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Geotechnical / Environmental Engineering • Materials Testing

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Preliminary Subsoil and Geologic Hazard Evaluation
Mountain Meadow Preserve
Blocks 2 & 3, Sky Harbor Subdivision, Steamboat Springs, Colorado

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CONCLUSIONS

Construction of the proposed residential subdivision 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 development 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 investigations on a site-specific basis should be performed prior to construction

PURPOSE AND SCOPE OF STUDY

This report presents the results of a preliminary subsoil and geologic hazard evaluation for Mountain Meadow Preserve Subdivision to be developed within Blocks 2 and 3 of the Sky Harbor Subdivision in Steamboat Springs, 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. 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 preliminary recommendations based on the proposed construction and the subsurface conditions encountered. A discussion of preliminary geotechnical engineering considerations, local geology and site conditions related to construction of the proposed residential subdivision are included.

PROPOSED DEVELOPMENT

We understand that the subject property will be developed with approximately 42 single family and duplex residential lots. In addition, paved roadways will be constructed along with the associated underground utilities. The roadways will be constructed to meet the local access road criteria, as set forth by the city.

We anticipate structure loadings to be light to moderate, typical of residential construction. If the proposed building conditions are significantly different from those described above, we should be notified to reevaluate the recommendations contained in this report.

It is our understanding that the majority of the site grading for this project will occur for the construction of the project roadways and individual driveways. Based on our discussions with Johnson Kunkel, it appears that the cut and fill slopes constructed for the roadways and driveways will be less than 3 feet in height and they will be constructed with a 2 (horizontal) to 1 (vertical) slope configuration. Deeper excavations will be required across the site during the installation of the water and sewer lines. Overlot grading across the proposed building lots is not proposed at this time.

SITE CONDITIONS

The project site is bordered on the west side by Steamboat Boulevard and on the south by Rockies Way (Old Mt. Werner Road). The Moraine Townhomes are situated to the north of this property and the Rockies Condominiums are situated to the east of the subject property. Single family and duplex residences are situated along the west side of Steamboat Boulevard.

The site was vacant at the time of this investigation and did not appear to have had any previous usage or grading activities. It should be noted that an overhead electrical power line crosses the northern half of the site in an east to west direction. The project site is generally vegetated with grasses and weeds. However, we did observe pine and deciduous trees scattered across the site. In addition, we observed cattails in the bottom of the drainages in several locations.

Several seasonal drainages are situated on the site. The drainages generally flow in a northeast to southwest direction. The drainages were dry at the time of this investigation. The topography of the site is highly variable due to the drainages which cross the site. The site generally slopes gently to moderately down to west, southwest, south and northwest to the drainage bottoms. A maximum elevation difference of approximately 30 feet exists across the site.

GEOLOGIC SETTING

The site is situated in the Southern Rocky Mountain Province and lies on the west flank of the Park Range. Portions of the Park Range are also referred to as the Gore Range. The Park Range Uplift has been interpreted as a product of the Laramide orogeny which 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 Tertiary age in the project area.

Specifically, the near surface bedrock in the area of the proposed development consists of Miocene Browns Park Formation, which consists of fluvial sandstones, siltstones and claystones.

Based on regional mapping, the near surface sandstone, siltstone and claystone beds of the Browns Park Formation are nearly horizontal in the project area. The overburden soils at the site consist mainly of residual and alluvial clay, sand and gravel soils associated with chemical and mechanical weathering of the bedrock materials. The overburden soil conditions at the site are discussed in greater detail later in this report.

FIELD INVESTIGATION

The field investigation for the project was conducted on June 10, 1999. Six (6) test pits were advanced at the approximate locations shown on Figure #2 to explore the subsurface conditions across the site. The locations of the test pits were determined by NWCC and the actual test pit locations were surveyed by Johnson Kunkel. It should be noted that the test pits were located at proposed sanitary sewer manhole sites. The elevations of the test pits were determined by interpolating between contours shown on the site plan provided. The test pits were advanced with a Cat 312 trackhoe and were logged by a representative of NWCC, Inc.

Samples of the subsurface materials obtained from the test pits were taken by hand driven California liners and small disturbed samples from the test pit walls. Depths at which the samples were taken are shown on the logs of the exploratory test pits in Figure #3. The Legend and Notes associated with the logs are shown in Figure #4.

LABORATORY INVESTIGATION

Samples obtained from the test pits were examined and classified in the laboratory by the project engineer. Laboratory testing included standard property tests such as natural moisture contents, dry unit weights, grain size analyses and Atterberg limits. Swell-consolidation testing was also conducted on samples of the clays to determine the compressibility or swell characteristics of the natural soils under loading and saturation.

Results of the laboratory testing program are shown on Figures #5 to #8 and are summarized in Table 1. The laboratory testing was conducted in general accordance with applicable ASTM specifications.

SUBSURFACE CONDITIONS

The subsurface conditions encountered in the test pits were somewhat variable and generally consisted of a layer of topsoil overlying natural clays and silts, clays, and sands and gravels to the maximum depth investigated, 10 feet. Graphic logs of the test pits are shown in Figure #3.

