Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

Applied Geotechnical Engineering Consultants, Inc.

GEOTECHNICAL INVESTIGATION

THE JOSHUAS

ST, GEORGE, UTAH

PREPARED FOR:

SOUTHGATE DEVELOPMENT
297 WEST HILTON DRIVE
ST. GEORGE, UT 84770

ATTENTION: GERRY BROWN

PROJECT NO. 981745

SEPTEMBER 16, 1999

158 West 1600 South • St. George, Utah 84770 • (435) 673-6850 • FAX (435) 673-1044

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CONCLUSIONS

1. The subsurface soil profile at the site generally consists of up 1½ feet of fill composed of lean to fat clay overlying expansive claystone bedrock to the maximum depth investigated, 9 feet. This is based on the soil profile within the lower level utility trench. The report prepared by Kleinfelder, Inc., indicates similar soil conditions on the upper (southern) portion of the site.

2. No subsurface water was encountered to the maximum depth investigated, 9 feet.

3. We recommend supporting the residences on drilled or steel-shaft helical piers extending at least of 15 feet into the claystone with a minimum pier length of 20 feet.

4. Piers may be designed for a net allowable bearing pressure of 40,000 psf. A minimum dead load of 10,000 psf should be sustained on the piers. If the minimum dead load requirement can not be met, the dead low deficit may be made up by increasing the pier length, assuming a skin friction of 1,200 psf.

5. A structural floor should be utilized in conjunction with the pier foundation system which is supported on grade beams designed to span the distance between piers. The grade beams are supported on the piers and a minimum 6-inch void should be provided below the grade beams to allow for expansion of the claystone.

6. Detailed recommendations for foundations and drainage are included in the report.

SCOPE OF WORK

This report presents the results of a Geotechnical Investigation for the proposed Joshuas Subdivision located in St. George, Utah, as shown on Figure 1. This report presents the subsurface conditions encountered, laboratory test results, and recommendations for the geotechnical aspects of the project.

Field exploration was conducted by logging sewer line trenches during the utility placement on the subject subdivision. Subsurface conditions encountered were logged and samples were collected from the sewer line trenches. Samples obtained during the field investigation were tested in the laboratory to determine physical and engineering characteristics of the on-site soil and bedrock. Results of the field exploration and laboratory tests were analyzed to develop recommendations for the proposed foundations.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

SITE CONDITIONS

At the time of our investigation, the site had been grubbed of vegetation and some fill had been placed on building pads. Some of the sewer line trenches were open and were logged to determine subsurface conditions. A portion of the utilities had been placed.

The site generally slopes down from south to north with terraces sloping down from west to east. The subdivision is located along the south side of Tonaquint Drive and north and west of the existing Legacy Subdivision.

FIELD STUDY

The field study was conducted on May 5, 1999. The field study consisted of logging and sampling of the sewer line trench which had been cut through the center of the northern portion of the subject site. The trench was logged and sampled approximately every 100 feet from west to east. The samples were obtained to perform laboratory testing to assist in determining the engineering properties of the subsurface soil and bedrock. Logs of the subsurface conditions encountered are shown graphically on Figures 3-4, and the notes are shown on Figure 5.

SUBSURFACE CONDITIONS

The subsurface soil profile generally consists of up to 1½ feet of fill composed of lean to fat clay overlying expansive claystone bedrock to the maximum depth investigated, 9 feet. Each soil type encountered is described below:

Fill - The fill is generally composed of sandy lean clay to fat clay with sand. It is stiff, dry, and brown in color.

Claystone - The claystone is moderately to highly plastic, very stiff to hard, moist, and dark red to purple to green to yellow in color. The upper 1 to 2 feet is generally weathered.

Laboratory tests conducted on the claystone indicate a natural dry density ranging from 118 to 133 pcf with a natural moisture content ranging from 5 to 12 percent, which indicates the claystone has not been wetted. Gradation tests indicate the fines contents (percent passing the No. 200 sieve) ranging from 20 to 89 percent. An Atterberg Limit test indicates a liquid limit ranging from 28 to 42 percent and a plasticity index ranging from 13 to 24 percent.

Several one-dimensional consolidation tests conducted on the claystone indicate it is slightly to highly expansive when wetted under 1,000 psf. A swell potential of up to 2.8 percent was measured.

Results of the laboratory tests are shown on the test pit logs, Figures 3-4, and the key to symbols are shown on Figure 5. The consolidation test results are shown graphically on Figures 6-8.

SUBSURFACE WATER

No groundwater was encountered to the maximum depth investigated, 9 feet. Fluctuations in the ground water level may occur over time. An evaluation of such fluctuations is beyond the scope of this report.

PROPOSED CONSTRUCTION

We anticipate single-family residences will be constructed in the subdivision. We anticipate the residences will be southwestern style homes with typical wood-framing and stucco veneer and tile roof. We anticipate wall loads on the order of 1 to 2 kips per lineal foot with column loads up to 20 kips. We also anticipate some walk-out basements may be utilized on the upper level. We anticipate desert-type landscaping will be utilized.

If the proposed construction or loading conditions are different from what is described above, we should be notified so additional recommendations may be provided.

RECOMMENDATIONS

Due to the presence of expansive claystone bedrock at the site, we recommend supporting the home on drilled or steel-shaft helical piers bearing on mudstone below the "active" zone as described herein. Detailed recommendations for the foundation system are described below:

A. **Foundations**

We recommend supporting the residence on straight-shaft drilled or steel-shaft helical piers extending at least 15 feet into the claystone with a minimum pier length of 20 feet. The following details should be followed when designing and installing the pier foundation:

a. The piers may be designed using an allowable end bearing pressure of 40,000 pounds per square foot. If steel piers are used, the capacity of the pier may limit the load on each pier. Drilled piers should be at least 10 inches in diameter.

b. Due to the existence of expansive materials, the piers should be designed and spaced so that a minimum dead load pressure of 10,000 psf is sustained based on the pier bottom end area of each pier. The following dead loads are calculated based on the pier diameter:

Pier Diameter (inches)	Minimum Dead Load/Pier (lbs)	Maximum Total Load/Pier (lbs)
6*	1,970	5,910
8*	3,500	10,500
10	5,460	16,360
12	7,860	23,560

