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

September 20, 2017

Urban Renewal Area
c/o Ralph Walton, III
610 Marketplace Plaza, Suite 100
Steamboat Springs, CO 80487

Job Number: 17-10873

Subject: Subsoil and Foundation Investigation, Iconic Entry – Arnold Barn Relocation, Mt. Werner Circle and Mt. Werner Road, Steamboat Springs, Colorado.

Ralph,

This report presents the results of the Subsoil and Foundation Investigation for the Iconic Entry/Arnold Barn Relocation to be constructed east of the intersection of Mt. Werner Circle and Mt. Werner Road in Steamboat Springs, Colorado.

NWCC, Inc.'s (NWCC) scope of work included obtaining data from cursory observations made at the site, logging of two test pits, sampling of the probable foundation soils and laboratory testing of the samples obtained. 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 Arnold Barn, currently situated next to the Meadows Parking Lot, will be restored and relocated to the east side of the intersection of Mt. Werner Circle and Mt. Werner Road. The Arnold Barn was constructed around 1928 out of wood, and is currently visibly deteriorating. NWCC has assumed the barn will be moved onto a concrete foundations and with a slab-on-grade floor system constructed at or near the existing ground surface.

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

**Site Conditions:** The proposed location for the Arnold Barn is located east of the intersection of Mt. Werner Road and Mt. Werner Circle, on a currently vacant Steamboat Ski Corp. property. The vegetation at the proposed site consists of grasses, weeds, pine trees, and aspen trees.

Topography of the site slopes moderately to the south-southwest, and has been previously graded and landscaped.

**Subsurface Conditions:** To investigate the subsurface conditions at the site, two test pits were advanced on September 7, 2017 with a Yanmar Vio 45 trackhoe. A site plan showing existing features along with the approximate test pit locations is presented in Figure #2.

Subsurface conditions encountered generally consisted of an approximately 8 inch thick layer of topsoil and organic materials at the ground surface overlying clays and gravels to approximately 3 to 4 feet beneath the existing ground surface (bgs). Claystone-siltstone bedrock materials were encountered below the clays and gravels and extended to the maximum depths excavated, 5' bgs, where practical rig refusal was encountered. Graphic logs of the exploratory test pits, along with associated Legend and Notes, are presented in Figure #3.

Clays and gravels were encountered beneath the topsoil layer and extended to a depth of 3' bgs in Test Pit 1 and 4' bgs in Test Pit 2. The clays and gravels were sandy, blocky, calcareous, fine to coarse grained, low to moderately plastic, very stiff to hard, dry, and light brown to brown. A sample of the clays and gravels classified as a CL soil in accordance with the United Soil Classification System (USCS).

Claystone-siltstone bedrock was encountered beneath the clays and gravels and extended to the maximum depths investigated. The claystone-siltstone bedrock materials were sandy, fine to grained, low to moderately plastic, hard, slightly moist and tan to brown in color. A sample of the claystone-siltstone bedrock from Test Pit 1 classified as a CL soil in accordance with the USCS, and a sample of the claystone-siltstone bedrock from Test Pit 2 classified as a ML soil in accordance with the USCS.

Swell-consolidation testing conducted on a sample of the natural sandy gravelly clays indicated the materials tested will exhibit a low to moderate swell potential when wetted under a constant load. The swell-consolidation test results are presented in Figure #4, and all the other laboratory test results are summarized in the attached Table 1.

Groundwater was not encountered in the test pits 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:** Based on the results of the field and laboratory investigations and our experience with similar projects in the area, NWCC believes a safe and economical foundation system will consist of spread or continuous footings placed directly on the natural clays and gravels or bedrock materials found below the topsoil and organic materials or any existing fill materials.

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 or bedrock materials 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 or bedrock materials undergo moisture changes. The

owner must be willing to accept the risk of foundation movement associated with placing shallow foundations on expansive materials.

1) Footings placed on the natural clays or bedrock materials should be designed using an allowable soil bearing pressure of 4,000 psf. Footings should also be designed using a minimum dead load pressure of at least 900 psf.

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

3) Any existing topsoil and organic materials or existing fill materials found beneath the footings when excavations are opened should be removed and footings extended down to the natural clays prior to structural fill or 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. Additional bearing capacity values along with the associated settlements are presented in Figure #5.

7) 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.

**Alternate Foundation Recommendations:** If the owner is not willing to accept the risks associated with placing the shallow foundations on swelling soils or bedrock materials, or if the minimum dead load requirement cannot be met, we recommend that the barn be placed on a deep foundation system consisting of straight shaft skin friction/end bearing piers drilled into the underlying natural clays and bedrock materials. Foundation movement should be within tolerable limits if the following design and construction precautions are observed.

