Desktop Review and Preliminary Geotechnical Engineering Report

BCHA Lafayette Property - Affordable Housing Development

SW Corner of E. Emma Street and N. 120th Street

Lafayette, Colorado

July 13, 2017

Terracon Project No. 22175065

Prepared for:

Boulder County Housing Authority (BCHA)
P.O. Box 471
Boulder, Colorado 80306

Prepared by:

Terracon Consultants, Inc.
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July 13, 2017

Boulder County Housing Authority (BCHA)
P.O. Box 471
Boulder, Colorado 80306

Attn: Mr. Ian Swallow
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E: iswallow@bouldercounty.org

RE: Desktop Review and Preliminary Geotechnical Engineering Report
BCHA Lafayette Property – Affordable Housing Development
Southwest Corner of E. Emma Street and N. 120th Street
Lafayette, Colorado
Terracon Project Number: 22175065

Mr. Swallow:

Terracon Consultants, Inc. (Terracon) has completed a desktop review of previous boring data and preliminary geotechnical engineering services for the project referenced above. This study was performed in general accordance with our proposal number P22175063 dated June 5, 2017. This report presents the findings of the subsurface explorations and provides preliminary information and recommendations concerning potential site development constraints, general earthwork, foundations, floor slabs and other earth connected phases of the project.

We appreciate the opportunity to be of service to you on this project. Materials testing and construction observation services are provided by Terracon as well. We would be pleased to discuss these services with you. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

COLORADO REGISTERED
ERIC S. WILLIS
27741
7/13/2017
PROFESSIONAL ENGINEER

Eric S. Willis, P.E.
Senior Project Manager/Engineer

Eric D. Bernhardt, P.E.
Geotechnical Department Manager

Copies to: Addressee (via email)

EXECUTIVE SUMMARY

A desktop review and preliminary geotechnical engineering services have been performed for the proposed affordable housing development to be located at the southwest corner of E. Emma Street and N. 120th Street in Lafayette, Colorado. Fourteen (14) previous test borings, designated TB-1 through TB-14, were reviewed for this study. The borings were completed in 2003 and 2008 and were drilled and sampled to depths of about 20 to 50 feet below the existing ground surface.

Based on the information obtained from our previous subsurface explorations and laboratory testing programs, the site appears suitable for the proposed construction from a geotechnical point of view. However, the following geotechnical conditions and considerations/concerns were identified and should be considered during preliminary planning and design:

- Subsoils encountered in the test borings generally consisted of about 14 to 32 feet of intermixed and/or alternating layers of lean clay with varying amounts of sand and silt, clayey sand and silty sand overlying sand and gravel with varying amounts of silt and clay. Claystone/siltstone bedrock was encountered below the overburden soils in some of the borings at depths of about 32 to 39 feet and these materials extended to the maximum depths explored.

- Groundwater was measured in the test borings in May of 2008 at depths of about 19 to 20 feet below existing ground surface. Groundwater levels can and should be expected to fluctuate over time in response to site development and with varying seasonal and weather conditions, irrigation demands on or adjacent to the site and with fluctuations in nearby water features. Based on preliminary data, groundwater is not expected to significantly impact site grading and development of the site unless deep site grading cuts, deep basements or deep utilities are planned for the project.

- Preliminary data indicates the overburden soils likely to influence foundation, slab and pavement performance have variable engineering properties. Some of the clays are expansive while other clay/sand samples showed collapse/settlement potential when wetted. The claystone/siltstone bedrock is expansive, but is located at depths unlikely to impact planned construction.

- The variability of the engineering properties of the overburden soils will present a greater than normal risk of excessive differential movement and damage to shallow foundations. Drilled piers socketed into bedrock are often used for support of structures where moisture-sensitive soils are present in order to control post-construction foundation movement. However, depth to bedrock (about 32 to 39 feet) would result in long pier lengths. Furthermore, groundwater conditions and caving sand/gravel indicate the need for temporary casing during pier installation. Constructing long piers and temporary casing

would be necessary for this site and would be costly. We believe installation of drilled piers are not practical or cost effective for this project.

