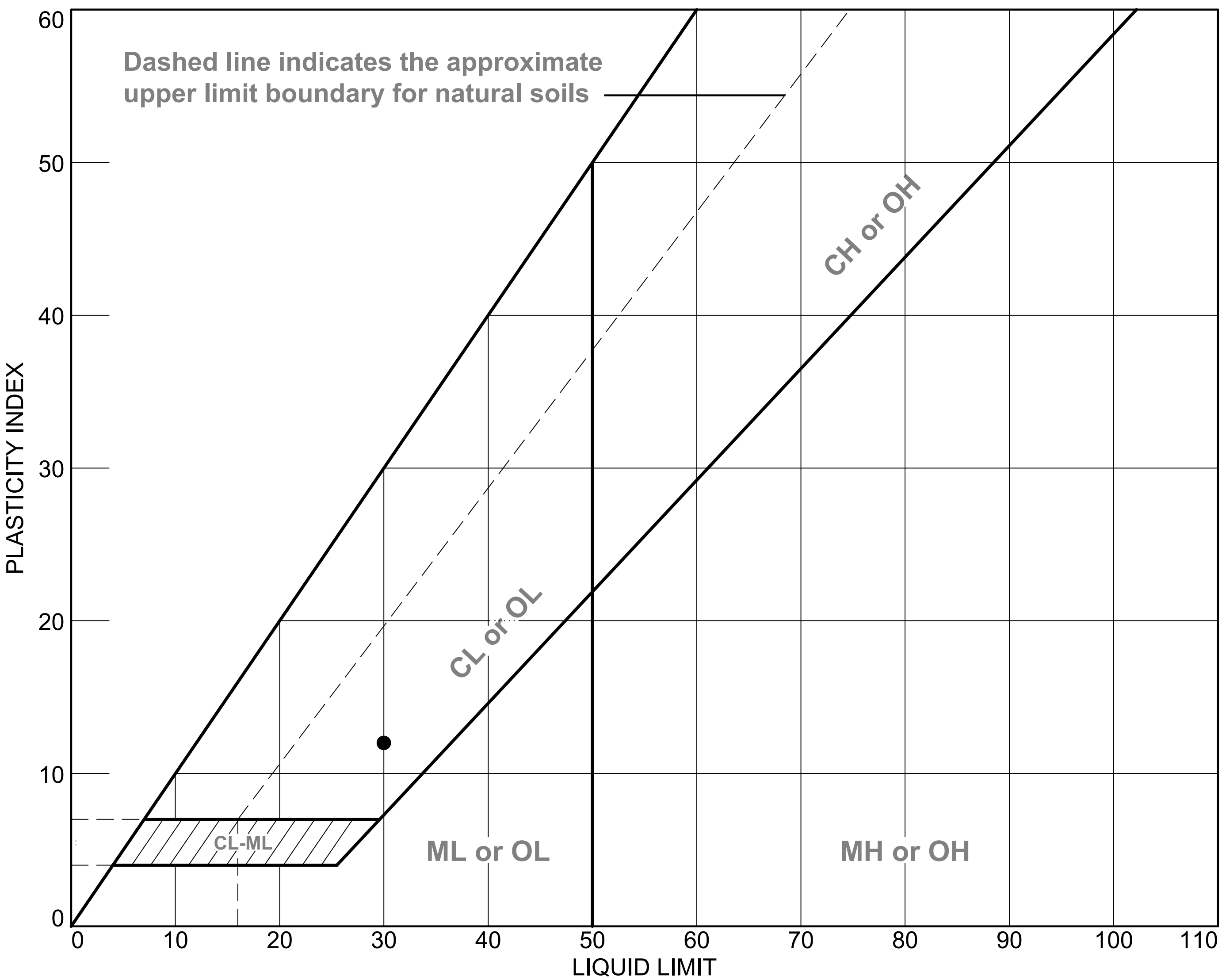
DOWL

Remarks:
Disturbed Sample

Figure

Tested By: S Brown **Checked By:** K Jones

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	BH-3, 5-6.5		5	10.7	18	30	12	CL