Topsoil was encountered at the ground surface in all of the test pits and ranged in thickness from approximately 18 to 30 inches. The topsoil was typically silty to clayey, dry to wet and black to brown in color. A layer of natural clay and silt was encountered in test pits 1, 3 and 4 below the topsoil materials. The clay and silt layer was approximately 12 to 18 inches thick. The clay and silt materials were slightly sandy to sandy, low to moderately plastic, soft, wet and mottled brown with iron staining. Samples of the clay and silt classified as CL-ML and CL soils in accordance with the Unified Soil Classification System.

Natural clays were encountered below the topsoil in test pits 2, 5 and 6 and extended to depths ranging from 3 1/2 to 8 feet below the ground surface. The clays were sandy to slightly sandy, moderately to highly plastic, stiff to very stiff, moist and brown to reddish brown in color. The clays classified as CL soils in accordance with the Unified Soil Classification System.

Natural sands and gravels were encountered beneath the clay and silt layer in test pits 1, 3 and 4 and beneath the clay layer in test pits 5 and 6 at depths ranging from 2 1/2 to 8 feet below the ground surface. The sands and gravels were silty to very clayey, fine to coarse grained with cobbles and small boulders, low plastic, dense, moist to very moist and brown to gray in color. The sands and gravels classified as SC to SC-GC soils in accordance with the Unified Soil Classification System.

Swell-consolidation testing conducted on relatively undisturbed samples of the natural clay and silt indicate that these materials will exhibit a moderate to high degree of consolidation under relatively light loads and then exhibit a nil to low swell potential when wetted under a constant load. Swell-consolidation testing conducted on samples of the clays indicate that these materials will exhibit a low to moderate degree of consolidation under light loads and then exhibit a low to moderate swell potential when wetted. The swell-consolidation test results are shown in Figures #5 through #8.

Free groundwater was not encountered in the test pits at the time of excavation. It should be noted that the groundwater conditions can be expected to fluctuate with changes in precipitation and runoff.

PRELIMINARY CONSTRUCTION CONSIDERATIONS

Foundations: The foundation recommendations for the proposed residential structures should be developed on an individual basis due to the highly variable nature of the subsoils. The final foundation grades for the structures should be carefully considered with the underlying soils conditions in mind. Foundations at the site may be founded on spread footings placed on the natural clays or sands and gravels. However, the foundations should not be placed on the topsoil or clay and silt materials. The location, depth and consistency of the clays 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 feasible.

Based on the field and laboratory investigations, maximum allowable bearing capacities for spread footings at the site will range from 2,500 psf to 4,000 psf. Estimated settlements for footings in this range is 1 inch. Dead loads ranging from 500 to 1,000 psf may be required for footings placed on low to moderate swelling clays and claycy sands to prevent and/or reduce the upward movement.

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 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 which can be taken to allow slab-on-grade construction.

Underdrains: Underdrain systems will be necessary to protect the lower levels of the structures due to the presence of stiff cohesive soils. Groundwater, localized perched or runoff water can infiltrate the foundations at the footing levels. This water can be one of the primary causes of differential foundation and slab movement, especially where expansive soils have been encountered.

Cut and Fill Slopes: Evidence of recent slope instability was not observed at the project site during our field investigation. Based on our experience with similar soils and subsurface conditions, we believe that the permanent cut slopes, less than 5 feet in depth, will be stable if they are constructed to a 2(H):1(V) or flatter slope configuration. The topsoil and clay and silt layers encountered near the ground surface may have to be excavated to a flatter slope configuration if groundwater seepage is observed in these materials.

Fills up to 5 feet in height may be constructed on 2(H):1(V) slopes provided the embankments and slopes are properly compacted and constructed on suitable bearing soils. We recommend the removal of all topsoil and wet, unstable materials from beneath fill areas prior to fill placement. The stripped areas should be thoroughly recompacted to provide a stable base prior to fill placement. Fill placed at the site

should be examined and tested to determine suitability for use as fill material prior to placement. The majority of the soils, exclusive of topsoil, should be suitable for use in the fills.

Fill materials placed in the roadway and building envelopes should be compacted to at least 95 percent of the maximum modified Proctor density determined in accordance with ASTM D-1557. Roadway construction in some low lying areas within the drainages may also require additional stabilization methods, such as placement of a geotextile stabilization fabric to provide a stable subgrade.

All surface and subsurface runoff should be directed away from all cuts and fills by providing good surface drainage and erosion control. All cut and fill slopes and other stripped areas should be protected against erosion by revegetation or other methods.

GEOLOGIC HAZARDS EVALUATION

Swelling Soils: The potential hazard of swelling materials at the site and remedial measures have been discussed above. Swell consolidation testing conducted on samples collected from the test holes indicate a very low to moderate swell potential exists at the site. The swell potential of any particular site can change erratically both in lateral and vertical extent. A careful site-specific subsurface investigation is necessary to determine the potential hazard from swelling soils and to provide recommendations to reduce the risk of construction on swelling materials.

Slope Stability: Existing and proposed slope geometry at the site has been discussed above. Areas of recent slope instability have not been observed at the site and we do not anticipate any problems with the stability of the natural or cut slopes at this site due to the gentle natural slopes and limited site grading proposed.

Seismic Activity: Seismic activity in the project area is considered to be low. According to the Uniform Building Code (1991) 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).

