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

May 19, 2023

Lauren Johnson
26445 Scrub Oak Path
Steamboat Springs, CO 80487

Job Number: 23-12970

Subject: Subsoil and Foundation Investigation, Johnson Barn/Shop, 29445 Scrub Oak Path, Routt County, Colorado.

Lauren,

This report presents the results of the Subsoil and Foundation Investigation for your proposed barn/shop to be constructed at 29445 Scrub Oak Path in Routt County, Colorado. The approximate location of the project site is shown in Figure #1.

NWCC, Inc. (NWCC) scope of our work included obtaining data from cursory observations made at the site, the logging of one test pit, the sampling of the probable foundation soils and the laboratory testing of the obtained samples. This report presents recommendations for economically feasible and safe type foundations, as well as allowable soil pressures and other design and construction considerations that are advisable, but not necessarily routine to quality design and building practices.

Proposed Construction: NWCC understands that the existing woodshed building will be moved/demolished, and a new barn/shop building will be constructed at the site. We have assumed the new building will be a one-story steel framed structure. We have also assumed the lower level of the new building will be constructed with a concrete slab-on-grade floor system placed near or above the existing ground surface.

For design purposes, we have assumed that the building loads will be light to moderate typical of this type of construction. If loadings or conditions are significantly different from those above, we should be notified to reevaluate the recommendations in this report.

Site Conditions: The building site is situated northwest of the residence building at 29445 Scrub Oak Path in Routt County, Colorado. The site is vegetated wide with landscape, shrubs, occasional pines, and willows to the west. Proposed building sits along the east side of a drainage/swale with willows. Existing detached garage is situated due east to southeast. The site is relatively flat but sits 3-4 feet lower than the gravel driveway.

Subsurface Conditions: To investigate the subsurface conditions at the site, one test pit was advanced on May 8, 2023 with a Yanmar ViO 45 backhoe. The approximate test pit location is shown in Figure #2.

The subsurface conditions encountered generally consisted of a layer of topsoil and organic materials overlying, natural clays to the maximum depth investigated, 6 feet below the existing ground surface (bgs). A graphic log of the exploratory test pit, along with the associated Legend and Notes, are presented in Figure #3.

A layer of natural topsoil and organic materials was encountered at the ground surface and was approximately 24 inches in thickness. Clays were encountered beneath the topsoil and organic materials and extended to a depth of 6 feet bgs. The clays were slightly sandy to very sandy, fine to coarse grained with gravel sized shale fragments, medium stiff, very moist to wet and brown in color.

A swell-consolidation test conducted on a samples of the natural clays indicates the materials tested exhibited a moderate degree of consolidation under initial loading (1,000 psf) and then a low swell potential when wetted under a constant load. The swell-consolidation test results are presented in Figure #4, and all of the other laboratory test results are summarized in the attached Table 1.

Seasonal subsurface runoff/groundwater was encountered at 2 feet in the test pit at the time of excavation. It should be noted that the groundwater conditions at the site can be expected to fluctuate with changes in precipitation and runoff and the flows in the drainage swale.

Foundation Recommendations: Based on the results of the field and laboratory investigations and our experience with similar projects, NWCC believes a safe and economical foundation system will consist of spread or continuous footings placed directly on the natural clays or on properly compacted structural fill materials placed over the natural clays.

The design and construction details presented below should be observed if a shallow foundation system is opted for. The precautions and recommendations itemized below will not prevent movement of the foundations if the underlying clays become wetted and swell. However, they should reduce amount of differential movement beneath the foundation system. Differential movements on the order of 1 to 2 inches could still occur if the clays undergo moisture changes. The owner must be willing to accept the risk of foundation movement associated with placing shallow foundations on expansive soils.

1) Footings placed on the undisturbed, natural clays or proper compacted structure fill designed using an allowable soil bearing pressure of 2,000 psf. A minimum dead load pressure of at least 600 psf should be used to reduce the risk of foundation movement associated with the expansive clays. Based on anticipated geologic site conditions, NWCC recommends a **Site Class C** designation be used in structural design calculations in accordance with Table 20.3-1 in Chapter 20 of ASCE 7-10.

2) Footings or pad sizes should be computed using the above soil pressures and placed on the natural undisturbed clays or on properly compacted structural fill materials placed over the natural sands and gravels.

3) Any topsoil and organic materials, existing fill materials, loose or soft natural soils encountered within the foundation excavations, should be removed and the excavations extended to competent natural soils prior to concrete or structural fill placement. Any fill materials placed beneath the footings should be a non-expansive granular soil approved by this office. Fill materials placed under the footings should be uniformly placed in 6 to 8 inch loose lifts and compacted to at least 100% of the maximum standard Proctor density and within 2% of the optimum moisture content determined in accordance with ASTM D-698. Structural fill materials should extend out from the edge of the footings on a 1(horizontal) to 1(vertical) or flatter slope.

4) Foundation walls should be designed and reinforced to span an unsupported distance of 10 feet or the length between pads, whichever is greater.

5) Footings or pads should be placed well enough below final backfill grades to protect them from frost heave. Forty-eight (48) inches is typical for this location considering normal snow cover and other winter factors.

6) Based on experience, we estimate the total settlement for footings and pads designed and constructed as discussed in this section will be approximately 1 inch. Additional bearing capacity values along with the associated settlements are presented in Figure #4.