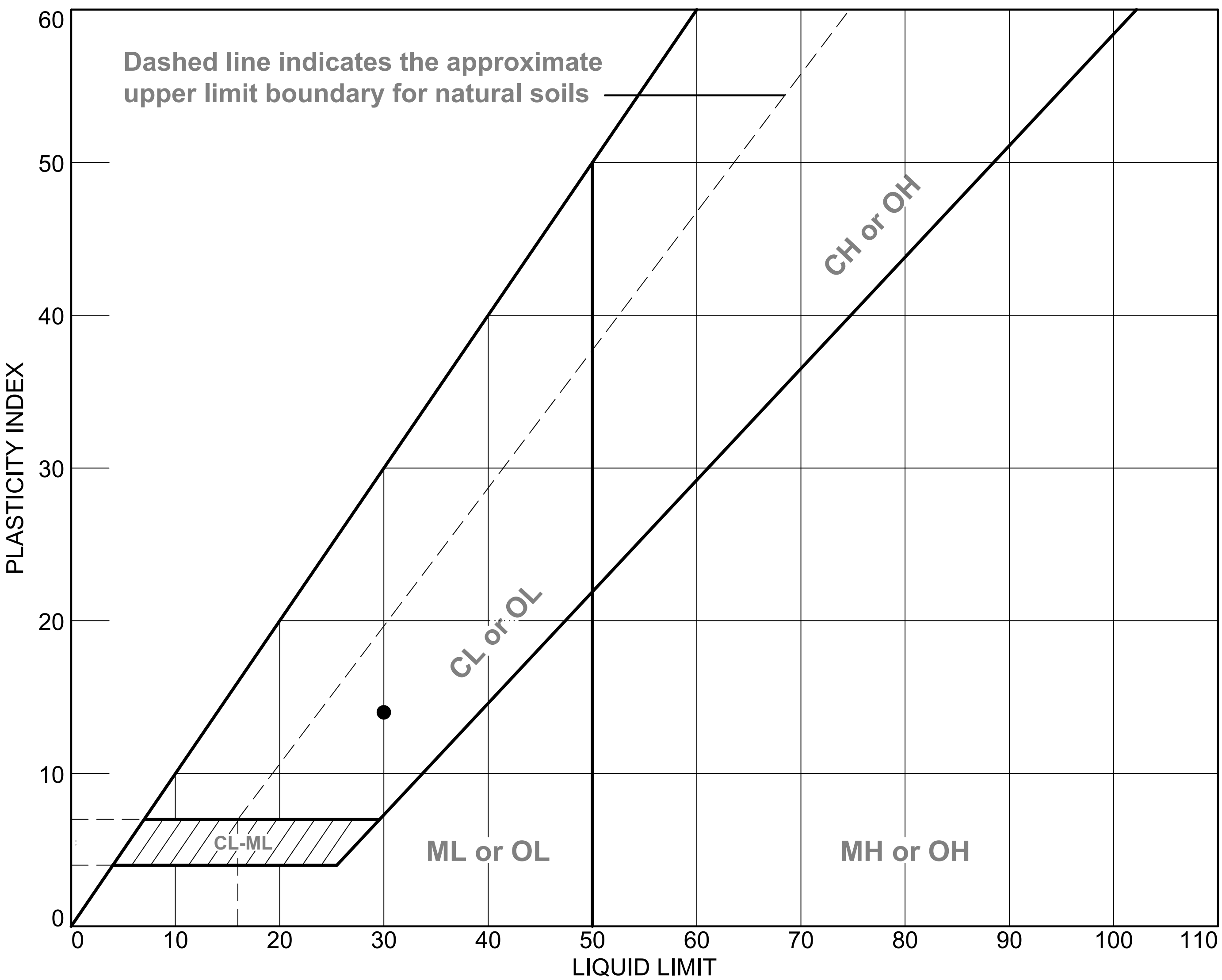
DOWL

Client: HFG Architecture

Project: Blackfeet Hospital Apartments

Project No.: 4027.21815.01 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

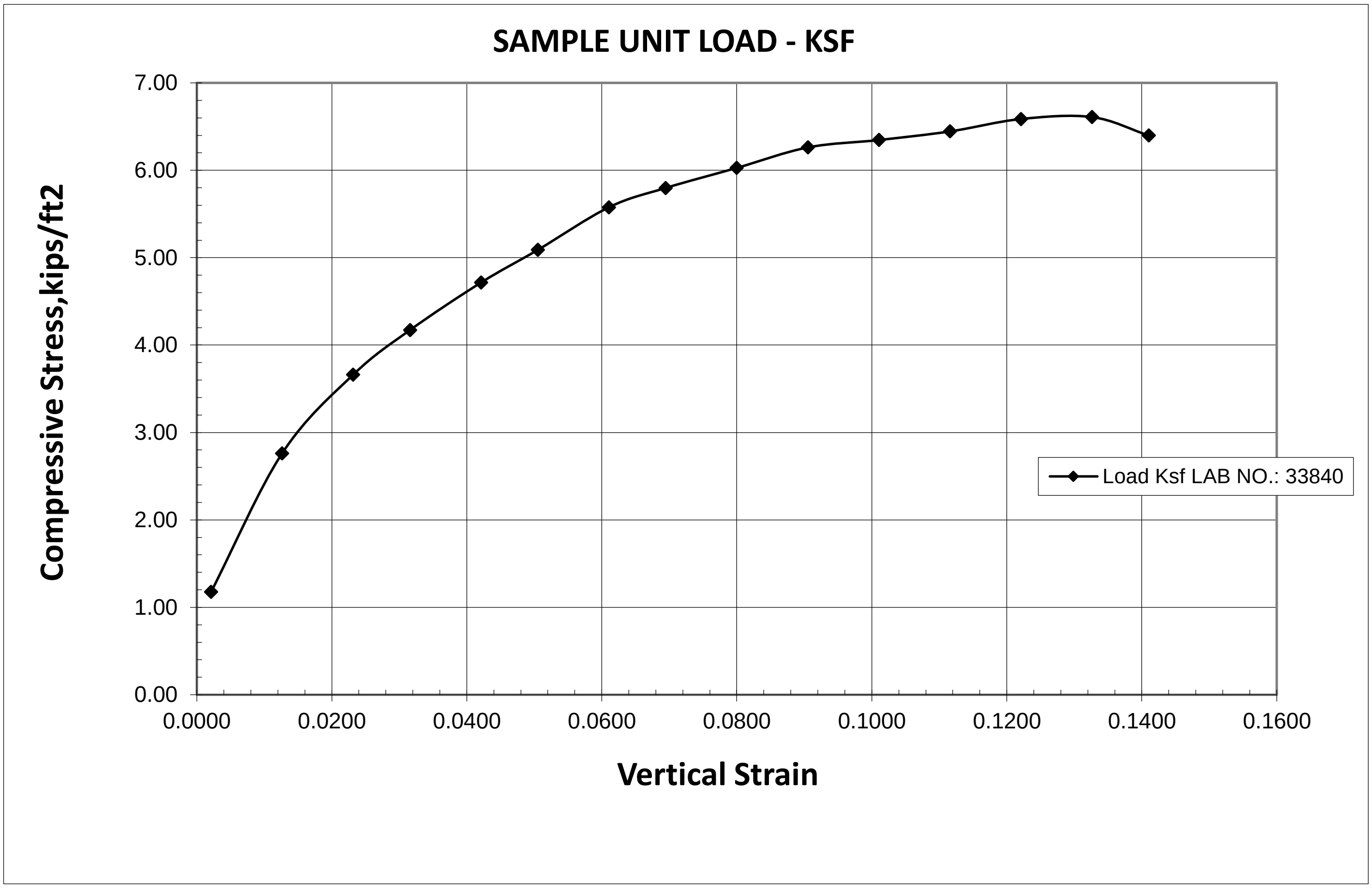
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	BH-4, 7.5-9		7.5	9.5	16	30	14	CL