*Steel piers only

If the minimum dead load requirement cannot be achieved and the piers are spaced as far apart as practical, the pier length should be drilled beyond the minimum penetration to make up the dead load deficit. This will require the use of drilled piers in these areas. Helical piers are not an option when the minimum dead load can not be achieved. The dead load deficit may be made up by assuming 1,200 pounds per square foot of skin friction for the portion of the pier below the minimum penetration depth of 15 feet into the bedrock. Generally, minimum dead load requirements can not be achieved on porches and overhangs. The additional pier length will generally be required in these areas where light roof loads are transferred to the piers.

c. Piers should be placed as far apart as practical in order to achieve minimum dead load recommendations and a minimum of three diameters apart center to center.

d. Concrete used in drilled piers should be a fluid mix with sufficient slump to fill in the voids between reinforcement steel and the pier hole. We recommend a slump of approximately 4 inches with a minimum compressive strength of 4,500 psf.

e. Drilled pier holes should be properly cleaned prior to placing concrete.

f. Care should be taken to assure the drilled piers are not over-sized (mushroomed) at the ground surface, which could reduce the end bearing pressure and/or provide an area where swelling soil/rock could place an uplift force on the pier. If necessary, a sonotube should be used at the surface.

g. Concrete should be placed in the piers the same day they are drilled. If caving occurs or water enters the pier holes, it may be necessary to place concrete immediately after the pier hole is completed. Failure to place concrete the day of drilling may require redrilling for additional bedrock penetration.

h. The piers should be structurally reinforced to resist tensile forces on the piers due to negative skin friction. The tensile force may be calculated utilizing at least 6 feet of pier length with a skin friction of 1,200 psf.

B. Floor Systems

1. Structural Floors

A structural floor system should be utilized in conjunction with the pier foundation system and should be supported on grade beams which are designed to span the distance between the piers. A structural engineer should design the grade beams. We recommend a 24-inch or deeper crawl space be provided below the residence. A 6-inch void should be provided below the grade beams to prevent the subgrade from exerting uplift forces on the grade beams. Subsequent to removing concrete forms from the grade beams, the void should be inspected to ensure the proper void space is provided.

2. Plumbing and Utility Lines

Plumbing lines and utility lines should be hung from the floor. Plumbing lines should have flexible joints were connections are made.

3. Exterior Porches

Exterior porches or overhangs which are tied to the home should be supported by the same foundation system as the remainder of the home.

4. Ventilation

Adequate ventilation should be provided for the crawl space below the structural floor. This removes moisture to prevent degradation and warping of the structural floor system.

C. **Subgrade Walls**

The subgrade walls should be designed for the lateral loads resulting from being backfilled. We recommend that subgrade walls be designed for an equivalent fluid weighing 60 pounds per cubic foot.

Under seismic conditions, the lateral earth pressures should be increased by 15 pounds per cubic foot. This assumes a horizontal ground acceleration of 0.16g.

D. **Garage Floor Slabs and Exterior Flatwork**

The garage floor slab and the exterior flatwork should be separated (free vertical movement) from the main structure. This generally is accomplished by providing a construction joint between the concrete flatwork and the home with heavy felt board. We also recommend a minimum 6 inches of clean free-draining gravel underlain by a 2 mil visqueen liner be placed under the slabs to assist in proper curing of the concrete. Curing joints should also be placed in the slabs at distances no greater than 30 times the slab thickness.

E. **Sulfate**

Based on our experience in the area, there is a relatively high concentration of water soluble sulfates which present presents a severe sulfate attack potential for concrete exposed to these materials. We recommend that Type II Modified or Type V cement in conjunction with fly ash be used in concrete that comes in contact with the natural soil. We also recommend a minimum of 4,500 psf concrete compressive strength.

F. Seismic Zone

The site is located in Seismic Zone 2-B based on the Uniform Building Code seismic zone map of the United States. The residence should be designed and constructed in accordance with Seismic Zone 2-B requirements using a soil type profile S_C.

G. Grading

During site grading, the following items should be maintained:

1. Subgrade Preparation

Prior to conducting site grading, the existing topsoil or soil containing significant organic material should be removed from the building pad area. We anticipate this will require removal of approximately 6 to 8 inches of on-site soil. Prior to fill placement, the existing subgrade should be scarified to a depth of 8 inches and recompacted to at least 95 percent of the maximum dry density as determined by ASTM D-698.

2. Compaction

Fill and backfill should be approved by the geotechnical engineer, placed in uniform lifts and compacted to the following minimum percentages of the maximum dry density as determined by ASTM D-698:

Area	Percent Compaction
Garage slab	95
Exterior flatwork concrete work	95
Landscaping areas	90
Wall backfill	90

3. Materials

   The on-site soils are suitable to be used as fill. The soil should be moisture conditioned to at least 2 percent greater than the optimum moisture content.

4. Surface Drainage

   Positive surface drainage should be provided around the perimeter of the residence. We recommend that the ground slope at least 6 inches in the first 10 feet beyond the residence. Roof downspouts and drains should discharge well beyond the limits of all backfill. We recommend that desert landscaping be utilized so that excessive water does not have the opportunity of seeping down to the underlying expansive bedrock.

H. Design Review/Construction Observation

Design review and construction observations are recommended to verify the recommendations in this report are properly implemented and followed.

In order to provide a foundation compliance report as required by St. George City, we recommend the following services be provided as a minimum:

a. Review the design layout along with calculated pier loads to verify minimum dead load requirements are achieved.

b. Observe the drilling/installation of the drilled or steel piers to verify adequate depth and proper hole cleaning is being achieved.

The following additional observations/testing are recommended:

1. Piers
   a. Observe the placement of reinforcing steel in several piers if drilled concrete piers are used.

b. Sample and test the concrete placed in piers to determine the slump and compressive strength if drilled concrete piers are used.

2. Grade Beams
   a. Observe the placement of the reinforcing steel in the grade beams.

   b. Sample and test the concrete to determine slump and compressive strength.

   c. Verify the proper void space is provided below the grade beam.

3. Wall/Garage Backfill

   Periodically test the wall/garage backfill for compaction.

The above observations should be conducted by qualified individuals and according to standard test methods (ASTM).