Faulting in the area is associated with the Park Range Uplift and is located west of Steamboat Springs. Numerous small faults make up what is known as the Steamboat Springs fault zone. The zone trends

north-south, dips steeply to the east and is located just west of Steamboat Springs and east of the project site. Movement has been inferred in Tertiary to Quaternary age rocks in the fault zone.

LIMITATIONS

This report is preliminary and suitable for general design and planning. The test pits were widely spaced to determine the general subsurface profile. Based on our present knowledge, there are no subsoil conditions which constitute a major hazard or would render the proposed development infeasible. Additional investigations are warranted to provide specific design criteria for individual building foundations, slabs, lateral earth pressures and other soil related construction activities.

If there are any further questions concerning this report, or if we may be of further service, please contact this office.

Sincerely,
NORTHWEST COLORADO CONSULTANTS, INC.

Brian D. Len, P.E.

cc: Johnson Kunkel

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Algermissen, S.T., 1969, Seismic Risk Studies in the United States. In Proceedings, 4th World Conference on Earthquake Engineering, Vol. 1: Santiago, Chile.

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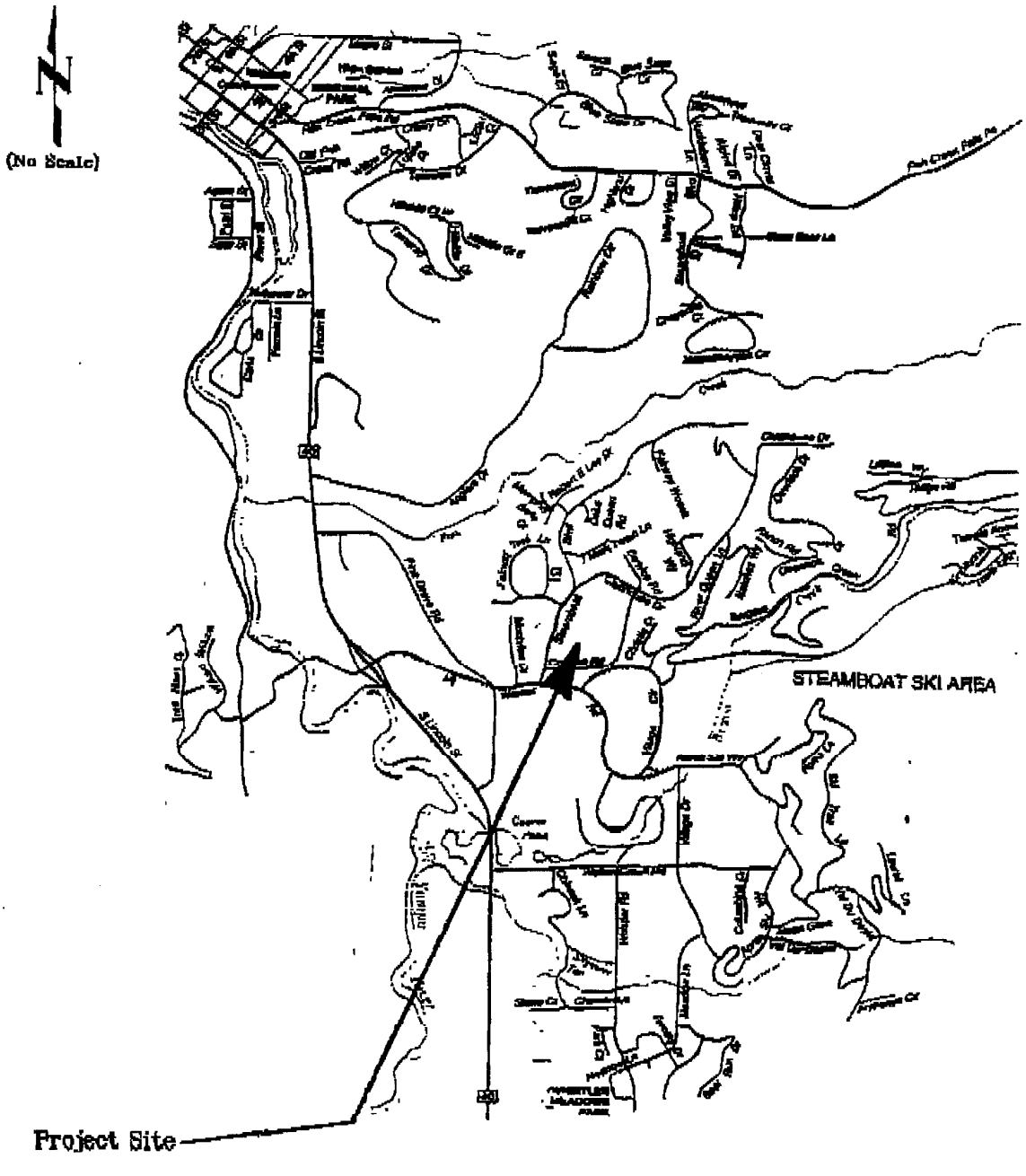
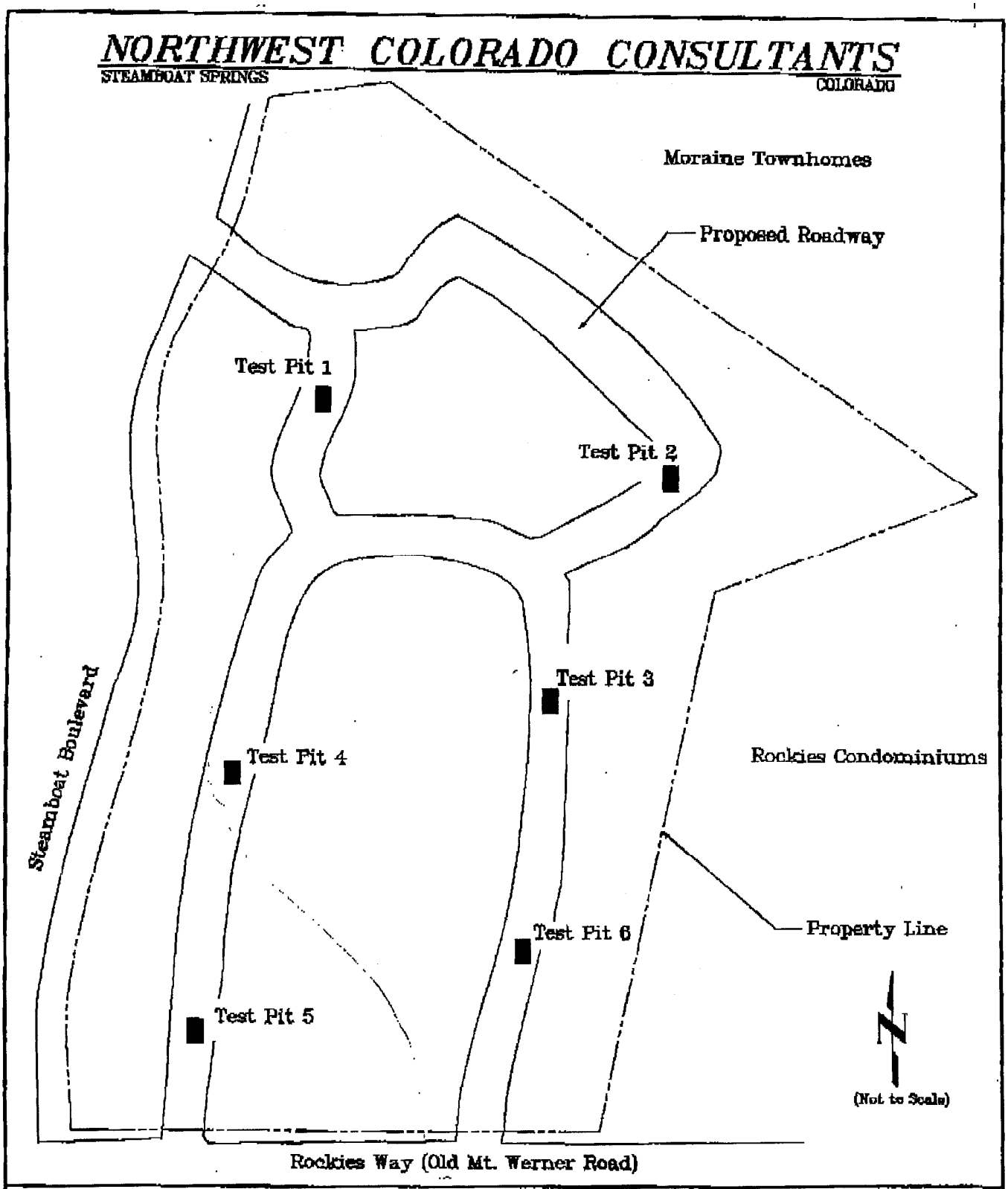
STEAMBOAT SPRINGS COLORADO