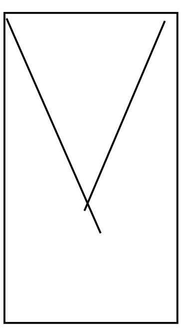
DOWL

Client: HFG Architecture
Project: Blackfeet Hospital Apartments

Project No.: 4027.21815.01 **Figure**

UNCONFINED COMPRESSION TEST

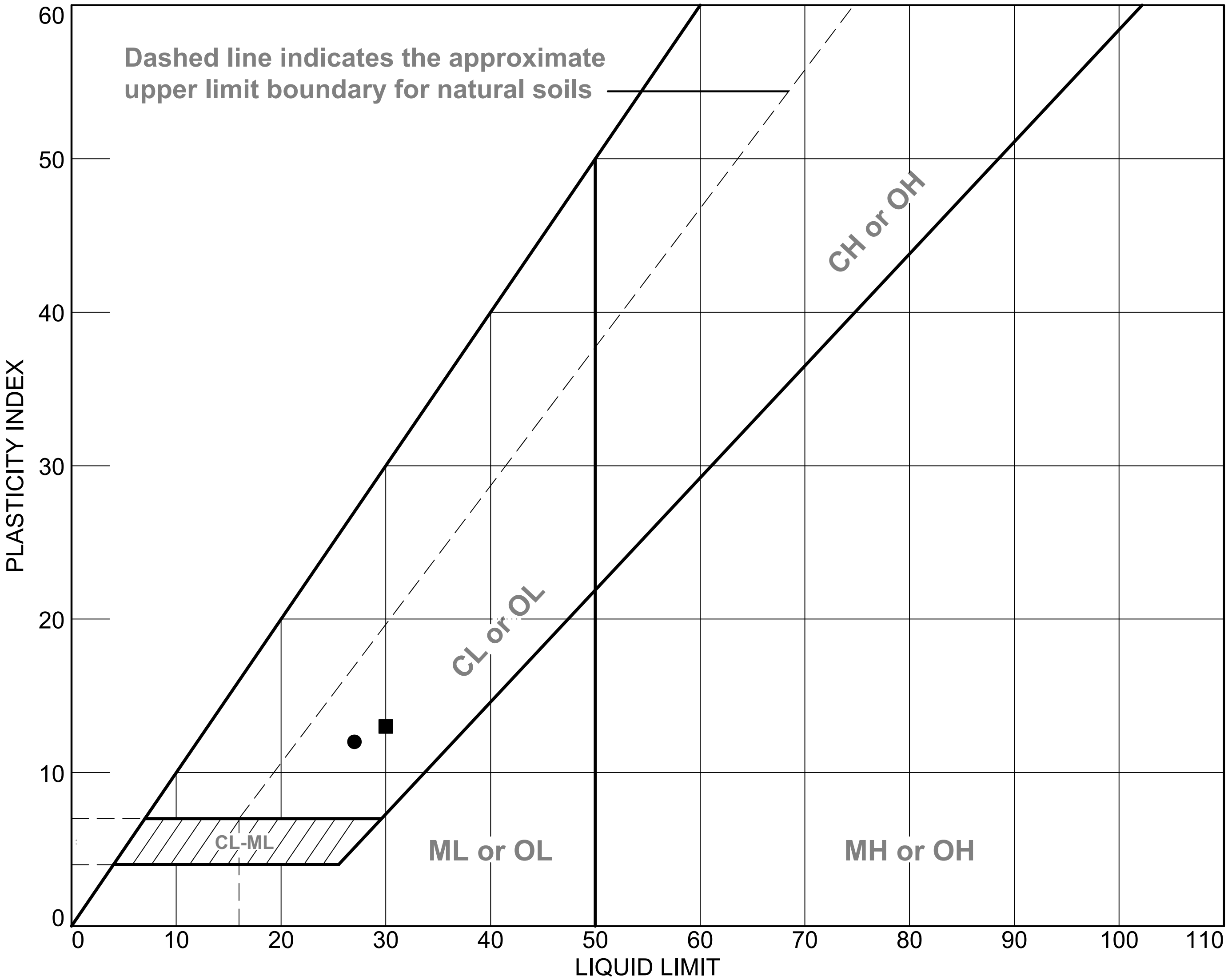


TYPE OF BREAK		GRADATION		ATTERBERG LIMITS	
		SIEVE	% PASSING	LIQUID LIMIT	
				PLASTIC LIMIT	
				PLASTIC INDEX	
				CLASSIFICATION	
				USCS	CL
				AASHTO	
% MOISTURE	10.1 %			DESCRIPTION	
WET UNIT WT.	141.1 PCF			Lean CLAY with Gravel	
DRY UNIT WT.	128.1 PCF				
U.C. STRENGTH, qu	6.61 KSF			SPECIFIC GRAVITY	
COHESION (qu/2)	3.31 KSF				

PROJECT:	Blackfeet Hospital	LAB NO.:	33840
PROJECT NO.:	4027.21815.01	SAMPLED BY:	DOWL
LOCATION:	B-4	DATE SAMPLED:	6/28/2019
DEPTH:	20-21.5	DATE TESTED:	7/26/2019
RATIO:	2.00		

DOWL

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	BH-5,6-6.5		6	10.6	15	27	12	CL
■	BH-5, 15-16.5		15	12.2	17	30	13	CL

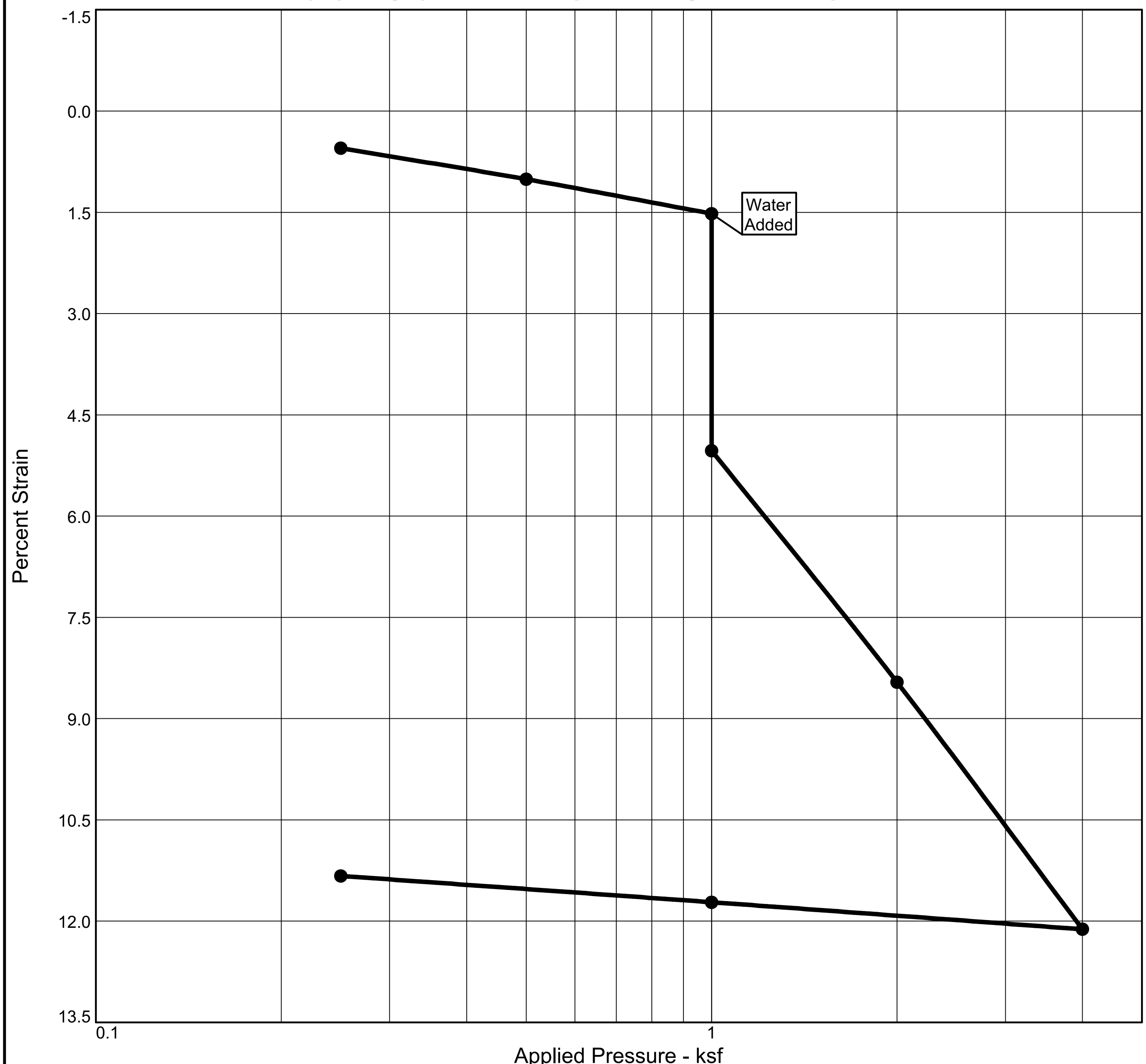
DOWL

Client: HFG Architecture

Project: Blackfeet Hospital Apartments

Project No.: 4027.21815.01 **Figure**

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_s	Swell Press. (ksf)	Clpse. %	e_o
Sat.	Moist.											
61.7 %	10.6 %	113.6	27	12	2.65	0.75	2.0	0.18	0.01		3.5	0.456