I. Pavement

1. Subgrade Support

   We anticipate that the subgrade materials at the site will consist of the on-site lean to fat clay. A California Bearing ratio of 5 percent was assumed for purposes of design.

2. Pavement Thickness

   Based on typical residential traffic conditions, a 20-year design life, and AASHTO design methods, the following pavement thicknesses are recommended:

Location	Asphaltic Concrete Thickness (inches)	Type II Base Course (inches)	Granular Fill (inches)
Interior Roads	2	6	12
Tonaquint Drive	3	10	30

Granular fill and base course should be tested to verify compaction is at least 95 percent of the maximum dry density as compared to ASTM D-1557. The natural subgrade soil should be tested to verify compaction is 95 percent of the maximum dry density as compared to ASTM D-698. The natural soil should be moisture conditioned to at least 2 to 4 percent on the wet side of the optimum moisture content prior to compacting.

3. Pavement Materials

The pavement materials should meet the St. George City specifications for gradation and quality. The pavement thicknesses indicated above assume that the base course is a high quality material with a CBR of at least 70 percent. Other materials may be considered for use in the pavement section. The use of other materials may result in other pavement material thicknesses.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the test pits excavated and the data obtained from laboratory testing. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface soil or groundwater conditions are found to be different from what is described in this report, we should be notified to reevaluate the recommendations given.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Arnold DeCastro, P.E.

Reviewed by: James E. Nordquist, P.E.
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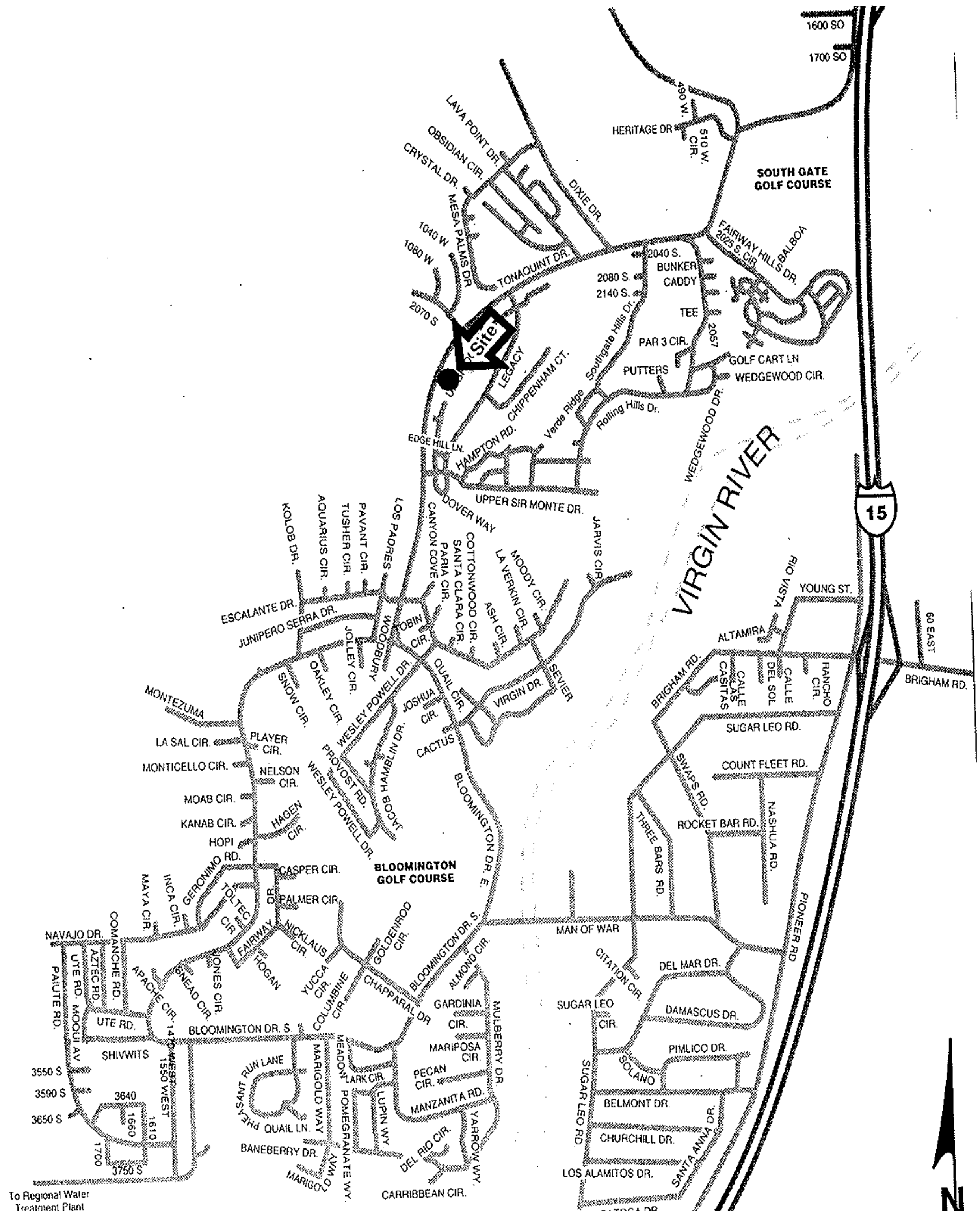
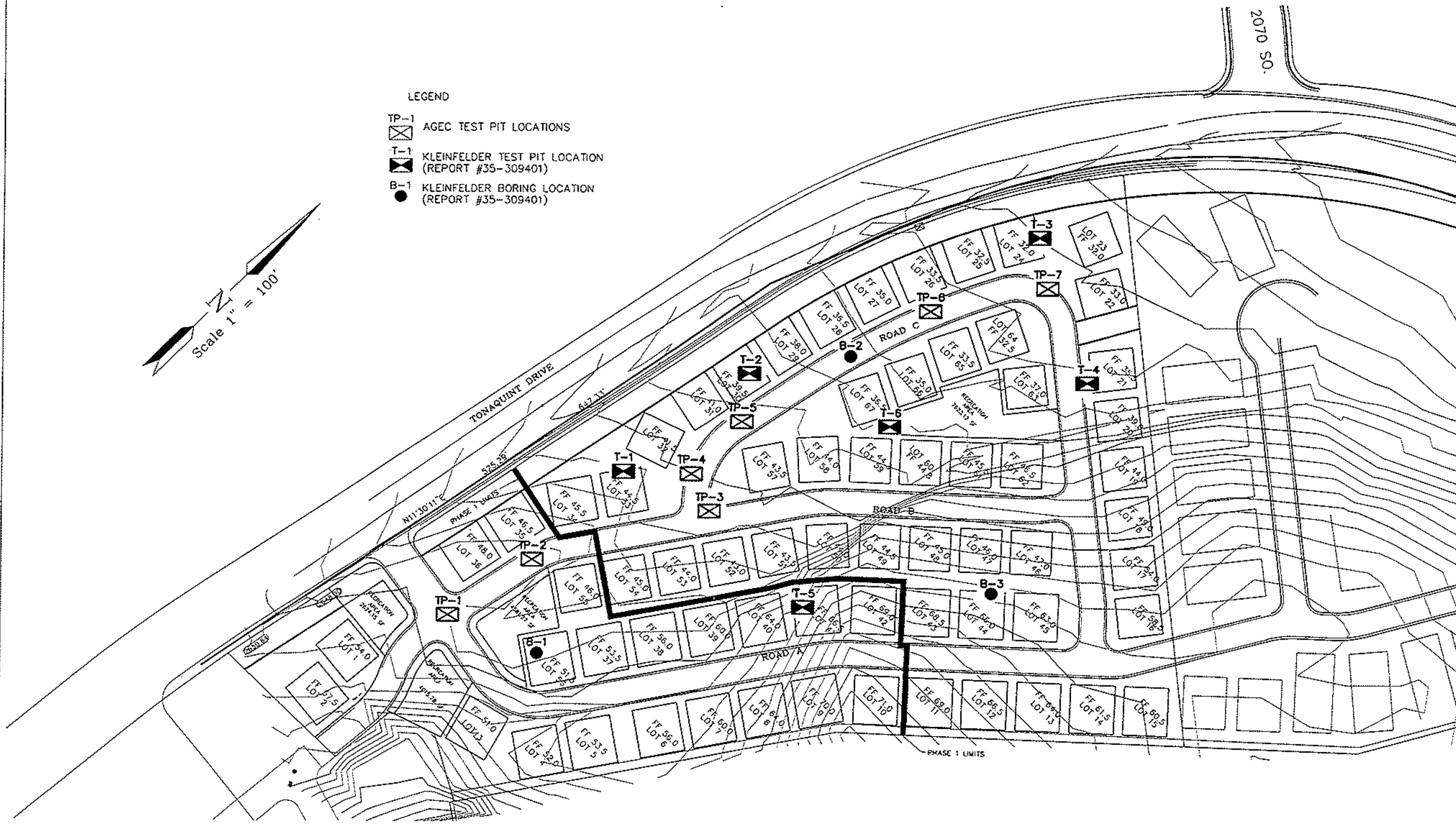


