NorthWest Colorado Consultants, Inc.
Geotechnical / Environmental Engineering • Materials Testing

February 29, 2024

Fuse Family Ventures
c/o Myles and Brodie Sherman
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brodie@fusefv.com

Job Number: 22-12805

Subject: Supplemental Retaining Wall Investigation, The Astrid, 2410 Ski Trail Lane, Steamboat Springs, Colorado.

Myles and Brodie,

This report presents the results of the Supplemental Geotechnical Investigation (SGI) for the proposed Astrid condominium buildings to be constructed in Steamboat Springs, Colorado. NWCC previously completed a Subsoil and Foundation Investigation under this job number dated December 22, 2022. After this report was issued, it was proposed that access to the condominiums be from Ski Trail Lane to the north of the Ski Inn Condos. Therefore, two additional test holes were drilled in the vicinity of the two proposed retaining walls along this proposed access. The approximate location of the project site is shown in the attached Figure #1.

ADDITIONAL PROPOSED CONSTRUCTION

This supplemental report addresses anticipated geotechnical conditions associated with the retaining walls in the vicinity of the proposed access road. Two retaining walls, designated as Retaining Walls 1 and 2, are proposed to the south of the proposed access road and to the north of the Ski Inn Condos. Walls 1 and 2 have proposed heights of approximately 9 to 10 feet. Several other walls are proposed throughout the site with proposed heights of approximately 4 to 13 feet. We understand that these walls will likely be stacked block or cast-in-place concrete walls. We also understand that an approximately 24-foot-tall wall that will likely be tiered, and will have soil nails is proposed for the site; however, this report does not address recommendations for the soil nailed walls.

SITE OBSERVATIONS

The proposed locations for Retaining Walls 1 and 2 are to the northwest of the Ski Inn Condominiums and to the east of Ski Trail Lane. A parking lot is located to the south-southeast of proposed Retaining Wall 1 and to the north-northwest of proposed Retaining Wall 2. Approximately 2 inches to 2 feet of snow was on the ground surface at the time of the

investigation. Topography is fairly flat in the parking lot due to previous grading. Fill appears to have been placed along the northwest side of the parking lot, and cuts appear to have been made along the southeast side of the parking lot. Natural topography appears to slope moderately to steeply down to the northwest. A drainage running approximately east to west appears to be located to the north of the parking lot. Vegetation appears to consist of landscaped grasses and pine trees, with natural aspen trees, grasses and deciduous brush to the north of the parking lot. The parking lot was plowed; however, large piles of snow related to the plowing of the parking lot were located around the perimeter of the parking lot.

SUBSURFACE CONDITIONS

To evaluate the subsurface conditions in the area of proposed Retaining Walls 1 and 2, NWCC advanced two (2) test holes (TH 15 & TH 16) with a truck-mounted CME 55 drill rig using 4-inch diameter continuous flight augers. The approximate test hole locations are shown in Figure #2.

The subsurface conditions encountered in this area were highly variable. Beneath the pavement section, fill materials were encountered in Test Hole 15 and extended to approximately 13 feet below the existing ground or pavement surface (bgs). Clays, sands and gravels were encountered beneath the fill materials in Test Hole 15 and extended to approximately 16 feet bgs. Sands and clays were encountered beneath the clays, sands and gravels in Test Hole 15 and extended to the maximum depth investigated, 20 feet bgs. Beneath the pavement section in Test Hole 16, natural clays were encountered which extended to 10 feet bgs.

Drive samples of the soils were obtained as the test holes were advanced using California liner samplers. Graphic logs of the exploratory test holes are provided in Figure #3. The legend and notes associated with the logs are shown in Figure #4.

Asphalt was encountered at the surface in both test holes and was approximately 3 to 4 inches in thickness. Pit run sands, gravels and cobbles were encountered beneath the asphalt and extended to approximately 2 ½ feet bgs in Test Hole 15 and 2 feet bgs in Test Hole 16.

Fill materials were encountered from approximately 2 ½ feet bgs to 13 feet bgs in Test Hole 15 and were highly variable. Fill materials were composed primarily of clays with occasional gravels and organics, which were sandy, low to moderately plastic, fine to coarse grained, medium stiff to stiff, moist to wet and dark brown to dark gray to mottled gray and brown with iron staining. A sample of the fill materials classified as a CL soil in accordance with the Unified Soil Classification System (USCS).

Natural clays, sands and gravels were encountered beneath the fill materials in Test Hole 15 and extended to approximately 16 feet bgs. The natural clays, sands and gravels were low plastic, fine to coarse grained, medium stiff to stiff, wet and brown to light brown in color.

