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

March 29, 2024

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Job Number: 23-13103

Subject: Subsoil and Foundation Investigation, Proposed Thunderhead Beach, 1965 Ski Time Square Drive, Steamboat Springs, Colorado

Craig,

This report presents the results of the Subsoil and Foundation Investigation for the proposed Thunderhead Beach project to be constructed at 1965 Ski Time Square Drive in Steamboat Springs, Colorado. The approximate location of the project site is shown in Figure #1.

NWCC, Inc.'s (NWCC) scope of work included obtaining data from cursory observations made at the site, logging of twelve (12) test holes and six (6) test pits, sampling of the probable foundation soils and laboratory testing of the samples obtained. This report has been prepared to summarize the data obtained and to present NWCC's conclusions and recommendations for foundations and design criteria, floor slabs, retaining walls, underdrain systems, site grading, and pavement section recommendations.

Proposed Construction: Based on our review of the project plans recently provided, it appears the proposed building will consist of eight (8) stories of retail and residential units above ground and two (2) stories of below grade parking. It also appears the lower levels of the building structure will be constructed using slab-on-grade floor systems located approximately 10 to 30 feet below the existing ground surface. NWCC understands that the client is currently inclining towards a mat slab foundation type.

NWCC understands that the proposed building loads will be moderate to high. If loadings or conditions are significantly different from those above, NWCC should be notified to reevaluate the recommendations in this report.

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Site Conditions: The subject property site is situated south and west of Ski Time Square Drive, north of the Steamboat Ski Area and east of the Creekside at Torian Plum building and Burgess Creek, which flows in a north to south direction along the west side of the existing access road. A site plan showing the existing features at the project site and the adjacent properties is provided in Figure #2.

The majority of the project is vacant with the exception of an asphalt surfaced access road along the west side of the property, a magic carpet beginner ski lift, and an asphalt surfaced parking lot at the east side of the property. Several construction trailers, storage sheds and shipping containers are presently located within the parking lot. It should be noted that the parking lot is currently being used as a construction storage area and as a construction access to the ski area, which is located south of the parking lot. NWCC understands that a hotel formerly occupied the site up until 2008.

Vegetation at the site consisted primarily of weeds and grasses with aspen trees and pine trees in the middle of the lot and along the north side of the property. A storm sewer system appears to run in an east to west direction at the southern part of the parking lot towards a sediment pond. Cattails are located in the wetland area/pond on the west side of the site.

Topography at the proposed building site is highly variable due to previous site grading and development, and generally slopes gently to moderately down to the southwest towards Burgess Creek with a steeper slope in the southeast corner of the property that slopes down to the west and northwest. A maximum elevation difference of approximately 20 to 25 feet appears to exist across the project site.

Subsurface Conditions: To investigate the subsurface conditions at the site, twelve (12) test holes were advanced at the site on June 7 and 8 and October 26 and 27 of 2023. Ten (10) of the holes were drilled using a truck-mounted CME 55 drill rig with 4-inch diameter continuous flight augers and two (2) of the test holes were advanced using an air rotary hammer drill (ODEX). Six (6) test pits were advanced at the site on September 19, 2023 with a CAT 416 trackhoe. The approximate test hole and test pit locations are shown in Figure #2.

Subsurface conditions encountered were variable and generally consisted of a layer of asphalt pavement or man-made fill materials overlying natural sands and gravels with clay interbeds, overlying claystone-sandstone bedrock of the Browns Park Formation. The claystone-sandstone bedrock extended to the maximum depths investigated in Test Hole 6 and Test Hole 11. It should be noted that practical rig refusal was encountered on boulders in all of the other test holes at varying depths. In addition, the drill casing and ODEX bit twisted off at a depth of 30 feet bgs on either a very large boulder or bedrock. Graphic logs of the test holes are presented in Figures #3 through #6, and the logs of the test pits are presented in Figure #7. The Legend and Notes associated with the logs are presented in Figures #8 and #9, respectively.

A layer of fill materials was encountered at the ground surface in all the test holes and test pits except for Test Hole 1 and Test Hole 2, and extended to depths ranging from approximately 4 to 12 feet below the existing ground surface (bgs). The fill materials consisted of sands and gravels to clays and silts that were low to moderately plastic, fine to coarse grained with cobbles and construction debris, loose to medium dense to dense, slightly moist to moist and dark brown to light brown to gray in color. Samples of the fill materials classified as CL, SC, SM and GM soils in accordance with the Unified Soil Classification System (USCS).

Natural sands and gravels were encountered beneath the fill materials in the test holes and test pits with the exception of Test Hole 7 and Test Pits 4, 5 and 6. The sands and gravels were encountered to depths ranging from approximately 8 to 34 feet bgs. The natural sands and gravels were slightly silty to very silty with occasional silty to clayey sand lenses, low to non-plastic, fine to coarse grained with cobbles and small to large boulders, medium dense to very dense, moist to wet and light brown to gray in color. Samples of the sands and gravels classified as SC and SM soils in accordance with (USCS).

Layers of natural clays were encountered within the natural sands and gravels in Test Holes 1, 2, 3, 11 and 12, and beneath the fill materials in Test Pit 4 and extended to depths approximately ranging from 7 to 15 feet bgs. The clays were slightly sandy to sand and clay, low to moderately plastic, fine to coarse grained, medium stiff to hard, slightly moist to wet and light brown to brown in color. Samples of the clays classified as CL soils in accordance with (USCS).

Claystone-sandstone bedrock of the Browns Park Formation was encountered beneath the sands and gravels in Test Holes 6 and 11, and extended to the maximum depths investigated in each test hole, approximately 39 and 40 feet bgs. The sandstone-claystone bedrock materials were low to moderately plastic, fine to medium grained, weathered to hard, moist and light brown to tan in color. A sample of the bedrock materials classified as a CL soil in accordance with the USCS.

Swell-consolidation testing conducted on samples of the fill materials and natural clays indicate these materials exhibited a very low to moderate swell potential when wetted under a constant load. Swell-consolidation test results are presented in Figures #10 through #16. All the other laboratory test results are summarized in the attached Tables 1 and 2.

Groundwater was encountered at depths of approximately 7, 11, 10, 11, 6, 12, 3, 12 and 9 feet bgs at the time of drilling in Test Holes 1, 2, 3, 4, 6, 8, 10, 11 and 12, respectively. Groundwater was also encountered at depths of approximately 3, 6 ½, and 10 ½ at the time of excavation in Test Pits 1, 2 and 5. Temporary casing was installed in Test Hole 11 so that the groundwater elevation can be monitored in the future. Groundwater was encountered at a depth of 12 feet bgs at the time of drilling and when measured 12 days after the drilling had been completed. It appears that the elevation of the groundwater in Test Hole 11 is presently 2 feet higher than the top of slab elevation in level P2 at this location. It should be noted that groundwater conditions at the site can be expected to fluctuate significantly with changes in precipitation and runoff at the site, as well as with the flows in Burgess Creek. It is likely that a higher perched water level, associated with the flows in Burgess Creek will be encountered during spring and early summer runoff.

Based on the subsurface conditions encountered at the site and the laboratory test results, we recommend a Site Class C be used for the foundation designs in accordance with Table 20.1-1 in Chapter 20 of ASCE 7-10.

Shallow Foundation Recommendations: Based on subsurface conditions encountered in the test holes and test pits, results of the field and laboratory investigations and our understanding of the proposed construction, NWCC believes an economically feasible and safe type of foundation system for the proposed building structures is a mat slab, spread footing or individual pad with grade beams founded on the natural sands and gravels or bedrock materials found below the existing fill materials or on properly compacted structural fill materials placed over the natural sands and gravels. Due to the presence of softer soils (clays and silts) within the sands and gravels, the allowable bearing pressure recommended below is based on the anticipated strength of these softer soils. Foundation movement should be within tolerable limits if the following design and construction precautions are observed.

1) Footings or mat slabs placed on the natural sands and gravels or on properly compacted structural fill materials placed over the natural sands and gravels should be designed

using an allowable soil bearing pressure of 2,500 psf. Footings or mat slabs placed on the bedrock materials may be designed for an allowable bearing pressure of 5,000 psf; however, these footings/mat slabs should also be designed using a minimum dead load pressure of at least 1,000 psf. A minimum dead load pressure is not required for the footings/ mat slabs placed on the sands and gravels or structural fill materials and all the clays are removed.

2) Footings or pad sizes should be computed using the above soil pressure and placed on the undisturbed sands and gravels or on properly compacted structural fill materials placed over the natural sands, gravels and cobbles after all of the existing fill materials and any exposed natural clays are removed. Spread footings placed on granular soils should have a minimum footing width of 16 inches.

3) Any existing fill materials, clays, silts and/or loose sands encountered within the foundation excavations should be removed prior to structural fill or concrete placement.

4) Fill materials should extend down from the edge of the footings/mat slabs at a 1 (horizontal): 1 (vertical) or flatter slope. Structural fill materials should be placed in 6 to 9-inch loose lifts and be compacted to at least 80 percent of the maximum relative density determined in accordance with ASTM D-4253/4254 if free draining gravels are used or 100 percent of the maximum standard Proctor density determined in accordance with ASTM D-698 if other granular/structural soils are used. NWCC recommends the structural fill materials placed below the groundwater meet the Colorado Department of Transportation (CDOT) specifications for Class B or C Filter materials, and the structural fill materials placed above the water table meet the CDOT specifications for Class 1 Structure Backfill.

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, 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 #17.

8) Care should be taken when excavating the foundations to avoid disturbing the supporting materials. Hand excavation or careful backhoe soil removal may be required in excavating the last few inches.

8) The client must retain NWCC 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 structural fill materials placed beneath the foundations for compaction.

Deep Foundation Recommendations: Due to the presence of soft soils within the sands and gravels, as well as two different bearing strata, an alternative would be a deep foundation system. Based on the subsurface conditions encountered in the test holes, the results of the field and laboratory investigations and our understanding of the proposed construction, NWCC recommends the proposed building structures be founded on straight-shaft piers drilled into the underlying claystone-sandstone bedrock.

Highly loaded shallow foundations placed on expansive clays or materials with differing swell/consolidation and bearing potentials can experience differential movements. The drilled pier foundation system has the advantage of providing a high supporting capacity and will also place the bottom of the piers in a zone of relatively stable moisture content and make it possible to load the piers sufficiently to resist the uplift pressures or consolidation of the overburden soils.

Foundation movements should be within tolerable limits of the following design and construction precautions are observed.

