North West Colorado Consultants, Inc.
Geotechnical / Environmental Engineering • Materials Testing
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1992 - 2012

December 13, 2013

Susan Crites
P.O. Box 771441
Steamboat Springs, CO 80477

Job Number: 13-9601

Subject: Subsoil and Foundation Investigation, Proposed Crites Residence, 41 McKinley Street, Steamboat Springs, Colorado.

Dear Sarah,

This report presents the results of the Subsoil and Foundation Investigation for the proposed Crites Residence to be constructed at 41 McKinley Street in Steamboat Springs, Colorado. The approximate location of the project site is shown on Figure 1.

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

**Proposed Construction**: Building plans were not available at the time of this investigation. NWCC assumes the proposed construction will generally consist of a one to two-story wood-framed structure constructed over a full-depth walkout lower level basement and an attached garage. Based on site topography, NWCC has also assumed that the lower levels of the residence and garage will be constructed utilizing concrete slab-on-grade floor systems placed from 0 to 8 feet below the existing ground surface. Based on topography, site grading is assumed to consist of unretained cuts and fills less than 6 feet in height or depth.

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

**Site Conditions:** Proposed building site is located at the north end of McKinley Street in Steamboat Springs, Colorado. An existing residence is located in the southwest portion of the site. The proposed residence will be constructed north of the existing residence, in the central portion of the lot. The

vegetation at the proposed building site consisted of grasses and weeds. Butcherknife Creek is located north of the property.

Site topography is variable and generally slopes gently to moderately down to the north on the order of 6 to 10 percent. A maximum elevation difference of approximately 5 to 8 feet appears to exist across the proposed building site.

**Subsurface Conditions:** To investigate the subsurface conditions, one test pit was advanced on November 13, 2013. A site plan showing the existing and proposed features and approximate test pit location is presented on Figure 2.

Subsurface conditions encountered were variable and generally consisted of a layer of topsoil and organic materials overlying natural clays to the maximum depth investigated, 8 feet beneath the existing ground surface (bgs). A graphic log of the exploratory test pit and the associated Legend and Notes, are presented on Figure 3.

A layer of natural topsoil and organic materials was encountered at the ground surface and was 30 inches in thickness. Natural clays were encountered beneath the topsoil and organic materials and extended to the maximum depth investigated. The clays were sandy, fine-grained, moderately plastic, very stiff to stiff, slightly moist to moist and light brown to brown in color. Samples of the natural clays classified as CL soils in accordance with the Unified Soil Classification System (USCS).

Swell-consolidation tests conducted on samples of the natural clays indicate the materials tested will exhibit a low to moderate swell potential when wetted under a constant load. The swell-consolidation test results are presented on Figures 4 and 5, and all of the other laboratory test results are summarized on Table 1.

Groundwater was not encountered in the test pit at the time of our investigation. It should be noted that the groundwater conditions at the site can be expected to fluctuate with seasonal changes in precipitation and runoff.

**Foundation Recommendations:** NWCC recommends the proposed residence be supported on a deep foundation advanced into the underlying clays based on the presence of moderately expansive soils at proposed shallow foundation grades. Shallow foundations placed on expansive soils similar to those encountered at this site can experience excessive differential foundation and floor slab movement.

NWCC recommends the foundation system consist of drilled straight-shaft skin friction/end bearing piers advanced into the underlying clays. Because the investigation depths associated with this investigation were limited to the upper 8 feet, NWCC strongly recommends at least one test hole be advanced at the site prior to finalizing the foundation design so the deeper subsurface/bedrock conditions can be evaluated.

Outlined below are design recommendations for a drilled pier foundation system. Differential foundation movement of one-half inch or less is anticipated for the drilled pier system.

1) A minimum pier diameter of 12 inches and a minimum pier length of 20 feet are recommended. A maximum pier length to diameter ratio of 25 should be used in pier design.

2) Piers should be designed using allowable skin friction value of 900 psf for the portion of the pier into the natural clays. An allowable end bearing pressure of 4,000 psf may also be used for properly cleaned and inspected piers in the natural clays.

3) Upper 5 feet of the pier penetration should be neglected in the skin-friction calculations.

4) A drill rig of sufficient size and operating condition should be used so piers holes can be properly cleaned and minimum length requirements can be achieved.

5) Piers should be reinforced their full length with at least one No. 5 reinforcing bar for each 16 inches of pier perimeter.

6) Piers should be properly cleaned and dewatered prior to steel and concrete placement.

7) A 4-inch void should be provided beneath grade beams to prevent the swelling soils from exerting uplift forces on grade beams and to concentrate pier loadings. A void should also be provided beneath necessary pier caps.

8) NWCC strongly recommends that at least one test hole be advanced at the building site prior to pier drilling operations.

9) NWCC should observe all test hole and pier drilling operations.

**Alternate Foundation Recommendations:** If the owner is aware of the risks associated with placing shallow foundations on swelling soils and can tolerate and/or design for the differential movements that could result if the expansive clays swell, then the structure may be supported by spread footings founded on 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 the movement of foundations if underlying clays become wetted and swell; however, they should reduce the amount of differential movement. Differential foundation movements of 1 to 2 inches are possible if the clays are subjected to wetting conditions.

