



GEOTECHNICAL STUDY

Haymeadow Development
Eagle, Colorado



Report Prepared for:

**Mr. Brandon Cohen
Abrika Properties, LLC
8250 SW 27th Avenue
Ocala, FL 34476**

**Project No. 21.5057
January 31, 2022**

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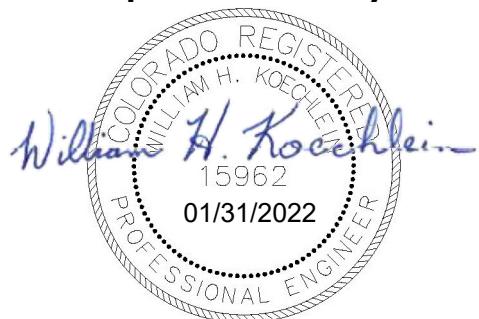
**Project No. 21.5057
January 31, 2022**

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COMMON ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ABC	aggregate base course
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADSC	Association of Drilled Contractors
AI	Asphalt Institute
APM	asphalt paving material
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
bgs	below ground surface
CDOT	Colorado Department of Transportation
CBR	California Bearing Ratio
CFR	Code of Federal Regulations
CGS	Colorado Geological Survey
CKD	cement of kiln dust stabilized subgrade
CMU	concrete masonry unit
CTB	cement treated base course
deg	degree
EDLA	equivalent daily load application
e_m	edge moisture variation distance
EPS	expanded polystyrene
ESAL	equivalent single axle loads
f'c	specified compressive strength of concrete at the age of 28 days
F_a	seismic site coefficient
FHWA	Federal Highway Administration
FS	factor of safety
F_v	seismic site coefficient
GSA	global stability analysis
GVW	gross vehicle weight
IBC	International Building Code
ICC-ES	International Code Council Evaluation Services, Inc.
IRC	International Residential Code
kip	1,000 pounds-force
km	kilometer
LTS	lime treated subgrade
MDD	maximum dry density
mg/L	milligrams per liter
MGPEC	Metropolitan Government Pavement Engineers Council
mm	millimeter
Mr	resilient modulus
MSE	mechanically stabilized earth
mV	millivolts
NAPA	National Asphalt Pavement Association
N_{DESIGN}	design gyrations
OMC	optimum moisture content

OSHA **Occupational Safety and Health Administration**
OWTS **onsite wastewater treatment system**
PCA **Portland Cement Association**
PCC **portland cement concrete**
pcf **pounds per cubic foot**
pci **pounds per cubic inch**
pH **power of hydrogen**
psf **pounds per square foot**
psi **pounds per square inch**
PT **post-tension**
S_s **mapped spectral accelerations for short periods**
UBC **Uniform Building Code**
USGS **United States Geological Survey**

Important Information about This Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer

will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. *Do not rely on an executive summary. Do not read selective elements only. Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the “Findings” Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site’s subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report’s Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are *not* final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals’ misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals’ plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note*

conspicuously that you’ve included the material for information purposes only. To avoid misunderstanding, you may also want to note that “informational purposes” means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time to permit them to do so.* Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled “limitations,” many of these provisions indicate where geotechnical engineers’ responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a “phase-one” or “phase-two” environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer’s services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, *proper implementation of the geotechnical engineer’s recommendations will not of itself be sufficient to prevent moisture infiltration.* Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. *Geotechnical engineers are not building-envelope or mold specialists.*



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1. PURPOSE

1.1 GENERAL

Cesare, Inc. (Cesare) performed a geotechnical study for the proposed Haymeadow Development Phase 1 and Phase 2 buildings to be located near Brush Creek Road in Eagle, Colorado. The study was made to characterize existing subsurface conditions at the site and assist in determining design criteria for planning, site development, foundation systems, interior floor systems, exterior flatwork, surface and subsurface drainage adjacent to structures, and to present other pertinent geotechnical issues. Information gathered during the field exploration and laboratory testing is summarized in Figures 1 and 2 and Appendices A through C. Cesare's opinions and recommendations presented in this report are based on data generated during this field exploration, laboratory testing, and its experience.

1.2 SCOPE OF SERVICES

The scope of services performed is detailed in Cesare's Proposal Agreement No. S210906 which was executed on October 4, 2021.

2. SUMMARY OF FINDINGS AND CONCLUSIONS

This section is intended as a summary only and does not include design details. The report should be read in its entirety and utilized for design.

- Clay and silt soil was encountered in the upper 6 to 16 feet of Cesare's borings and were underlain by sand and gravel to depths of about 14-1/2 to 36 feet below ground surface. Bedrock was encountered in nine borings at depths of 14-1/2 to 36 feet.
- Groundwater was measured at depths of 8 feet or less in Borings B-1, B-3, B-4, B-6, B-7, B-8, B-9, B-10, and B-XP. Shallow groundwater was encountered on the southern and western sides of Phase 1 and measured as shallow as 6.8 feet.
- The site is underlain by Eagle Valley evaporite bedrock. Evaporite is hydrocompactive; prone to collapse upon wetting. Dissolution can lead to soil collapse, or in extreme situations, sinkholes. No sinkholes were observed on the site or in the vicinity, but open voids can occur in the subsurface that have not yet resulted in surface expressions.
- Additional geologic hazards include debris flows, corrosive soil, and radon.
- The soil types present onsite classify as Seismic Class Type D according to the 2018 IBC (ASCE 7, Chapter 20), based on penetration tests and Cesare's experience.
- Silt and clay soil was encountered at anticipated shallow foundation bearing depths. Settlement calculations indicate a risk of settlement of foundations supported on this soil. The proposed buildings may be supported on a shallow foundation system, provided the subgrade soil is overexcavated, moisture conditioned, and recompacted a minimum of 18 inches below foundations in Phase 1 and 3 feet below foundations in Phase 2. As a lower risk alternative, the buildings may be supported by a deep foundation system, such as drilled piers or micropiles.
- Good surface drainage should be established and positive drainage away from the structures and other site improvements should be provided during construction and maintained throughout the life of the proposed structures. Below grade areas, such as basements and crawlspaces (if any), should be provided with an exterior perimeter subsurface drainage system.

3. SITE CONDITIONS

The site is located north of Brush Creek Road between Sylvan Lake Road and Ouzel Lane in Eagle, Colorado. A vicinity map is shown in Figure 1. Cesare understands that the Haymeadow Development will be divided into different tract development phases. The tracts included in this study are Tract RMF-1 (Phase 1) and Tract RMF-2 (Phase 2). See boring location plans (Figures 2a and 2b) for the location of the tracts. The site is currently undeveloped land that was previously an irrigated agricultural field used for hay. The site is bound to the north by undeveloped land consisting of steep hills with occasional trees, to the east and west by undeveloped land previously used for agriculture, and to the south by Brush Creek Road followed by Brush Creek. Topography of Phase 1 slopes down gently from west to east with a grade change of about 9 feet. Topography of Phase 2 slopes down gently from north to south with a grade change of about 10 feet. Topography east and west of the site is similar; however, the topography north of the site grades steeply up to the north.

Vegetation onsite consists of native grasses and weeds. Surface conditions were dry and dusty. A drainage swale approximately 2 to 3 feet deep and 6 to 8 feet wide flows north to south from the northwestern Phase 1/Phase 2 line to the southeastern corner of Phase 1. The swale contained no visible water at the time of this study. North and east of the site, prior to Cesare's exploration, roadway construction of Mount Hope Circle and Snowy Peak Drive have been completed.



Photo 1. View looking north at Phase 1 followed by Phase 2 and the steep hills north of the site.

4. PROPOSED CONSTRUCTION

In conversations with Range Construction (Mr. Michael Hood), Cesare understands Phase 2 will have a combination of seven structures; each structure will be three stories in height, with no below grade crawlspace or basement and is assumed to be slab-on-grade. Each structure will have six units with a single-car garage slab-on-grade. Each structure will encompass about 5,300 square feet. Cesare

understands Phase 2 will have a combination of two or three structures; each structure will be two to three stories in height, with no below grade crawlspace or basement and is assumed to be slab-on-grade. Each structure will encompass about 8,000 square feet. The foundations for both phases will require an estimated 5 to 8 feet of excavation. Cesare anticipates that changes to existing site grades will be minimal and limited to about 4 feet of cut and/or fill to achieve final surface grades. The locations of Cesare's borings are shown in Figure 2.

Retention ponds are planned south of Phase 1, between Brush Creek Road and the proposed extension of Sylvan Lake Road. Pond 1A is existing and a new proposed pond is planned approximately 400 feet west of Pond 1A.

5. GEOLOGIC CONDITIONS

The "Geologic Map of the Eagle Quadrangle, Eagle County, Colorado" prepared for the USGS by Lidke, dated 2002, indicates that surficial deposits onsite likely consist of:

- "Alluvium and colluvium, undivided (Holocene to middle Pleistocene)"
- "Intermediate terrace alluvium (late to middle Pleistocene)"

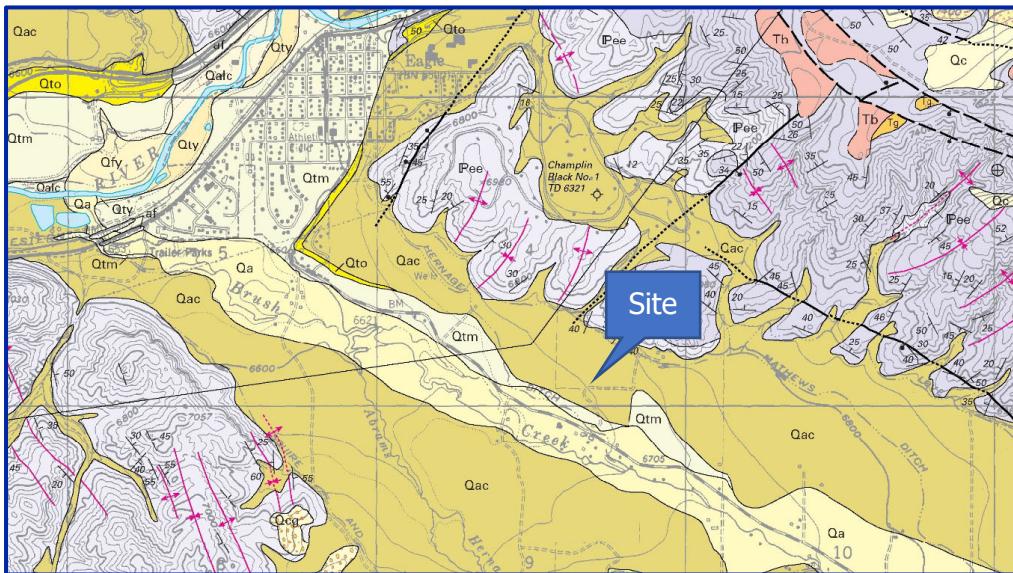


EXHIBIT 1. Snapshot of "Geologic Map of the Eagle Quadrangle, Eagle County, Colorado: U.S. Geological Survey, Miscellaneous Field Studies Map MF-2361", scale 1:24,000, by Mr. David J. Lidke, 2002 (annotated by Cesare).

The "Colorado Map of Potential Evaporative Dissolution and Evaporative Karst Subsidence Hazards" prepared for the CGS by Jonathan L. White, dated 2012, indicates that bedrock onsite consists of Eagle Valley evaporite. The site is mapped in the Eagle Collapse Center and nearby are mapped point locations of localized ground depressions, caverns or sinkholes formed from the dissolution of evaporite rock.

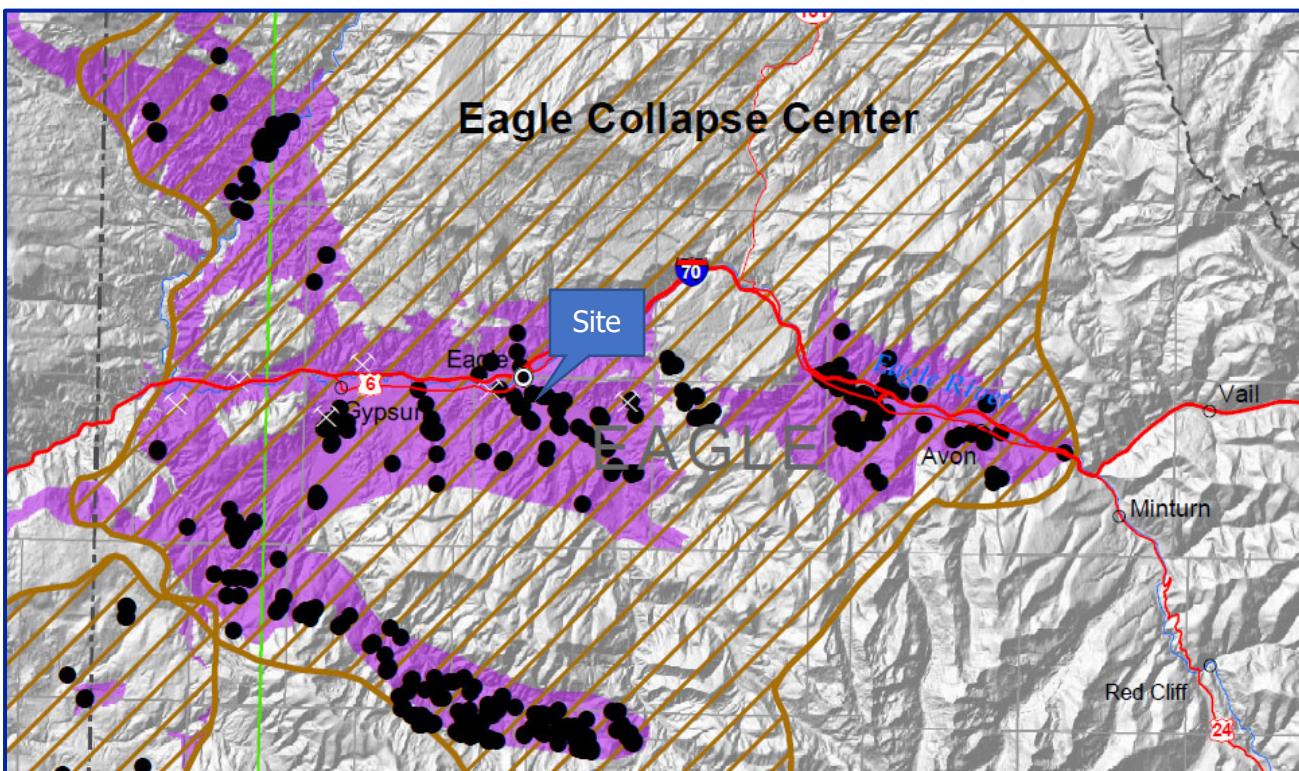
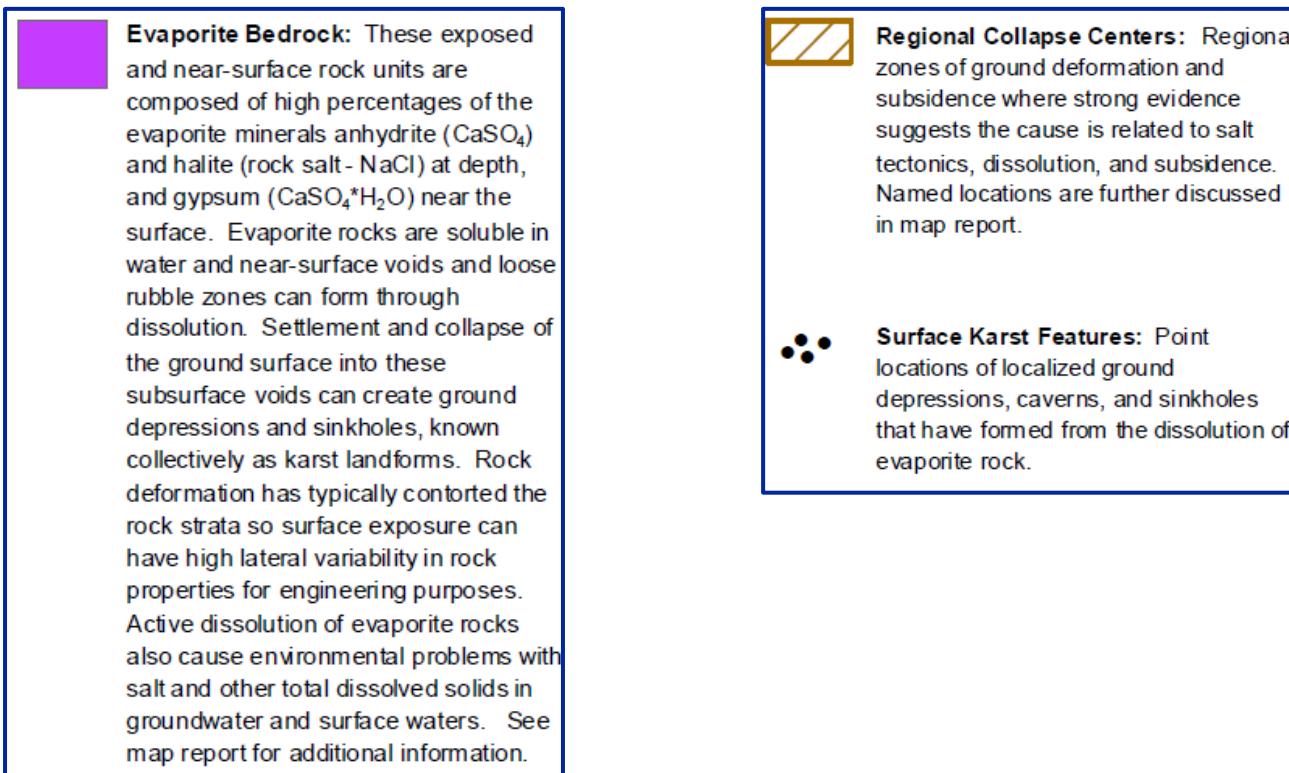


EXHIBIT 2. Snapshot of "Map of Potential Evaporite Karst Hazards in Colorado" by the CGS Critical Hazards Program (annotated by Cesare).



The "Map of Potential Geologic Hazards" prepared for Eagle County by Charles S. Robinson and Associates, Inc., dated 1975 indicates the site is mapped in a debris fan (dfa) and corrosive soil area. Hazards associated with a debris fan include areas of possible recurrent flooding, debris flows, and hydrocompaction. Corrosive soil is soil which may contain minerals in variable amounts that produce serious detrimental effects on concrete, metal, or other substances that are in contact with the soil. Additional discussion of corrosive soil is presented in Section **20.1 SULFATE EXPOSURE**.

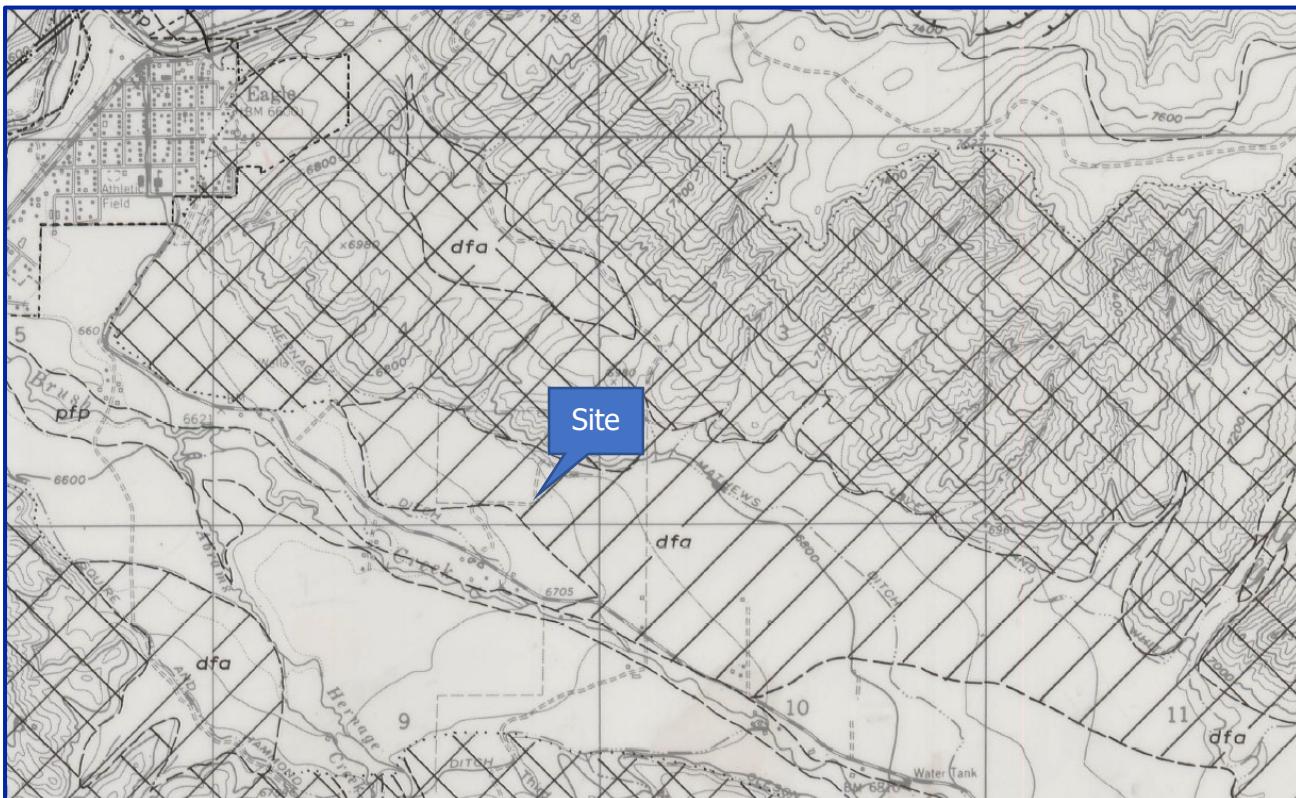
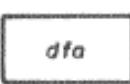


EXHIBIT 3. Snapshot of "Map of Potential Hazards" by Robinson, 1975 (annotated by Cesare).



dfa

Debris Fan

Areas of possible recurrent flooding, debris flows and hydrocompaction.



Corrosive soils

Soils which may contain minerals in variable amounts that produce serious detrimental effects on concrete, metal or other substances that are in contact with the soil.

6. FIELD EXPLORATION

Subsurface conditions were explored on November 3 through 5 and November 15 through 17, 2021 by drilling 14 borings in Phase 1 and 7 borings in Phase 2 at the locations indicated in Figure 2. Borings were drilled 9.9 to 50 feet deep using either 4 inch solid-stem augers, 5 inch diameter ODEX, or 7.5 inch diameter hollow stem augers.

Borings B-1, B-9, B-19, and B-XP were completed as groundwater monitoring wells with 2 inch solid over polyvinyl chloride (PVS) well screen pipe (slot size 0.010 inch), bentonite chip backfill plugs, and 3 foot yellow stick up well monuments. In addition, filter material (10/20 silica sand) was placed around the well screen. Graphical logs of the subsurface conditions observed, locations of sampling, and details of the monitoring wells are presented in the boring logs contained in Appendix A. An additional boring will be drilled and completed as a groundwater monitoring well adjacent to the new proposed pond.



Photo 2. View of drilling operations looking north. Paved Mount Hope Circle can be seen on the right.

7. LABORATORY TESTING

Cesare personnel returned samples obtained during field exploration to its laboratory where professional staff visually classified them and assigned testing to selected samples to evaluate pertinent engineering properties. Laboratory tests performed are listed in Table 7.1. Further discussion of laboratory testing and the laboratory test results are presented in Appendix B.

TABLE 7.1. Laboratory Testing Performed

Laboratory Test	To Evaluate
Grain size analysis	Grain size distribution for classification purposes.
Atterberg limits	Soil plasticity for classification purposes.
Swell/consolidation	Effect of wetting and loading on the soil.
Water soluble sulfate content	Potential corrosivity of the soil on cementitious material.

8. SUBSURFACE CONDITIONS

Cesare's borings encountered silt and clay with varying amounts of sand, underlain by sand and gravel with occasional to frequent cobbles and boulders, underlain by varying bedrock, including evaporite.

- Overburden soil consisting of silt and clay with varying amounts of sand was encountered to depths of 6 to 16 feet. Two samples tested for unit weight at this site had relatively low in-place moisture and density that is typical of collapsible soil.
- Overburden soil consisting of sand and gravel with varying amounts of clay was encountered from depths of about 6 to 16 feet to depths of about 14.5 to 36 feet.
- Bedrock was varying and consisted of evaporite, sandstone, siltstone, and shale. Bedrock was encountered at depths of 14.5 to 36 feet.
- Groundwater was encountered in most of the borings at depths of 8 to 21 feet at the time of drilling.
- Additional groundwater measurements were taken 1 to 2 days and 12 to 14 days after drilling. Groundwater was shallowest at Borings B-6, B-8, and B-10 at depths of about 7 feet.
- Several borings caved at or near the level of groundwater when checked several days after drilling.

The subsurface conditions encountered in Cesare's borings are reasonably consistent with those described in Section **5. GEOLOGIC CONDITIONS**. These observations represent conditions at the time of field exploration and may not be indicative of other times or other locations.

9. GROUNDWATER

Groundwater was encountered and temporary monitoring wells were installed in Borings B-1, B-9, B-19, and B-XP to monitor groundwater levels. An additional groundwater monitoring well is planned adjacent to the proposed stormwater pond. The temporary monitoring wells consist of PVC well screen, gravel filter pack, and 3 foot stick up monuments. Refer to Cesare's boring logs in Appendix A for details of well construction. A "Notice of Intent" (NOI) was submitted to the Colorado Department of Water Resources (DWR) at least 3 business days prior to drilling the borings and installation of the wells. Also, a well construction report was submitted to DWR for each well installed within 60 days of drilling completion. Digital readers were installed in each monitoring well and groundwater levels will be checked periodically. Measurements will be taken twice per day, set at 12 hours apart, and will be presented to the client upon the client's request. All temporary monitoring wells must be abandoned within 18 months of installation in accordance with DWR abandonment requirements, unless the wells are permitted as permanent monitoring wells. When groundwater

monitoring is completed, Cesare can abandon each of the monitoring wells, when directed by the client. Fees for abandoning the wells are not included in this study.

Borings and monitoring wells were checked for the presence of groundwater during drilling. Borings were temporarily covered and checked for water 1 to 2 and 12 to 14 days after drilling. Additional groundwater measurements were recorded when the digital readers were installed on January 19, 2022. Measurements are summarized in Table 9.1.

TABLE 9.1. Groundwater Measurements

Boring ID	Date Drilled	Depth of Water (ft) and Number of Days after Drilling the Measurement was Made			
		While Drilling	1 to 2 Days	12 to 14 Days	2 Months
B-1*	11/17/21	8			9.3
B-2	11/03/21	10		9	
B-3	11/03/21	9		7.5	
B-4	11/15/21	9		7.2	
B-5	11/05/21	Dry			
B-6	11/15/21	11	6.9		
B-7	11/05/21	9		6.8	
B-8	11/16/21	8	7.1		
B-9*	11/16/21	9			9.8
B-10	11/05/21	10		7	
B-11	11/15/21	No data			
B-12	11/05/21	11		9.1	
B-13	11/15/21	17	15.1		
B-14	11/17/21	19			
B-15	11/04/21	20		19.4	
B-16	11/04/21	Dry			
B-17	11/03/21	No data			
B-18	11/03/21	Dry			
B-19*	11/16/21	Dry			Dry
B-20	11/17/21	21			
B-21	11/03/21	No Data			
B-XP*	11/17/21	9			7.8

*Boring completed as monitoring well

Groundwater can be expected to fluctuate and can be influenced by variations in seasons, weather, precipitation, drainage, vegetation, landscaping, irrigation, leakage of water and/or wastewater systems, etc., both onsite and offsite. Discontinuous zones of perched water may exist or develop within the overburden material and/or upper zones of the bedrock. Cesare's field explorations were performed during the fall when groundwater levels are usually lowest. Groundwater levels will very likely be higher in the spring and early summer.

10. GEOLOGIC HAZARDS

The following subsections present a cursory review of geologic publications. A detailed geologic hazards assessment was not the focus of Cesare's scope of services. However, Cesare is available and capable of performing a detailed geologic hazards assessment if it is requested.

10.1 EAGLE VALLEY EVAPORITE BEDROCK

Bedrock outcroppings comprised of Eagle Valley evaporite were observed north of the site. Additionally, this site is underlain by Eagle Valley evaporite. Evaporite is hydrocompactive; prone to collapse upon wetting. Severe subsidence could cause adverse land impacts; if the strain of differential settlement exceeds the strength of a structure foundation, utility line, or pavement, then structural distress and damage might occur. Dissolution can lead to soil collapse, or in extreme situations, sinkholes. No sinkholes were observed on the site or in the vicinity, but open voids can occur in the subsurface that have not yet resulted in surface expressions. A primary driving factor for sinkhole development is changes in groundwater levels. Site development should be planned to minimize changes to existing groundwater conditions.



Photo 4. View looking north at evaporite bedrock visible on the surface directly north of the site.

10.2 DEBRIS FLOWS

The Eagle County geohazards assessment maps list debris fan hazards on this site. The mapped hazard includes areas of possible recurrent flooding, debris flows, and hydrocompaction. The silt and clay soil encountered on this site is likely colluvial soil and is potentially collapsible.

10.3 CORROSIVE SOIL

The Eagle County geohazards assessment maps list corrosive soil hazards on this site. The mapped hazard includes soil which may contain minerals in variable amounts that produce serious detrimental effects on concrete, metal, or other substances that are in contact with the soil. Laboratory testing of water soluble sulfates of the soil at this site indicated a severe exposure class and more discussion of sulfate attack on concrete is presented in Section **20.1 SULFATE EXPOSURE**.

10.4 RADON

Radon gas is a colorless, odorless gas that is produced by the decay of minerals in soil and rock. The Colorado Department of Public Health and Environment issued a news release on March 31, 2014 that stated, “*all 64 counties are categorized as Zone I for radon, or high-risk by the Colorado Department of Public Health and Environment*”. The potential for radon gas is likely and the site and/or planned structures should be evaluated by specialists in radon gas detection and management.

10.5 SEISMIC CONSIDERATIONS

The soil types present onsite classify as Seismic Class Type D according to the 2018 IBC (ASCE 7, Chapter 20), based on penetration tests and Cesare’s experience. Additional geophysical studies are necessary to justify a different site classification.

11. GEOTECHNICAL CONSIDERATIONS

11.1 SHALLOW GROUNDWATER

Groundwater was recorded as shallow as 6.8 feet below ground surface at this site. Cesare’s field explorations were performed during the fall when groundwater levels are usually lowest. Groundwater levels will very likely be higher in the spring and early summer. Cesare installed groundwater monitoring wells to observe the change in groundwater. If groundwater rises, it may impact the proposed construction on this site. If groundwater is anticipated to be within the extent of shallow foundations excavations, a dewatering system may be needed. If needed, a contractor specializing in the design and construction of temporary dewatering should be contacted.

11.2 MOISTURE SENSITIVE SOIL

Results of swell/consolidation testing performed on samples obtained from the site is summarized in Table 11.1.

TABLE 11.1 Summary of Swell/Consolidation Laboratory Testing

Sample Location	Material Type	Swell (+) or Compression (-) Upon Wetting (%)	Inundation Pressure (psf)	Generalized Volume Change Category
B-1 at 4 feet	Clay (CL)	-0.1	500	Low
B-5 at 4 feet	Silt (ML)	-0.2	500	Low
B-8 at 4 feet	Clay (CL)	-0.1	500	Low
B-10 at 4 feet	Clay (CL)	-0.1	500	Low
B-12 at 9 feet	Clay (CL)	-0.2	1,000	Low
B-14 at 1 foot	Clay (CL)	-0.8	1,000	Low
B-16 at 4 feet	Silt (ML)	-1.1	1,000	Low
B-17 at 1 foot	Clay (CL)	-1.7	500	Low
B-17 at 9 feet	Clay (CL)	0.0	1,000	N/A
B-19 at 14 feet	Clay (CL)	-1.3	1,000	Low
B-21 at 1 foot	Clay (CL)	1.6	500	Low

11.3 SETTLEMENT POTENTIAL AND RISK

The collapse susceptibility of the site soil was evaluated by reviewing the geology, site history, and Cesare's laboratory testing program. Collapsible soil can be identified by relatively low in-place density, low natural moisture content, and consolidation testing. As shown in Table 12.2, Cesare's consolidation testing indicated a low hazard; however, two samples in the borings drilled in Phase 2 had dry densities less than 95pcf which is indicative of collapsible soil.

This site has previously been irrigated. It is possible that the upper soil on this site has been saturated and soil collapse and ground settlement have already been induced. It is not known if the site soil has been saturated uniformly or if there has been vertical penetration through the low permeability clay and silt soil in the upper 6 to 16 feet. Additionally, the induced collapse would only have occurred from the saturated soil overburden stresses. The wetting of the collapsible soil without additional loading may not have resulted in substantial decrease in void space and the planned foundation loading could still cause significant settlement.

The potentially collapsible soil encountered onsite is moisture sensitive and prone to consolidate upon an increase in moisture content (i.e., wetting). This material is stable at its existing moisture content, but upon further wetting, may consolidate. The amount of consolidation that can potentially occur depends on the thickness, depth, and consolidation potential of the moisture sensitive strata and the degree of moisture increase. Some moisture increase is inevitable after site development as a result of covering the soil and reducing the evaporation from the soil. Additional moisture increase can occur from irrigation. Moisture increase can also result from poor or inadequate surface drainage, inoperable subsurface drainage, or utility ruptures or leaks.

12. FOUNDATION RECOMMENDATIONS

If the risks associated with moisture sensitive soil can be tolerated, a shallow spread footing foundation may be used at this site. As a lower risk alternative, the proposed structures may be supported on a deep foundation, such as drilled piers or micropiles. Shallow foundation and deep foundation recommendations are included in the sections below.

12.1 SPREAD FOOTINGS

The proposed structures may be founded on conventional spread footings or pad type footings, provided the subgrade soil beneath the foundations are overexcavated, moisture conditioned, and replaced as structural fill below footings. Overexcavation and replacement should extend below foundation bearing level 18 inches in Phase 1 and 3 feet in Phase 2. Foundations bearing on controlled, structural fill below frost depth in accordance shall be constructed with the following design recommendations:

- a) A frost depth of 42 inches should be assumed for this area.
- b) Footings should be designed for a maximum allowable soil bearing pressure of 2,500_psf based on dead load plus full live load.
- c) Continuous footings should have a minimum width of 18 inches and isolated pad type footings should have a minimum dimension of 24 inches.
- d) Using the soil pressure recommended above, Cesare estimates the maximum settlement for the structure will be on the order of 1 inch, with differential settlement potentially on

the order of 0.5 inches. Footings should be proportioned as much as practicable to reduce differential settlement. If soil is not overexcavated, moisture conditioned, and recompacted a minimum of 18 inches below footings in Phase 1 and 3 feet below footings in Phase 2, anticipated foundations settlements will be greater.

- e) Steel reinforcement for continuous concrete foundation walls should be designed to span localized settlements over a distance of 10 feet.
- f) Footing excavation, overexcavation, and placement of structural fill should be observed by a Cesare representative prior to concrete placement to determine if bearing conditions are consistent with those assumed to develop its recommendations.

12.2 DRILLED PIERS

The proposed structure may be founded on straight shaft drilled piers designed in accordance with the following recommendations:

- a) Dead load plus full live load of the structure should be used for pier sizing.
- b) Maximum allowable end bearing pressure of 20,000 psf.
- c) No side shear shall be used to resist downward axial load (compression load) for any portion of the pier in natural soil.
- d) Allowable side shear of 2,000 psf for the portion of pier in competent bedrock (blow counts of 50/12 or harder).
- e) Minimum dead load pressure is assumed to be zero.
- f) Piers should be reinforced their full length to resist tension forces.
- g) Piers should have a center-to-center spacing of at least 3 pier diameters when designing for vertical loading conditions or be designed as a group.
- h) Piers should have a maximum length to diameter ratio of about 30 for constructability and observation purposes.
- i) Piers shall have a minimum diameter of 18 inches.
- j) Piers shall have a minimum penetration of 2 feet into competent bedrock (blow counts of 50/12 or harder).
- k) Casing of a portion of the drilled shafts may be necessary to permit proper cleaning and observation prior to concrete placement because of groundwater conditions and caving through more than 3 inches of water, unless proper tremie techniques are utilized to place concrete from the bottom of the shaft or the water is removed. Drilled shafts shall not be allowed to remain open overnight.
- l) Difficult drilling may be encountered in the very hard sandstone lenses. Use of coring equipment may be required. Pier penetration may not be decreased unless acceptable by the geotechnical engineer.
- m) Concrete for each pier should be formed at the top of the pier, if necessary, to achieve a uniform diameter at the top of the pier. Excess concrete or overpour resulting in enlargement of the pier shall be removed.
- n) Proper concrete mixture design for drilled shafts varies with the design stress intensity, anticipated concrete placement procedures, and spacing of the reinforcement. It is recommended that current design and construction procedures outlined by the ACI and the International ADSC be followed. Per these guidelines, current practice is to use a concrete mixture design slump in the range of 5 to 7 inches if casing is to be utilized or

the shaft is heavily reinforced. A design slump in the range of 7 to 9 inches with 3/4 inch maximum size aggregate is recommended if concrete is to be placed by tremie or pumping methods. Additional recommendations as outlined by ACI and ADCS should also be followed.

- o) Pier drilling should be observed by a Cesare representative in an effort to confirm that actual subsurface conditions are consistent with those presented in this study. If conditions deviate significantly, recommendations may need to be modified.

12.3 MICROPILES

The proposed structure can be supported on grouted micropiles in accordance with the following recommendations:

- a) Micropile design should conform with the *Micropile Design and Construction Reference Manual*, Publication FHWA NHI-05-039, dated December 2005, as published by the Federal Highway Administration.
- b) Based on the four classifications of micropiles defined in FHWA NHI-05-039 (A, B, C, and D) and considering local practice, Cesare anticipates that a Type A micropile will be constructed; i.e., grout will be tremied to the bottom of the drilled shafts and no excess pressure above the fluid head of the grout will be applied to the grout.
- c) The micropiles should extend at least 5 feet into the competent bedrock (blow counts of 50/12 or harder).
- d) Cesare recommends a minimum drilled micropile diameter of 4 inches.
- e) Dead load plus full live load of the structure should be used for micropile sizing for downward axial loading. Micropile design and installation is typically performed by specialty contractors. The selection of appropriate grout-to-ground bond strengths for micropiles is typically the responsibility of the local design contractor because the values are dependent on installation methods and equipment, which varies from contractor to contractor. Typical grout-to-ground bond values for various ground conditions and installation methods can be found in Table 5-3 of the FHWA NHI-05-039 design manual. To enable preliminary design calculations and development of foundation plans, the following initial preliminary allowable values of grout-to-ground bond strength are suggested; 100 psi in tension or compression for that portion of the micropile that is embedded in competent bedrock (blow counts of 50/12 or harder).
- f) No side shear shall be used to resist downward axial load (compression load) for any portion of the micropile in natural soil.
- g) Micropiles should have a minimum center-to-center spacing of 30 inches or 3 pile diameters, whichever is greater, to avoid group efficiency reduction.
- h) Connection between the micropiles and the structures shall be designed and detailed by the structural engineer.
- i) Micropiles should be reinforced their full length to resist tension forces. Size, grade, type, and positioning of reinforcement shall be determined by the structural engineer.
- j) The design parameters provided herein consider no dead load on the micropile and concrete will be placed using gravity methods (i.e., not pressure grouted). Cesare anticipates that permanent steel casing will be used in the upper portion of the shaft for load transfer from the foundation wall into the micropile.

- k) Grouting must be performed using appropriate tremie techniques from the bottom of the drilled shaft up. The structural engineer shall determine whether grout tubing (if used) can remain in the shaft after grouting is completed.
- l) Grout for each micropile shall be formed at the top of the micropile, as necessary, to provide a uniform diameter the full length of the micropile. Excess grout or overpour resulting in enlargement of the micropile shall be removed.
- m) Grout placement shall occur the same day as drilling. Drilled shafts shall not be left open overnight.
- n) It is recommended that grout may/be designed for severe exposure to water soluble sulfates as defined by ACI 318R-34. ACI recommends that a modified Type V cement with a maximum water:cementitious ratio of 0.50 and a minimum 28 day compressive strength of 4,000 psi be used for severe sulfate exposure levels. The use of pozzolan can further reduce the exposure.
- o) Difficult drilling may be encountered in boulders and/or lenses of very hard sandstone bedrock.
- p) Micropile installation (i.e., from drilling through grouting) should be observed by a Cesare representative in an effort to confirm that actual subsurface conditions are consistent with those presented in this study. If conditions deviate significantly, recommendations may need to be modified.

12.4 CLOSELY SPACED PIER REDUCTION FACTORS

12.4.1 Axial Loading

The minimum recommended center-to-center spacing of piers in a group is 2.0 times the average pier diameter. The load capacity of piers which are up to 3 pier diameters apart should be designed as a single block using the breadth and width of the pier group. Piers 3 to 8 pier diameters apart should be designed using a linear efficiency reduction factor of 0.7 to 1.0. Piers spaced greater than 8 diameters apart can be considered having an efficiency factor of 1.0. These group efficiency reductions factors are based on analyses which consider shear capacity only.

13. LATERAL EARTH PRESSURES

13.1 FOUNDATION WALLS

Lateral pressures on walls depend on the type of wall, hydrostatic pressure behind the wall, type of backfill material, and allowable wall movements. Cesare recommends drain systems be constructed behind walls to reduce the potential for hydrostatic pressures to develop. Where anticipated wall movements are greater than 0.5% of the wall height, lateral earth pressures can be estimated for an "active" condition. Where anticipated wall movement is less than approximately 0.5% of the wall height or wall movement is constrained, lateral earth pressures should be estimated for an "at rest" condition. Recommended lateral earth pressures for onsite material are provided in Table 14.1.

The recommended values for lateral earth pressures provided in Table 14.1 are given in terms of an equivalent unit weight. The equivalent unit weight multiplied by the depth below the top of the ground surface is the horizontal pressure against the wall at that depth. The resulting pressure distribution is a triangular shape. These soil pressures are for horizontal backfill with no surcharge

loading or hydrostatic pressures. If these criteria cannot be met, Cesare should be contacted for additional criteria.

Cesare understands that resistance to lateral loading for footing foundations may be a concern. The unfactored or ultimate coefficients of sliding resistance between concrete and bearing soil are provided in Table 14.1.