VICINITY MAP

Job Name: Mountain Meadow Preserve	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subd., Steamboat Springs	Figure #1



SITE PLAN / LOCATION OF TEST PITS

Job Name: Mountain Meadow Preserve	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subd., Steamboat Springs	Figure #2

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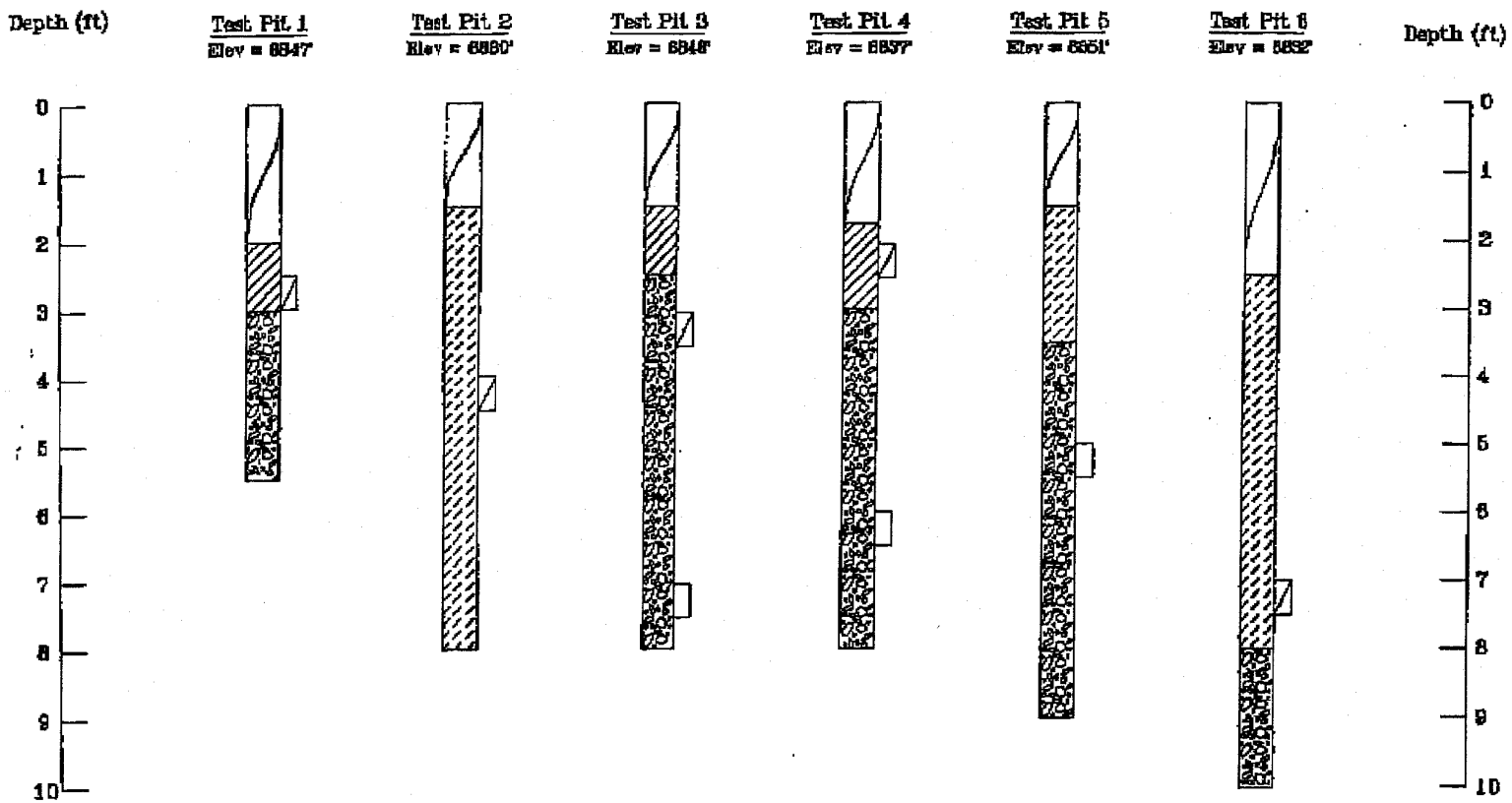

LOGS OF EXPLORATORY TEST PITS

Job Name: Mountain Meadow Preserve	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subdivision, Steamboat Springs, CO	Figure #3

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LEGEND

TOPSOIL: Silty to clayey, dry to wet and black to brown.

CLAY & SILT: Slightly sandy to sandy, low to moderately plastic, soft, wet and mottled brown with iron staining.

CLAY: Sandy to slightly sandy, moderately to highly plastic, stiff to very stiff, moist and brown to reddish brown.

SANDS & GRAVELS: Silty to very clayey, fine to coarse grained with cobbles and small boulders, low plastic, dense, moist to very moist and brown to gray.

Small disturbed bag sample.

Hand drive sample, 2-inch California Liner sample.

NOTES:

1) Test pits were excavated on June 10, 1999 with a Cat 312 trackhoe.

2) Test pit locations were determined by NWCC and excavated at the manhole locations staked in the field by Johnson Kunkel.

3) Elevations of the test pits were determined by interpolating between the contours shown on the plan provided by Johnson Kunkel.

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

LEGEND & NOTES

Job Name: Mountain Meadow Preserve	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subd., Steamboat Springs	Figure #4