981745	AGEC	Vicinity Map of Study Area (St. George, Utah)	Figure 1



AGEC
Applied Geotechnical Engineering Consultants

The Joshuas
St. George, Utah
Geotechnical Investigation
Project No. 981745

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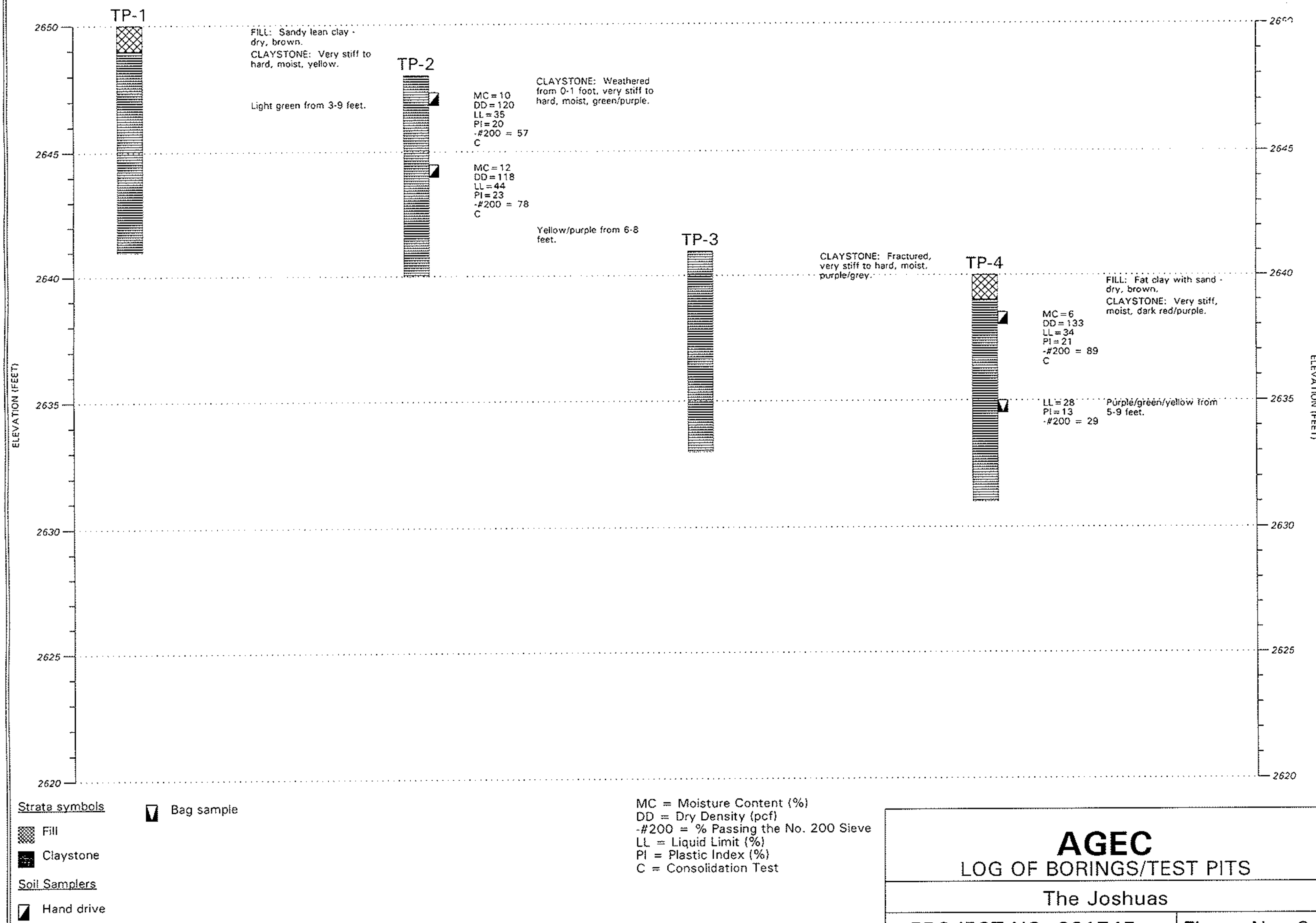