1) Footings placed on the undisturbed natural clays should be designed using an allowable soil bearing pressure of 3,000 psf and a minimum dead load pressure of 1,000 psf.

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

3) Topsoil and organic materials found at proposed footings elevations should be removed and excavations extended down to the undisturbed clays 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 the 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) Continuous footings or pads should be placed well enough below final backfill grades to protect them from frost heave. Forty-eight (48) inches is recognized by the regional building authority as the minimum footing burial depth.

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

**Floor Slabs:** NWCC assumes the lower levels of the residence and garage will be constructed with concrete slab-on-grade floor systems. On-site soils, with the exception of topsoil and organic materials, are capable of supporting slab-on-grade construction. However, floor slabs present a very 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 natural clays, NWCC believes 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 must be taken to reduce structural damage that could result from movement should the underslab clays be subjected to moisture changes.

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

2) Interior non-bearing partition walls resting on the floor slabs must 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 on Figure 6.

3) A minimum 6-inch gravel layer must 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 of the topsoil and organic materials should be removed prior to placement of the underslab gravels or new structural fill materials.

4) Floor slabs must be provided with control joints placed a maximum of 12 feet on center in each direction to help control shrinkage cracking. Joint locations should be carefully checked to assure

that the natural, unavoidable cracking will be controlled. Control joint depths should be a minimum of ¼ of the slab thickness.

5) Underslab soils must 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) It has been NWCC's experience that the risk of floor slab movement can be reduced by removing at least 2 feet of the expansive materials and replacing them with a well compacted, non-expansive fill. If this is done or if fills are required to bring the underslab soils to the desired grade, 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.

NWCC anticipates differential slab movement resulting from expansive soil conditions will be 1-inch or less with implementation of the measures indicated above. The above precautions and recommendations will not prevent floor slab movement in the event the clay beneath the floor slabs undergo moisture changes. However, they should reduce the amount of damage if such movement occurs. If the anticipated floor slab movement is not acceptable, the owner should consider implementation of a structural floor system over a well-vented crawl space or void form materials.

**Perimeter Drain System:** NWCC recommends perimeter drainage systems be used to provide site drainage and shallow groundwater relief around the building structure. The perimeter drainage system is the primary means for controlling moisture conditions beneath the structure and, therefore, is a major factor in satisfactory building performance at sites where expansive soils are present.

NWCC recommends the lower level of the residence be protected by a perimeter drainage system to help reduce problems associated with surface and subsurface drainage during high runoff periods. Localized perched groundwater associated with seasonal or other surface runoff events can infiltrate the lower levels of the structure from the building perimeter at foundation levels. This water can be one of the primary causes of differential foundation and slab movement, especially when expansive soils are encountered. Excessive moisture in crawl space areas or lower levels can lead to rotting and mildewing of wooden structural members and the formation of mold and mold spores. The formation of mold and mold spores could have detrimental effects on the air quality in these areas, which in turn can lead to potential adverse health effects.

Drainage systems should be provided around the structure at lower level perimeter foundation locations. Drainpipes should be placed at least 6 inches below adjacent footing or grade beam voids or 12 inches below adjacent floor slabs. NWCC recommends the use of perforated PVC pipe for the drainpipe that meets ASTM 3034/SDR35 requirements to minimize the potential for crushing the pipe during backfill operations and provide long-term durability and performance. Drainpipe perforations should be oriented down at the 4 o'clock and 8 o'clock positions to promote rapid water runoff. Drainpipes should be covered with at least 12 inches of free draining gravel and should be protected from contamination by a filter

covering of Mirafi 140N subsurface drainage fabric or an equivalent product. Drainpipes should have a minimum slope of 1 percent and daylight at an outfall that is protected from freezing, or be led to a sump from which the water can be pumped. Multiple daylights should be considered for larger and more complex structures. Caution should be taken when backfilling so as not to damage or disturb the installed drain systems. The drainage system should include at least one cleanout, be protected against intrusion by animals at the outfall and be tested prior to backfilling. NWCC should be retained to observe underdrain systems and flow testing prior to backfill in order to verify installation and performance.

An impervious membrane should be provided at the base of the foundation walls and footings to enhance perimeter drain performance and prevent water from infiltrating through voided areas and/or under footings and entering underslab or crawlspace areas. Barrier should consist of a heavy-duty impervious membrane material approved by NWCC and placed as shown on Figure 7.

**Foundation Walls and Retaining Structures:** Foundation walls and retaining structures that are laterally supported and can be expected to undergo only a moderate amount of deflection should be designed using a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 45 pcf for imported, free draining granular backfill and 60 pcf for the on-site materials.

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

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

NWCC recommends imported granular soils for backfilling foundation walls and retaining structures because their use results in lower lateral earth pressures. Imported granular materials should consist of a well graded sand or sand and gravel mixture and contain less than 7 percent passing the No. 200 sieve. Granular foundation wall backfill placed for reduced lateral earth pressures should be sloped from the base of the wall at an angle of at least 45 degrees from the vertical. Upper 2 to 3 feet of fill should be a relatively impervious soil or pavement structure to prevent surface water infiltration into the backfill.

Wall backfill should be carefully placed in uniform lifts and compacted to at least 95 percent of the maximum standard Proctor density, near optimum moisture content. Free draining granular backfill should

be compacted to approximately 70% of the maximum relative density (ASTM D5253/5254). 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 structure should be sloped (minimum of 1.0 inch per foot) to drain away from the structure 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 foundation walls, 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.