1) A minimum pier diameter of 12 inches, a minimum bedrock penetration of 6 feet and a minimum pier length of 15 feet are recommended. A maximum pier length to diameter ratio of 25 is also recommended.

2) Piers should be designed using allowable skin friction value of 900 psf for the portion of pier drilled into the natural clays and 3,000 psf for the portion of the piers drilled into the competent bedrock materials. The upper 5 feet of pier penetration should be neglected in skin-friction calculations. A drill rig of sufficient size, type and operating condition should be used so bottom of the piers can be cleaned out properly and minimum length requirements can be met. Due to the presence of cobbles and boulders, difficult drilling and/or rock coring should be anticipated. If bottom of piers are properly cleaned and approved by an engineer from this office, then an allowable end bearing pressure of 30,000 psf for the bedrock materials used in the design.

3) Piers should be reinforced their full length with at least one #5 reinforcing rod for each 16 inches of pier perimeter.

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

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

6) NWCC strongly recommends at least one test hole or test pier be drilled at the building site prior to starting the pier drilling operations. Test holes/piers should be drilled to evaluate deeper subsoil/bedrock conditions and verify recommendations given above.

7) A representative of NWCC must observe the test hole and pier drilling operations.

**Floor Slabs:** NWCC has assumed the barn a concrete slab-on-grade floor system will be constructed for the barn at or near the existing ground surface. On-site soils, with the exception of the topsoil and organic materials and any existing fill 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 clays encountered at this site, 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 damage, which 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 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 must be provided beneath all floor slabs to act as a capillary break and to help distribute pressures. Prior to placing the gravel, 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, any topsoil and organic materials or existing fill 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. Locations of the joints should be carefully checked to assure that natural, unavoidable cracking will be controlled. Depth of the control joints should be a minimum of ¼ the thickness of the slab.

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 floor slab could result in differential movement after 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 underslab areas 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.

Following 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.

**Underdrain System:** Any floor levels constructed below the existing or finished ground surfaces and the foundations should be protected by underdrain systems to help reduce the problems associated with surface and subsurface drainage during high runoff periods.

Localized perched water or runoff can infiltrate the lower levels of the structure at the 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 level can also lead to rotting and mildewing of wooden structural members and the formation of mold and mold spores. 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.

Drains should be located around entire perimeter of the lower levels and be placed and at least 12 inches below any floor slab or crawl space levels and at least 6 inches below the foundation voids and bottom of the foundation walls or footings. NWCC recommends the use of perforated PVC pipe for the drainpipe, which meets or exceeds ASTM D-3034/SDR 35 requirements, to minimize potential for pipe crushing

during backfill operations. Holes in the drainpipe should be oriented down between 4 o'clock and 8 o'clock to promote rapid runoff of water. Drainpipe should be surrounded 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. Drains should have a minimum slope of 1/8 inch per foot and be daylighted at positive outfalls protected from freezing, or be led to sumps from which water can be pumped. The use of interior laterals, multiple daylights or sumps may be required for the proposed structure. Caution should be taken when backfilling so as not to damage or disturb the installed underdrain. NWCC recommends the drainage system include a cleanout every 100 feet, be protected against intrusion by animals at outfalls and be tested prior to backfilling. NWCC also recommends the client retain our firm to observe the underdrain systems during construction to verify that they are being installed in accordance with recommendations provided in this report and observe a flow test prior to backfilling the system.

In addition, NWCC recommends an impervious barrier be constructed to keep water from infiltrating through the voided areas and/or under footings and/or foundation walls. Barrier should be constructed of an impervious material, which is approved by this office and placed below the perimeter drain and up against the sides of the foundation walls. A typical perimeter/underdrain detail is shown in Figure #7.

Placement of an impervious membrane and/or properly compacted clays in crawl space areas to the top of the footings or at least 12 inches above the top of the foundation voids or bottom of the foundation walls should help reduce the moisture problems in these areas.

**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 60 pcf for on-site materials.

Cantilevered retaining structures at the site can be expected to deflect sufficiently to mobilize full active earth pressure condition. Therefore, cantilevered structures may be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 35 pcf for imported, free draining granular backfill and 50 pcf for 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 earth pressures on foundation walls and retaining structures and the structural engineer should carefully evaluate these additional lateral loads when designing foundation and retaining walls.

Lateral resistance of retaining wall foundations placed on undisturbed natural soils at the site will be a combination of sliding resistance of the footings on the foundation materials and passive pressure against the sides of 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. Fill placed against the sides of footings to resist lateral loads should be compacted to at least 100% of the maximum standard Proctor density and near the optimum moisture content.