Natural sands and clays were encountered beneath the natural clays, sands and gravels in Test Hole 15 and extended to the maximum depth investigated, 20 feet bgs. The natural sands and clays were low plastic, fine to coarse grained, medium stiff to stiff to medium dense, wet and brown to light brown in color. A sample of the sands and clays classified as a CL/SC soil in accordance with the USCS.

Natural clays were encountered beneath the pit run sands, gravels and cobbles in Test Hole 16 and extended to 10 feet bgs. The natural clays were slightly sandy to sandy, low to moderately plastic, fine to coarse grained with occasional gravels, stiff, moist and reddish brown in color. Samples of the clay classified as CL soils in accordance with the USCS.

Swell-consolidation testing conducted on samples of the fill materials and natural clays indicate the materials tested exhibited a low to moderate degree of swell when wetted under a constant load. Swell-consolidation test results are summarized in Figures #5 and #6, and laboratory test results are summarized in the attached Table 1.

Groundwater was encountered in Test Hole 15 at approximately 8 feet bgs at the time of the investigation. Groundwater conditions are expected to fluctuate with changes in precipitation and runoff.

RETAINING WALL RECOMMENDATIONS

Based on our experience with the design and construction of similar walls and the anticipated subsurface conditions, NWCC has developed the following general recommendations for the design and construction of stacked boulder, stacked concrete block and cast-in-place concrete retaining walls at the project site. It should be noted that this report does not address the elevation and layout of the stacked blocks or boulders for the retaining wall. It should also be noted that the clays encountered at the site were expansive, and there is a risk associated with placing retaining walls on the expansive clays. Differential movements on the order of 1 to 2 inches could occur if the clays undergo moisture changes.

Due to site constraints (property lines, existing building structures, existing utilities, and depth of excavations required to reach suitable bearing soils), the walls discussed below may not be feasible at all locations, and they may have to be under pinned with micropiles and tiebacks. The use of soldier piles with lagging should also be considered. NWCC can provide design parameters for these types of walls if requested.

If needed, a one-second peak ground acceleration of 0.157 can be used in the design. Additional parameters for the design of the retaining walls are included in Table A below.

TABLE A
PARAMETERS FOR RETAINING WALL DESIGN

SOIL TYPE	Unit Weight, γ (pcf)	Saturated Unit Weight, γ_{sat} (pcf)	Angle of Internal Friction (°)	Approx Angle of Soil Structure Friction (°)
Overburden	112.3	126	0	0
Bedrock	129.6	135	30	15
Granular fill	145	155	40	20

Stacked Boulder Walls: Based on NWCC's experience with similar walls, we have developed the following design and construction recommendations for stacked boulder retaining walls:

- Boulders shall have a minimum diameter of 2 to 3 feet. Angular boulders are preferred;
- Boulders shall consist of hard, durable granite, gneiss or other approved rock materials;
- Boulder walls shall be constructed to a maximum height of 10 feet or less with materials placed in a stable configuration that maximizes rock-to-rock contact. Finished slope face shall be constructed at a 0.5 (Horizontal) to 1(Vertical) or flatter slope;
- A horizontal distance of at least 3 feet, or ½ the height of the lower wall, whichever is greater, must separate the top of the lower wall and the base of the upper wall for terraced walls.
- Base width of boulders shall be at least one-half of total wall height;
- Base layer of boulders shall be keyed into competent, natural soils a minimum of 1 foot;
- Contractor shall have a demonstrated history of successful construction of this type of wall;
- A drainage blanket and drainage system shall be incorporated into wall construction. The drainage blanket shall consist of washed or screened rock materials placed at the back of

the wall to aid in drainage and fill voids. A drainage system consisting of a 4-inch diameter perforated PVC pipe covered with a layer of free draining gravel shall be placed at the base of the walls. The drain should be uniformly graded to a daylighted outfall with at least a 1 percent slope;

Please note NWCC should observe wall excavations and construction to verify subsurface conditions and wall construction. If groundwater seepage is encountered in excavations, additional stabilization and/or dewatering measures may be required. These measures may include installation of additional drainage systems, placement of additional boulder fills and/or soil nailing (drilled and grouted slope reinforcement).

Although groundwater seepage is not anticipated in the proposed cuts, seepage may occur after construction and greatly reduce stability of the slope. Additionally, there is a risk of rockfall associated with this wall system. Stacked boulders can be undermined due to excessive runoff or other disturbance, and there is a risk of rockfall resulting in damage to downslope areas. Therefore, a qualified engineer should periodically inspect the walls after completion to verify drainage and wall bearing conditions. The owner should also periodically monitor the site. Any indications of wall movement or groundwater seepage should be immediately brought to the attention of NWCC.