7) We strongly recommend the client retain our firm to observe the foundation excavations when they are near completion to identify the bearing soils and confirm the recommendations in this report, as well as test the structure fill materials placed beneath the footings for compaction.

Alternate Foundation Recommendations: An alternative type of foundation system would consist of helical screw piles advanced into the underlying sands and gravels or bedrock material. The helical screw pile foundations will place the bottom of the foundation in a zone of relatively stable moisture content and mitigate the risk of foundation movement from swelling of the natural clays.

Utilizing this type of foundation, each column is supported on a single or group of screw piles, and the structures are founded on grade beams or pile caps supported by a series of piles. Load applied to the piles is transmitted to the natural soils through the end bearing pressure at the helices of the screw pile. Foundation movement should be less than ½-inch if the following design and construction conditions are observed.

The helical screw pile foundation system should be designed by a qualified engineer, using industry standards and be installed by a licensed/certified installer. If pile groups are required, we recommend a minimum pile spacing of 3 times the largest helix to achieve the maximum capacity of each individual pile. Lateral loads should be resisted using battered piles or tiebacks or through passive soil pressures against foundation walls or grade beams.

We strongly recommend at least one test pile be advanced at the site to confirm subsoil conditions and establish torque versus depth relationships to determine the proper shaft and helix size and type. In addition,

load testing of the helical screw piles is strongly recommended to verify the design capacity of the piles. A representative of this office should observe the test pile, load test and helical screw pile installations.

NWCC also recommends the following:

- Minimum 6-inch diameter helix;
- Minimum 8 foot depth of top helix;
- Minimum installation torque of 4,000 ft-lbs;
- Full-time installation observation by a qualified special inspector;
- Review of the Contractor's quality control plan regarding instrumentation calibration and testing, materials QC and pile installation procedures.

Floor Slabs: NWCC understands the lower level of the proposed building will be constructed with a concrete slab-on-grade floor system. The on-site soils, apart from the topsoil and organic materials or any existing fill materials, are capable of supporting slab-on-grade construction. However, floor slabs present a difficult problem where swelling materials are present near floor slab elevation because sufficient dead load cannot be imposed on them to resist the uplift pressure generated when the materials are wetted and expand. Based on the moisture-volume change characteristics of the clays encountered at this site, we believe slab-on-grade construction may be used, provided the risk of distress resulting from slab movement is recognized and special design precautions are followed.

The following measures should be taken to reduce the damage, which could result from movement should the underslab sands and clays be subjected to moisture changes.

1) Floor slabs should be separated from all bearing walls, columns and their foundation supports with a positive slip joint. We recommend the use of ½-inch thick cellotex or impregnated felt.

2) Interior non-bearing partition walls resting on the floor slabs should be provided with a slip joint, preferably at the bottom, so that in the event the floor slab moves, this movement is not transmitted to the upper structure. This detail is also important for wallboard and doorframes and is shown in Figure #6.

3) A minimum 6-inch gravel layer should be provided beneath all floor slabs to act as a capillary break and to help distribute pressures. Prior to placing the gravel, the excavation should be shaped so that if water does get under the slab, it will flow to the low point of the excavation. In addition, all the existing fill materials or topsoil and organic materials should be removed prior to placement of the underslab gravels or new fill materials.

4) Floor slabs should be provided with control joints placed a maximum of 10 to 12 feet on center in each direction, depending on slab configuration, to help control shrinkage cracking. The location of the joints should be carefully checked to assure that the natural, unavoidable cracking will be controlled. The depth of the control joints should be a minimum of ¼ of the thickness of the slab.

5) Underslab soils should be kept as close as possible to their in-situ moisture content. Excessive wetting or drying of these soils prior to placement of the floor slab could result in differential movement after the slabs are constructed.

6) If fills are required to bring the underslab soils to the desired grade, the fill should consist of non-expansive, granular materials. The fill should be uniformly placed and compacted in 6 to 8 inch loose lifts to at least 95% of the maximum standard Proctor density at or near the optimum moisture content, as determined by ASTM D-698.

The above precautions and recommendations will not prevent floor slab movement in the event the clays beneath the floor slabs undergo moisture changes. However, they should reduce the amount of damage if such movement occurs. The only way to eliminate the risk of all floor slab movement is to construct a structural floor over a well-vented crawl space or void form materials.

Perimeter Drainage System: To enhance site drainage and improve foundation and interior slab-on-grade performance, NWCC recommends a perimeter drainage system be installed around the building perimeter. Localized perched water or runoff can infiltrate the structure at the foundation level. This water can be one of the primary causes of differential foundation and slab movement.

The drainage system should be located around the entire building perimeter and be placed and at least 12 inches below interior slab or crawl space grades and a minimum of 24 inches below final grades to provide frost protection. Ideally, the drainage system should be centered along roof drip-line locations. In locations where roof drip-lines are not present, the drainage system may be located within 24 inches of foundation walls. Drains should be insulated using 2-inches of rigid polystyrene insulation board in locations higher than 48 inches below final grade to provide protection against freezing.