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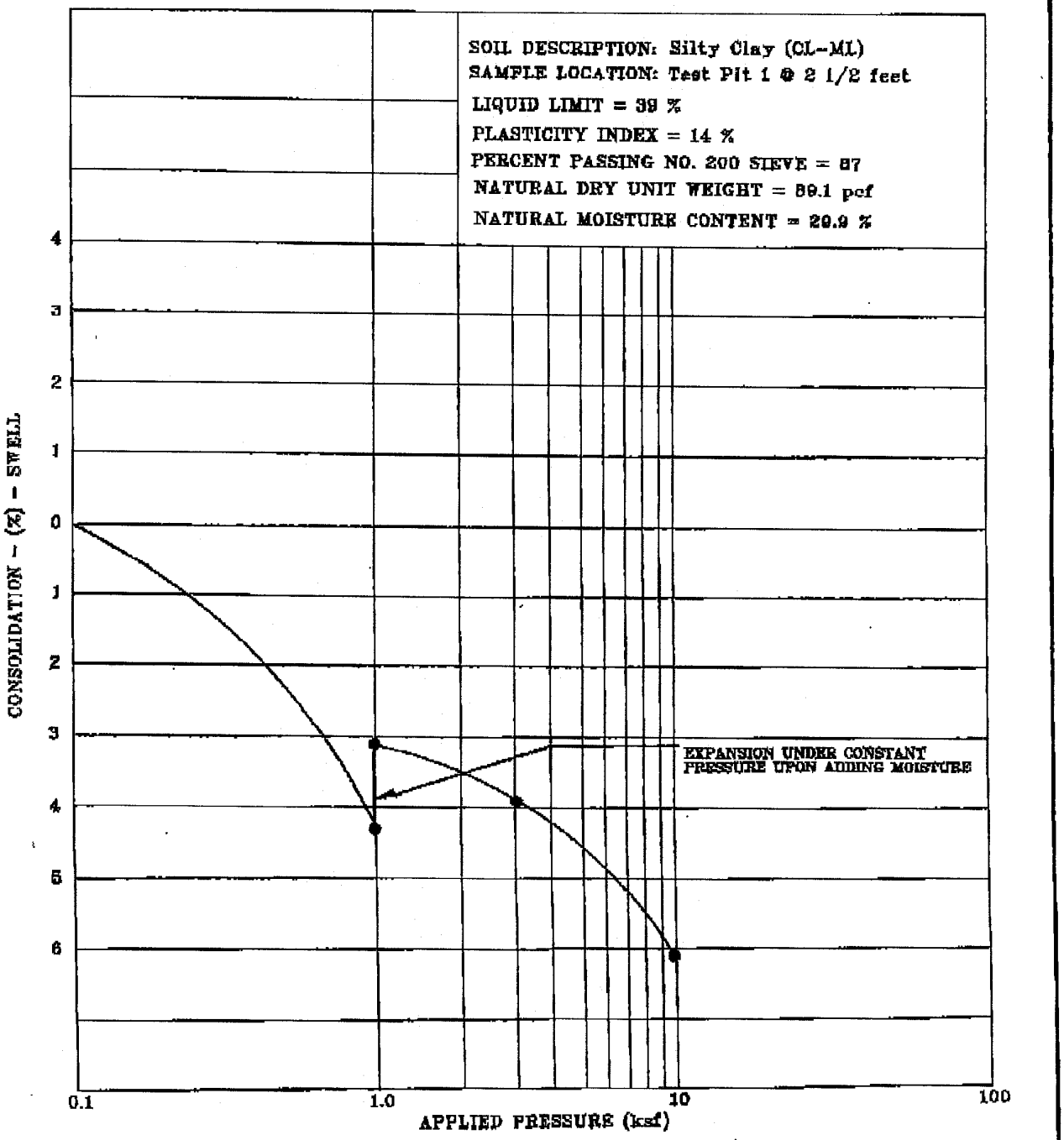

SWELL – CONSOLIDATION TEST RESULTS

Job Name: Mountain Meadow Subdivision	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subd., Steamboat Springs	Figure #5

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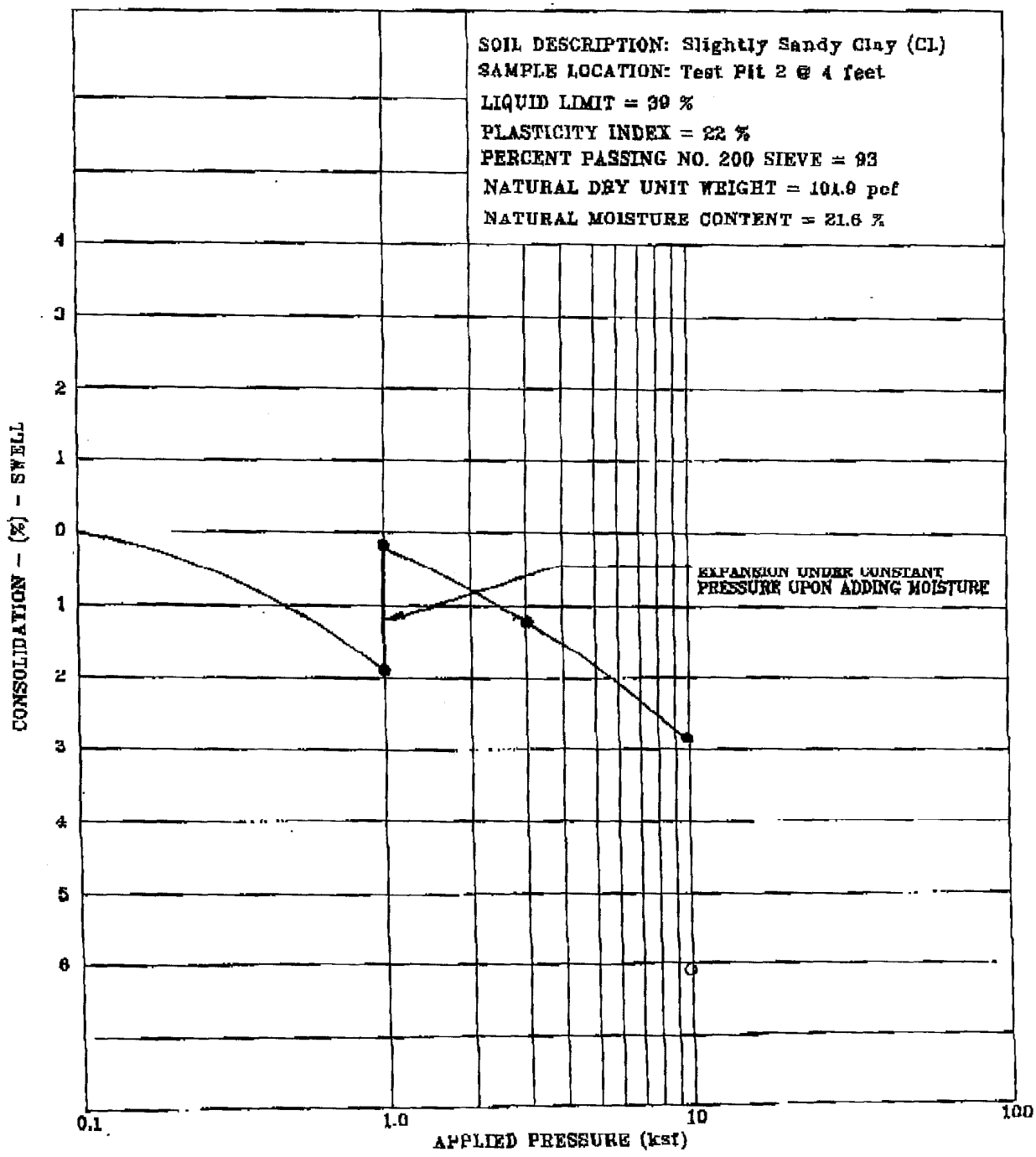

