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

REVIEWED FOR CODE COMPLIANCE
04/01/2022

November 30, 2020

Kristen Feiges
PO Box 775731
Steamboat Springs, CO 80477

Job Number: 20-12032

Subject: Subsoil and Foundation Investigation, Proposed Feiges Barn & Greenhouse, 28880 County Road 14A, Routt County, Colorado.

Kristen,

This report presents the results of the Subsoil and Foundation Investigation for the Feiges barn and greenhouse to be constructed at 28880 County Road 14A 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 either a wood-framed or steel-framed single-story barn and a 33 or 42-foot diameter wood-framed geodesic greenhouse will be constructed at the site. We understand the floors of the barn and the greenhouse will be dirt floors.

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 north of County Road 14A approximately 850 feet west of the intersections of County Road 14 and County Road 14A in Routt County, Colorado. The site was vacant at the time of our investigation. Vegetation at the building site consists of hay grasses. The topography at the site consists of a gentle rise running generally east to west. The site slopes down to the north and east towards a southeast to northwest running irrigation ditch. To the south, the site slopes gently to the south where it meets County Road 14A. The proposed site location is in the general vicinity of the rises highest point. A maximum elevation difference of approximately 2 to 4 feet exists across the building sites.

Subsurface Conditions: To investigate the subsurface conditions at the site, one test pit was advanced on November 5, 2020, with a trackhoe. 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 overlying natural sands that extended to the maximum depth investigated, 7 ½ 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 topsoil and organic materials was encountered at the ground surface in the pit and was approximately 18 inches in thickness. Clays were encountered below the topsoil and organics and extended to a depth of 5 ½ feet bgs. The clays were nil to slightly sandy, moderately to highly plastic, fine-grained stiff to very stiff, slightly moist to moist, and light brown to brown in color. A sample of the clays classified as a CL soil in accordance with the Unified Soil Classification System. The sands were clayey, fine to coarse-grained with gravels and cobbles, low to moderately plastic, medium dense, moist, and brown to red-brown in color. A sample of the sands classified as a SC soil in accordance with the Unified Soil Classification System.

Swell-consolidation testing conducted on a sample of the clays indicates the materials tested exhibited a moderate swell potential when wetted under a constant load. The swell-consolidation test results are presented in Figure #4, and other laboratory test results are summarized in the attached Table 1.

Groundwater was not encountered 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.

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 sands found below the clays, topsoil, and organic materials, or on properly compacted structural fill materials placed over the natural sands after the clays are removed.

The design and construction details presented below should be observed if a shallow foundation system is opted for.

1) Based on the swell potential of the natural clays, all footing excavations should be extended through the topsoil and organic layer and the natural clays and into the underlying sands.

2) Footings placed on the undisturbed, sands or properly compacted structural fill materials placed over the sands should be designed using an allowable soil bearing pressure of 3,000 psf, a minimum dead load will not be required. 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.

3) Footings or pad sizes should be computed using the above soil pressures and placed on the natural undisturbed sands found below the topsoil and organic material and natural clays, or on properly compacted structural fill materials placed over the sands.

4) Any topsoil and organic materials or clays found beneath the footings when excavations are opened should be removed and footings extended down to the underlying sands prior to concrete or structural fill placement. Any fill materials placed beneath the footings should be a non-expansive granular soil approved by NWCC prior to placement. Fill materials placed under the footings should be uniformly placed and compacted in 6 to 8 inch loose lifts and compacted to at least 100% of the maximum standard Proctor density and within 2% of the optimum moisture content determined in accordance with ASTM D-698.

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

6) 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.

7) Based on experience, NWCC estimates 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 #5.

8) NWCC must be retained by the client to observe the foundation excavations when they are near completion to identify bearing soils and confirm the recommendations in this report, as well as test the structural fill materials placed under the footings for compaction.

Alternate Foundation Recommendations: If the owner is aware of the risks associated with placing shallow foundations on expansive soils and can tolerate and/or design for differential movements that could result if the natural clays become wetted and swell, then the structure may be supported by spread, drilled or continuous footings founded on undisturbed 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 underlying clays become wetted and swell. However, they should reduce the amount of differential movement beneath the foundation system. Differential movements on the order of 1 to 2 inches could still occur if 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 natural clays should be designed using an allowable soil bearing pressure of 3,000 psf. Footings should also be designed using a minimum dead load pressure of at least 1,200 psf to reduce the risk of foundation movement.