Stacked Block Walls: The stacked block walls should be backfilled with free draining gravels uniformly placed and compacted in 12-inch maximum loose lifts to at least 75% of the maximum relative density. The first tier of blocks should be keyed into the natural, undisturbed soils or compacted fill materials at least 1 foot. The fill materials placed in front of the wall should be granular soils compacted to at least 95% of the maximum modified Proctor density and within 3 percent of the optimum moisture content determined in accordance with ASTM D1557. A leveling course, consisting of a minimum of 12 inches of free draining gravels, should be placed over the natural soils or properly compacted fill materials prior to placing the first course of wall units (bottom blocks). NWCC must observe the excavations at the base of the wall prior to placement of the gravel fill materials.

The excavations and walls should be drained by the placement of a 4-inch diameter perforated PVC pipe surrounded with at least 12 inches of free draining gravel. The drain should be located behind the wall and at the base of the excavation. The drain should be uniformly graded to a daylighted outfall with at least a 1 percent slope. Proper surface drainage should be provided around all of the finished slopes to direct surface and subsurface runoff away from the wall.

Cast-In-Place Concrete Walls: NWCC recommends the following design criteria be used in the design and construction of cast-in-place concrete retaining walls.

- Footings placed on the undisturbed, natural sands and clays, natural clays or properly compacted structural fill materials placed over the natural sands and clay or sands and gravels should be designed using an allowable soil bearing pressure of 2,500 psf. As much dead load as can be reasonably achieved should be used to counteract the uplift pressure generated when the clays.

- Footings or pad sizes should be computed using the above soil pressures and placed on the natural undisturbed sands and clays or sands and gravels found below any existing fill materials and/or any topsoil and organic materials, or on properly compacted structural fill materials placed over the natural sands and clays.

- Any existing fill materials, topsoil and organic materials, loose or soft natural soils encountered within the foundation excavations should be removed and the excavations extended to competent natural soils prior to structural fill or concrete placement.

- Any fill materials placed beneath the footings should be a non-expansive granular soil approved by NWCC. Structural fill materials should be uniformly placed and compacted in 6-to-8-inch loose lifts and compacted to at least 100% of the maximum standard Proctor density and within 2% of the optimum moisture content determined in accordance with ASTM D-698. Structural fill materials should extend out from the edge of footings on a 1(horizontal) to 1(vertical) or flatter slope.

- We strongly recommend that the client retain NWCC to observe the foundation excavations when they are near completion to identify the bearing soils and confirm the recommendations in this report, as well as test the fill materials placed under the foundations for compaction.

- Retaining walls on the site can be expected to deflect sufficiently to mobilize the full active earth pressure condition. Therefore, cantilevered structures may be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 35 pcf for imported, free draining granular backfill and 50 pcf for the on-site soils.

- Foundation walls and retaining structures should be designed for appropriate hydrostatic and surcharge pressures such as adjacent buildings, traffic and construction materials. An upward sloping backfill and/or natural slope will also significantly increase the earth pressures on foundation walls and retaining structures and the structural engineer should carefully evaluate these additional lateral loads when designing the foundation and retaining walls.

- The lateral resistance of retaining wall foundations placed on undisturbed natural soils or properly compacted fill materials at the site will be a combination of the sliding

resistance of the footings on the foundation materials and the passive pressure against the sides of the footings. Sliding friction can be taken as 0.4 times the vertical dead load. Passive pressure against the sides of the footing can be calculated using an equivalent fluid pressure of 250 pcf. The fill placed against the sides of the footings to resist lateral loads should be compacted to at least 100% of the maximum standard Proctor density and near the optimum moisture content.

- NWCC recommends imported granular soils for backfilling foundation walls and retaining structures because their use results in lower lateral earth pressures. Imported granular materials should be placed to within 2 to 3 feet of the ground surface, be free draining and have less than 5 percent passing the No. 200 sieve. Granular soils behind foundation and retaining walls should be sloped from the base of the wall at an angle of at least 45 degrees from the vertical. Upper 2 to 3 feet of fill should be a relatively impervious soil or pavement structure to prevent surface water infiltration into the backfill.

- Wall backfill should be carefully placed in uniform lifts and compacted to at least 95 percent of the maximum standard Proctor density and near the optimum moisture content. Care should be taken not to overcompact the backfill since this could cause excessive lateral pressure on the walls. Some settlement of deep foundation wall backfill materials will occur even if the material is placed correctly.