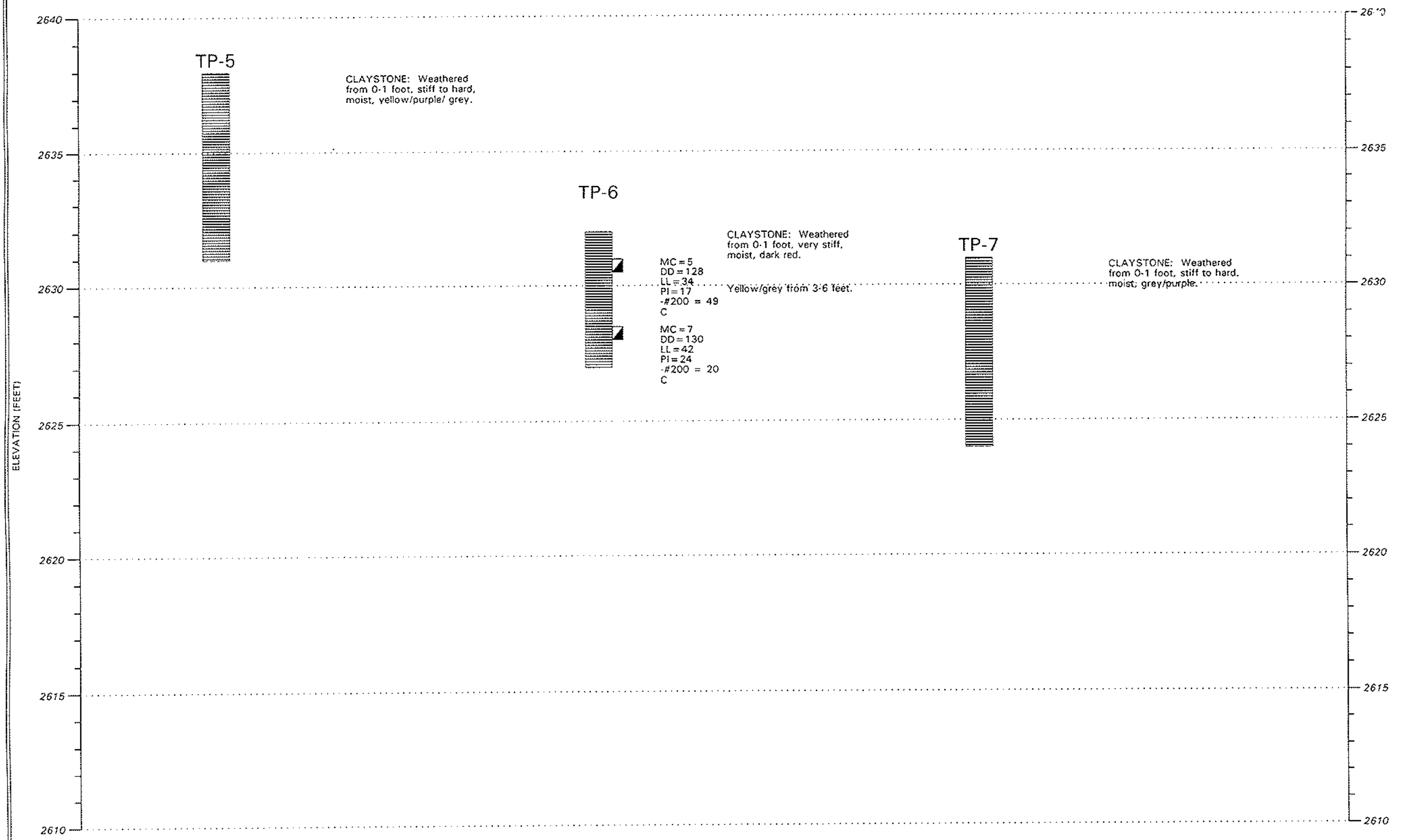
MC = Moisture Content (%)
DD = Dry Density (pcf)
-#200 = % Passing the No. 200 Sieve
LL = Liquid Limit (%)
PI = Plastic Index (%)
C = Consolidation Test

AGEC

LOG OF BORINGS/TEST PITS

The Joshuas

PROJECT NO. 981745 | Figure No. 3



Strata symbols

- Fill
- Claystone

Soil Samplers

- Hand drive
- Bag sample

MC = Moisture Content (%)
DD = Dry Density (pcf)
-#200 = % Passing the No. 200 Sieve
LL = Liquid Limit (%)
PI = Plastic Index (%)
C = Consolidation Test

