



Preliminary Subsoil Investigation and Geologic Hazard Evaluation  
Proposed Overlook Park Subdivision/Victory Highway  
A Parcel of Land Located in Section 1, Township 6 North, Range 85 West  
Steamboat Springs, Colorado

Prepared For:

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## TABLE OF CONTENTS

Conclusions .....	1
Purpose and Scope of Study .....	1
Proposed Development .....	1
Site Conditions .....	2
Field Investigation .....	2
Laboratory Investigation .....	3
Subsurface Conditions .....	3
Preliminary Residential Construction Considerations & Recommendations .....	4
Roadway and Pavement Section Recommendations .....	5
Retaining Structures .....	7
Geologic Hazard Evaluation .....	9
Limitations .....	11
References .....	13
Vicinity Map .....	Figure #1
Site Plan/ Location of Test Holes / Pits .....	Figure #2
Logs of Exploratory Test Holes .....	Figures #3
Logs of Exploratory Test Pits .....	Figures #4
Legend and Notes .....	Figure #5
Swell-Consolidation Test Results .....	Figures #6 through #9
Standard Proctor Test Results .....	Figures #10 and #11
Stacked Boulder Wall Detail .....	Figure #12
Summary of Laboratory Test Results .....	Table 1

## **Conclusions**

We believe that the construction of the proposed residential development and roadways is feasible from a geotechnical standpoint provided the recommendations in this report are followed. A discussion of geologic and geotechnical considerations related to the proposed residential development and roadway construction are outlined herein. It should be noted that this investigation is preliminary in nature with regards to the construction of the individual building sites and detailed Subsoil and Foundation Investigations on a site-specific basis should be performed prior to design and construction.

## **Purpose and Scope of Study**

This report presents the results of a Preliminary Subsoil Investigation and Geologic Hazard Evaluation for the Proposed Overlook Park Subdivision and the Victory Highway to be developed within a parcel of land located in Section 1 of Township 6 North, Range 85 West in the City of Steamboat Springs, Routt County, Colorado. The approximate location of the project site is shown in Figure #1.

A field exploration program was conducted to obtain general information on subsurface conditions. Material samples obtained during the subsurface investigation were tested in the laboratory to provide data on the general classification and engineering characteristics of the on-site soils and bedrock materials. The results of the field and laboratory investigations are presented herein.

This report has been prepared to summarize the data obtained and to present our conclusions and recommendations based on our current understanding of the proposed construction and development, and the subsurface conditions encountered. A discussion of preliminary geotechnical engineering considerations, local geology and site conditions related to construction of the proposed residential development and Victory Highway are included.

## **Proposed Development**

It is our understanding that the proposed development will consist of the construction of a residential subdivision with approximately 153 residential building lots to be located to the southwest, west and northwest of the West Acres Mobile Home Park and the West End Village Subdivision in Steamboat Springs, Colorado. It is also our understanding that the project will consist of the construction of approximately 3,700 feet Victory Highway from Downhill Drive to the western edge of the proposed subdivision. A number of other residential streets will be

constructed within the subdivision, as well as an extension to Abbey Way, which presently ends at the west edge of West End Village Subdivision.

Based on several versions of the preliminary plans provided by Landmark Consultants, Inc. (Landmark) and dated January 16, May 27 and July 10 and 17, 2008, it appears that overlot site grading, consisting of cuts and fills on the order of 1 to 10 feet will occur across the majority of the residential subdivision. However, substantially larger cuts will be required along the north side of Victory Highway (east end) and along the northern edge of the property and north of the cul-de-sac that is located north of East Slate Circle. It appears that relatively large cut slopes and possibly retaining walls or other types of retaining structures will be constructed these areas. It also appears that several other smaller retaining walls, 10 feet or less in height will be constructed along the northern edge of Victory Highway.

We anticipate structure loadings from the residential development will range from light to moderate. If loadings or conditions are significantly different from those described above, we should be notified to reevaluate the recommendations contained in this report.

## **Site Conditions**

The property generally consists of vacant undisturbed rural land located in Steamboat Springs, Colorado. The property is bordered to the west by similar, undeveloped agricultural land, on the north by the Steamboat Springs Airport and other undeveloped land, on the south by U.S. Highway 40, and on the east by the West Acres Mobile Home Park and the West End Village Subdivision.

The topography of the site is highly variable and generally consists of flat to steeply sloping hillsides. A drainage that generally flows in an east to west direction is located in the central part of the property and the adjacent hillsides generally slope down towards the drainage. The hillsides situated to the north of the drainage generally slope moderately to steeply down to the southeast, south and southwest; whereas the hillsides situated to the south of the drainage generally slope moderately to steeply down to the northeast, north and northwest. On the extreme southern edge of the property the hillside slopes very steeply down to the south towards U.S. Highway 40.

The vegetation across the site is variable and generally consists of grasses, weeds, sagebrush and deciduous brush.

## **Field Investigation**

The field investigations for the project were conducted on May 21, June 2, 3, and 20, 2008. Nine (9) test holes and thirteen (13) test pits were drilled/excavated at the approximate locations shown on Figure #2 to explore the subsurface conditions across the site. Locations of the test holes and test pits were determined by pacing from roadway centerline staking in the field provided by Landmark Consulting, Inc. prior to this investigation. The test holes were advanced with an all-terrain mounted drill rig using 4-inch diameter continuous flight augers. The test

pits were excavated with a Cat 320C trackhoe, as well as a Yanmar 45 trackhoe. Logs of the exploratory test holes are shown in Figure #3 and the logs of the exploratory test pits are shown in Figure #4. The Legend and Notes associated with the logs are shown in Figure #5.

## **Laboratory Investigation**

Samples obtained from the test holes/pits were examined and classified in the laboratory by the project engineer. Laboratory testing included standard property tests such as natural moisture contents, unit weights, grain size analyses and Atterberg limits. Swell-consolidation testing was also conducted on samples of the clays and bedrock materials to evaluate the compressibility or swell characteristics of the soils and bedrock materials under loading and saturation. Standard Proctor tests and R-Value tests were conducted on large disturbed samples of the overburden soils and bedrock materials obtained from the proposed cut areas.

The swell-consolidation test results are summarized later in this report and are shown in Figures #6 through #9, whereas the standard Proctor test results are shown in Figures #10 and #11. All of the other test results are summarized in the attached Table 1. The laboratory testing was conducted in general accordance with applicable ASTM/AASHTO specifications.

## **Subsurface Conditions**

The subsurface conditions encountered in the test holes and test pits were highly variable and generally consisted of a layer of topsoil and organic materials overlying natural clays, sands and gravels, and claystone-shale bedrock materials that extended to the maximum depth investigated, 30 feet. Graphic logs of the exploratory test holes/pits are shown in Figures #3 and #4, and the associated Legend and Notes are presented in Figure #5.

A layer of topsoil and organic materials was encountered at the ground surface in all of the test holes and test pits, and ranged from 6 to 60 inches in thickness, with the thicker amounts of topsoil being encountered in the extreme northern end of the project.

Natural clays were encountered below the topsoil and organic materials in test holes 1, 4, 5, 6, 7, 8, and 9, as well as in test pits 1 through 8 and 10 through 13. The natural clays extended to the maximum depth investigated in test holes 7 and 9, as well as in test pits 6, 7, 8, and 13. The natural clays were slightly sandy to sandy with occasional bedrock fragments, moderately to highly plastic, medium stiff to hard, moist to very moist and brown to gray in color with calcareous stringers. Samples of the natural clays classified as CL, CL-CH, CH-CL, and CH soils in accordance with the Unified Soil Classification System. An R-Value test conducted on a sample of the remolded clays exhibited a value less than 5.

Natural sands and gravels were encountered beneath the clays in test pit 12, as well as beneath the claystone-shale bedrock materials in test hole 1. The sands and gravels extended to the maximum depths investigated in test hole 1

and test pit 12. The sands and gravels were silty to clayey with occasional cobbles, low to non-plastic, dense, dry to slightly moist and brown in color. A sample of the natural sands and gravels classified as a GM-GC soil in accordance with the Unified Soil Classification System.

Weathered claystone-shale bedrock materials were encountered below the topsoil and organic materials in test holes 2 and 3, and test pit 9. The weathered shale materials were also encountered beneath the clays in test hole 6 and test pit 11. The weathered bedrock materials were slightly sandy to sandy, low to moderately plastic, weathered, moist to very moist and gray to dark gray in color. An R-Value test conducted on a sample of the remolded weathered claystone-shale bedrock materials exhibited a value less than 5.

Claystone-shale bedrock materials were encountered beneath the clays or weathered bedrock materials in test holes 1 through 5 and test hole 8, as well as in test pits 1 through 5 and test pits 9 and 10. The claystone-shale bedrock materials extended to a depth of 15 feet in test hole 1, and to the maximum depth investigated in the other test holes and test pits. The claystone-shale bedrock materials were slightly sandy to sandy, low to moderately plastic, weathered to hard, moist to slightly moist and gray to dark gray in color. Samples of the claystone-shale bedrock materials classified as CL soils in accordance with the Unified Soil Classification.

Swell-consolidation testing conducted on relatively undisturbed samples of the natural clays and claystone-shale bedrock materials indicate that the materials tested will exhibit a moderate to high swell potential when wetted under a constant load. As noted previously, the swell-consolidation test results are shown in Figures #6 through #9, and all of the other test results are summarized in the attached Table 1.

Groundwater seepage was encountered in test holes 5 and 6 at depths of 9 and 17 feet, as well as in test pits 2, 4, 5, 9, and 10 at depths ranging from 8 ½ to 14 ½ feet below the existing ground surface at the time of this investigation. It should be noted that the groundwater conditions can be expected to fluctuate with changes in precipitation and runoff conditions across the site.

## **Preliminary Residential Construction Considerations & Recommendations**

Foundations: The foundation recommendations for all of the proposed residences should be developed on an individual basis due to the highly variable nature of the subsurface conditions and swell potentials of the soils and bedrock materials. The final foundation grades for the structures should be carefully considered with the underlying soil conditions in mind. Due to the swell potential of the clays and bedrock materials encountered at the site, the residences will most likely need to be founded on straight-shaft piers or helical/screw piles advanced into the underlying natural clays or bedrock materials. The location, depth and consistency of the soils and bedrock materials encountered during this investigation were highly variable and site specific investigations and sampling should be conducted for each structure to determine which foundation type is most appropriate and feasible.