NWCC recommends imported granular soils for backfilling foundation walls and retaining structures because their use results in lower lateral earth pressures. Imported granular materials should be placed to within 2 to 3 feet of the ground surface. Imported granular soils should be free draining and have less than 7 percent passing the No. 200 sieve. Granular soils placed 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 backfill since this could cause excessive lateral pressure on the walls. Some settlement of deep foundation wall backfill materials will occur even if materials are placed correctly.

**Surface Drainage:** Proper surface drainage at this site is of paramount importance for minimizing infiltration of surface drainage into 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 structures should be sloped (minimum of 1.0 inch per foot) to drain away from structures in all directions to a minimum of 10 feet. Ponding must be avoided. If necessary, raising top of foundation walls to achieve a better surface grade is advisable.

2) Non-structural backfill placed around 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. 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 foundations should be impervious in nature to minimize infiltration of surface water into 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 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 ground surface adjacent to foundation walls.

**Limitations:** The recommendations provided in this report are based on the soils encountered at this site and NWCC's understanding of the proposed construction. NWCC believes this information gives a high degree of reliability for anticipating behavior of the construction; however, NWCC's 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.

Swelling soils and bedrock materials were encountered at this site. These materials are stable at their natural moisture content but can shrink or swell with changes in moisture. The behavior of swelling soils is not fully understood. The 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 and bedrock materials. As noted previously, the owner must be made aware there is a risk in construction on these types of materials. 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 structure should be brought to the attention of NWCC.

This report is based on the investigation at the described site and on specific anticipated construction as stated herein. If either of these conditions is changed, the results would also most likely change. Therefore, NWCC strongly recommends that our firm be contacted prior to finalizing the construction plans so that we can verify our recommendations are being properly incorporated into the construction plans. Man-made or natural changes in the conditions of a property can also occur over 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 NWCC may be of further service, please do not hesitate to contact us.

Sincerely,
**NWCC, INC.**

Erika K. Hill, E.I.T.
Project Engineer

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

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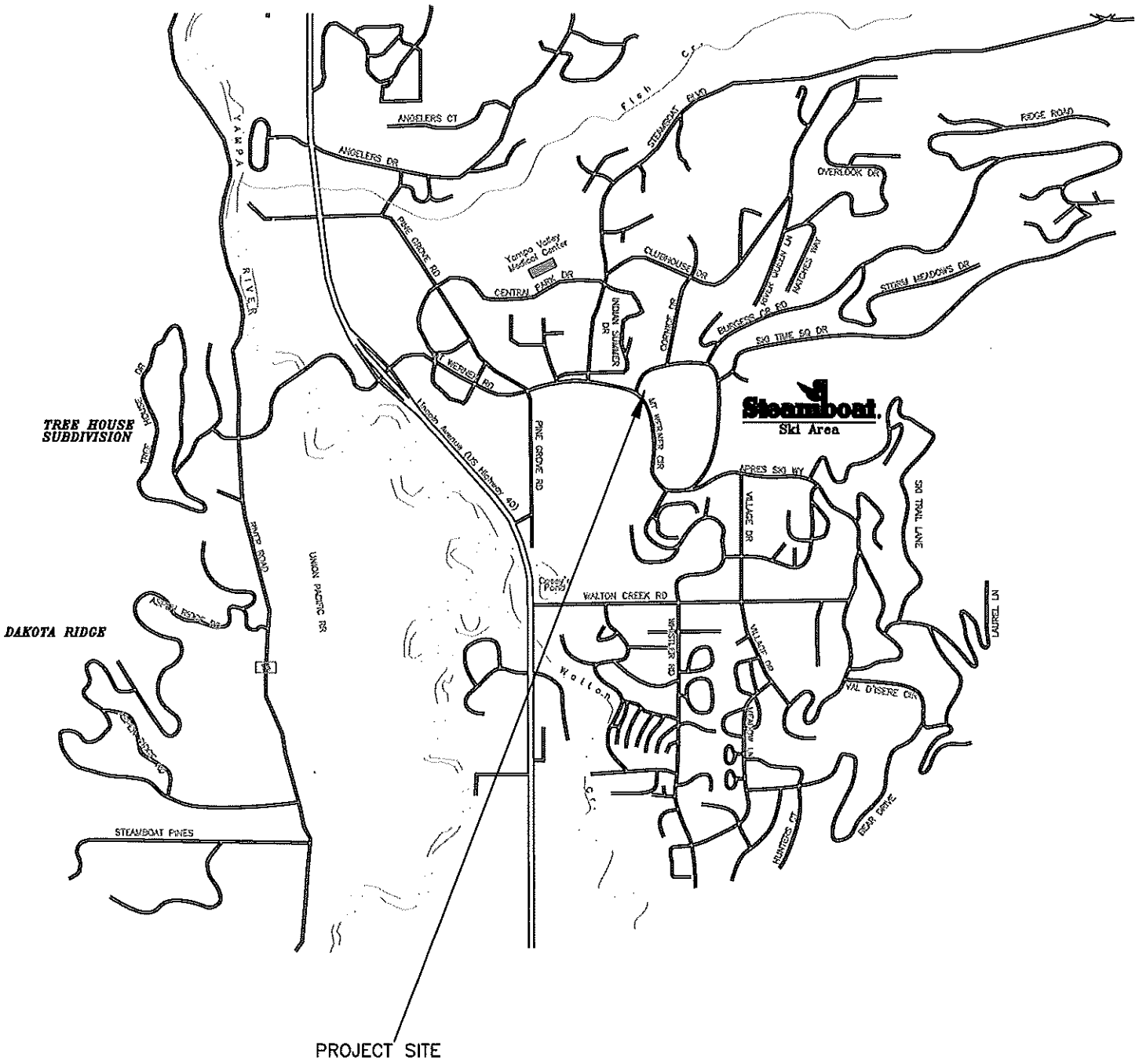