1) Piers drilled into the undisturbed claystone-sandstone bedrock materials may be designed using an allowable end bearing pressure of 40,000 psf and an allowable skin friction value of 4,000 psf, for the portion of the pier in the undisturbed bedrock materials. The piers should also be designed to resist lateral loads assuming a modulus of horizontal subgrade reaction in the overburden soils of 75 tcf and a modulus of horizontal subgrade reaction of 300 tcf in the bedrock materials. This modulus value is given for a 1 foot wide pier and must be corrected for pier size.

2) A minimum pier length of 20 feet and a minimum bedrock penetration of 10 feet are recommended. A maximum pier length to diameter ratio of 25 is also recommended.

3) A minimum pier diameter of 24 inches is recommended to facilitate proper cleaning, casing and inspection of the piers, as well as to aid in the removal of the cobbles and boulders from the pier holes.

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

5) Piers should be properly cleaned, dewatered and approved by this office prior to steel and concrete placement.

6) Due to the presence of sands, gravels, cobbles, boulders, and groundwater in the test holes, casing and dewatering equipment will probably be required to reduce water infiltration and caving. The concrete should not be placed in more than 3 inches of water unless the tremie and/or pump methods are used to place the concrete.

7) The pier drilling contractor should mobilize equipment of sufficient size and operating condition to handle the temporary casing, be able to drill and/or core through the larger boulders and achieve the required bedrock penetration.

8) A representative of this office should observe the pier drilling operations.

L-Pile Parameters: Table A below outlines our recommendations for soil parameters to be used in the LPILE design program.

TABLE A
PARAMETERS FOR LPILE DESIGN

SOIL TYPE	LPILE SOIL TYPE	YOUNG'S MODULUS (x 10E6 psi)	EFFECTIVE UNIT WEIGHT (pcf)	UNDRAINED SHEAR STRENGTH Cu (psf)	Internal Friction Φ' (deg.)	E_{50}
Sands and Gravels With Clay Interbeds	Stiff Clay w/o Free Water	0.020	125.0	0	35	0.007
Claystone-Sandstone Bedrock	Weak Rock	0.10	125.0	4000	15	0.004

Additional Deep Foundation Recommendations: An alternative deep foundation type to the drilled piers recommended above would consist of a micropile foundation system drilled through the existing fill materials, any soft natural soils and the natural cobbles and boulders and into the underlying bedrock materials. NWCC recommends the micropiles penetrate at least 10 feet into the bedrock materials.

A micropile is a relatively small diameter (typically less than 12 inches) grouted pile with internal reinforcement. A micropile contractor should be provided with the foundation plans and structural loads to determine the type, size, number and layout of the micro-piles.

Pile load tests should be conducted to assess the bond strength properties of the soil. A minimum of five (5) test piles are recommended. The grout to bond strength will depend on the type of pile used and type of soil. A representative of this office should observe the load test and installation of micropiles.

It should be noted that small to large boulders, as well as clay layers, were encountered in the test holes. In addition, relatively shallow groundwater was encountered in the test holes and test pits. Therefore, the above conditions should be anticipated for the design and construction of the micropiles. The pile drilling contractor should mobilize equipment of sufficient size and operating condition to be able to drill through the larger boulders and achieve the required bedrock penetration.

NWCC also recommends the following:

- 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 installation procedures

Floor Slabs: We assume the lower levels of the building will be constructed with a mat slab floor system constructed at 10 to 30 feet below the existing ground surface. On-site soils, with the exception of the 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 natural 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. NWCC recommends the following special design and construction precautions be followed so the amount of movement in the floor slabs can be reduced.

1) Floor slabs should 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) 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 of the existing fill materials and any natural topsoil and organic materials should be removed prior to placement of the underslab gravels or new fill materials.

3) Floor slabs should be provided with control joints placed a maximum of 10 to 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 joints should be a minimum of ¼ of the thickness of the slab in depth.

4) 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.

5) It has been NWCC's experience that the risk of floor slab movement can be reduced by removing any expansive clays 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. 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. In addition, all of the existing fill materials must be removed prior to fill placement.

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 remove all of the clays, construct a structural floor over a well-vented crawl space or void form materials, or construct a thickened mat slab foundation system.

Underdrain System: NWCC understands the foundation will most likely be designed to be water-tight and resist hydrostatic pressure, and that no permanent dewatering system will be required or installed. In the case that this is **not** done, NWCC recommends the lower levels of the buildings be protected by underdrain systems to help reduce the problems associated with the shallow groundwater, surface and subsurface drainage during high runoff periods. Groundwater or runoff can infiltrate the foundation at the foundation and floor slab levels. This water can be one of the primary causes of differential foundation and slab movement.

Structures constructed below the groundwater level must be protected by an underdrain system and be waterproofed and designed to resist hydrostatic uplift. Designing the structure to resist hydrostatic uplift is the only completely safe way to protect the lower levels. If an underdrain system is used, the owner should be aware of the risk of damage to the structure should the underdrain system become inoperative during the life of the facility. The design of the underdrain system should consider the consequences of hydrostatic uplift if the permanent dewatering system fails.

The underdrain systems should be located around the entire perimeter of the buildings and below the floor slabs. The underdrains should be located at least 1 to 2 feet below the lower floor level elevations. The underdrain systems should consist of a layer of free draining granular material beneath the floor slab connected to the perimeter and lateral drains. The lateral drains should be spaced on approximately 15 foot centers beneath the floor slabs. We recommend the use of perforated PVC pipe for the drainpipe which meets or exceeds ASTM 3034/SDR 35 requirements, to minimize the potential for crushing the pipe during backfill operations. The drainpipe should be surrounded by at least 12 inches of free draining gravel. The holes in the drainpipe should be oriented down between 4 o'clock and 8 o'clock to promote rapid runoff of the water. The drainage system should be protected from contamination by a filter covering of Mirafi 140N subsurface drainage fabric or an equivalent product. The drainpipes should have a minimum slope of 1/8 inch per foot and should be daylighted at a positive outfall(s) protected from freezing, or be led to sumps from which the water can be pumped. Caution should be taken when backfilling so as not to damage or disturb the installed underdrain. We recommend the drainage systems include cleanouts spaced no greater than 50 feet, be protected against intrusion by animals at the outfall(s) and be tested prior to backfilling.

The design of an underdrain system for the proposed buildings should be finalized after the excavations for the buildings have been completed and the flow rate of groundwater to be removed from the building can be estimated. The actual quantities of water which must be pumped from the sumps to dewater the lower level of the excavation should be determined at the time of construction by conducting pumping tests from the sumps. NWCC can assist in the design of the dewatering system.

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 on the basis of 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 increase the earth pressures on foundation walls and retaining structures.

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. 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, near the optimum moisture content.

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.

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) The 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. It is our understanding that the roof runoff will be collected and discharged into the proposed stormwater drainage system. Roof overhangs, which project two to three feet beyond the foundation, should be considered if gutters or roof runoff collection systems 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 buildings.

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

Site Grading: Temporary cuts for foundation construction should be constructed to OSHA standards for temporary excavations. Permanent, unretained cuts should be kept as shallow as possible and should not exceed a 3(Horizontal) to 1(Vertical) configuration for the existing fill materials and a 2(Horizontal) to 1(Vertical) configuration for the natural soils.

We recommend permanent, unretained cuts be limited to 15 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's office should be notified immediately to evaluate the site if seepage is encountered or deeper cuts are planned and determine if additional investigations and/or stabilization measures are warranted.

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.

Fills up to 15 feet in height can be constructed at the site and should be constructed to a 2(Horizontal) to 1(Vertical) or flatter configuration. The fill areas should be prepared by stripping any existing fill materials and 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. The fills should be properly benched/keyed into the natural hillsides after the existing fill materials, natural topsoil, and organic materials, silts, and clays have been removed. The fill materials should consist of the on-site soils (exclusive of topsoil, organics, or silts) and be uniformly placed and compacted in 6 to 8-inch loose lifts to the minimum density value and moisture content range indicated above.

Proper 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. NWCC recommends that a maximum of 4 inches of topsoil be placed over the new cut and fill slopes. It should be noted that the newly placed topsoil materials may slough/slide off the slopes during the spring runoff seasons until the root zone in the vegetated cover establishes.

A qualified engineer experienced in this area should prepare site grading and drainage plans. The contractor must 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.

Pavement Recommendations: Pavement section alternatives presented below are based on field and laboratory investigations, assumed traffic loadings indicated below, pavement design procedures presented in the AASHTO Guide for Design of Pavement Structures and our experience with similar sites and conditions.

Based on the results of the field and laboratory investigations and our understanding of the proposed construction, it appears the materials to be encountered at proposed pavement subgrade elevations will most likely consist of existing fill materials. The fill materials generally classified as SC-CL and SC-SM soils in accordance with the USCS and as A-4 soils in accordance with the AASHTO classification system. These materials are generally considered to provide fair support for pavement structures.

NWCC recommends the pavement areas subjected to both automobile and truck traffic be constructed with a composite pavement section consisting of at least 4 inches of hot mix asphalt (HMA) placed over 4 inches of CDOT Class 6 aggregate base course (ABC) and 8 inches of subbase materials consisting of CDOT Class 2 aggregates. Pavements for areas subjected to automobile traffic only, such as automobile parking spaces/stalls, may be constructed with a composite pavement section consisting of at least 3 inches of HMA placed over 4 inches of Class 6 ABC and 8 inches of subbase aggregates. In lieu of the flexible pavement sections provided above, a minimum of 6 inches of Portland cement concrete (PCC) should be used in the automobile and truck traffic areas and a minimum of 5 inches of PCC should be used in the automobile parking spaces/stalls.

NWCC recommends the areas subjected to heavy truck traffic turning movements, such as in apron areas in front of any trash dumpster approach areas or at loading docks, be paved with a rigid pavement section consisting of at least 8 inches of PCC. Sidewalks subjected to pedestrian traffic should be paved using at least 4 inches of PCC and 5 inches of PCC in areas where occasional emergency or snow removal vehicle traffic is anticipated.

Prior to placement of subbase materials, any existing fill materials and sandy clays should be removed to a depth of at least 3 feet below the proposed pavement grade. NWCC recommends the exposed fill materials be uniformly mixed and removed or screen off all of the construction debris materials, moisture treated to within 2 % of the optimum moisture content and then be recompacted to at least 95 % of the maximum standard Proctor density. Depending on the time of year when subgrade preparation is considered, moisture conditioning including drying and/or moistening of subgrade materials will most likely be required in order to attain uniform compaction. NWCC also recommends that the properly moisture conditioned and recompacted subgrade soils be proofrolled with a loaded tandem dump truck or water truck prior to placing the subbase gravels. Areas exhibiting deflection and rutting will most likely require deeper stabilization. The depth and type of stabilization should be determined at the time of construction.