TABLE 13.1. Lateral Earth Pressures and Coefficients of Sliding Resistance for Onsite Material

Backfill Material Type	Unit Weight* (pcf)	Equivalent Unit Weight (pcf)			Coefficient of Sliding Resistance
		Active	At Rest	Passive	
Onsite native clay/silt	120	43	64	332	0.35
Imported granular soil	125	39	59	406	0.40

Wet unit weight of soil does not account for hydrostatic load or the effects of buoyancy.

14. INTERIOR FLOORS

The natural silt and clay soil has the potential for collapse. Cesare recommends overexcavating and recompacting the soil a minimum of 12 inches below slabs-on-grade to reduce the risk of slab-on-grade movement due to collapsible soil.

The soil may contain cobbles, as noted in Boring B-1, which can result in uneven soil excavation surfaces for slabs-on-grade. Cesare recommends a 4 inch layer of compacted screened rock to provide a level surface for slabs-on-grade.

The natural silt and clay soil exhibited negligible swell potential. Concrete slabs placed on this material or on properly placed structural fill comprised of this material do not require special considerations for accommodating movement as a result of expansive soil.

14.1 SLAB-ON-GRADE CONSTRUCTION DETAILS

Slab-on-grade cracking can result from compression of the supporting soil and also from concrete curing stresses. If slab-on-grade floors are chosen, Cesare recommends that design and construction of all interior slab-on-grade floors incorporate the following considerations and precautions. These details will not reduce the amount of movement but are intended to reduce potential damage should some settlement of the supporting subgrade take place. The ACI Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)" should be consulted regarding methods/techniques to reduce the occurrence of concrete shrinkage cracks and other potential issues associated with concrete finishing and curing.

- A vapor barrier is recommended beneath concrete slabs-on-grade that will support equipment sensitive to moisture or will be covered with wood, tile, carpet, linoleum, or other moisture sensitive or impervious coverings. Location of the vapor barrier should be in accordance with recommendations provided by ACI 302.2R-06, "Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials." Further discussion of vapor barriers is presented in Appendix C.

- b) Plumbing beneath slabs should be eliminated, where practicable. Where such plumbing is unavoidable, it should be thoroughly pressure tested during construction for leaks prior to slab placement.

- c) Backfill in utility trenches beneath slabs should be compacted as specified in Section **17**.

STRUCTURAL FILL/BACKFILL SOIL.

- d) Plumbing and utilities that pass through the slab should be isolated from the slabs.
- e) Separate slabs from foundation walls, interior columns, and utilities with a joint which allows/provides free vertical movement of the slab (i.e., floating slab construction).
- f) Provide frequent control joints in the slab. Refer to ACI 302.1R-15.
- g) Use of load transfer devices at construction and contraction joints is recommended when positive load transfer is required (See ACI 302.1R).

14.2 STRUCTURALLY SUPPORTED FLOORS

A floor system that is supported by the foundation system and has an air or void space (typically a crawlspace) below the floor so that it is not in contact with the underlying soil is considered a structurally supported or structurally suspended floor. If potential movement of slab-on-grade floors and associated cracking/distress are not considered tolerable by the owner, developer, architect, or structural engineer for any reason, a structurally supported floor should be provided.

There are design and construction issues associated with structurally supported floors that must be considered, such as ventilation and lateral loads. Where structurally supported floors are installed, the minimum required air space depends on the material used to construct the floor. Building codes require a clearance space of at least 18 inches above exposed soil if untreated wood floor components are used. Where other support material is used, a minimum clearance space of 8 inches is recommended. This minimum clearance space should be maintained between any point on the underside of the floor system (including beams and plumbing) and the surface of the exposed soil. The minimum clearance between the crawlspace ground surface and the structural floor members and suspended plumbing should be constructed to meet minimum code or recommended clearances.

Where structurally supported floors are used, utility connections, including water, gas, air duct, and exhaust stack connections to floor supported appliances should be capable of absorbing some deflection of the floor. Plumbing that passes through the floor should ideally be hung from the underside of structural floor and not lay on the bottom of the excavation. This configuration may not be achievable for some parts of the installation. It is prudent to maintain the minimum clearance space below all plumbing lines. If trenching below the lines is necessary, Cesare recommends sloping these trenches so they discharge to the foundation drain. Penetrations through the foundation wall should allow for at least 2 inches of clearance and/or be provided with flexible connections. The ground surface below the structurally supported floor should be sloped to the perimeter drain.

Control of humidity in crawlspaces is important for indoor air quality and performance of wood floor systems. The Moisture Management Task Force of Metro Denver has compiled discussion and recommendations regarding best practices for control of humidity in below grade, underfloor spaces. An engineering professional with expertise in the design and construction of crawlspace humidity control should be contacted.

15. EXTERIOR FLATWORK

Flatwork supported on foundation wall backfill may settle and crack if the backfill is not properly moisture conditioned and compacted.

Exterior flatwork should be isolated from the structures. Exterior flatwork should be expected to move, although measures can be incorporated into construction to limit the movement or effects of the movement. Cesare recommends flatwork not be doweled into structure foundations, but rather supported on a haunch to limit settlement. The haunch should extend the full length of the slab.

Exterior flatwork, such as driveways and sidewalks, are normally constructed as slabs-on-grade. Porches and patios are increasingly constructed as structurally supported slabs, which in Cesare's opinion, is the most positive means of keeping slabs from moving and adversely affecting the operation of doors or means of egress. Cesare recommends that landings and slabs at egress doors, as well as porches and patios, be constructed as structurally supported elements if potential movement cannot be tolerated.

Simple decks that are not integral to the structure and can tolerate foundation movement can be constructed with less substantial foundations. A short pier or footing bottomed below frost depth can be used if movement is acceptable and if acceptable by local building requirements. Use of deeper foundation elements can reduce potential movement. Footings or short piers should not be underlain by wall backfill, due to risk of settlement. Inner edges of decks may be constructed on haunches and detailed such that movement of the deck foundations will not cause distress to the structure.

15.1 OVERHANGING ROOFS

Porches, patios, or decks with overhanging roofs that are integral to the structure, such that foundation movement cannot be tolerated, should be constructed with the same foundation type as the structure.

16. EXCAVATIONS

16.1 STRUCTURE EXCAVATIONS

Conventional earthmoving equipment should be adequate for shallow excavation of the onsite soil. All excavations should be properly sloped and/or braced, and local and federal safety codes observed. Slopes and other areas void of vegetation should be protected against erosion. If temporary shoring is required, a contractor specializing in design and construction of shoring should be contacted.

It is the contractor's responsibility to provide safe working conditions and comply with the regulations in OSHA Standards-Excavations, 29 CFR Part 1926. The following guidelines are provided for planning purposes. Sloping and shoring requirements must be evaluated at the time of construction by the contractor's competent person as defined by OSHA. OSHA classifications for various material types and the steepest allowable slope configuration corresponding to those classifications are shown in Table 16.1.

TABLE 16.1. Allowable Slope Configuration for Onsite Material

Material Type	OSHA Classification	Steepest Allowable Slope Configuration*
Onsite native silts and clays	Type B	1:1
Onsite soil below groundwater	Type C	1-1/2:1

* Units horizontal to units vertical. The values shown apply to excavation less than 20 feet in height. Conditions can change and evaluation is the contractor's responsibility.

The classifications and slope configurations in Table 16.1 assume that there is no standing water in the excavations and there is no seepage from the slope into the excavations, unless otherwise specified. The above classifications and slope configurations assume that the material in the excavations is not fractured, adversely bedded, jointed, nor left open to desiccate, crack, or slough, and are protected from surface runoff. There are other considerations regarding allowable slope configurations that the contractor is responsible for, including proximity of equipment, stockpiles, and other surcharge loads to the excavation. The contractor's competent person is responsible for all decisions regarding slope configuration and safety conditions for excavations.

Excavations should not undermine existing foundation systems of structures or infrastructure unless they are adequately protected. At a minimum, new excavations should not intersect a line drawn on a 45 degree angle down and away from the bottom edge of the existing foundation systems or bottom edge of infrastructure. If this condition cannot be met, shoring or staged excavations may be required. If shoring is required, a condition survey of the adjacent structures is recommended before construction starts and upon completion of construction. In Cesare's experience, condition surveys include, but may not be limited to, photographs of any distress to adjacent structures.

Permanent slopes should be no steeper than 2:1 and revegetated or otherwise protected from erosion.

16.2 UTILITY EXCAVATIONS

Difficulty may be experienced in the construction of utilities at this site. Cobbles and boulders were encountered in Cesare's borings. Boulders may be encountered in utility trench excavations. Large or specialized equipment may be required to excavate trenches and to move these boulders. Bearing material loosened or disturbed by the removal of boulders should be recompacted or removed. If utility excavations extend past the measured groundwater levels, groundwater may be encountered. Excavation into groundwater shall be considered in utility design and construction.

17. STRUCTURAL FILL/BACKFILL SOIL

Where fill/backfill soil is necessary, the suitable onsite inorganic soil may be used. At this site, unsuitable material is defined as topsoil, organics, trash, ash, frozen material, hard lumps and clods, and particles larger than 3 inches. Existing onsite fill material can be reused for structural fill/backfill, provided it is free of unsuitable material. If unsuitable material is encountered in the existing fill, it must be removed before the existing fill can be reused as fill/backfill. Recommendations for fill/backfill placement are:

- Clods or lumps shall be broken down to a maximum size of 3 inches. Pieces larger than 3 inches shall be removed from the fill/backfill.

- b) Fill/backfill material should be placed in loose lifts and compacted in accordance with Table 17.1.
- c) Maximum loose lift thickness shall be 6 inches, depending on the type of equipment used to apply compactive effort and shall be reduced if the specified compaction cannot be obtained with the equipment used.
- d) Fill/backfill should not be placed if material is frozen or if the placement surface is frozen.
- e) Fill/backfill material should be placed and spread in horizontal lifts of uniform thickness in a manner that avoids segregation.
- f) Placement surface should be kept free of standing water, debris, and unsuitable material during placement and compaction of fill/backfill material.
- g) Fill/backfill maximum allowable particle size is 3 inches. Do not incorporate oversize material in the fill/backfill that is incapable of being broken down by the equipment and methods being employed to process and compact the fill/backfill. Process and compact material in the lift, as necessary, to produce the specified fill/backfill characteristics. If oversize particles remain in the lift after processing and compacting, remove oversize material to produce a fill/backfill within specified requirements.
- h) Overlot fill placement and compaction should be observed and tested on a full-time basis by a representative of Cesare. At a minimum, utility trench backfill should be tested in accordance with jurisdictional requirements.

TABLE 17.1. Compaction Specifications

Fill Location	Material Type (General)	AASHTO Classification	Moisture Content (%)	Relative Compaction (%)	Compaction Standard
Structural fill (includes all overlot grading)	Granular material that is clean to silty	A-1, A-2-4, A-2-5, A-3, A-4, A-5	$\pm 2\%$ of OMC	$\geq 98\%*$	Standard Proctor (ASTM D698)
	Fine grained material and granular material with plastic fines	A-2-6, A-2-7 A-6, A-7	0% to $+3\%$ of OMC	$\geq 98\%*$	Standard Proctor (ASTM D698)
Fill in nonstructural areas (e.g., landscaping)	Granular material that is clean to silty	A-1, A-2-4, A-2-5, A-3, A-4, A-5			Standard Proctor (ASTM D698)
	Fine grained material and granular material with plastic fines	A-2-6, A-2-7 A-6, A-7	0% to $+3\%$ of OMC	$\geq 90\%*$	Standard Proctor (ASTM D698)

* If fill thickness greater than 15 feet is planned, additional requirements may apply.

17.1 IMPORT FILL

Material imported for structural fill should be tested and approved for use onsite by the project geotechnical engineer prior to hauling to the site. Proctor and classification tests should be conducted to determine if the fill meets required specifications. Fill material should be well graded meeting the specifications in Table 17.2.

TABLE 17.2. Import Fill Specifications

Soil Parameter	Specification
Maximum particle size	1.5 inch
Percent finer than No. 200 sieve	10% to 20%
Liquid limit	20% to 30%
Plasticity index	5% to 10%

18. SUBSURFACE DRAINAGE

The bottom of foundations should be established as high as practical to reduce the potential for pumping of groundwater. The water table level was measured at 6.9 to 19 feet below the existing ground surface in Phase 1 and 19.4 to 21 feet below the existing ground surface in Phase 2. Groundwater should not be a concern in Phase 2; however, in Phase 1, groundwater was measured within 3 feet of the assumed bottom of foundation level at the time of this study. Temporary piezometers have been installed and groundwater readings will continue to be taken.

During wetter seasons or wetter years, the water table could rise significantly. Shallow foundation and utility construction may be below the groundwater table. Temporary dewatering may be required to excavate below the groundwater table. A contractor specializing in the design and construction of temporary dewatering should be contacted.

If the design team decides on a structurally supported floor, Cesare recommends foundation walls be provided with a water resistant treatment and a peripheral subsurface drainage system. Cesare recommends exterior perimeter drains, rather than interior perimeter drains, for most conditions because for water to reach interior perimeter drains, it must first pass beneath the foundations. This increases the risk of wetting the soil beneath the foundations, which increases the risk for foundation movement. It is difficult to quantify the increase in risk associated with using interior rather than exterior perimeter drains, but foundation movement can cause distress to structures, such as cracking of walls, slabs, and finishes, and out-of-plumb doors and windows. If the owner accepts the increased risk associated with using interior rather than exterior perimeter drains, Cesare may be contacted to provide a typical perimeter drain detail.

19. SURFACE DRAINAGE

Good drainage and surface water management is important. Performance of site improvements, such as foundations, floors, and hardscape are often adversely affected by failing to establish and/or maintain good site drainage. Grades must be adjusted to provide positive drainage away from the buildings and other site improvements during construction and maintained throughout the life of the proposed facility. The following drainage precautions are recommended:

- a) Ground surface around the perimeter foundation walls should be sloped to drain away from the structure in all directions. Current building codes require a minimum slope of 6 inches in the first 10 feet (5%) of the structure. At the completion of construction, Cesare recommends a continuous slope away from foundations of 12 inches in the first 10 feet (10%), where site constraints permit. Cesare recommends that concrete and pavement adjacent to structures slope at a rate of at least 2% away from the structure or as

otherwise required by ADA criteria. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond.

- b) Joints that occur at locations where paving or flatwork abuts the structure should be properly sealed with flexible sealants and maintained.
- c) Ground surface should be sloped so water will not pond between or adjacent to structures and other site improvements. Curbs, sidewalks, paths, plants, or other improvements should not block, impede, or otherwise disrupt surface runoff. Use of chases and weep holes to promote drainage is encouraged. Landscape edging should be perforated or otherwise constructed in a manner to prevent ponding of surface water, especially in the vicinity of the backfill soil.
- d) Drainage swales should be located as far away from the foundation as practicable.
- e) If site constraints do not allow for the recommended slopes, the project civil engineer shall provide a method for drainage that is equivalent to the recommendations herein. Water should not be allowed to pond adjacent to or near foundations, flatwork, or other improvements.
- f) Roof downspouts and other water collection systems should discharge onto pavements or extend away from the structure well beyond the limits of the backfill zone using downspout extensions, appropriately sized splash blocks, or other means. Buried downspout extensions are discouraged as they can be difficult to monitor and maintain.
- g) Irrigation directly adjacent to the buildings is discouraged and should be minimized. Sprinkler lines, zone control boxes, and sprinkler drains shall be located outside the limits of the foundation backfill. Sprinkler systems should be placed so that the spray from the heads, under full pressure, does not fall within 5 feet of the foundation walls.
- h) Plants, vegetation, and trees that require moderate to high water usage are discouraged and should not be located within 5 feet of foundation walls.
- i) Plantings within 10 feet of the foundation should be placed in watertight planters/containers.
- j) The project civil engineer shall perform measurements to document that positive drainage, as described in this section or as otherwise designed by the project civil engineer is achieved. Maintenance of surface drainage is imperative subsequent to construction and is the responsibility of the owner and/or tenant.

20. SOIL CHEMICAL TESTING

20.1 SULFATE EXPOSURE

Water soluble sulfate contents of 0.0% to 0.17% were measured on clay samples obtained in Phase 1. Water soluble sulfate contents of 0.0% to 1.6% were measured on clay samples obtained in the proposed Phase 2. Results are summarized in Appendix B. The PCA publication, *Design and Control of Concrete Mixtures* 2002 and the ACI publication, *Building Code Requirements for Structural Concrete and Commentary* consider this exposure class S1 (moderate) for Phase 1 and S2 (severe) for Phase 2. Recommendations for all concrete which will be in contact with or within 6 inches of the clay soils tested are shown in Table 20.1.

TABLE 20.1 Information from ACI 318-08 - Table 4.3.1

Water Soluble Sulfates (%)	Exposure Class	Maximum (w/cm)*	Minimum f_c , (psi)	Cementitious materials† (types)			Calcium Chloride Admixture
				ASTM C150	ASTM C595	ASTM C1157	
<0.10	S0	N/A	2,500	No type restriction	No type restriction	No type restriction	No restriction
≤0.10 to <0.20	S1 Moderate	0.50	4,000	II [‡]	IP (MS) IS (<70) (MS)	MS	No restriction
≤0.20 to ≤2.00	S2 Severe	0.45	4,500	V [§]	IP (HS) IS (<70) (HS)	HS	Not permitted
>2.00	S3 Very Severe	0.45	4,500	V + pozzolan or slag ^{II} or IS (<70) (HS)+pozzolan or slag ^{II}	IP (HS)+pozzolan or slag ^{II} or IS (<70) (HS)+pozzolan or slag ^{II}	HS+pozzolan or slag ^{II}	Not permitted

*For lightweight concrete, see ACI 318-08 4.1.2.

†Alternative combinations of cementitious materials listed in Table 4.3.1 shall be permitted when tested for sulfate resistance and meeting the criteria in ACI 318-08 4.5.1.

‡For seawater exposure, other types of Portland cements with tricalcium aluminate (C₃A) contents up to 10 percent are permitted if the w/cm does not exceed 0.40.

§Other available types of cement such as Type III or Type I are permitted in Exposure Classes S1 or S2 if the C₃A contents are less than 8 or 5 percent, respectively.

¶ The amount of the specific source of the pozzolan or slag to be used shall not be less than the amount that has been determined by service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slag to be used shall not be less than the amount tested in accordance with ASTM C1012 and meeting the criteria in ACI 318-08 4.5.1.

Refer to ACI 318-08 R4.3.1 for further interpretation of this table.

21. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical study. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical study should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute Cesare's best estimate of those measures that are necessary to help the structures perform in a satisfactory manner based on the information generated during this study, training, and experience in working with these conditions.

22. LIMITATIONS

This document has been prepared as an instrument of service for the exclusive use of Abrika Properties, LLC. for the specific application to the project as discussed herein and has been prepared in accordance with geotechnical engineering practices generally accepted in the state of Colorado at the date of its preparation. No warranties, either expressed or implied, are intended or made. This document should not be assumed to contain information for other parties or other purposes.

The findings of this study are valid as of the date its preparation. Changes in the conditions of a

property can occur with the passage of time, whether due to natural processes or the works of people on this or adjacent properties. Standards of practice evolve in engineering and changes in applicable or appropriate standards may occur, whether a result from legislation or the broadening of knowledge. Accordingly, the findings of this study may be invalidated wholly or partially by changes outside of Cesare's control, therefore, this study is subject to review and should not be relied upon without such review after a period of 3 years.

In the event that changes, including but not limited to, the nature, type, design, size, elevation, or location of the project or project elements as outlined in this report are made, the conclusions and recommendations contained in this report shall not be considered valid unless Cesare reviews the changes and either confirms or modifies the conclusions of this report in writing.

Cesare should be retained to review final plans and specifications that are developed for proposed construction to judge whether the recommendations presented in this report and any addenda have been appropriately interpreted and incorporated in the project plans and specifications as intended.

The exploration locations for this study were selected to obtain a reasonably accurate depiction of underground conditions for design purposes and these locations are often modified based on accessibility and the presence of underground or overhead utility conflicts. Variations from the soil conditions encountered are possible. These variations may necessitate modifications to Cesare's design recommendations, therefore, Cesare should be retained to observe subsurface conditions, once exposed, to evaluate whether they are consistent with the conditions encountered during Cesare's exploration and that the recommendations of this study remain valid. If parties other than Cesare perform these observations and judgements, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

Cesare's scope of services for this report did not include either specifically, or by implication, any environmental assessment of the site or identification of contaminated or hazardous material or conditions. Additionally, none of the services performed in connection with this study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not, of itself, be enough to prevent mold from growing in or on the structures involved.

At a minimum, Cesare should be retained during construction to observe and/or test:

- completed excavations.
- placement and compaction of fill.
- pier/pile drilling operations.
- proposed import or onsite fill material.

Cesare offers many other construction observations, materials engineering, and testing services and can be contacted to discuss further.



PROJECT NO:	21.5057		
PROJECT NAME:	Haymeadow Development		
DRAWN BY:	ZLM	CHECKED BY:	RSG
DWG DATE:	11.22.21	REV. DATE:	--

FIGURE 1
Vicinity Map

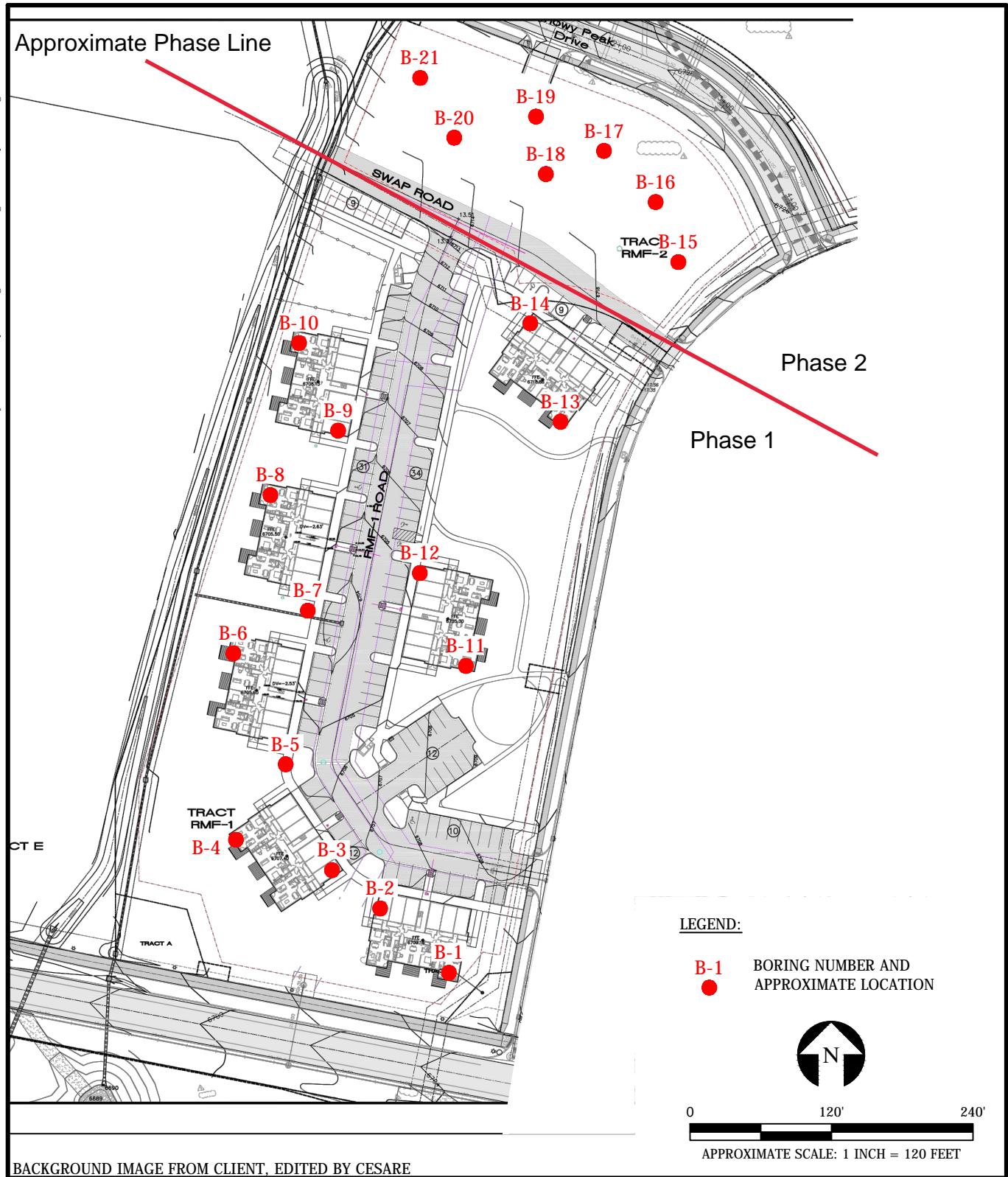
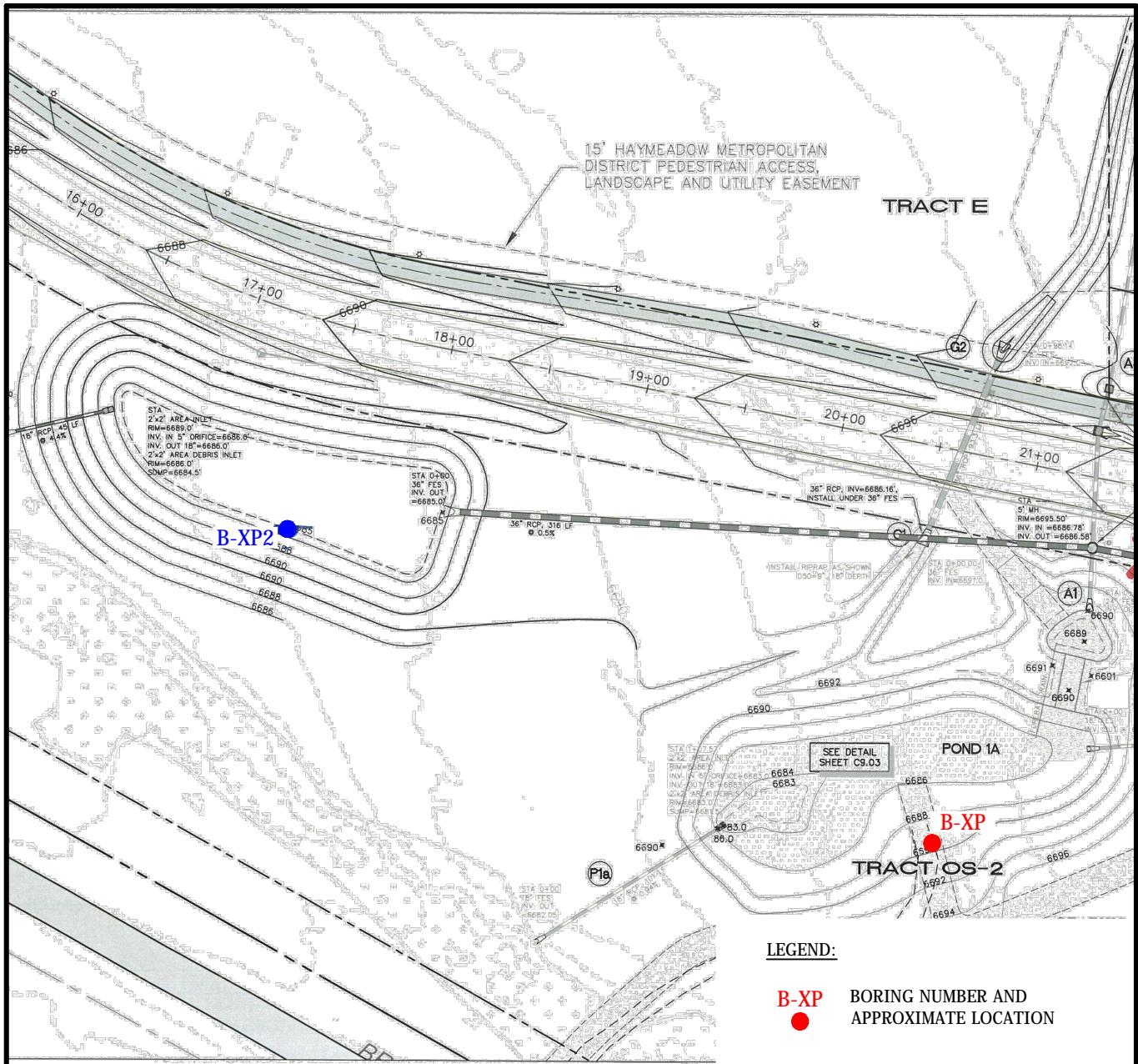


FIGURE 2a
Boring Location Plan

PROJECT NO:	21.5057		
PROJECT NAME:	Haymeadow Development		
DRAWN BY:	ZLM	CHECKED BY:	RSG
DWG DATE:	01.12.21	REV. DATE:	--



BACKGROUND IMAGE FROM CLIENT, EDITED BY CESARE

FIGURE 2b
Boring Location Plan

PROJECT NO:	21.5057		
PROJECT NAME:	Haymeadow Development		
DRAWN BY:	ZLM	CHECKED BY:	RSG
DWG DATE:	01.12.21	REV. DATE:	--

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants



APPENDIX A

Field Exploration

FIELD EXPLORATION

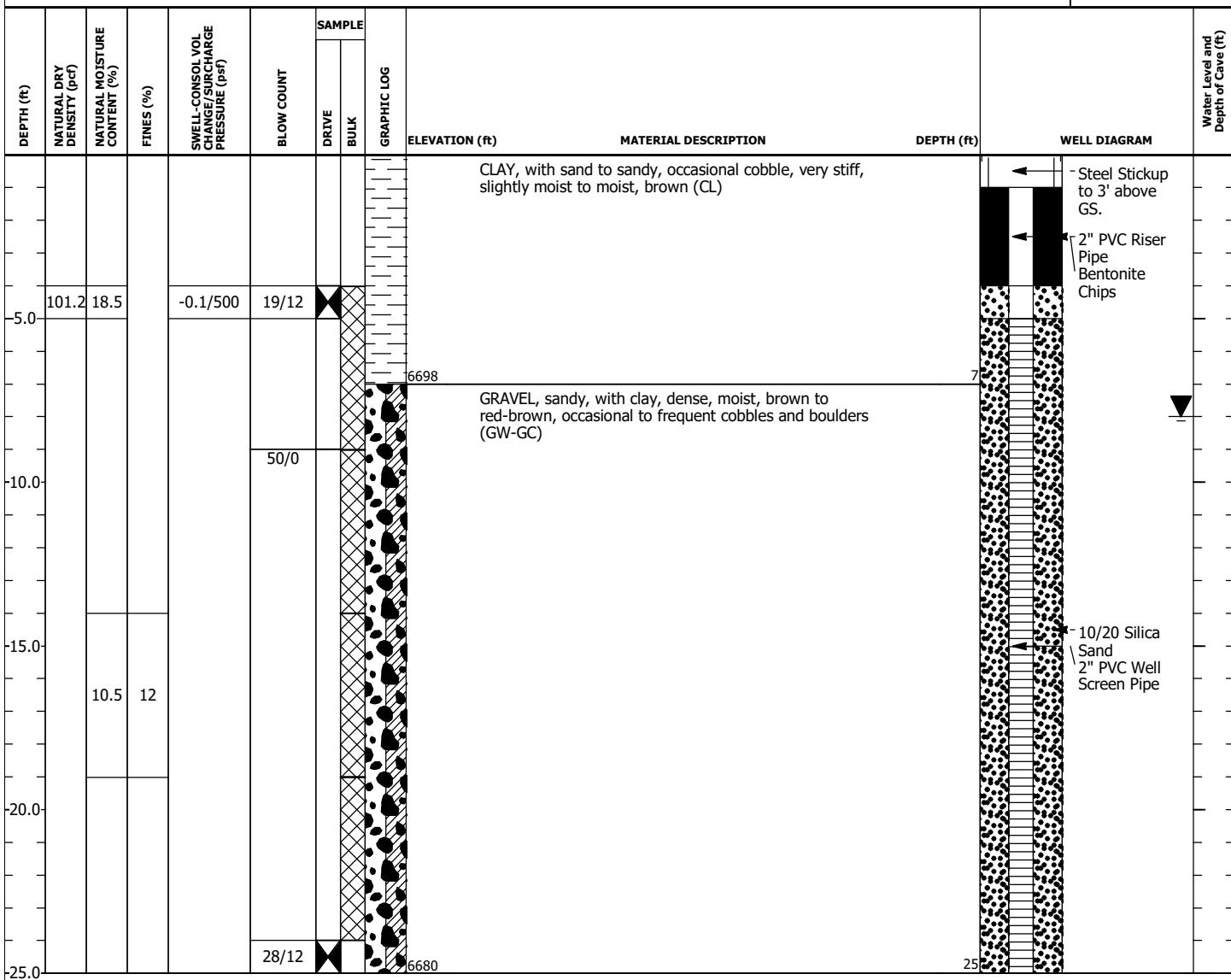
Samples of the subsoil were obtained using modified California and standard split spoon. Modified California and standard split spoon samplers were driven into the soil by dropping a 140 pound hammer through a free fall of 30 inches. The modified California sampler is a 2-1/2 inch outside diameter by 2 inch inside diameter device lined with brass tubes. The split spoon sampler is a 2 inch outside diameter by 1-3/8 inch inside diameter device. The procedure to drive these samplers into the soil and to record the number of blows required to drive the sampler into the soil is known as a penetration test. The number of blows required for the sampler to penetrate 12 inches gives an indication of the relative stiffness of cohesive soil, relative density of non-cohesive soil, and relative hardness of sedimentary bedrock material encountered. Bulk samples were collected from cuttings generated during drilling. Locations of sampling and penetration test results are presented on the boring logs contained in this appendix.

Cesare installed temporary monitoring wells in Boring(s) B-1, B-9, B-19 and B-XP. An additional monitoring well (B-XP2) will be installed adjacent to the proposed detention pond. Details about well construction can be found in section 6. Groundwater level measurements within the temporary monitoring wells are included in Table 9.1. Groundwater can be expected to fluctuate with variations in seasons, drainage, site vegetation, irrigation, or weather conditions.

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-1
BORING LOCATION		BORING ELEVATION	6705ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX	DATE STARTED	11/17/2021	
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/17/2021	

B-1

Page 1 of 1



Boring terminated at 25 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING



BULK SAMPLE

▽# WATER LEVEL # DAYS AFTER DRILLING



MODIFIED CALIFORNIA SAMPLER

→# DEPTH OF CAVE # DAYS AFTER DRILLING



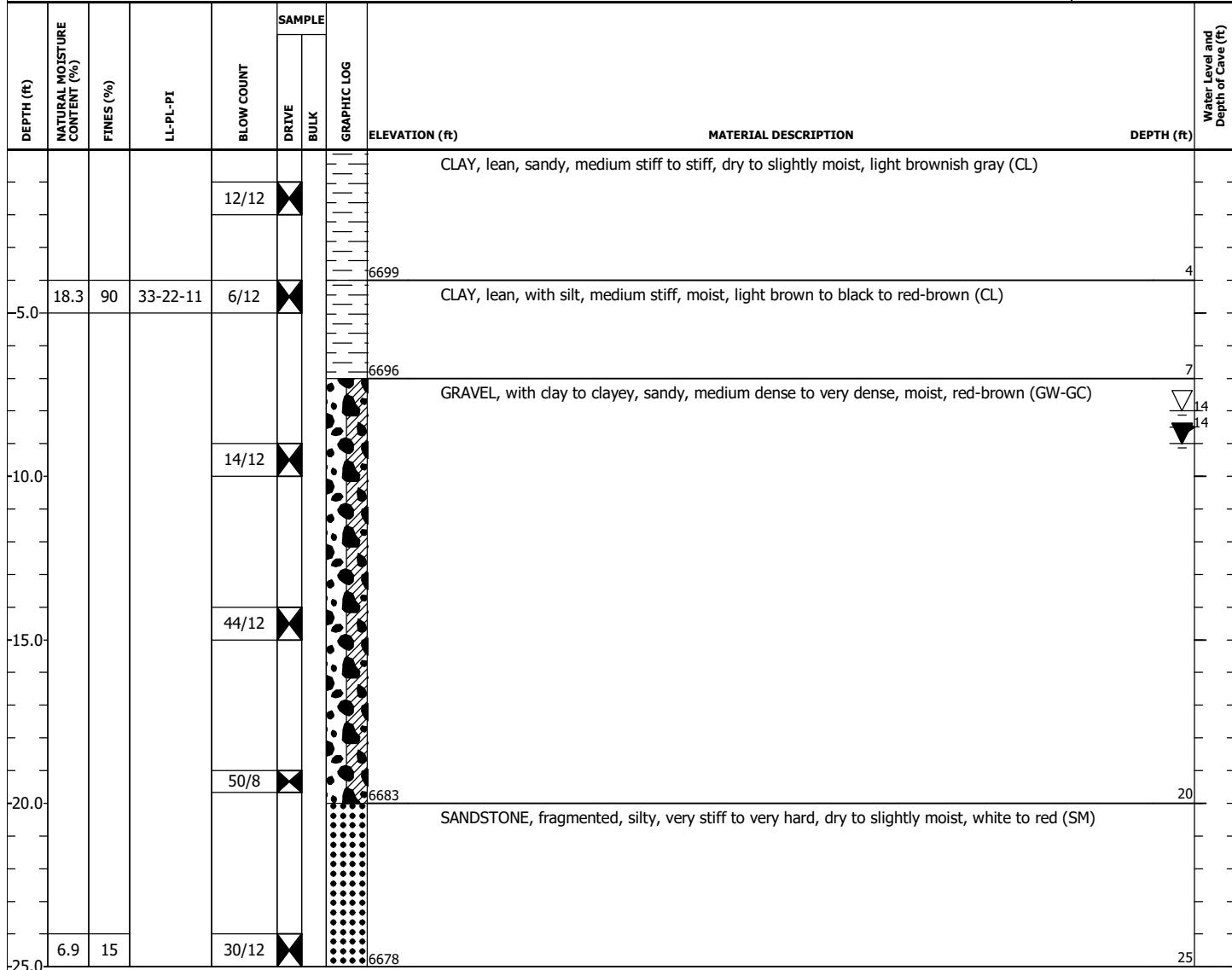
↑ DEPTH OF REFUSAL



PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-2
BORING LOCATION		BORING ELEVATION	6703ft.	
DRILLING COMPANY/RIG	Odell Drilling/CME-45	CESARE REP.	Z. Moore	
DRILLING METHOD	4in. Diameter SSA	DATE STARTED	11/3/2021	
HAMMER SYSTEM	Automatic Hammer	DATE COMPLETED	11/3/2021	

B-2

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LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

 MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

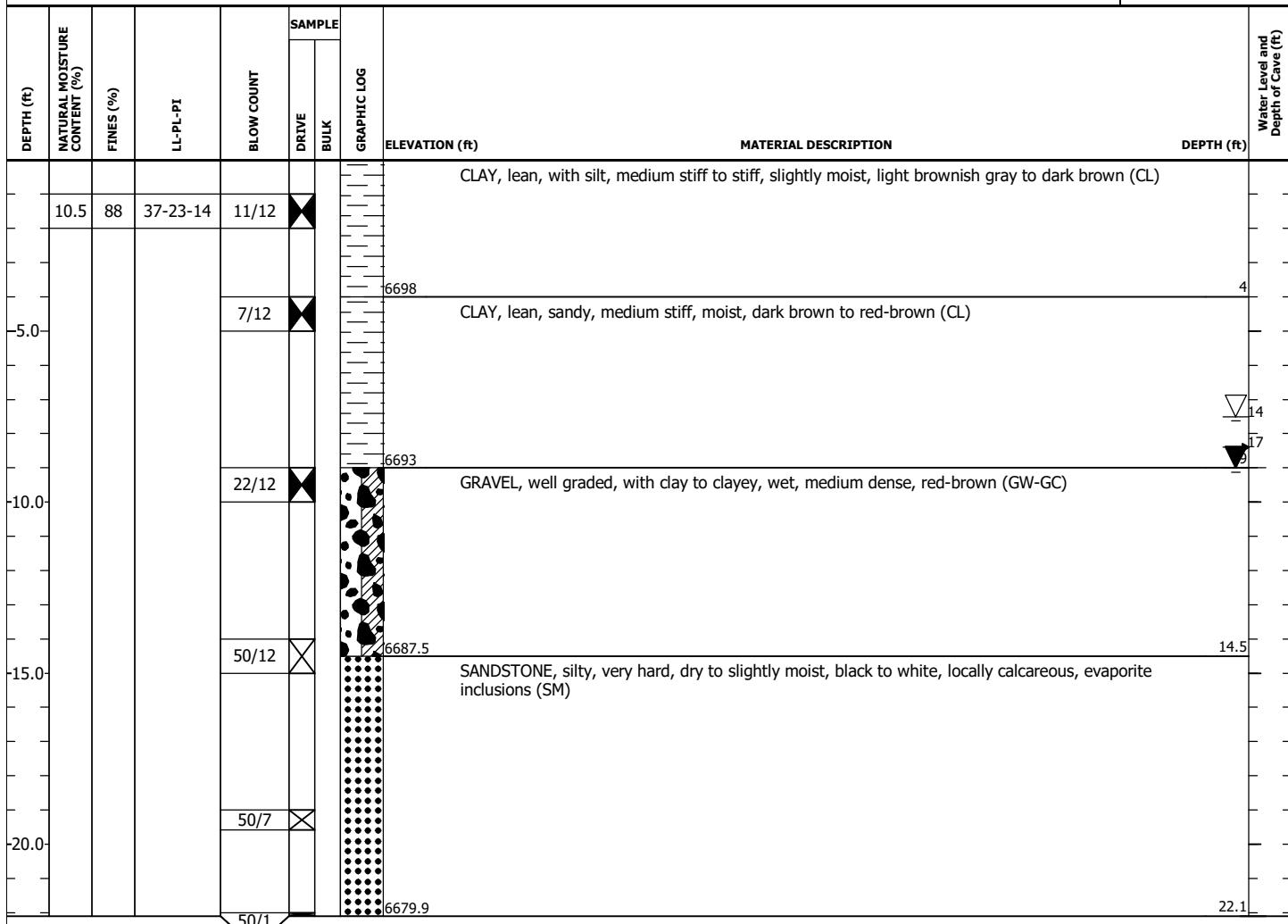
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057
BORING LOCATION		BORING ELEVATION	6702ft.*
DRILLING COMPANY/RIG	Odell Drilling/CME-45	CESARE REP.	Z. Moore
DRILLING METHOD	4in. Diameter SSA	DATE STARTED	11/3/2021
HAMMER SYSTEM	Automatic Hammer	DATE COMPLETED	11/3/2021

B-3

Page 1 of 1



*Elevation estimated by interpolating between nearby boring elevations.