Perimeter drainage system piping should be constructed using perforated PVC pipe that meets or exceeds ASTM D-3034/SDR 35 requirements to provide satisfactory long-term function and rapid runoff of water. The holes in the drainpipes should be oriented down between 4 o'clock and 8 o'clock to promote rapid runoff of the water. The drainpipes should be covered with at least 12 inches of free draining gravel and be protected from contamination by a geotextile filter fabric covering of Mirafi 140N subsurface drainage fabric or an equivalent product. The drainpipes should have a minimum slope of 1 percent and be daylighted at positive outfalls that are protected from freezing. If the drainpipes cannot be daylighted, the drains should be led to sumps where the water can be pumped. Multiple daylights or sumps are recommended for the proposed structures. A typical shallow perimeter/drain detail is shown in Figure #7.

Caution should be taken when backfilling so as not to damage or disturb the installed drains. NWCC recommends the drainage piping include cleanouts provided at minimum 100-foot intervals, be protected against intrusion by animals at the outfalls and be tested prior to backfilling. NWCC should be retained to provide periodic observations of underdrain construction to verify installation has been accomplished in general accordance with these recommendations. Flow testing of the system is recommended.

Foundation Walls and Retaining Structures: Foundation walls and retaining structures, which are laterally supported and can be expected to undergo only a moderate amount of deflection, may be designed for a

lateral earth pressure computed on the basis of an equivalent fluid unit weight of 45 pcf for imported, free draining granular backfill and 55 pcf for the on-site soils.

Cantilevered retaining structures on the site can be expected to deflect sufficiently to mobilize the full active earth pressure condition. Therefore, cantilevered structures may be designed for a lateral earth pressure computed based on an equivalent fluid unit weight of 35 pcf for imported, free draining granular backfill and 45 pcf for the on-site soils.

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

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

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

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

Surface Drainage: Proper surface drainage at this site is of paramount importance for minimizing the infiltration of surface drainage into the wall backfill and bearing soils, which could result in increased wall pressures, differential foundation and slab movement. The following drainage precautions should be observed during construction and at all times after the structures have been completed:

1) Ground surface surrounding the structures should be sloped (minimum of 1.0 inch per foot) to drain away from the structures in all directions to a minimum of 10 feet. Ponding must be avoided. If necessary, raising the top of foundation walls to achieve a better surface grade is advisable.

2) Non-structural backfill placed around the structures should be compacted to at least 95% of the maximum standard Proctor density at or near the optimum moisture content in order to minimize

future settlement of the fill. The backfill should be placed immediately after the braced foundation walls are able to structurally support the fill. Puddling or sluicing must be avoided.

3) Top 2 to 3 feet of soil placed within 10 feet of the foundations should be impervious in nature to minimize infiltration of surface water into the wall backfill.

4) Roof downspouts and drains should discharge well beyond the limits of all backfill. Roof overhangs, which project two to three feet beyond the foundations, should be considered if gutters are not used.

5) Landscaping, which requires excessive watering and lawn sprinkler heads, should be located a minimum of 10 feet from the foundation walls of the structures.

6) Plastic membranes should not be used to cover the ground surface adjacent to foundation walls.

Limitations: The recommendations provided in this report are based on the soils encountered at this site and our understanding of the proposed construction. We believe that this information gives a high degree of reliability for anticipating the behavior of the proposed structures; however, our recommendations are professional opinions and cannot control nature, nor can they assure the soils profiles beneath those or adjacent to those observed. No warranties expressed or implied are given on the content of this report.

Expansive soils were encountered at this site. These soils are stable at their natural moisture content but can shrink or swell with changes in moisture and loading. The behavior of expansive soils is not fully understood. The swell and/or consolidation potential of any particular site can change erratically both in lateral and vertical extent. Moisture changes also occur erratically, resulting in conditions, which cannot always be predicted. The recommendations presented in this report are based on the current state of the art for foundations and floor slabs on swelling/consolidating soils. The owner should be aware that there is a risk in construction on these types of soils. Performance of the structures will depend on following the recommendations and in proper maintenance after construction is complete. As water is the main cause for volume change in the soils, it is necessary that the changes in moisture content be kept to a minimum. This requires judicious irrigation and providing positive surface drainage away from the structures. Any distress noted in the structures should be brought to the attention of this office.

This report is based on the investigation at the described site and on the specific anticipated construction as stated herein. If either of these conditions is changed, the results would also most likely change. Therefore, NWCC strongly recommends that our firm be contacted prior to finalizing the construction plans so that we can verify that our recommendations are being properly incorporated into the construction plans. Man-made or natural changes in the conditions of a property can also occur over a period of time. In addition, changes in requirements due to state of the art knowledge and/or legislation do from time to time occur. As a result, the findings of this report may become invalid due to these changes. Therefore, this report is subject to review and not considered valid after a period of 3 years or if conditions as stated above are altered.

It is the responsibility of the owner or his representative to ensure that the information in this report is incorporated into the plans and/or specifications and construction of the project. It is advisable that a

contractor familiar with construction details typically used to dealing with the local subsoils and climatic conditions be retained to build the structures.

If you have any questions regarding this report or if we may be of further service, please do not hesitate to contact us.

Sincerely,
NWCC, INC.