**Site Grading:** NWCC assumes site grading will include relatively minor unretained cuts and fills less than 8 feet in height or depth, based on site topography and assumed construction. Due to gentle topography, slope instability is not anticipated; however, NWCC should review site grading plans if they are different than those assumed. The following recommendations should be observed for site grading design and construction.

1) Temporary cuts for foundation construction should meet OSHA safety standards for trenching and temporary excavations. Permanent, unretained cuts for driveways or building sites should be kept as shallow as possible and should not exceed a 3(Horizontal) to 1(Vertical) configuration for the topsoil and organic materials and 2(H):1(V) configuration for the natural clay. Cuts should be limited to 10 feet in height or less unless stable bedrock is encountered. The risk of slope instability will be significantly increased if groundwater seepage is encountered in the cuts.

NWCC should be notified immediately to evaluate the site if seepage is encountered or deeper cuts are planned. Additional investigations and/or stabilization measures may be warranted.

2) Contractor should provide a construction sequencing plan for excavation, wall construction and bracing and backfilling for the steeper and more sensitive portions of the site prior to starting the excavations or construction

3) Excavating during periods of low runoff at the site can reduce potential slope instability during excavation. Excavations should not be attempted during the spring or early summer when seasonal runoff and groundwater levels are typically high.

4) Fills up to 10 feet in height can be constructed to a 2(H):1(V) or flatter configuration. Fill areas should be prepared by stripping topsoil and organics, scarification and compaction to at least 95% of the maximum standard Proctor density and within 2% of optimum moisture content as determined by ASTM D698. Fills should be benched/keyed into the natural hillsides after the topsoil and organic materials have been stripped using minimum 6-foot wide benches. Fill materials may consist of the on-site soils (exclusive of topsoil, organics or silts) and should be uniformly placed and compacted in 6 to 8 inch loose lifts to the minimum density value and moisture content range indicated above.

5) Surface drainage features should be provided around all permanent cuts and fills and steep natural slopes to direct surface runoff away from these areas. Cuts, fills and other stripped areas should be protected against erosion by revegetation or other methods. Areas of concentrated drainage should be avoided and may require the use of riprap for erosion control.

6) A registered professional engineer experienced in site plan preparation in this geographic area is recommended for site grading and drainage plan preparation.

**Limitations:** Recommendations given in this report are based on the soils encountered at this site and NWCC's assumptions regarding the proposed construction. NWCC believes this information gives a high degree of reliability for anticipating 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 express or implied are given on the content of this report.

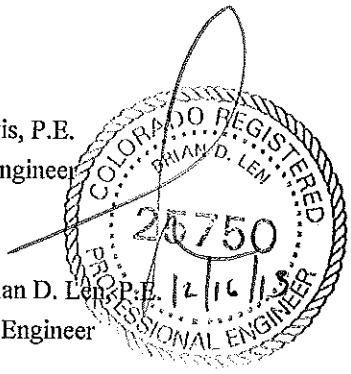
Swelling soils were encountered at this site. These soils are stable at their natural moisture content but can shrink or swell with changes in moisture. Behavior of swelling soils is not fully understood. Swell or consolidation potential of any particular site can change erratically both in lateral and vertical extent. Moisture changes also occur erratically, resulting in conditions, which cannot always be predicted. Recommendations presented in this report are based on the current state of the art for foundations and floor slabs on swelling soils. Owner must be made aware that there is a risk in construction on these types of soil. Performance of the structure 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 structure. Structural distress noted should be brought to the attention of NWCC.

This report is based on the investigation at the described site and on the specific anticipated construction as stated herein. If either of these conditions is changed, the results would also most likely change. 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 insure that the information in this report is incorporated into the plans and/or specifications and construction of the project.