Floor Slabs: Lightly to moderately loaded floor slabs-on-grade can be constructed at the site with varying degrees of protection from swelling subgrade materials depending on the swell potential. A layer of free draining gravel beneath the slab, separation from bearing walls and columns, control joints and subgrade overexcavation and replacement are some of the measures that should be taken to allow slab-on-grade construction. However, structural floor systems constructed over crawlspaces should be used in the areas where the swell potential is known to be moderate to very high or in areas where the client and/or structure cannot tolerate the differential floor slab movement that will occur when the moisture-sensitive soils or bedrock materials become wetted and swell or consolidate.

Underdrain Systems: Underdrain systems will be necessary to protect the lower levels and crawl space areas of the structures due to the presence of stiff cohesive soils and a likely seasonal perched water table. Groundwater, localized perched or runoff water can infiltrate the foundation areas at the foundation levels. This water can be one of the primary causes of differential foundation and slab movement, especially where expansive clays and bedrock have been encountered.

## **Roadway and Pavement Section Recommendations**

Site Grading Recommendations: Based on our experience with similar soil conditions and the results of the slope stability analyses conducted by our firm for this site, we recommend that unretained cut slopes in the topsoil and organic materials be constructed to no steeper than a 3 (Horizontal) to 1 (Vertical) slope configuration. The unretained cut slopes constructed in the overburden soils and weathered bedrock materials should be constructed to no steeper than a 2 (Horizontal) to 1 (Vertical) slope configuration. Unretained cut slopes in competent claystone-shale bedrock materials may be cut to a 1(Horizontal) to 1(Vertical) slope configuration; however placement of topsoil and revegetation of these slopes will not be very successful. Flatter slopes than those indicated above for the overburden soils and bedrock materials are often desirable in that they help reduce erosion and minor sloughing of newly completed cut slopes and also help revegetation efforts.

Groundwater seepage between the topsoil and overburden soil/bedrock contact zone may occur across the site in the roadway cuts during heavy runoff periods. However, if seepage is encountered deeper in the overburden soils or bedrock, this seepage will significantly increase the risk of slope instability, and these areas will need to be reevaluated. Additional slope stabilization and/or drainage measures may be required in areas where groundwater seepage is encountered or if unstable materials are observed. Therefore, we strongly recommend that an engineer from this office observe the cut slopes as they are constructed so that potentially unstable and problem areas can be evaluated and remediated before the construction is completed.

We recommend that the unretained fill slopes be constructed to a 2 (Horizontal) to 1 (Vertical) or flatter configuration. All embankments must be properly compacted and constructed on suitable bearing soils after the topsoil and organic materials are removed. The fills should be properly benched into hillsides exceeding 4

(Horizontal) to 1 (Vertical). The on-site soils and bedrock materials, exclusive of the topsoil and organic materials, should be suitable for use in roadway embankment and utility trench backfill. These materials may require moisture conditioning (wetting or drying) to bring them to near optimum moisture content prior to placement and compaction. We recommend that common roadway embankment fill materials and utility trench backfill materials be uniformly placed and compacted in 6 to 8 inch loose lifts to at least 95 percent of the maximum standard Proctor density and within 3 percent of the optimum moisture content determined in accordance with ASTM D-698/AASHTO T-99. We also recommend that a representative of this office observe and test the fill materials as they are placed in the embankments

All of the cut and fill slopes and any other stripped areas should be protected against erosion by revegetation or other methods. Riprap or other erosion control measures will probably be required in areas of concentrated drainage and steeper slopes. We recommend that a maximum of 4 inches of topsoil and organic materials be placed over the finished cut and fill slopes to prevent sloughing/sliding of these materials off of the slope before the vegetation has been adequately established.

Pavement Section Recommendations: Based on the available traffic information, our experience with similar projects and the results of the R-Value testing conducted on samples of the soils and bedrock materials encountered across the site, we recommend that Victory Highway and the main subdivision collector roadways be paved with a composite section consisting of at least 4 inches of asphalt overlying a minimum of 4 inches of aggregate base course (Class 6) and at least 8 inches of pit run sand and gravel subbase material.

It is our understanding that Victory Highway will be extended at a later date to the west and will eventually connect with County Road #42. Based on our discussions with the City of Steamboat Springs, an additional traffic load of 15,000 ADT will be subjected to the pavement after it is connected and the adjoining developments are built. Therefore, we recommend that Victory Highway, which is to originally be constructed with a 4-inch asphalt mat, be overlaid with an additional 3 ½ inches of asphalt before the traffic from the adjoining developments is placed on Victory Highway.

The residential streets subjected to less traffic, such as the cul-de-sacs, can be paved with a composite section consisting of at least 3 inches of asphalt overlying a minimum of 4 inches of aggregate base course (Class 6) and at least 6 inches of pit run sand and gravel subbase material.

The asphalt pavement should consist of a hot bituminous plant mix material meeting the job mix formula established by a qualified engineer and which meets Colorado Department of Transportation (CDOT) specifications. Placement and compaction of the hot bituminous plant mix should generally conform to CDOT guidelines outlined in Section 401 of the Standard Specifications for Road and Bridge Construction and range from 92 to 96 percent of the maximum Rice density.

The base course materials should consist of a well-graded aggregate base course material that meets Class 6 grading and durability requirements. The subbase materials should consist of pit run sand and gravel material that meets Class 3 grading requirements. The base course and subbase aggregates should be compacted to at least 95 percent of the maximum modified Proctor density and within 2 percent of the optimum moisture content determined in accordance with ASTM D-1557/AASHTO T-180.

Prior to placing the subbase aggregates, the subgrade soils along the subject roadways should be proofrolled with a loaded dump truck. Areas exhibiting signs of excessive deflection or rutting (greater than 1 inch) should be scarified to a minimum depth of at least 12 inches, properly mixed and moisture conditioned to bring the soils to within 2 percent of the optimum moisture content and then be recompacted to at least 95% of the maximum standard Proctor density determined in accordance with ASTM D698. Additional stabilization measures may be required if the subgrade materials cannot be properly moisture conditioned and stabilized.

## **Retaining Structures**

Based on our review of the proposed roadway grading plans provided by Landmark, it appears that all of the unretained cut and fill slopes for this project have been designed with a 2 (horizontal) to 1 (vertical) slope configuration. However, it is our understanding that retaining structures/walls are proposed for three of the cut areas situated along the northern side of Victory Highway and along the northern and eastern property lines situated north of the cul-de-sac located north of East Slate Circle. Based on our review of the plans provided by Landmark, it appears that 3 separate walls will be required along the north side of Victory Highway with the middle and western walls being 10 feet or less in height and the eastern wall ranging from 5 to 22 feet in height. The proposed cuts and height of the retaining structures for areas located north of the cul-de-sac have not yet been provided. Based on our conversations with Landmark, it appears that they are considering using stacked boulder walls or MSE walls to retain these areas, with the exception of the larger cut located at the eastern end of Victory Highway. Outlined below are our recommendations for the retaining structures to be used at the site.

Stacked Boulder Walls: Due to the highly variable soil conditions encountered along the northern edge of the proposed subdivision and along the northern side of the Victory Highway alignment, and the slope stability concerns we have with the redeposited clays that were encountered along portions of the site, we recommend that if stacked boulder walls are opted for they not exceed a height of 10 feet, unless stable bedrock materials are encountered in the excavations. We also recommend that the walls be constructed with boulders having a minimum diameter of 2 to 3 feet and that the boulders consist of hard, durable granite, gneiss or other approved rock materials. The boulders should be placed in a stable configuration that maximizes rock-rock contact and at a 0.5 (horizontal) to 1 (vertical) or flatter slope by a contractor having experience in building these types of walls. The base of the walls should be at least half as wide as the total wall height and the base layer of boulders should be keyed into the natural, undisturbed soils or bedrock materials, exclusive of the topsoil, a minimum of 2 feet. We do

not recommend the use of terraced walls in these areas unless the total height of all of the terraced walls is less than 10 feet, or stable bedrock materials are encountered in the excavations. The base of the walls should be drained by the placement of a 4-inch diameter perforated PVC pipe covered with a layer of free draining gravel. The drains should be located behind the walls and at the bases of the excavations. The drains should be uniformly graded to a daylighted outfall with at least a 2 percent slope. Additional drainage details may be required if groundwater seepage is encountered in the excavations as the walls are constructed. A typical stacked boulder retaining wall cross section is shown in the attached Figure #12. Proper surface drainage should be provided around all of the finished slopes to direct surface and subsurface runoff away from the walls.

We believe that the stacked boulder retaining walls, less than 10 feet in height, should adequately retain the smaller cut slopes at the project site if properly constructed and drained. We strongly recommend that the client retain our firm to observe the construction of the boulder walls as they are being installed to verify the subsurface conditions at the base of the wall, as well as to verify that the recommendations outlined above are being properly followed. It should be noted that there is a risk of isolated rock falls occurring with this type of wall if the boulders are undermined due to excessive runoff or disturbed, resulting in damage to the downslope areas. Therefore, a qualified engineer should periodically inspect the walls after completion to verify the condition of the walls. Any indications of wall movement or groundwater seepage should be immediately brought to the attention of a qualified engineer. In addition, this type of wall will require periodic maintenance after the walls are completed and the owner of the walls should be made aware of the inspections and maintenance items that will be required in the future.

MSE Walls: It is our understanding that Landmark Consultants is also considering the use of mechanically stabilized earth (MSE) retaining structures with possibly a stacked block face. We believe that this type of retaining wall system will be feasible for the smaller walls to be constructed at the site. However, we do not believe that this type of retaining structure will be feasible for the larger cut located at the east end of Victory Highway, due to the site constraints and the length of horizontal layers of geogrid that will be required behind the wall. We recommend consultation with a specialty design-build contractor to design the MSE Walls.

We recommend that in the design of the MSE walls, the design-build contractor assume that they will be retaining the natural clays. We recommend that a cohesion value of 0.75 ksf, an internal angle of friction of 15 degrees and a unit weight of 125 pcf be used in the design of the retaining structures for the clays. However, if claystone-shale bedrock materials are encountered in the excavations, then a cohesion value of 1.5 ksf, an internal angle of friction of 25 degrees and a unit weight of the 128 pcf may be used in the design for the portion of the walls retaining the bedrock materials.