AGEC
LOG OF BORINGS/TEST PITS
The Joshuas
PROJECT NO. 981745 | Figure No. 4

NOTES

1. Exploratory test pits were excavated using a CAT EL300B trackhoe on April 5 and 6, 1999.

2. Groundwater was not encountered at the time of the investigation.

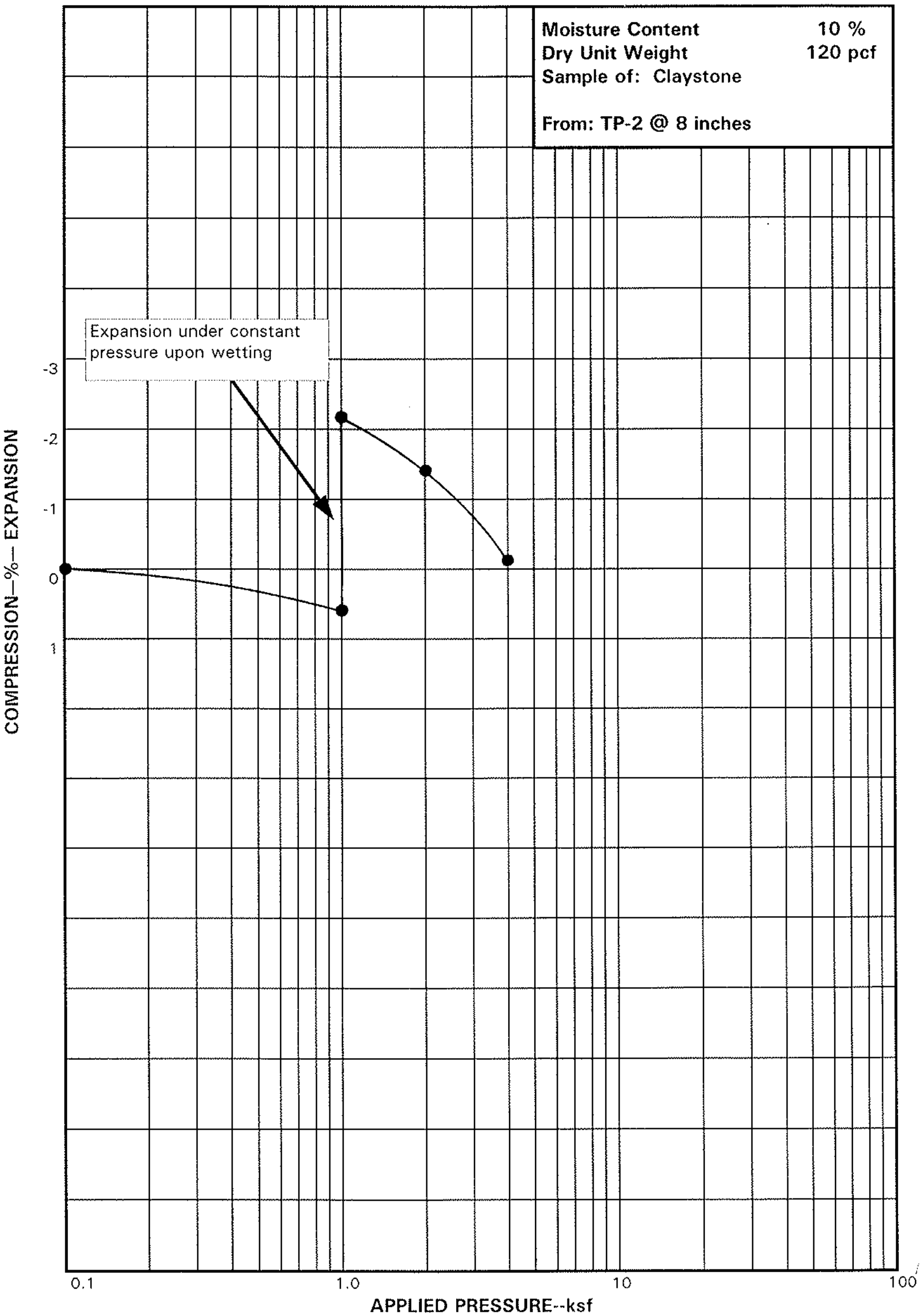
3. Test pit locations were determined by the sewer manhole numbers and are shown on Figure 2. Elevations were extrapolated from contours on the site plan provided.

4. The test pit locations and elevations should be considered accurate only to the degree implied by the method used.

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

AGEC LOG OF BORINGS/TEST PITS	
Southgate Villages	
PROJECT NO. 981745	Figure No. 5

Applied Geotechnical Engineering Consultants, Inc.