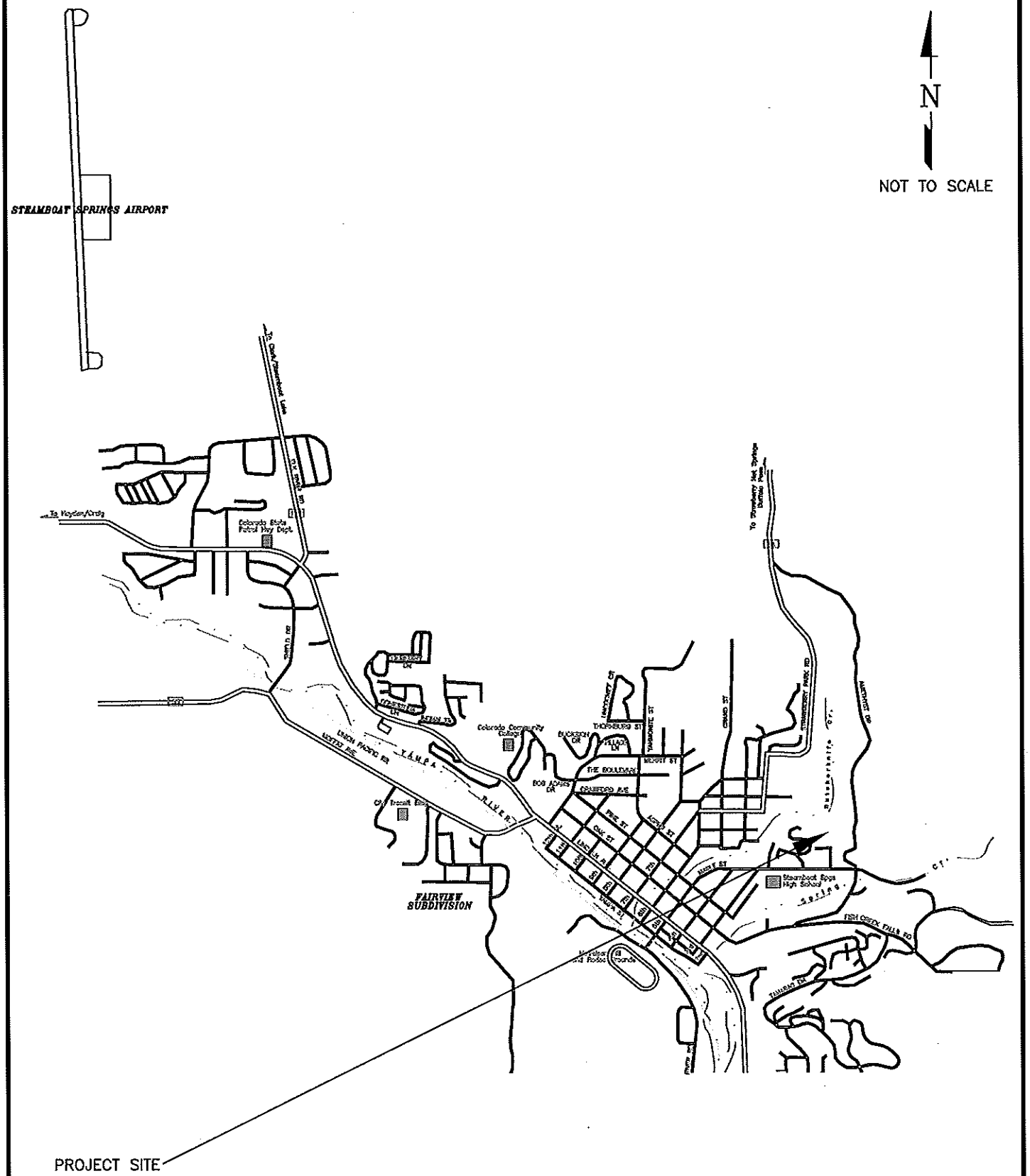
If you have any questions regarding this report or if we may be of further service, please do not hesitate to contact us.

Sincerely,
**NWCC, INC.**




Timothy S. Travis, P.E.
Senior Project Engineer

Reviewed by Brian D. Len, P.E.
Senior Principal Engineer

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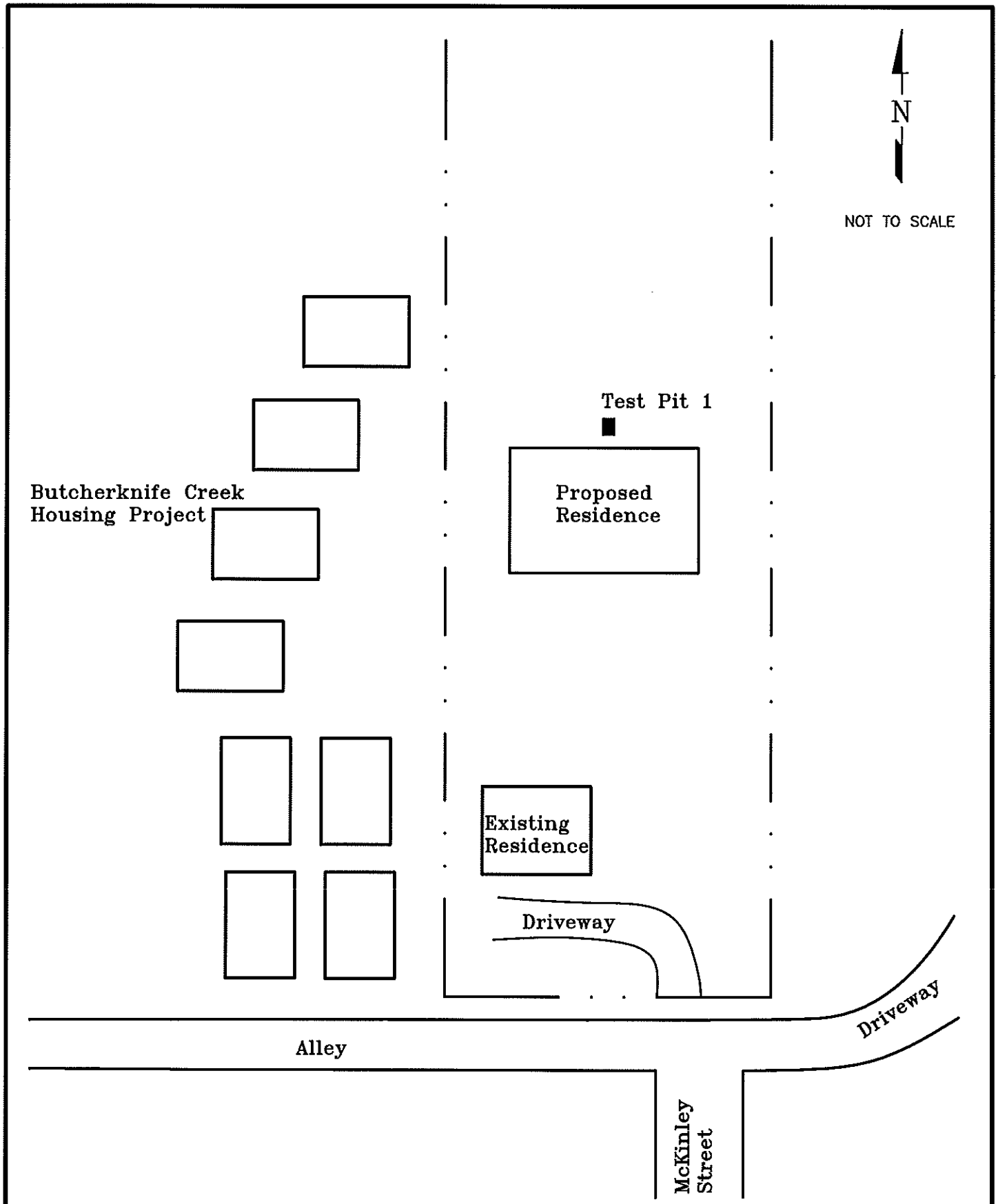
|---|---|---|
| Title: VICINITY MAP | Date: 12/11/13 | NWCC North West Colorado Consultants Inc. Geotechnical / Environmental Engineering - Materials Testing (970)879-7668 - Fax (970)879-7891 2593 Copper Ridge Drive Steamboat Springs, Colorado 80487 |
| Job Name: Proposed Crites Residence | Job No. 13-9601 | |
| Location: 41 McKinley Street, Steamboat Springs, Colorado | Figure 1 | |