LIMITATIONS

The recommendations presented in this report are based on the subsurface conditions encountered during the field investigations, and our experience with these types of soils. Variations in subsurface conditions described in this report may occur. If subsurface conditions or construction plans differ significantly from those assumed or anticipated, we should be informed so that our recommendations can be reevaluated.

It is the responsibility of the owner or his representative to ensure that these recommendations are incorporated into the construction plans and documents. Please note that NWCC does not assume responsibility for the contractor's safety, means, methods, technologies or procedures.

Expansive soils were encountered at this site. These materials are stable at their natural moisture content but can shrink or swell with changes in moisture. The behavior of expansive soils is not fully understood. The swell or consolidation potential of a site can change erratically both in lateral and vertical extent. Moisture changes also occur erratically, resulting in conditions which cannot always be predicted. Recommendations presented in this report are based on the current state of the art for foundations on swelling soils.

The performance of the retaining wall structures at this part of the site will depend on following the recommendations and in proper maintenance after construction is complete. As water is the main cause for volume change in the soils, it is necessary that the changes in moisture content be kept to a minimum. This requires judicious irrigation and providing positive surface drainage away from the structures. Any distress noted in the structures should be brought to the attention of NWCC.

This report is based on the investigation at the described site and on the specific anticipated construction as stated herein. If either of these conditions is changed, the results would also most likely change. Therefore, NWCC strongly recommends that our firm be contacted prior to finalizing the construction plans so that we can verify our recommendations are being properly incorporated into the construction plans.

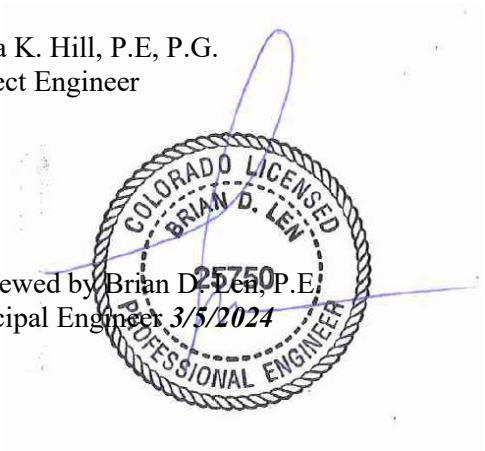
Man-made or natural changes in the conditions of a property can also occur over time. In addition, changes in requirements due to state-of-the-art knowledge and/or legislation do from time to time occur. As a result, the findings of this report may become invalid due to these changes. Therefore, this report is subject to review and not considered valid after a period of 3 years or if conditions as stated above are altered. It is the responsibility of the owner or his representative to ensure that the information in this report is incorporated into the plans and/or specifications and construction of the project.

We believe that this information gives a high degree of reliability for anticipating the behavior of the proposed retaining walls; however, our recommendations are professional opinions and cannot control nature, nor can they assure the soils profiles beneath those or adjacent to those observed. No warranties expressed or implied are given on the content of this report.

If you have any questions regarding this report, our recommendations, or if we may be of further service, please contact the undersigned.

Sincerely,
NWCC, INC.