SWELL - CONSOLIDATION TEST RESULTS

Job Name: Mountain Meadow Subdivision	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subd., Steamboat Springs	Figure #6

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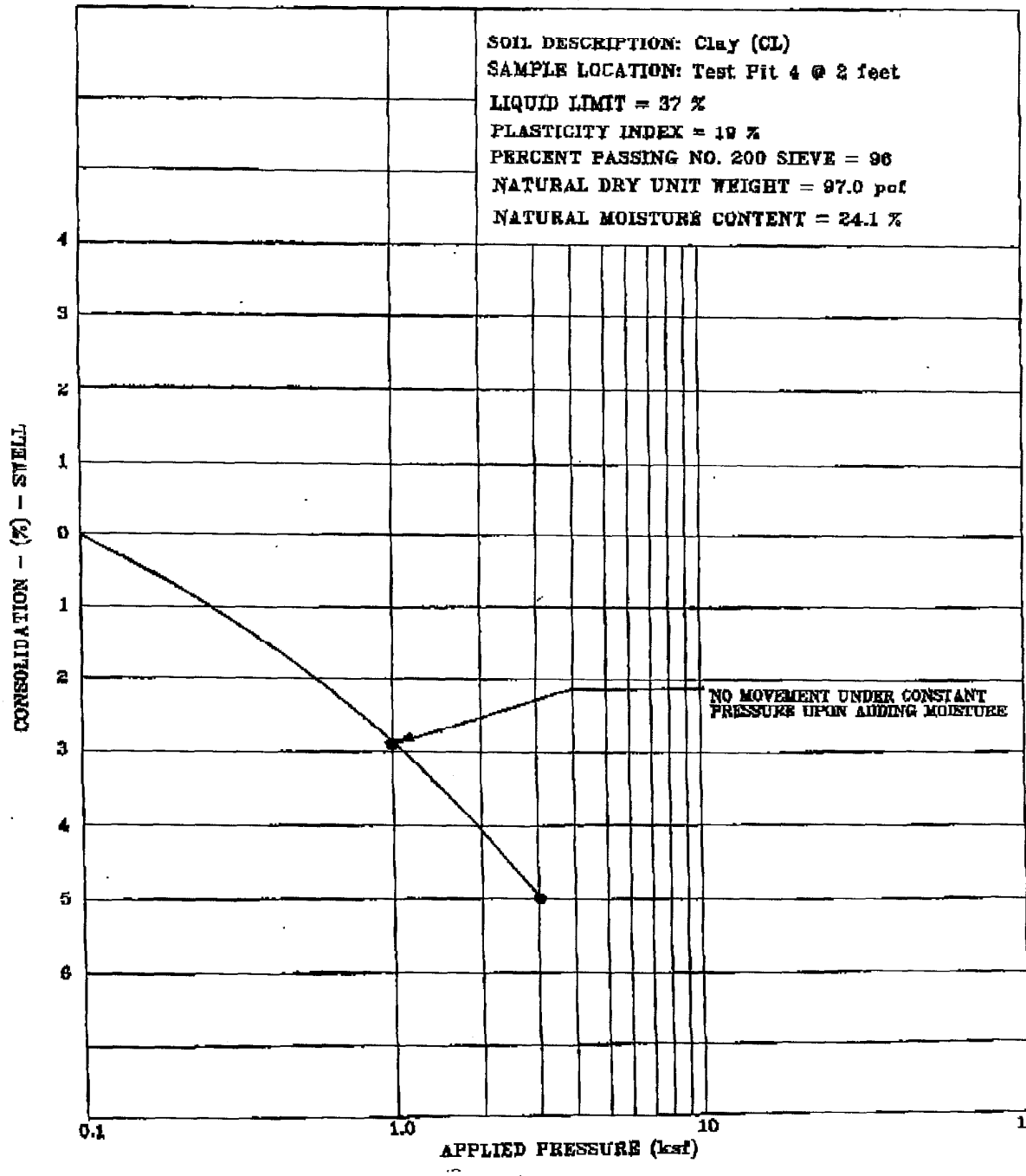