Project No. 981745 CONSOLIDATION TEST RESULTS Figure 6

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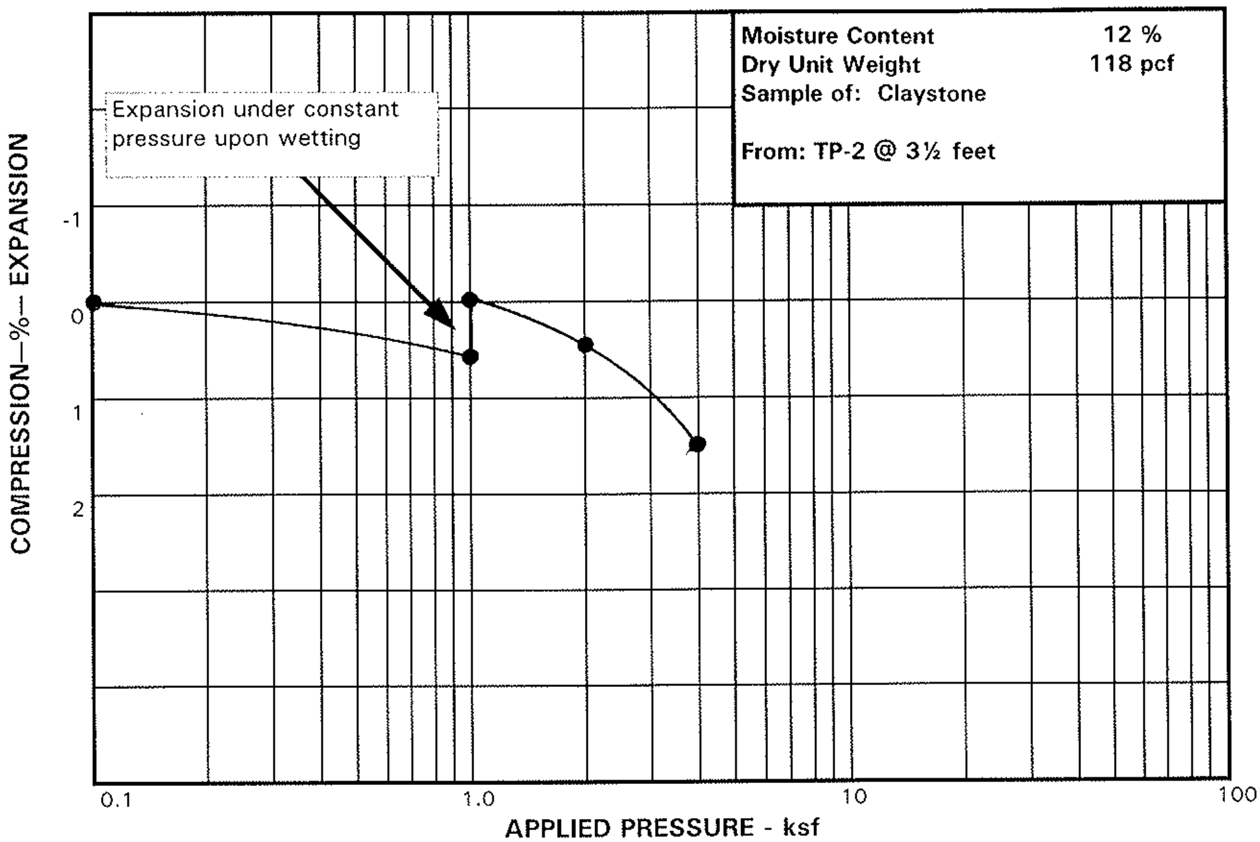
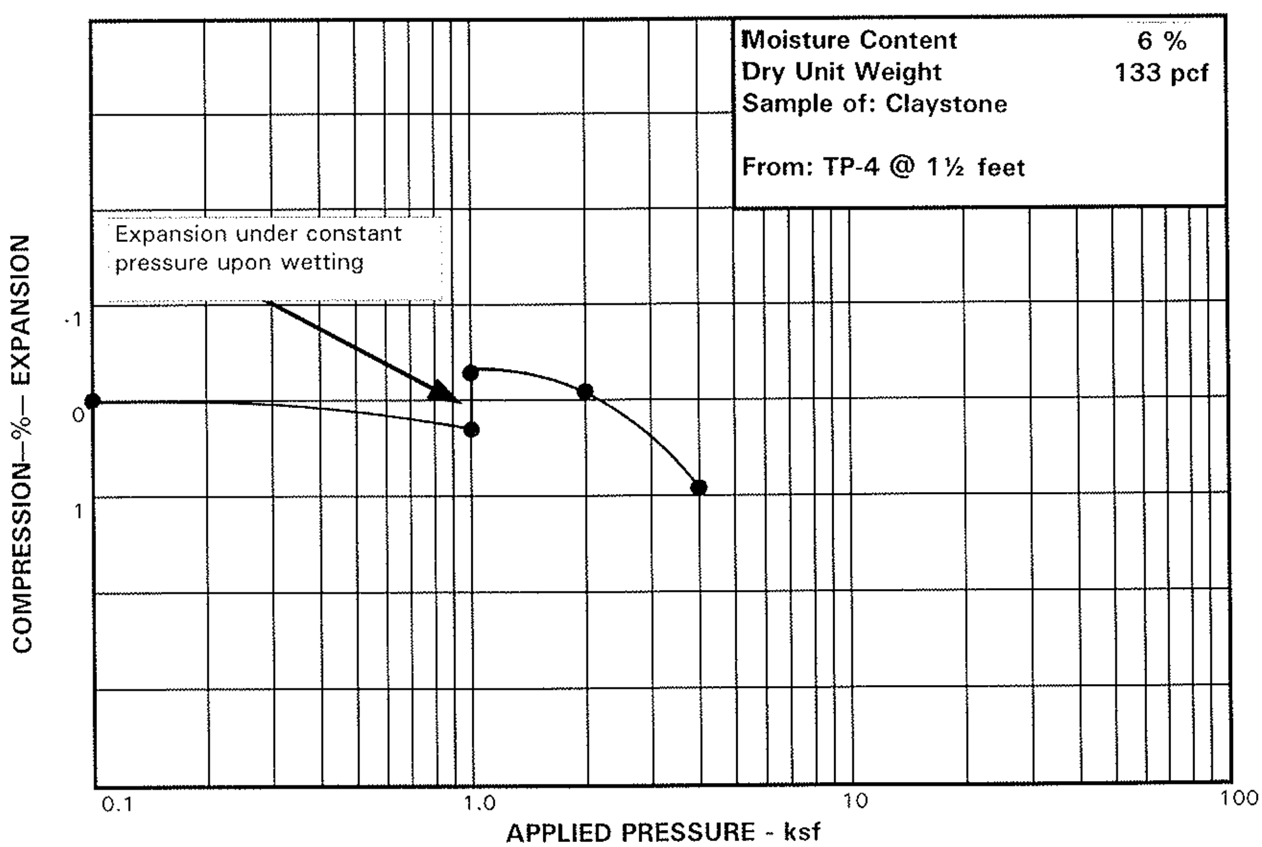
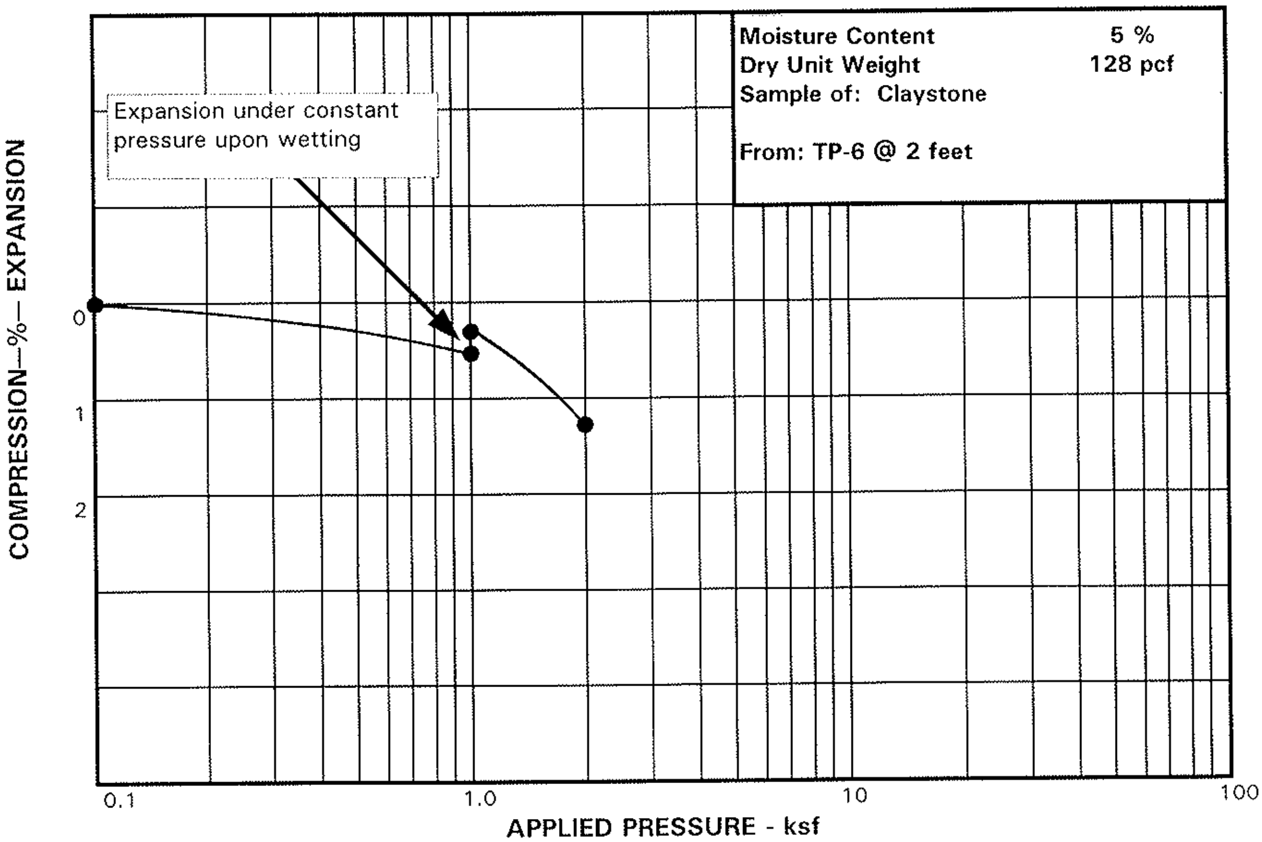
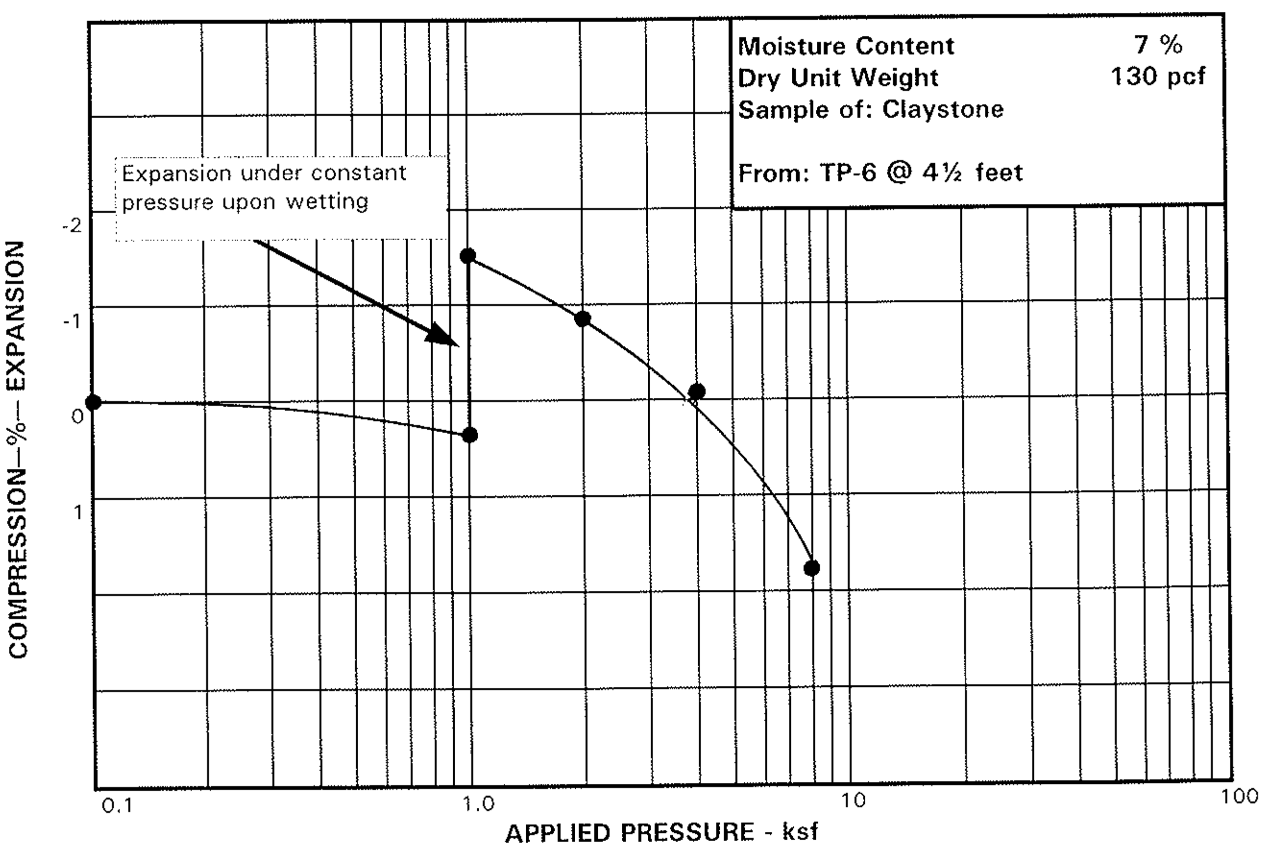




Project No. 981745 CONSOLIDATION TEST RESULTS Figure 7

Applied Geotechnical Engineering Consultants, Inc.





Project No. 981745 CONSOLIDATION TEST RESULTS Figure 8

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Table 1

Summary of Laboratory Test Results

The Joshuas

Project No. 981745

Sample Location		Moisture Content (%)	Dry Density (pcf)	Percent Passing the No. 200 Sieve	Atterberg Limits		Swell (%)	Soil Type
Test Pit #	Depth (feet)				Liquid Limit (%)	Plastic Index (%)		
2	⅔	10	120	57	35	20	2.8	Claystone
2	3½	12	118	78	44	23	0.6	Claystone
4	1½	6	133	89	34	21	0.5	Claystone
4	5	-	-	29	28	13	-	Claystone
6	2	5	128	49	34	17	0.3	Claystone
6	4½	7	130	20	42	24	1.9	Claystone