2) Footings or pad sizes should be computed using the above soil pressures and placed on the natural clays encountered below the topsoil and organic materials.

3) Any topsoil and organic materials or soft natural clays found beneath the footings when excavations are opened should be removed and footings extended down to competent natural clays or sands prior to concrete placement. Footings may have to be narrow or interrupted to maintain the minimum dead load. Foundation design should be closely checked to assure that it distributes loads per the allowable pressures given.

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, NWCC estimates total settlement for footings and pads designed and constructed as discussed in this section will be approximately 1 inch.

7) NWCC should be retained by the client to observe the foundation excavations when they are near completion to identify bearing soils and confirm the recommendations in this report.

Floor Slabs: NWCC understands the floors of the proposed barn and greenhouse will consist of dirt and soil. However, if the client opts to construct concrete slab-on-grade floor systems, we recommend the following recommendations be followed to reduce the risk of floor slab movement.

The on-site soils, apart from the topsoil and organic 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 sands and 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 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 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) Due to the expansive nature of the natural clays, ideally all of the clays should be removed down to the natural sands. The clays should then be replaced with a well compacted, non-expansive fill. If removal of all clay materials is not economically feasible, NWCC recommends at least 2 feet of the expansive clays be removed and replaced with a well compacted, non-expansive fill.

7) The fill should consist of non-expansive, granular materials. Fill should be uniformly placed and compacted in 6 to 8-inch 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, or remove all of the clays.

Underdrain System Recommendations: NWCC understands the floor levels of the proposed barn and greenhouse will consist of dirt and soil. NWCC assumes that the floor levels for the barn and/or greenhouse will be situated slightly above the finished ground surface around the exterior of the buildings. To enhance site drainage and improve foundation performance, NWCC recommends a shallow perimeter drainage system be installed around the perimeter of the buildings. Localized runoff can infiltrate the structures at the foundation level. This water can be one of the primary causes of differential foundation and slab movement.

The drainage systems should be located around the entire building perimeter and be placed and at least 12 inches below interior floor 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. A typical perimeter/underdrain 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 systems is also recommended.

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 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 soil 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, the changes in moisture content must 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 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 deal 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.