Based on preliminary data and the type of construction planned, it appears buildings could be supported on spread footings along with conventional concrete slabs-on-grade or post-tensioned slab-on-ground (PTSOG) foundations bearing on a uniform zone of modified (over-excavated, moisture conditioned and re-compacted) on-site soils provided some movement can be accepted. The ground modification technique involves over-excavation below building footprints to a specified depth or elevation and re-working the same material to provide a zone of low swelling and well compacted fill. The final recommended depth of over-excavation below shallow foundations (and slabs) cannot be precisely determined without more closely spaced borings in each building and additional laboratory testing. Preliminary data suggests over-excavation and recompaction on the order of about 5 to 12 feet, or more, below the existing ground surface may be necessary.

- Based on preliminary data, we estimate slab heave of up to about 3 inches, or more, due wetting of the expansive clays is possible, while settlement due to collapsible soil of up to about 2 inches is possible. Consequently, ground modification below slabs should be anticipated on this site in order to reduce movement and enhance performance of floor slabs. For PTSOG construction, the foundations are structurally integral with the floor and should perform better than spread footings and conventional slab-on-grade floors for the soil conditions encountered on the site. If slab movement cannot be accepted, the use of structural floor systems supported independent of the ground should be considered.

- Expansive clays will likely be encountered at or near pavement subgrade on portions of the site and depending upon final grading. Pavements supported directly on expansive soils will move and crack to some degree and could create a maintenance problem and provide poor performance and serviceability. To reduce risk of movement and enhance pavement performance, subgrade modification/swell mitigation should be anticipated on portions of the site. Swell mitigation would likely involve over-excavation, moisture treatment and recompaction of a portion of the expansive subgrades.

- On-site soils typically appear suitable for use as engineered fill/backfill on the site provided they are properly processed, moisture conditioned and compacted. Import materials should be evaluated and approved by the geotechnical engineer prior to delivery to the site.

- The opinions and recommendations presented in this report are intended for preliminary design and planning purposes only. A design-level geotechnical exploration will be required on the site in order to design and construct foundations, floor slabs, pavements

and other site improvements once final building locations, foundation loads and site grading have been determined.

This summary should be used in conjunction with the entire report for preliminary design and planning purposes. It should be recognized details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

DESKTOP REVIEW and PRELIMINARY GEOTECHNICAL ENGINEERING REPORT
BCHA LAFAYETTE PROPERTY – AFFORDABLE HOUSING
SW CORNER of E. EMMA STREET and N. 120TH STREET
LAFAYETTE, COLORADO

Terracon Project No. 22175065
July 13, 2017

1.0 INTRODUCTION

A desktop review and preliminary geotechnical engineering services have been performed for the proposed affordable housing development to be located at the southwest corner of E. Emma Street and N. 120th Street in Lafayette, Colorado. Fourteen (14) previous test borings, designated TB-1 through TB-14, were reviewed for this study. The borings were completed in 2003 and 2008 and were drilled and sampled to depths of about 20 to 50 feet below the existing ground surface. Boring Logs along with a Boring Location Plan and vicinity map are included in Appendix A.

The purpose of these services is to provide information and preliminary geotechnical engineering recommendations relative to:

- subsurface soil and bedrock conditions
- groundwater conditions
- general earthwork considerations
- excavation/utility construction
- foundations
- floor slabs
- pavements
- site drainage considerations

The conclusions and recommendations contained in this report are based upon the results of field and laboratory testing from past borings drilled at the indicated locations, experience with similar soil conditions, structures and our understanding of the proposed project. As such, the opinions and recommendations presented in this report are intended for preliminary design and planning purposes only and cannot be relied upon for final design.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-2, Boring Location Plan
Proposed development	We understand the project site may be developed for affordable housing.

Item	Description
Building construction	The size, type, number and locations of buildings have not been accurately determined. However, conceptual information indicates buildings could range from 60 to 100-unit apartments, smaller 6 to 12-unit dwellings, four-plex, tri-plex and duplex units along with some possible single-unit dwellings. Buildings will likely be single to 3 to 4-story structures using wood frame construction. Basement construction is not planned for any of the buildings, except possibly for the single-unit structures. Crawl-space construction is not likely for the project.
Foundation loads	Foundation loads were not available at the time of this report. However, considering the size and type of construction, we anticipate relatively light to moderate loads with no unusual loading conditions. Based on our experience with similar projects, we assume the following loads: ■ **Columns/Point Loads**: 50 to 100 kips (assumed) ■ **Wall/Line Loads**: 2 to 4½ klf (assumed)
Grading	Grading plans were not developed at the time of this report; however, we anticipate some mass grading will be needed for site drainage and other development considerations. For purposes of this proposal, we have considered cuts or fills on the order of about 5 feet, or less.
Cut and fill slopes	Assumed to be no steeper than 3H:1V (Horizontal to Vertical)
Infrastructure	Installation of underground utilities and construction and paving of private parking areas and access drive lanes/streets.