NWCC recommends the HMA materials consist of an approved “Superpave” mix designed by a qualified, registered engineer. The mix design should be designed using the SX gradation and mixed with PG 58-28 oil or higher performance graded asphaltic materials. The mix should be produced and placed by a qualified contractor and should be compacted to between 92 and 96 percent of the maximum theoretical (Rice) density. Quality control activities should be conducted on paving materials at the time of placement.

ABC materials should consist of well-graded aggregate base course materials that meet CDOT Class 6 ABC grading and durability requirements. Base course and subbase materials (Class 2 Subbase) should be uniformly placed and compacted in 4 to 6-inch loose lifts to at least 95 % of the maximum modified Proctor density and within +/- 2 % of the optimum moisture content as determined by ASTM D1557.

Concrete pavement materials shall be based on a mix design established by a qualified engineer. Concrete should have a minimum 28-day compressive strength of 4,500 psi, be air entrained with approximately 6 percent air and have a maximum water/cement ratio of 0.42. Concrete should have a maximum slump of 4 inches and should contain control joints not greater than 10 to 12 feet on centers, depending on the slab configurations. The depth of the control joints should be at least ¼ of the slab thickness.

The collection and diversion of surface and subsurface drainage away from the paved areas is extremely important to satisfactory performance of the pavement. The design of the surface and subsurface drainage features should be carefully considered to remove all water from paved areas and to prevent ponding of water on and adjacent to paved areas.

Limitations: The recommendations provided in this report are based on the soils and bedrock materials 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 proposed structures; 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.

Expansive soils and bedrock materials were encountered at the site. These soils are stable at their natural moisture content but can shrink or swell considerably with changes in moisture. The behavior of expansive soils and bedrock materials is not fully understood. The swell potential of a 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 design and construction practices for foundations and floor slabs on expansive soils and bedrock materials. The owner and future owners should be aware that there is a risk in construction on these types of soil. The 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 these soils and bedrock materials, 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 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 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.

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.

Brian D. Len, P.E.
Principal Engineer ***4/4/2024***

Reviewed by Erika Hill, P.E., P.G.
Senior Project Engineer

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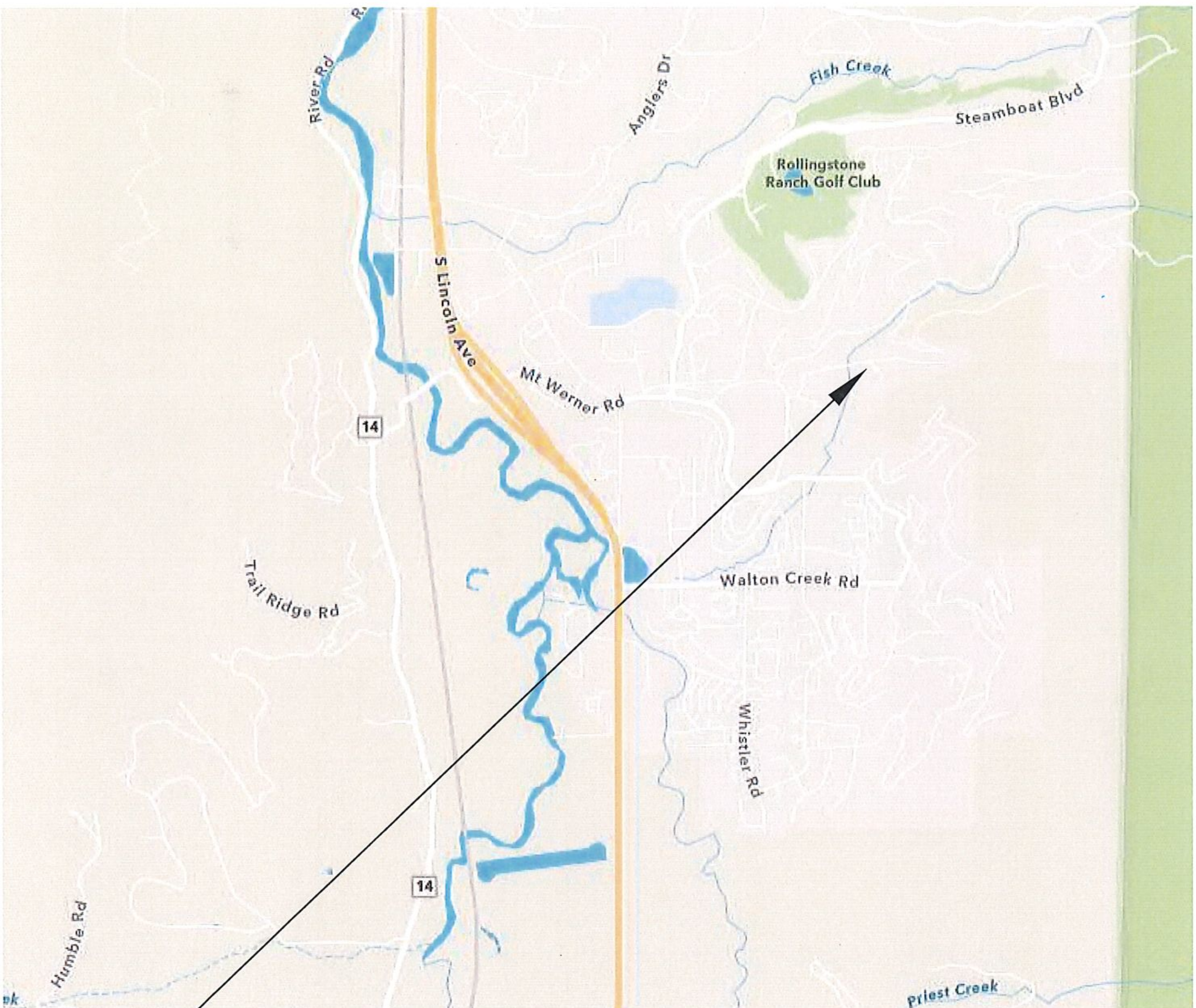
NOT TO SCALE



PROJECT SITE

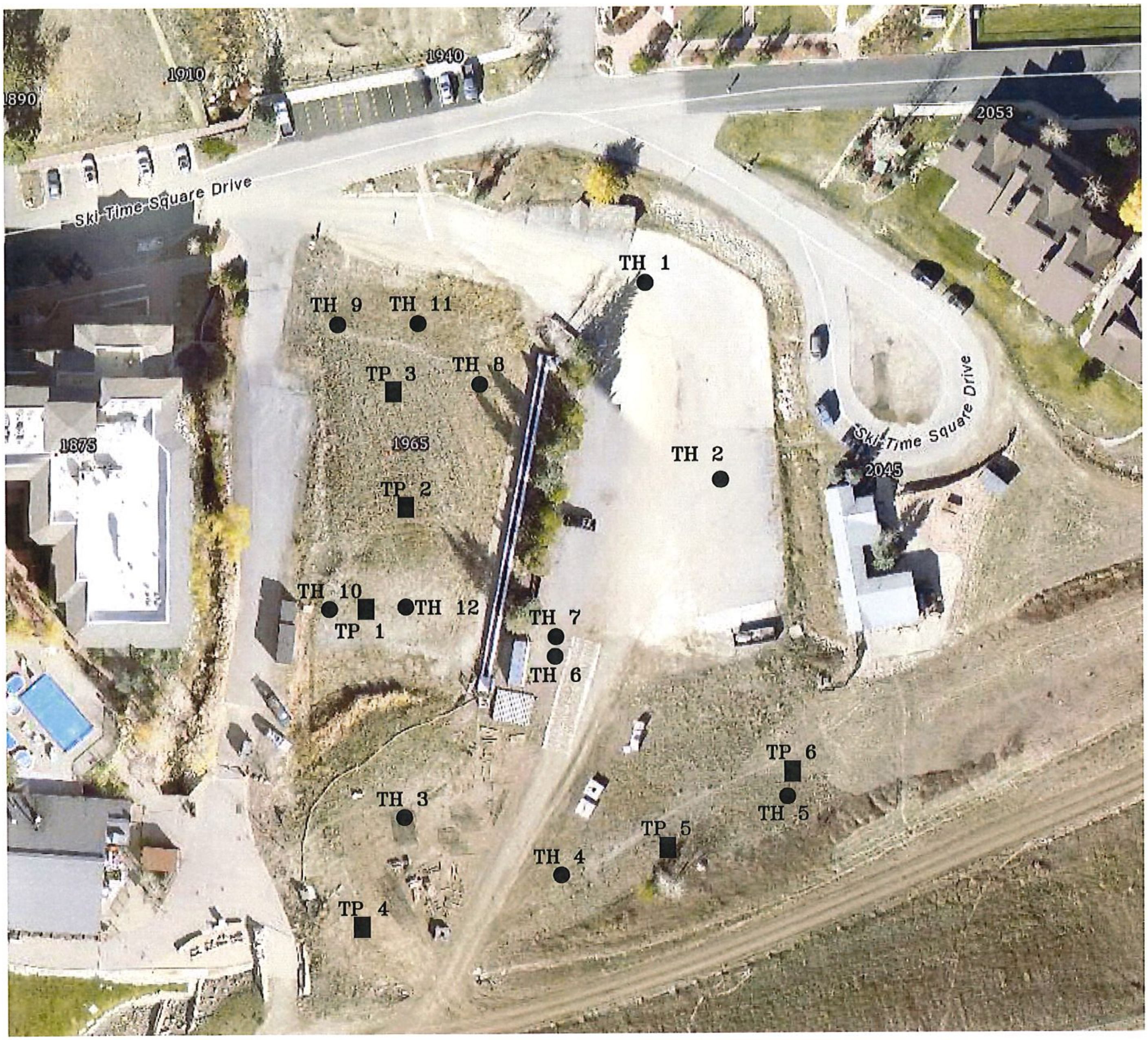
Title: VICINITY MAP	Date: 10/30/23	NWCC North West Colorado Consultants, Inc.
Job Name: Thunderhead Beach	Job No. 23-13103	Geotechnical / Environmental Engineering · Materials Testing
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #1	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487