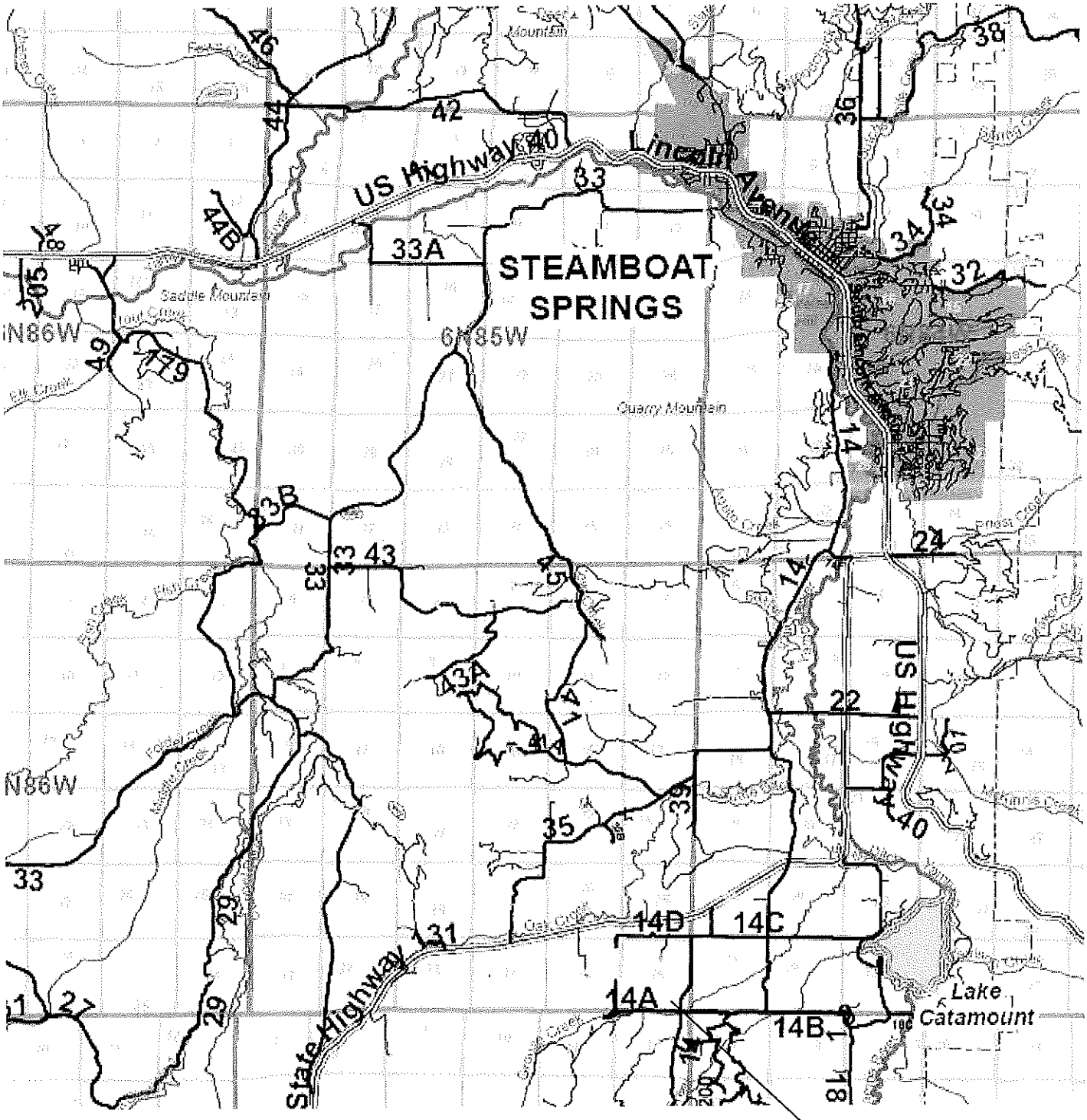
Sincerely,
NWCC, INC.