Should any of the above information or assumptions be inconsistent with the planned construction, or if we have misunderstood any aspect of the project, we should be contacted as soon as possible to confirm and/or modify our conclusions and preliminary recommendations.

2.2 Site Location and Description

Item	Description
Location	The project site is located at the southwest corner of E. Emma Street and N. 120th Street in Lafayette, Colorado. The property encompasses roughly 24 acres. The general location of the project site is 39.9926° N 105.0737° W.

Item	Description
Existing improvements/site features	The property is currently a vacant parcel of land with no major improvements. The site is bordered on the north by agricultural land, on the east by sparse single-family homes and on the west by the Peak to Peak Charter School campus. Commercial/light industrial development borders the south side and the (former) Burlington Northern railroad tracks form the southwest boundary of the property. Satellite imagery indicates an apparent staging area existed near the southwest corner of the property.
Current ground cover	Current ground cover on most of the site consists of a dense growth of weeds/grasses along with scattered small trees/shrubs.
Existing topography	Based on available aerial imagery and review of the USGS topographic map of the area, the ground surface on the site appears to slope gently down to the east and northeast with an estimated elevation difference of about 10 feet across the property. Surface slopes on most of the site are estimated to be on the order of 1 to 3 percent.
Water features	Significant water features were not observed on or immediately adjacent to the subject site. The most prominent water features in the vicinity of the site include Coal Creek and Rock Creek located about 2,000 to 3,000 feet to the south and east of the property.

3.0 SUBSURFACE CONDITIONS

The geology of the site is presented in the following report section. A summary of subsurface conditions encountered in our borings follows the geology section.

3.1 Geology

The project area is located within the Colorado Piedmont section of the Great Plains physiographic province. The Colorado Piedmont, formed during Late Tertiary and Early Quaternary time (approximately 2,000,000 years ago), is a broad, erosional trench which separates the Southern Rocky Mountains from the High Plains. Structurally, the site lies along the western flank of the Denver Basin. During the Late Mesozoic and Early Cenozoic Periods (approximately 70,000,000 years ago), intense tectonic activity occurred, causing the uplifting of the Front Range and associated down-warping of the Denver Basin to the east. Relatively flat uplands and broad valleys characterize the present-day topography of the Colorado Piedmont in this region.

Surficial geologic conditions at the site, as mapped by the U.S. Geological Survey (USGS) ([1]Machette, 1977), consist of Loess (Ql) of Pleistocene age. These materials have been described as light-gray-brown to light-brown windblown sand, silt and clay. A layer of sand with gravel, probably Broadway Alluvium (Qb), was encountered below the Loess. Bedrock mapped in the vicinity of the project site consists of the Laramie Formation (Kl) of Upper Cretaceous age. The upper part of the Laramie Formation in the area has been described as shale, siltstone, lignitic claystone, and coal, interbedded with finely laminated sandstone. Several subbituminous coal beds, as much as 6 feet thick, are located near the base of the upper part of the formation. Coal has been mined from the Laramie Formation in the Lafayette-Louisville-Broomfield area. Bedrock was encountered in some of the borings at depths ranging from about 32 to 39 feet below existing ground surface. Our field exploration generally confirmed the conditions anticipated from the geologic map.

We reviewed the Boulder County Subsidence Investigation ([2]Dames & Moore, 1986) regarding coal mine subsidence in the area. This study indicates the subject site has not been undermined and is not located within the limits of potential subsidence as defined by this study. However, zones of low to moderate potential for subsidence are located in the vicinity of the project site. Evaluation of risk associated with subsidence at the site is beyond the scope of this report. We suggest an engineer/geologist experienced with subsidence issues be consulted to determine whether other studies should be undertaken and/or further evaluation is warranted.