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

☒ SPLIT SPOON

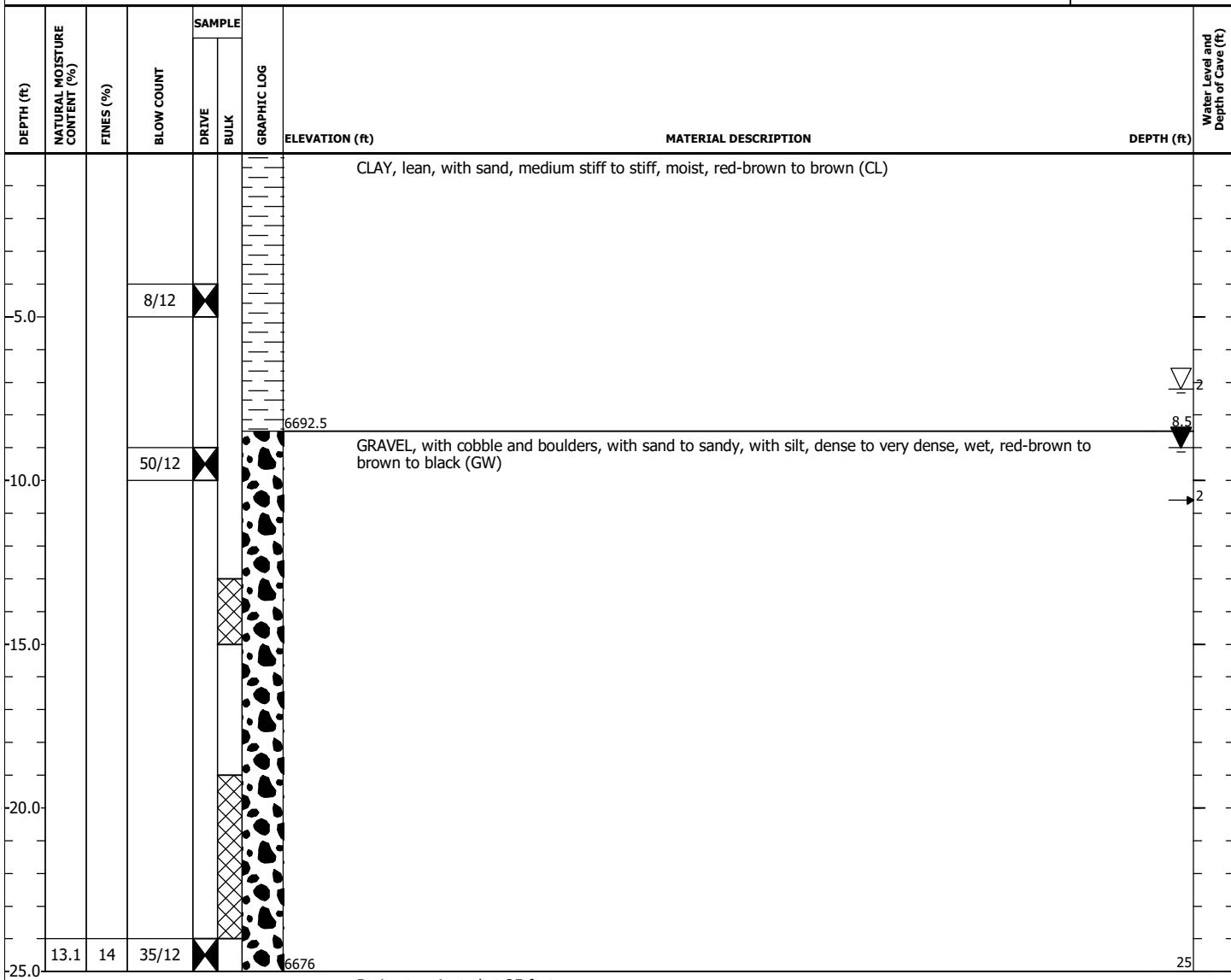
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-4
BORING LOCATION		BORING ELEVATION	6701ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX	DATE STARTED	11/15/2021	
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/15/2021	

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Page 1 of 1



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING



BULK SAMPLE

▽# WATER LEVEL # DAYS AFTER DRILLING



MODIFIED CALIFORNIA SAMPLER

→# DEPTH OF CAVE # DAYS AFTER DRILLING



DEPTH OF REFLISA



DESIRE, INC.

Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-5
BORING LOCATION		BORING ELEVATION	6702ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore	
DRILLING METHOD	7.5in. Diameter HSA	DATE STARTED	11/5/2021	
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/5/2021	

B-5

Page 1 of 1

Boring terminated at 9.92 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

 MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

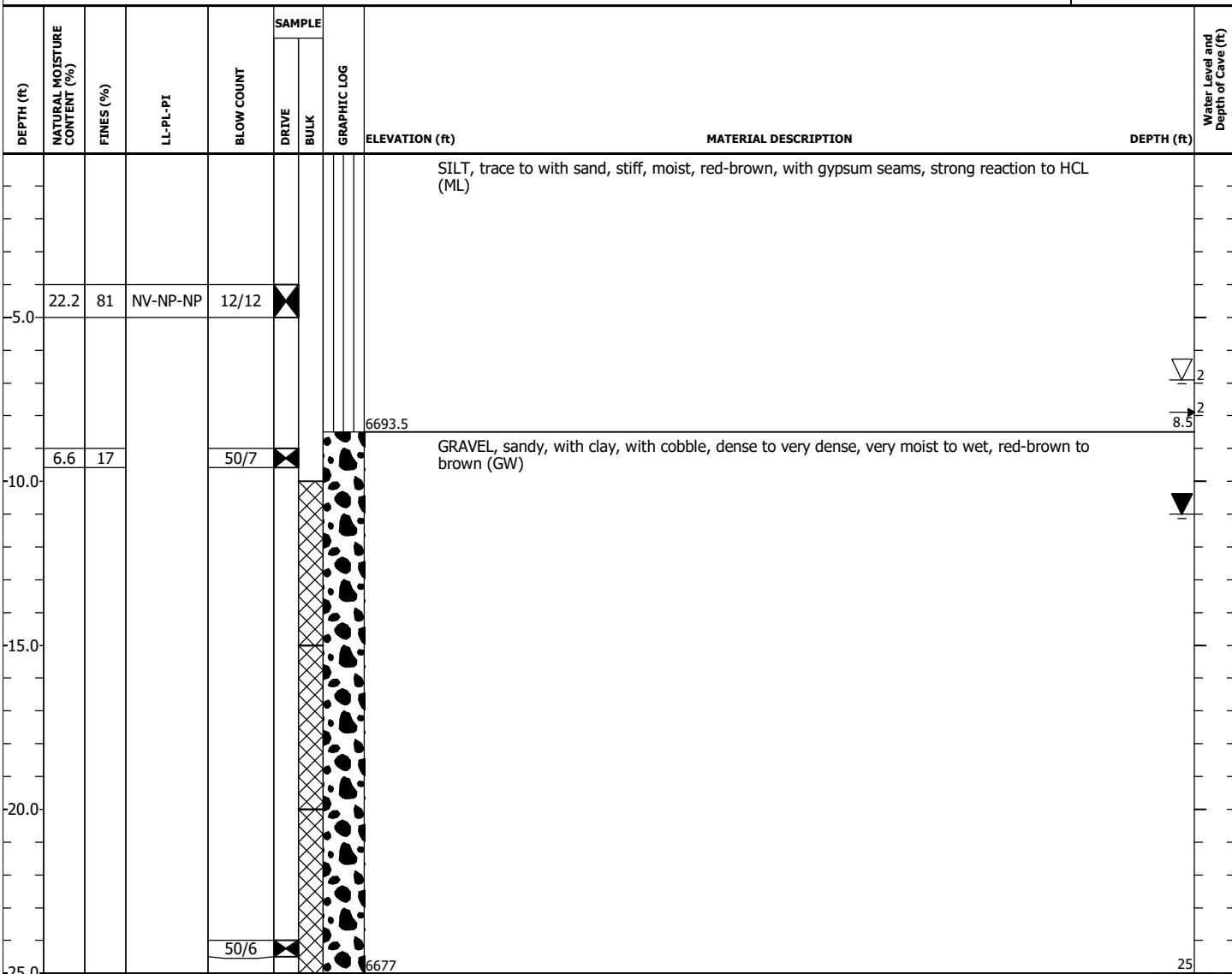
A square icon containing a large 'X' with a vertical line through it, representing a split spoon.

SPLIT SPOON

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development			PROJECT NUMBER	21.5057	B-6
BORING LOCATION				BORING ELEVATION	6702ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120			CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX			DATE STARTED	11/15/2021	
HAMMER SYSTEM	Rope & Cathead			DATE COMPLETED	11/15/2021	Page 1 of 1



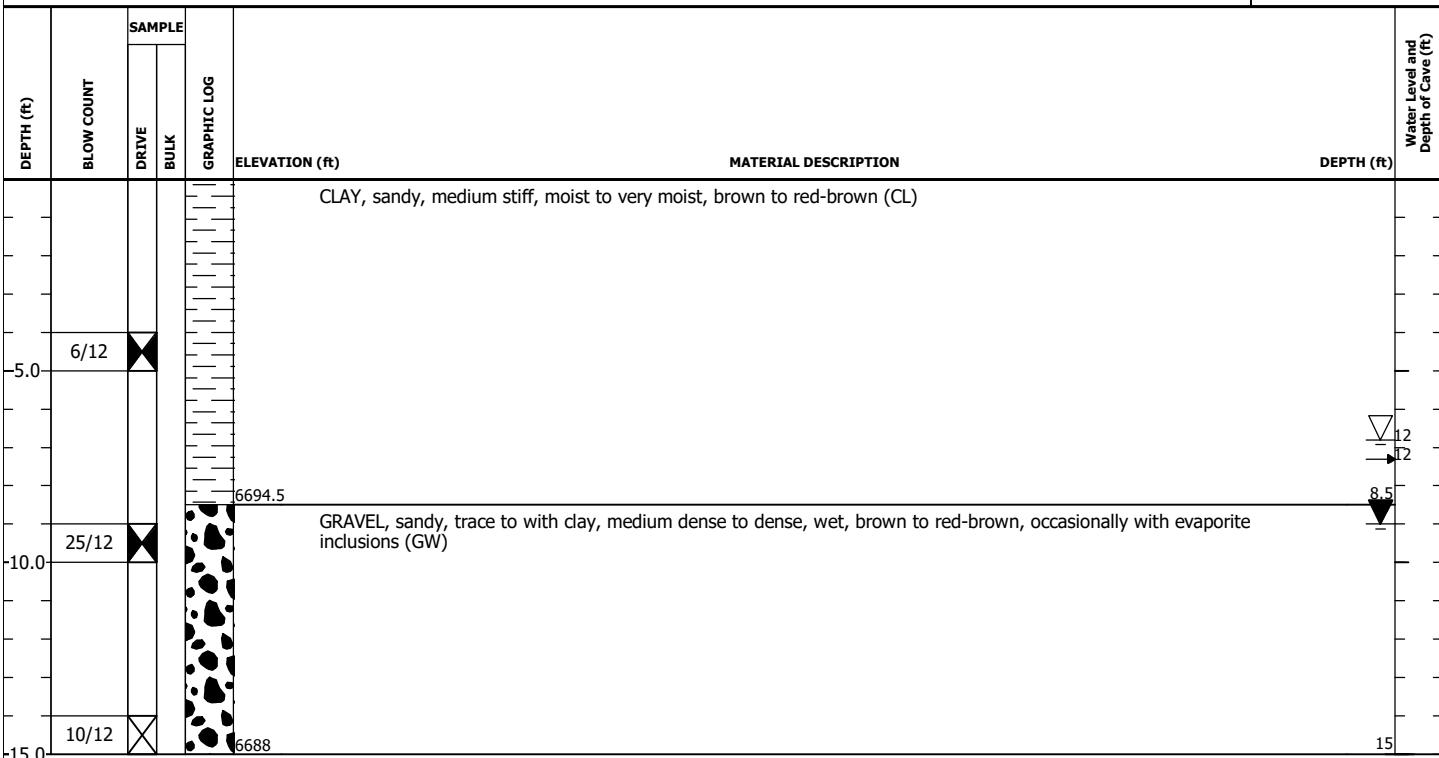
LEGEND

- WATER LEVEL AT TIME OF DRILLING
- WATER LEVEL # DAYS AFTER DRILLING
- DEPTH OF CAVE # DAYS AFTER DRILLING
- DEPTH OF REFUSAL

- BULK SAMPLE
- MODIFIED CALIFORNIA SAMPLER

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-7
BORING LOCATION		BORING ELEVATION	6703ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore	
DRILLING METHOD	7.5in. Diameter HSA	DATE STARTED	11/5/2021	
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/5/2021	

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LEGEND

▽ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

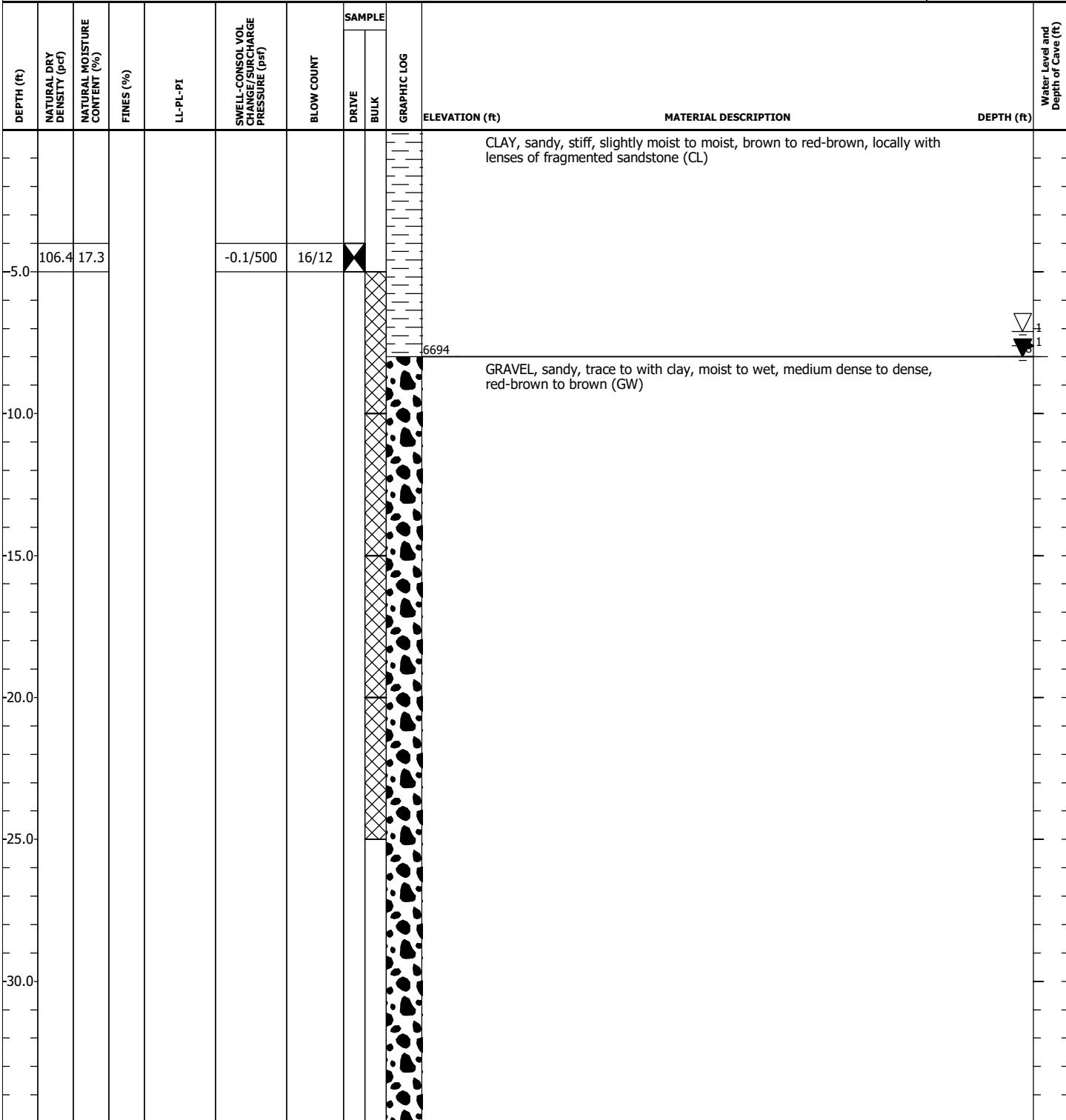
▽# WATER LEVEL # DAYS AFTER DRILLING

☒ SPLIT SPOON

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development			PROJECT NUMBER	21.5057	B-8
BORING LOCATION				BORING ELEVATION	6702ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120			CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX			DATE STARTED	11/16/2021	
HAMMER SYSTEM	Rope & Cathead			DATE COMPLETED	11/16/2021	Page 1 of 2



LEGEND

- ▼ WATER LEVEL AT TIME OF DRILLING
- ▽# WATER LEVEL # DAYS AFTER DRILLING
- # DEPTH OF CAVE # DAYS AFTER DRILLING
- ↑ DEPTH OF REFUSAL

- ☒ BULK SAMPLE
- ☒ MODIFIED CALIFORNIA SAMPLER

PROJECT NAME	Haymeadow Development				PROJECT NUMBER	21.5057	B-8
BORING LOCATION	Dakota Drilling/Diedrich 120				BORING ELEVATION	6702ft.	
DRILLING COMPANY/RIG	5in. Diameter ODEX				CESARE REP.	Z. Moore	
DRILLING METHOD	Rope & Cathead				DATE STARTED	11/16/2021	
HAMMER SYSTEM					DATE COMPLETED	11/16/2021	Page 2 of 2

DEPTH (ft)	NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT (%)	FINES (%)	IL-PI-PI	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)	BLOW COUNT	SAMPLE		GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
							DRIVE	BULK					
-50.0	13.6	36	NV-NP-NP			37/12	☒		6652			50	
-40.0						47/12	☒					36	
-35.0													
-30.0													
-25.0													
-20.0													
-15.0													
-10.0													
-5.0													
0.0													
5.0													
10.0													
15.0													
20.0													
25.0													
30.0													
35.0													
40.0													
45.0													
50.0													

Boring terminated at 50 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ BULK SAMPLE

▽# WATER LEVEL # DAYS AFTER DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

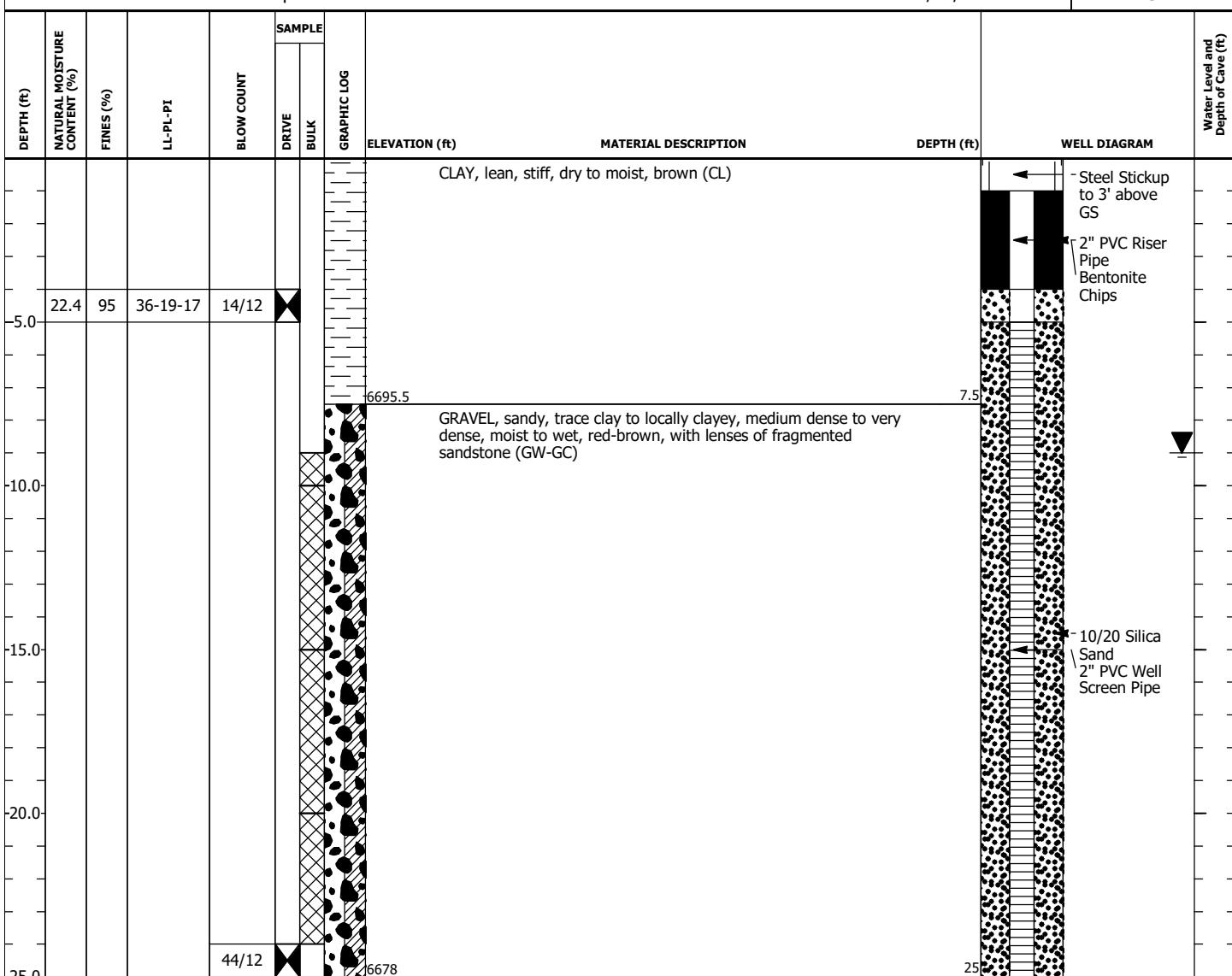
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-9
BORING LOCATION		BORING ELEVATION	6703ft.*	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX	DATE STARTED	11/16/2021	
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/16/2021	

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Page 1 of 1



Boring terminated at 25 feet

*Elevation estimated by interpolating between nearby boring elevations.

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING



BULK SAMPLE

▽# WATER LEVEL # DAYS AFTER DRILLING



MODIFIED CALIFORNIA SAMPLER

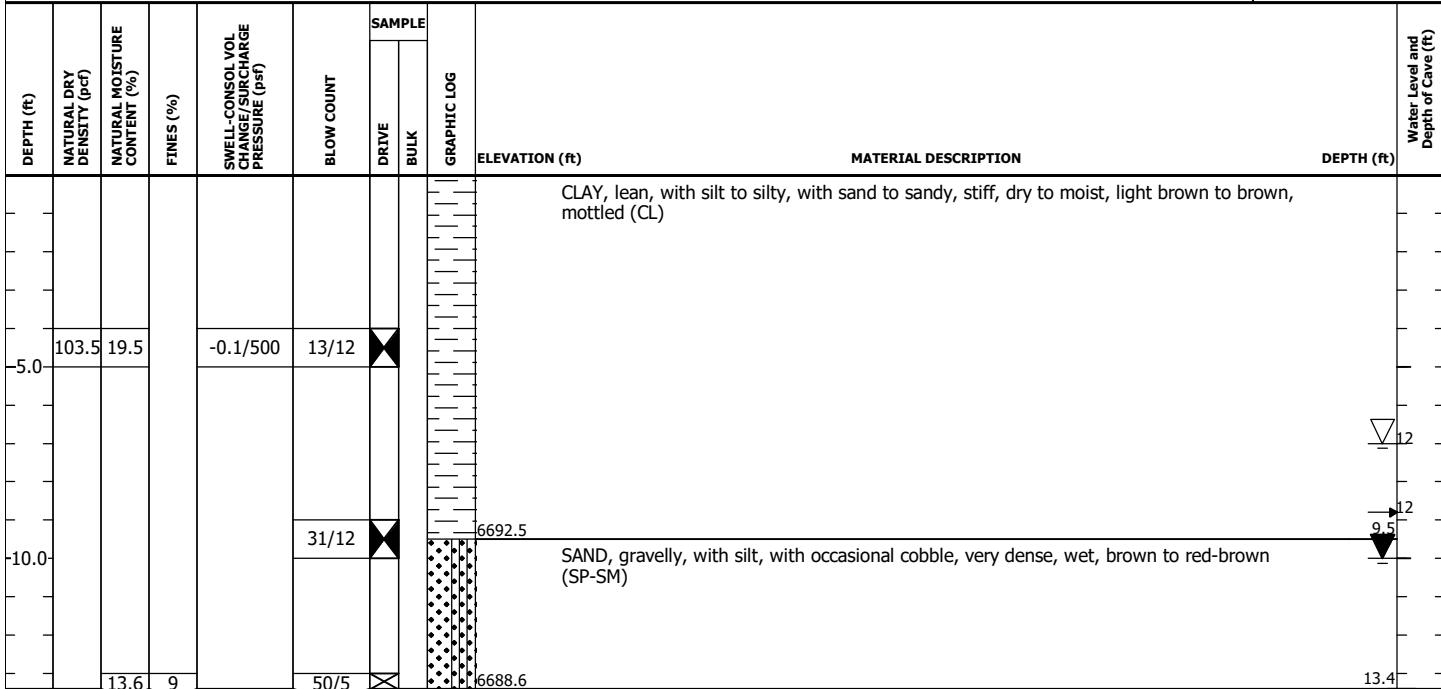
→# DEPTH OF CAVE # DAYS AFTER DRILLING



↑ DEPTH OF REFUSAL



PROJECT NAME	Haymeadow Development			PROJECT NUMBER	21.5057	B-10
BORING LOCATION				BORING ELEVATION	6702ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120			CESARE REP.	Z. Moore	
DRILLING METHOD	7.5in. Diameter HSA			DATE STARTED	11/5/2021	
HAMMER SYSTEM	Rope & Cathead			DATE COMPLETED	11/5/2021	Page 1 of 1



Boring terminated at 13.4 feet

LEGEND

▽ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

☒ SPLIT SPOON

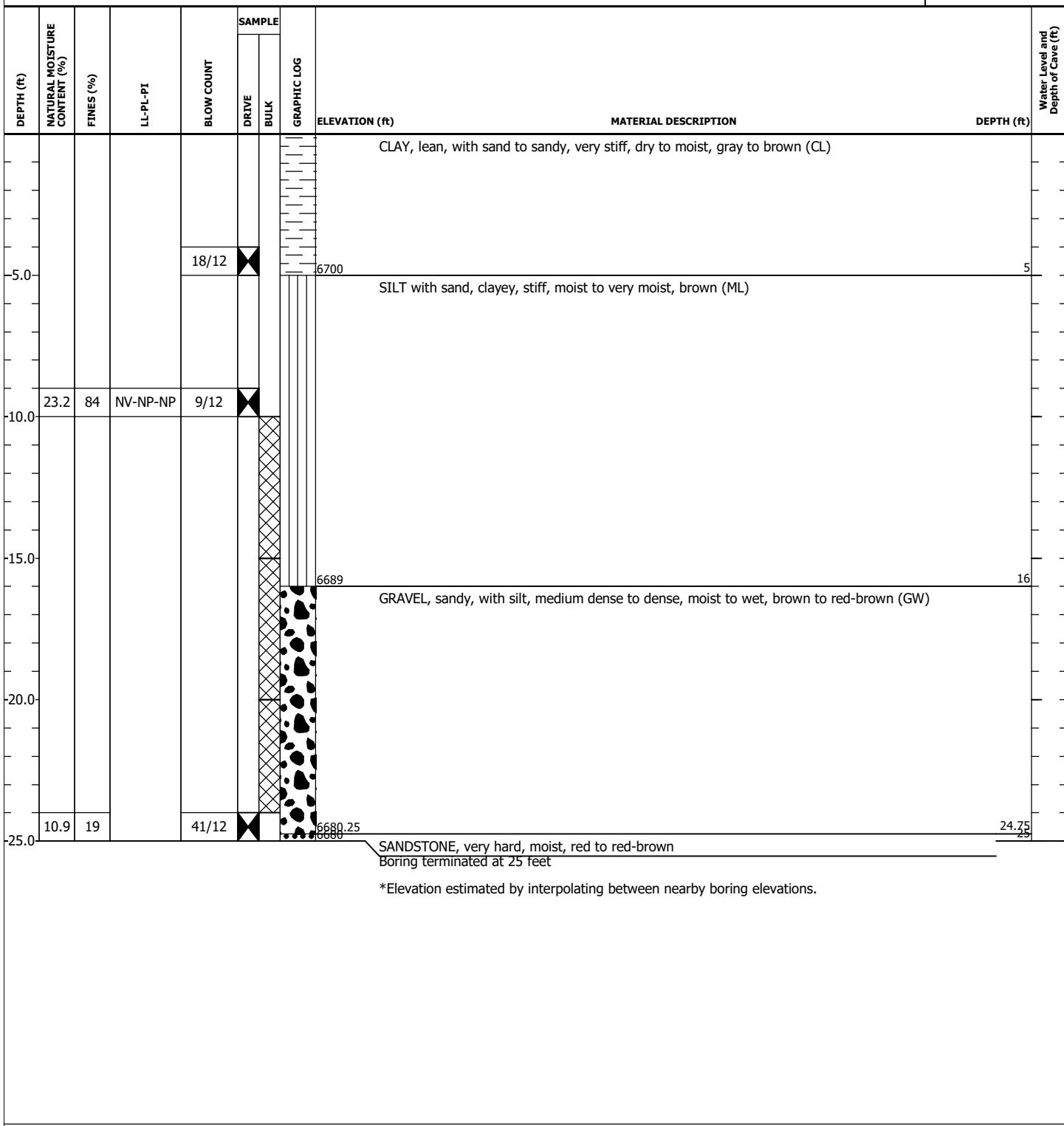
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057
BORING LOCATION		BORING ELEVATION	6705ft.*
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore
DRILLING METHOD	5in. Diameter ODEX	DATE STARTED	11/15/2021
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/15/2021

B-11

Page 1 of 1



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ BULK SAMPLE

▽# WATER LEVEL # DAYS AFTER DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

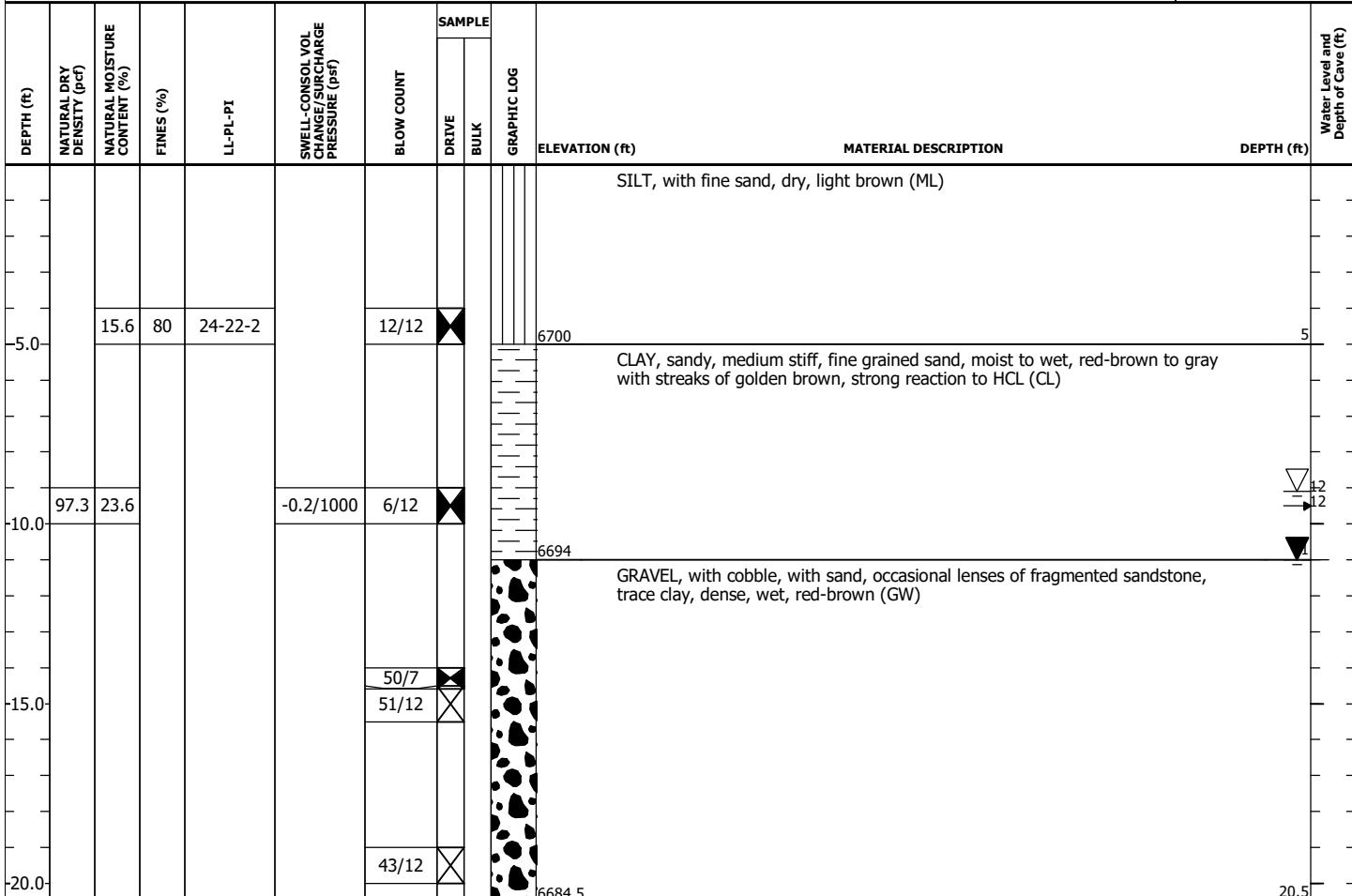
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-12
BORING LOCATION		BORING ELEVATION	6705ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore	
DRILLING METHOD	7.5in. Diameter HSA	DATE STARTED	11/5/2021	
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/5/2021	

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Page 1 of 1



Boring terminated at 20.5 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

 MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

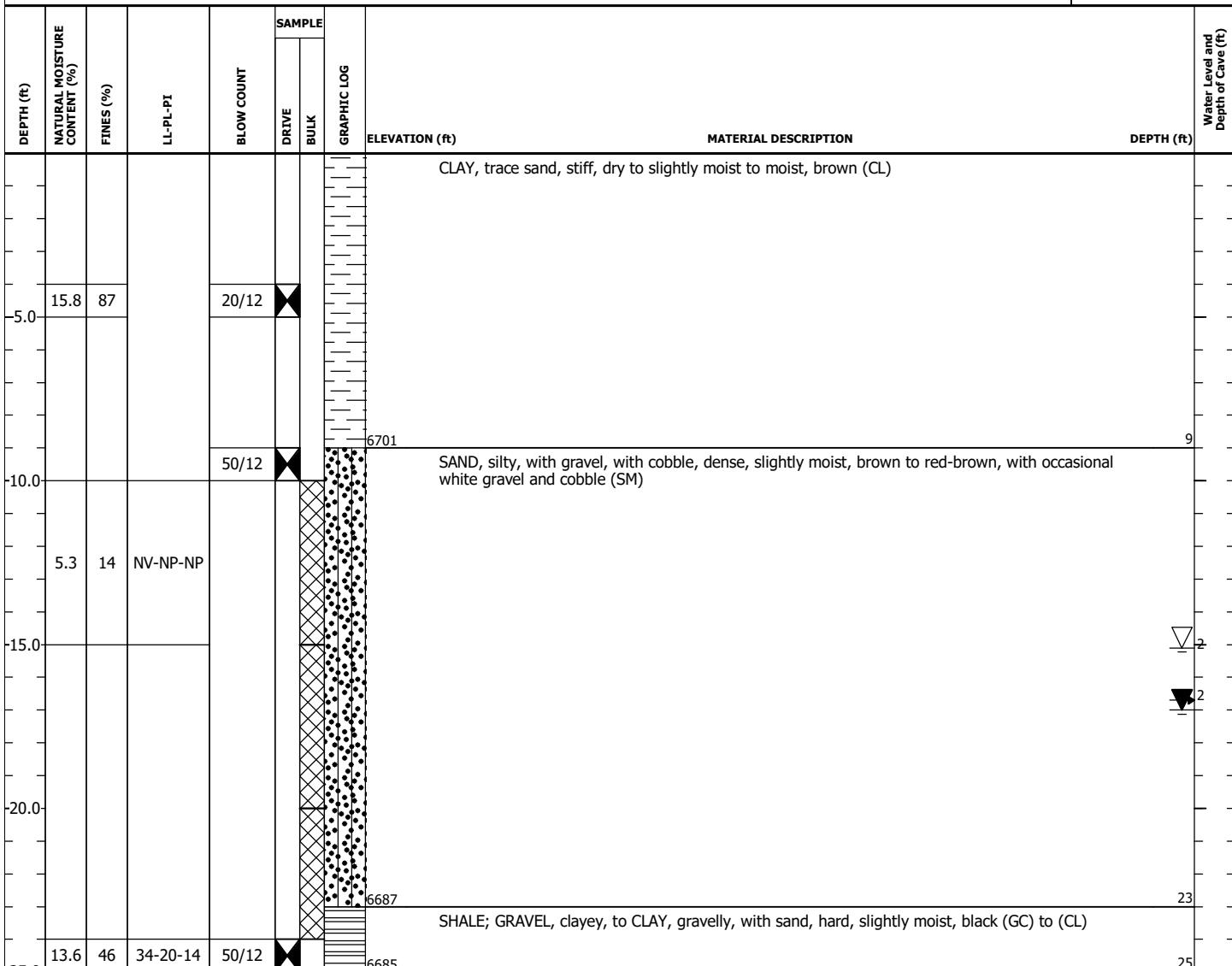
A square icon containing a black 'X' shape, representing a split spoon.