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| **Title:** VICINITY MAP | **Date:** 9/20/2017 | NWCC Northwest Colorado Consultants, Inc. Geotechnical / Environmental Engineering · Materials Testing |
| **Job Name:** Iconic Entry – Arnold Barn | **Job No.** 17-10873 | (970)879-7888 · Fax (970)879-7891 2560 Copper Ridge Drive Steamboat Springs, Colorado 80487 |
| **Location:** Mt. Werner Circle and Mt. Werner Road, Steamboat Springs, Colorado | **Figure** #1 | |

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NOT TO SCALE


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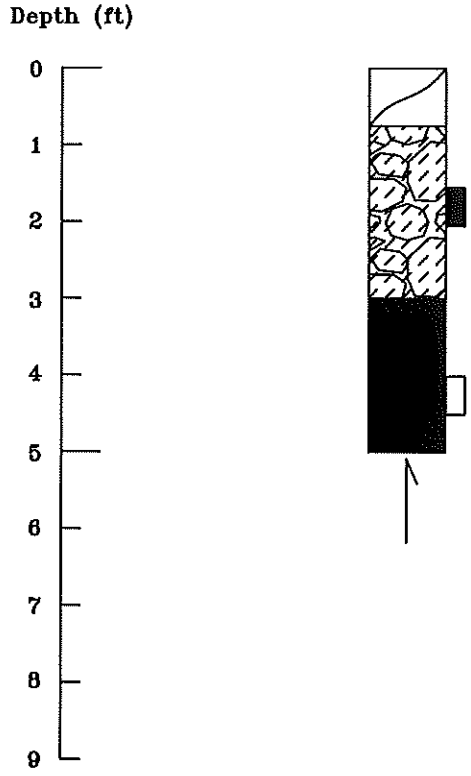
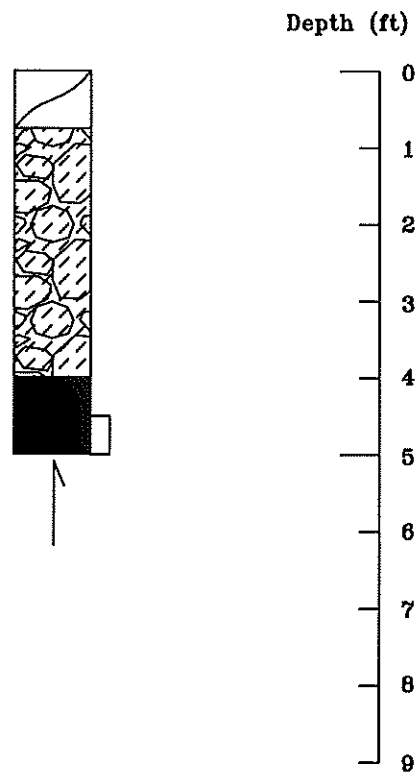
| Title: SITE PLAN–LOCATION OF TEST PITS | Date: 9/20/2017 | NWCC North West Colorado Consultants Inc. Geotechnical / Environmental Engineering · Materials Testing |
| Job Name: Iconic Entry – Arnold Barn | Job No. 17-10873 | (970)879-7688 · Fax (970)879-7691<br>2560 Copper Ridge Drive<br>Steamboat Springs, Colorado 80487 |
| Location: Mt. Werner Circle and Mt. Werner Road, Steamboat Springs, Colorado | Figure #2 | |

## Test Pit 1




## Test Pit 2




**LEGEND:**

- TOPSOIL
- CLAYS AND GRAVELS: Sandy, blocky, fine to coarse grained, low to moderately plastic, very stiff to hard, dry, calcareous, and light brown to brown.
- CLAYSTONE–SILTSTONE BEDROCK: Sandy, fine grained, low to moderately plastic, hard, slightly moist, and tan to brown.
- Hand Drive California Liner Sample.
- Small Disturbed Sample.
- Indicates depth of rig refusal on bedrock materials.