Bjorn R. Lund, E.I.T.
Project Engineer

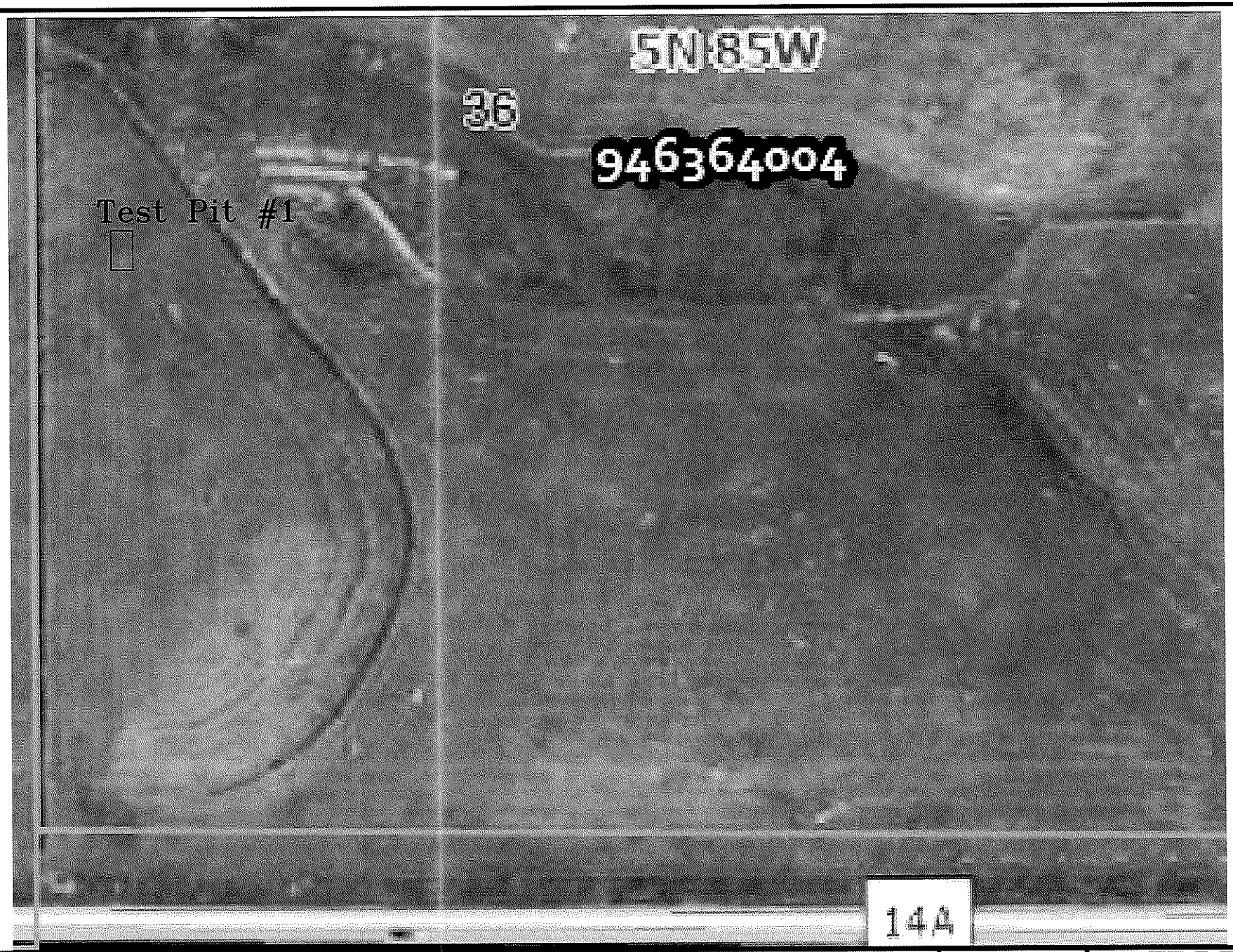
COLORADO LICENSED BRIAN D. DEN 25750 PROFESSIONAL ENGINEER

12/2/20

Reviewed by: Brian D. Den, P.E.
Principal Engineer



Title: VICINITY MAP	**Date:** 11/9/2020	NWCC Northwest Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Proposed Feiges Barn & Greenhouse	**Job No.** 20-12032	(970)879-7888- Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 28880 County Road 14A, Routt County, CO	**Figure** #1	



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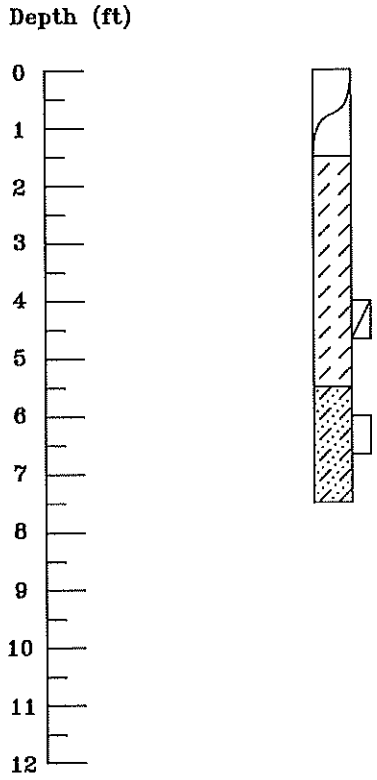
NOT TO SCALE

Title: SITE PLAN – TEST PIT LOCATIONS		Date: 11/9/2020
Job Name: Proposed Feiges Barn & Greenhouse		Job No. 20-12032
LOCATION: 28880 County Road 14A, Routt County, CO		Figure #2

NWCC
North West Colorado Consultants, Inc.
Geotechnical / Environmental Engineering - Materials Testing
(970)879-7688- Fax (970)879-7691
2550 Copper Ridge Drive
Steamboat Springs, Colorado 80487

Test Pit 1



LEGEND:

TOPSOIL.

CLAY: Nil to slightly sandy, moderately to highly plastic, fine grained, stiff to very stiff, slightly moist to moist and light brown to brown.