● = TH Indicates Test Hole

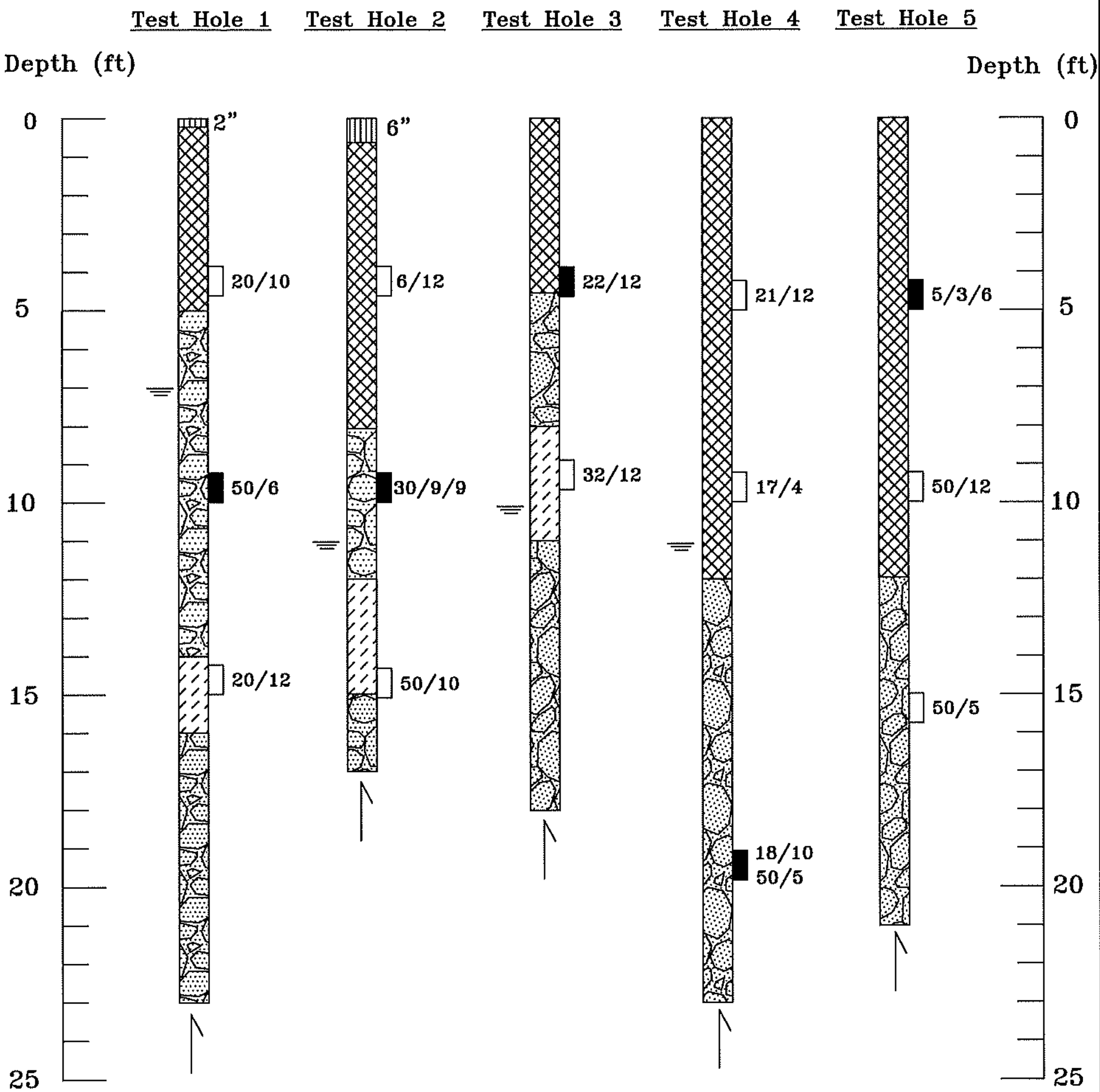
■ = TP Indicates Test Pit

N

NOT TO SCALE



Title: SITE PLAN– LOCATION OF TEST HOLES & TEST PITS	**Date:** 10/30/23	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: Thunderhead Beach	**Job No.** 23–13103	
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	**Figure** #2	



Title: LOGS OF EXPLORATORY TEST HOLES	Date: 10/30/23
Job Name: Thunderhead Beach	Job No. 23-13103
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #3

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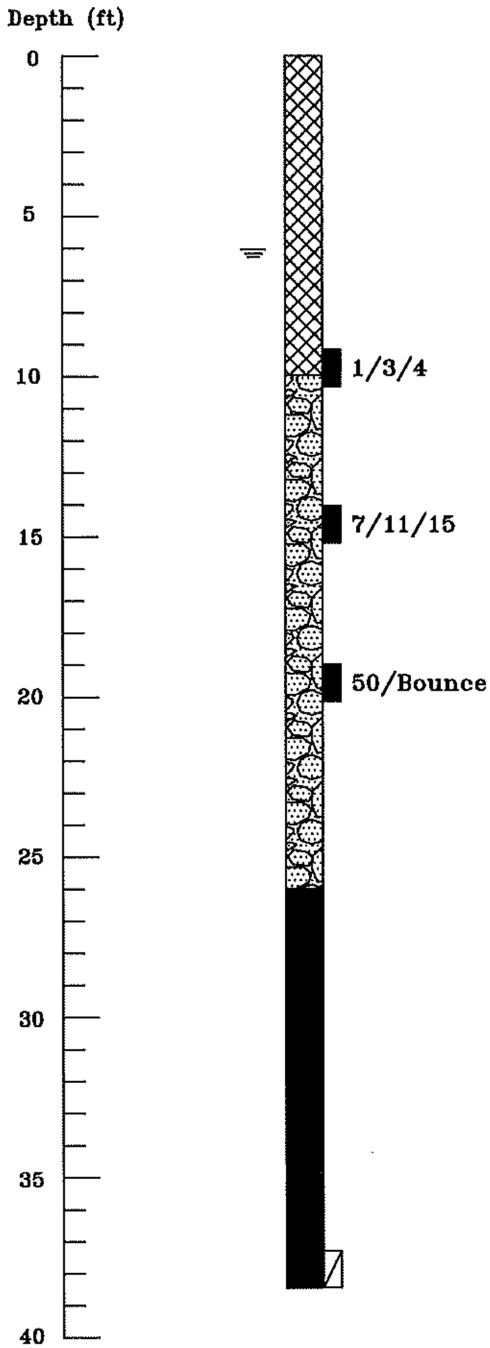
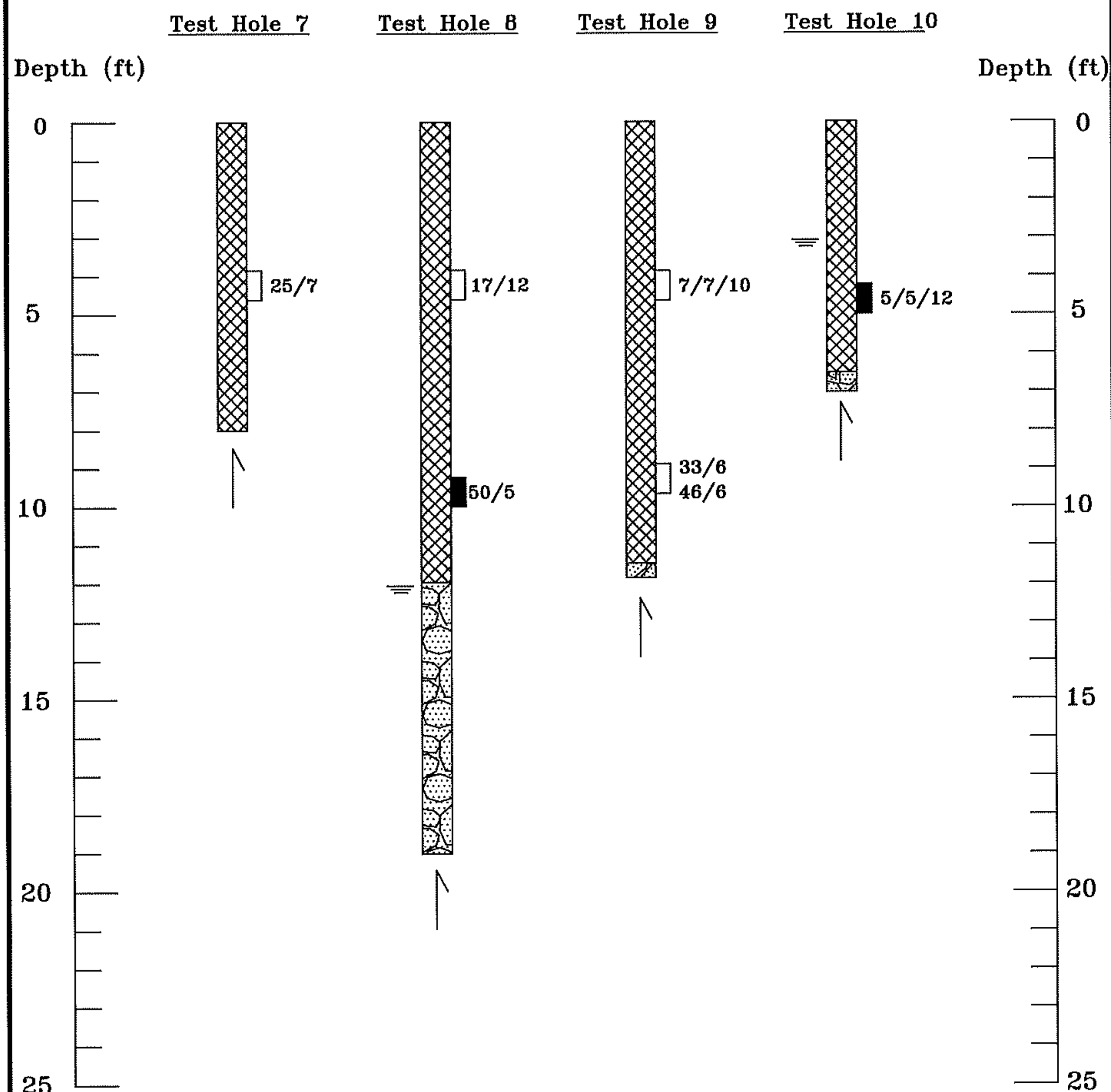
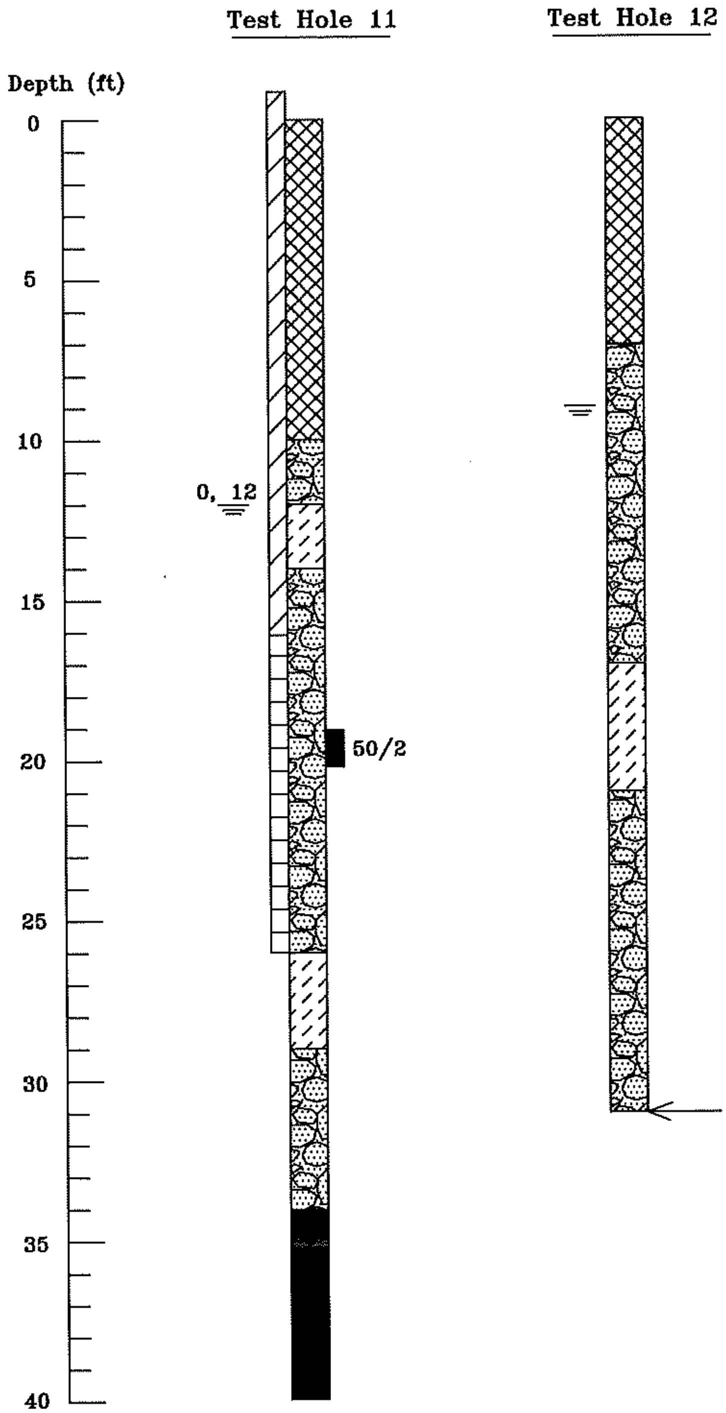
Test Hole 6