Enrique M. Lopez
Project Engineer

COLORADO LICENSED
BRIAN D. LEE
25750
PROFESSIONAL ENGINEER

Reviewed by Brian D. Lee, P.E.
Principal Engineer

CC. Kevin Meyer-Anthem

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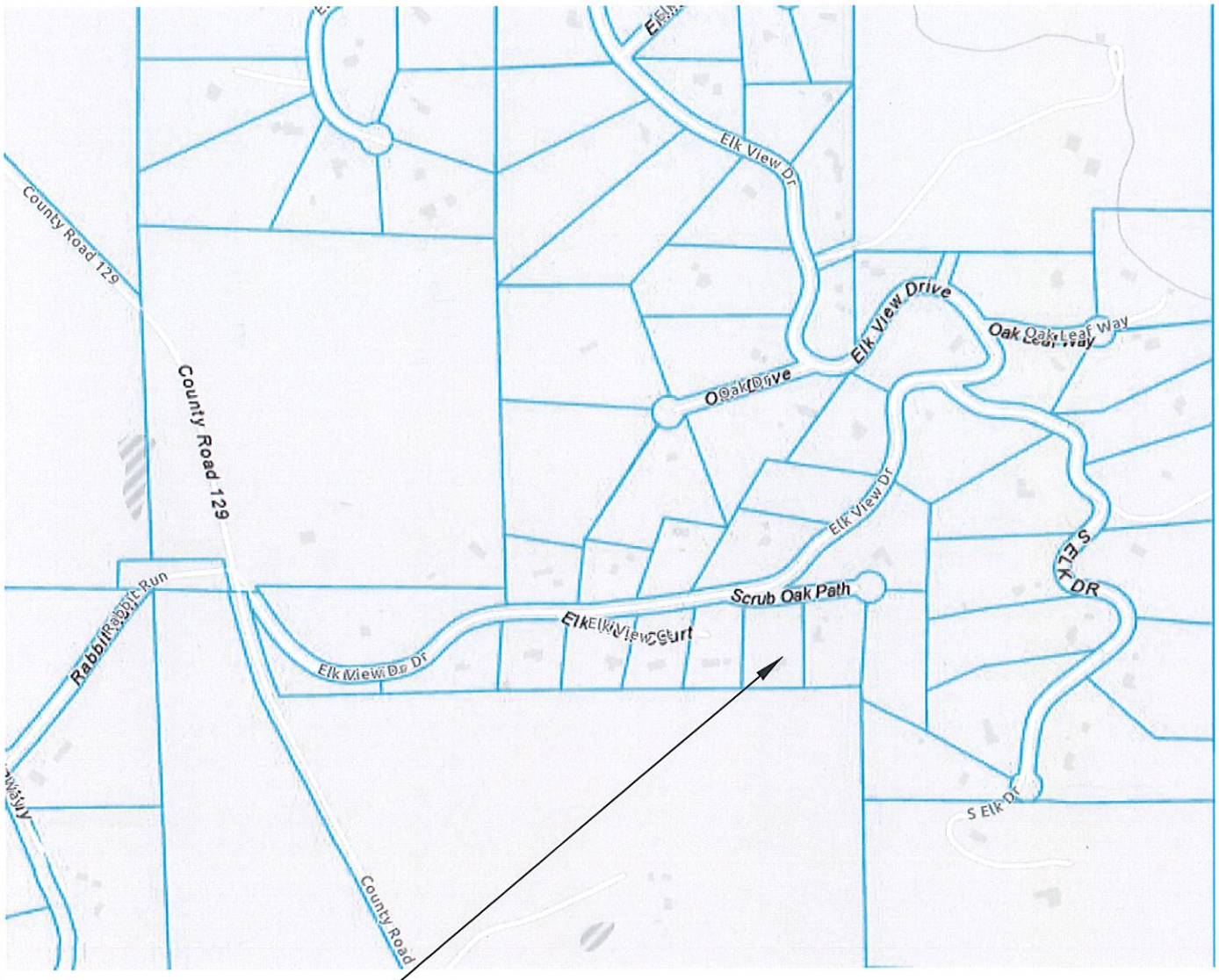
(NOT-TO-SCALE)



PROJECT SITE

Title: VICINITY MAP	**Date:** 5/15/2023	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Proposed Johnson Barn/Shop	**Job No.:** 23-12970	(970)879-7888 Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 29445 Scrub Oak Path, Routt County, Colorado	**Figure:** #1	