**NOTES:**

1) Test pits were excavated on September 7, 2017 with a Yanmar Vio 45 trackhoe.
2) Test pit locations were determined by NWCC in the field by pacing from existing site features.
3) Elevations of the test pits were not measured and the logs are drawn to the depths investigated.
4) The lines between materials shown on the test pit logs represent the approximate boundaries between material types and transitions may be gradual.

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| Title: LOGS, LEGEND AND NOTES | Date: 9/20/2017 | NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering · Materials Testing |
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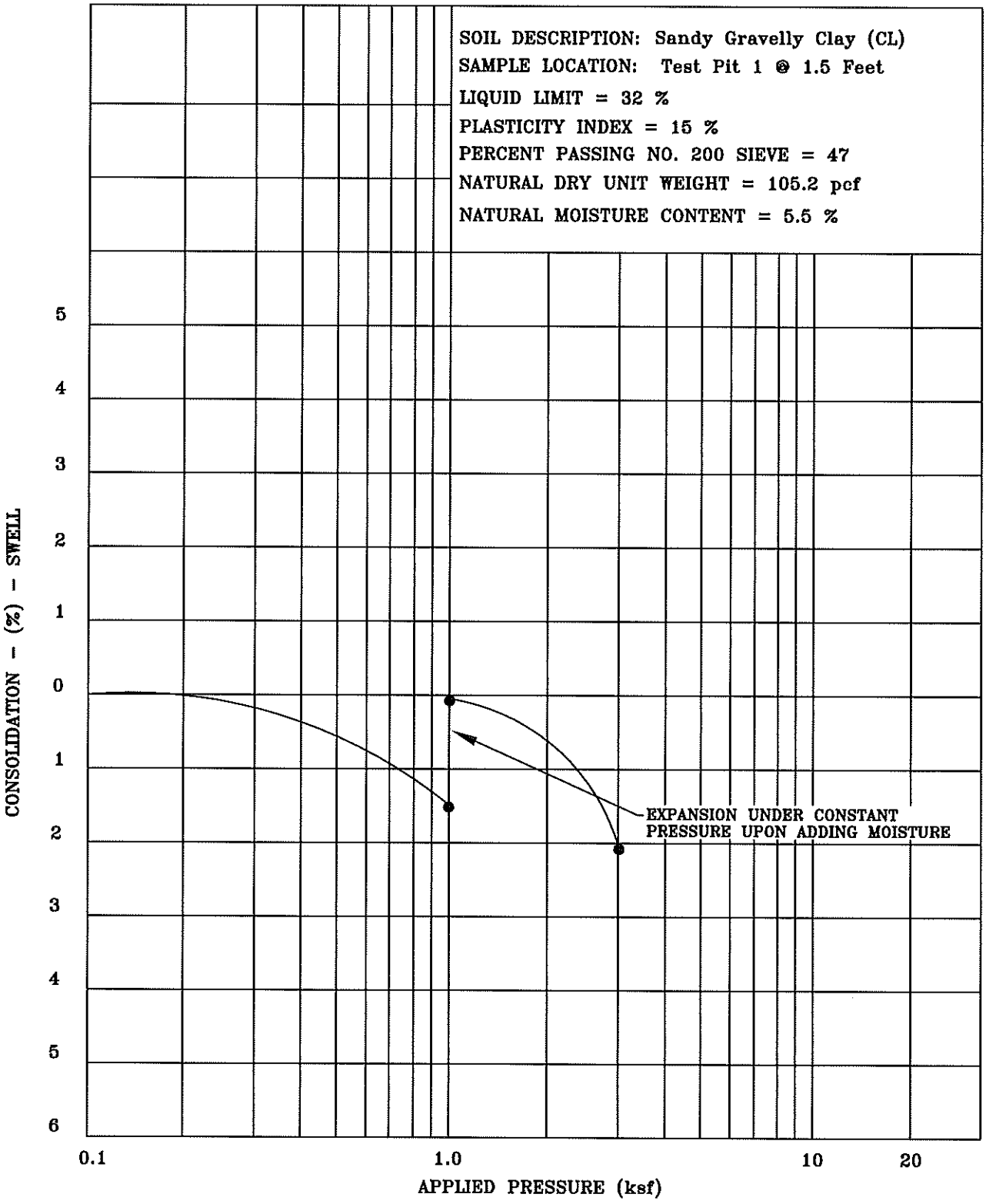
| Location: Mt. Werner Circle and Mt. Werner Road, Steamboat Springs, Colorado | Figure #3 | |