CLAYEY SAND: Fine to coarse grained with gravels and cobbles, low to moderately plastic, medium dense, moist, brown to red brown.

Hand Drive Sample–California Liner.

Small Disturbed Sample.

NOTES:

1) Test pit was excavated on November 5, 2020 with a Yanmar Vio 45 trackhoe.

2) Test pit location was determined by the client by pacing from existing site features.

3) The 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: 11/10/2020
Job Name: Proposed Feiges Barn & Greenhouse	Job No. 20-12032
Location: 28880 County Road 14A, Routt County, CO	Figure #3

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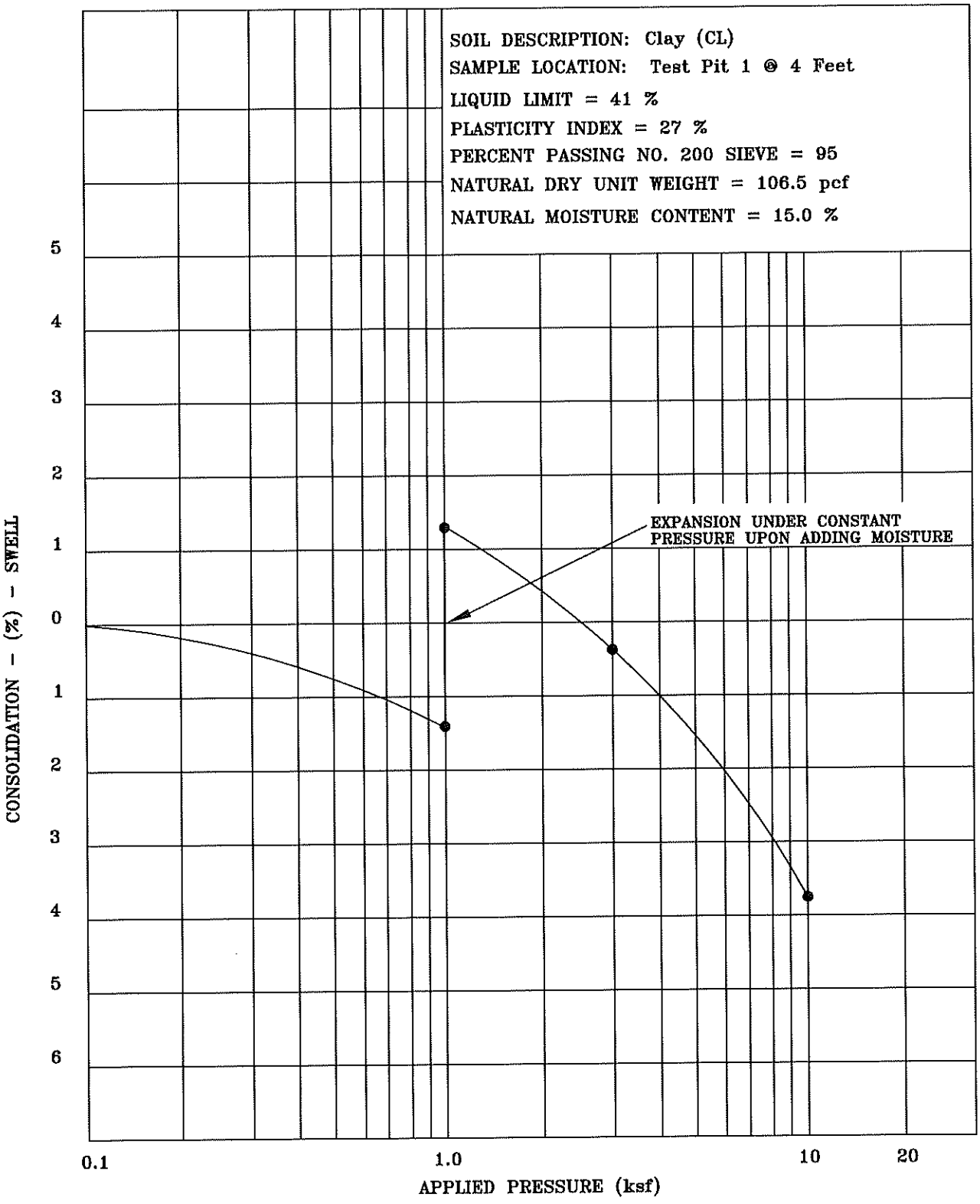
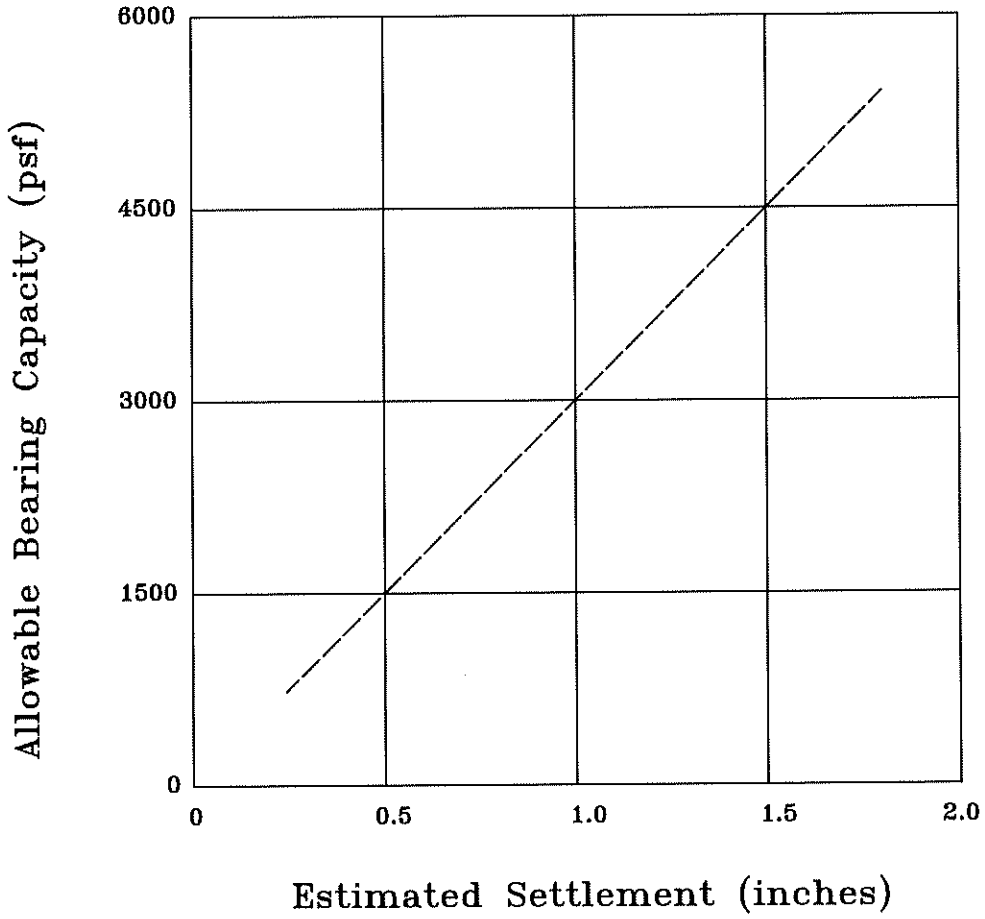
Geotechnical / Environmental Engineering - Materials Testing
(970)879-7688 - Fax (970)879-7891
2580 Copper Ridge Drive
Steamboat Springs, Colorado 80487