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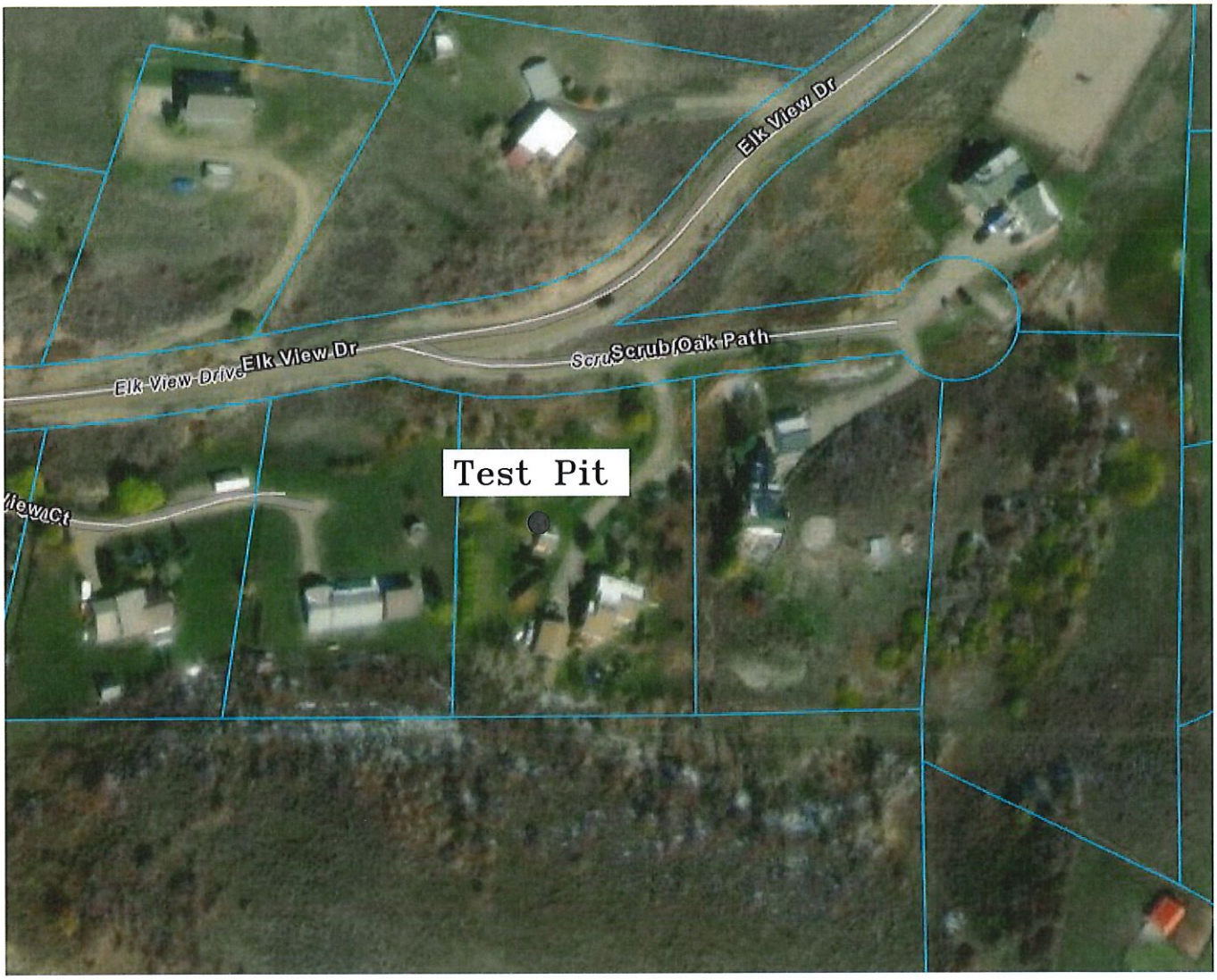
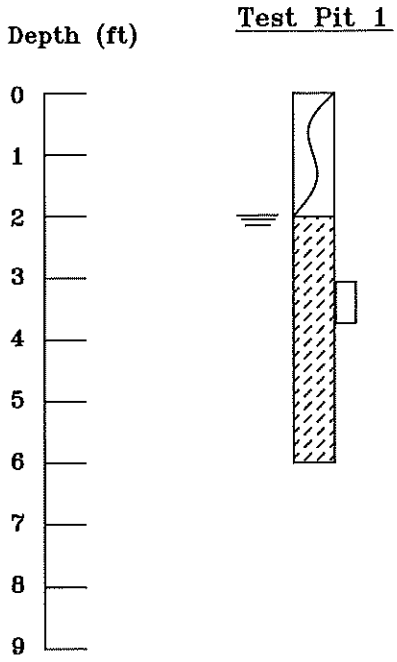
NOT TO SCALE



Title: SITE PLAN–LOCATION OF TEST HOLE	Date: 5/15/23	NWCC Northwest Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Proposed Johnson Barn/Shop	Job No. 23–12970	(970)879-7888 • Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 29445 Scrub Oak Path, Routt County, Colorado	Figure #2	



LEGEND:

TOPSOIL AND ORGANICS.

CLAY: Slightly Sandy to very sandy with gravel sized shale fragments, fine to coarse grained, moderately to highly plastic, medium stiff, very moist to wet and brown.

Hand Drive Sample – 2" California Liner.

Indicates depth at which groundwater was encountered while excavating.

NOTES:

1) Test pit was excavated on May 8, 2023 with a Yanmar Vi0 45 backhoe.

2) Test pit location was determined in the field by the client.

3) Elevation of the test pit was not measured and the log is drawn to the depth investigated.

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

Title: LOG, LEGEND AND NOTES		Date: 5/15/23
Job Name: Proposed Johnson Barn/Shop		Job No. 23-12970
Location: 29445 Scrub Oak Path, Routt County, Colorado		Figure #3