MATERIAL DESCRIPTION	USCS	AASHTO
Gravelly Lean CLAY with Sand	CL	

Project No. 4027.21815.01 **Client:** HFG Architecture

Project: Blackfeet Hospital Apartments

Source of Sample: BH-5,6-6.5 **Depth:** 6

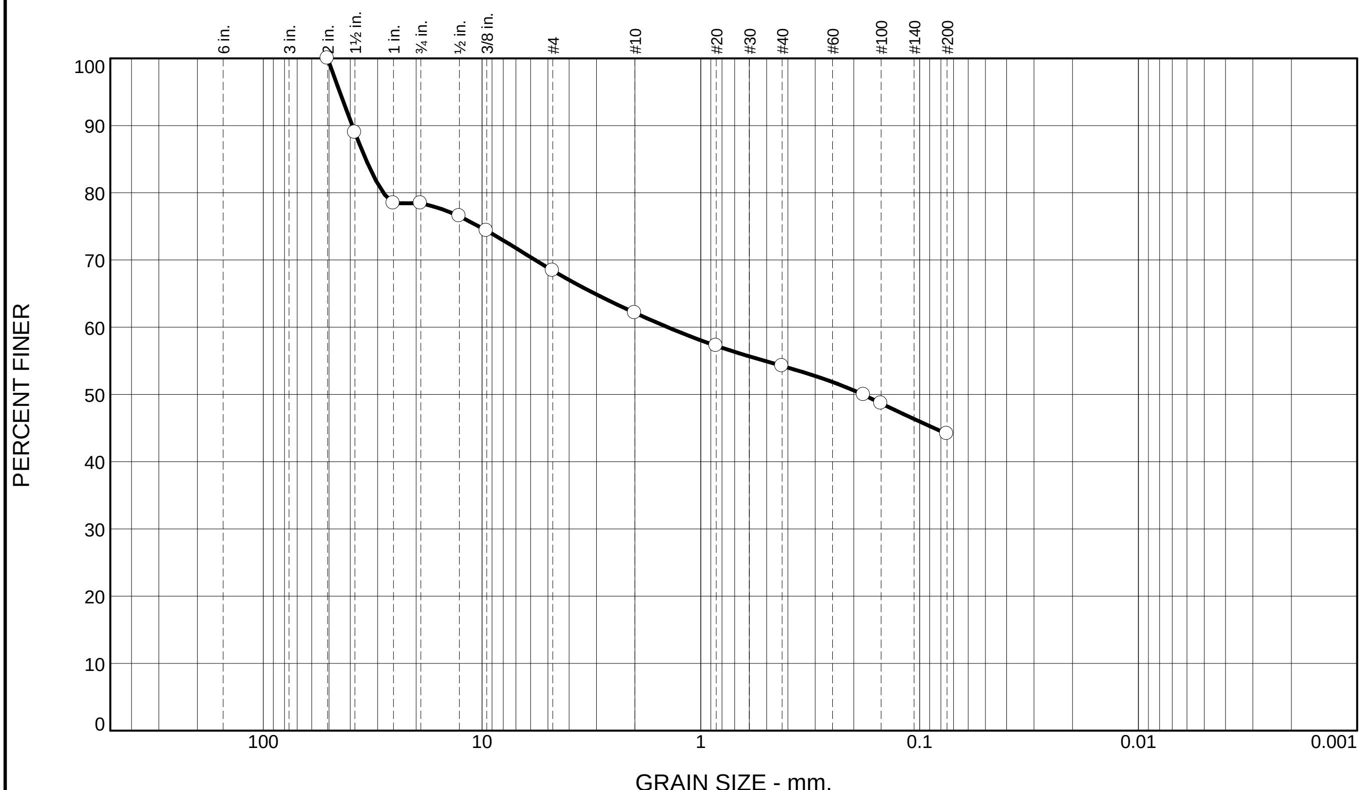
DOWL

Remarks:
Disturbed Sample

Figure

Tested By: S Brown **Checked By:** K Jones

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	21.6	10.0	6.3	7.9	10.0	44.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2	100.0		
1.5	89.0		
1	78.4		
.75	78.4		
.5	76.5		
.375	74.4		
#4	68.4		
#10	62.1		
#20	57.2		
#40	54.2		
#80	49.9		
#100	48.7		
#200	44.2		

* (no specification provided)