SPLIT SPOON

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development			PROJECT NUMBER	21.5057	B-13
BORING LOCATION				BORING ELEVATION	6710ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120			CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX			DATE STARTED	11/15/2021	
HAMMER SYSTEM	Rope & Cathead			DATE COMPLETED	11/15/2021	Page 1 of 1

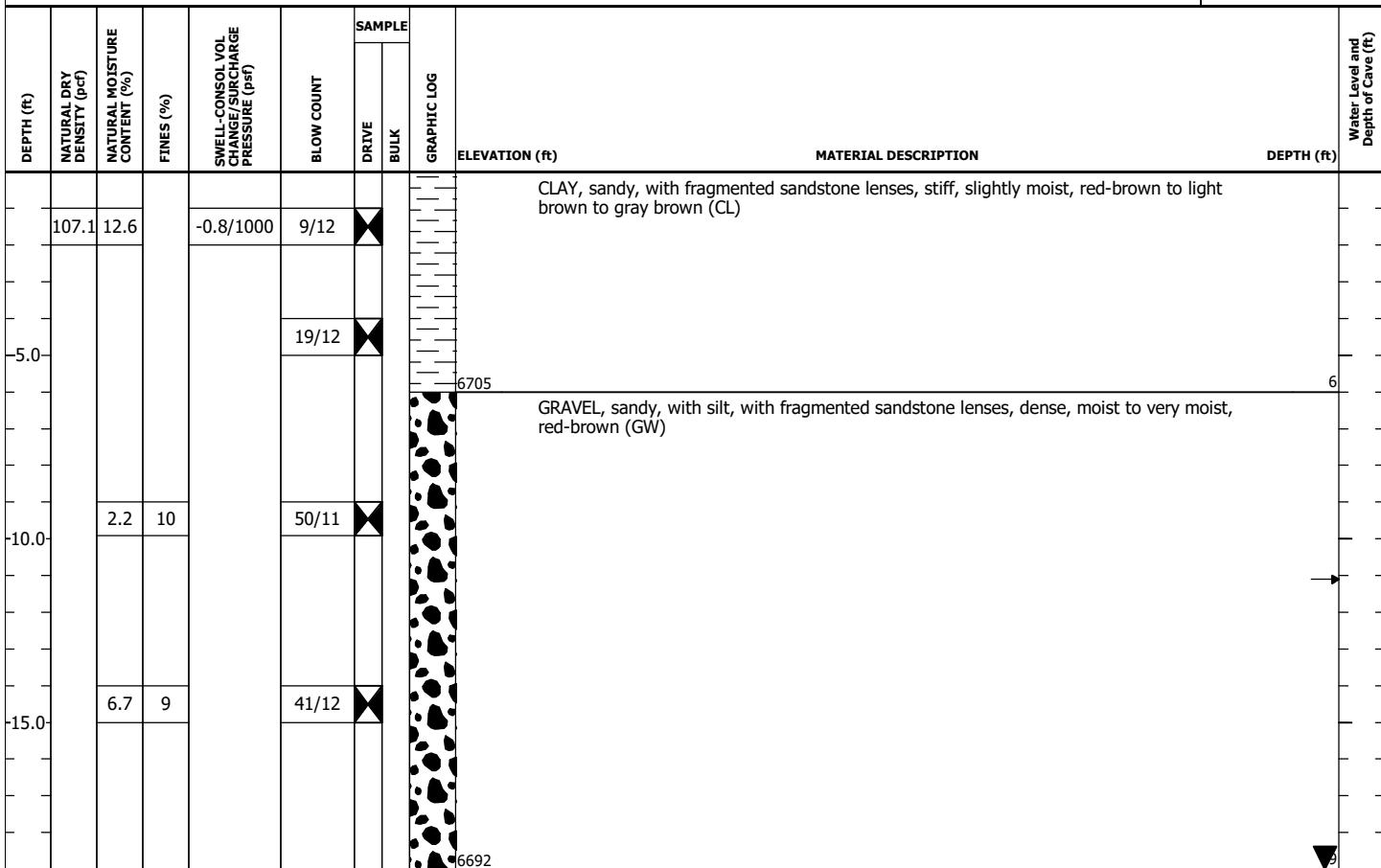


LEGEND

- ▼ WATER LEVEL AT TIME OF DRILLING
- ▽# WATER LEVEL # DAYS AFTER DRILLING
- # DEPTH OF CAVE # DAYS AFTER DRILLING
- ↑ DEPTH OF REFUSAL

- ☒ BULK SAMPLE
- ☒ MODIFIED CALIFORNIA SAMPLER

PROJECT NAME	Haymeadow Development			PROJECT NUMBER	21.5057	B-14
BORING LOCATION				BORING ELEVATION	6711ft.	
DRILLING COMPANY/RIG	Odell Drilling/CME-45			CESARE REP.	Z. Moore	
DRILLING METHOD	4in. Diameter SSA			DATE STARTED	11/4/2021	
HAMMER SYSTEM	Automatic Hammer			DATE COMPLETED	11/4/2021	Page 1 of 1



Boring terminated at 19 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

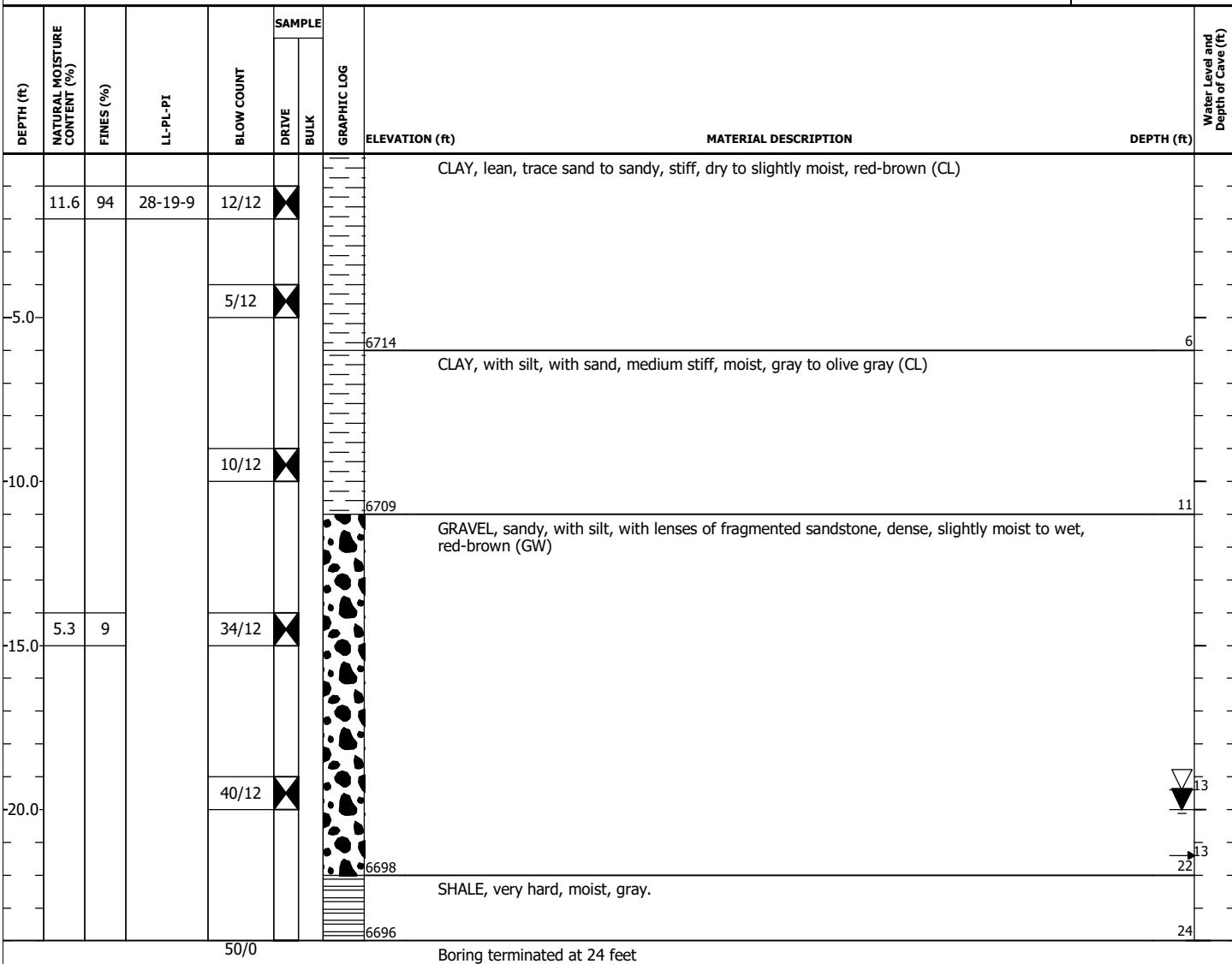
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-15
BORING LOCATION		BORING ELEVATION	6720ft.	
DRILLING COMPANY/RIG	Odell Drilling/CME-45	CESARE REP.	Z. Moore	
DRILLING METHOD	4in. Diameter SSA	DATE STARTED	11/4/2021	
HAMMER SYSTEM	Automatic Hammer	DATE COMPLETED	11/4/2021	

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LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

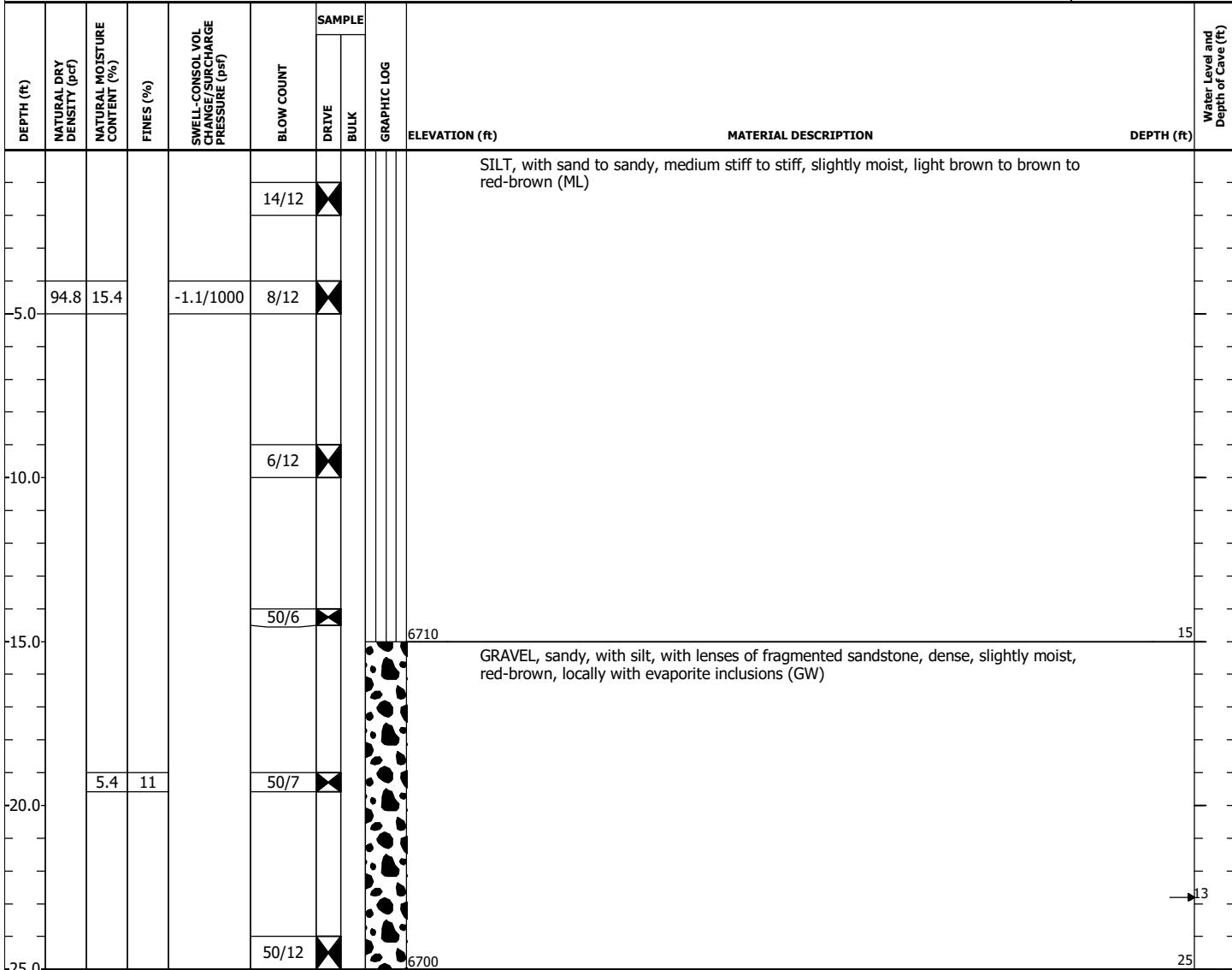
 MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development			PROJECT NUMBER	21.5057	B-16
BORING LOCATION				BORING ELEVATION	6725ft.	
DRILLING COMPANY/RIG	Odell Drilling/CME-45			CESARE REP.	Z. Moore	
DRILLING METHOD	4in. Diameter SSA			DATE STARTED	11/4/2021	
HAMMER SYSTEM	Automatic Hammer			DATE COMPLETED	11/4/2021	Page 1 of 1



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

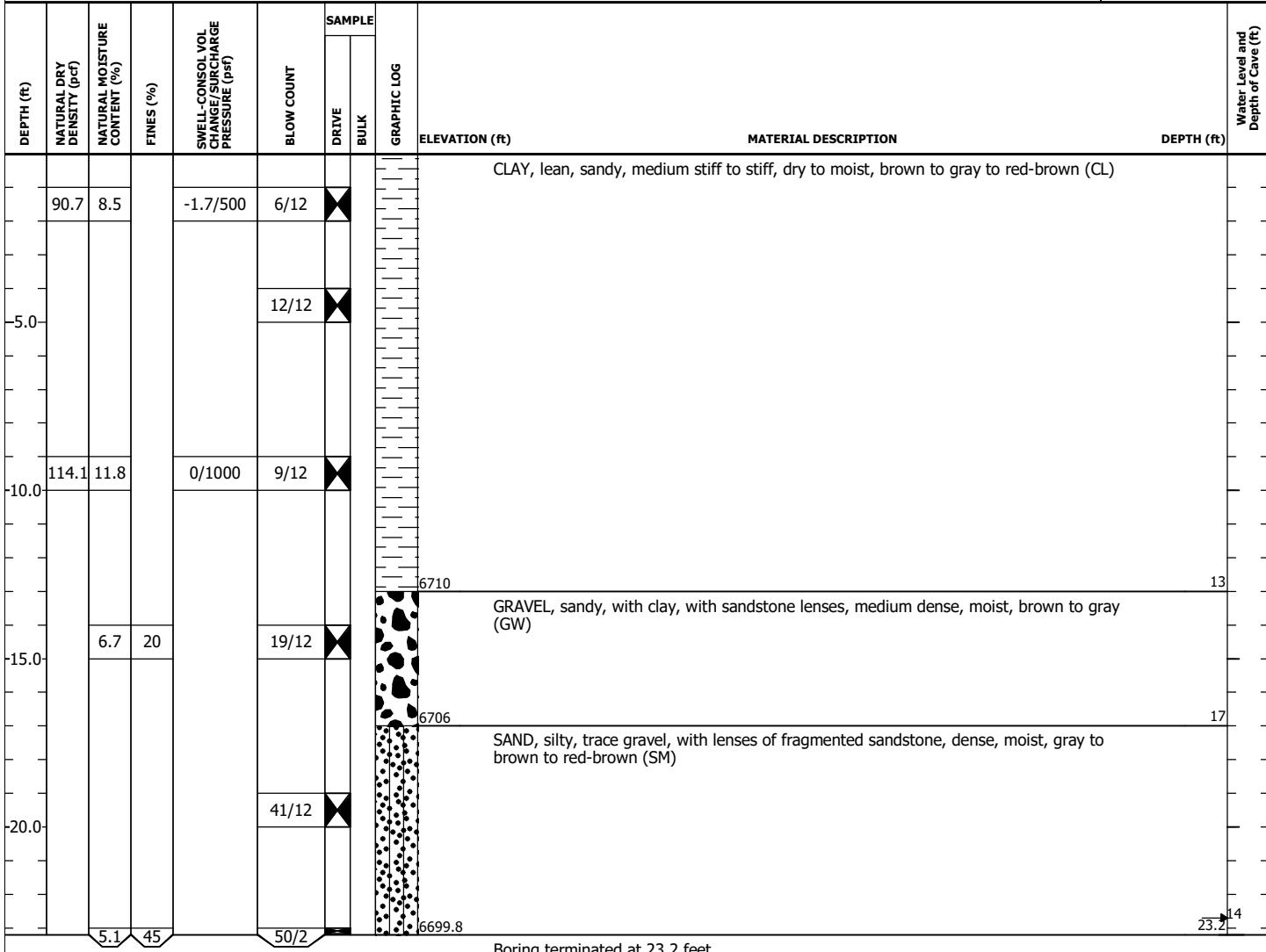
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-17
BORING LOCATION		BORING ELEVATION	6723ft.	
DRILLING COMPANY/RIG	Odell Drilling/CME-45	CESARE REP.	Z. Moore	
DRILLING METHOD	4in. Diameter SSA	DATE STARTED	11/3/2021	
HAMMER SYSTEM	Automatic Hammer	DATE COMPLETED	11/3/2021	

B-17

Page 1 of 1



Boring terminated at 23.2 feet

LEGEND

 WATER LEVEL AT TIME OF DRILLING

 MODIFIED CALIFORNIA SAMPLER

▽ # WATER LEVEL # DAYS AFTER DRILLING

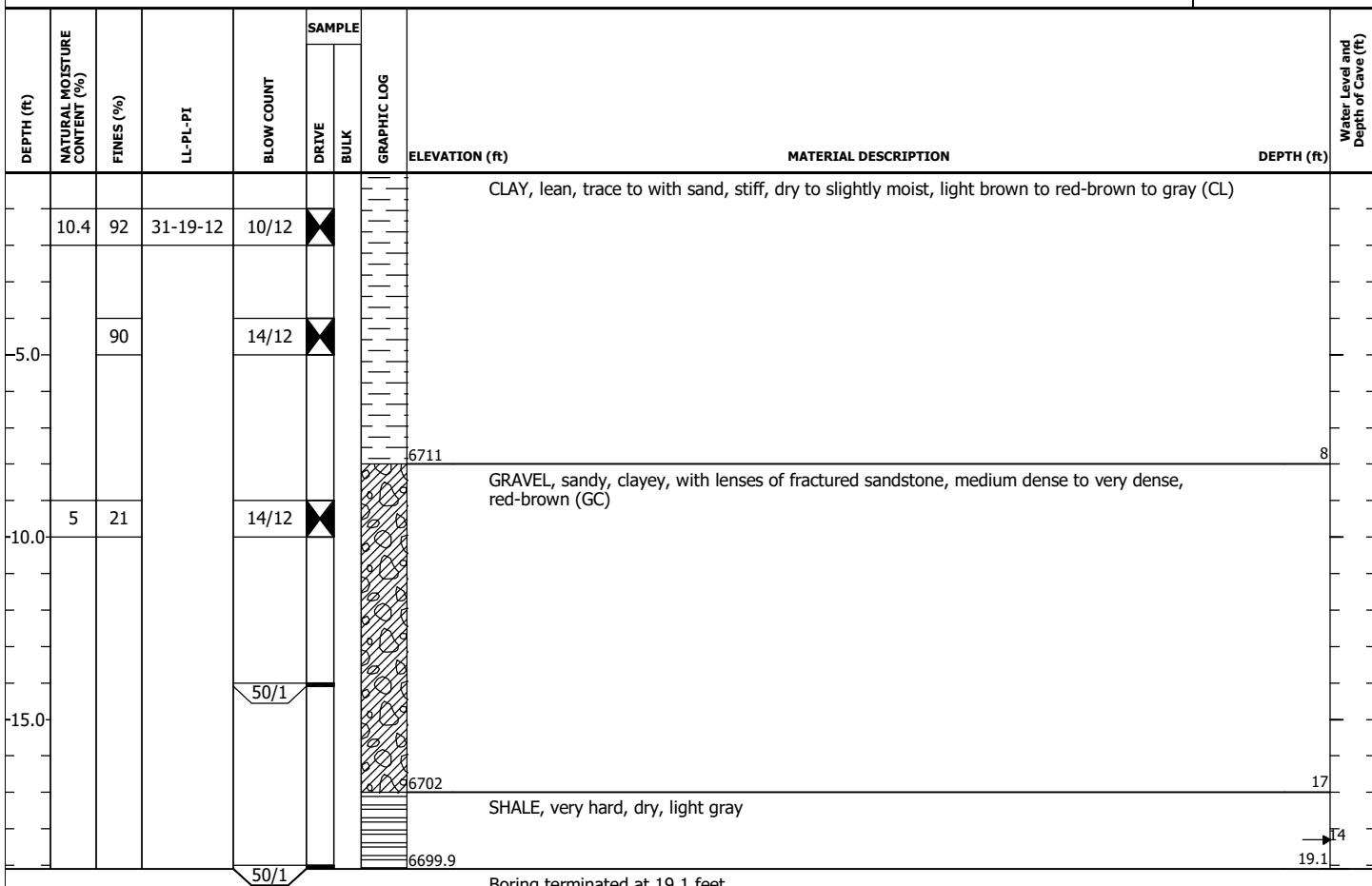
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057
BORING LOCATION		BORING ELEVATION	6719ft.
DRILLING COMPANY/RIG	Odell Drilling/CME-45	CESARE REP.	Z. Moore
DRILLING METHOD	4in. Diameter SSA	DATE STARTED	11/3/2021
HAMMER SYSTEM	Automatic Hammer	DATE COMPLETED	11/3/2021

B-18

Page 1 of 1



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

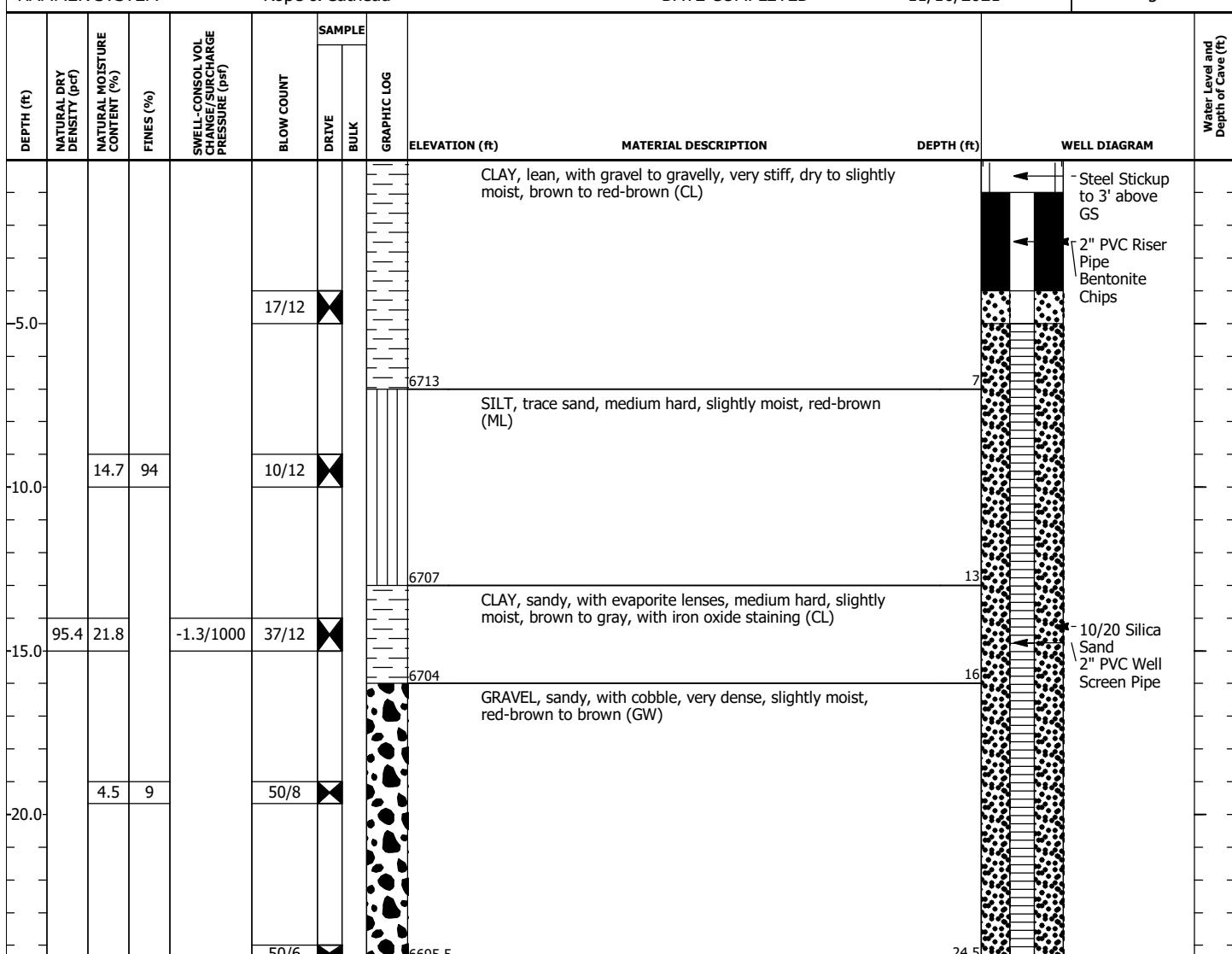
▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development			PROJECT NUMBER	21.5057	B-19
BORING LOCATION				BORING ELEVATION	6720ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120			CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX			DATE STARTED	11/16/2021	
HAMMER SYSTEM	Rope & Cathead			DATE COMPLETED	11/16/2021	

Page 1 of 1



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

■ MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

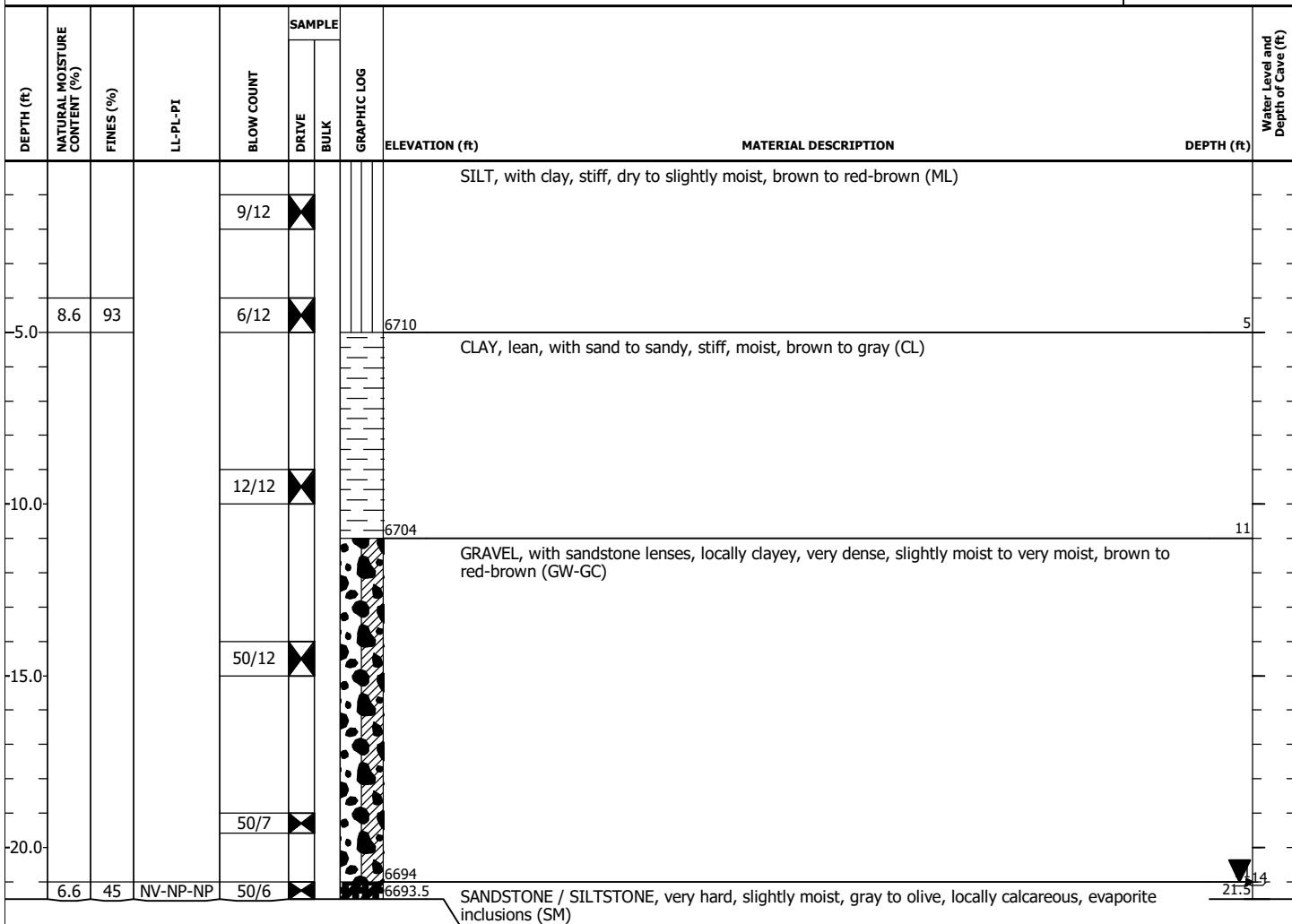
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057
BORING LOCATION		BORING ELEVATION	6715ft.
DRILLING COMPANY/RIG	Odell Drilling/CME-45	CESARE REP.	Z. Moore
DRILLING METHOD	4in. Diameter SSA	DATE STARTED	11/3/2021
HAMMER SYSTEM	Automatic Hammer	DATE COMPLETED	11/3/2021

B-20

Page 1 of 1



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

▽# WATER LEVEL # DAYS AFTER DRILLING

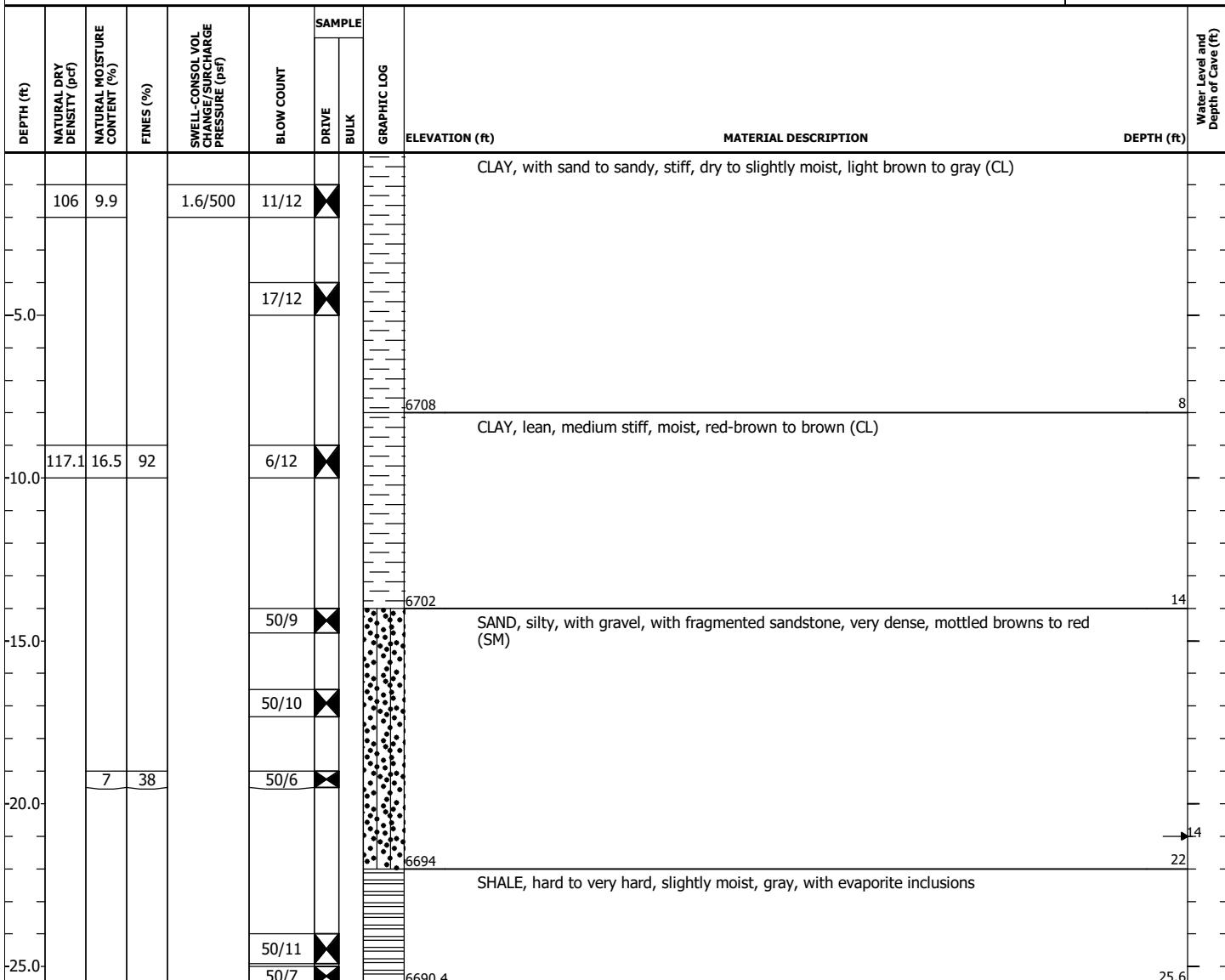
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057
BORING LOCATION		BORING ELEVATION	6716ft.
DRILLING COMPANY/RIG	Odell Drilling/CME-45	CESARE REP.	Z. Moore
DRILLING METHOD	4in. Diameter SSA	DATE STARTED	11/3/2021
HAMMER SYSTEM	Automatic Hammer	DATE COMPLETED	11/3/2021

B-21

Page 1 of 1



Boring terminated at 25.6 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

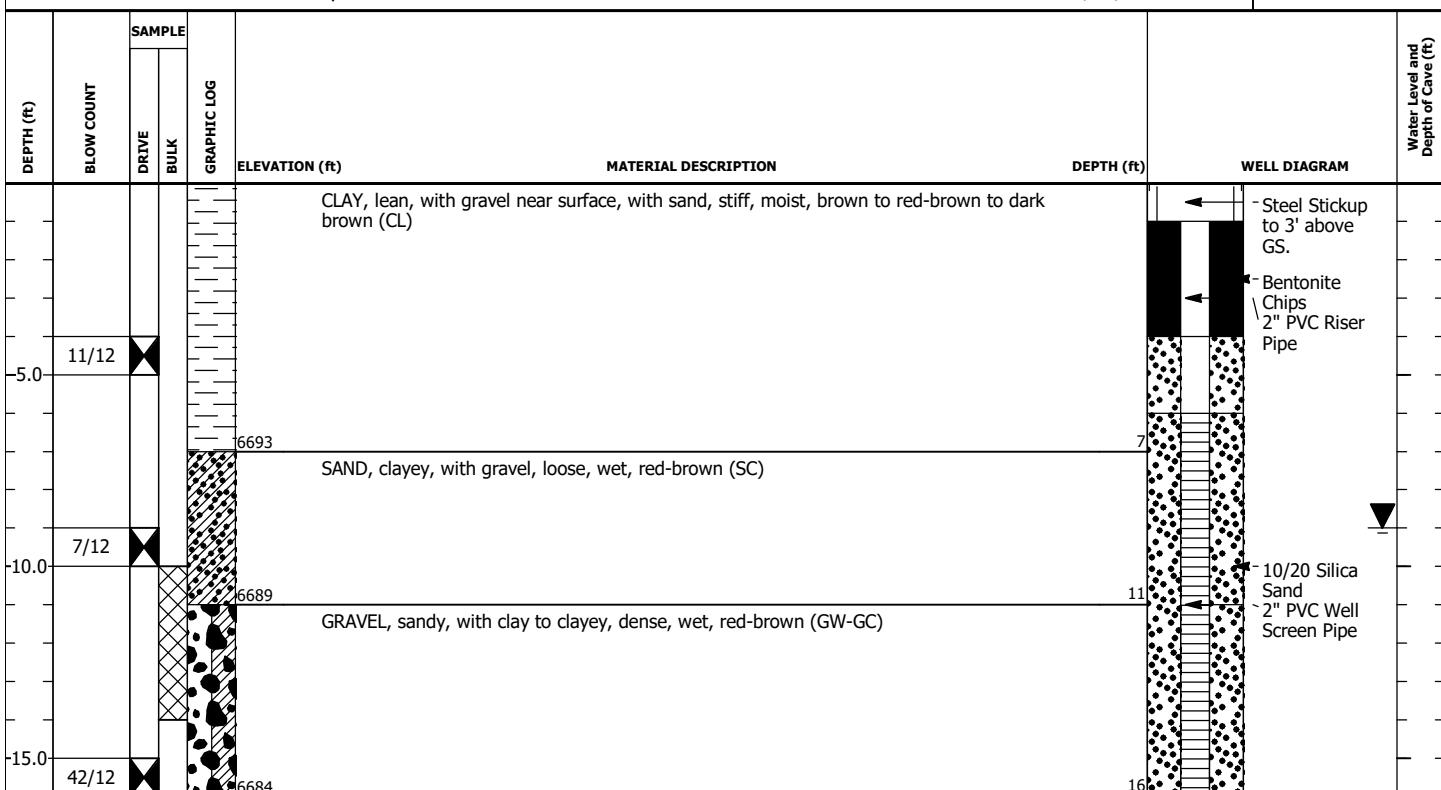
▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

PROJECT NAME	Haymeadow Development	PROJECT NUMBER	21.5057	B-XP
BORING LOCATION		BORING ELEVATION	6700ft.	
DRILLING COMPANY/RIG	Dakota Drilling/Diedrich 120	CESARE REP.	Z. Moore	
DRILLING METHOD	5in. Diameter ODEX	DATE STARTED	11/17/2021	
HAMMER SYSTEM	Rope & Cathead	DATE COMPLETED	11/17/2021	

Page 1 of 1



Boring terminated at 16 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ BULK SAMPLE

▽# WATER LEVEL # DAYS AFTER DRILLING

☒ MODIFIED CALIFORNIA SAMPLER

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL



APPENDIX B

Laboratory Testing

LABORATORY TESTING

Swell/consolidation testing was performed on samples collected using a modified California sampler to evaluate the effect of wetting and loading on the soil. The samples were loaded to 500 or 1,000 psf and then inundated with water. Additional laboratory testing performed included gradation, Atterberg limits, unit weight, natural moisture content, and water-soluble sulfates tests.

SUMMARY OF LABORATORY TEST RESULTS

 Haymeadow Development
 Project No. 21.5057

Sample Location		Natural Dry Density (pcf)	Natural Moisture Content (%)	Water Soluble Sulfates (%)	Gradation			Atterberg Limits		Swell/Consolidation			Material Type
Boring	Depth (feet)				Gravel (%)	Sand (%)	Silt/Clay (%)	Liquid Limit (%)	Plasticity Index (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)	
B-1	4	101.2	18.5							500	-0.1		CLAY, sandy, brown
B-1	14		10.5		60	28	12						GRAVEL, sandy, with clay, reddish brown
B-2	1			0.00									CLAY, sandy, brown
B-2	4		18.3		0	10	90	33	11				CLAY, brown (CL), A-6(10)
B-2	24		6.9		59	26	15						SANDSTONE, fragmented, silty, reddish brown
B-3	1		10.5		0	12	88	37	14				CLAY, brown (CL), A-6(13)
B-3	4			0.00									CLAY, sandy, brown
B-4	24		13.1		49	37	14						GRAVEL, sandy, with silt, reddish brown
B-5	4	101.4	20.8							500	-0.2		SILT, sandy, brown
B-6	4		22.2		0	19	81	NV	NP				SILT, with sand, brown (ML), A-4
B-6	9		6.6		60	23	17						GRAVEL, sandy, with clay, brown
B-7	4			0.17									CLAY, sandy, dusky red
B-8	4	106.4	17.3	0.05						500	-0.1		CLAY, sandy, dusky red
B-8	49		13.6		27	37	36	NV	NP				SANDSTONE, silty, with gravel, brown (SM), A-4
B-9	4		22.4		0	5	95	36	17				CLAY, brown (CL), A-6
B-10	4	103.5	19.5							500	-0.1		CLAY, silty, sandy, brown
B-10	13		13.6		29	62	9						SAND, gravelly, with silt, reddish brown
B-11	4			0.00									CLAY, sandy, brown
B-11	9		23.2		0	16	84	NV	NP				SILT, with sand, reddish brown (ML), A-4
B-11	24		10.9		49	32	19						GRAVEL, sandy, with silt, reddish brown
B-12	4		15.6		0	20	80	24	2				SILT, with sand, brown (ML), A-4
B-12	9	97.3	23.6							1,000	-0.2		CLAY, sandy, dusky red
B-13	4		15.8	0.00	0	13	87						CLAY, brown
B-13	10 to 14		5.3		37	49	14	NV	NP				SAND, silty, with gravel, reddish brown (SM), A-1-a

SUMMARY OF LABORATORY TEST RESULTS

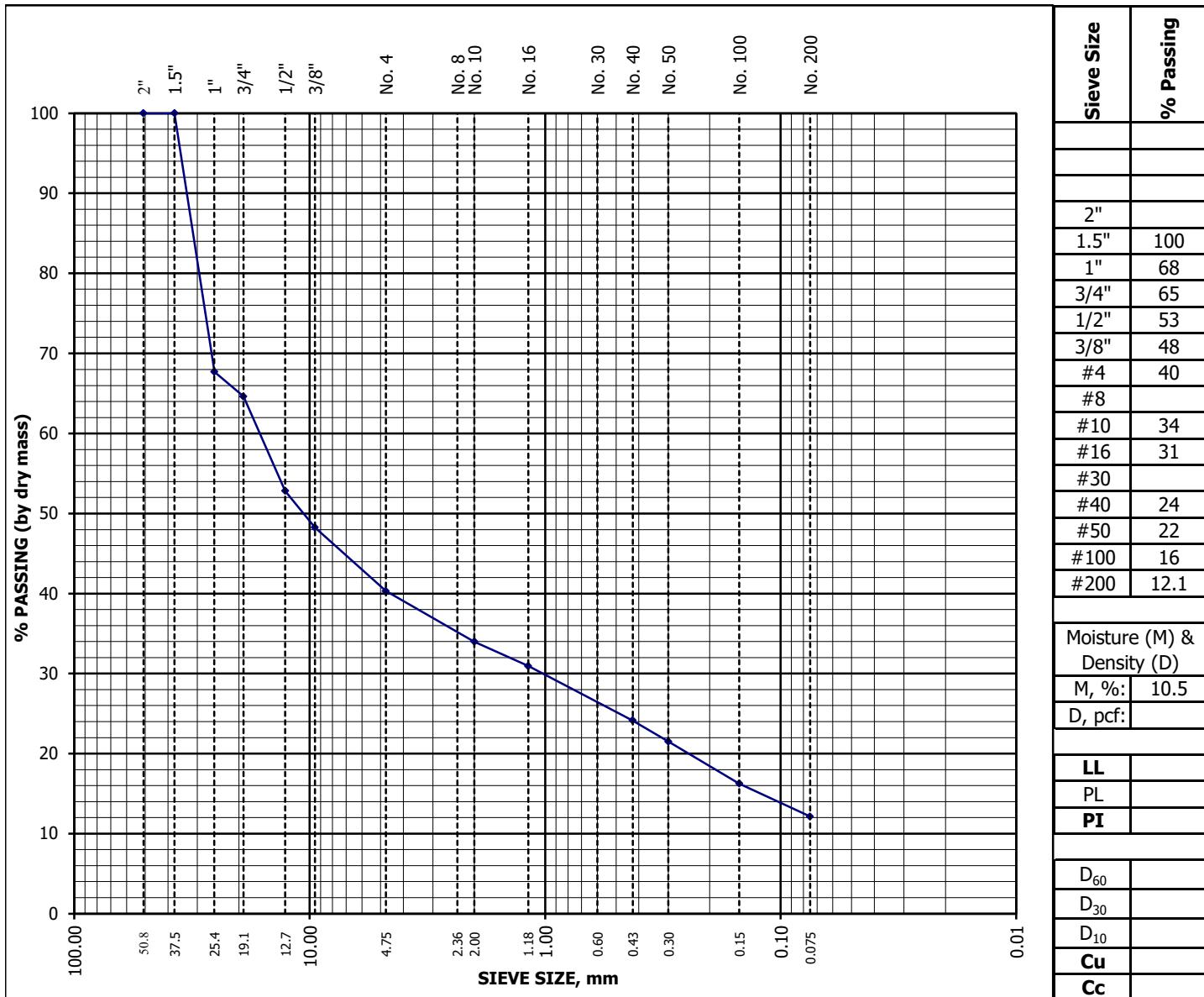
 Haymeadow Development
 Project No. 21.5057