Due to the gently sloping topography on the property, geologic hazards at the site are anticipated to be low. Seismic activity in the area is anticipated to be low; and from a structural standpoint, the property should be relatively stable. With proper site grading around proposed structures and re-vegetation of stripped areas, erosion problems at the site should be minor.

Mapping completed by the Colorado Geological Survey ([3]Hart, 1972), indicates the site is situated in an area of "Moderate Swell Potential". Potentially expansive materials mapped in this area include bedrock, weathered bedrock and colluvium (surficial units). Site specific swell testing performed indicates the overburden sands and clays have variable engineering properties. Swell testing indicates the sand/clay samples tested have low to high swell potential when wetted. In addition,

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[1] Machette, Michael N., 1977 ***Geologic Map of the Lafayette Quadrangle, Adams, Boulder and Jefferson Counties, Colorado,*** United States Geological Survey, Map GQ-1392.

[2] Dames & Moore, May 6, 1986, ***Final Report, Boulder County Subsidence Investigation.***

[3] Hart, Stephen S., 1972, ***Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado***, Colorado Geological Survey, Environmental Geology No. 7.

some of the overburden soils show low to moderate collapse potential when wetted under constant load and moderate to high compressibility under additional applied load. The claystone/siltstone bedrock is expansive, but is located at depths unlikely to impact planned construction.

Regarding the potential for radioactive substances on the property, it is normal in the Front Range of Colorado and the nearby Eastern Plains area to measure elevated accumulations of radon gas in poorly ventilated spaces that are in contact with soil or bedrock. Radioactive nuclides are common in igneous and metamorphic rock mined for concrete aggregates in this area and in the soils and sedimentary rocks underlying the subject site. Because these sources exist or will exist on most sites in the area, there is a potential for radon gas accumulation in poorly ventilated spaces.

The only method to accurately evaluate radon concentrations in a closed area is to perform radon testing in completed structures. Typical radon mitigation methods can include sealing soil gas entry areas and by periodic ventilation of below grade spaces. We recommend builders make provision for underslab or crawl space ventilation where structures contain below-grade spaces. This may be as simple as providing for ventilation of foundation drain systems.

3.2 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Approximate Depth to Bottom of Stratum	Material Encountered	Consistency or Relative Density/ Hardness	General Engineering Properties
About 4 to 6 inches	Vegetative soil layer	N/A	N/A
About 14 to 32 feet	Intermixed and/or alternating layers of lean clay with varying amounts of sand and silt, clayey sand and silty sand	**Clays:** Stiff to hard **Sands:** Very loose to medium dense	Variable; low to high swell potential, nil to moderate collapse potential when wetted under constant load and low to comparatively high compressibility under additional applied load, low to moderate load bearing capacity

Approximate Depth to Bottom of Stratum	Material Encountered	Consistency or Relative Density/ Hardness	General Engineering Properties
About 32 to 39 feet in borings TB-3, 6, 7, 11, 13 and 14, extended to bottom of other borings	Sand with gravel, varying amounts of silt and clay, occasional lean to fat clay lenses, some cobbles	Loose to dense	Judged to be non-expansive or have only low swell potential, low to moderate load bearing capacity
Extended to bottom of borings TB-3, 6, 7, 11, 13 and 14	Claystone/siltstone bedrock	Medium hard to very hard	Judged to have moderate to high swell potential, high load bearing capacity

Subsurface conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil/bedrock types; in-situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A.

3.3 Laboratory Testing

The laboratory testing program was designed to provide index and/or engineering properties for those soils/bedrock which influence foundation, floor slab and pavement design and performance. The soil/bedrock samples tested for this study have the following physical and/or engineering properties:

Boring No.	Depth (ft.)	Silt or Clay Content (%)	Liquid Limit (%)	Plasticity Index (%)	Expansion/Consolidation (%/Surcharge Load, psf)	Unconfined Compressive Strength (psf)
TB-1	4				-0.5/500	
TB-1	9				-0.1/1000	
TB-1	14					2,020
TB-2	4	34	27	12	-0.5/500	
TB-2	14				+0.4/1000	
TB-3	4				-0.4/500	
TB-3	9	55	29	14	+0.1/500	
TB-3	14					4,340
TB-4	9				-2.8/1000	
TB-4	14				-0.1/1000	
TB-5	9				-0.4/500	
TB-6	4				+2.0/500	
TB-6	9				+1.7/1000	
TB-7	5				-0.9/500	