Material Description

Clayey GRAVEL with Sand

Atterberg Limits

PL=17 LL=30 PI=13

Classification

USCS=GC AASHTO=

Remarks

Sampled By: DOWL
F.M.=3.11

Location: B-5
Sample Number: 33839 **Depth:** 15-16.5 **Date:** 7/25/2019

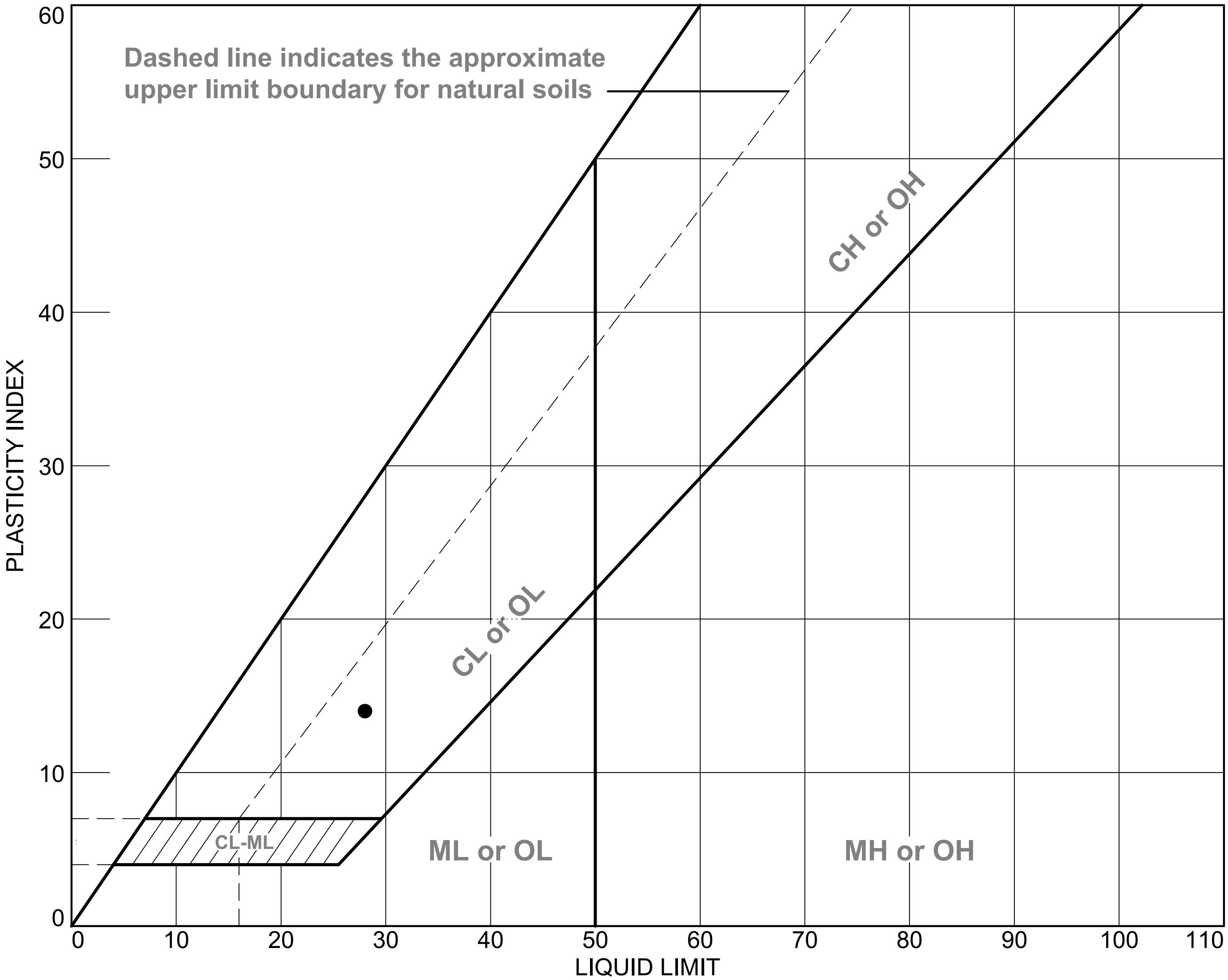
DOWL

Client: HFG Architecture
Project: Blackfeet Hospital Apartments

Project No: 4027.21815.01 **Figure** 03

Tested By: CC **Checked By:** J. Miller

LIQUID AND PLASTIC LIMITS TEST REPORT



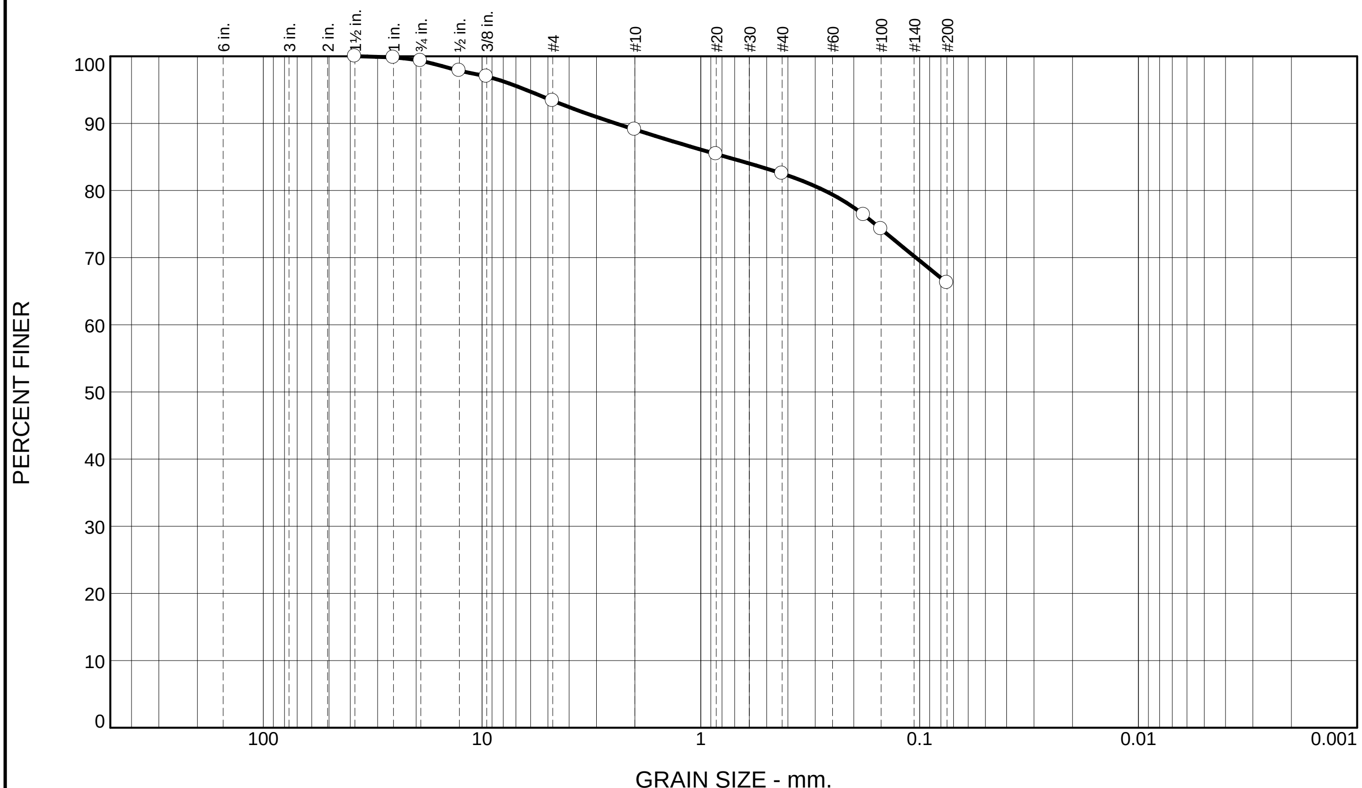
SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	BH-6, SH		7.5	9.5	14	28	14	CL

DOWL

Client: HFG Architecture
Project: Blackfeet Hospital Apartments

Project No.: 4027.21815.01 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.7	5.9	4.3	6.6	16.2	66.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	99.8		
.75	99.3		
.5	97.8		
.375	97.0		
#4	93.4		
#10	89.1		
#20	85.4		
#40	82.5		
#80	76.4		
#100	74.3		
#200	66.3		

* (no specification provided)

Material Description

Sandy Lean CLAY

Atterberg Limits

PL= 14 LL= 30 PI= 16

Classification

USCS= CL AASHTO= A-6(8)

Remarks

Sampled By: DOWL
Natural Moisture: 8.7%
F.M.=0.95

Location: B-7
Sample Number: 33793 **Depth:** 2.0-9.5 **Date:** 7/26/2019

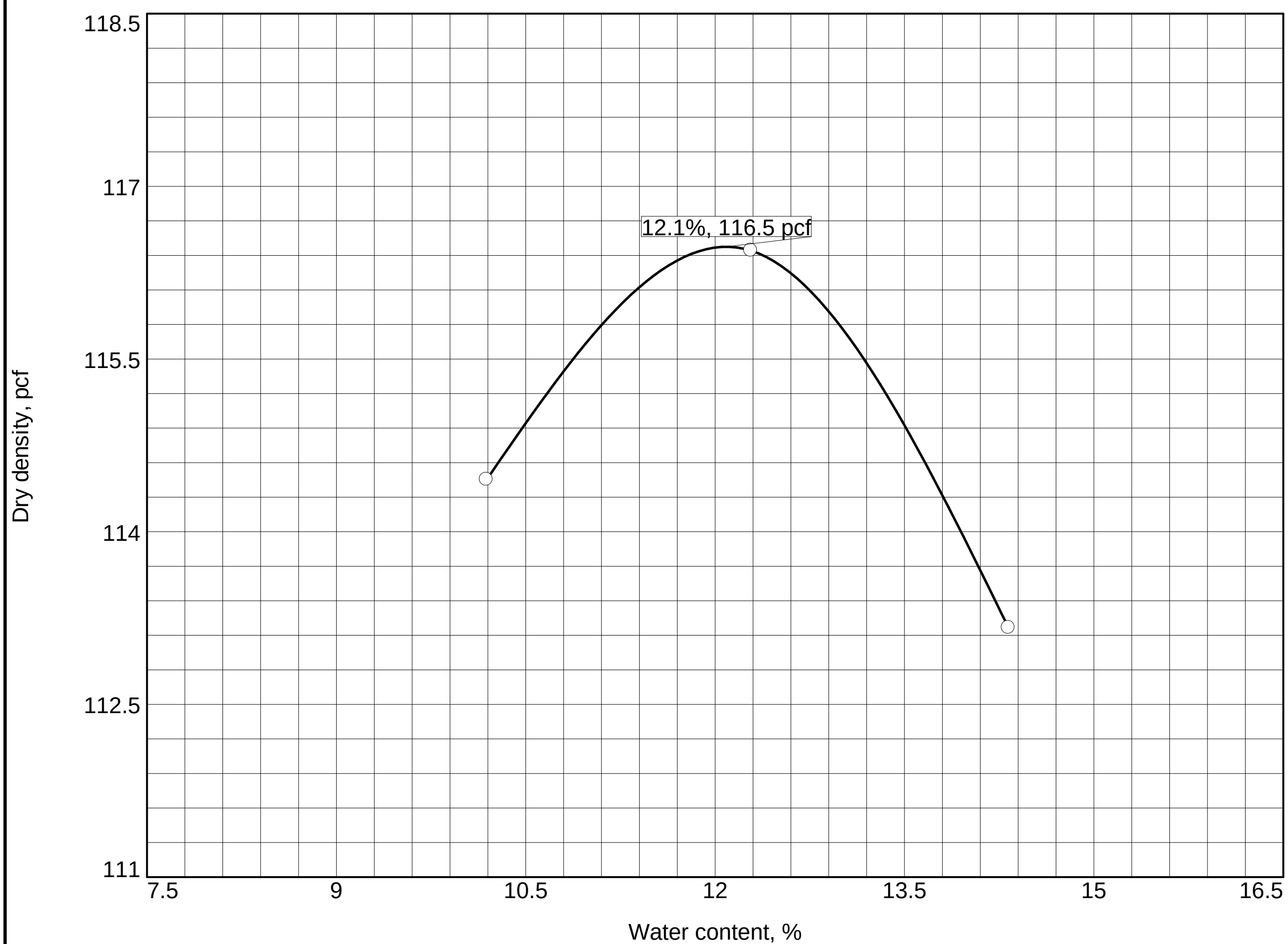
DOWL

Client: HFG Architecture
Project: Blackfeet Hospital Apt

Project No: 4027.21815.01 **Figure**

Tested By: CC **Checked By:** J. Miller

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard
ASTM D4718-15 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
2.0-9.5	CL	A-6(8)			30	16	6.6	66.3