Title: LOGS OF EXPLORATORY TEST HOLE	Date: 10/30/23	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering - Materials Testing (970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive - P.O. Box 775226 Steamboat Springs, Colorado 80477
Job Name: Thunderhead Beach	Job No. 23-13103	
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #4	



Title: LOGS OF EXPLORATORY TEST HOLES	Date: 10/30/23	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: Thunderhead Beach	Job No. 23-13103	
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #5	



Title: LOGS OF EXPLORATORY TEST HOLES

Date: 10/30/23

Job Name: Thunderhead Beach

Job No. 23-13103

Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado

Figure #6

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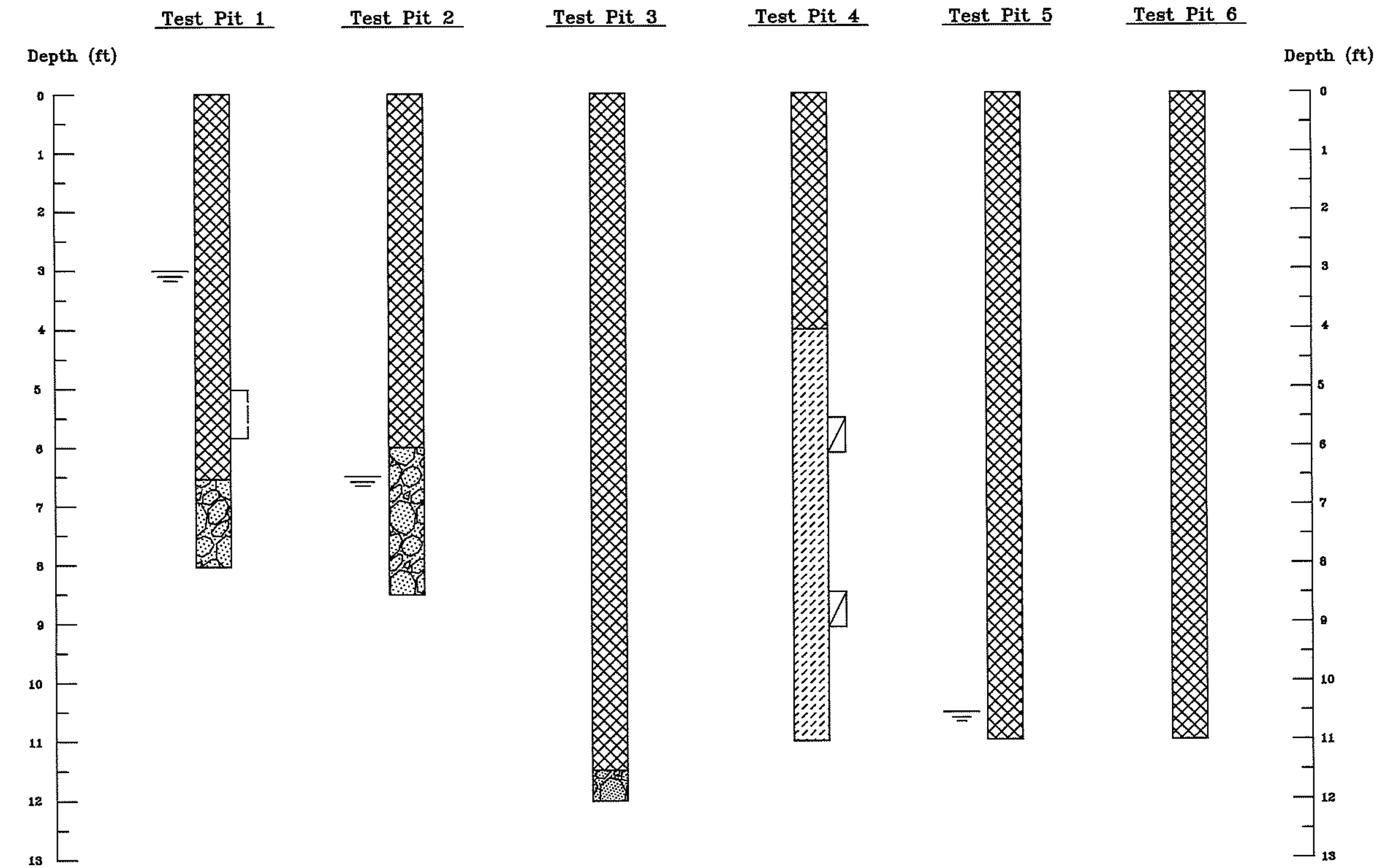

Title: LOGS OF EXPLORATORY TEST PITS	Date: 10/30/23	
Job Name: Thunderhead Beach	Job No. 23-13103	
LOCATION: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #7	

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LEGEND:

ASPHALT.

FILL: Sands and gravels, clays and silts, low to moderately plastic, fine to coarse grained with cobbles and construction debris, loose to medium dense, slightly moist to moist and dark brown to light brown to gray.

SANDS AND GRAVELS: Slightly silty to silty with occasional silty to clayey sand lenses, low to non plastic, fine to coarse grained with cobbles and small boulders, medium dense to very dense, moist to wet and light brown to gray.

CLAYS: Slightly sandy to sand and clay, low to moderately plastic, fine to coarse grained, medium stiff to hard, slightly moist to moist and light brown to brown.

CLAYSTONE–SANDSTONE BEDROCK: Low to moderately plastic, fine to medium grained, weathered to hard, moist, and light brown to tan.

Large Disturbed Sample.

Small Disturbed Sample.

Drive Sample, 2" California Liner Sampler.

Drive Sample, Split Spoon Sampler.

20/10 Drive Sample Blow Count, indicates that 20 blows of a 140–lb. hammer falling 30 inches were required to drive the sampler 10 inches.

Indicates depth to groundwater at the time of drilling/excavation.

12 Indicates depth to groundwater 12 days after drilling was completed.

Indicates Refusal on Boulders or Cobbles.

Indicates Casing/Drill Head Lost.

Indicates Solid 2" Diameter PVC Casing.

Indicates Slotted 2" Diameter PVC Casing.

Title: LEGEND	Date: 10/30/23
Job Name: Thunderhead Beach	Job No. 23–13103
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #8

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NOTES:

1) The test holes were drilled on September 7 & 8, and October 26 & 27 of 2023 with a CME 55 drill rig using a Rotary Hammer Drill (ODEX) and 4-inch diameter continuous flight augers. The test pits were excavated with a Cat 416 trackhoe on September 19, 2023.