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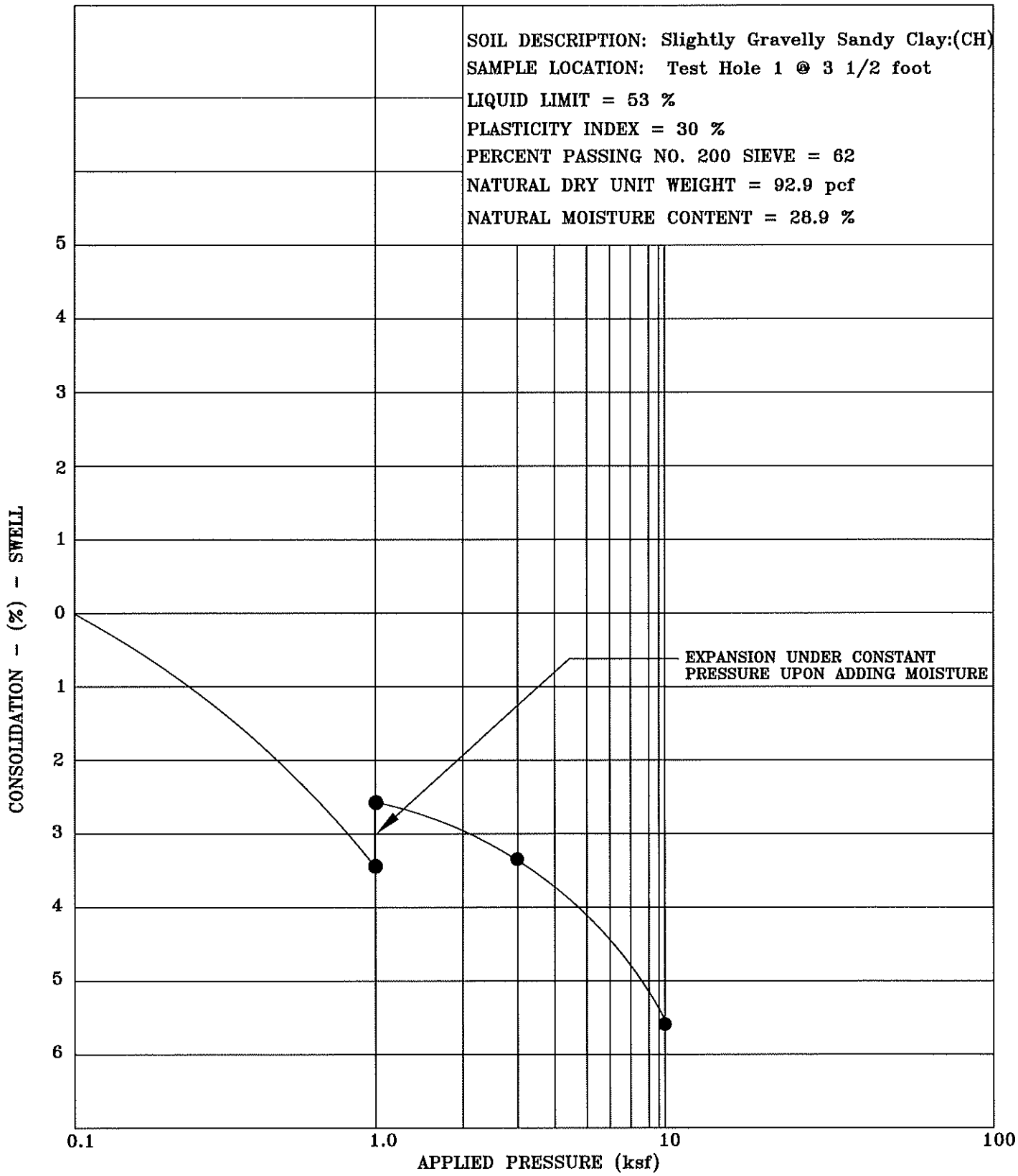

Title: SWELL–CONSOLIDATION TEST RESULTS		Date: 5/15/23	
Job Name: Proposed Johnson Barn/Shop		Job No. 23-12970	
Location: 29445 Scrub Oak Path, Routt County, Colorado		Figure #4	