SWELL – CONSOLIDATION TEST RESULTS

Job Name: Mountain Meadow Subdivision	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subd., Steamboat Springs	Figure #7

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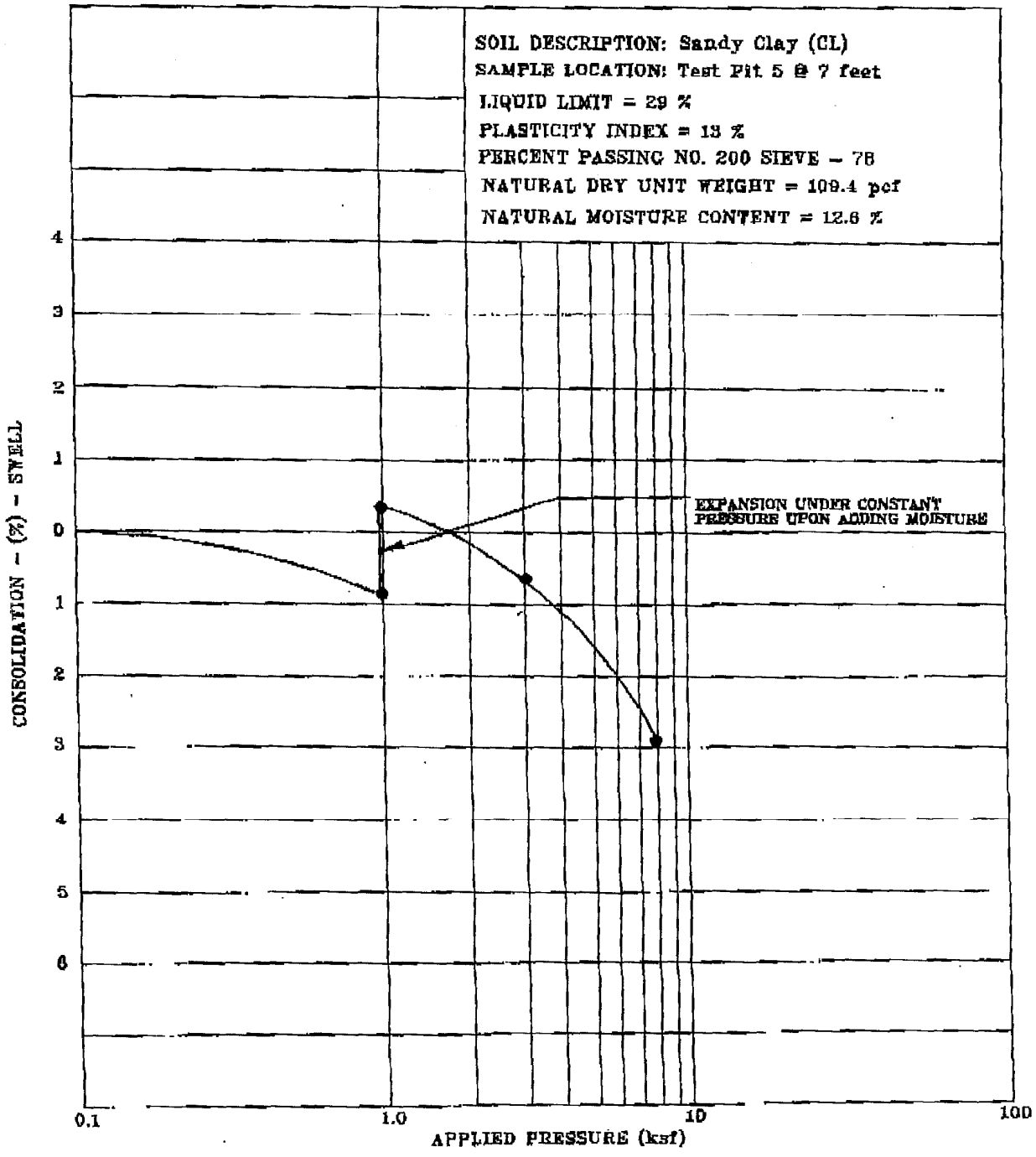

SWELL – CONSOLIDATION TEST RESULTS

Job Name: Mountain Meadow Subdivision	Job No. 99-3994
Location: Blocks 2 & 3, Sky Harbor Subd., Steamboat Springs	Figure #8

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TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	ATTERBERG LIMITS		GRADATION		PERCENT PASSING No. 200 SIEVE	UNCONFINED COMPRESSIVE STRENGTH (psf)	SOIL or BEDROCK DESCRIPTION	UNIFIED SOIL CLASS.
TEST HOLE	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
TP-1	2 1/2	29.9	89.1	39	14	0	13	87		Silty Clay	CL-ML
TP-2	4	21.6	101.9	39	22	0	7	93		Slightly Sandy Clay	CL
TP-3	7	9.3	———	22	6	36	49	15		Sand and Gravel	SC-GC
TP-4	2	24.1	97.0	37	19	0	4	96		Clay	CL
TP-4	5	11.1	———	30	12	14	52	34		Clayey Sand w/Gravel	SC
TP-5	7	12.6	109.4	29	13	0	22	78		Sandy Clay	CL
TP-6	5	7.2	———	24	10	28	52	20		Clayey Gravelly Sand	SC

JOB NO. 99-3994