SOIL DESCRIPTION: Sandy Gravelly Clay (CL)
SAMPLE LOCATION: Test Pit 1 @ 1.5 Feet
LIQUID LIMIT = 32 %
PLASTICITY INDEX = 15 %
PERCENT PASSING NO. 200 SIEVE = 47
NATURAL DRY UNIT WEIGHT = 105.2 pcf
NATURAL MOISTURE CONTENT = 5.5 %

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| Title: SWELL-CONSOLIDATION TEST RESULTS | | Date: 9/20/2017 |
| Job Name: Iconic Entry - Arnold Barn | | Job No. 17-10873 |
| Location: Mt. Werner Circle and Mt. Werner Road, Steamboat Springs, Colorado | | Figure #4 |


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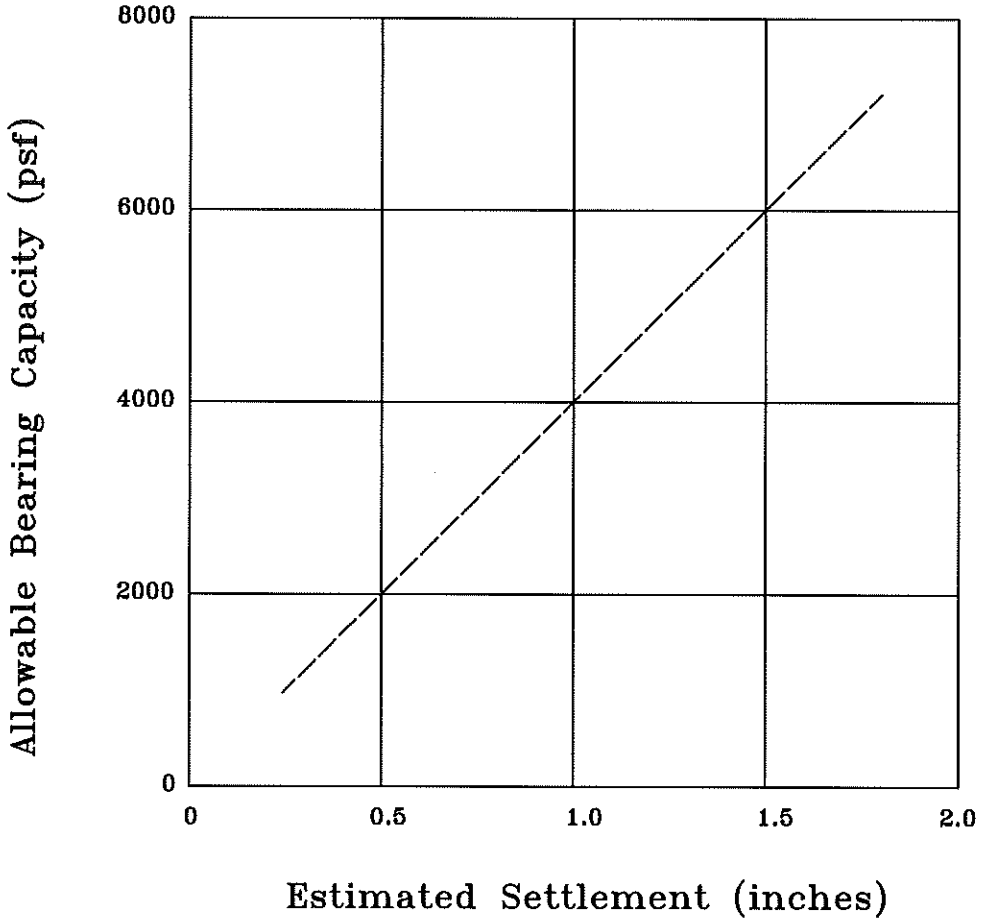


Note: These values are based on footing widths of 1 to 4 feet. If the footing width is to be greater than 4 feet in width, then we should be notified to re-evaluate these recommendations.