Soil-Nailed Retaining Walls: Based on the soil conditions encountered along Victory Highway, as well as in the northern end of the subdivision, and the site constraints related to the adjacent properties, we strongly recommend

that the larger cuts (greater than 10' in height) be retained with soil-nailed retaining walls. This type of retaining structure will be constructed as the excavations are advanced from the top of the slopes down to the bottom of the excavations. This type of retaining structure can be constructed with a near vertical face and the finished surface of the wall can be finished with a variety of surfaces ranging from shotcrete to precast blocks to gabion baskets to treated timbers. We recommend consultation with a specialty design-build contractor to design the soil-nailed structures, as well as to explore other retaining wall alternatives.

We recommend that in the design of the soil-nailed walls, the design-build contractor assume that they will be retaining the natural clays. We recommend that a cohesion value of 0.75 ksf, an internal angle of friction of 15 degrees and a unit weight of 125 pcf be used in the design of the retaining structures for the clays. However, if claystone-shale bedrock materials are encountered in the excavations, then a cohesion value of 1.5 ksf, an internal angle of friction of 25 degrees and a unit weight of 128 pcf may be used in the design for the portion of the walls retaining the bedrock materials.

H-Pile/Lagging Walls: If the soil-nailing is not feasible due to the length of the required nails, then we recommend that a retaining wall consisting of Steel H-piles and wood lagging be used to retain the larger cuts, such as at the east end of Victory Way. The steel H-piles should be set vertically at a spacing of 4 to 6 feet. The actual spacing should be determined in the final design. The H-piles typically extend down into the natural soils or bedrock materials below the bottom of the excavation at least 1.5 to 2 times the height of the excavation. We recommend that the H-piles be set in a predrilled hole that is slightly larger in diameter than the H-pile and the annulus between the edge of the hole and the pile be filled with a flowable fill material having a minimum compressive strength of 50 psi. After the piles are set, the excavation can proceed from the top of the piles down to the base of the excavation. The wood lagging should be placed between the piles as the excavation is completed and the space between the wood lagging and the back of the excavation should be filled with free draining pea (3/8") gravel. We recommend that a qualified structural engineer or a qualified design-build contractor complete the design of the walls. We recommend that the soil values given above for the soil-nailed walls be used in the design of the Pile/Lagging Walls. We also recommend that a modulus of subgrade reaction of 90 tcf be used for the portion of the pile advanced into the natural clays and a modulus of subgrade reaction of 200 tcf for the portion of the pile advanced into the underlying competent bedrock materials.

## **Geologic Hazard Evaluation**

Slope Stability: The stability of both the natural and proposed cut and fill slopes have been considered in this evaluation. Aerial photographs were also used to provide a further evaluation of the site geomorphology.

We observed evidence of historic landslide activity in the form of hummocky topography in several portions of the site. These areas include near the base of the north facing slope of the Abbey Road extension and along the north

side of the Victory Highway site, as well as to the north and east of East Slate Circle. These areas are shown in Figure #2. The hummocky topography is likely the result of historic landslide activity, probably in the form of small-scale slumps and debris flows within the overburden soils. These features are now obscured by erosion and are mostly subtle and difficult to delineate. Our subsurface investigation of these areas suggests that the failures occurred in the overburden soils, with the exception of a moderate slump block of shale bedrock material located several hundred feet north of test hole 6 and Victory Highway. In general, the subsurface conditions in these areas consist of stiff to hard overburden clays overlying claystone-shale bedrock. Groundwater was encountered in test holes 5 and 6 at depths of 10 to 15 feet beneath the existing ground surface and in test pits 2, 4, 5 and 9 at depths of 8 to 13 feet beneath the existing ground surface.

Shale bedrock of the Mancos Formation was poorly exposed along the ridgelines and upper steep slope faces that surround the lower meadow areas and, where exposed, the bedrock displays near horizontal to slightly dipping bedding down to the southeast on the order of 10%. The outcrops exposed in the steep slope faces form very steep slopes of approximately 50% and are relatively stable. Small rafts of vegetation and overburden soil form small hummocks on the lower portions of these slopes.

Based on the topography and our experience with similar soil and bedrock conditions, we believe that there is generally a low risk of slope instability associated with the current development plan of the property. For much of the site, we believe that properly designed and constructed roadway cut and fill slopes should be safe from slope stability problems. However, cut slopes along the north side of Victory Way between Stations 15+00 and 30+00 cut across the toe of likely landslide deposited overburden soils and could become unstable as the result of the proposed site grading. Therefore, an engineer from this office should observe any excavations in this portion of the site as the excavations are completed.

Based on our review of the Routt County Geologic Hazard map, it appears that the steeper portions of the property located along the north side of the proposed development and Victory Highway are mapped as Potentially Unstable Slopes (PUS). This implies a previously stable slope could become unstable due to disturbance from development related activities. We recognize this hazard classification as a general, all-encompassing grouping of slopes that do not exhibit signs of instability at this time, but may have isolated steep topographical areas, or other isolated soil and/or groundwater conditions which may be conducive to small-scale slope failures.

Swelling Soils: The potential hazards from swelling materials at the site and remedial measures have been discussed above. Swell-consolidation tests conducted on samples collected from the test holes indicate a variable swell potential ranging from low to high exists across the site. A site-specific Subsoil and Foundation Investigation for each individual building site will be necessary to better evaluate the potential hazard from swelling soils and to provide recommendations to reduce the risk of construction on swelling materials, since the swell potential of any particular site can change erratically both in lateral and vertical extent.

Geologic Setting and Seismic Activity: The project site is situated in the Southern Rocky Mountain Province and lies one to two miles west of the west flank of the Park Range. Portions of the Park Range are also referred to as the Gore Range in this area. The Park Range Uplift has been interpreted as a product of the Laramide orogeny that probably began in early Cretaceous time and reached its peak in Paleocene time. The Park Range uplift is anticlinal in nature with a core of igneous and metamorphic rocks flanked by sedimentary rocks of Cretaceous age in the project area.

Specifically, the near surface bedrock in the project site consists of the Cretaceous Mancos Shale Formation. The Mancos Shale Formation consists of a deep marine shale deposit up to 5,000 feet in thickness. The shale is typically low to moderately plastic, hard to very hard, fissile and dark gray to gray. The near surface claystone-shale beds of the Mancos Shale Formation are nearly horizontal in much of the project area. An isolated bedrock outcrop in the Williams property displayed a gentle dip to the southeast.

Overlying the near surface bedrock, residual and colluvial clay soils are the products of chemical and mechanical erosion processes that continue. Some these residual and colluvial have experienced slumping, probably during a wetter climatic period than is currently being experienced.

Seismic activity in the project area is considered to be low. According to the Uniform Building Code (1997) all of Colorado is located in Zone 1. This classification implies the following seismic risk: "minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 second; corresponding to intensities V and VI on the Modified Mercalli Intensity Scale" (Algermissen, 1969). Based on the UBC definitions, levels of peak horizontal ground acceleration should not exceed 0.04g with a 90 percent probability level. Two earthquakes of significance have been recorded in Steamboat Springs since 1870. Both earthquakes, March 1895 and February 1955, corresponded to Modified Mercalli Intensities of V (Kirkham and Rogers, 1981). Based on the subsurface conditions encountered across the site and our review of the available literature, we also recommend that a Site Class of D be used for this project in accordance with Table 1615.1.1 of the IBC 2003.

## **Limitations**

This report is preliminary and suitable for general design and planning. The test holes and test pits advanced for this investigation were widely spaced to investigate the general subsurface profiles across the proposed development and highway. Based on our present knowledge, there are no subsurface or geological conditions, which constitute a major hazard or would render the proposed development and roadway construction infeasible. However, we recommend that additional subsurface investigations be conducted to provide specific design criteria for the individual building foundations, slabs, lateral earth pressures and other soil related construction activities.

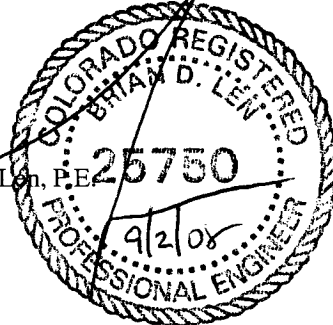
We strongly recommend that the owner retain NWCC, Inc. to monitor the construction of the roadways and other development related site work to ensure compliance with the specifications and verify that the subsoil and

groundwater conditions encountered in the field during construction are similar to those assumed herein. If there are any further questions concerning this report, or if we may be of further service, please contact this office.

Sincerely,  
NWCC, INC.

Josh P. Frappart, E.I.T.

Reviewed by Brian D. Len, P.E.



xc: Bob Frank - Landmark Consultants, Inc.