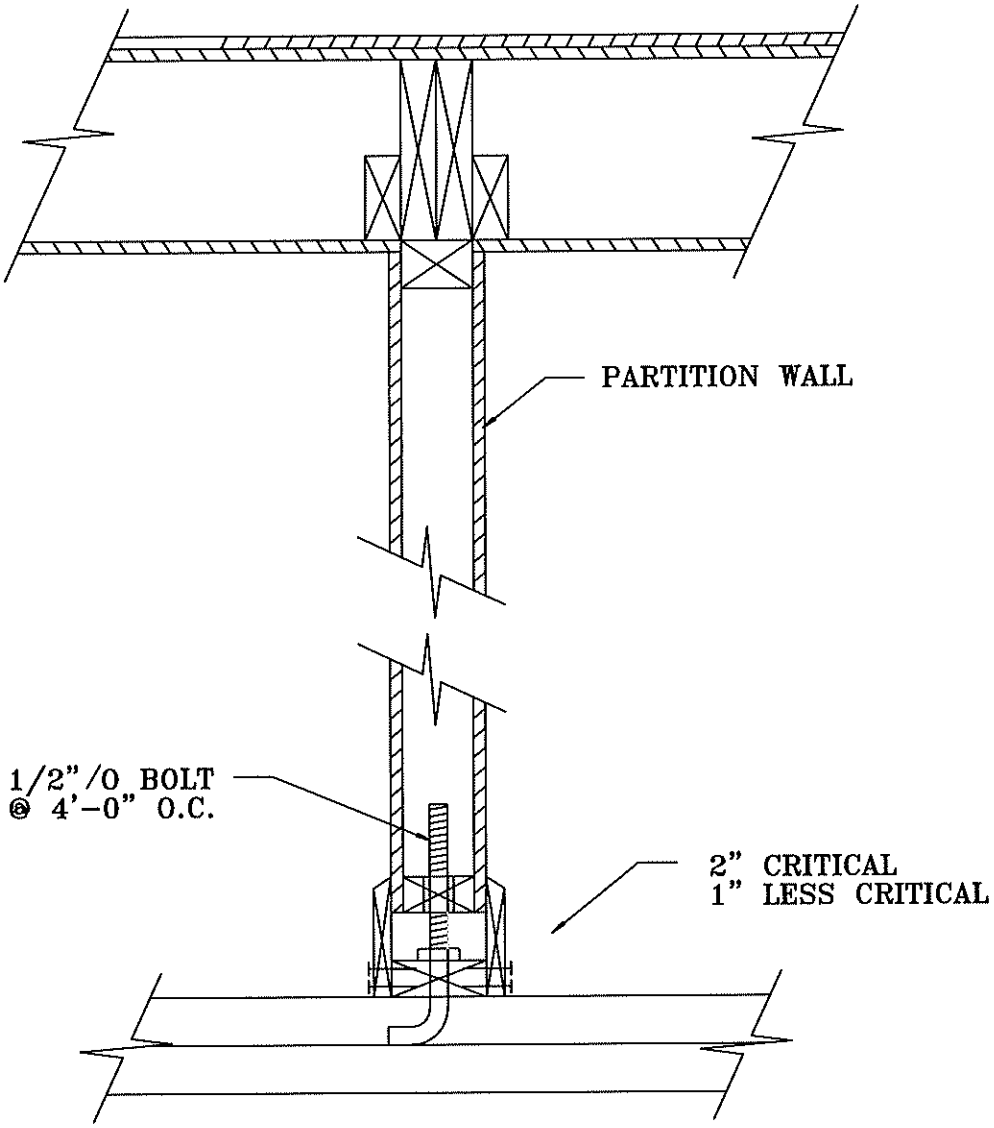


Title: SWELL-CONSOLIDATION TEST RESULTS		Date: 11/10/2020	NWCC North West Colorado Consultants Inc Geotechnical / Environmental Engineering - Materials Testing (970)879-7888 - Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Job Name: Proposed Feiges Barn & Greenhouse		Job No. 20-12032	
Location: 28880 County Road 14A, Routt County, Colorado		Figure #4	