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| Title: BEARING CAPACITY CHART | Date: 9/19/2017 | 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 |
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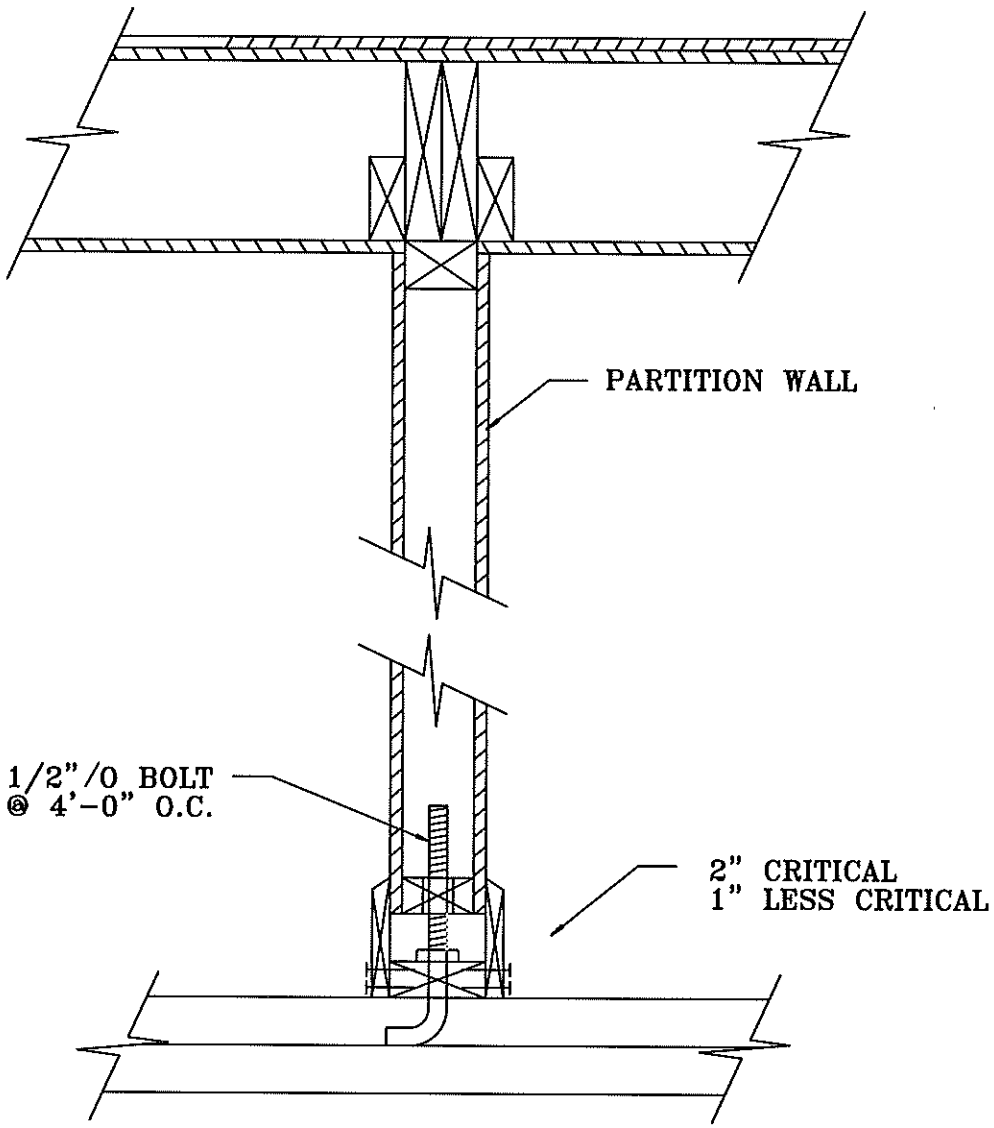
| Location: Mt. Werner Circle and Mt. Werner Road, Steamboat Springs, Colorado | Figure #5 | |