## REFERENCES

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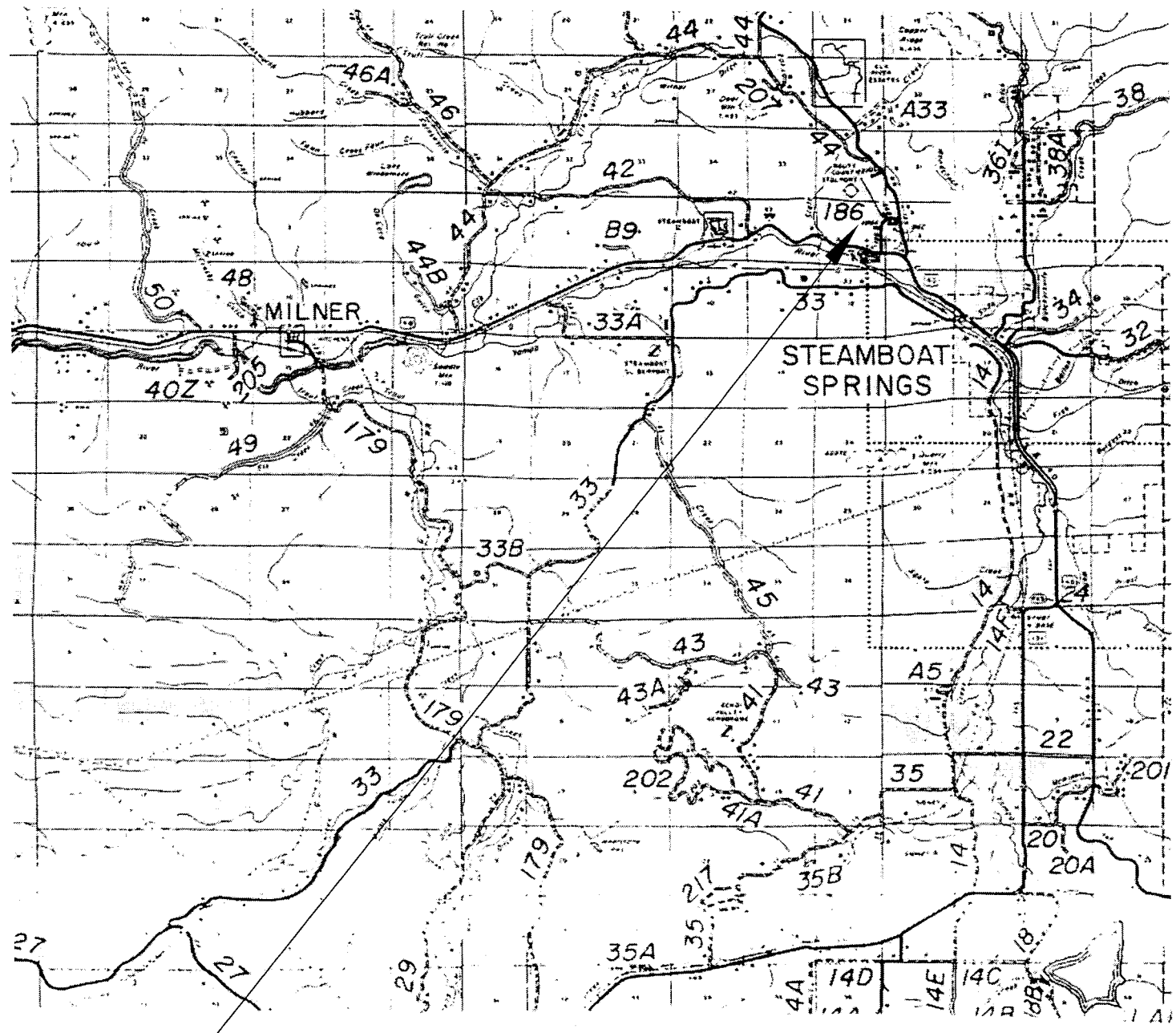
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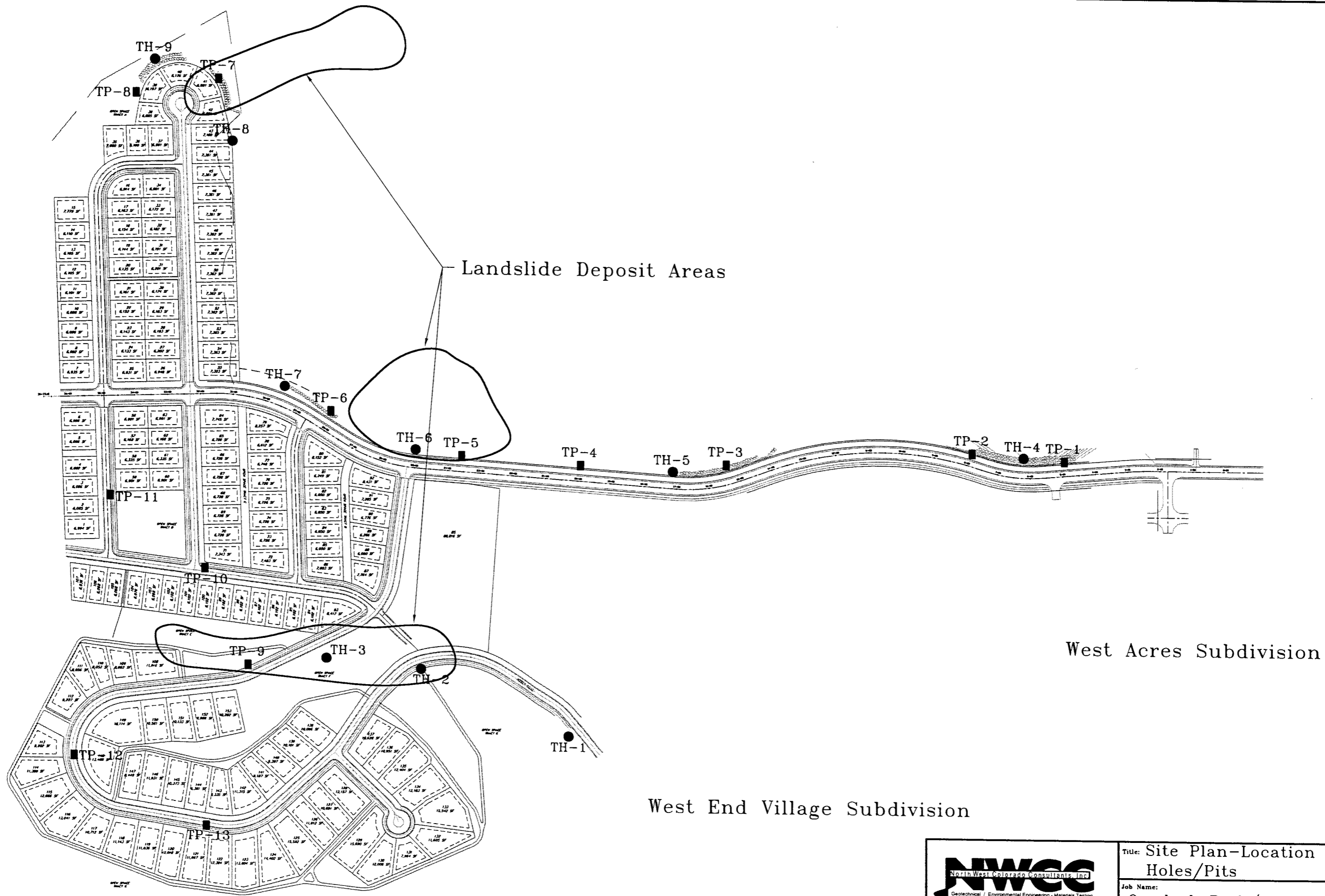


NOT TO SCALE



PROJECT SITE

Title: VICINITY MAP	Date: 6/27/08	 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: Overlook Park/Victory Highway	Job No. 08-7985	
Location: Steamboat Springs, Colorado	Figure #1	



West Acres Subdivision

West End Village Subdivision

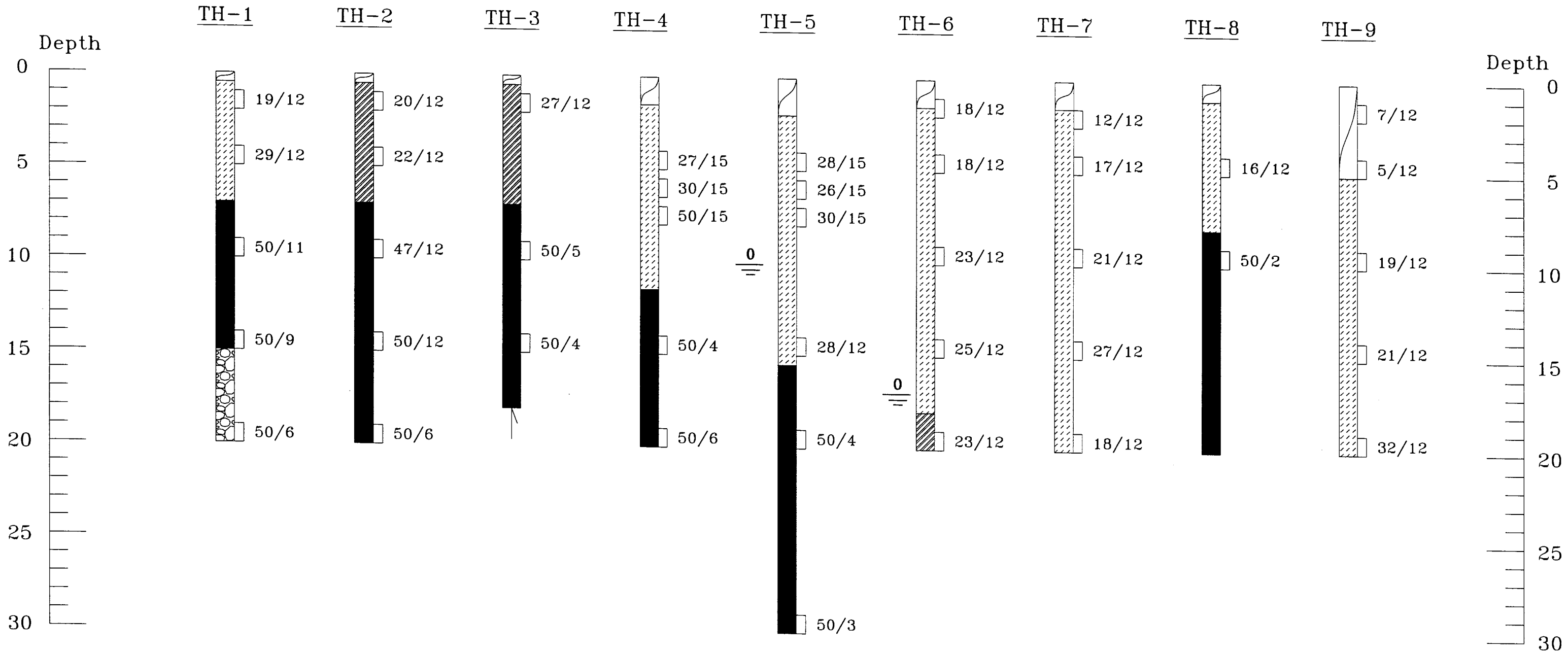
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 North West Colorado Consultants, Inc.  
 Geotechnical / Environmental Engineering - Materials Testing  
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 2580 Copper Ridge Drive  
 Steamboat Springs, Colorado 80487

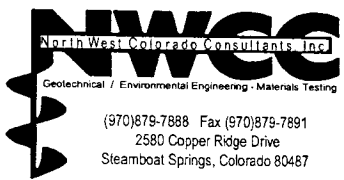
Title: Site Plan-Location of Test Holes/Pits