Sample Location		Natural Dry Density (pcf)	Natural Moisture Content (%)	Water Soluble Sulfates (%)	Gradation			Atterberg Limits		Swell/Consolidation			Material Type
Boring	Depth (feet)				Gravel (%)	Sand (%)	Silt/Clay (%)	Liquid Limit (%)	Plasticity Index (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)	
B-13	24		13.6		35	19	46	34	14				SHALE; GRAVEL, clayey, with sand, dark brown (GC), A-6(3)
B-14	1	107.1	12.6							1,000	-0.8		CLAY, sandy, brown
B-14	9		2.2		65	25	10						GRAVEL, sandy, with silt, reddish brown
B-14	14		6.7		59	32	9						GRAVEL, sandy, with silt, reddish brown
B-15	1		11.6		0	6	94	28	9				CLAY, reddish brown (CL), A-4(7)
B-15	4			0.00									CLAY, sandy, brown
B-15	14		5.3		67	24	9						GRAVEL, sandy, with silt, reddish brown
B-16	4	94.8	15.4							1,000	-1.1		SILT, sandy, brown
B-16	19		5.4		53	36	11						GRAVEL, sandy, with silt, reddish brown
B-17	1	90.7	8.5							500	-1.7		CLAY, sandy, brown
B-17	9	114.1	11.8							1,000	0.0		CLAY, sandy, brown
B-17	14		6.7		47	33	20						GRAVEL, sandy, with clay, brown
B-17	23		5.1		6	49	45						SAND, silty, reddish brown
B-18	1		10.4		0	8	92	31	12				CLAY, brown (CL), A-6(10)
B-18	4			0.00	0	10	90						CLAY, brown
B-18	9		5.0		43	36	21						GRAVEL, sandy, clayey, reddish brown
B-19	9		14.7		0	6	94						SILT, reddish brown
B-19	14	95.4	21.8							1,000	-1.3		CLAY, sandy, brown
B-19	19		4.5		61	30	9						GRAVEL, sandy, with silt, reddish brown
B-20	4		8.6		0	7	93						SILT, reddish brown
B-20	9			1.60									CLAY, sandy, brown
B-20	21		6.6		13	42	45	NV	NP				SANDSTONE / SILTSTONE, with gravel, olive brown (SM), A-4
B-21	1	106.0	9.9							500	1.6	2,350	CLAY, sandy, brown
B-21	9	117.1	16.5		1	7	92						CLAY, brown
B-21	19		7.0		13	49	38						SAND, silty, with gravel, reddish brown

GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-22
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212181 Reviewer: G. Hoyos
 Sample Location: B-1 at 14'
 Visual Description: GRAVEL, sandy, with silt, reddish brown

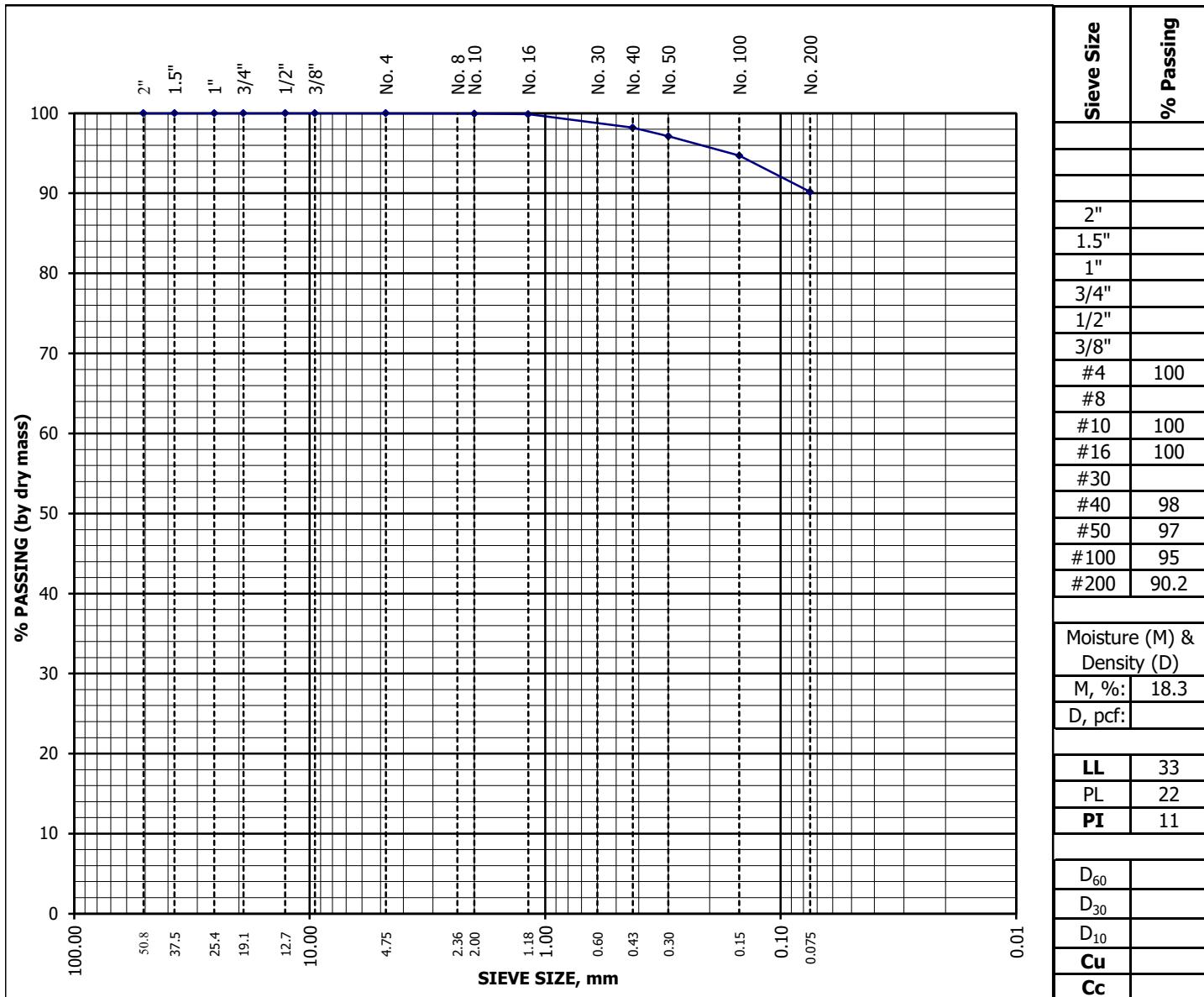
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-22
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212182 Reviewer: G. Hoyos
 Sample Location: B-2 at 4'
 Visual Description: CLAY, brown

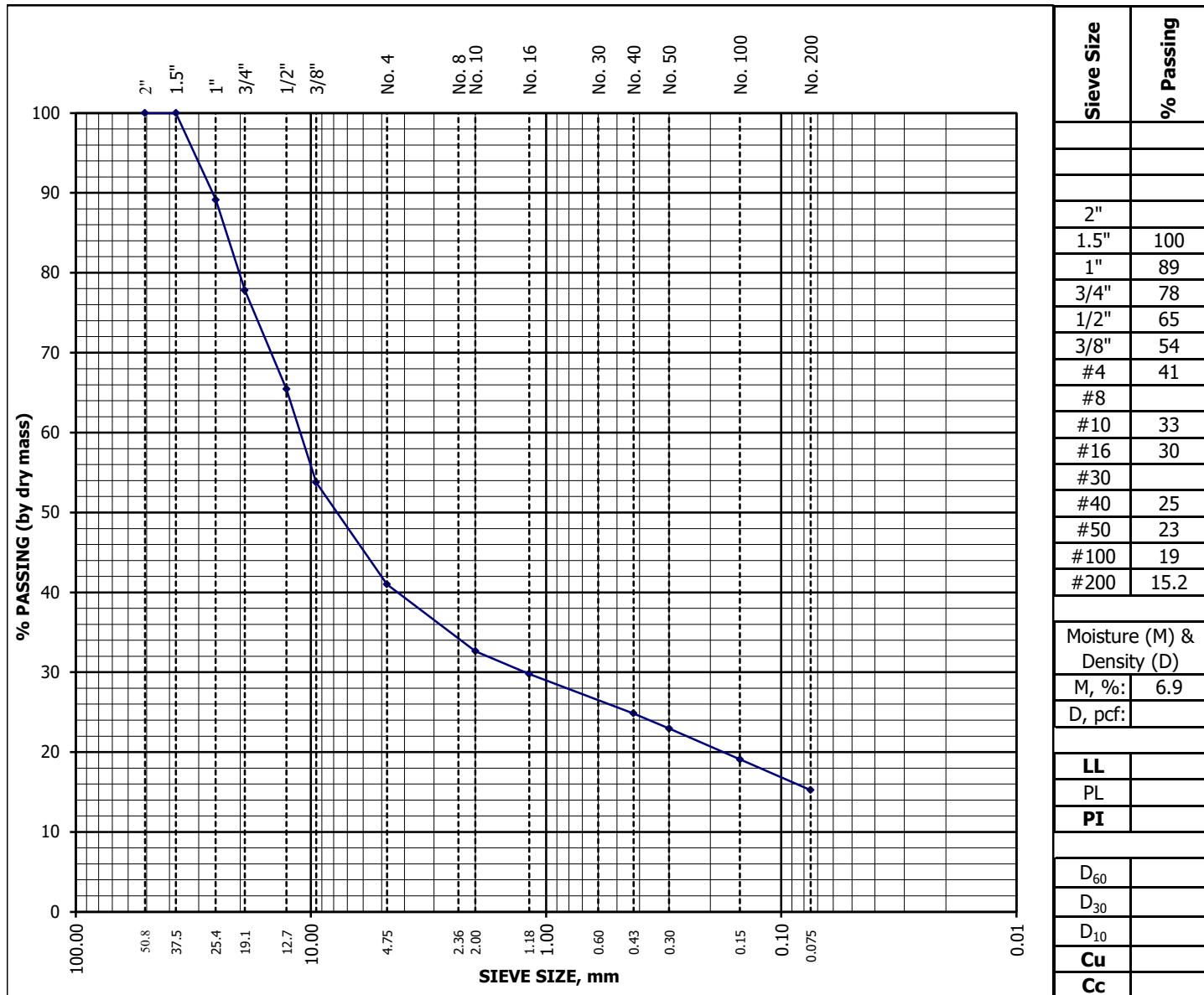
AASHTO M 145 Classification: A-6 **Group Index:** 10
Unified Soil Classification System
(ASTM D 2487): (CL) Lean clay



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212183 Reviewer: G. Hoyos
 Sample Location: B-2 at 24'
 Visual Description: SANDSTONE, fragmented, reddish brown

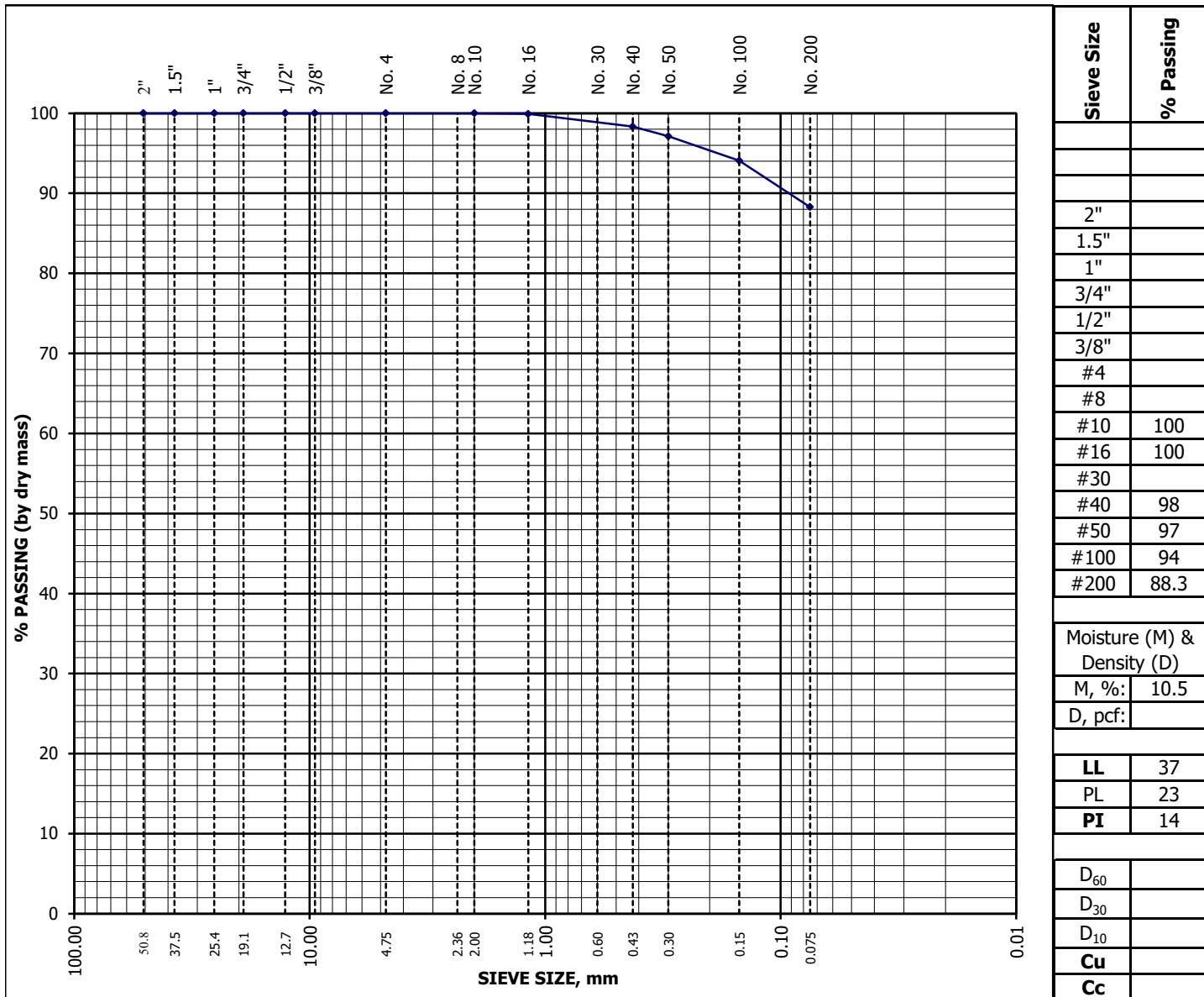
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212184 Reviewer: G. Hoyos
 Sample Location: B-3 at 1'
 Visual Description: CLAY, brown

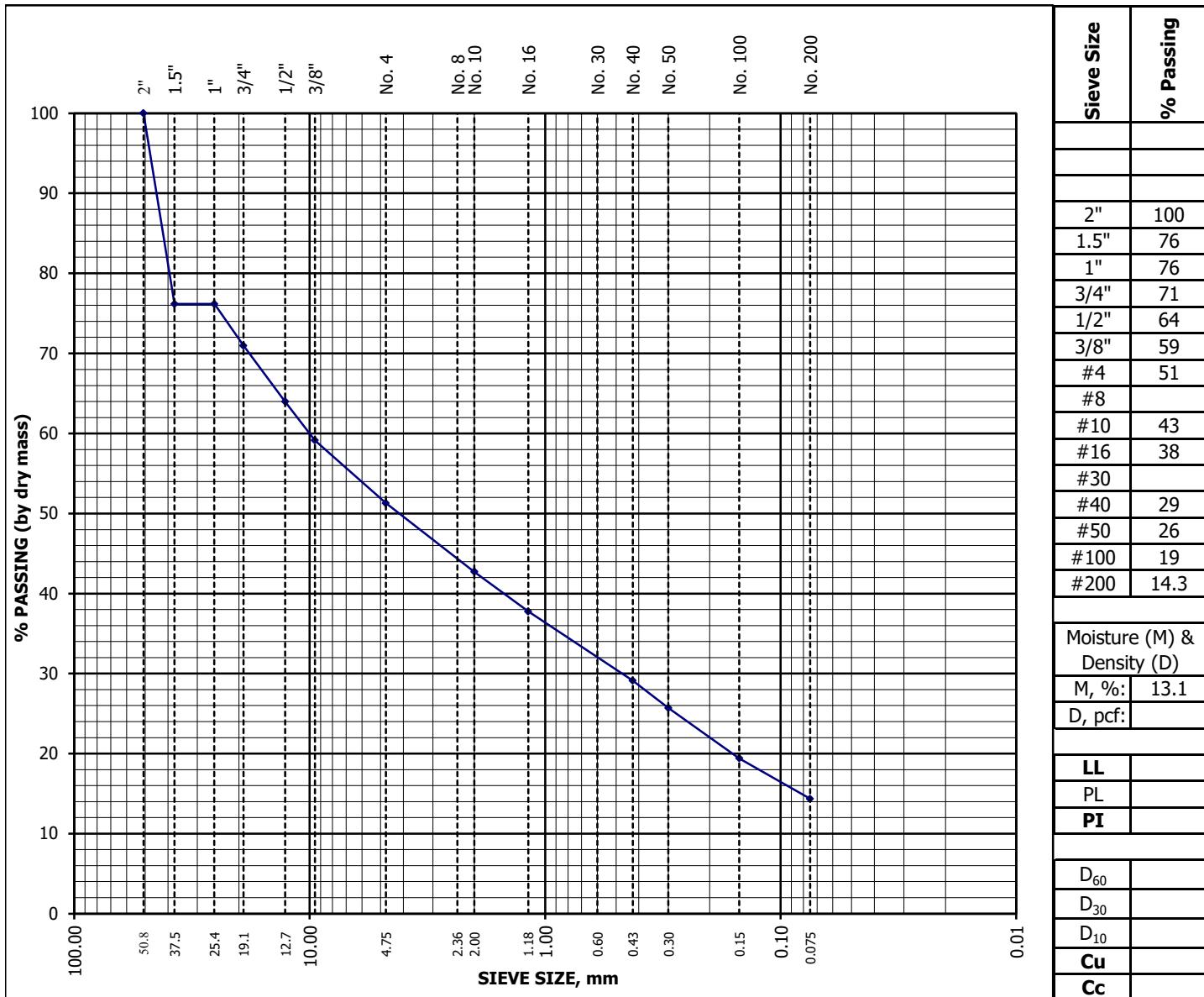
AASHTO M 145 Classification: A-6 **Group Index:** 13
Unified Soil Classification System
(ASTM D 2487): (CL) **Lean clay**



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212185 Reviewer: G. Hoyos
 Sample Location: B-4 at 24'
 Visual Description: GRAVEL, sandy, with silt, reddish brown

AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()

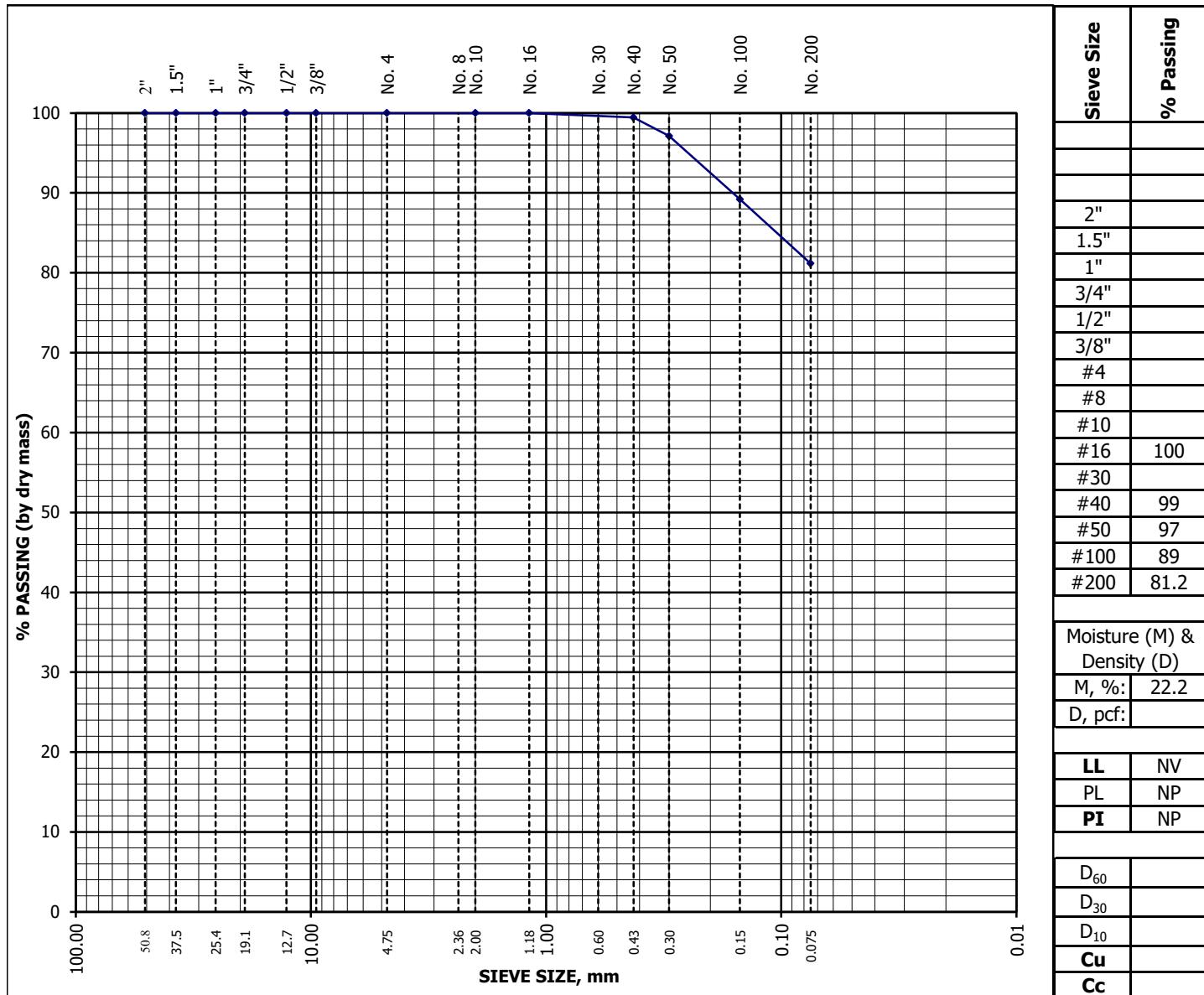




GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-21
Project Name: Haymeadow Development Technician: C. Zoetewey
Lab ID Number: S212186 Reviewer: G. Hoyos
Sample Location: B-6 at 4'
Visual Description: SILT, with sand, brown

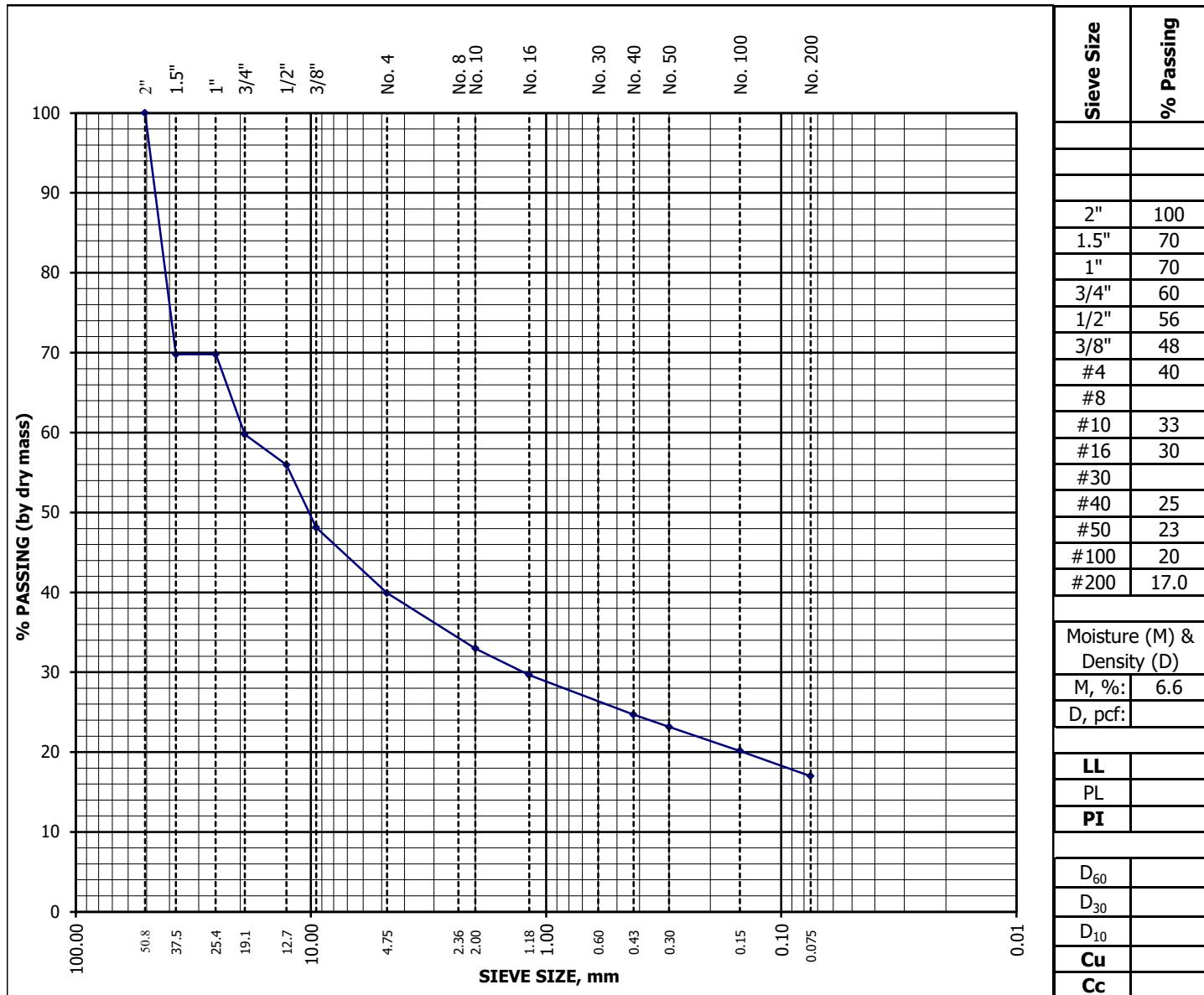
AASHTO M 145 Classification: A-4 **Group Index:** 0
Unified Soil Classification System **(ASTM D 2487):** (ML) **Silt with sand**



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212187 Reviewer: G. Hoyos
 Sample Location: B-6 at 9'
 Visual Description: GRAVEL, sandy, with clay, brown

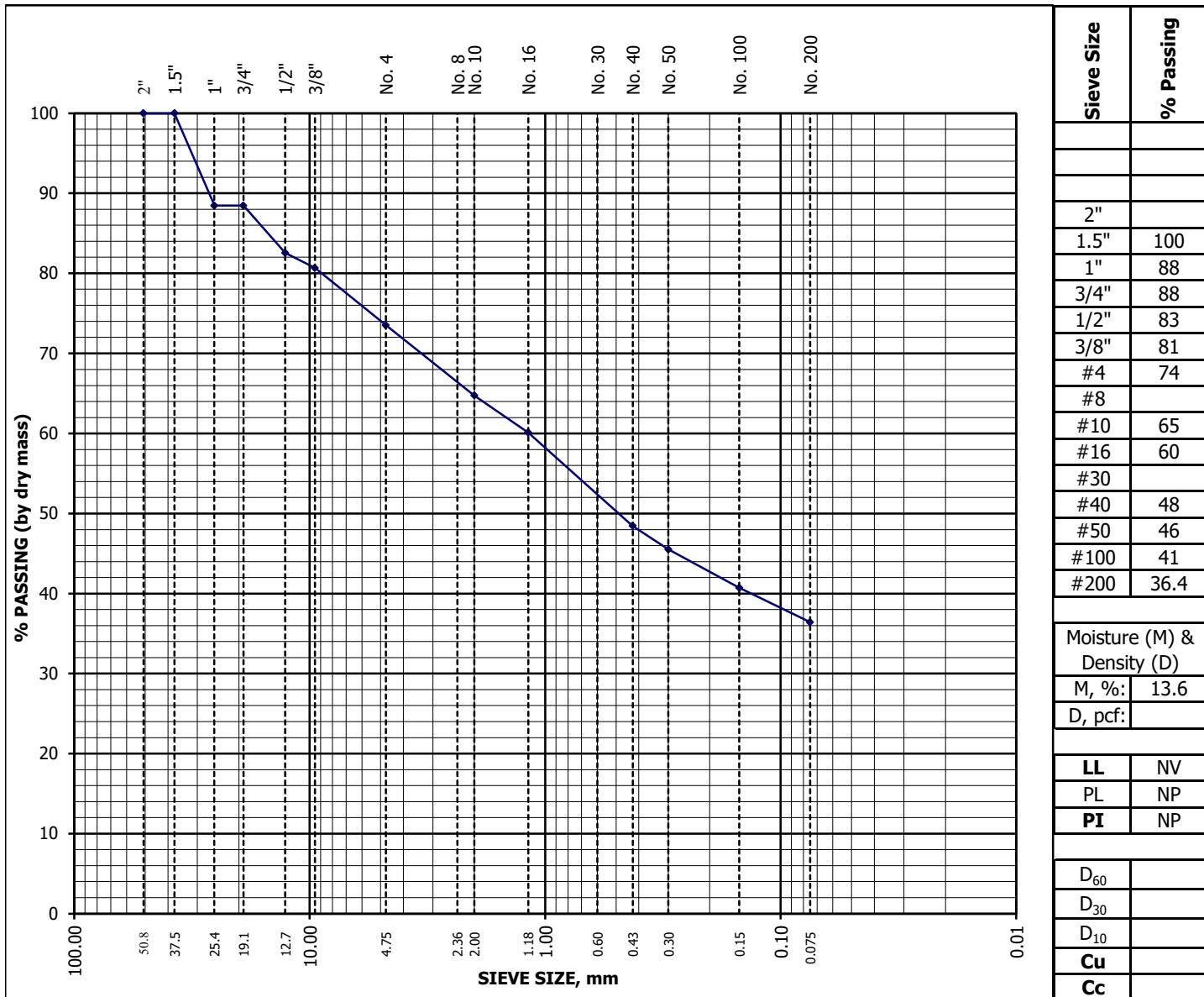
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212188 Reviewer: G. Hoyos
 Sample Location: B-8 at 49'
 Visual Description: SAND, silty, with gravel, brown

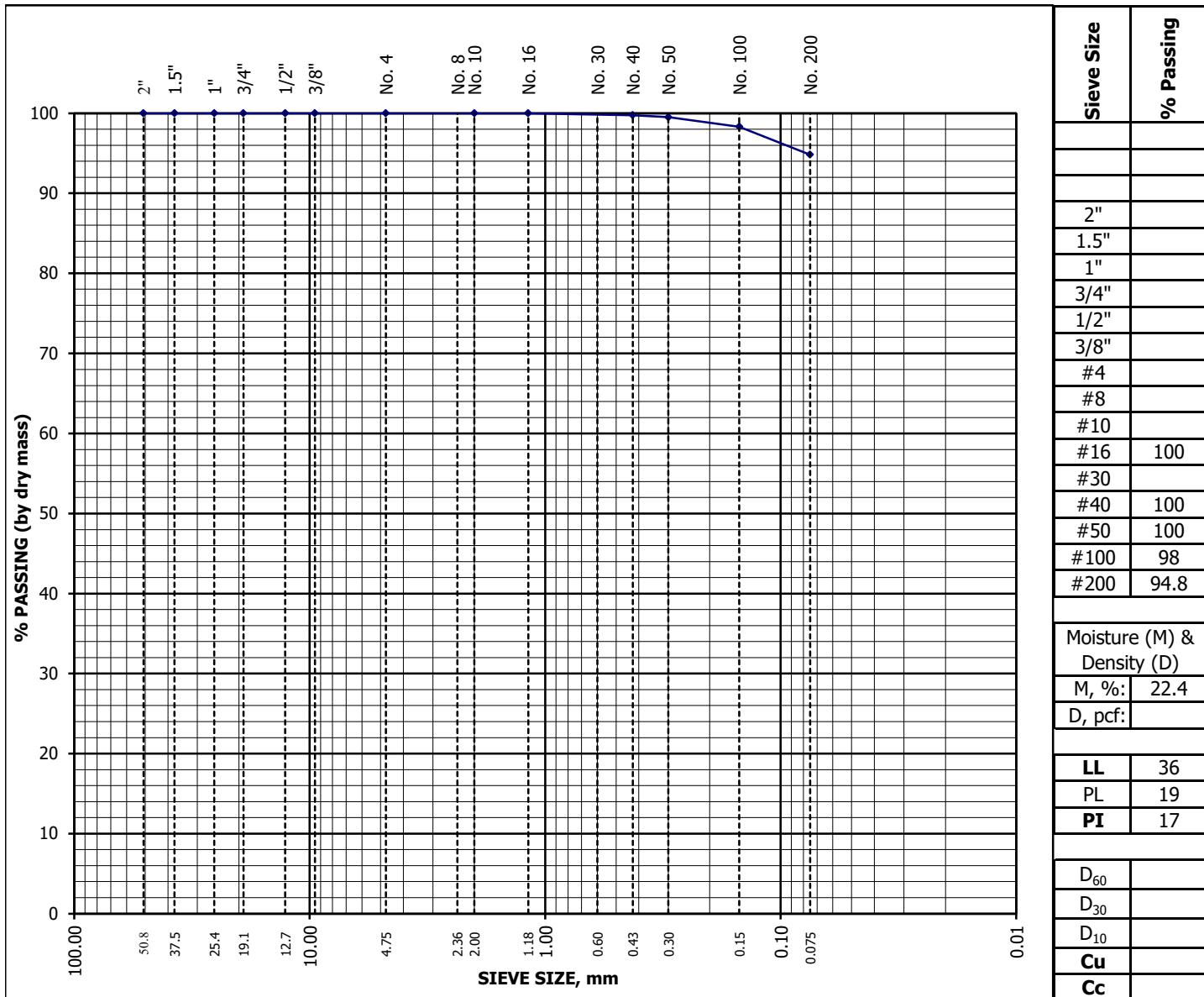
AASHTO M 145 Classification: A-4 **Group Index:** 0
Unified Soil Classification System
(ASTM D 2487): (SM) Silty sand with gravel



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 22-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212189 Reviewer: G. Hoyos
 Sample Location: B-9 at 4'
 Visual Description: CLAY, brown

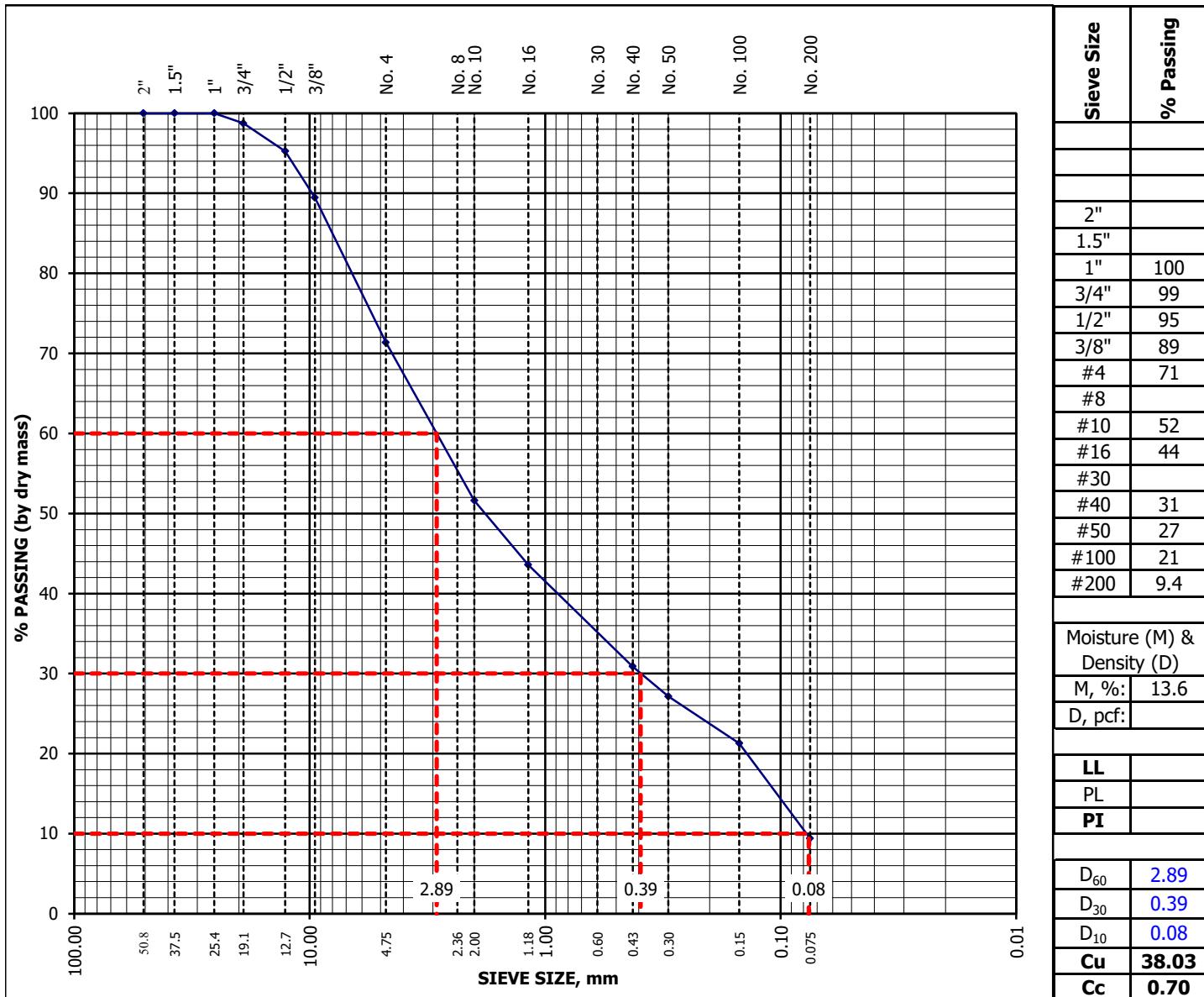
AASHTO M 145 Classification: A-6 **Group Index:** 16
Unified Soil Classification System
(ASTM D 2487): (CL) Lean clay



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 27-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212190 Reviewer: G. Hoyos
 Sample Location: B-10 at 13'
 Visual Description: SAND, gravelly, with silt, reddish brown

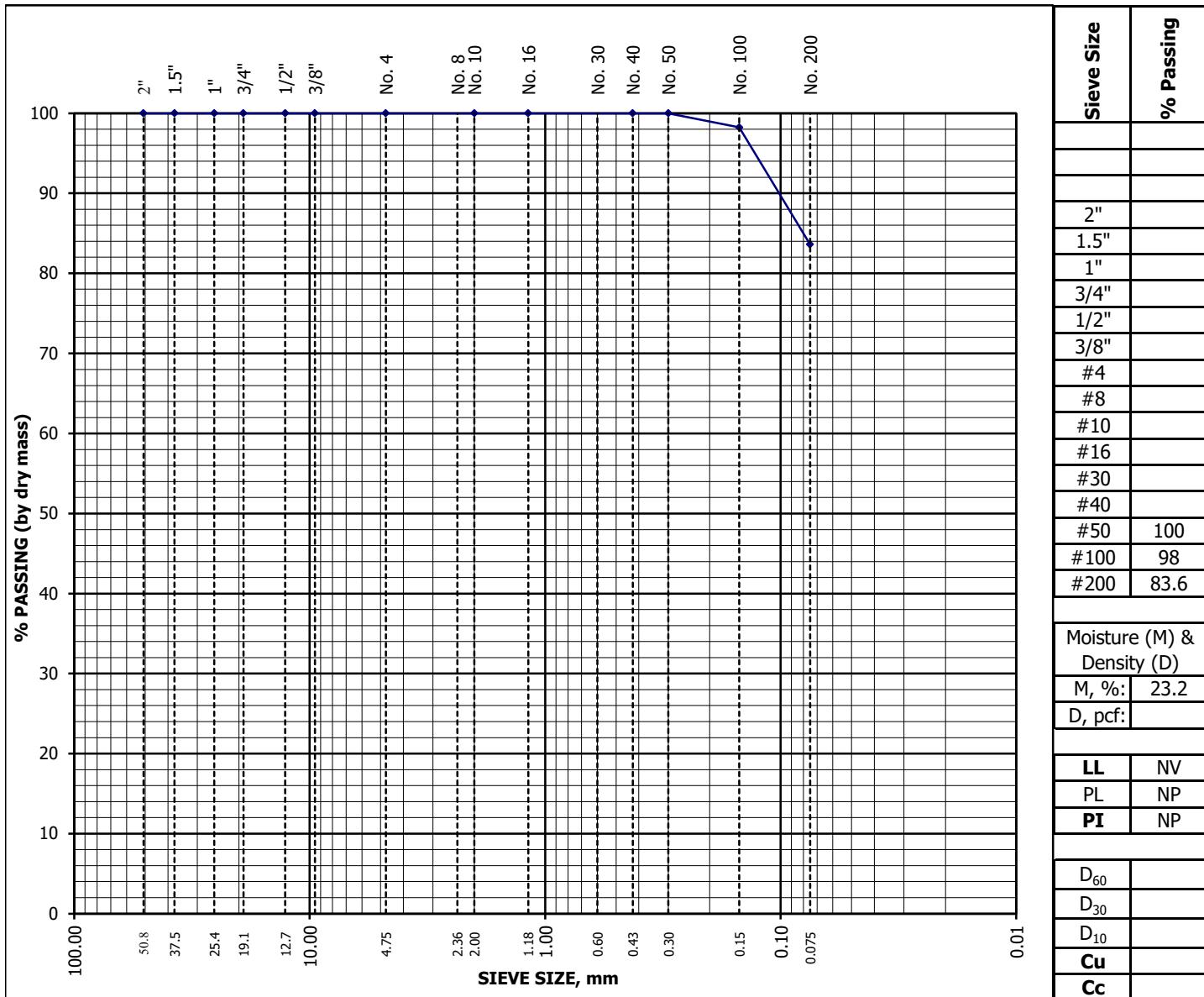
AASHTO M 145 Classification: _____ Group Index: _____
 Unified Soil Classification System
 (ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 27-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212191 Reviewer: G. Hoyos
 Sample Location: B-11 at 9'
 Visual Description: SILT, with sand, reddish brown

AASHTO M 145 Classification: A-4 **Group Index:** 0
Unified Soil Classification System
(ASTM D 2487): (ML) **Silt with sand**