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 116.5 pcf	114.2 pcf	Sandy Lean CLAY
Optimum moisture = 12.1 %	12.8 %	

Project No. 4027.21815.01 **Client:** HFG Architecture
Project: Blackfeet Hospital Apt

○**Location:** B-7 **Sample Number:** 33793

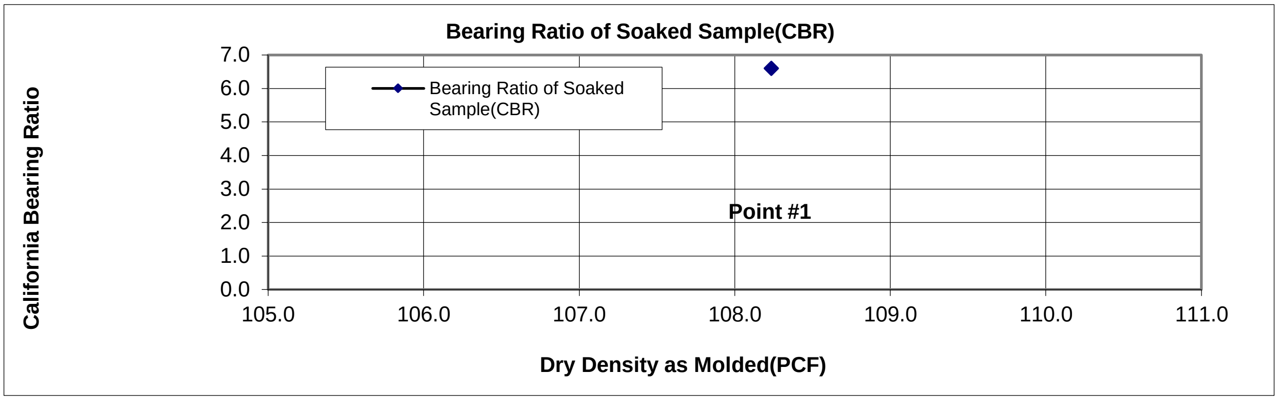
DOWL

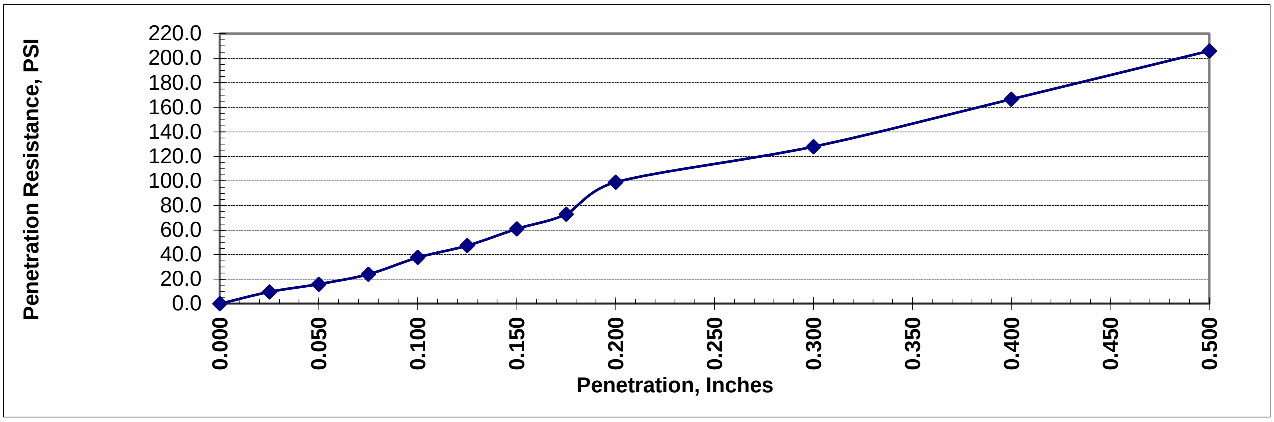
Remarks:
Sampled By: DOWL
Natural Moisture: 8.7%

Figure 01

Tested By: CC **Checked By:** J. Miller

CALIFORNIA BEARING RATIO





ASTM: D698 Maximum Dry Density: 114.2 Optimum Moisture: 12.8%

TEST RESULTS

	Point #1	Point #2	Point #3
Percent of Maximum Dry Density	94.8%		
Dry Density As Molded(pcf)	108.2		
Dry Density After 96 Hour Soak(pcf)	107.1		
Moisture Content(%):			
Before Compaction	12.8%		
After Compaction	12.7%		
Top 1" After Soak	16.9%		
Average After Soak	13.6%		
Swell(% of Initial Height)	0.2%		
Surcharge Amount(psf)	102.4		
Bearing Ratio of Soaked Sample(CBR)	6.6		

ATTERBERG LIMITS	
LIQUID LIMIT	30
PLASTIC LIMIT	14
PLASTIC INDEX	16

CLASSIFICATION	
USCS	CL
AASHTO	A-6(8)