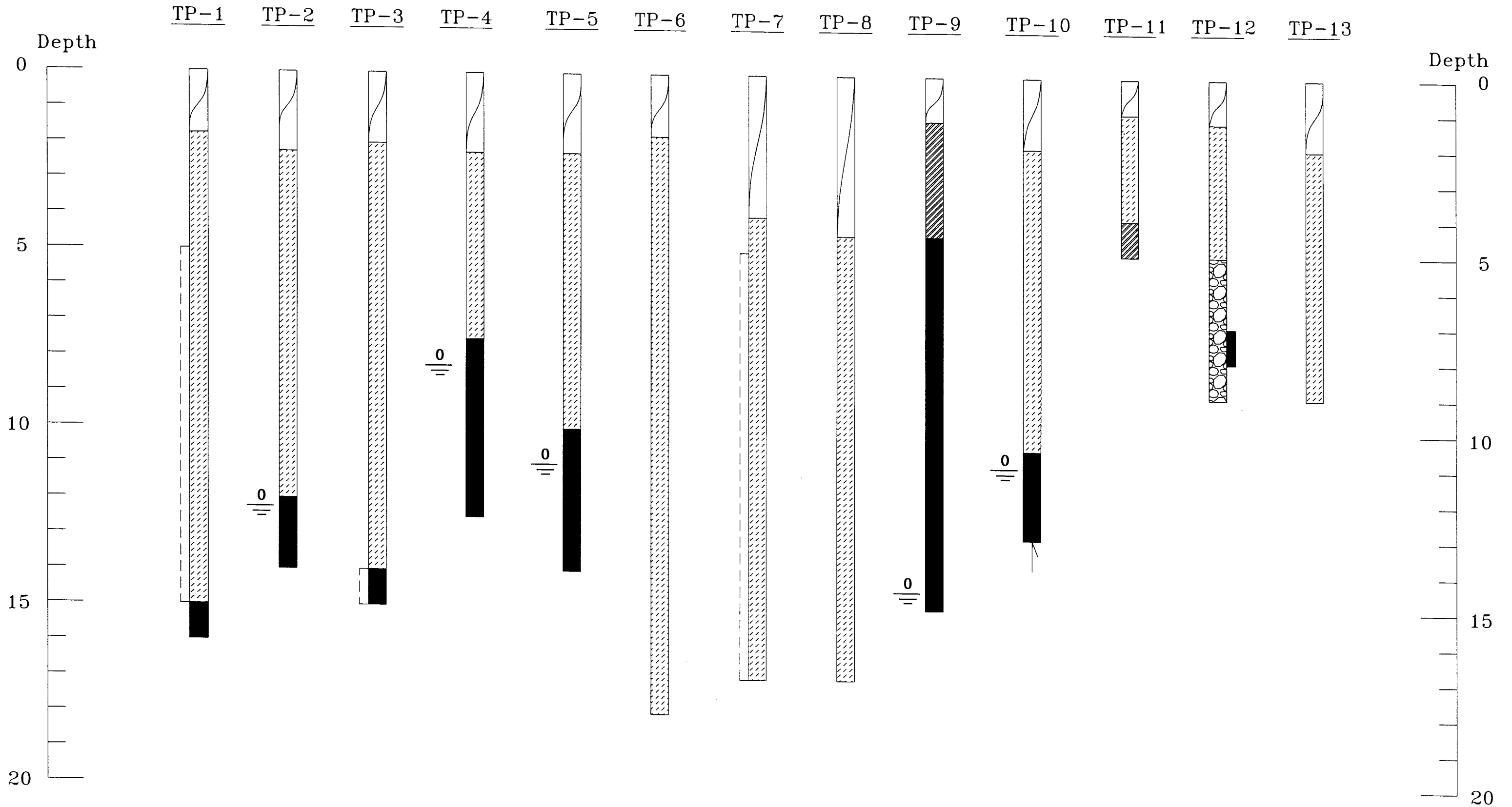
Job Name: Overlook Park/Victory Highway

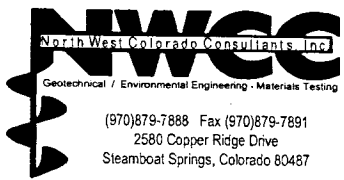
Location: Steamboat Springs, Colorado

Job No.: 08-7985      Date: 6/27/08      FIGURE: #2



 <p><b>NWCC</b> 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</p>	Title: Logs of Exploratory Test Holes		
	Job Name: Overlook Park/ Victory Highway		
	Location: Steamboat Springs, Colorado		
	Job No.: 08-7985	Date: 6/27/08	FIGURE: #3



 <p><b>NWCC</b> 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</p>	Title: Logs of Exploratory Test Pits		
	Job Name: Overlook Park/ Victory Highway		
	Location: Steamboat Springs, Colorado		
	Job No.: 08-7985	Date: 6/27/08	FIGURE: #4

**LEGEND:**



TOPSOIL AND ORGANICS:



CLAYS: Slightly sandy to sandy with occasional bedrock fragments, moderately to highly plastic, medium stiff to hard, moist to very moist and brown to gray in color with calcareous stringers.



SANDS AND GRAVELS: Silty to clayey with occasional cobbles, low to non-plastic, dense, dry to slightly moist and brown in color.



WEATHERED CLAYSTONE-SHALE BEDROCK: Slightly sandy to sandy, low to moderately plastic, weathered, moist to very moist and gray to dark gray in color.



CLAYSTONE-SHALE BEDROCK: Slightly sandy to sandy, low to moderately plastic, hard to very hard, moist to slightly moist and gray to dark gray in color.



Drive Sample, 2-inch I.D. California Liner Sampler.



Small Disturbed Sample



Large Disturbed Sample

19/12 Drive Sample Blow Count, indicates 19 blows of a 140-pound hammer falling 30 inches were required to drive the sampler 12 inches.



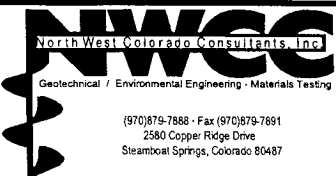
Indicates depth at which groundwater was encountered at the time of drilling.



Indicates depth at which practical rig refusal was encountered in bedrock materials.

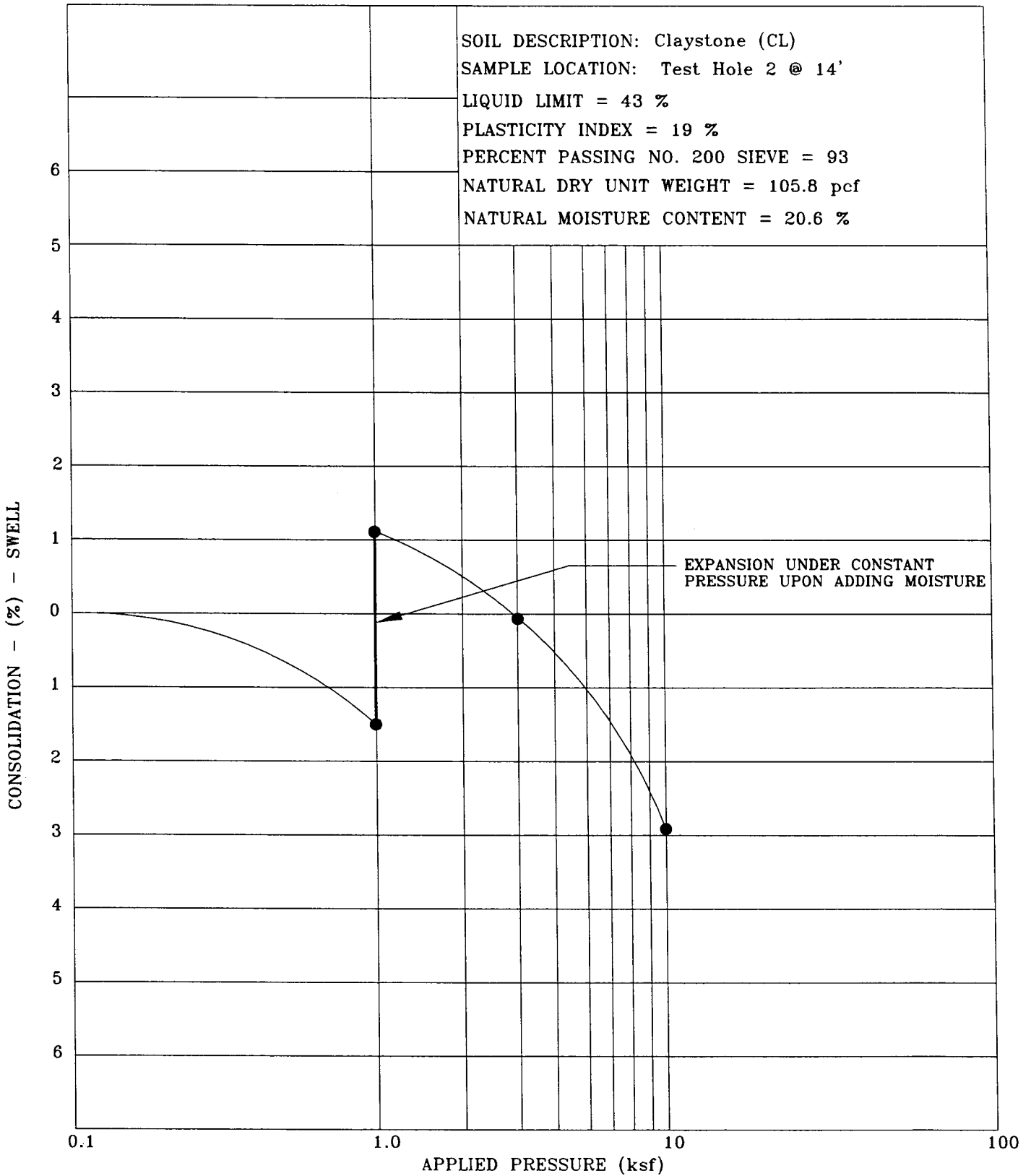
**NOTES:**

- 1) The test holes were drilled on June 2 and 3, 2008 with an all terrain drill rig using 4-inch diameter continuous flight power augers.
- 2) The test pits were excavated on May 21 and June 20, 2008 with a Cat 320C trackhoe and a Yanmar 45 trackhoe.
- 3) Locations of the test holes and test pits were determined by pacing from existing roadways centerline stakes.
- 4) Elevations of the test holes and test pits were not measured and logs are drawn to the depths investigated.
- 5) The lines between materials shown on the logs represent the approximate boundaries between material types and transitions may be gradual.
- 6) The water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water levels will probably occur with time.