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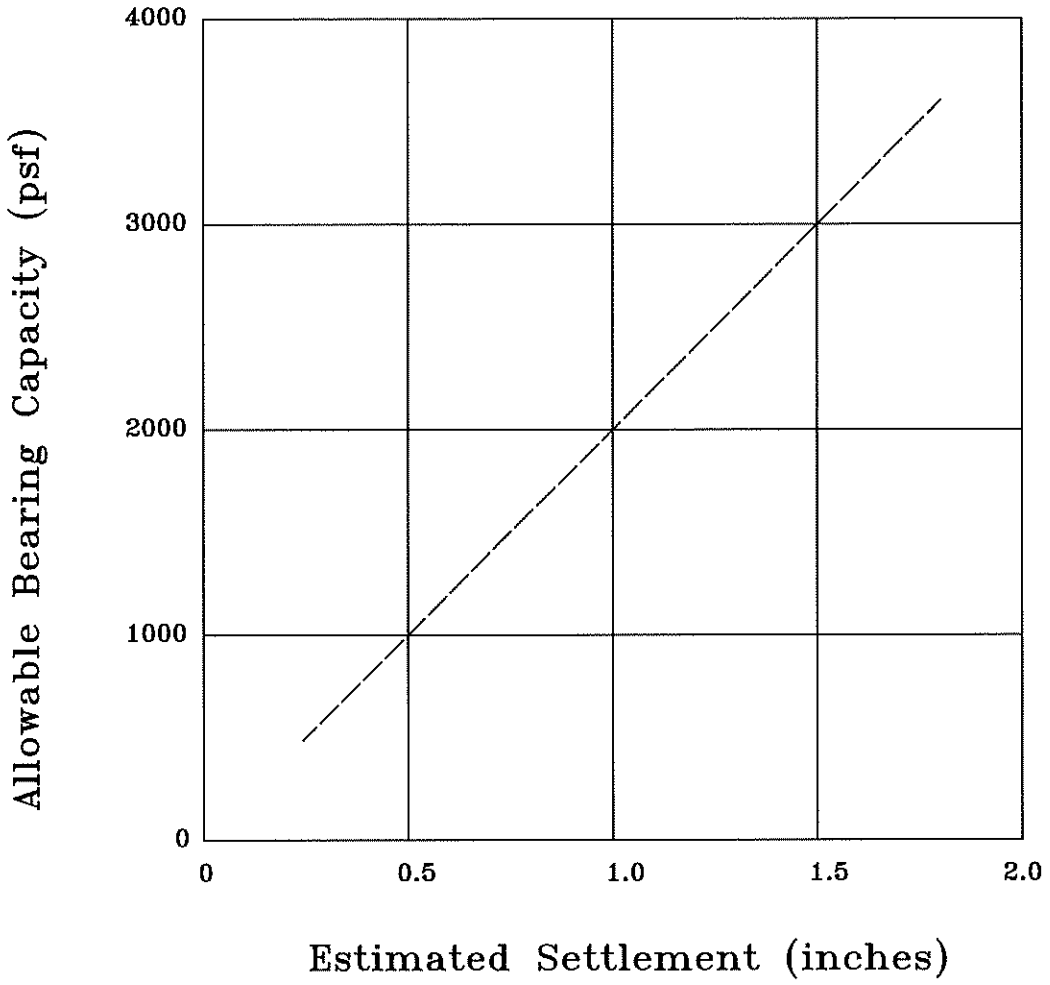
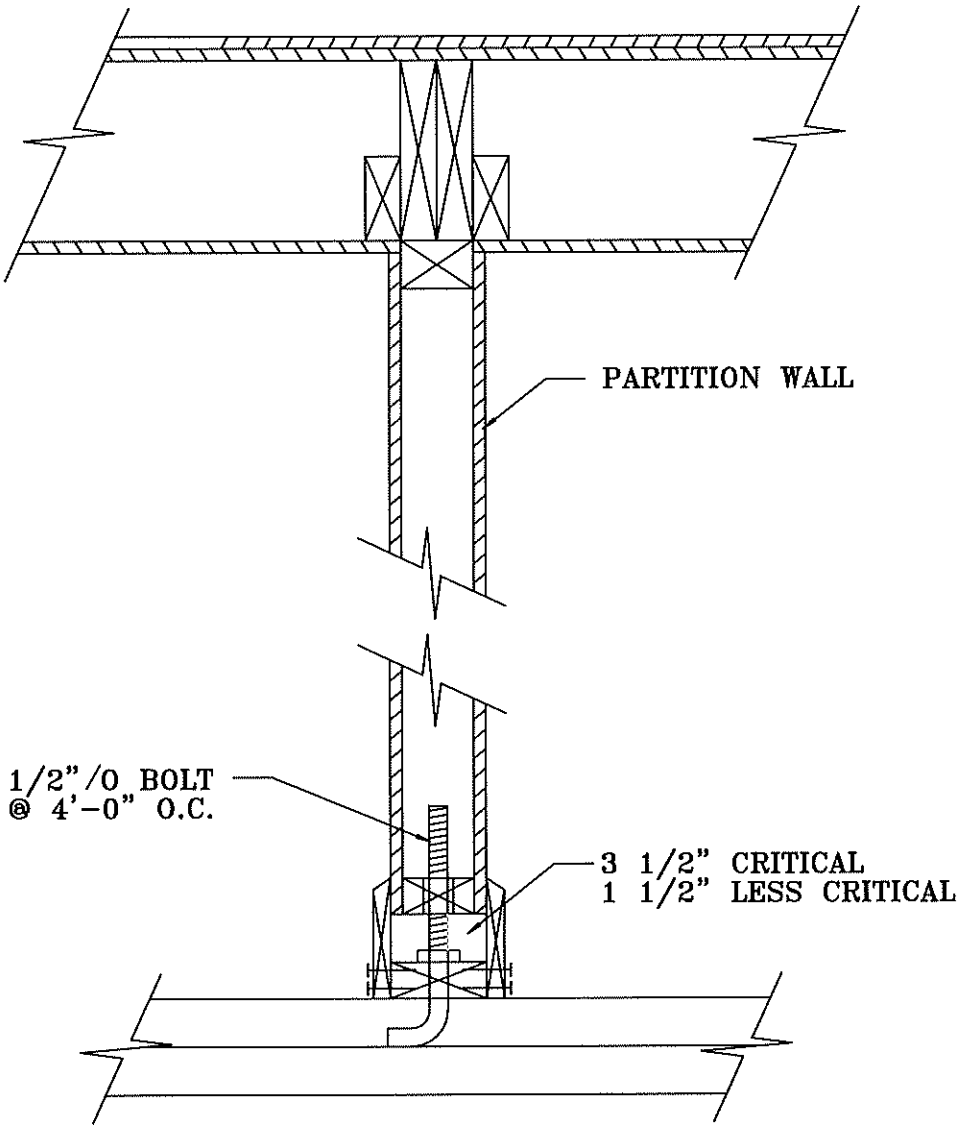


Note: These values are based on footing widths of 1 to 4 feet. If the footing width is to be greater than 4 feet in width, then we should be notified to re-evaluate these recommendations.