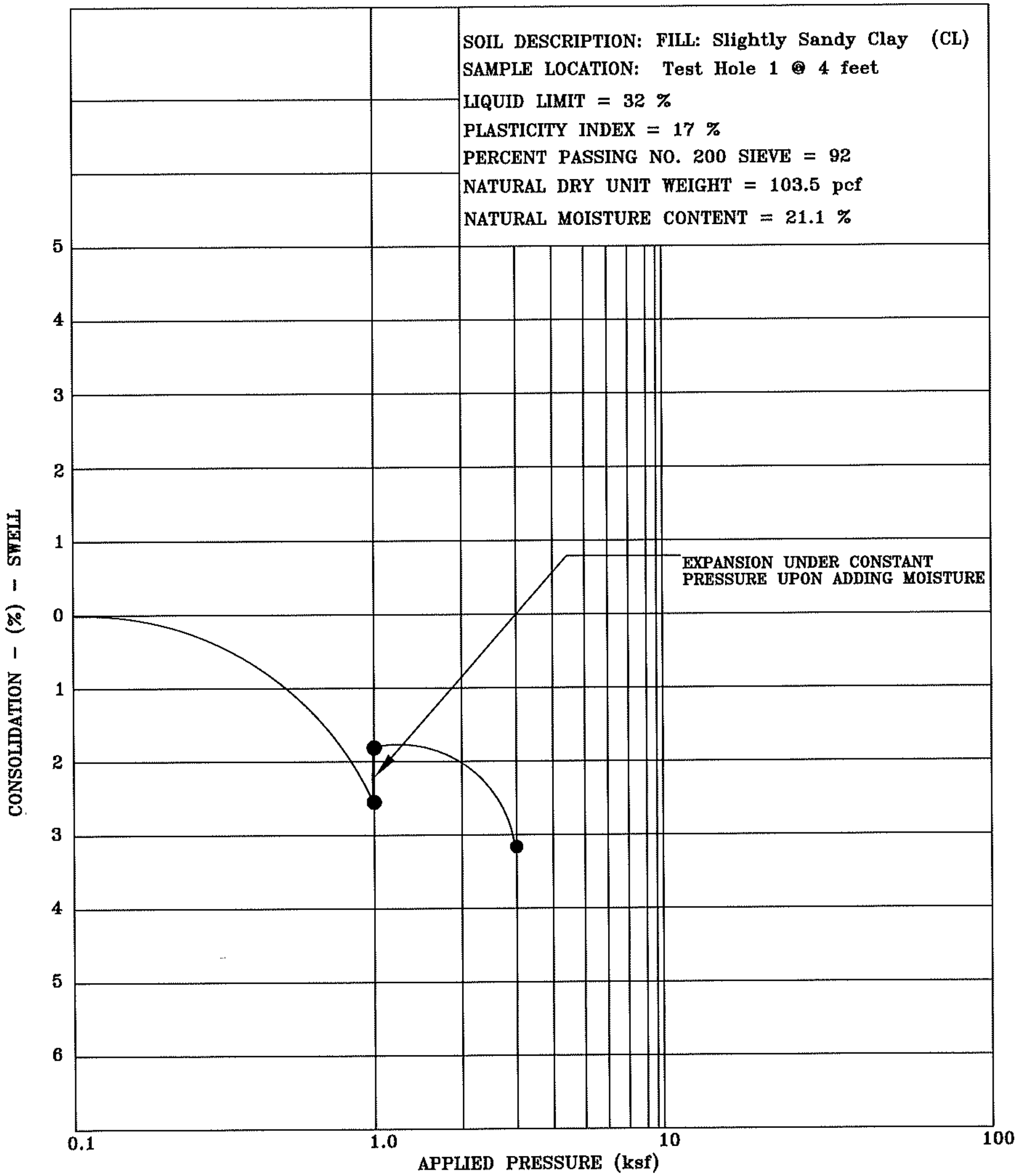
2) Locations of the test holes and test pits were determined in the field by NWCC by pacing from topographic features at the site.

3) Elevations of the test holes & pits were not determined and the logs are drawn to the depths investigated.

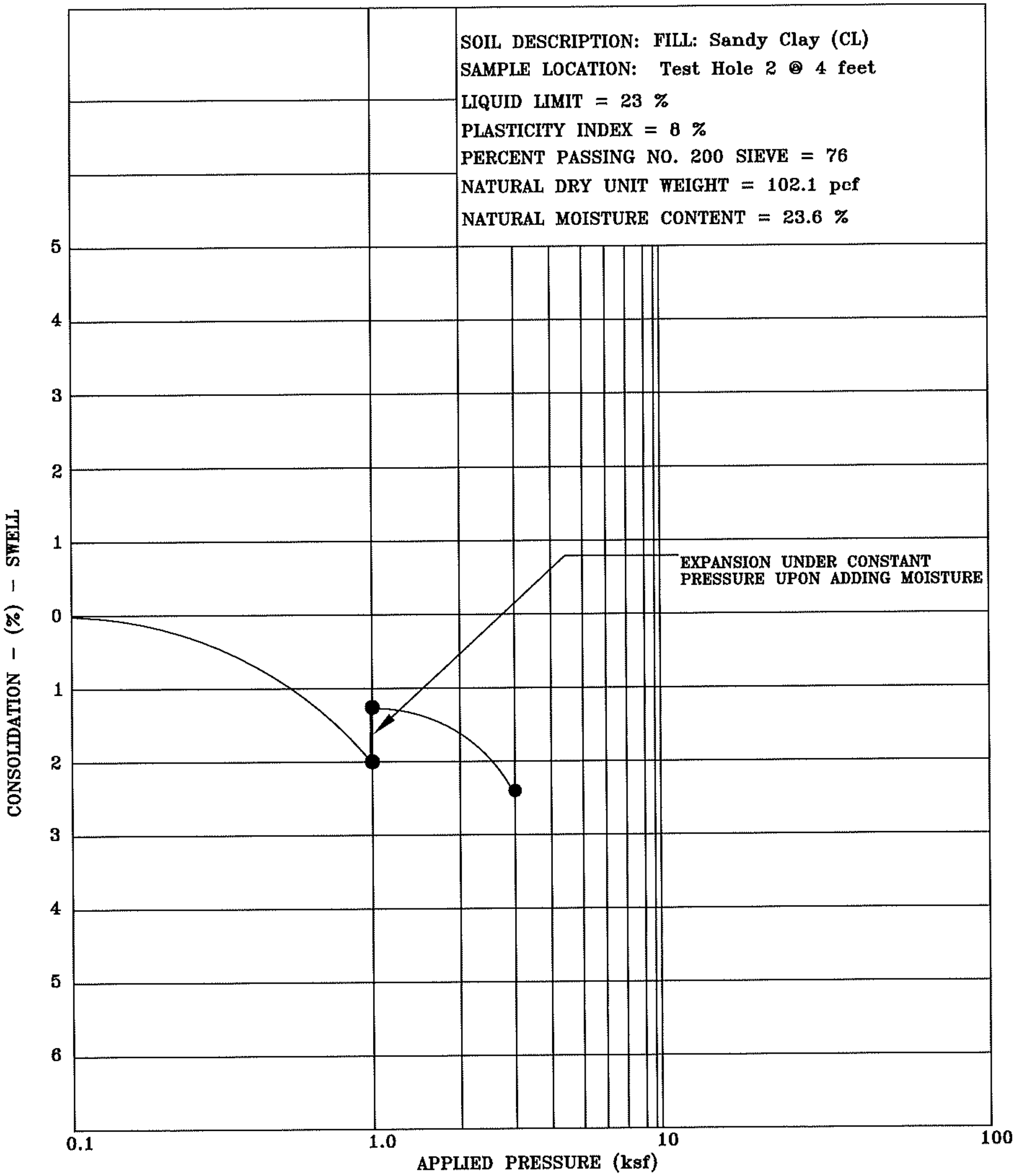
4) The lines between materials shown on the logs represent the approximate boundaries between material types and transitions may be gradual.

5) The water level readings shown on the logs were made at the time of excavation/drilling. Fluctuations in the water levels will probably occur with time.

Title: NOTES	Date: 10/30/23	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering · Materials Testing
Job Name: Thunderhead Beach	Job No. 23-13103	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive · P.O. Box 775226 Steamboat Springs, Colorado 80477
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #9	



Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 10/30/23	North West Colorado Consultants, Inc.
Job Name: Thunderhead Beach	Job No. 23-13103	Geotechnical / Environmental Engineering · Materials Testing
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #10	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487



Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 10/30/23		
Job Name: Thunderhead Beach	Job No. 23–13103		
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #11		