<b>Title:</b> LEGEND AND NOTES	<b>Date:</b> 6/27/08	
<b>Job Name:</b> Overlook Park/Victory Highway	<b>Job No.</b> 08-7985	
<b>Location:</b> Steamboat Springs, Colorado	<b>Figure</b> #5	

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SOIL DESCRIPTION: Claystone (CL)  
 SAMPLE LOCATION: Test Hole 2 @ 14'  
 LIQUID LIMIT = 43 %  
 PLASTICITY INDEX = 19 %  
 PERCENT PASSING NO. 200 SIEVE = 93  
 NATURAL DRY UNIT WEIGHT = 105.8 pcf  
 NATURAL MOISTURE CONTENT = 20.6 %



Title: SWELL-CONSOLIDATION TEST RESULTS

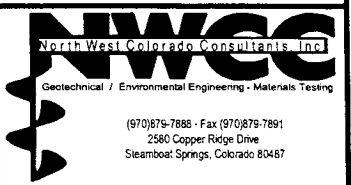
Date: 6/27/08

Job Name: Overlook Park/Victory Highway

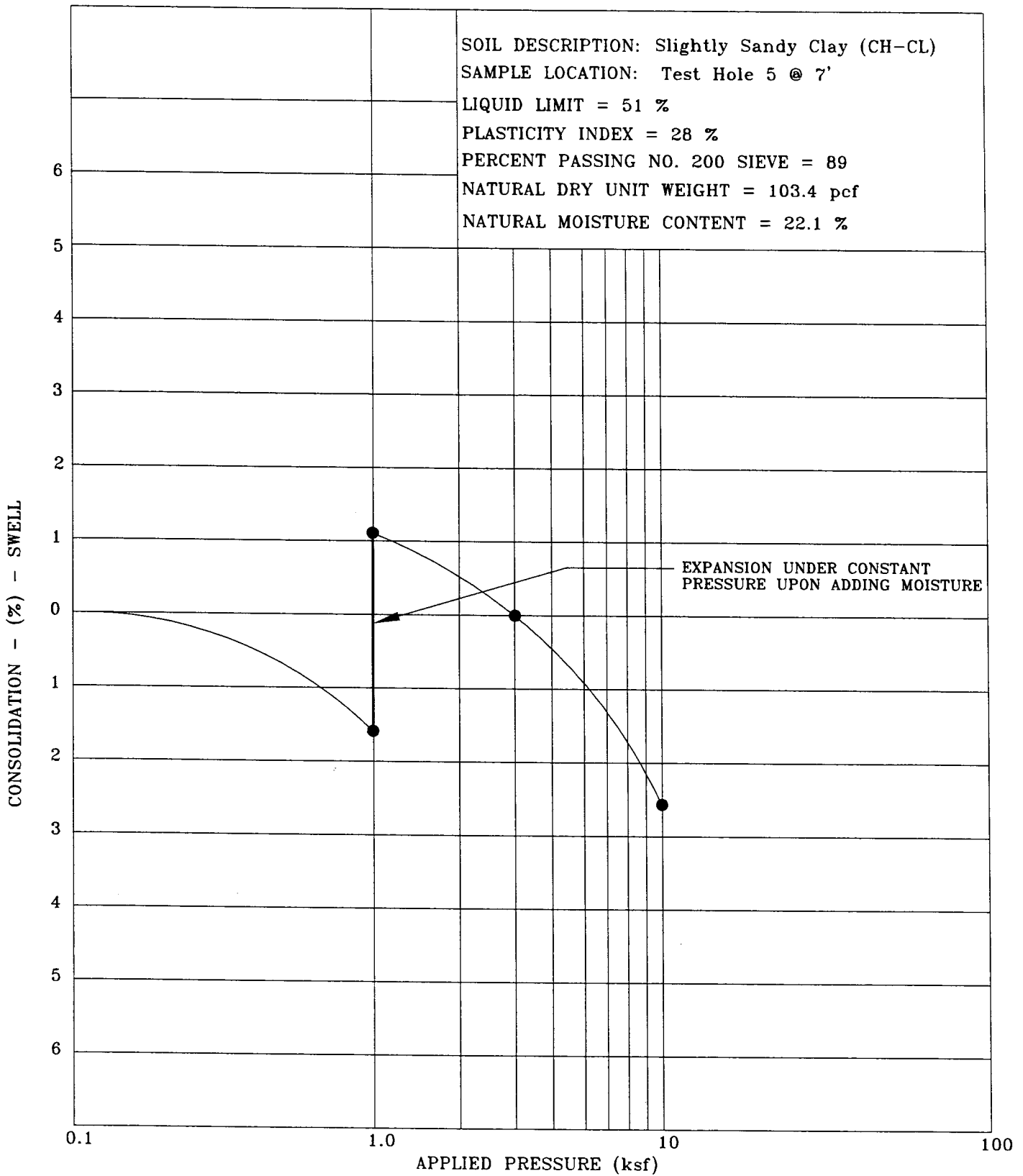
Job No. 08-7985

Location: Steamboat Springs, Colorado

Figure #6



SOIL DESCRIPTION: Slightly Sandy Clay (CH-CL)  
 SAMPLE LOCATION: Test Hole 5 @ 7'  
 LIQUID LIMIT = 51 %  
 PLASTICITY INDEX = 28 %  
 PERCENT PASSING NO. 200 SIEVE = 89  
 NATURAL DRY UNIT WEIGHT = 103.4 pcf  
 NATURAL MOISTURE CONTENT = 22.1 %



Title: SWELL-CONSOLIDATION TEST RESULTS

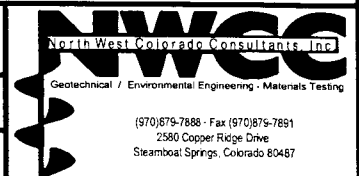
Date: 6/27/08

Job Name: Overlook Park/Victory Highway

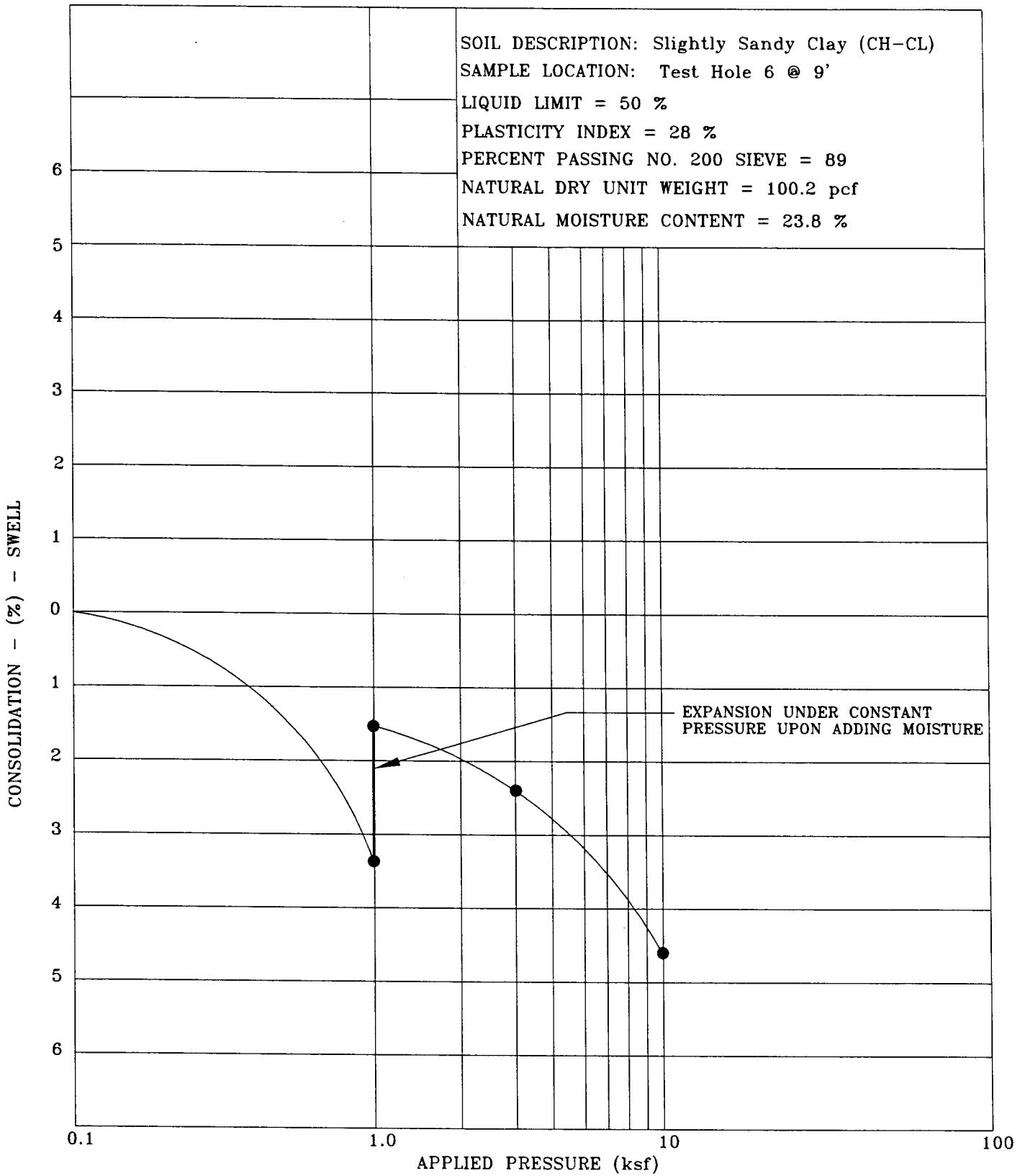
Job No. 08-7985

Location: Steamboat Springs, Colorado

Figure #7



SOIL DESCRIPTION: Slightly Sandy Clay (CH-CL)  
 SAMPLE LOCATION: Test Hole 6 @ 9'  
 LIQUID LIMIT = 50 %  
 PLASTICITY INDEX = 28 %  
 PERCENT PASSING NO. 200 SIEVE = 89  
 NATURAL DRY UNIT WEIGHT = 100.2 pcf  
 NATURAL MOISTURE CONTENT = 23.8 %