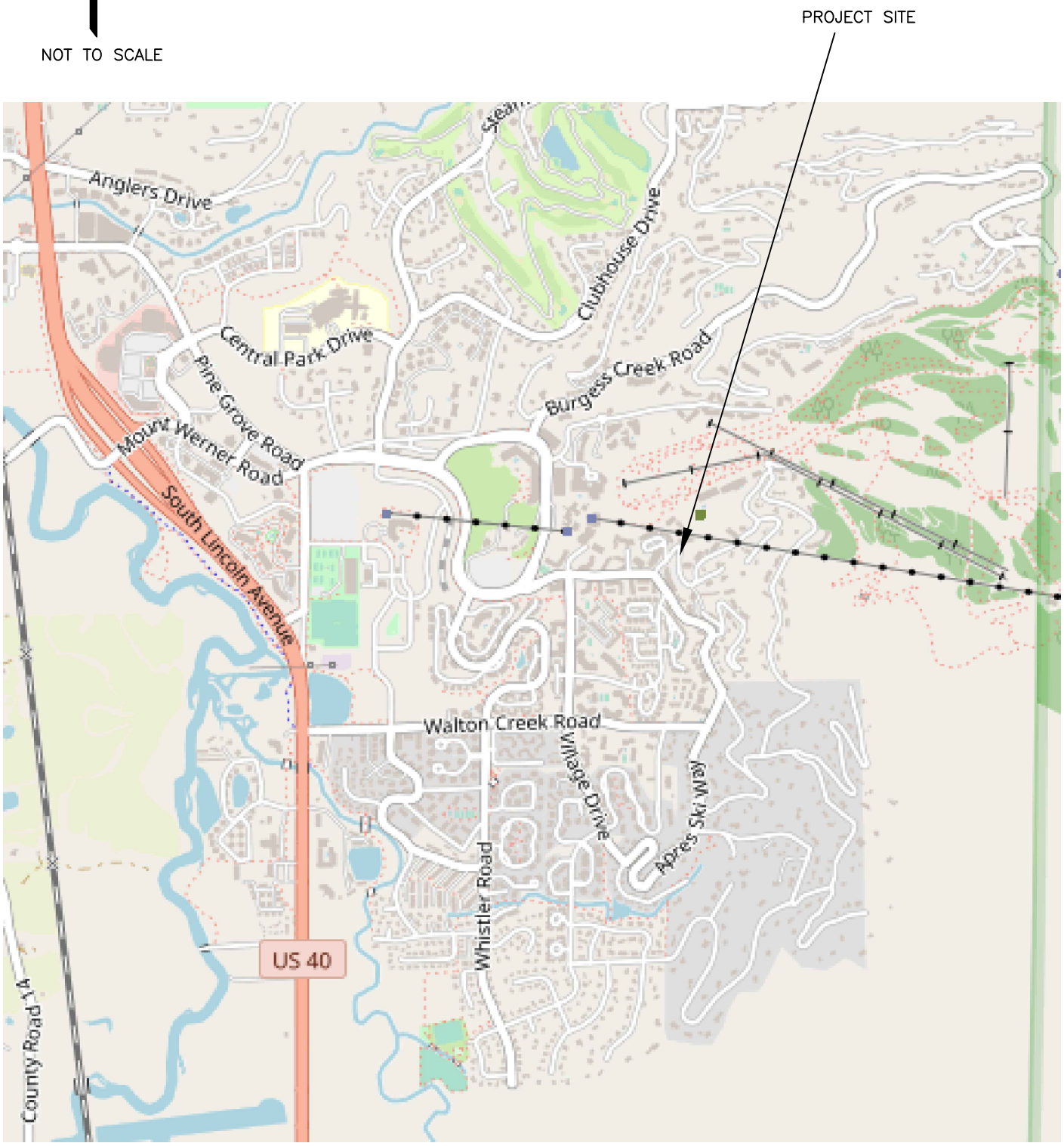
Erika K. Hill, P.E, P.G.
Project Engineer