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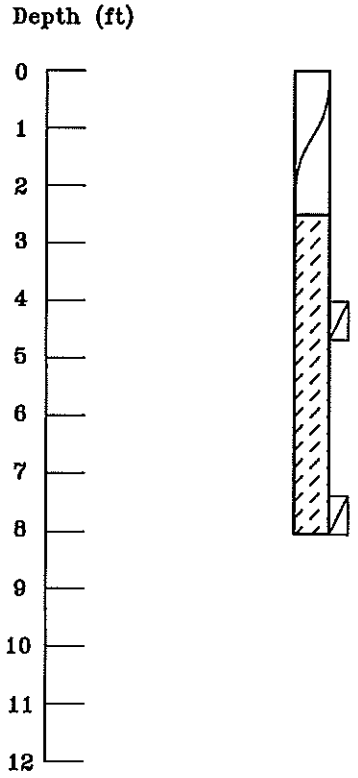
|---|---|---|
| Title: SITE PLAN–LOCATION OF TEST PITS | Date: 12/11/13 | NWCC Northwest Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing (970)879-7658 • Fax (970)879-7691 2583 Copper Ridge Drive Steamboat Springs, Colorado 80487 |
| Job Name: Proposed Crites Residence | Job No. 13-9601 | |
| Location: 41 McKinley Street, Steamboat Springs, Colorado | Figure 2 | |

## Test Pit 1




**LEGEND:**

TOPSOIL AND ORGANICS.

CLAYS: Sandy, fine-grained, moderately plastic, very stiff to stiff, slightly moist to moist and light brown to brown in color.

Hand Drive Sample-California Liner.