Title: SWELL-CONSOLIDATION TEST RESULTS

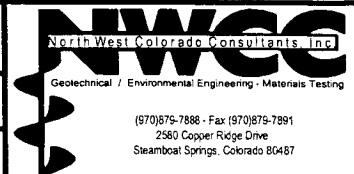
Date: 6/27/08

Job Name: Overlook Park/Victory Highway

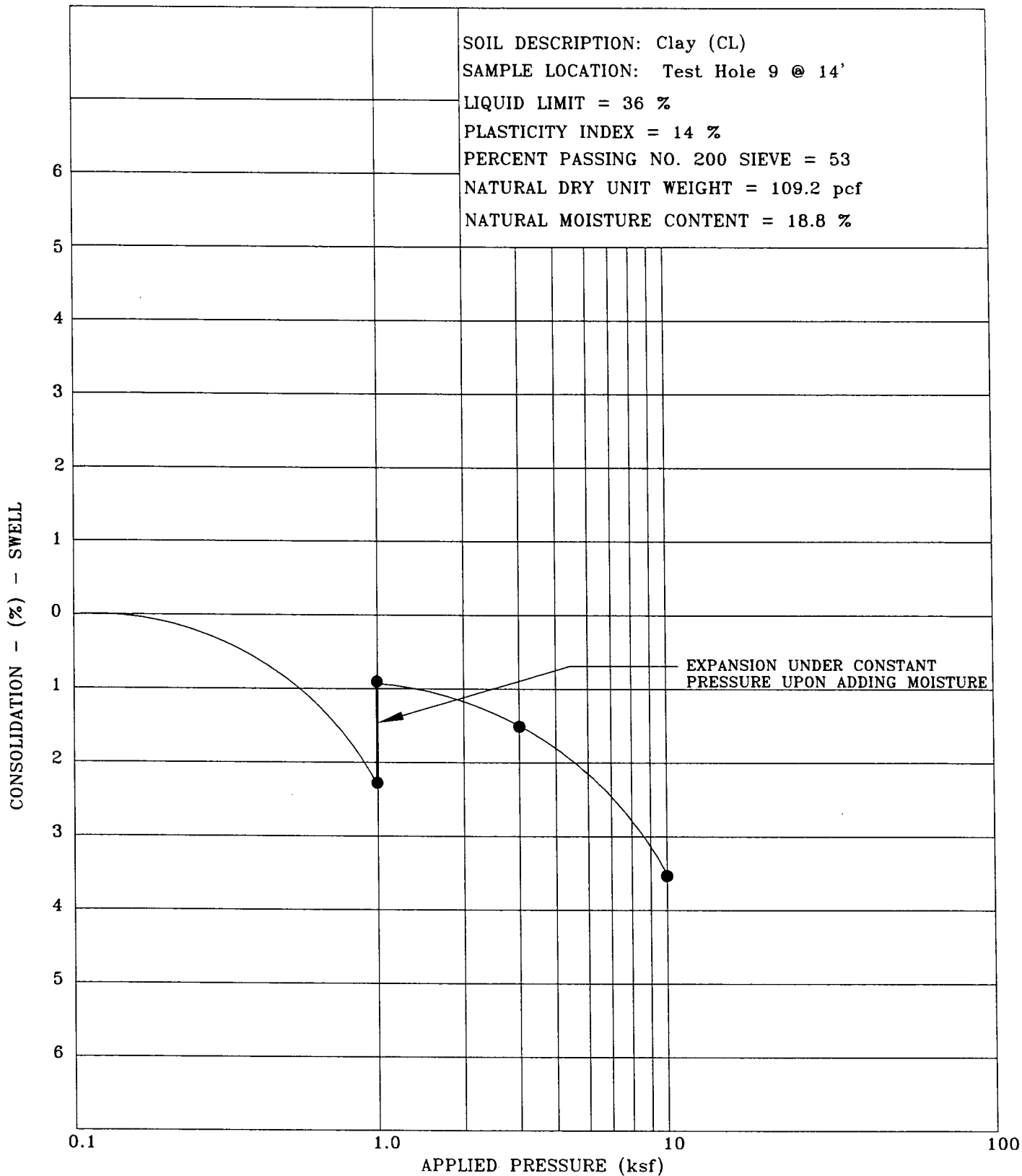
Job No. 08-7985

Location: Steamboat Springs, Colorado

Figure #8



SOIL DESCRIPTION: Clay (CL)  
 SAMPLE LOCATION: Test Hole 9 @ 14'  
 LIQUID LIMIT = 36 %  
 PLASTICITY INDEX = 14 %  
 PERCENT PASSING NO. 200 SIEVE = 53  
 NATURAL DRY UNIT WEIGHT = 109.2 pcf  
 NATURAL MOISTURE CONTENT = 18.8 %