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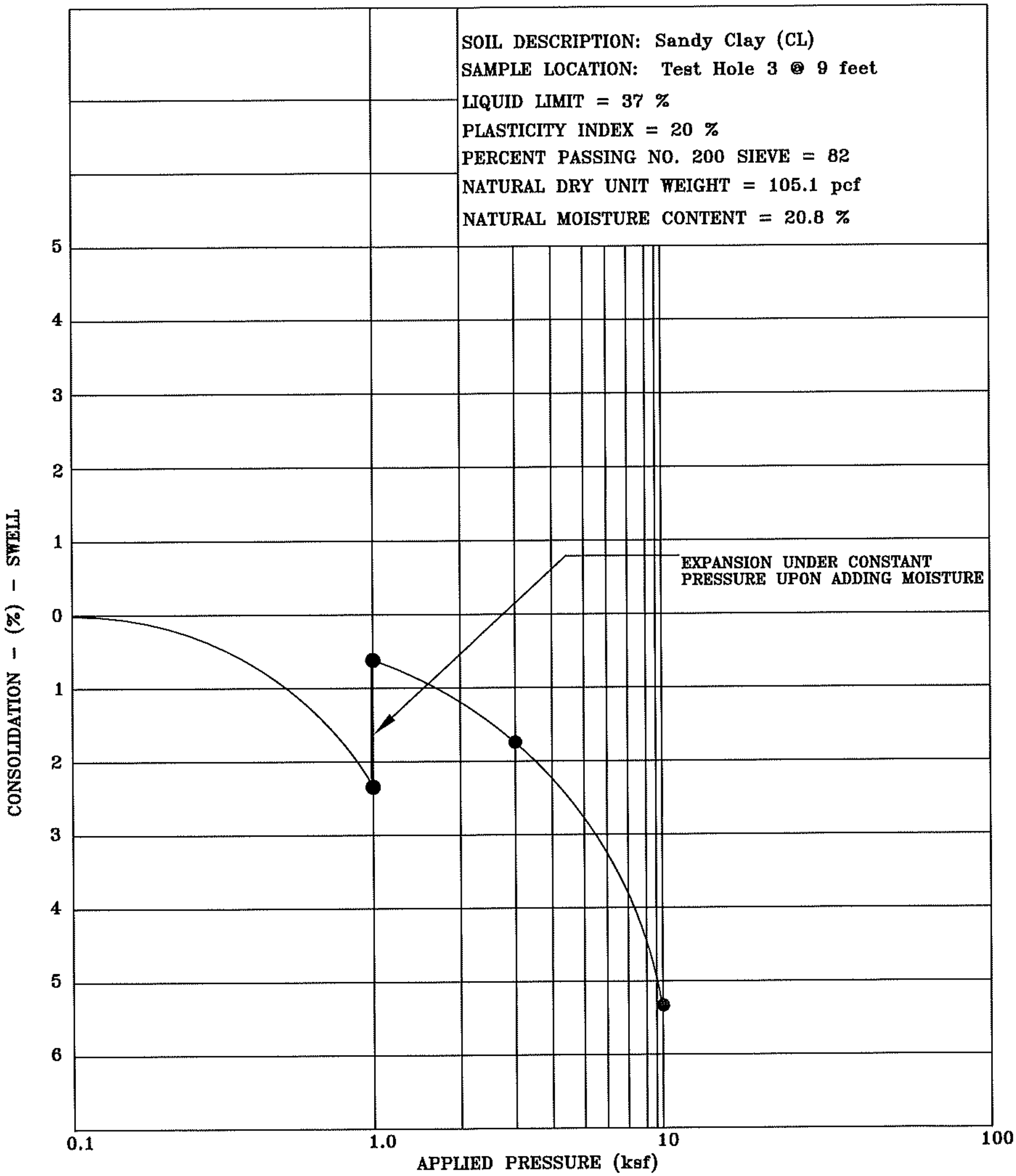
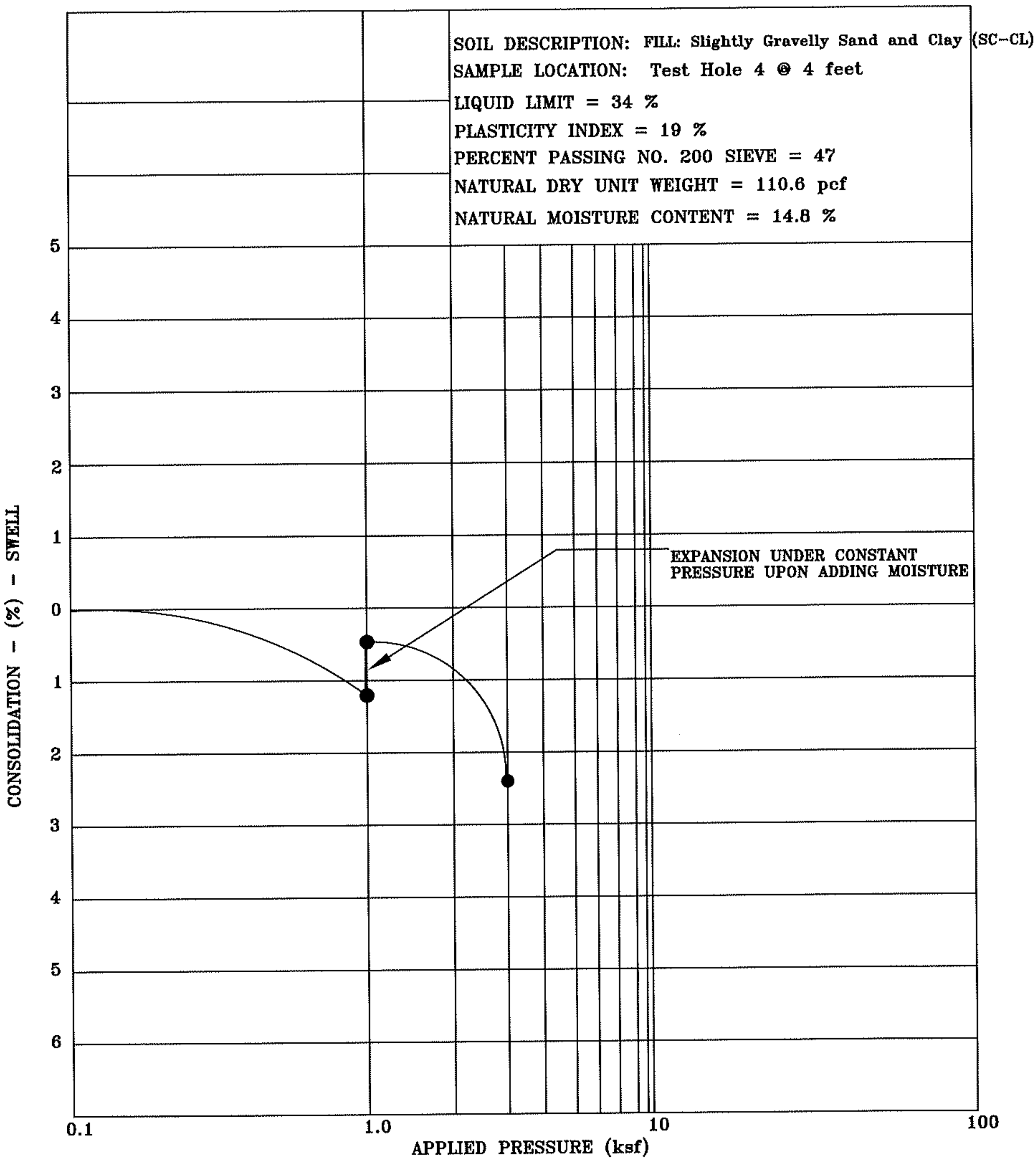


Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 10/30/23	NWCC North West Colorado Consultants, Inc.
Job Name: Thunderhead Beach	Job No. 23–13103	Geotechnical / Environmental Engineering - Materials Testing
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #12	(970)879-7888 - Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487



Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 10/30/23
Job Name: Thunderhead Beach	Job No. 23-13103
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #13

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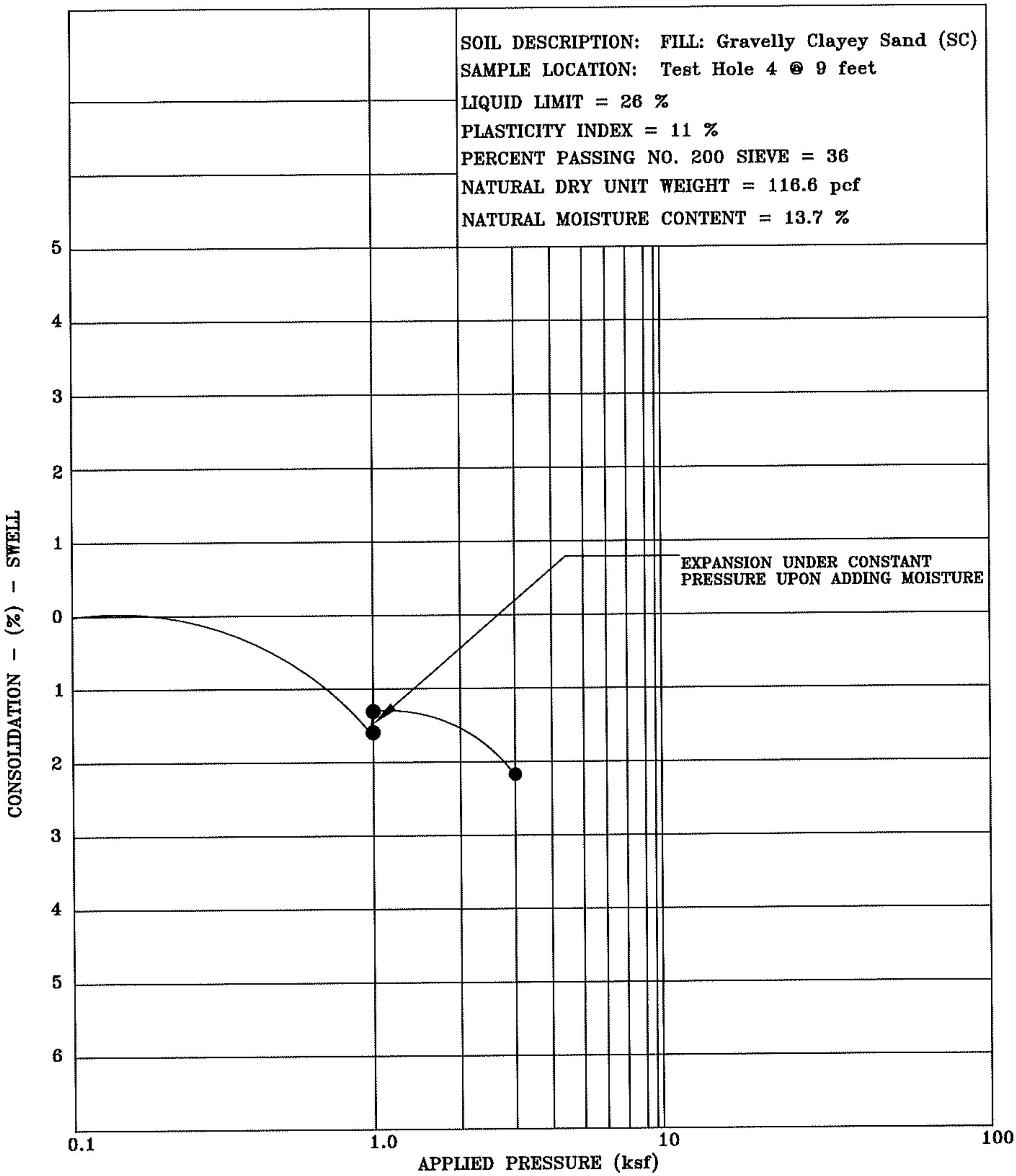
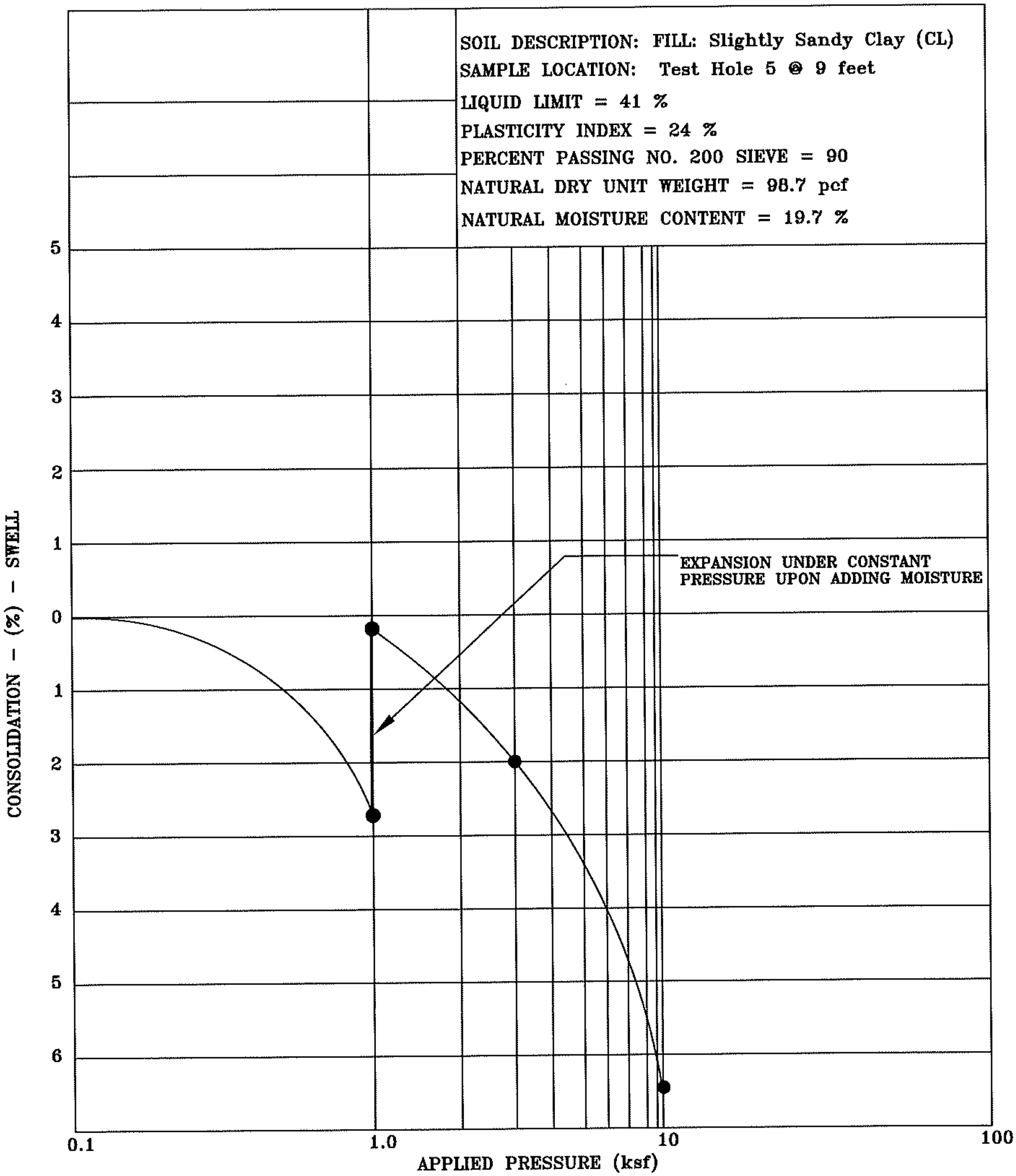


Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 10/30/23	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering · Materials Testing (970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Job Name: Thunderhead Beach	Job No. 23-13103	
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #14	



Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 10/30/23
Job Name: Thunderhead Beach	Job No. 23-13103
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #15

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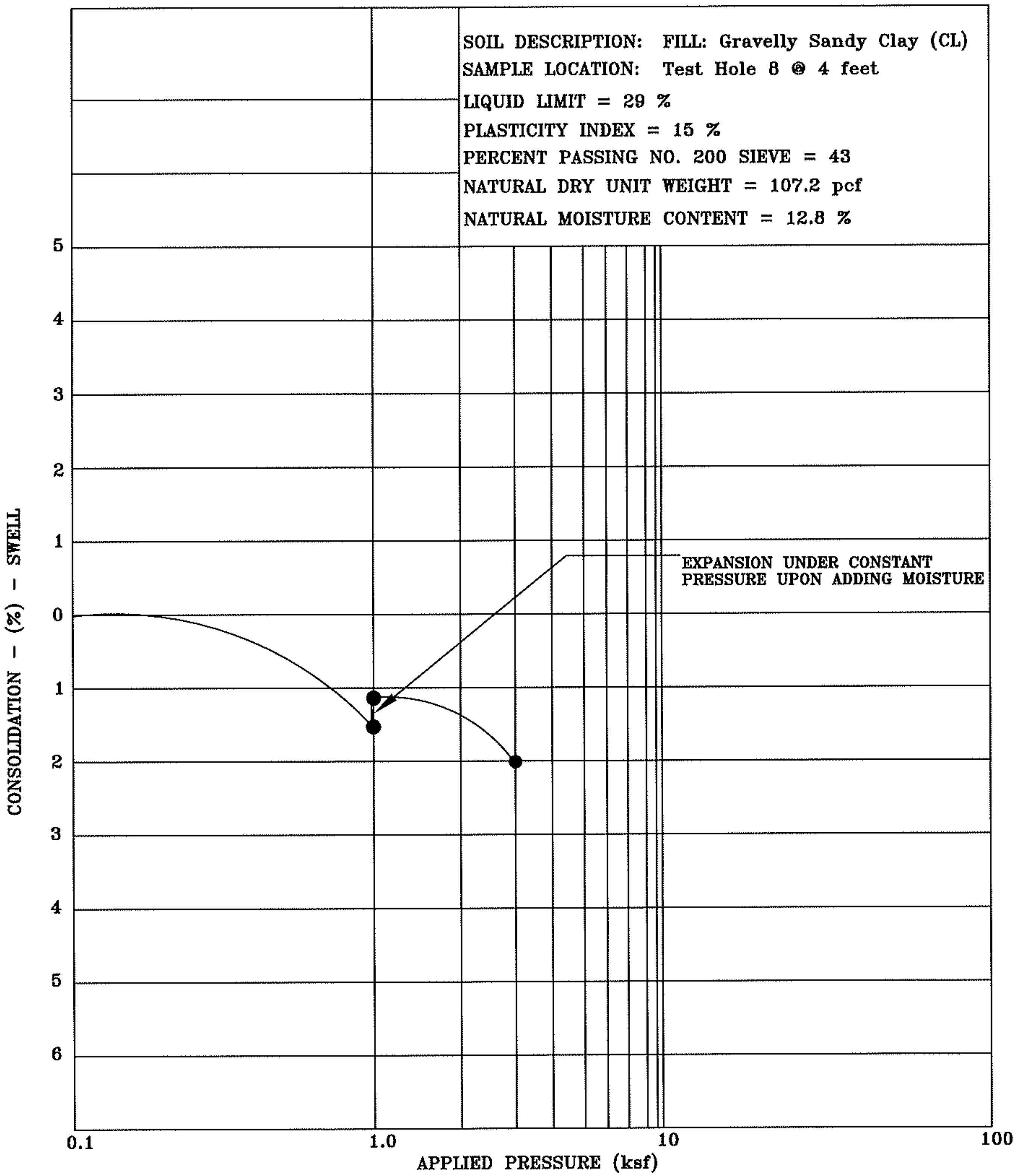
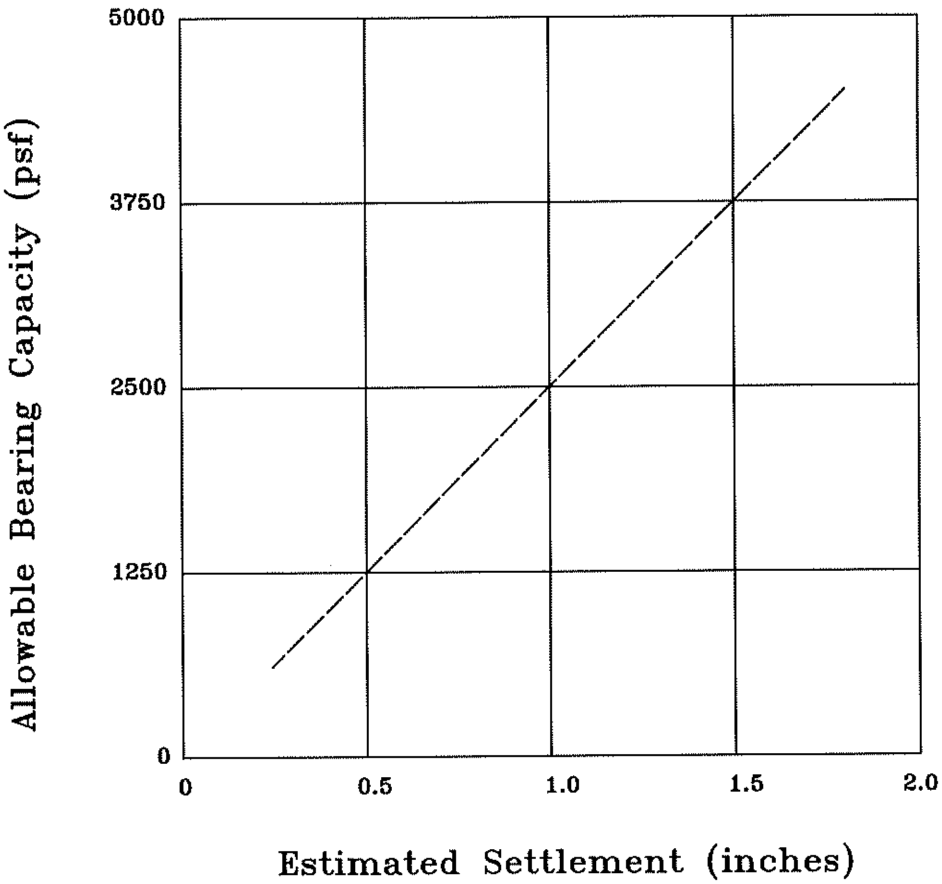


Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 10/30/23	North West Colorado Consultants, Inc.
Job Name: Thunderhead Beach	Job No. 23–13103	Geotechnical / Environmental Engineering · Materials Testing
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #16	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487



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: 10/30/23	North West Colorado Consultants, Inc.
Job Name: Thunderhead Beach	Job No. 23-13103	Geotechnical / Environmental Engineering · Materials Testing
Location: 1965 Ski Time Square Drive, Steamboat Springs, Colorado	Figure #17	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487

NWCC, Inc.

TABLE 1 OF 2

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 HOLE	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
1	4	21.1	103.5	32	17	0	8	92		FILL: Slightly Sandy Clay	CL
1	14	21.4	104.2	29	11	3	28	69	4,300	Sandy Clay	CL
2	4	23.6	102.1	23	8	0	24	76		FILL: Sandy Clay	CL
3	9	20.8	105.1	37	20	1	17	82		Sandy Clay	CL
4	4	14.8	110.6	34	19	5	48	47		FILL: Slightly Gravelly Sand and Clay	SC–CL
4	4	13.6	116.9	30	13	11	45	44	7,700	FILL: Slightly Gravelly Sand and Clay	SC–CL
4	9	13.7	116.6	26	11	20	44	36		FILL: Gravelly Clayey Sand	SC
4	19	19.1		28	10	23	43	34		Gravelly Clayey Sand	SC
5	9	19.7	98.7	41	24	1	9	90		FILL: Slightly Sandy Clay	CL
6	14	14.4		NV	NP	25	52	23		Silty Gravelly Sand	SM
6	38	17.0		29	15	1	41	58		BEDROCK: Claystone–Sandstone	CL
7	4	10.1	114.3	NV	NP	33	41	26		FILL: Silty Gravelly Sand	SM
8	4	12.8	107.2	29	15	29	28	43		FILL: Gravelly Sandy Clay	CL

JOB NUMBER: 23–13103

NWCC, Inc.

TABLE 2 OF 2

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 HOLE	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
9	9	9.7		NV	NP	33	53	14		FILL: Silty Gravelly Sand	SM
10	4	15.9		24	7	10	59	31		FILL: Sightly Gravelly Clayey Sand	SC
TP 1	5 1/2	5.1		NV	NP	53	38	9		FILL: Silty Very Sandy Gravels	GM

* TP indicates Test Pit

JOB NUMBER: 23-13103