**NOTES:**

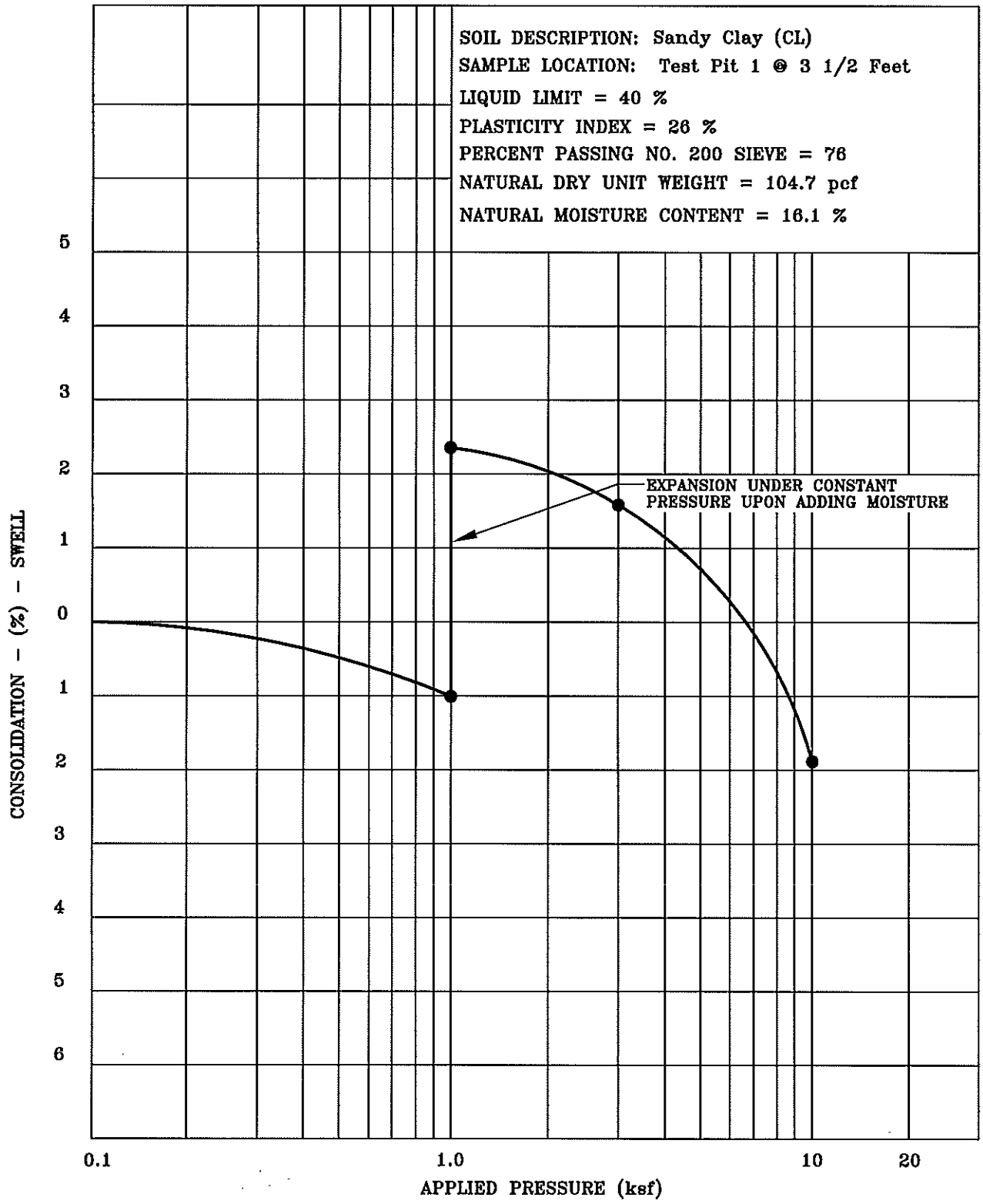
1) Test pit was excavated on November 13, 2013 with a Bobcat 337 mini-trackhoe.

2) Test pit location was determined by pacing from topographic features at the site.

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: LOGS, LEGEND AND NOTES | Date: 12/11/13 | NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering • Materials Testing (970)879-7668 • Fax (970)879-7691 2553 Copper Ridge Drive Steamboat Springs, Colorado 80487 |
| Job Name: Proposed Crites Residence | Job No. 13-9601 | |
| Location: 41 McKinley Street, Steamboat Springs, Colorado | Figure 3 | |

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| Title: SWELL–CONSOLIDATION TEST RESULTS | | Date: 12/11/13 |
| Job Name: Proposed Crites Residence | | Job No. 13-9601 |
| Location: 41 McKinley Street, Steamboat Springs, Colorado | | Figure 4 |

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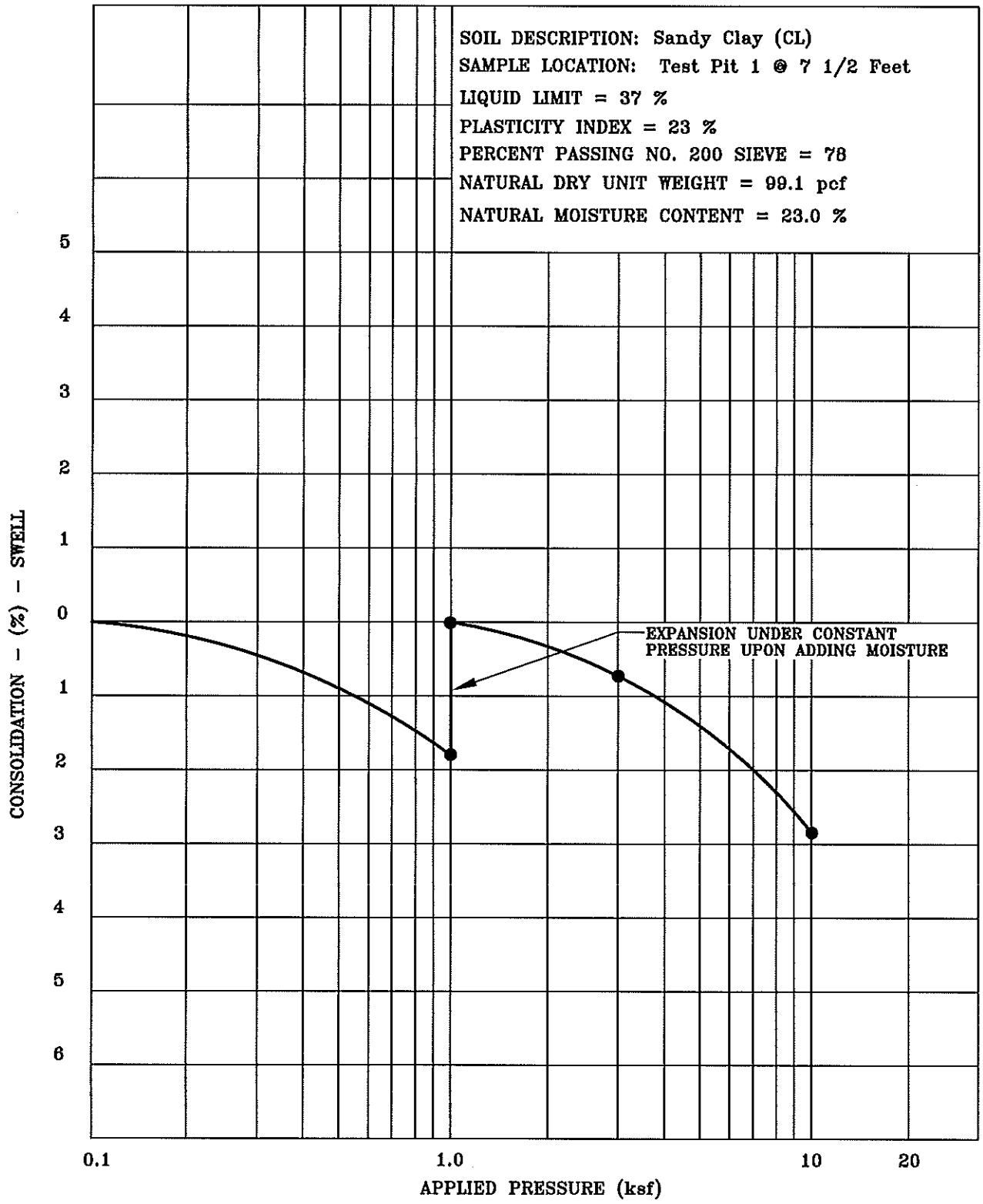
North West Colorado Consultants, Inc.
Geotechnical / Environmental Engineering - Materials Testing
(970)879-7668 - Fax (970)879-7891
2553 Copper Ridge Drive
Steamboat Springs, Colorado 80487