Reviewed by Brian D. Len, P.E.
Principal Engineer *3/5/2024*

N

NOT TO SCALE

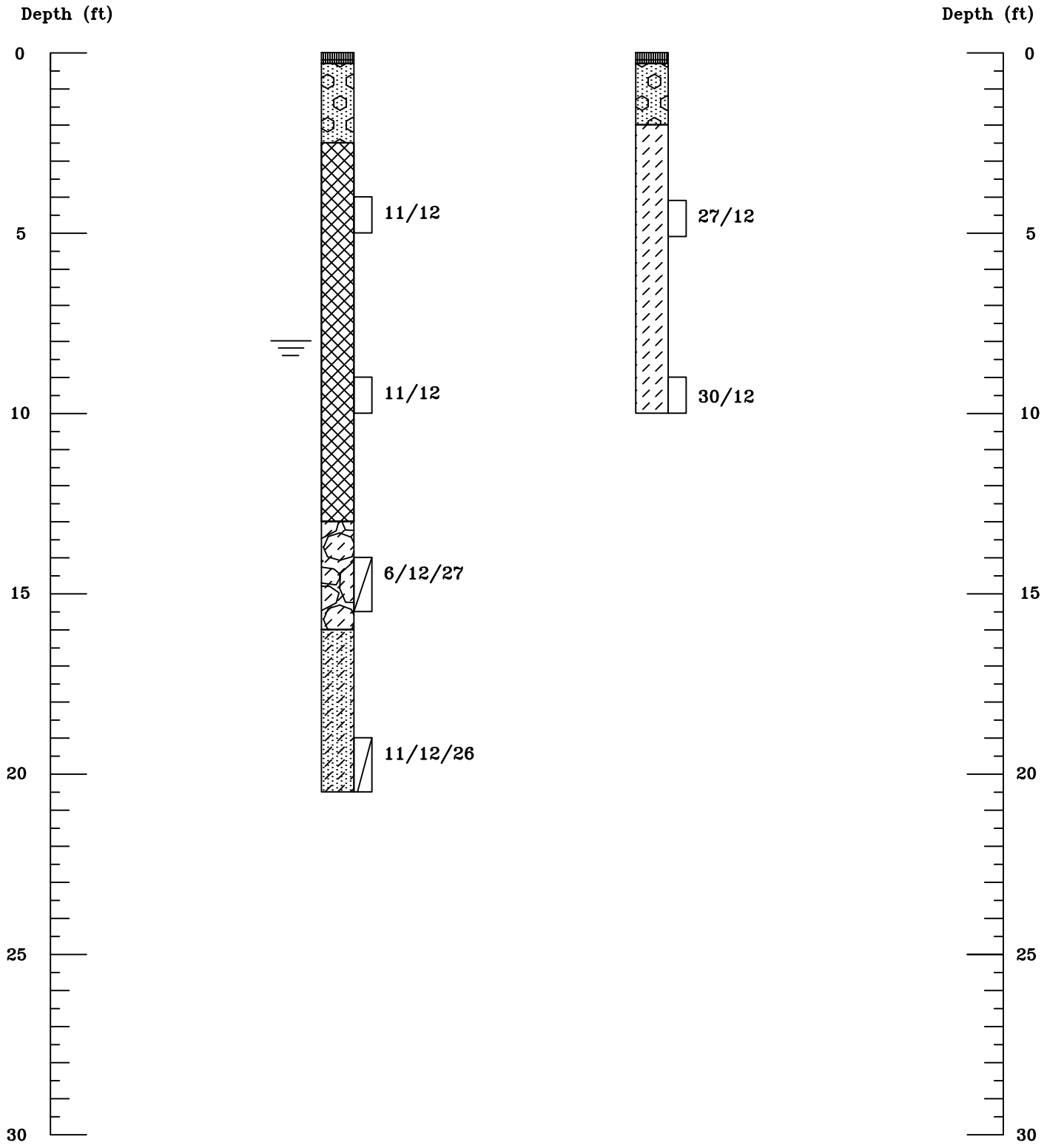


Title: VICINITY MAP		**Date:** 2/29/24	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing
Job Name: The Astrid		**Job No.** 22-12805	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 2410 Ski Trail Lane, Steamboat Springs, Colorado		**Figure** #1	

N

NOT TO SCALE

Title: Approximate Test Hole Locations	**Date:** 1/3/23	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing
Job Name: The Astrid	**Job No.** 22-12805	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: Ski Trail Lane, Steamboat Springs, Colorado	**Figure** #2	



Title: LOGS OF EXPLORATORY TEST HOLES	Date: 1/3/23	
Job Name: The Astrid	Job No. 22-12805	
Location: Ski Trail Lane, Steamboat Springs, Colorado	Figure #3	

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LEGEND:

ASPHALT

PIT RUN SANDS, GRAVELS and COBBLES

FILL: Clay with occasional gravels and organics, sandy, low to moderately plastic, fine to coarse grained, medium stiff to stiff, moist to wet and dark brown to dark gray to mottled gray and brown with iron staining.

CLAYS, SANDS AND GRAVELS: Low plastic, fine to coarse grained, medium stiff to stiff, wet and brown to light brown.

SANDS AND CLAYS: Low plastic, fine to coarse grained, medium stiff to stiff to medium dense, wet and brown to light brown.

CLAYS: Slightly sandy to sandy, low to moderately plastic, fine to coarse grained with occasional gravels, stiff, moist and reddish brown.

Drive Sample, 2–inch I.D. California Liner Sampler.

Drive Sample, Standard split spoon sampler.

11/12 Drive Sample Blow Count, indicates 11 blows of a 140–pound hammer falling 30 inches were required to drive the sampler 12 inches.

6/12/27 Drive Sample Blow Count, indicates 8 blows of a 140–pound hammer falling 30 inches were required to drive the sampler the first 6 inches, 13 blows were required to drive the sampler the next 6 inches, and 16 blows were required to drive the sampler the final 6 inches.

Indicates depth at which groundwater was encountered when measured at time of drilling.

NOTES:

1) Test holes were drilled on January 22, 2024 with a truck–mounted CME55 drill rig using 4–inch diameter continuous flight augers.