Boring No.	Depth (ft.)	Silt or Clay Content (%)	Liquid Limit (%)	Plasticity Index (%)	Expansion/Consolidation (%/Surcharge Load, psf)	Unconfined Compressive Strength (psf)
TB-7	9				+1.4/1000	
TB-7	14				-0.3/1000	
TB-8	2				+6.1/250	
TB-8	9				+1.1/1000	
TB-8	14					10,600
TB-9	2				+5.1/250	
TB-9	5					11,800
TB-9	9				-0.4/1000	
TB-9	14					6,600
TB-9	19	8	NP	NP		
TB-10	5				+0.7/500	
TB-10	9				+2.3/1000	
TB-10	14					7,000
TB-11	4					11,900
TB-11	9	79	43	27	+5.5/1000	
TB-11	14				+0.3/1000	
TB-11	19				+0.1/1000	
TB-12	4					9,100
TB-12	9				+4.8/1000	
TB-12	14				+0.1/1000	
TB-13	9				-0.2/500	
TB-13	14				+0.1/1000	
TB-14	4					13,550
TB-14	9				+5.5/500	
TB-14	14					11,400
TB-14	39				+2.9/1000	

NP = Non-Plastic

3.4 Groundwater

Based upon review of U.S. Geological Survey Maps ([4]Hillier, et al, 1983), regional groundwater beneath the project area predominates in colluvial or windblown materials, or in fractured weathered consolidated sedimentary bedrock located at a depth near ground surface. Seasonal variations in groundwater conditions are expected since the aquifer materials may not be

[4]Hillier, Donald E.; Schneider, Paul A., Jr.; and Hutchinson, E. Carter, 1983, ***Depth to Water Table (1979) in the Boulder-Fort Collins-Greeley Area, Front Range Urban Corridor, Colorado***, United States Geological Survey, Map I-855-I.

perennially saturated. Groundwater is generally encountered at depths ranging from 5 to 20 feet below ground surface; depth to seasonal groundwater can be 10 feet or less.

The boreholes were observed while drilling and after completion for the presence and level of groundwater. In addition, delayed water levels were also obtained in the borings. The water levels observed in the boreholes are noted on the attached boring logs, and are summarized below:

Boring Number	Depth to groundwater shortly after drilling, ft.	Depth to groundwater 1 to 2 days after drilling, ft.
TB-1	None encountered	Dry at 19½ (4/3/2003)
TB-2	21	20½ (4/3/2003)
TB-3	22	20½ (4/3/2003)
TB-4	22	19½ (4/3/2003)
TB-5	None encountered	Dry at 19½ (4/3/2003)
TB-6	20	20 (5/23/2008)
TB-7	22	20 (5/23/2008)
TB-8	20	19 (5/23/2008)
TB-9	19	19 (5/23/2008)
TB-10	19	19½ (5/23/2008)
TB-11	19	19 (5/23/2008)
TB-12	19	19 (5/23/2008)
TB-13	19	19 (5/23/2008)
TB-14	19	19½ (5/23/2008)

These observations represent short-term groundwater conditions at the time of and shortly after the field explorations, and may not be indicative of other times, or at other locations. Our experience indicates groundwater levels, for a given year, are typically highest in early summer.

Groundwater levels can and should be expected to fluctuate in response to site development and with varying seasonal and weather conditions, irrigation demands on or adjacent to the site and with fluctuations in nearby water features. Therefore, groundwater levels during construction or at other times in the future may be higher or lower than the levels indicated on the boring logs. Seasonal fluctuations on the order of 3 to 4 feet are not uncommon; greater fluctuations are possible.

Fluctuations in groundwater levels can best be determined by implementation of a groundwater monitoring plan. Such a plan would include installation of groundwater monitoring wells, and periodic measurement of groundwater levels over a sufficient period of time.