DESCRIPTION

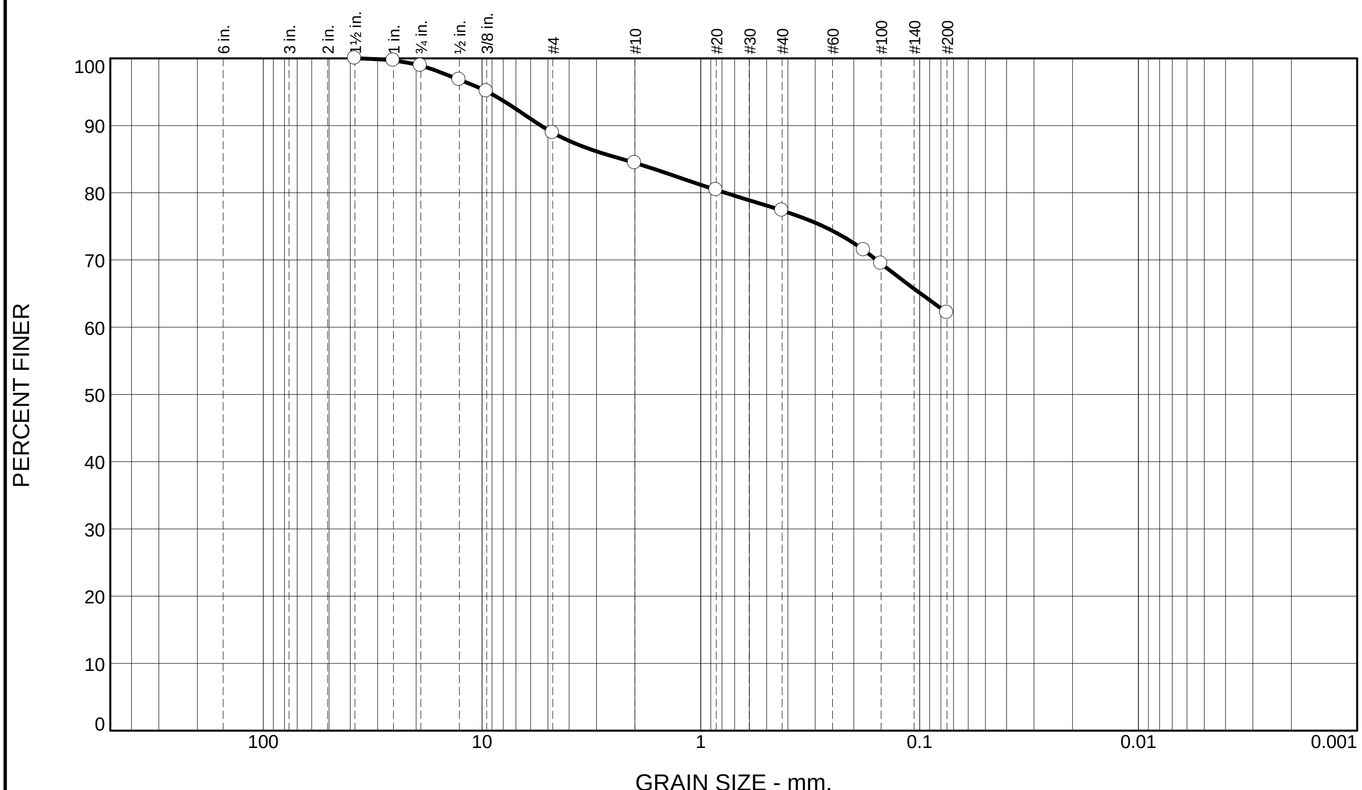
Sandy Lean CLAY

Remarks:

PROJECT:	Blackfeet Hospital		
PROJECT NO.:	4027.21815.01	LAB NO.:	33793
LOCATION:	B-7	SAMPLED BY:	DB
DEPTH:	2.0-9.5	DATE SAMPLED:	6/28/2019
SAMPLE NO.:	0	DATE TESTED:	8/1/2019

DOWL

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.1	10.0	4.5	7.0	15.2	62.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	99.7		
.75	98.9		
.5	96.8		
.375	95.1		
#4	88.9		
#10	84.4		
#20	80.4		
#40	77.4		
#80	71.5		
#100	69.5		
#200	62.2		

* (no specification provided)

Material Description

Sandy Lean CLAY

Atterberg Limits

PL= 14 LL= 28 PI= 14

Classification

USCS= CL AASHTO= A-6(6)

Remarks

Sampled By: DOWL
Natural Moisture: 10.7%
F.M.=1.26

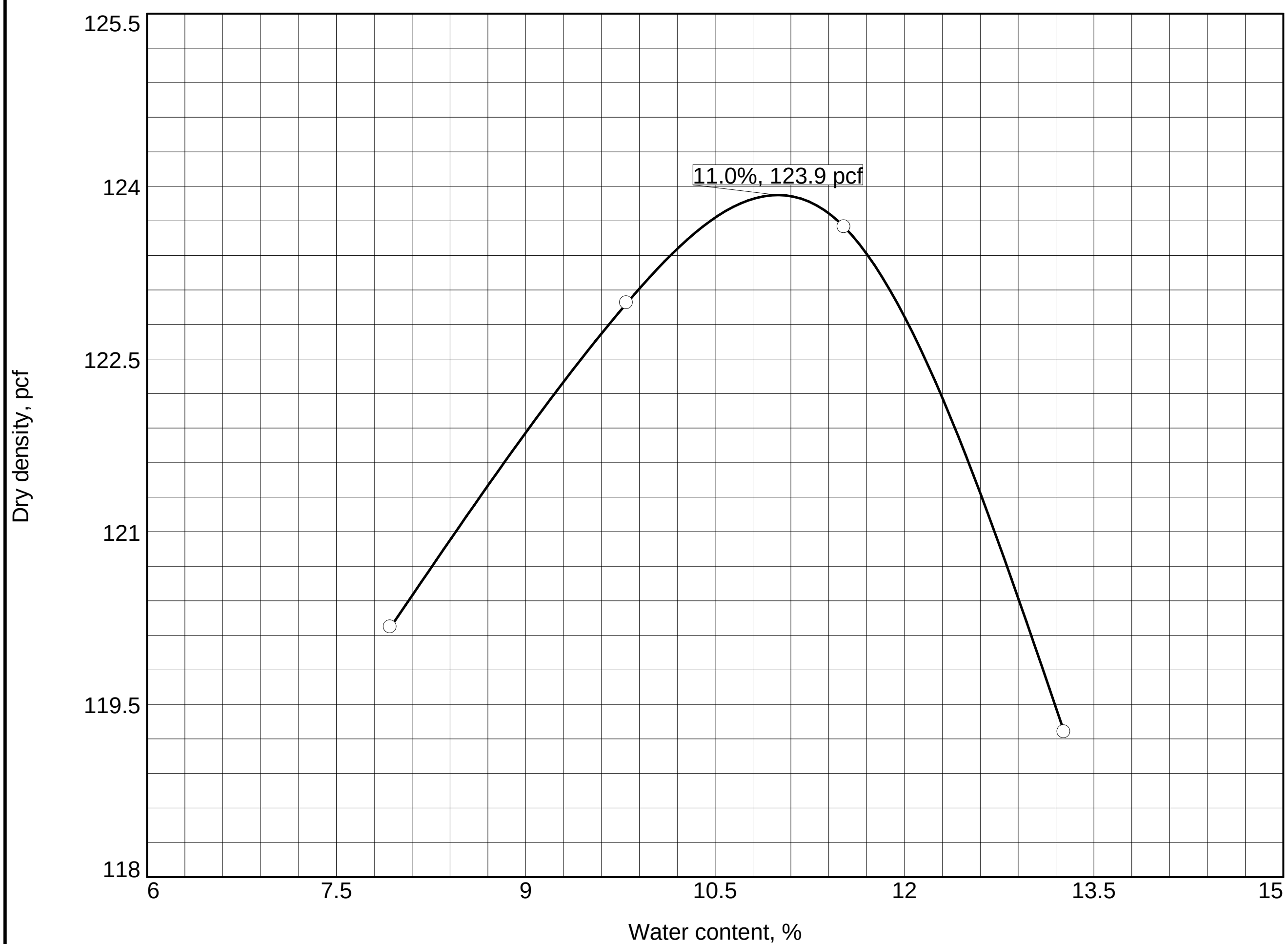
Location: B-8
Sample Number: 33794 **Depth:** 2.0-9.5 **Date:** 7/26/2019

Client: HFG Architecture
Project: Blackfeet Hospital Apt
Project No: 4027.21815.01 **Figure** 02

DOWL

Tested By: CC **Checked By:** J. Miller

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard
ASTM D4718-15 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
2.0-9.5	CL	A-6(6)			28	14	11.1	62.2

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 123.9 pcf	120.5 pcf	Sandy Lean CLAY
Optimum moisture = 11.0 %	12.2 %	

Project No. 4027.21815.01 **Client:** HFG Architecture
Project: Blackfeet Hospital Apt

○**Location:** B-8 **Sample Number:** 33794

DOWL

Remarks:
Sampled By: DOWL
Natural Moisture: 10.7%

Figure 02

Tested By: CC **Checked By:** J. Miller

APPENDIX C: PHOTOGRAPH LOG

Drilling Boring B-1 – View Northeast – Mobile B-59 Truck-Mounted Drill Rig

Cut Slope Northwest of Boring B-1 – View Southwest

Boring B-1 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-1 – Standard Penetration Test Sample – 2.5 to 4.0 feet