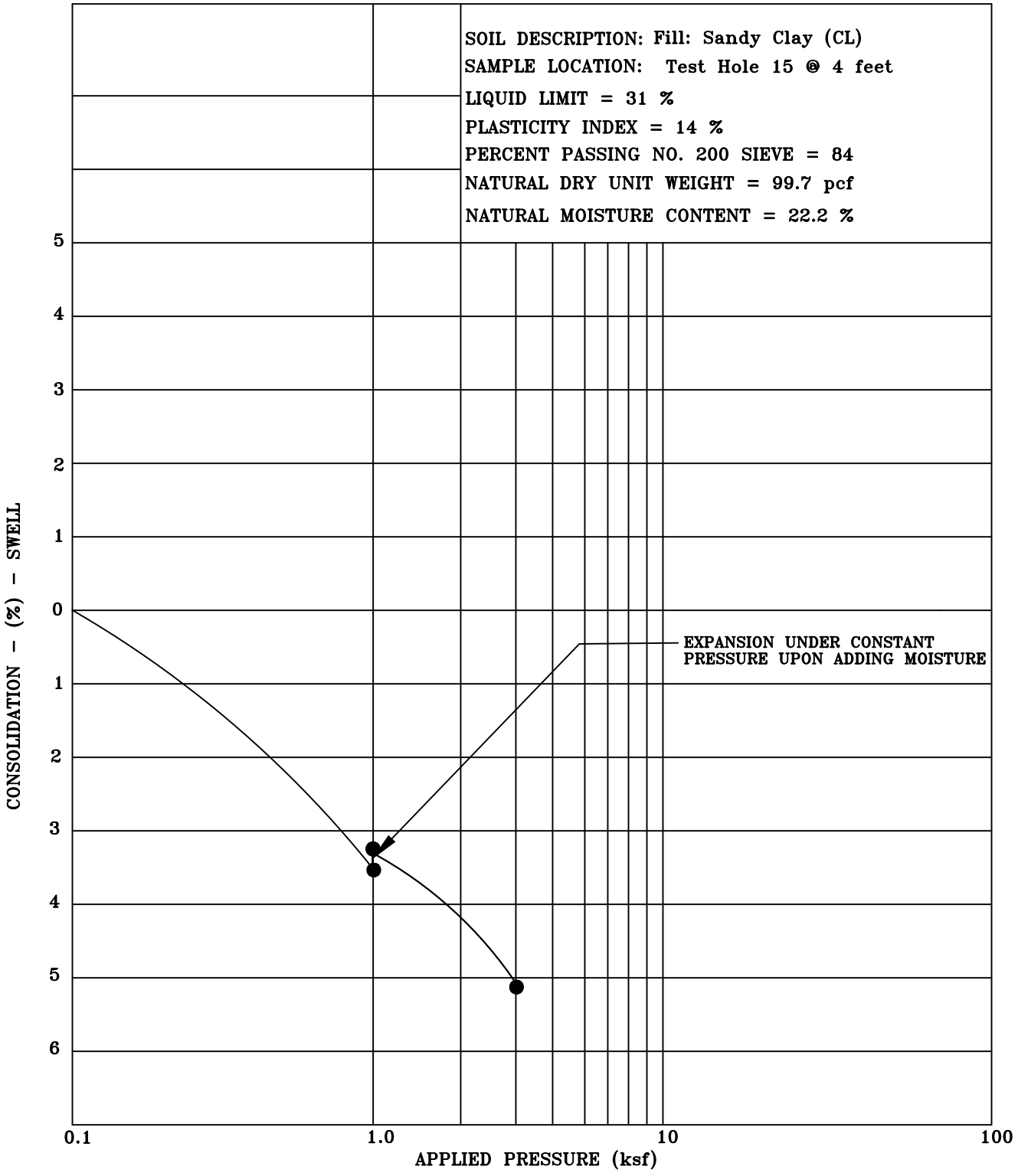
2) Locations of the test holes were determined in the field by pacing from existing features at the site.

3) Elevations of the test holes were not measured and logs are drawn to the depths investigated.