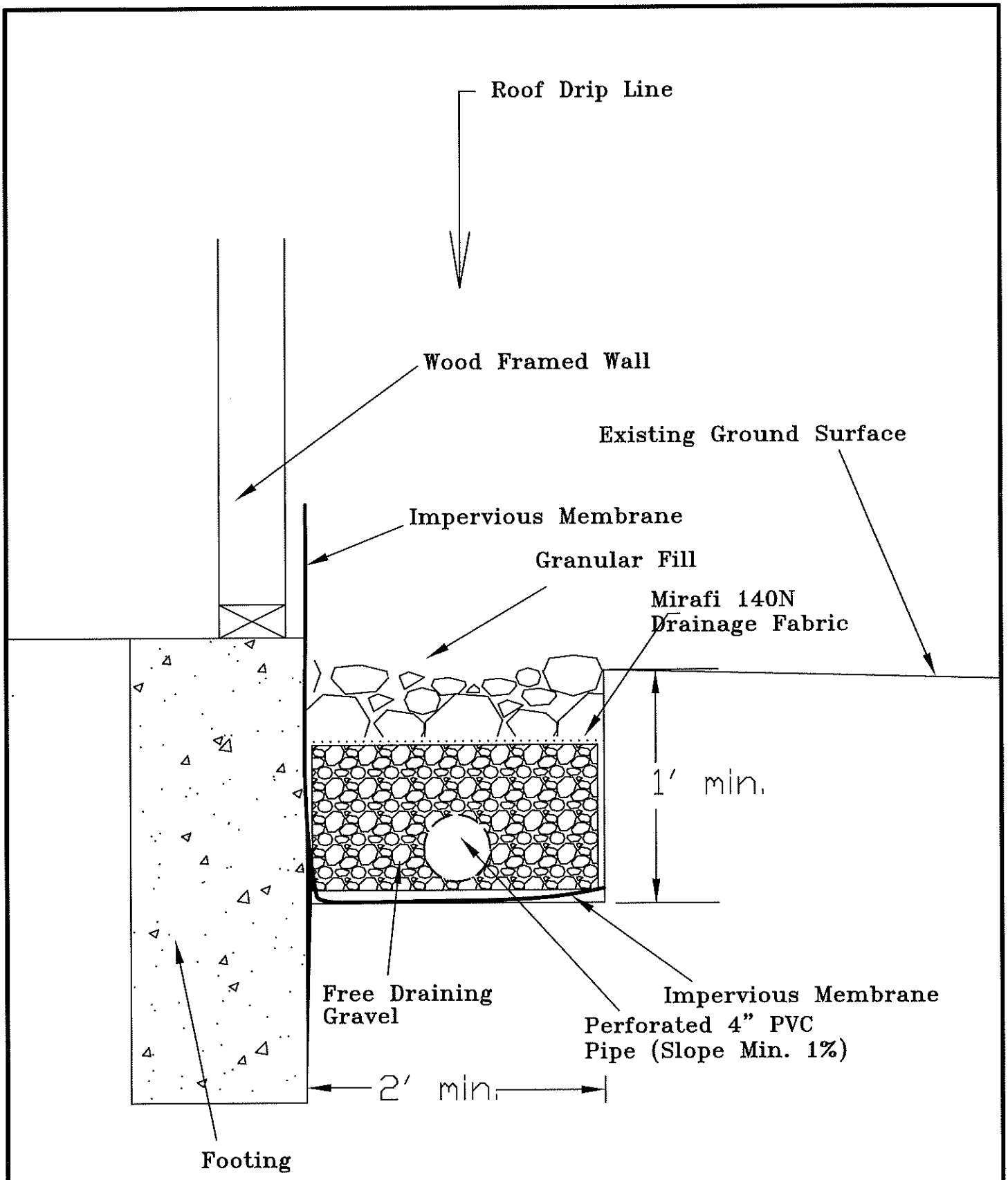


Note: These values are based on footing widths of 1 to 4 feet. If the footing width is to be greater than 4 feet in width, then we should be notified to re-evaluate these recommendations.

Title: BEARING CAPACITY CHART	Date: 11/10/2020	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Proposed Feiges Barn & Greenhouse	Job No. 20-12032	(970)879-7888 - Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 28880 County Road 14A, Routt County, CO	Figure #5	



Title: HUNG PARTITION WALL DETAIL	Date: 11/10/2020	NWCC Northwest Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing
Job Name: Proposed Feiges Barn & Greenhouse	Job No. 20-12032	(970)879-7688 Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Location: 28880 County Road 14A, Routt County, CO	Figure #6	



Title: PERIMETER DRAINAGE SYSTEM CROSS SECTION	Date: 11/19/2020	NWCC Northwest 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 Feiges Barn & Greenhouse	Job No. 20-12032	
Location: 28880 County Road 14A, 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	4	15.0	106.5	41	27	0	5	95		Clay	CL
1	6	6.5		30	19	7	74	19		Clayey Sand	SC

JOB NUMBER: 20-12032