Title: BEARING CAPACITY CHART	Date: 5/15/23	NWCC Northwest Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Proposed Johnson Barn/Shop	Job No. 23-12970	(970)879-7888 - Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 29445 Scrub Oak Path, Routt County, Colorado	Figure #5	



Title: HUNG PARTITION WALL DETAIL	Date: 5/15/23	
Job Name: Proposed Johnson Barn/Shop	Job No. 23-12970	
Location: 29445 Scrub Oak Path, Routt County, Colorado	Figure #6	

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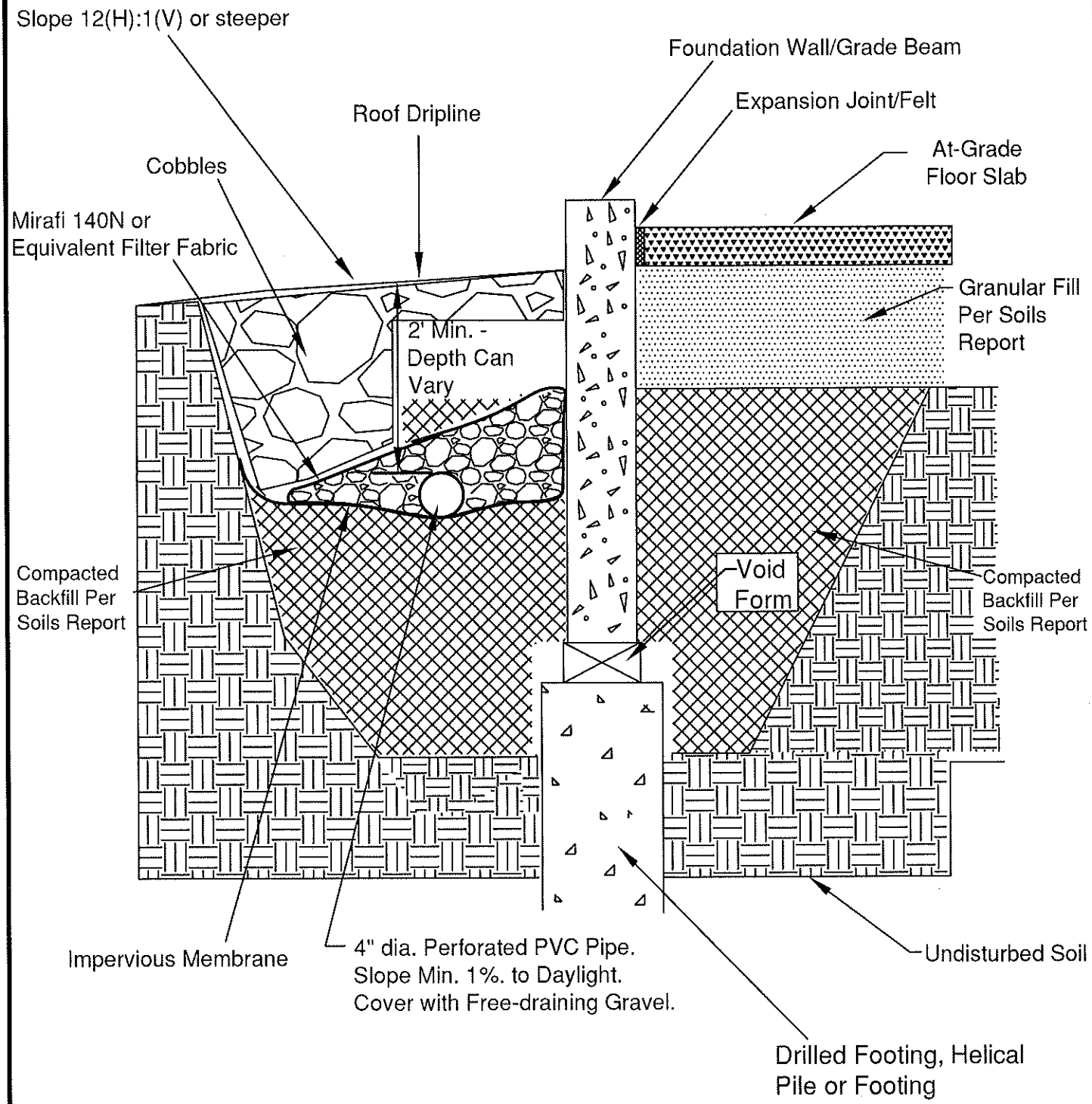

Title: SHALLOW PERIMETER DRAIN DETAIL		**Date:** 5/15/23	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing (970)879-7888 - Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Job Name: Proposed Johnson Barn/Shop		**Job No.** 23-12970	
Location: 29445 Scrub Oak Path, Routt County, Colorado		**Figure** #7	

NWCC, Inc.

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	ATTERBERG LIMITS		GRADATION		PERCENT PASSING No. 200 SIEVE	UNCONFINED COMPRESSIVE STRENGTH (psf)	SOIL or BEDROCK DESCRIPTION	UNIFIED SOIL CLASS.
TEST Pit	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
1	3 1/2	28.9	92.9	53	30	6	32	62		Slightly Gravelly Sandy Clay	CH

JOB NUMBER: 22-12970