Title: SWELL-CONSOLIDATION TEST RESULTS

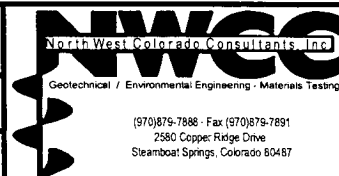
Date: 6/27/08

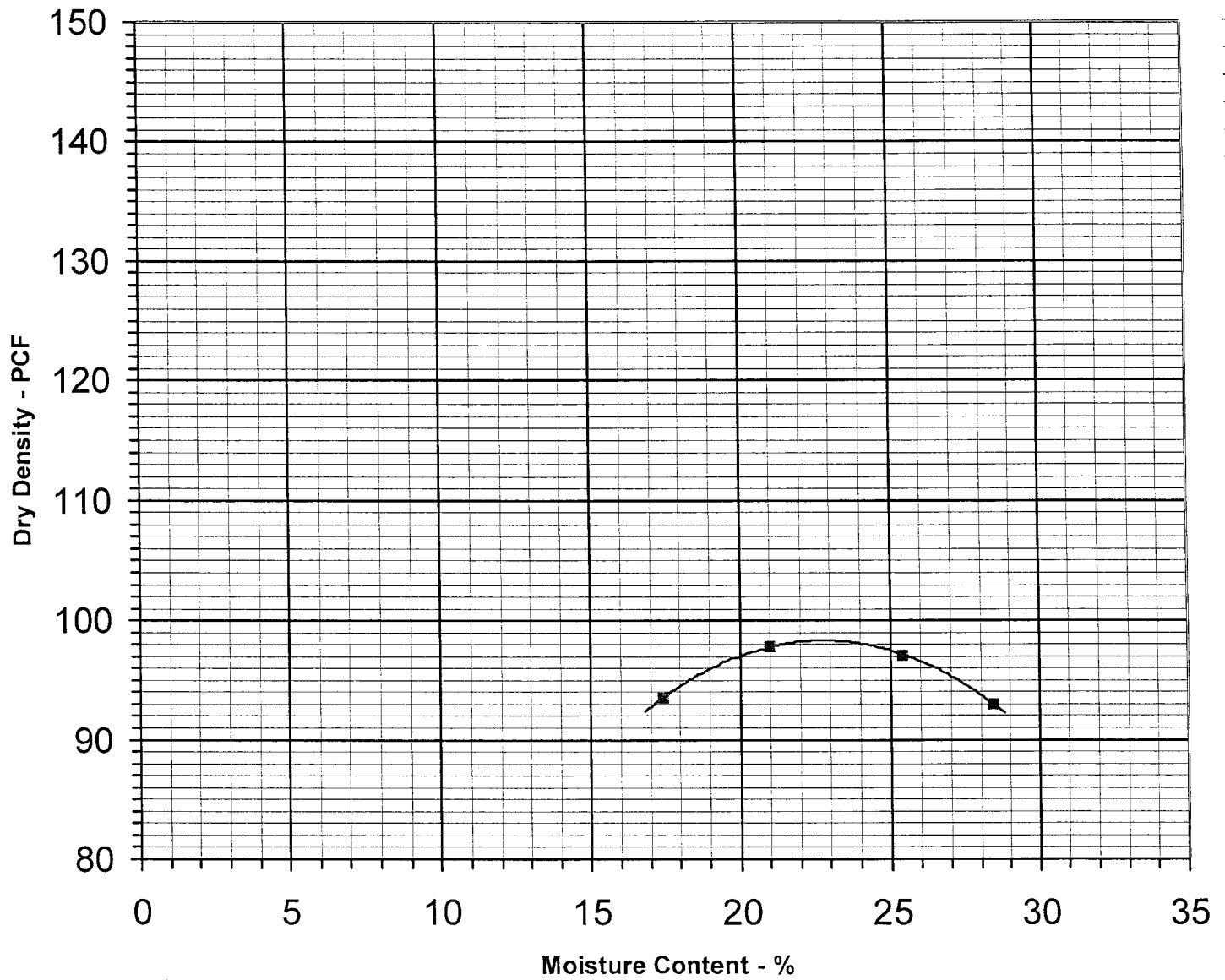
Job Name: Overlook Park/Victory Highway

Job No. 08-7985

Location: Steamboat Springs, Colorado

Figure #9

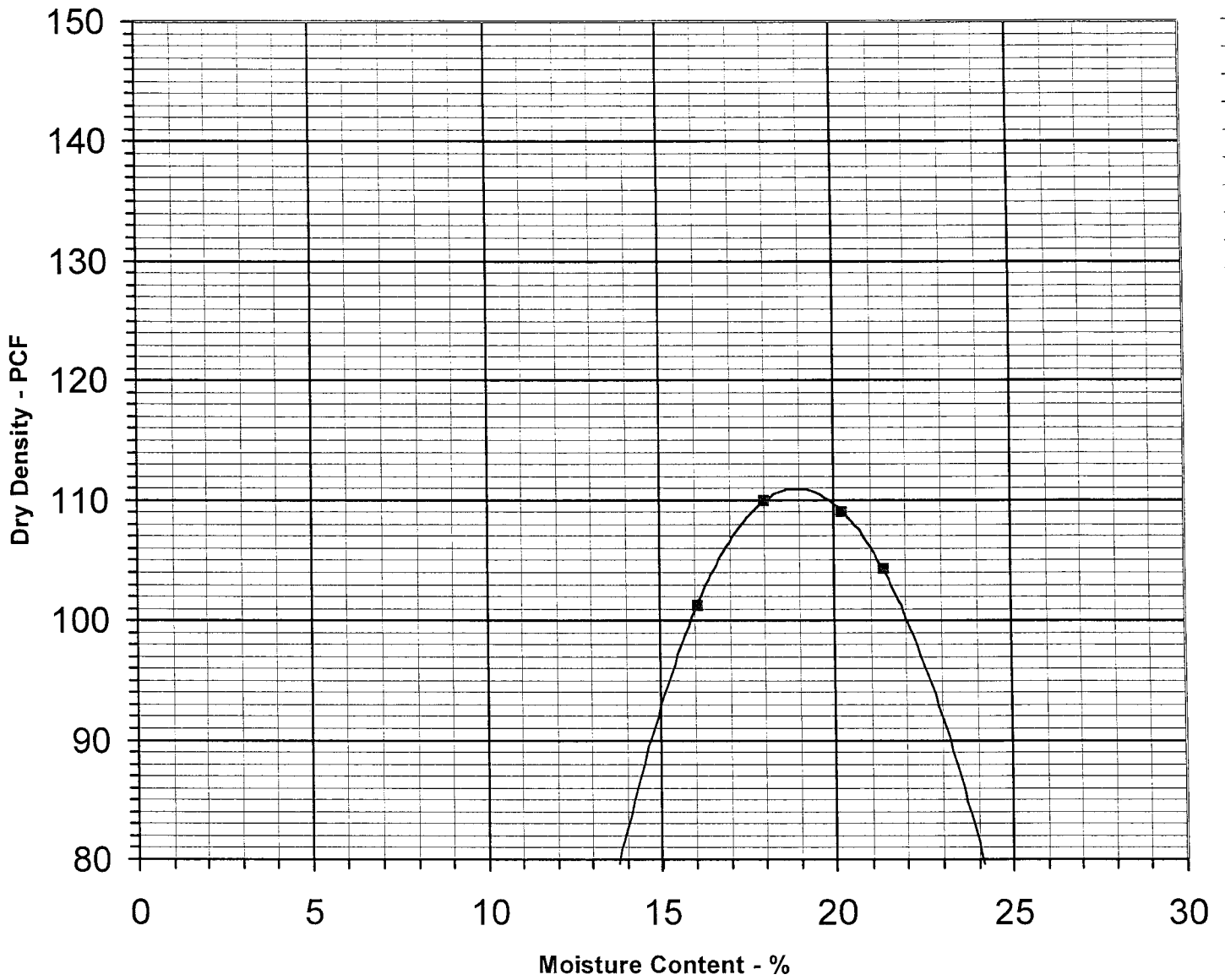




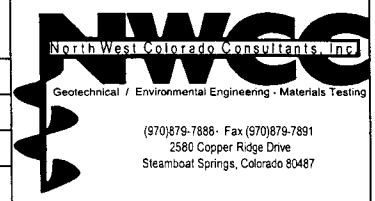
Job Name: Overlook Park/Victory Highway		<b>PROCTOR TEST RESULTS</b>	
Sample Location: Test Pit 1 @ 5-15'			
Soil Description: Slightly Sandy Clay		Sample No. 1P	
Maximum Dry Density: 98.3 pcf	Opt. Moisture Content: 22.9 %	Procedure: ASTM D698	
Liquid Limit: 50	Plasticity Index: 26	Date: 5/22/08	
Gravel: 0 %	Sand: 7 %	Silt & Clay (-200): 93 %	Job. No. 08-7985 Figure: #10

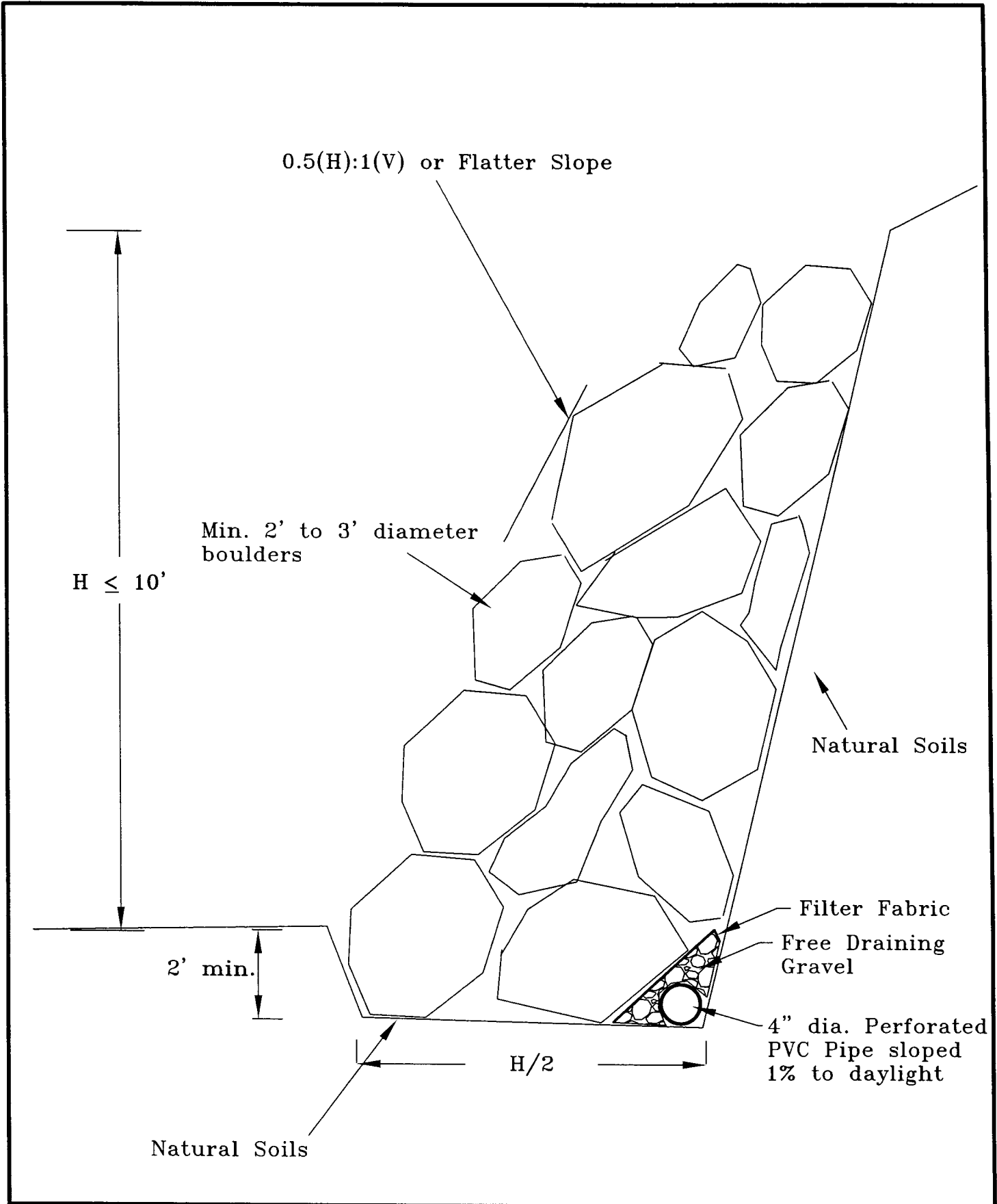
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Job Name: Overlook Park/Victory Highway		<b>PROCTOR TEST RESULTS</b>
Sample Location: TP 3 @ 14-15'		
Soil Description: Claystone-Shale		Sample No. 2P
Maximum Dry Density: 110.8 pcf	Opt. Moisture Content: 19.0 %	Procedure: ASTM D698
Liquid Limit: 39	Plasticity Index: 18	Date: 5/22/08
Gravel: 0 %	Sand: 10 %	Silt & Clay (-200): 90 %
		Job. No. 08-7985 Figure: #11






<b>Title:</b> Stacked Boulder Wall Detail	<b>Date:</b> 7/20/08	 <small>North West Colorado Consultants, Inc.</small>
<b>Job Name:</b> Overlook Park/Victory Highway	<b>Job No.:</b> 06-7985	<small>Geotechnical / Environmental Engineering - Materials Testing</small>
<b>Location:</b> Steamboat Springs, Colorado	<b>Figure</b> #12	<small>(970)879-7888 • Fax (970)879-7891          2580 Copper Ridge Drive • P.O. Box 775226          Steamboat Springs, Colorado 80477</small>

TABLE 1 - 1 of 2

SUMMARY OF LABORATORY TEST RESULTS

TEST HOLE	SAMPLE LOCATION DEPTH (feet)	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.
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
1	1	21.9	99.8	48	24	0	19	81		Sandy Clay	CL-CH
1	9	16.6	113.2	41	16	0	25	75	13,300	Claystone	CL
2	4	24.5	103.1	41	15	0	25	75	6,300	Claystone	CL
2	14	20.6	105.8	43	19	1	6	93		Claystone	CL
3	14	7.2	115.0	42	24	0	15	85		Claystone	CL
4	7	19.8	103.8	57	30	0	1	99	6,100	Clay	CH
5	7	22.1	103.4	51	28	0	11	89		Slightly Sandy Clay	CH-CL
5	14	23.4	101.8	54	32	0	2	98	8,300	Clay	CH-CL
6	4	21.7	102.1	38	15	0	19	81	3,800	Sandy Clay	CL
6	9	23.8	100.2	50	28	0	11	89		Slightly Sandy Clay	CH-CL
7	4	19.5	106.5	45	21	0	3	97	5,100	Clay	CL-CH
7	19	21.7	104.1	43	22	0	20	80	5,700	Sandy Clay	CL
8	4	24.1	100.4	53	32	0	5	95	6,600	Clay	CH-CL

TABLE 1 - 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	20.9	105.0	40	20	10	31	59	4,900	Clay with Bedrock Fragments	CL
9	14	18.8	109.2	36	14	5	42	53		Clay with Bedrock Fragments	CL
TEST PIT											
12	7-8	6.7		24	5	56	28	16		Silty Clayey Sandy Gravels	GM-GC
1	5-15	22.9*	98.3*	50	26	0	7	93		Slightly Sandy Clay	CL-CH
3	14-15	19.0*	110.8*	39	18	0	10	90		Claystone-Shale	CL

\* Indicates optimum moisture content and maximum dry density per ASTM D698