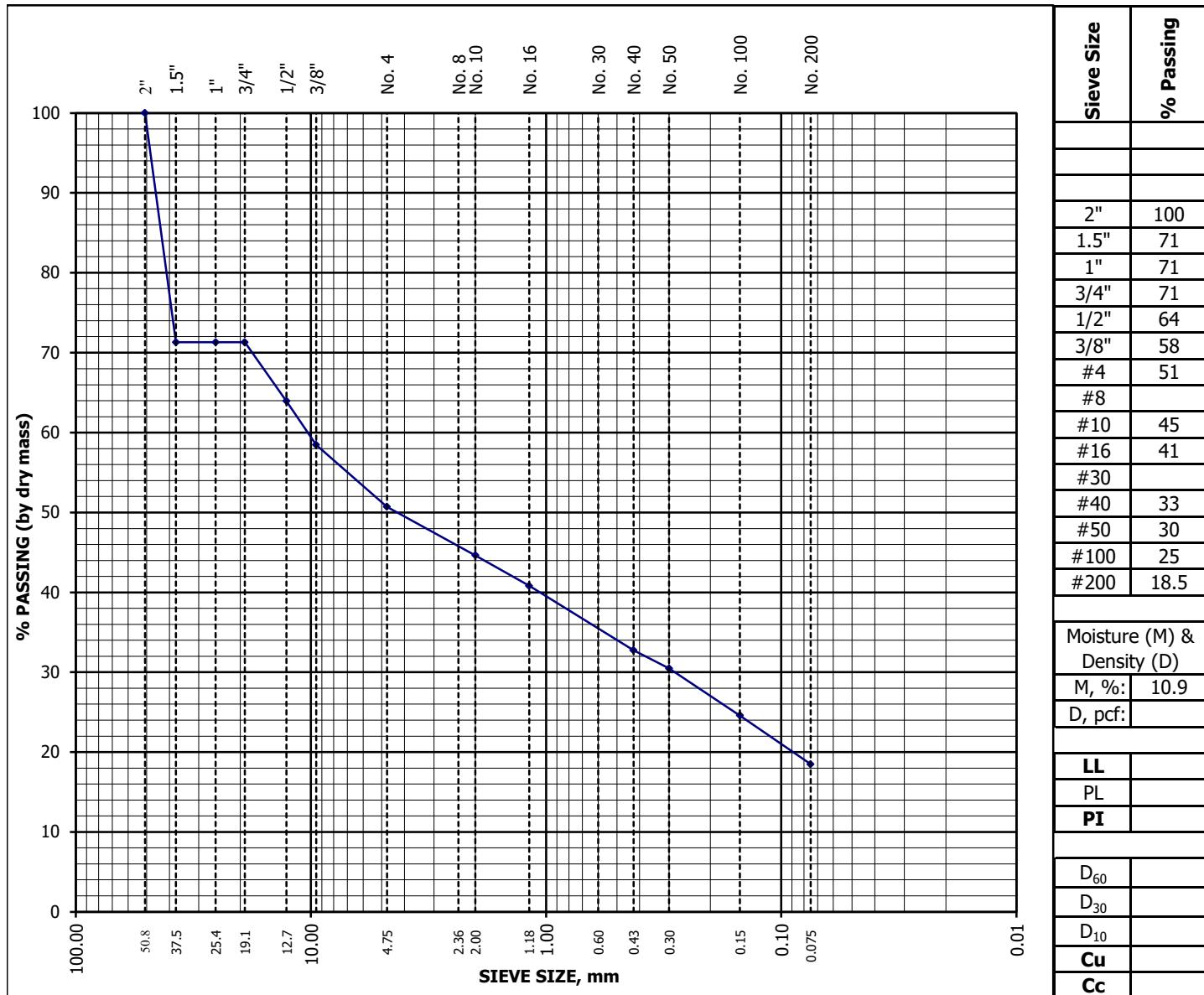




GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 27-Dec-21
Project Name: Haymeadow Development Technician: C. Zoetewey
Lab ID Number: S212192 Reviewer: G. Hoyos
Sample Location: B-11 at 24'
Visual Description: GRAVEL, sandy, with silt, reddish brown

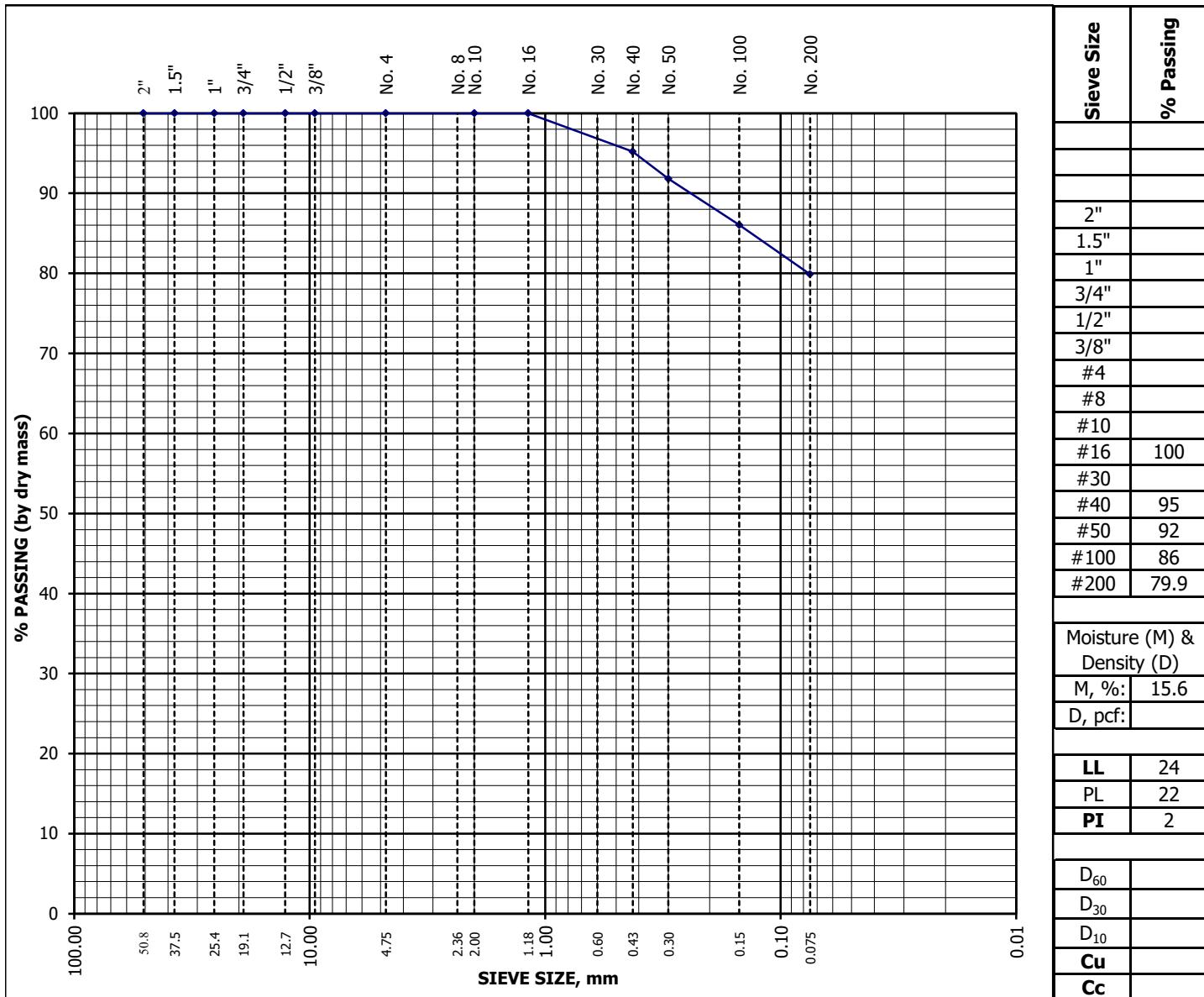
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System _____
(ASTM D 2487): _____ ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 27-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212193 Reviewer: G. Hoyos
 Sample Location: B-12 at 4'
 Visual Description: SILT, with sand, brown

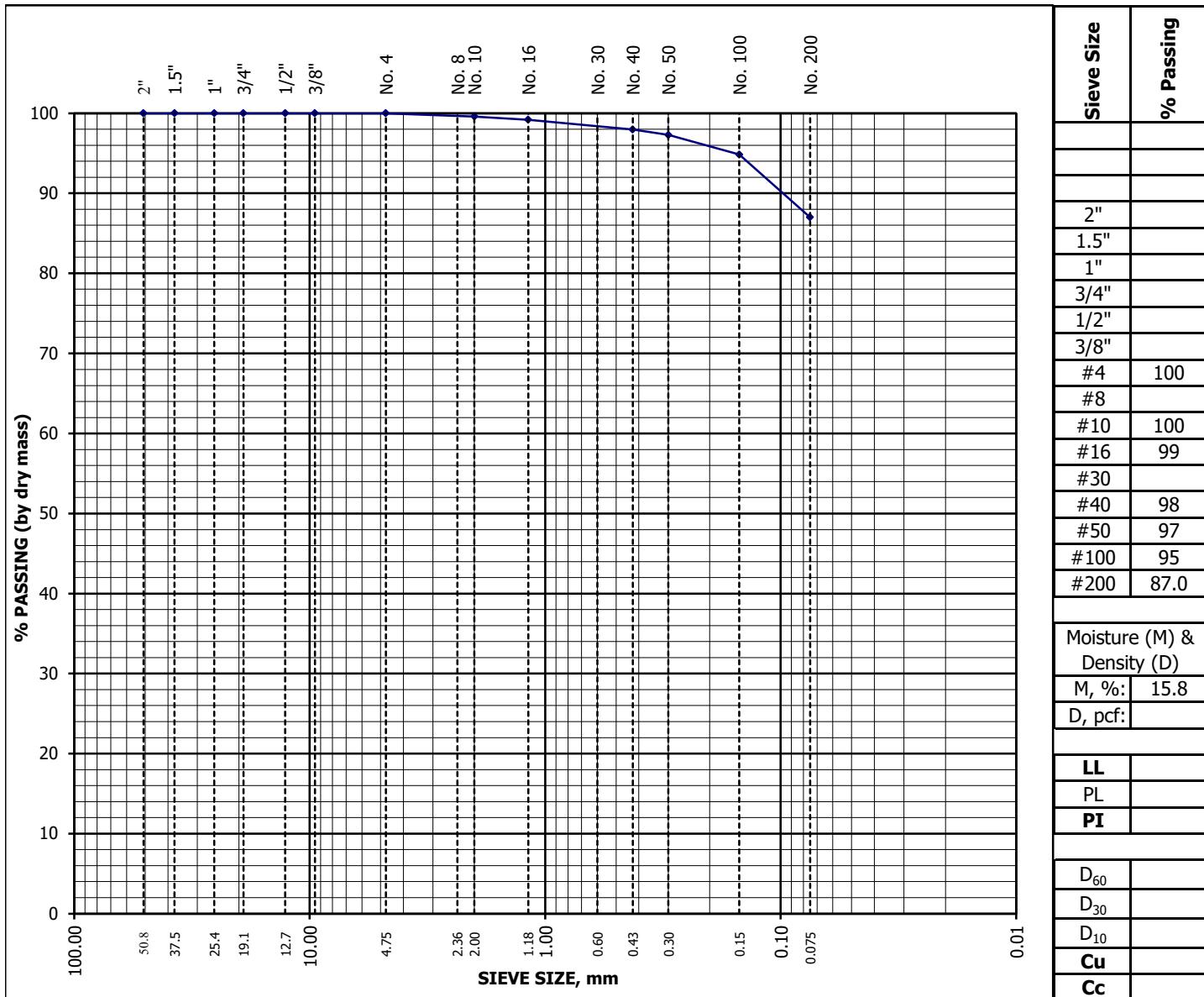
AASHTO M 145 Classification: A-4 **Group Index:** 0
Unified Soil Classification System
(ASTM D 2487): (ML) **Silt with sand**



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 27-Dec-22
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212194 Reviewer: G. Hoyos
 Sample Location: B-13 at 4'
 Visual Description: CLAY, brown

AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()

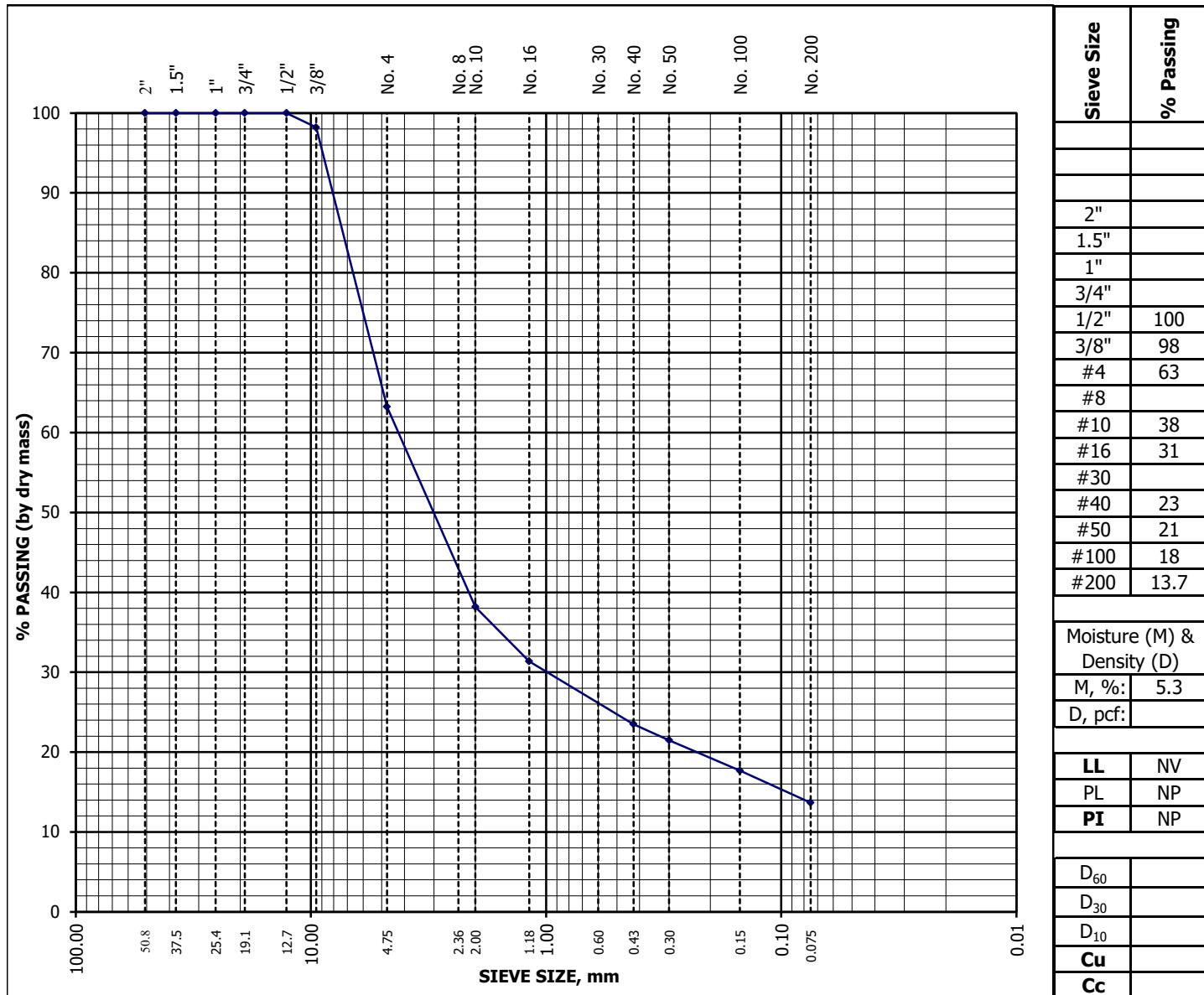




GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 27-Dec-22
Project Name: Haymeadow Development Technician: C. Zoetewey
Lab ID Number: S212195 Reviewer: G. Hoyos
Sample Location: B-13 at 10' to 14'
Visual Description: SAND, silty, with gravel, reddish brown

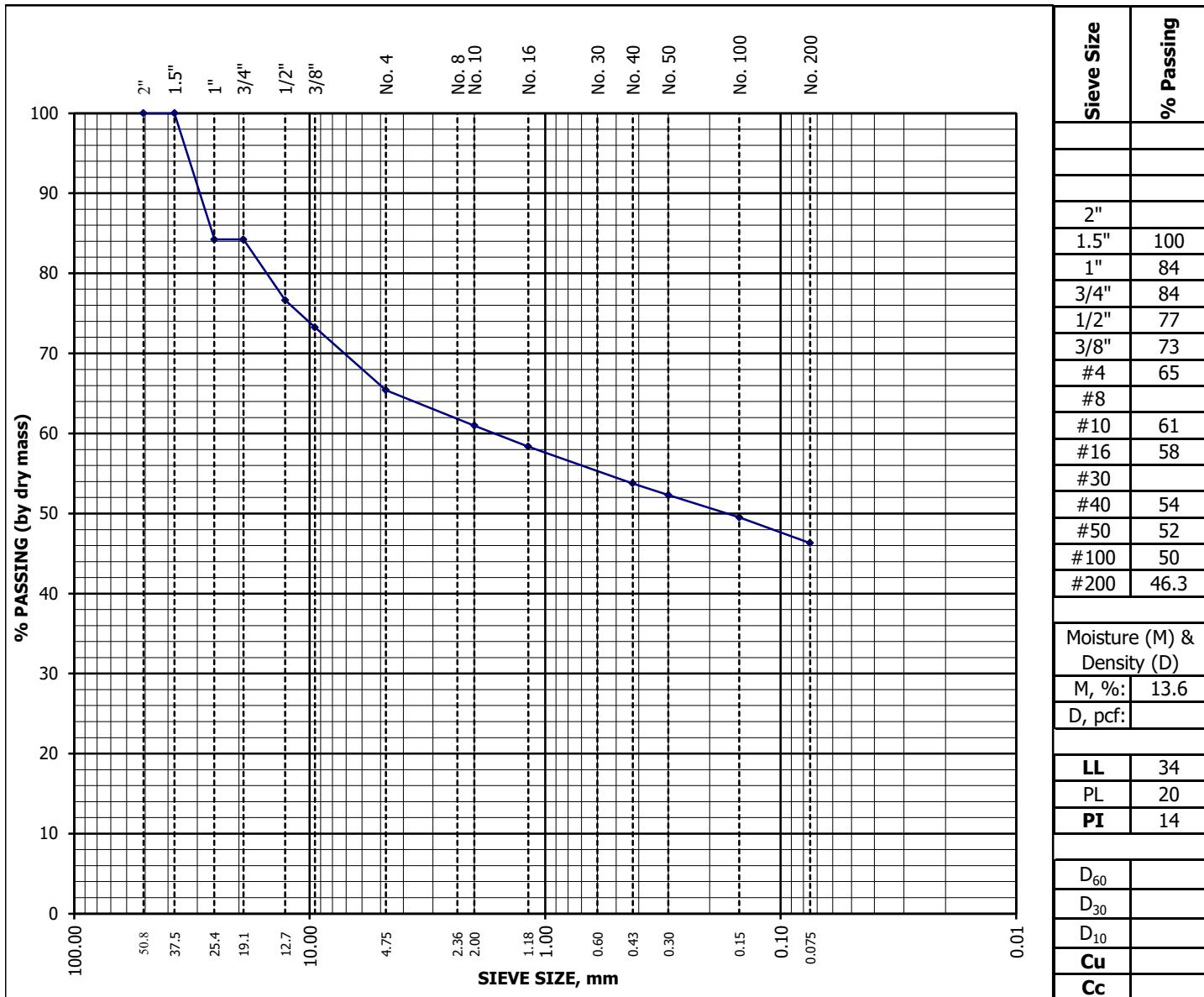
AASHTO M 145 Classification: A-1-a **Group Index:** 0
Unified Soil Classification System **(ASTM D 2487):** (SM) **Silty sand with gravel**



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 29-Dec-21
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212196 Reviewer: G. Hoyos
 Sample Location: B-13 at 24'
 Visual Description: GRAVEL, clayey, with sand, dark brown

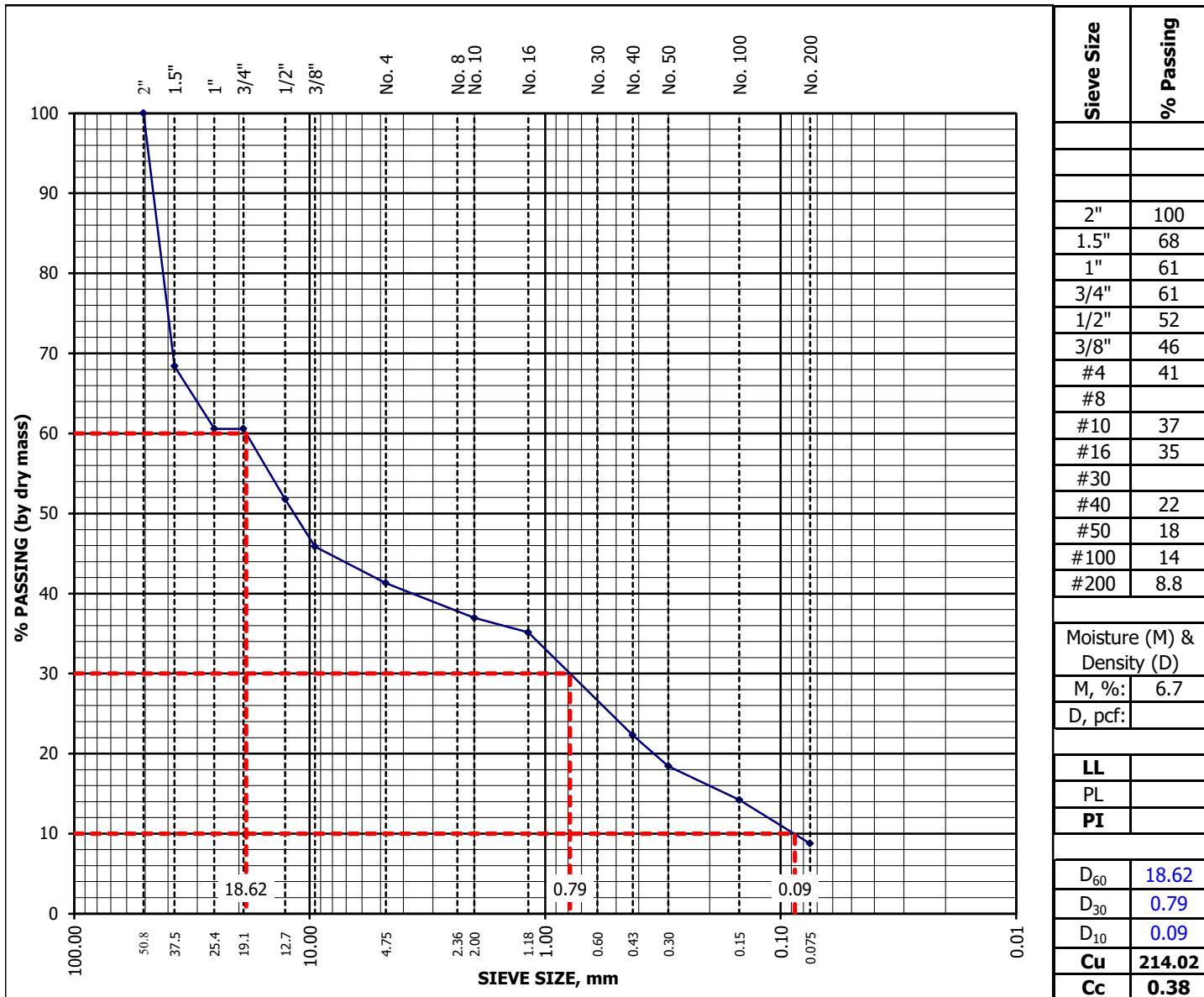
AASHTO M 145 Classification: A-6 **Group Index:** 3
Unified Soil Classification System
(ASTM D 2487): (GC) **Clayey gravel with sand**



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 29-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212197 Reviewer: G. Hoyos
 Sample Location: B-14 at 14' Visual Description: GRAVEL, sandy, with silt, reddish brown

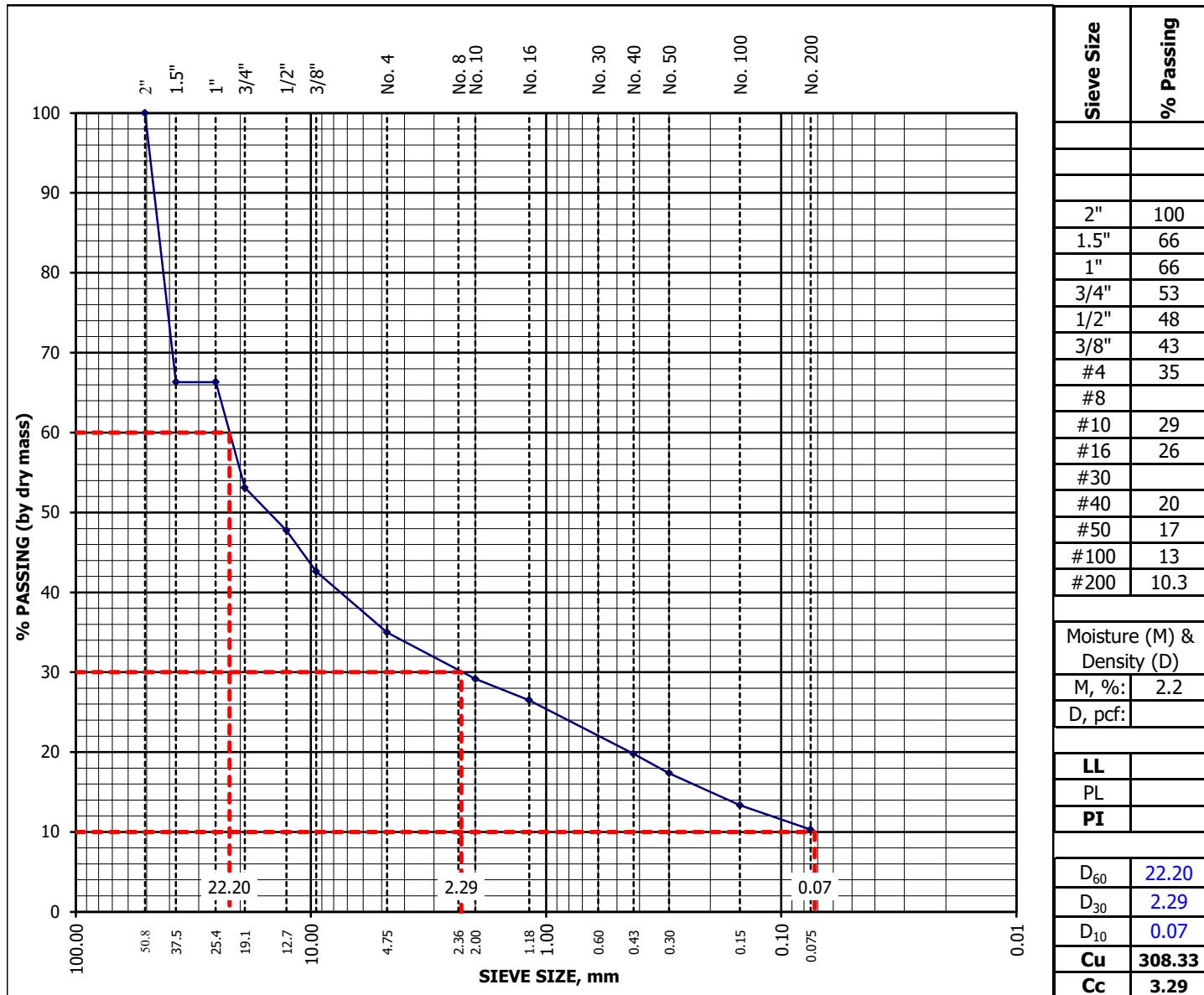
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 3-Jan-22
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212200 Reviewer: G. Hoyos
 Sample Location: B-14 at 9'
 Visual Description: GRAVEL, sandy, with silt, reddish brown

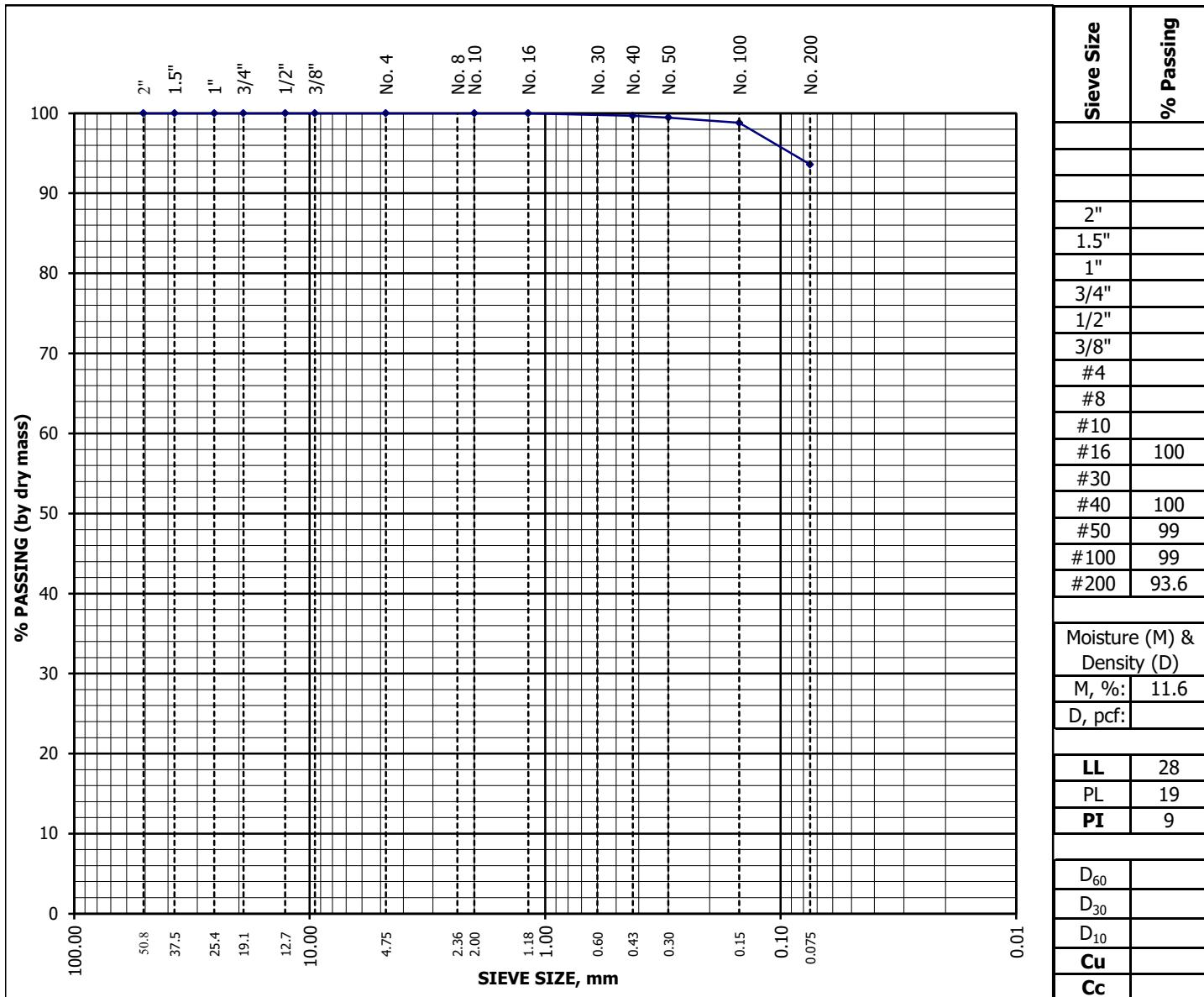
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 29-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212198 Reviewer: G. Hoyos
 Sample Location: B-15 at 1' Visual Description: CLAY, reddish brown

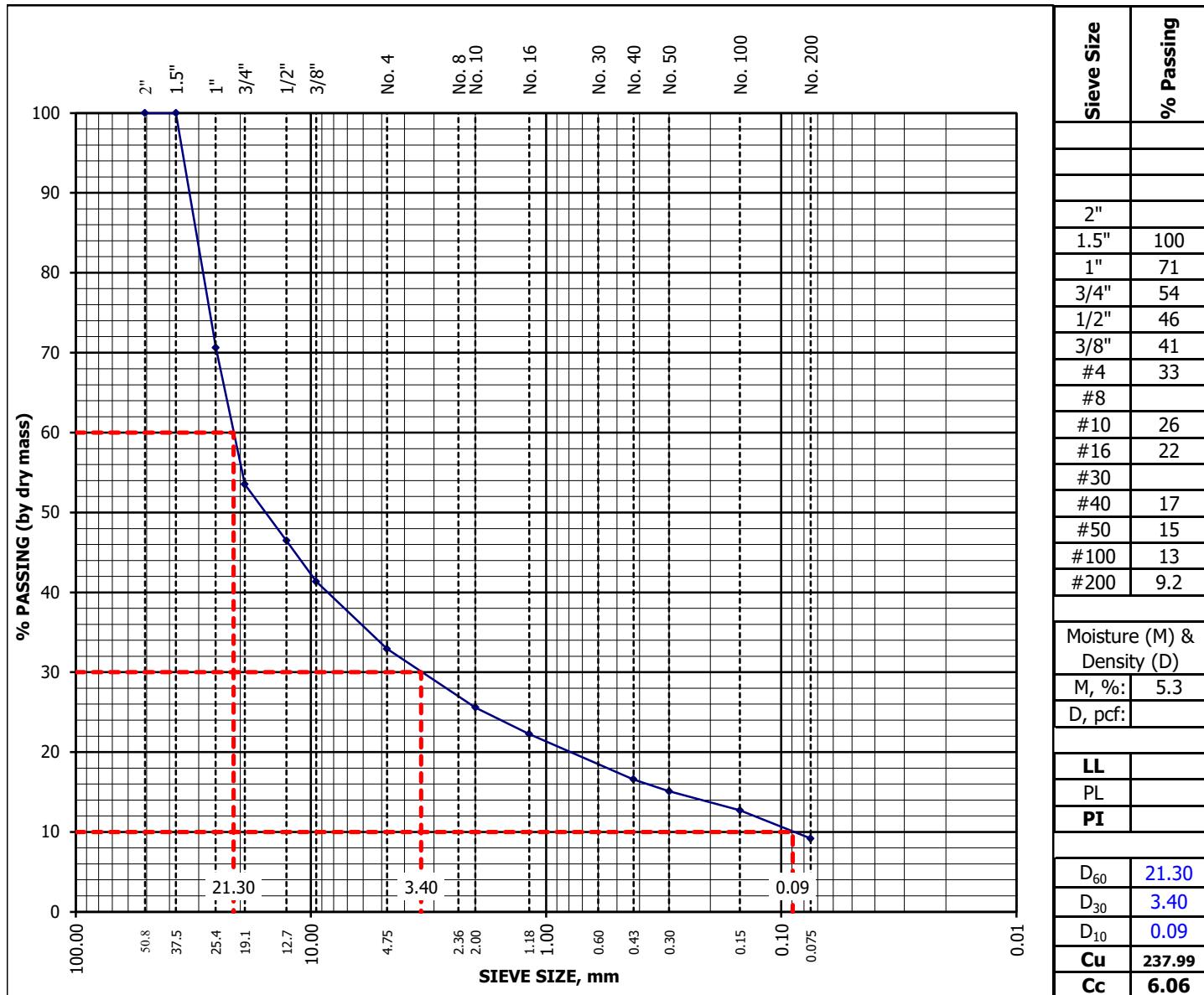
AASHTO M 145 Classification: A-4 **Group Index:** 7
Unified Soil Classification System
(ASTM D 2487): (CL) Lean clay



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 29-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212199 Reviewer: G. Hoyos
 Sample Location: B-15 at 14' Visual Description: GRAVEL, sandy, with silt, reddish brown

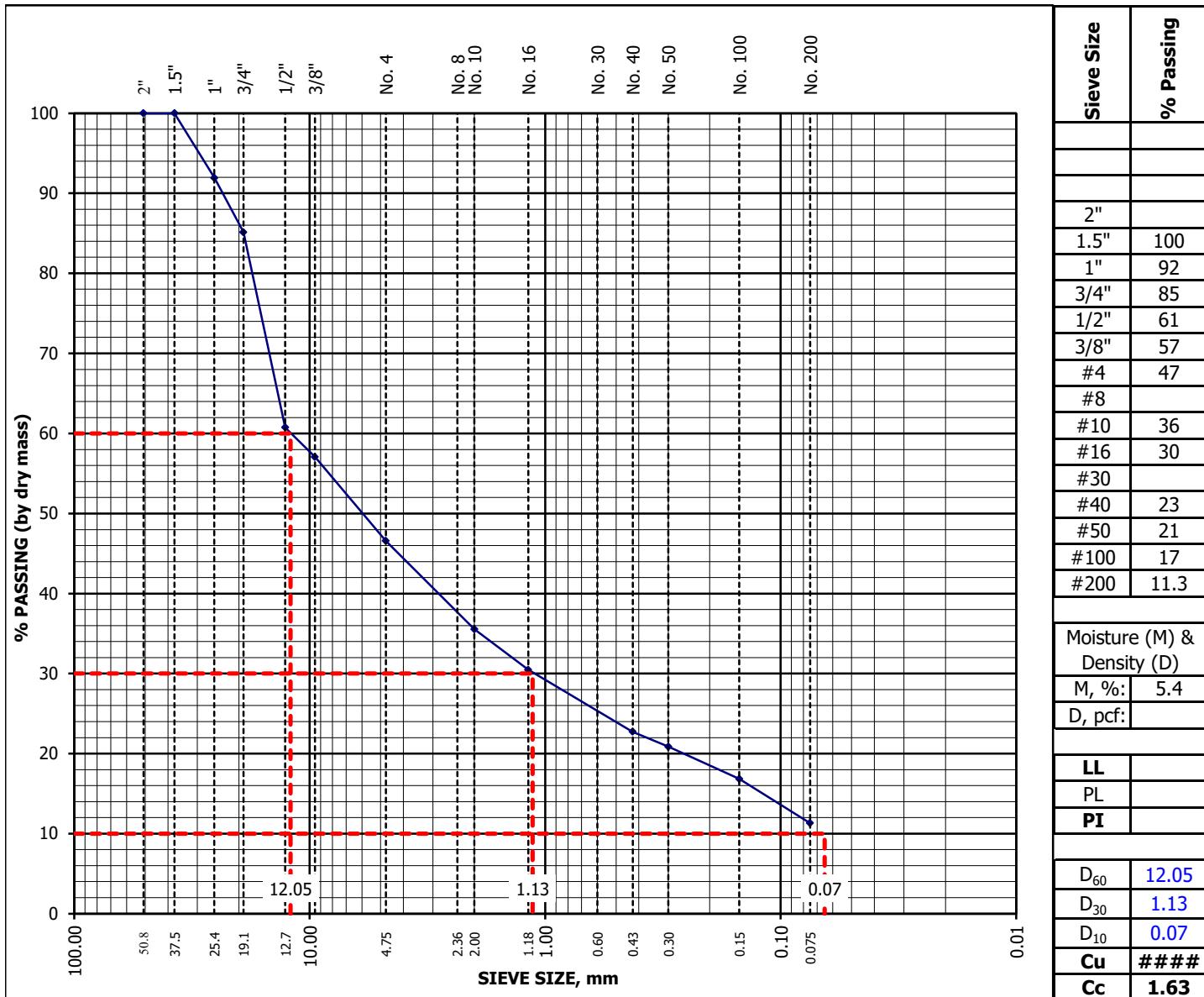
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 29-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212201 Reviewer: G. Hoyos
 Sample Location: B-16 at 19'
 Visual Description: GRAVEL, sandy, with silt, reddish brown

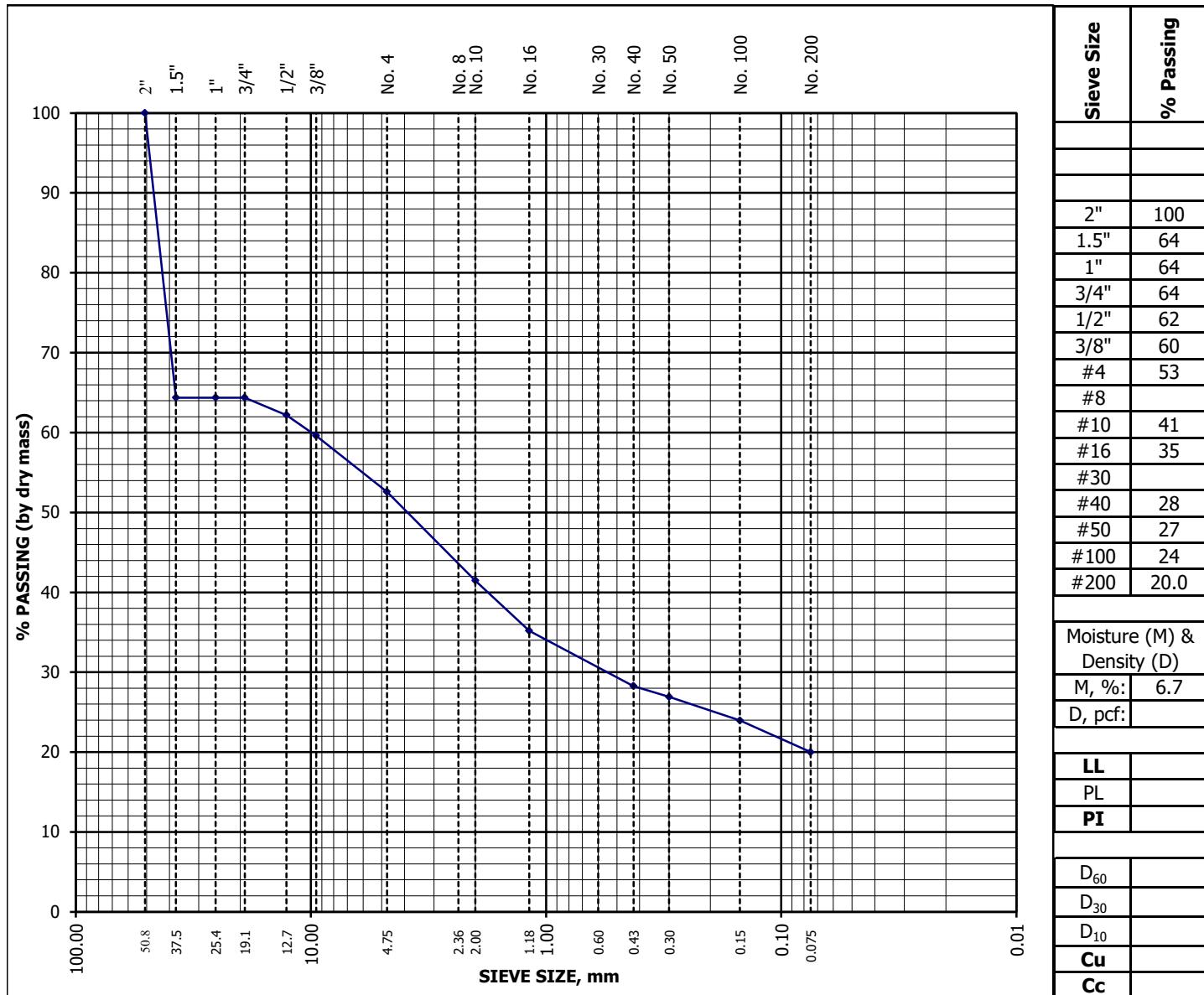
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 29-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212202 Reviewer: G. Hoyos
 Sample Location: B-17 at 14'
 Visual Description: GRAVEL, sandy, with clay, brown