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| Title: SWELL-CONSOLIDATION TEST RESULTS | | Date: 12/11/13 |
| Job Name: Proposed Crites Residence | | Job No. 13-9601 |
| Location: 41 McKinley Street, Steamboat Springs, Colorado | | Figure 5 |

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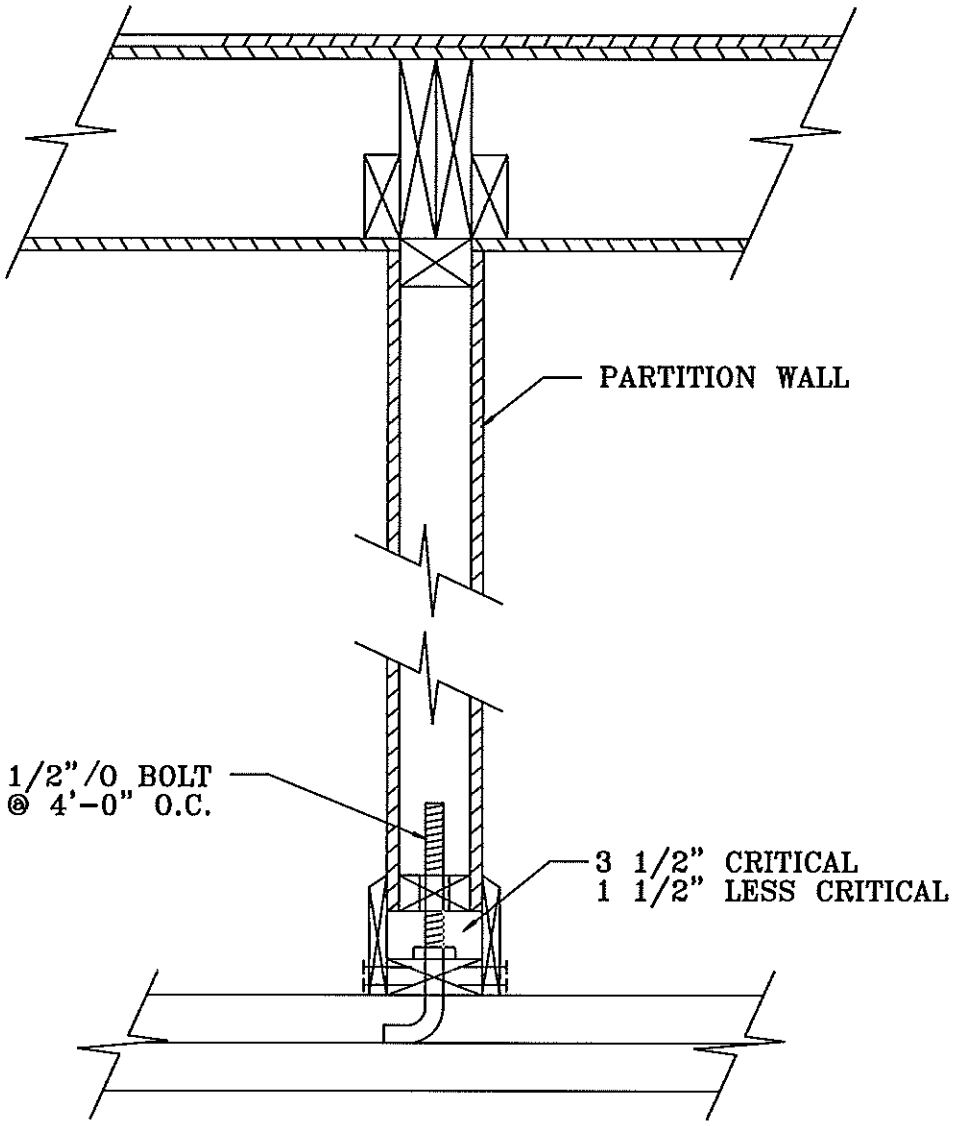
Northwest Colorado Consultants, Inc.
Geotechnical / Environmental Engineering - Materials Testing
(970)879-7668 - Fax (970)879-7691
2560 Copper Ridge Drive
Steamboat Springs, Colorado 80487