Boring B-1 – Standard Penetration Test Sample – 5.0 to 6.5 feet

Boring B-1 – Standard Penetration Test Sample – 7.5 to 9.0 feet

Boring B-1 – Standard Penetration Test Sample – 10.0 to 11.5 feet

Boring B-1 – Dames and Moore Penetration Test Sample – 12.5 to 14.0 feet

Boring B-1 – Standard Penetration Test Sample – 15.0 to 16.5 feet

Boring B-1 – Standard Penetration Test Sample – 20.0 to 21.5 feet

Boring B-1 – Hollow-stem Auger Cuttings – Approximately 10 to 18 feet

Boring B-1 – Standard Penetration Test Sample – 25.0 to 26.5 feet

Boring B-1 – Hollow-stem Auger Cuttings – Approximately 23 to 28 feet

Boring B-1 – Dames and Moore Penetration Test Sample – 30.0 to 31.5 feet

Boring B-1 – Standard Penetration Test Sample – 35.0 to 36.5 feet

Boring B-1 – Standard Penetration Test Sample – 36.0 to 36.5 feet

Boring B-1 – Standard Penetration Test Sample – 40.0 to 41.5 feet

Drilling Boring B-2 – View Northwest – Mobile B-59 Truck-Mounted Drill Rig

Boring B-2 Drilling Area – View Southwest – Most Right Orange Cone

Boring B-2 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-2 – Standard Penetration Test Sample – 2.5 to 4.0 feet

Boring B-2 – Standard Penetration Test Sample – 5.0 to 6.5 feet

Boring B-2 – Dames and Moore Penetration Test Sample – 9.0 feet

Boring B-2 – Dames and Moore Penetration Test Sample – 7.5 to 8.0 feet

Boring B-2 – Standard Penetration Test Sample – 10.0 to 11.5 feet

Boring B-2 – Shelby Tube Test Sample – 12.5 to 14.5 feet

Boring B-2 – Standard Penetration Test Sample – 15.5 to 16.0 feet

Boring B-2 – Dames and Moore Penetration Test Sample – 20.0 to 21.5 feet

Boring B-2 – Standard Penetration Test Sample – 25.0 to 26.5 feet

Boring B-2 – Dames and Moore Penetration Test Sample – 30.0 to 31.5 feet

Boring B-2 – Hollow-stem Auger Cuttings – Approximately 20 to 30 feet

Drilling Boring B-3 – View Northwest – Mobile B-59 Truck-Mounted Drill Rig

Drilling Boring B-3 – View West – Mobile B-59 Truck-Mounted Drill Rig

Boring B-3 – Standard Penetration Test Sample – 2.5 to 4.0 feet

Boring B-3 – Standard Penetration Test Sample – 5.0 to 6.5 feet

Boring B-3 – Standard Penetration Test Sample – 7.5 to 9.0 feet

Boring B-3 – Standard Penetration Test Sample – 10.0 to 11.5 feet

Boring B-3 – Standard Penetration Test Sample – 12.5 to 14.0 feet

Boring B-3 – Hollow-stem Auger Cuttings – Approximately 5 to 10 feet

Boring B-3 – Standard Penetration Test Sample – 15.0 to 16.5 feet

Boring B-3 – Hollow-stem Auger Cuttings – Approximately 17 to 19 feet

Boring B-3 – Standard Penetration Test Sample – 20.0 to 21.5 feet

Boring B-3 – Standard Penetration Test Sample – 25.0 to 26.5 feet

Boring B-3 – Hollow-stem Auger Cuttings – Approximately 25 to 30 feet

Boring B-3 – Standard Penetration Test Sample – 30.0 to 31.5 feet

Boring B-4 – View Southeast – Geotechnical Boring Area

Drilling Boring B-4 – View Southeast – Mobile B-59 Truck-Mounted Drill Rig

Boring B-4 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-4 – Standard Penetration Test Sample – 2.5 to 4.0 feet

Boring B-4 – Standard Penetration Test Sample – 5.0 to 6.5 feet

Boring B-4 – Standard Penetration Test Sample – 7.5 to 9.0 feet

Boring B-4 – Dames and Moore Penetration Test Sample – 10.0 to 11.5 feet

Boring B-4 – Standard Penetration Test Sample – 12.5 to 14.0 feet

Boring B-4 – Standard Penetration Test Sample – 15.0 to 16.5 feet

Boring B-4 – Dames and Moore Penetration Test Sample – 20.0 to 21.5 feet

Boring B-4 – Standard Penetration Test Sample – 25.0 to 26.5 feet

Boring B-4 – Standard Penetration Test Sample – 30.0 to 31.5 feet

Boring B-4 – Hollow-stem Auger Cuttings – Approximately 25 to 33 feet

Boring B-4 – Standard Penetration Test Sample – 35.0 to 36.5 feet

Drilling Boring B-5 – View North – Mobile B-59 Truck-Mounted Drill Rig

Drilling Boring B-5 – View Northeast – Mobile B-59 Truck-Mounted Drill Rig

Boring B-5 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-5 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-5 – Dames and Moore Penetration Test Sample – 6.5 feet

Boring B-5 – Standard Penetration Test Sample – 7.5 to 9.0 feet

Boring B-5 – Standard Penetration Test Sample – 10.0 to 11.5 feet

Boring B-5 – Standard Penetration Test Sample – 12.5 to 14.0 feet

Boring B-5 – Standard Penetration Test Sample – 13.5 to 13.8 feet

Boring B-5 – Dames and Moore Penetration Test Sample – 15.0 to 16.5 feet

Boring B-5 – Hollow-stem Auger Cuttings – Approximately 10 to 16 feet

Boring B-5 – Standard Penetration Test Sample – 20.0 to 21.5 feet

Boring B-5 – Standard Penetration Test Sample – 25.0 to 26.5 feet

Boring B-5 – Shelby Tube Test Sample – 30.0 to 32.0 feet

Boring B-5 – Standard Penetration Test Sample – 32.0 to 33.5 feet

Drilling Boring B-6 – View North – Mobile B-59 Truck-Mounted Drill Rig

Drilling Boring B-6 – View Southwest – Mobile B-59 Truck-Mounted Drill Rig

Boring B-6 Drilling Area – View Southeast

Boring B-6 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-6 – Standard Penetration Test Sample – 2.5 to 4.0 feet

Boring B-6 – Standard Penetration Test Sample – 5.0 to 6.5 feet

Boring B-6 – Shelby Tube Test Sample – 7.5 to 9.5 feet

Boring B-6 – Standard Penetration Test Sample – 9.5 to 11.0 feet

Boring B-6 – Standard Penetration Test Sample – 12.5 to 14.0 feet

Boring B-6 – Standard Penetration Test Sample – 15.0 to 16.5 feet

Boring B-6 – Hollow-stem Auger Cuttings – Approximately 12 to 17 feet

Boring B-6 – Standard Penetration Test Sample – 20.0 to 21.5 feet

Boring B-6 – Standard Penetration Test Sample – 24.5 to 25.0 feet

Boring B-6 – Standard Penetration Test Sample – 30.0 to 31.5 feet


Drilling Boring B-7 – View Northeast – Mobile B-59 Truck-Mounted Drill Rig

Boring B-7 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-7 – Standard Penetration Test Sample – 2.5 to 4.0 feet

Boring B-7 – Standard Penetration Test Sample – 5.0 to 6.5 feet

Boring B-7 – Standard Penetration Test Sample – 7.5 to 9.0 feet

Boring B-7 – Standard Penetration Test Sample – 10.0 to 11.5 feet

Drilling Boring B-8 – View Southwest – Mobile B-59 Truck-Mounted Drill Rig

Boring B-8 – Standard Penetration Test Sample – 0.0 to 1.5 feet

Boring B-8 – Standard Penetration Test Sample – 2.5 to 4.0 feet

Boring B-8 – Standard Penetration Test Sample – 5.0 to 6.5 feet

Boring B-8 – Standard Penetration Test Sample – 7.5 to 9.0 feet