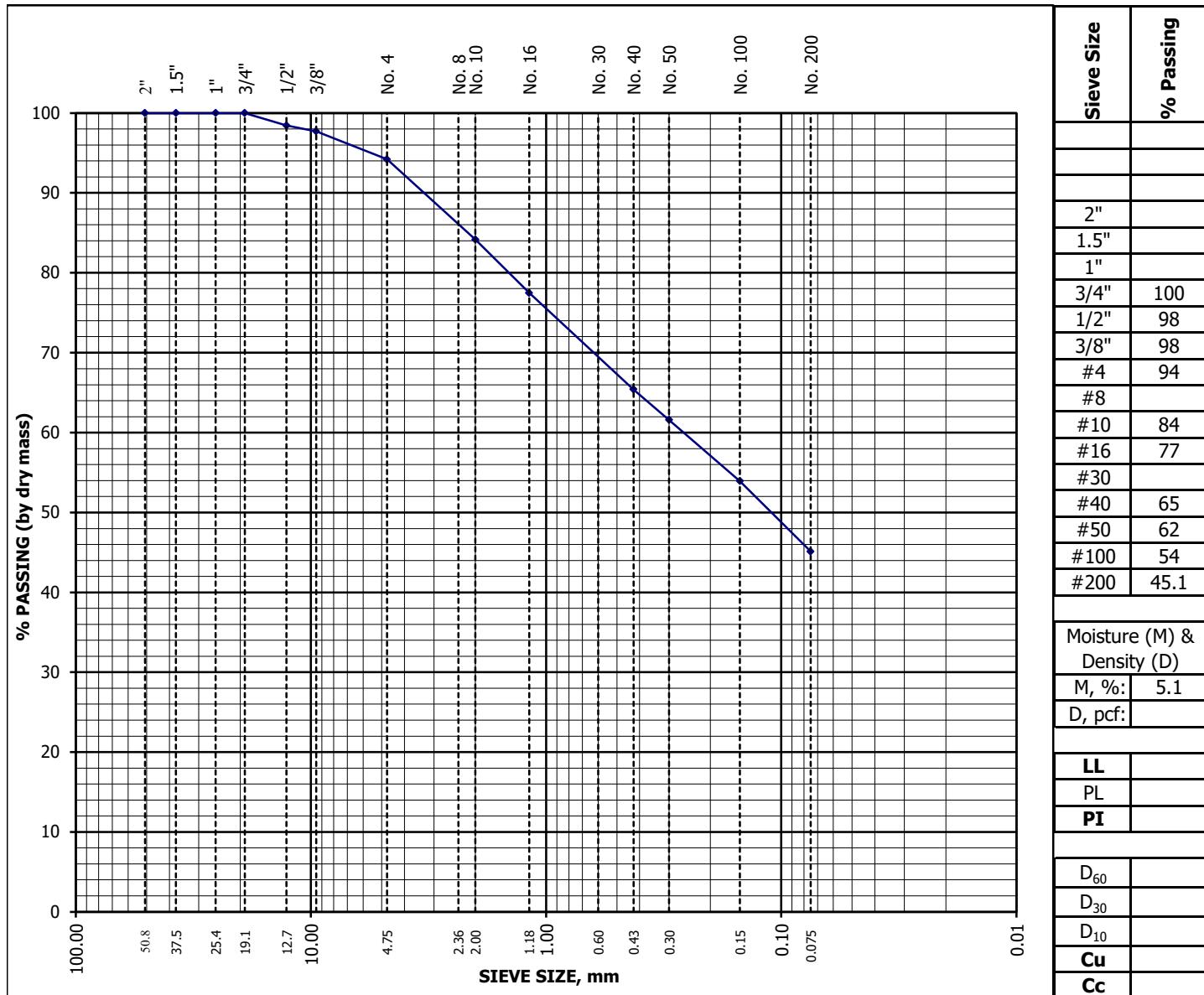
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 30-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212205 Reviewer: G. Hoyos
 Sample Location: B-17 at 23'
 Visual Description: SAND, silty, reddish brown

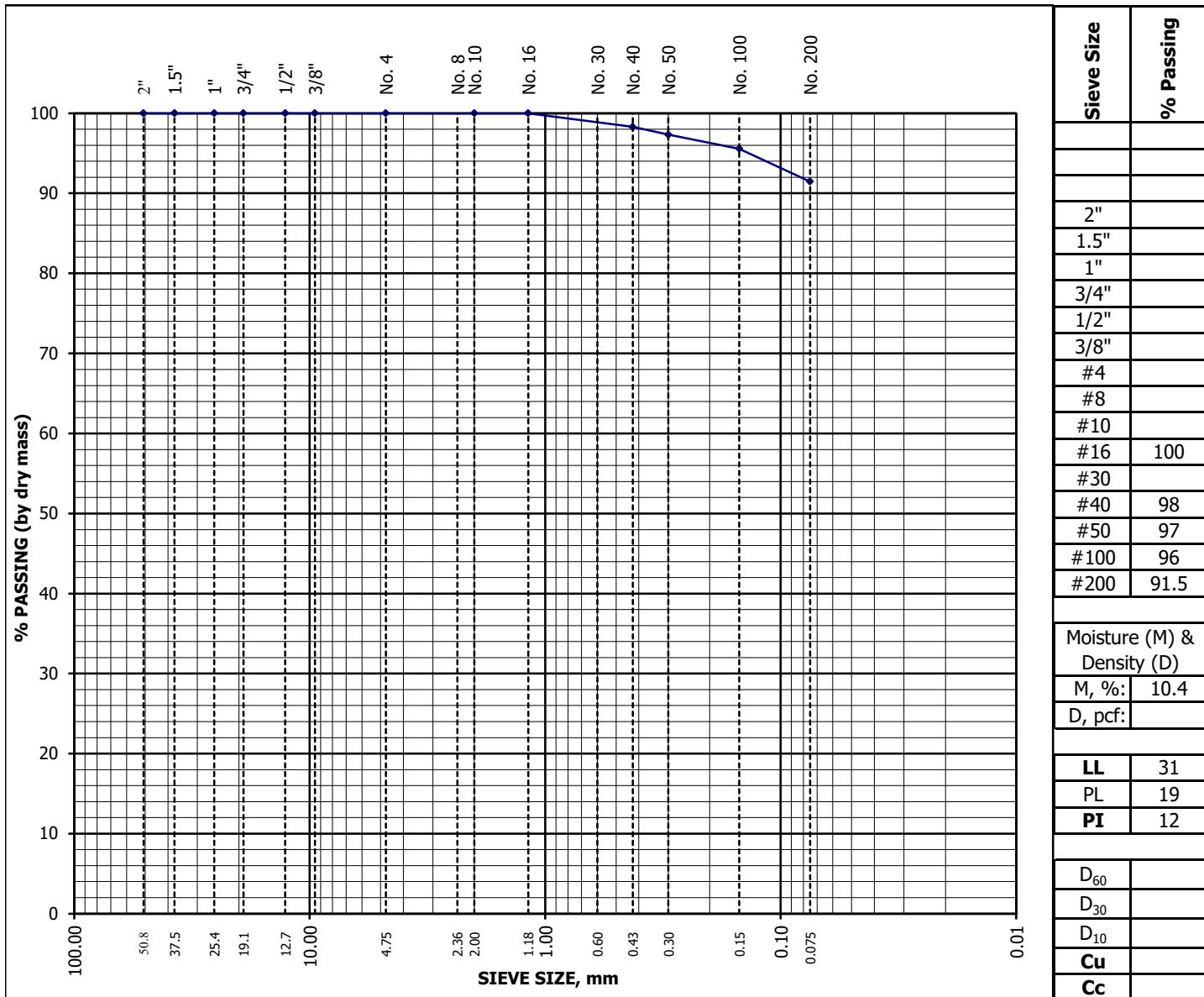
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 29-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212203 Reviewer: G. Hoyos
 Sample Location: B-18 at 1'
 Visual Description: CLAY, brown

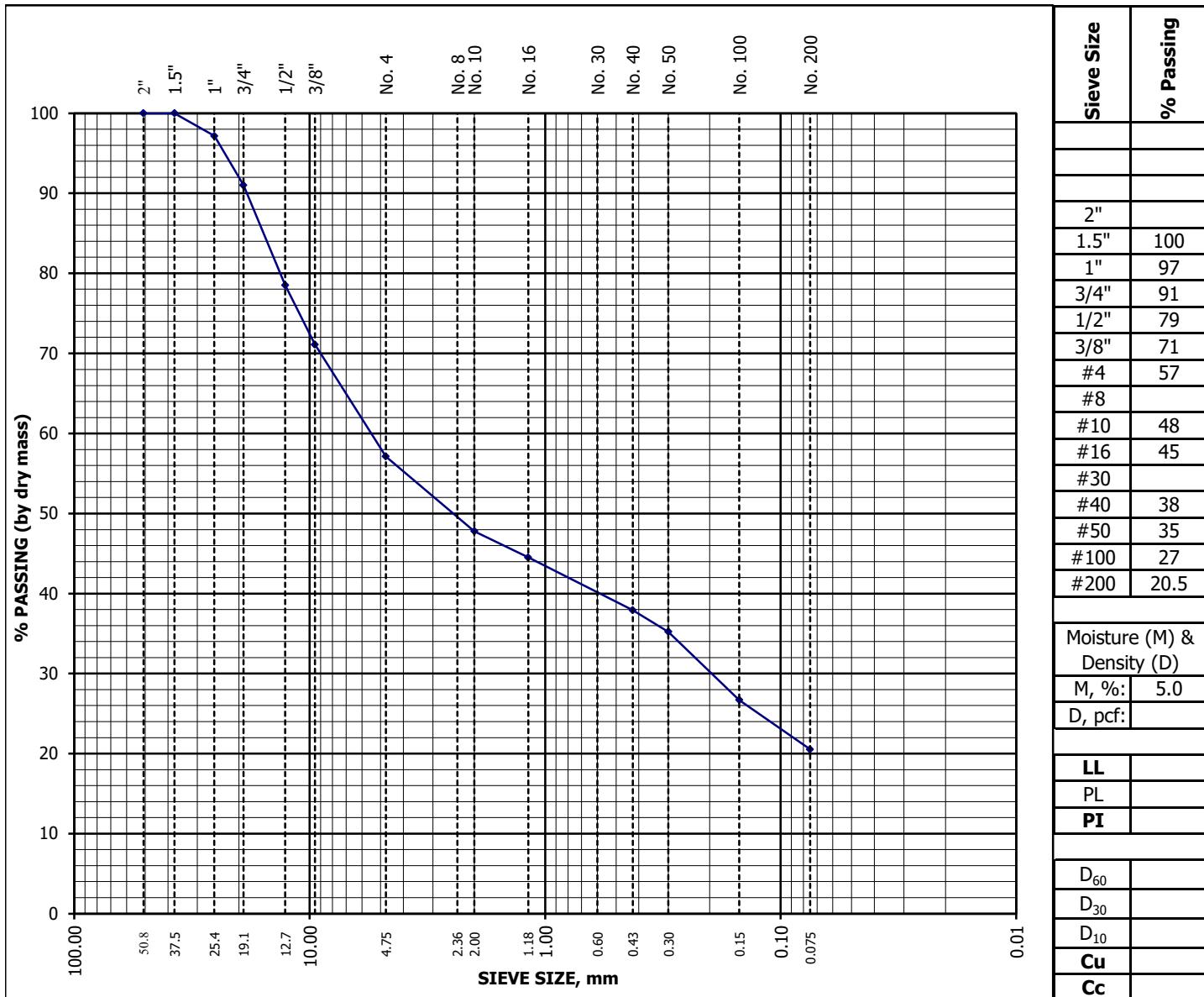
AASHTO M 145 Classification: A-6 **Group Index:** 10
Unified Soil Classification System
(ASTM D 2487): (CL) **Lean clay**



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 30-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212204 Reviewer: G. Hoyos
 Sample Location: B-18 at 9'
 Visual Description: GRAVEL, sandy, with silt, reddish brown

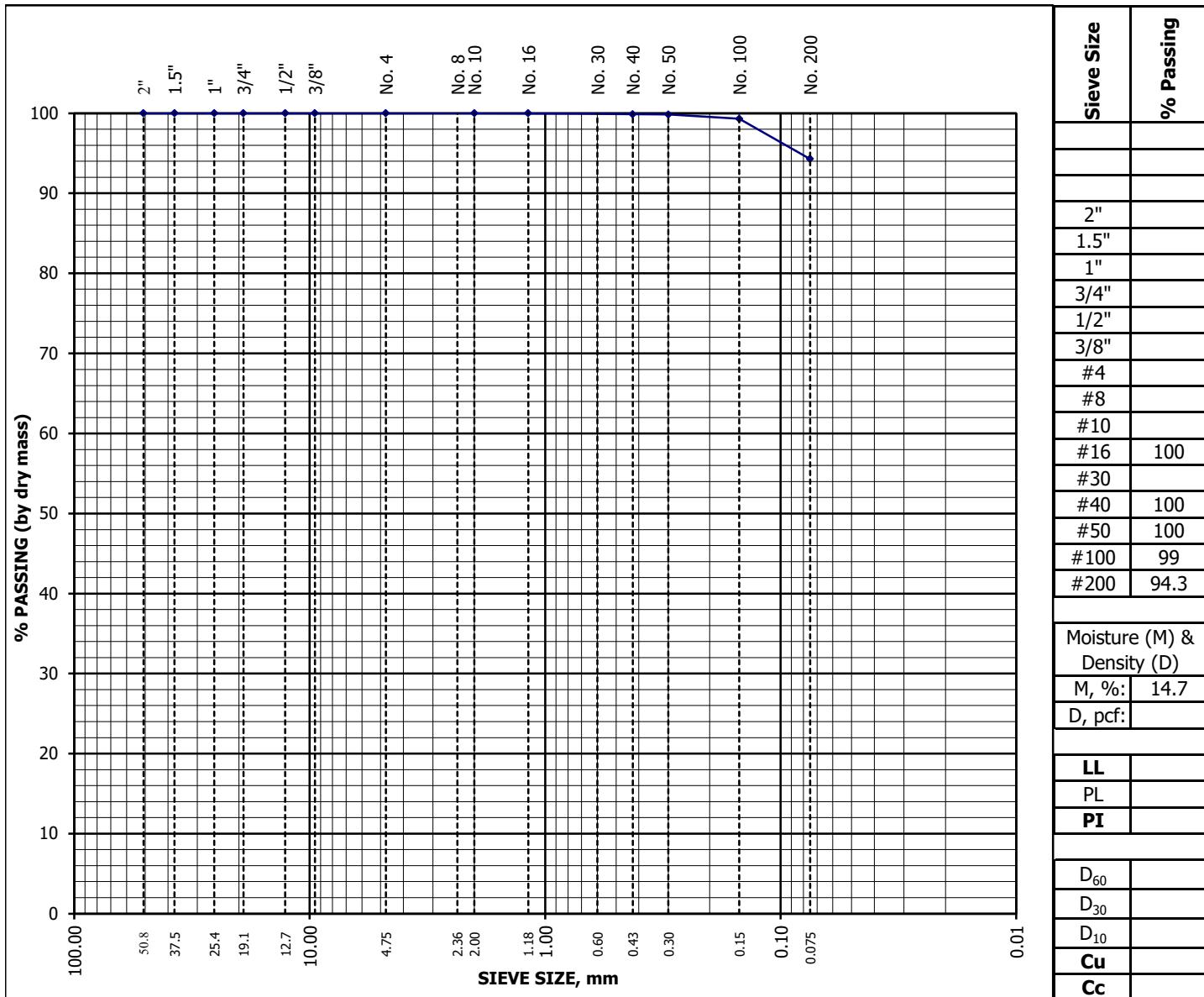
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 30-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212206 Reviewer: G. Hoyos
 Sample Location: B-19 at 9'
 Visual Description: SILT, reddish brown

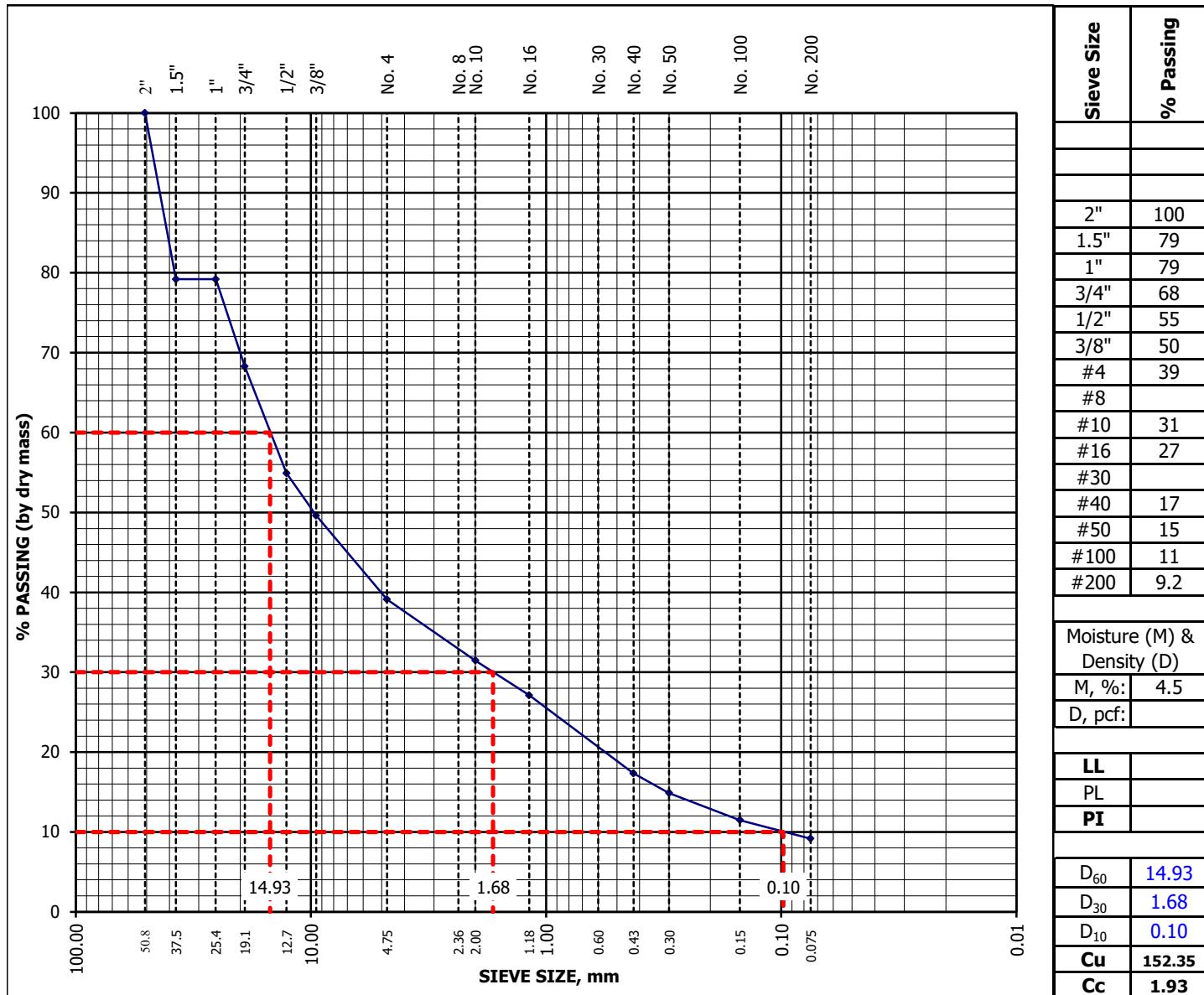
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 3-Jan-22
 Project Name: Haymeadow Development Technician: C. Zoetewey
 Lab ID Number: S212207 Reviewer: G. Hoyos
 Sample Location: B-19 at 19'
 Visual Description: GRAVEL, sandy, with silt, reddish brown

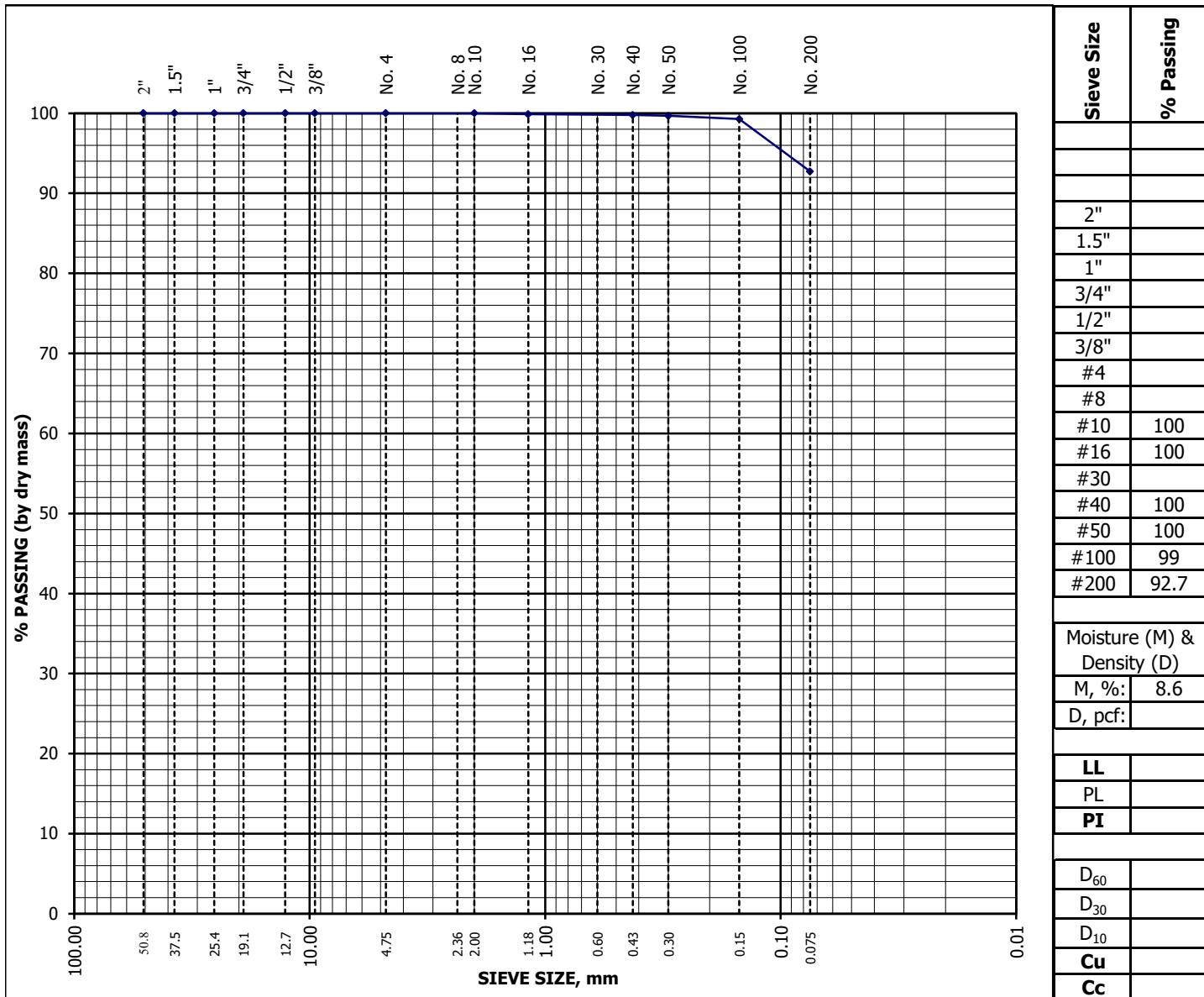
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 30-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212208 Reviewer: G. Hoyos
 Sample Location: B-20 at 4'
 Visual Description: SILT, reddish brown

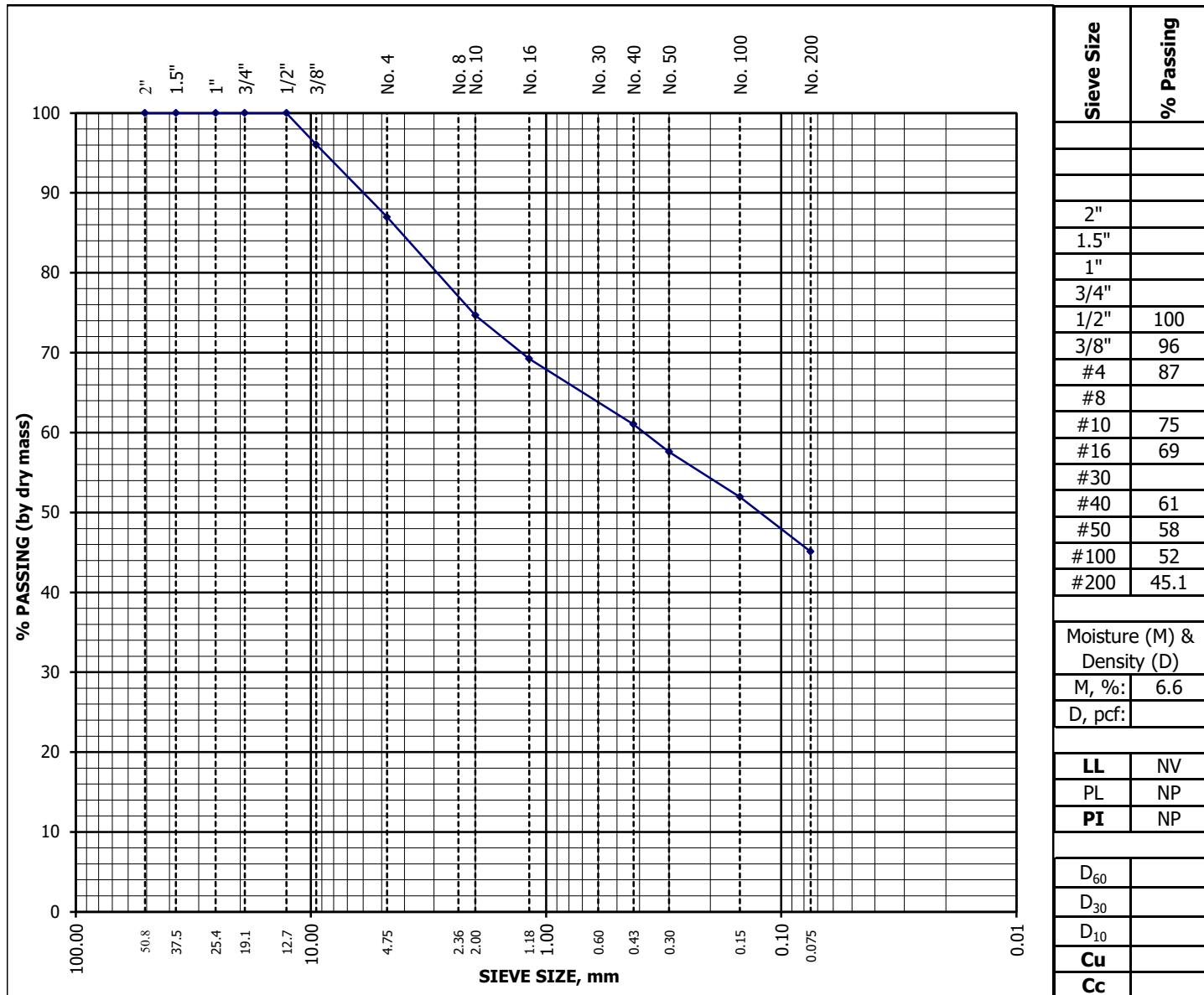
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 3-Jan-22
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212209 Reviewer: G. Hoyos
 Sample Location: B-20 at 21'
 Visual Description: SAND, silty, with gravel, olive brown

AASHTO M 145 Classification: A-4 **Group Index:** 0
Unified Soil Classification System
(ASTM D 2487): (SM) Silty sand

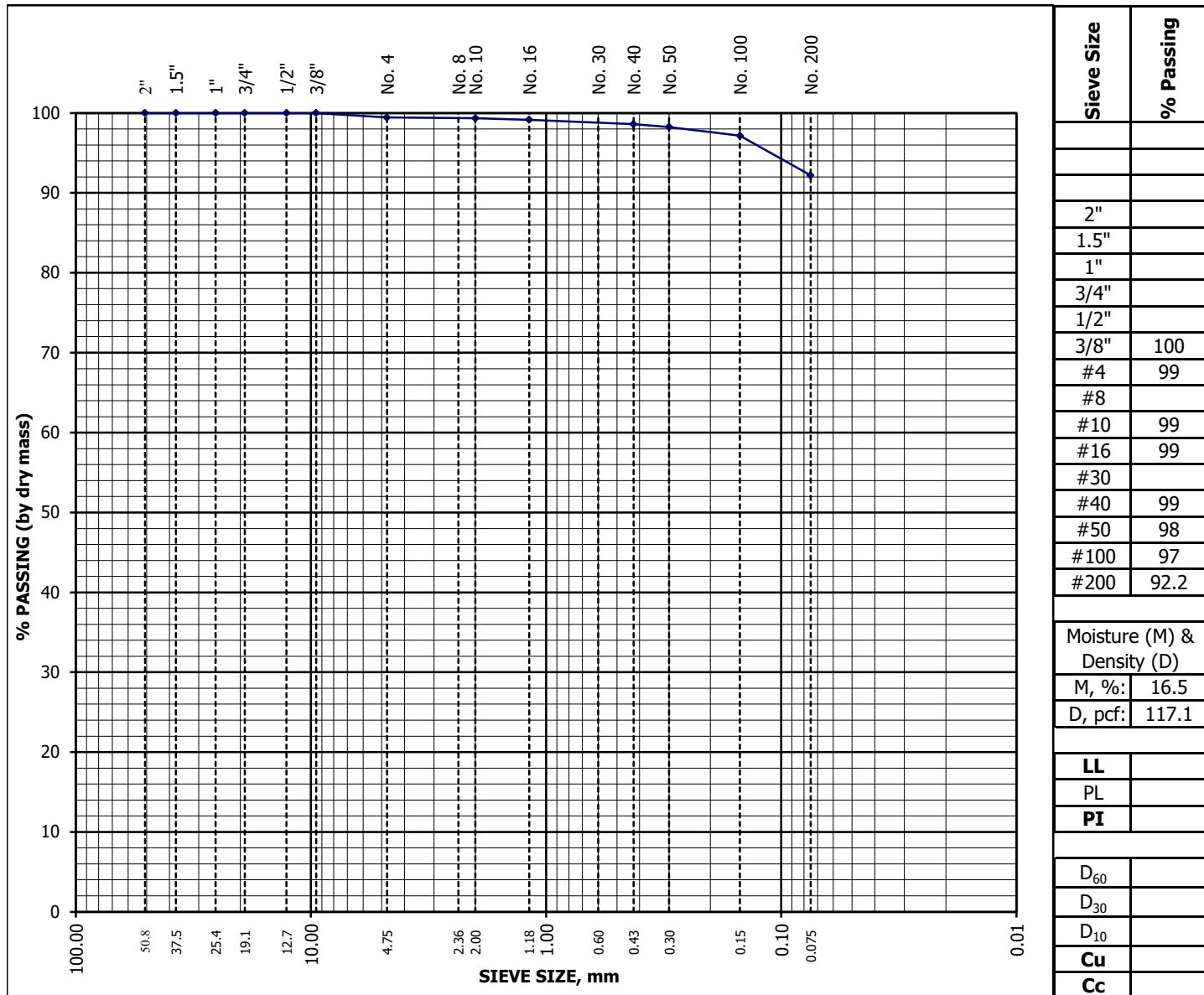




GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 3-Jan-22
Project Name: Haymeadow Development Technician: C. Zoetewey
Lab ID Number: S212210 Reviewer: G. Hoyos
Sample Location: B-21 at 9'
Visual Description: CLAY, brown

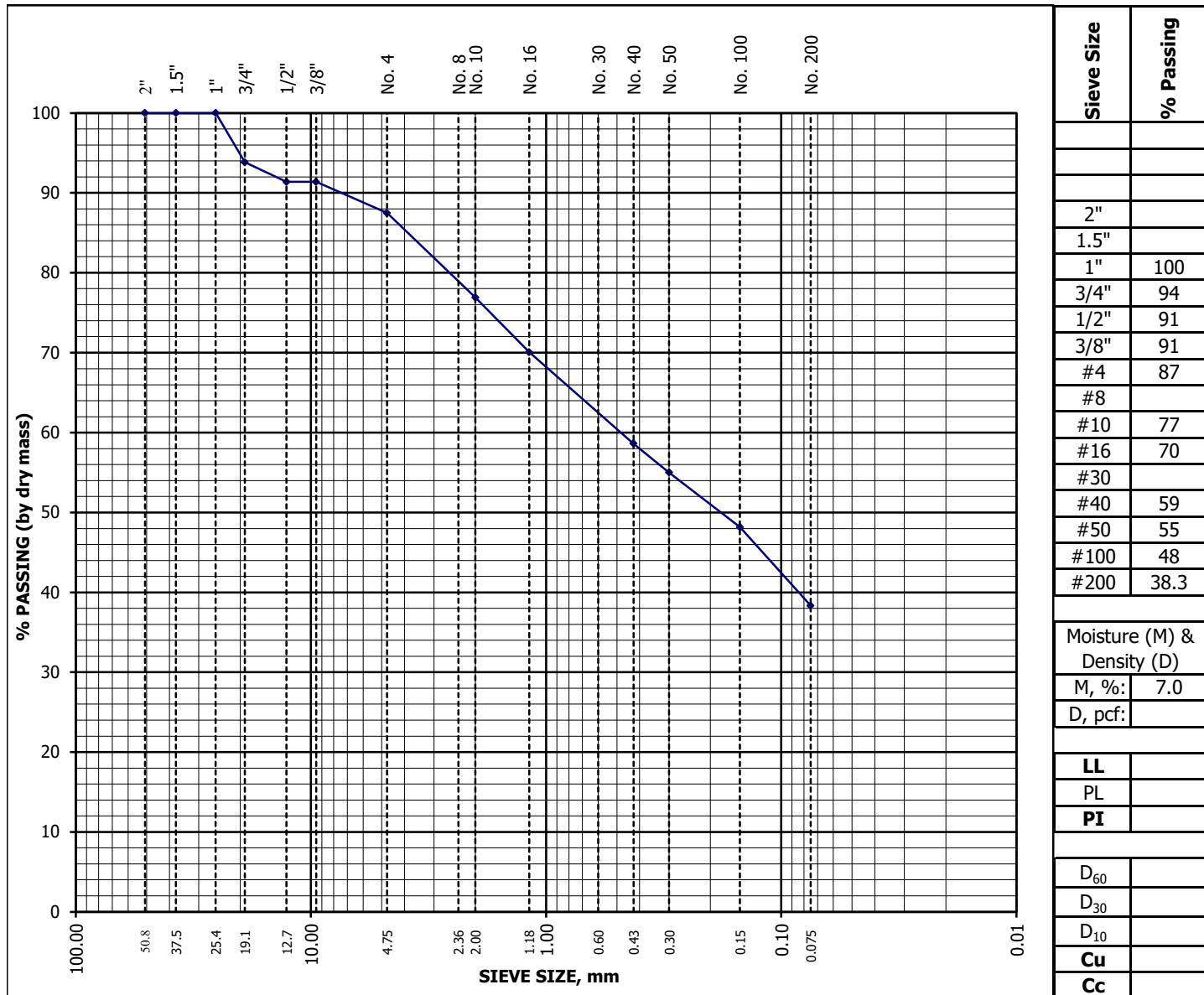
AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System _____
(ASTM D 2487): _____ ()



GRADATION PLOT - SOIL & AGGREGATE

Project Number: 21.5057 Date: 30-Dec-21
 Project Name: Haymeadow Development Technician: N. Veatch
 Lab ID Number: S212211 Reviewer: G. Hoyos
 Sample Location: B-21 at 19'
 Visual Description: SAND, silty, with gravel, reddish brown

AASHTO M 145 Classification: _____ **Group Index:** _____
Unified Soil Classification System
(ASTM D 2487): ()



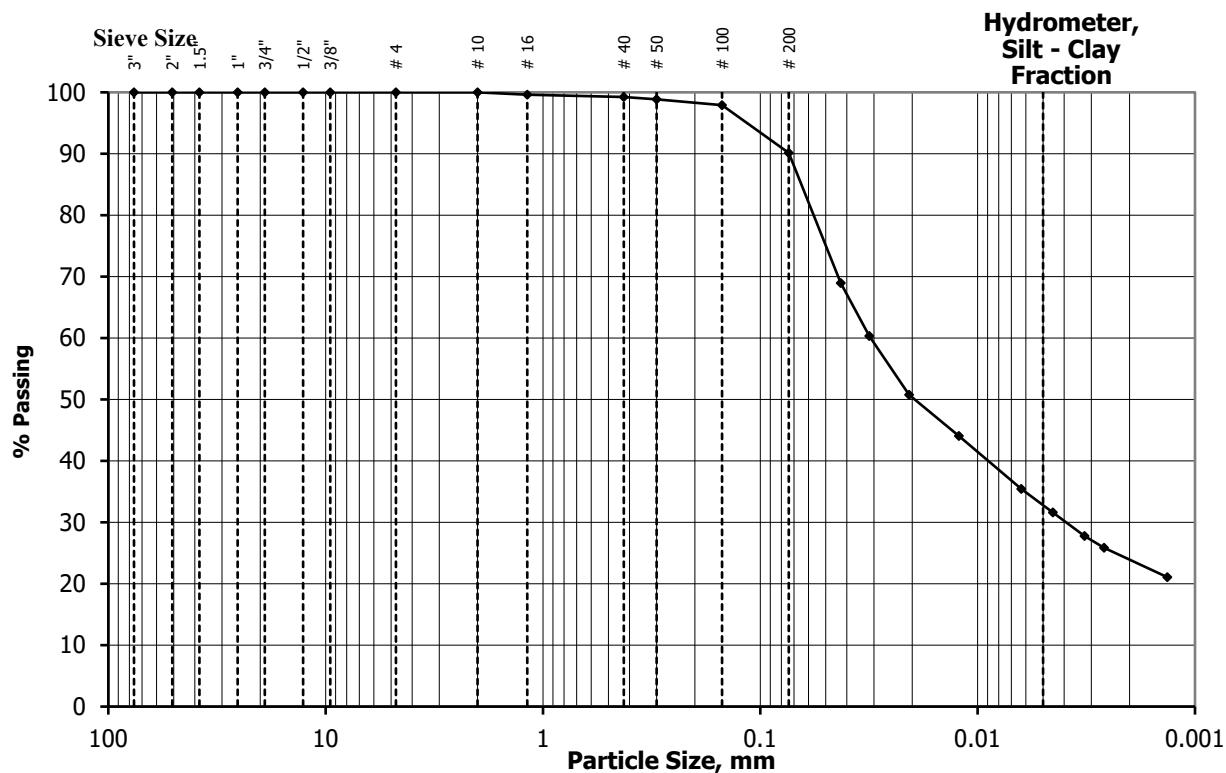


PARTICLE SIZE ANALYSIS (ASTM D422)

Project Number: 21.5057 Date: 12/04/21
 Project Name: Haymeadow Development Technician: J. Holiman
 Lab ID Number: 2121725 Reviewer: G. Hoyos
 Sample Location: B-18 at 4'
 Visual Description: SILT, clayey, with sand, brown

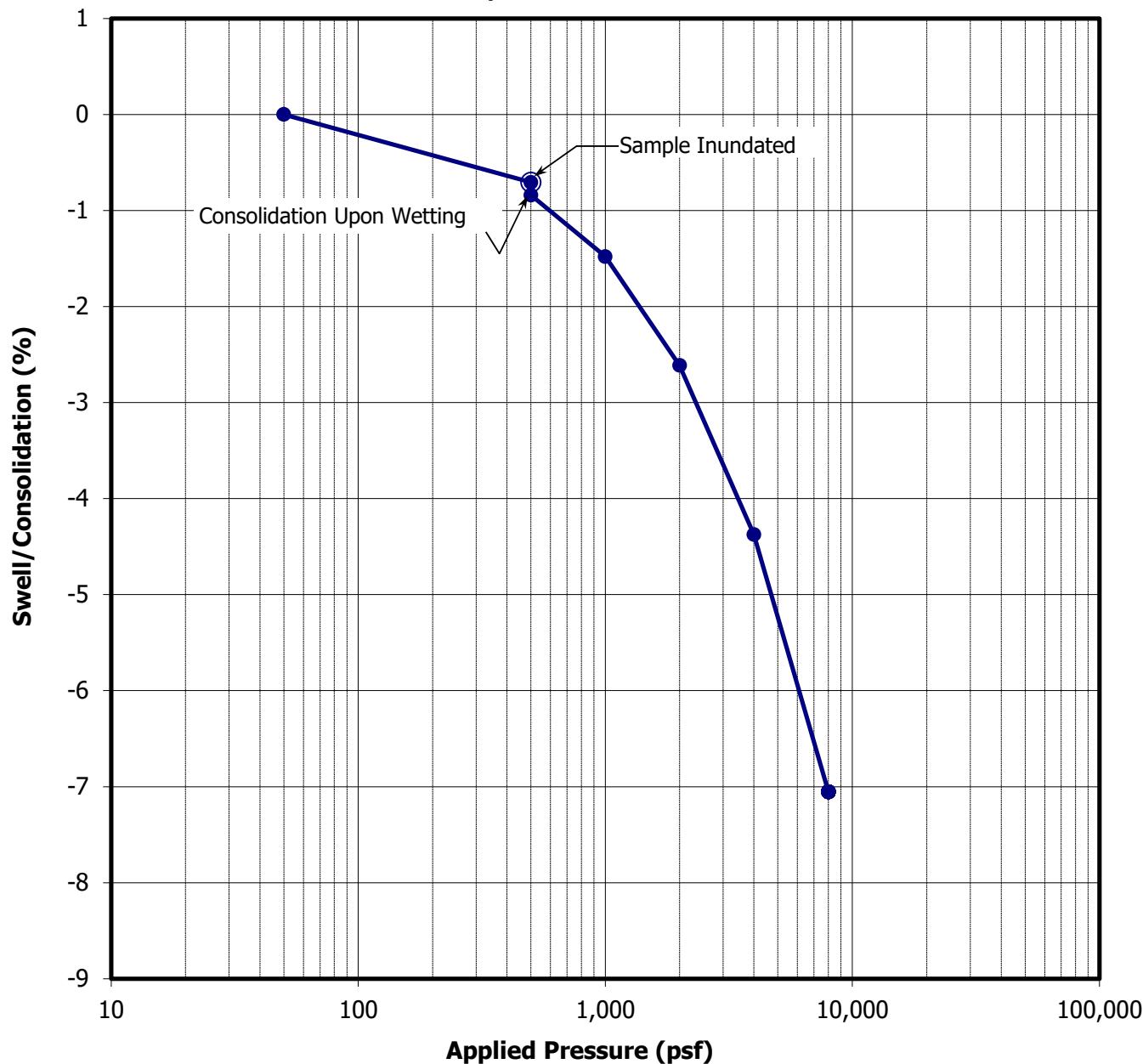
Soil Classification (USCS): _____

Sieve Size	% Passing	Hydrometer	
		Particle Size	% Passing
3"	100	43 Micron	69
2"	100	32 Micron	60
1-1/2"	100	21 Micron	51
1"	100	12 Micron	44
3/4"	100	6 Micron	35
1/2"	100	4.5 Micron	32
3/8"	100	3.2 Micron	28
#4	100	2.6 Micron	26
#10	100	1.3 Micron	21
#16	100	% Gravel: 0	
#40	99	% Sand: 10	
#50	99	% Silt: 57	
#100	98	% Clay (< 5 micron): 33	
#200	90		