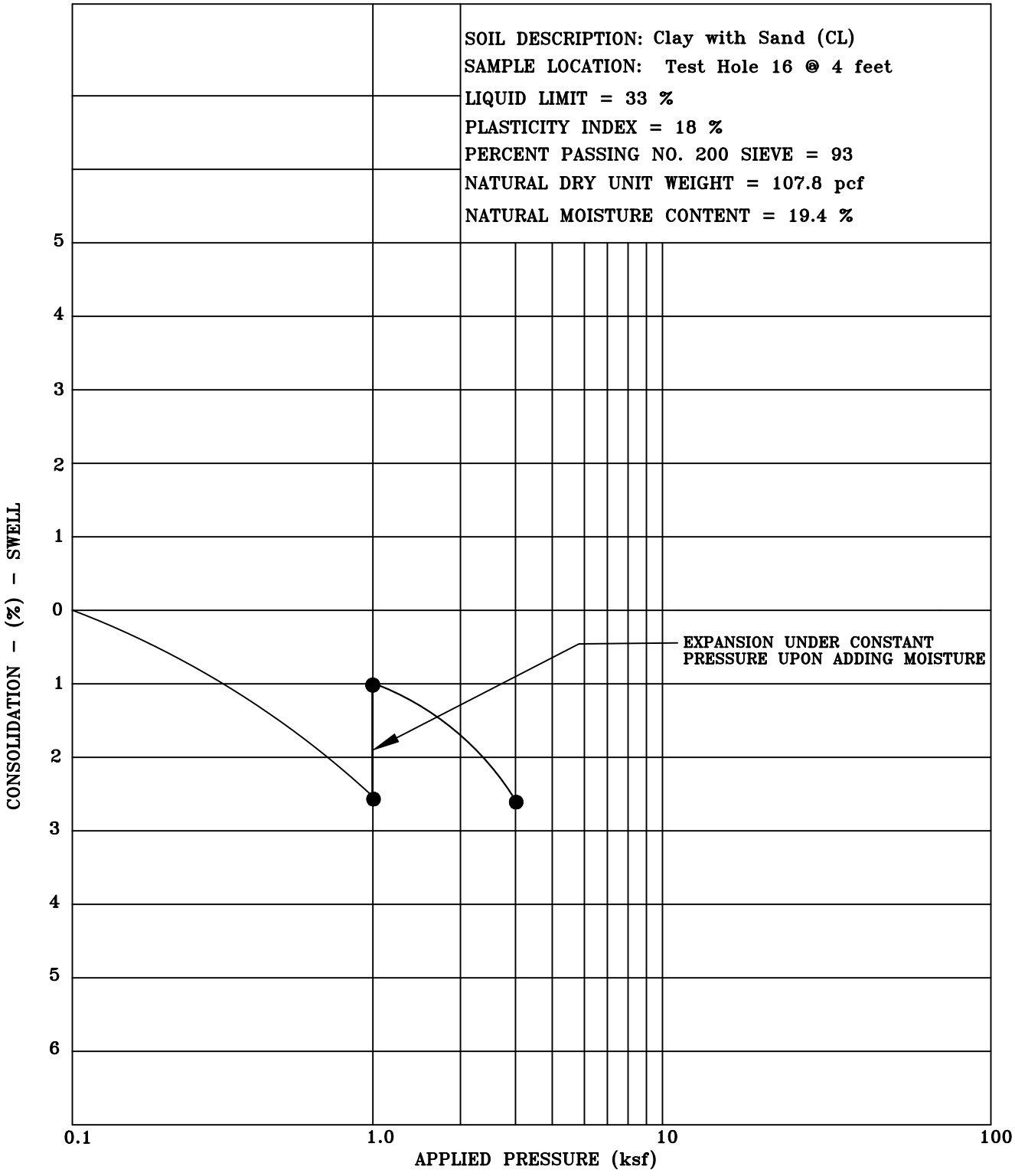
4) The lines between materials shown on the logs represent the approximate boundaries between material types and transitions may be gradual.

5) The water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water levels will probably occur with time.

Title: LEGEND AND NOTES	Date: 2/28/24	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing
Job Name: The Astrid	Job No. 22–12805	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive • P.O. Box 775226 Steamboat Springs, Colorado 80477
Location: 2410 Ski Trail Lane, Steamboat Springs, Colorado	Figure #4	



Title: SWELL–CONSOLIDATION TEST RESULTS		**Date:** 2/28/24	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing
Job Name: The Astrid		**Job No.** 22–12805	(970)879-7888• Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 2410 Ski Trail Lane, Steamboat Springs, Colorado		**Figure** #5	



Title: SWELL–CONSOLIDATION TEST RESULTS		Date: 2/28/24	
Job Name: The Astrid		Job No. 22–12805	
Location: 2410 Ski Trail Lane, Steamboat Springs, Colorado		Figure #6	

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NWCC, Inc.

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	ATTERBERG LIMITS		GRADATION		PERCENT PASSING No. 200 SIEVE	UNCONFINED COMPRESSIVE STRENGTH (PSF)	SOIL or BEDROCK DESCRIPTION	UNIFIED SOIL CLASS.
TEST HOLE	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
15	4	22.2	99.7	31	14	2	14	84		FILL: Sandy Clay	CL
15	19	22.1		31	11	1	49	50		Sand and Clay	CL/SC
16	4	19.4	107.8	33	18	0	7	93		Clay with Sand	CL
16	9	20.4	105.7	38	23	0	30	70	7,550	Sandy Clay	CL

JOB NUMBER: 22-12805