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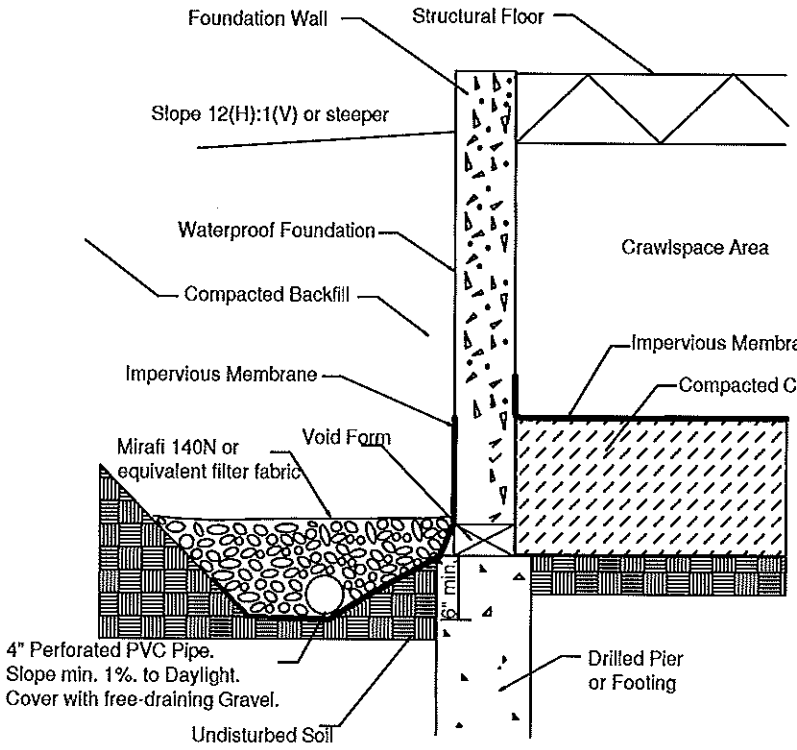
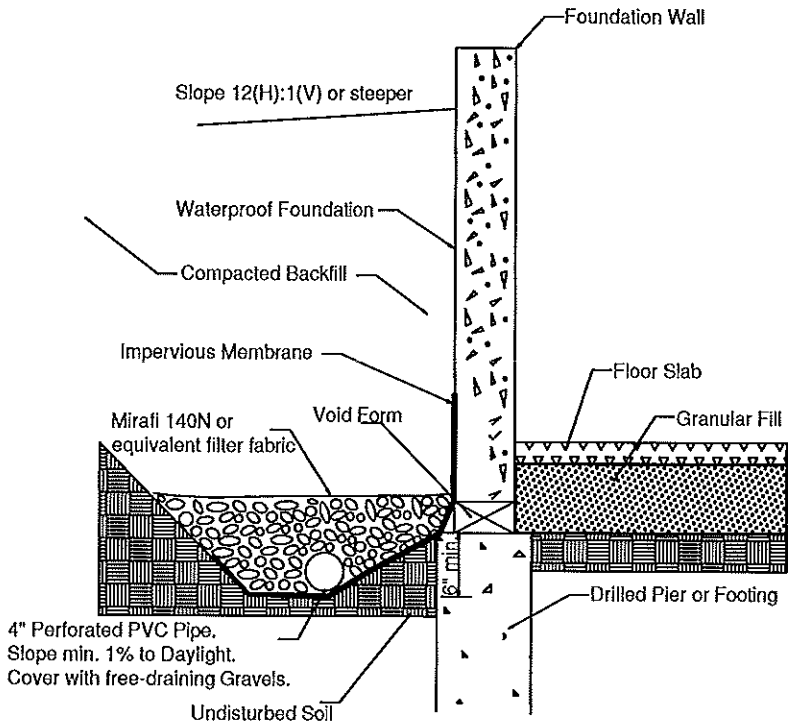
| Title: HUNG PARTITION WALL DETAIL | Date: 12/11/13 | NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing (970)879-7650 - Fax (970)879-7691 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487 |
| Job Name: Proposed Crites Residence | Job No. 13-9601 | |
| Location: 41 McKinley Street, Steamboat Springs, Colorado | Figure 6 | |




Crawlspace Area




Lower Level with
Floor Slab

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|---|---|---|
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| Job Name: Proposed Crites Residence | Job No. 13-9601 | |
| Location: 41 McKinley Street, Steamboat Springs, 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 | 16.1 | 104.7 | 40 | 26 | 0 | 24 | 76 | | Sandy Clay | CL |
| | | | | | | | | | | | |
| 1 | 7 1/2 | 23.0 | 99.1 | 37 | 23 | 0 | 22 | 78 | | Sandy Clay | CL |
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JOB NUMBER: 13-9601