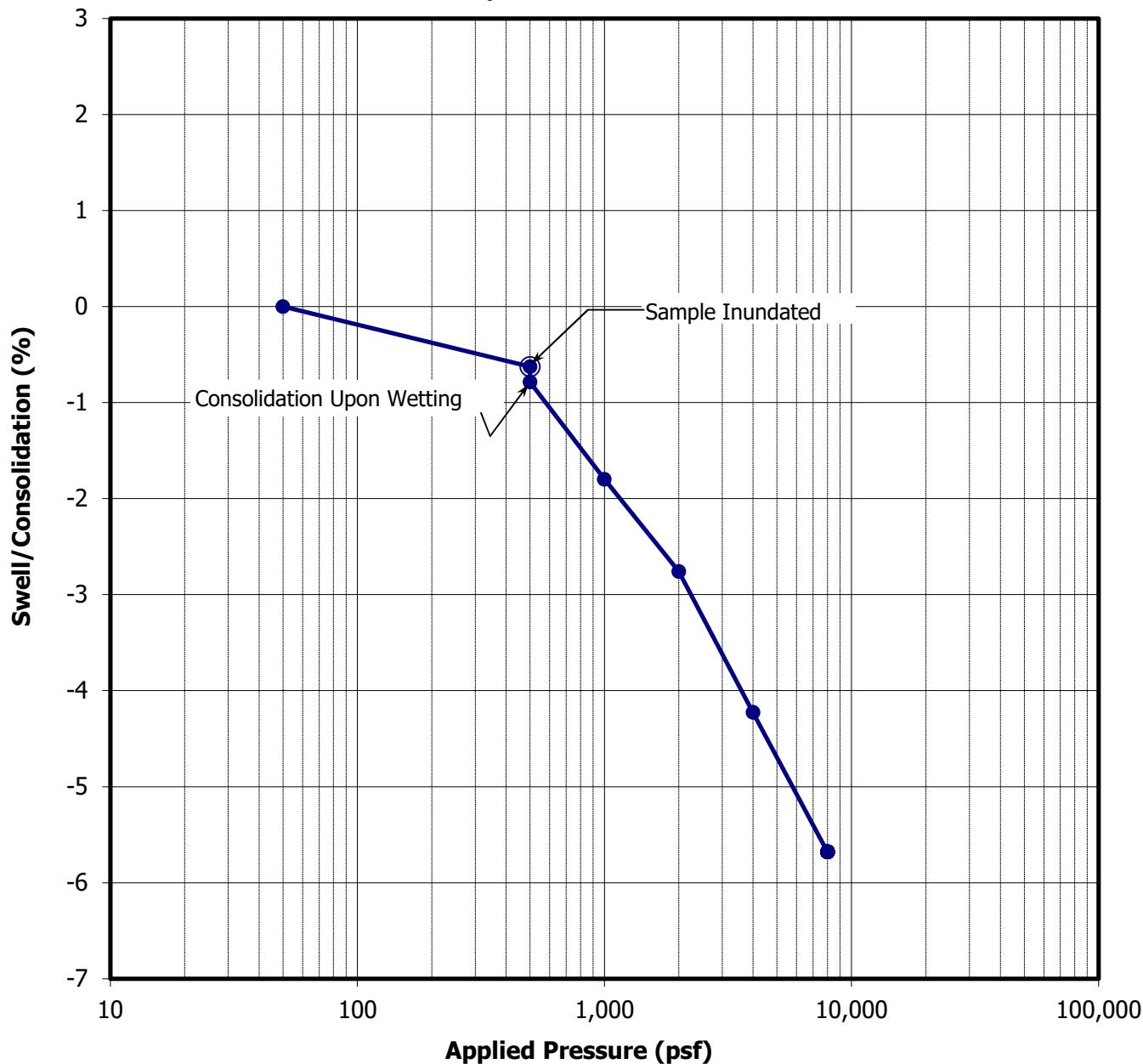
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-1	4	CLAY, sandy, brown	101.2	18.5	500	-0.1	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121704



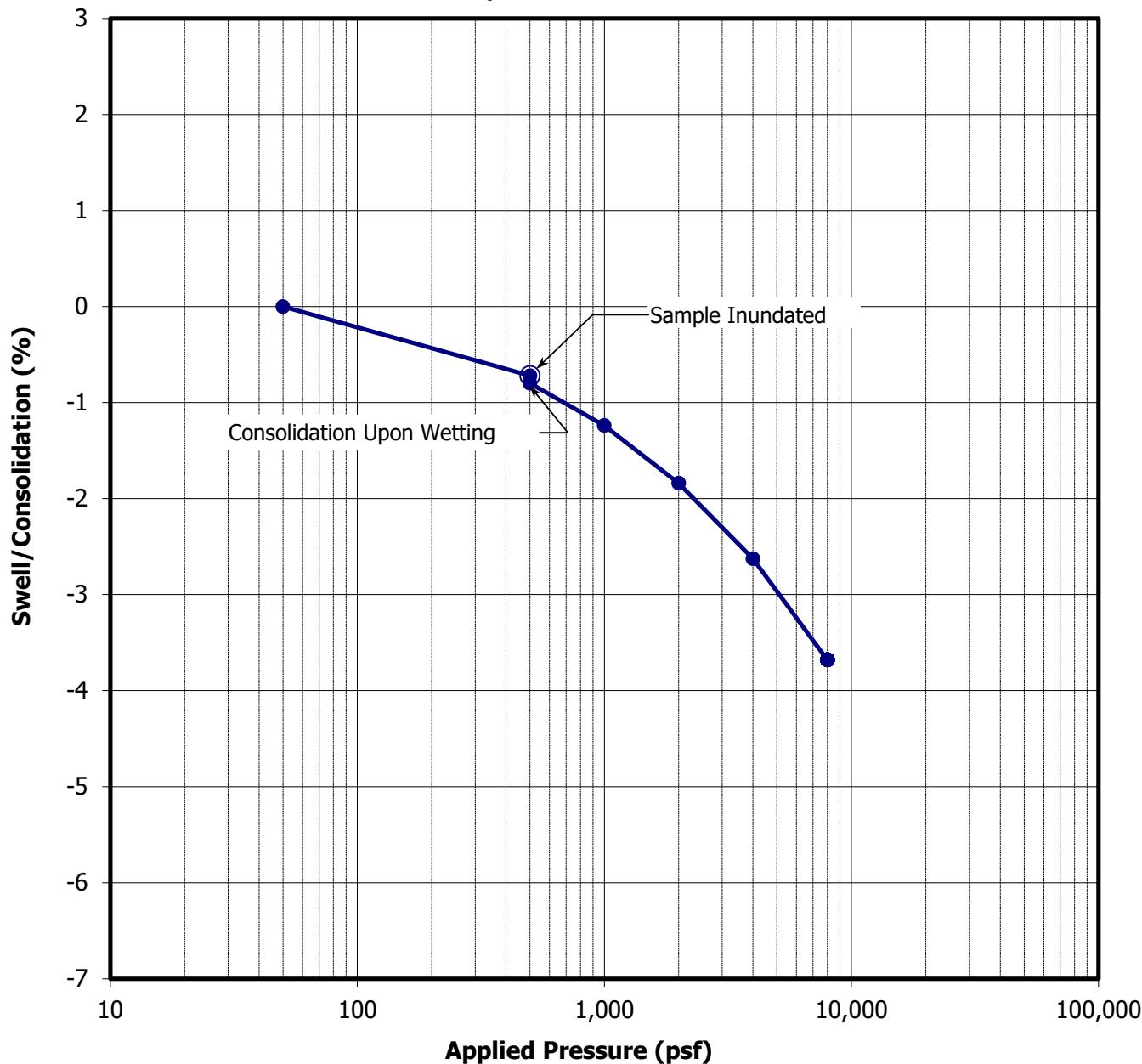
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-5	4	SILT, sandy, brown	101.4	20.8	500	-0.2	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121707



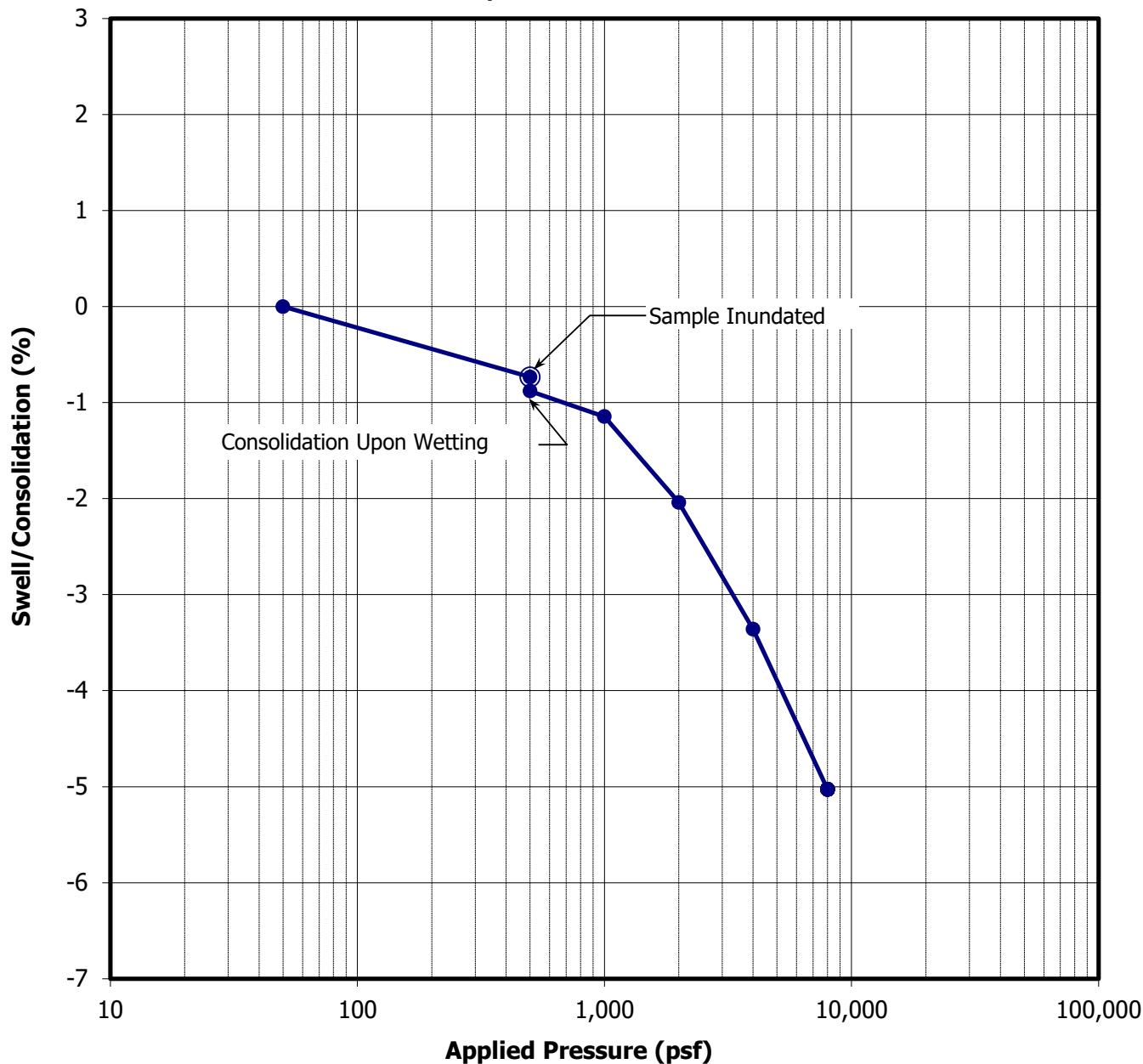
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-8	4	CLAY, sandy, dusky red	106.4	17.3	500	-0.1	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121709



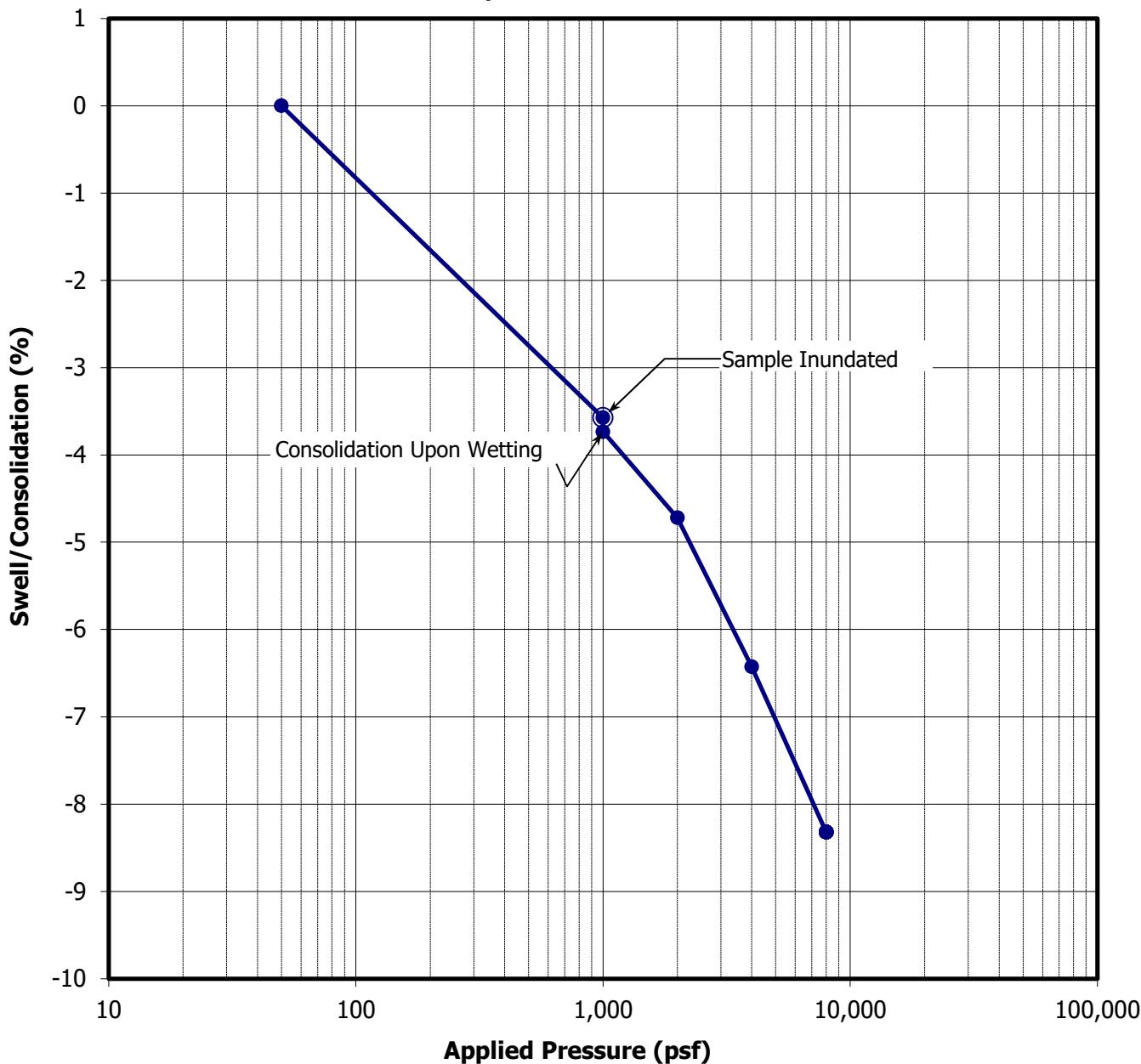
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-10	4	CLAY, sandy, brown	103.5	19.5	500	-0.1	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121710



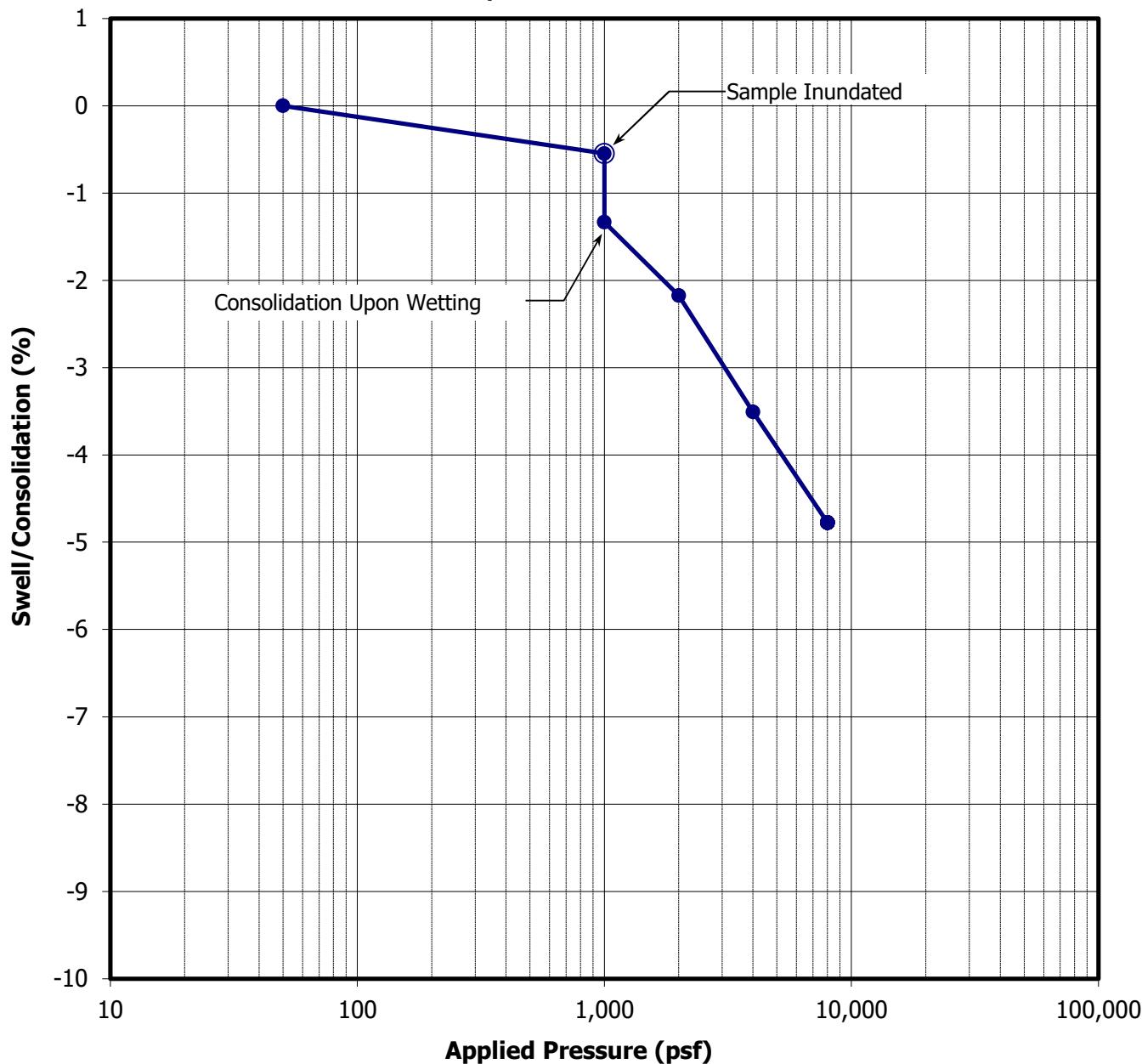
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-12	9	CLAY, sandy, dusky red	97.3	23.6	1,000	-0.2	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121712



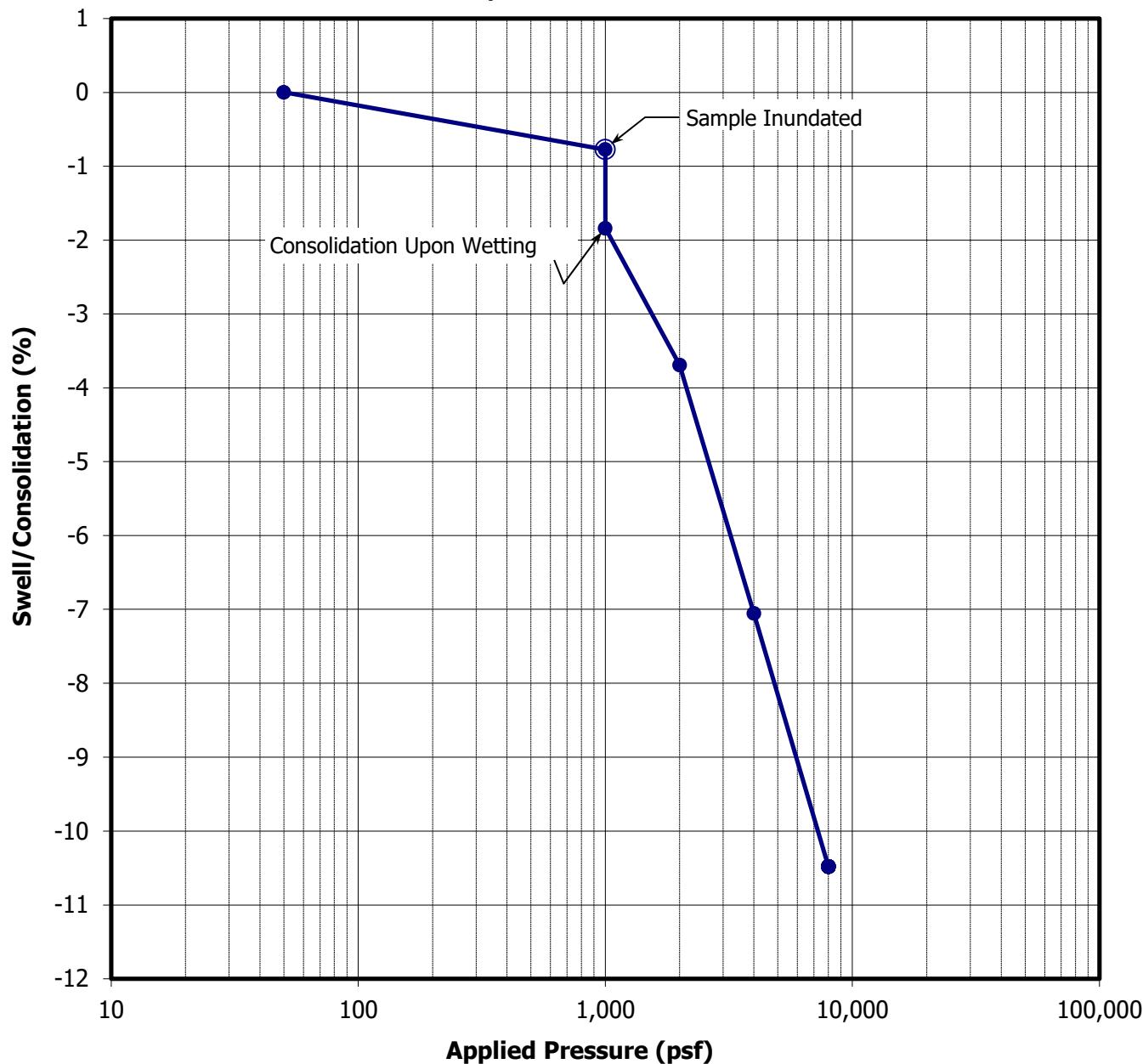
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-14	1	CLAY, sandy, brown	107.1	12.6	1,000	-0.8	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121714



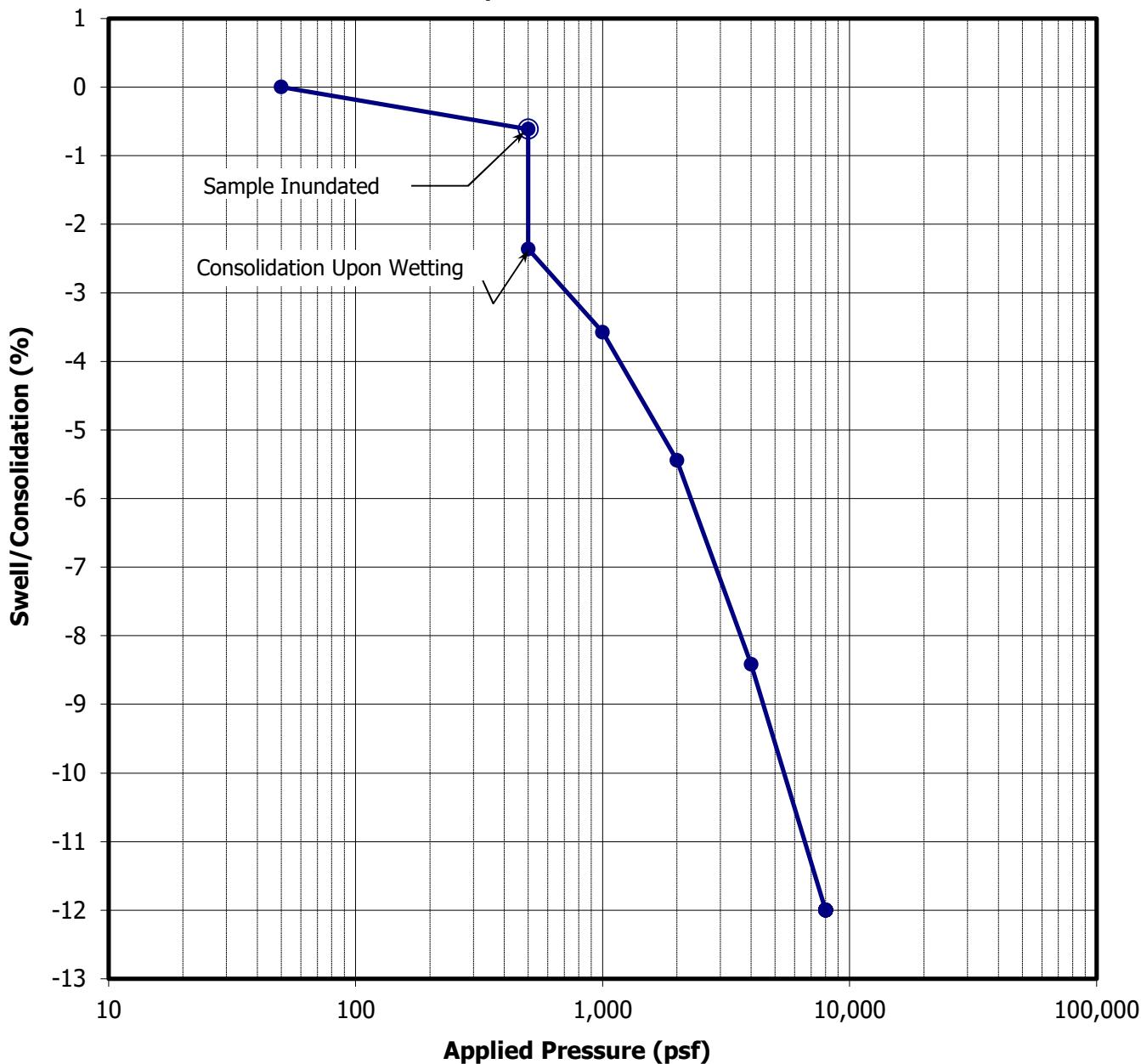
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-16	4	CLAY, sandy, brown	94.8	15.4	1,000	-1.1	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121721



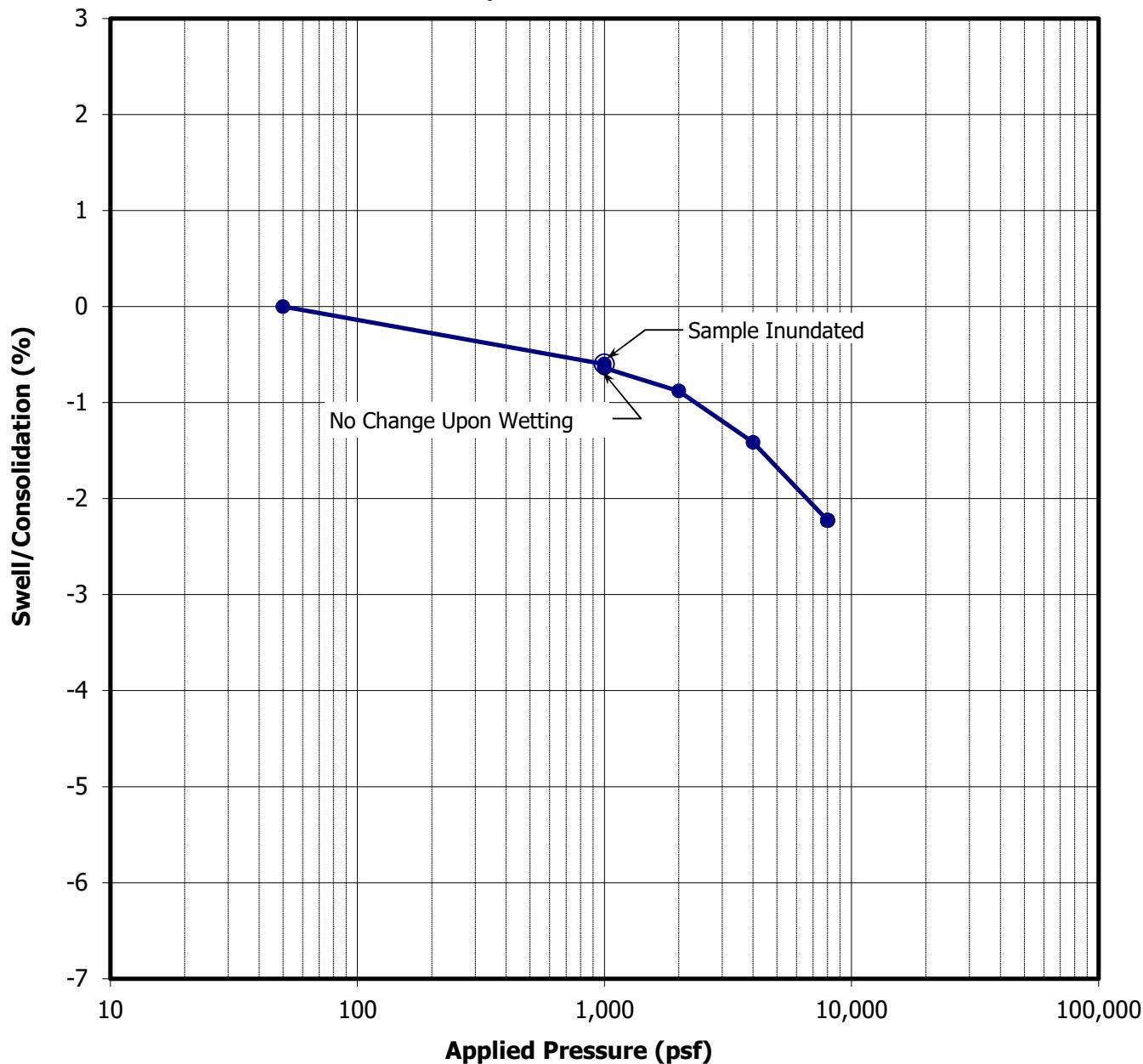
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-17	1	CLAY, sandy, brown	90.7	8.5	500	-1.7	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121723



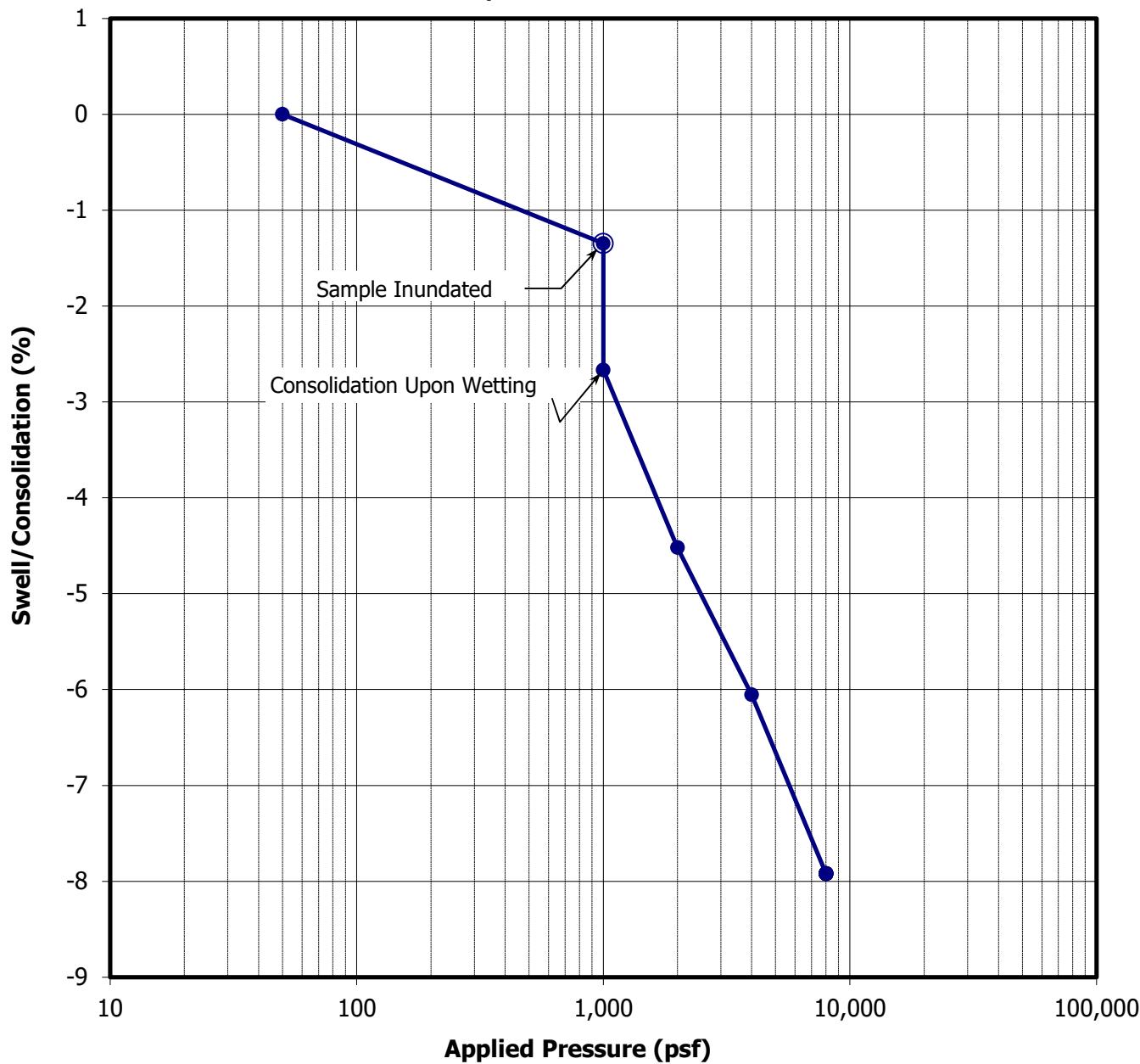
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-17	9	CLAY, sandy, brown	114.1	11.8	1,000	0.0	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121724



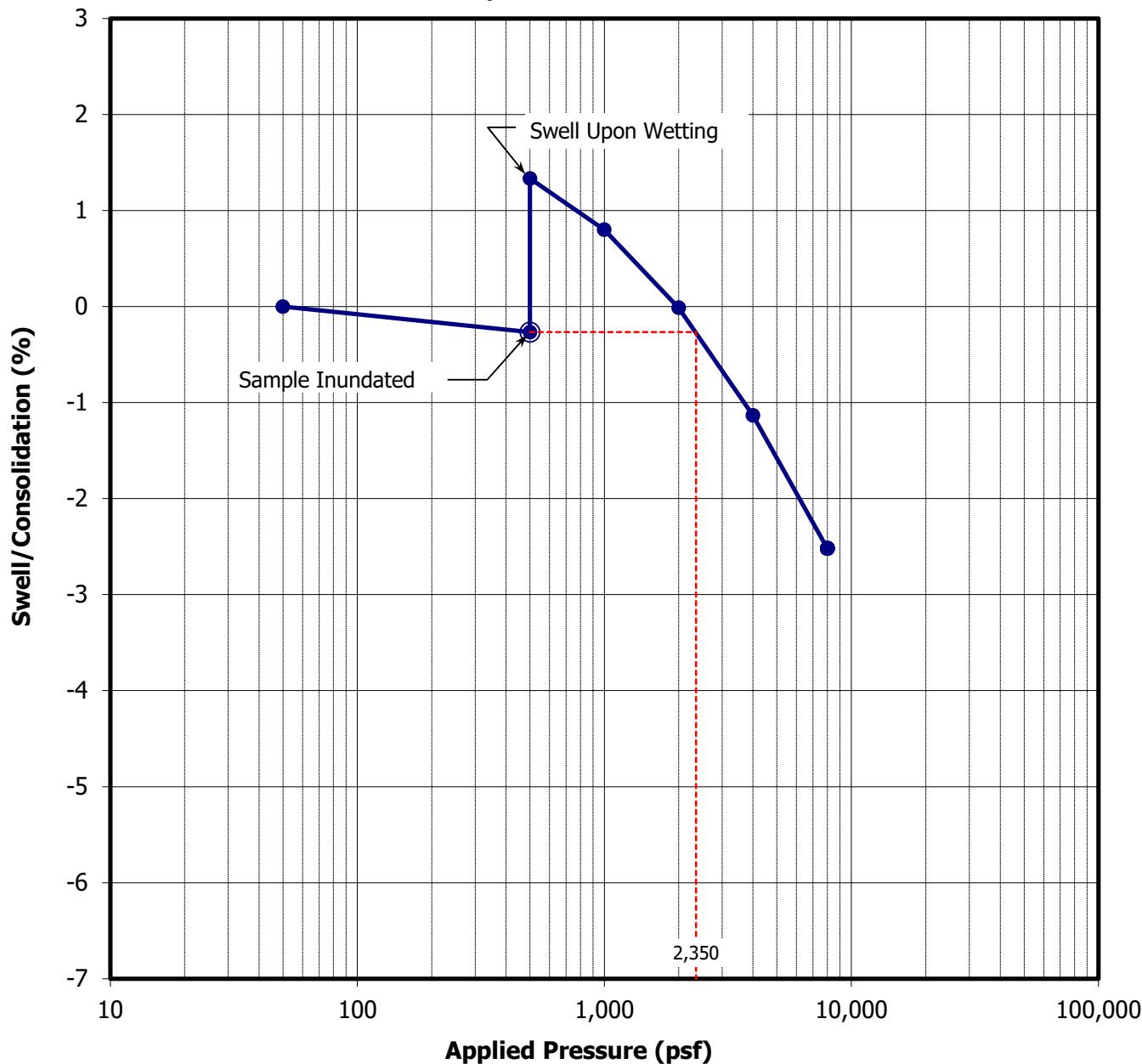
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-19	14	CLAY, sandy, brown	95.4	21.8	1,000	-1.3	N/A
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121726



SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (ft)	Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-21	1	CLAY, sandy, brown	106.0	9.9	500	1.6	2,350
Project Number	Project Name						Lab ID Number
21.5057	Haymeadow Development						2121728



APPENDIX C

Vapor Barriers

VAPOR BARRIERS

If it is determined that a vapor retarder/barrier is warranted, Cesare recommends the vapor barrier comply with ASTM E1745, and if moisture sensitive flooring will be utilized, have a permeance below 0.01 perms before and after mandatory conditioning testing. The vapor retarder/barrier should be installed per ASTM E1643 and the design professional should consider project specific requirements in specification verbiage. See the ACI Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)" for additional discussion and guidance regarding the use of vapor retarders/barriers beneath floor slabs.

The 2018 IBC, Section 1805.2 Dampproofing states that where hydrostatic pressure will not occur, as determined by Section 18-03.5.4, floors shall be dampproofed in accordance with this section.

Section 1805.2 Floors, states,

"Dampproofing materials for floors shall be installed between the floor and the base course required by Section 1805.4.1, except where a separate floor is provided above a concrete slab. Where installed beneath the slab, dampproofing shall consist of not less than 6-mil (0.006 inch; 0.152 mm) polyethylene with joints lapped not less than 6 inches (152 mm), or other approved methods or materials. Where permitted to be installed on top of the slab, damp proofing shall consist of mopped-on bitumen, not less than 4-mil; (0.004 inch; 0.102 mm) polyethylene, or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instructions".

Section 1805.4.1 Floor Base Course, states,

"Floors of basements, except as provided for in Section 1805.1.1 shall be placed over a floor base course not less than 4 inches (102 mm) in thickness that consists of gravel or crushed stone containing no more than 10 percent of material that passes through a No. 4 (4.75mm) sieve. Exception: Where a site is in well-drained gravel or sand/gravel mixture soils, a floor base course is not required."

Cesare recommends that slabs be constructed directly on the existing subgrade soil without the addition of a layer of base course material and that the architect be consulted regarding the need for a vapor retarder or vapor barrier. Decision to include a vapor retarder/barrier beneath the slab is dependent on the sensitivity of floor coverings and building use to moisture.