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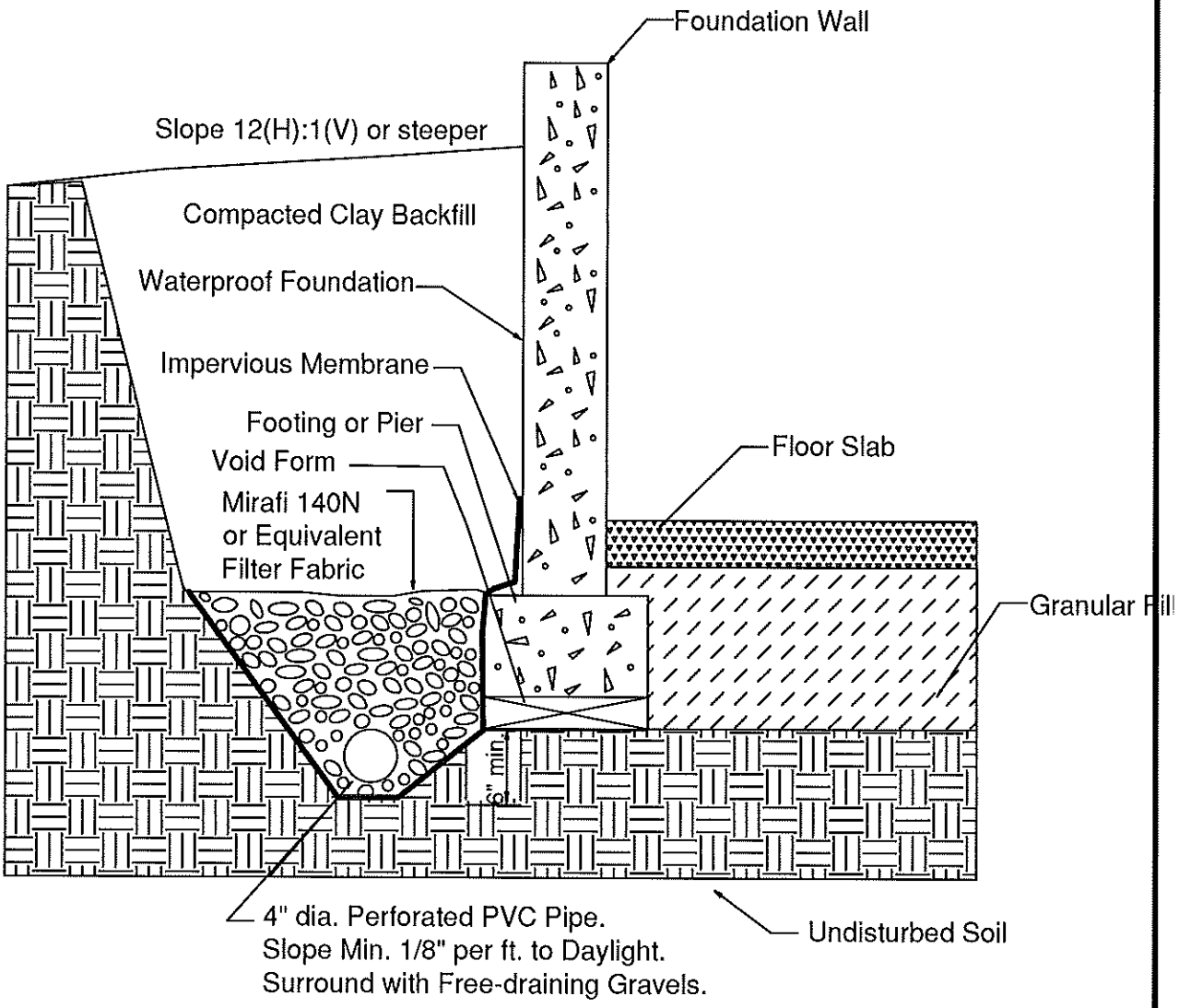
| Title: HUNG PARTITION WALL DETAIL | Date: 9/19/2017 | NWCC Northwest Colorado Consultants, Inc. Geotechnical / Environmental Engineering · Materials Testing |
| Job Name: Ionic Entry – Arnold Barn | Job No. 17-10873 | (970)879-7888 · Fax (970)879-7891<br>2580 Copper Ridge Drive<br>Steamboat Springs, Colorado 80487 |
| Location: Mt. Werner Circle and Mt Werner Road, Steamboat Springs, Colorado | Figure #6 | |

# Floor Slab

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| Title: PERIMETER/UNDERDRAIN DETAIL | | Date: 9/20/2017 |
| Job Name: Iconic Entry – Arnold Barn | | Job No. 17-10873 |
| Location: Mt. Werner Circle and Mt. Werner Road, Steamboat Springs, Colorado | | Figure #7 |


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*NWCC, Inc.*

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

| SAMPLE LOCATION | | NATURAL MOISTURE CONTENT (%) | NATURAL DRY DENSITY (pcf) | ATTERBERG LIMITS | | GRADATION | | PERCENT PASSING No. 200 SIEVE | UNCONFINED COMPRESSIVE STRENGTH (PSF) | SOIL or BEDROCK DESCRIPTION | UNIFIED SOIL CLASS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST PIT | DEPTH (feet) | | | LIQUID LIMIT (%) | PLASTICITY INDEX (%) | GRAVEL (%) | SAND (%) | | | | |
| | | | | | | | | | | | |
| 1 | 1.5 | 5.5 | 105.2 | 32 | 15 | 31 | 22 | 47 | | Sandy Gravelly Clay | CL |
| | | | | | | | | | | | |
| 1 | 4 | 11.7 | | 31 | 16 | 0 | 28 | 72 | | Claystone–Siltstone | CL |
| | | | | | | | | | | | |
| 2 | 4.5 | 11.9 | | 30 | 8 | 0 | 14 | 86 | | Claystone–Siltstone | ML |
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JOB NUMBER: 17–10873