4.0 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

4.1 Geotechnical Considerations

Based on geotechnical conditions encountered in our test borings, the site appears suitable for the proposed construction from a geotechnical point of view. No geotechnical constraints were identified which, in our opinion, would preclude development of the site. However, we have identified several geotechnical conditions that will impact design, construction and performance of foundations, floor slabs and other site improvements. These include expansive clays and collapse/settlement-prone clays/sands encountered in the upper part of the soil profile on the site. These conditions will require particular attention in the preliminary design and planning of the project and are discussed in the following sections.

4.1.1 Expansive Soils and Collapse/Settlement-Prone Soils

Review of geologic maps and our boring data indicate the overburden soils on the site are likely wind-blown (loess) deposits. Wind-deposited clays, silts and sands can be prone to collapse and compression when loaded and wetted. In addition, some of the samples have a porous soil structure, low in-place moisture content and low dry density. These properties are normally indicative of collapse/settlement-prone soils. Swell-consolidation tests indicate low to moderate collapse potential when wetted under constant load and moderate to comparatively high compression under additional applied load. In addition, expansive clays are present in the upper part of the soil profile on this site. Based on preliminary data, we believe the majority of the expansive clays and collapse/settlement-prone soils are present within the upper 5 to 12 feet below existing ground surface. The claystone/siltstone bedrock is expansive, but is located at depths (about 32 to 39 feet below existing grade) unlikely to impact planned construction.

The expansive clays and collapse/settlement-prone soils will present a greater than normal risk of excessive differential movement and damage to shallow foundations and floor slabs. Consequently, special design and/or earthwork recommendations (ground modification involving over-excavation, moisture conditioning and recompaction) should be anticipated on this site in order to reduce risk and mitigate the impact of the expansive clays and collapse/settlement-prone soils on the planned construction. Typical mitigation techniques are discussed in other sections of this report.

4.2 General Site Grading/Earthwork

Grading plans were not developed at the time of this report. We anticipate some grading will be needed for site drainage and other development considerations. Based on site topography (relatively uniform and gently sloping) and elevation of surrounding streets, we do not anticipate site grading cuts or fills will exceed about 5 feet. We should be contacted to review preliminary and/or final site grading plans when they become available.

Groundwater was encountered in the test borings at the time of the field explorations at depths of about 19 to 20½ feet below existing grades. Unless deep site grading cuts, deep basements or deep utilities are planned for the project, groundwater is not expected to significantly impact site grading and development of the site.

Subgrade soils exposed at shallow depth are anticipated to be relatively stable upon initial exposure and should not yield or deform excessively during earthwork operations. However, the stability of the subgrade may be affected by precipitation, excessive compaction water, repetitive construction traffic, or other factors.

If unstable or soft ground conditions develop during earthwork activities, some method of soil improvement or stabilization will be needed prior to fill placement and/or foundation, slab and pavement construction. Prior to placing fill or structures on soft and yielding subgrade, we recommend stabilization by either scarifying and drying back wet soil, undercutting weak areas and replacement with select granular fill and possibly geogrid, or by placing a layer of angular rock and crowding it into the subgrade until a firm base is achieved. If large areas require stabilization, chemical treatment of the soils may be a more effective alternative.

The ground surface in area of fill placement and new construction should be stripped of vegetation, organic matter, debris and other unsuitable materials. These materials should be wasted from the site or placed in areas of the development that will never be under structures, pavements, utilities, flatwork and other site improvements. The cleared and stripped ground should be evaluated for general stability prior to fill placement or construction. Although not encountered in our borings, it is possible existing fill may be encountered on the southwest part of the site in the vicinity of the former staging area. Existing fill (if encountered) should not be relied upon for support and should be re-worked (removed, moisture conditioned and recompacted) prior to new fill placement and/or construction.

For permanent slopes in compacted fill or cut areas where saturation of the slopes or seepage will not occur, we suggest slopes of 3:1 (horizontal to vertical), or less to reduce erosion and maintenance problems. Some minor raveling or surface sloughing should be anticipated on slopes constructed at this angle until vegetation is re-established. If saturated or steeper slopes and/or slopes over about 10 feet in height are anticipated, or if structures or other surcharge loads will be located within a distance of the slope height from the crest of the slope, the slopes should be evaluated for stability on an individual basis.

Slopes should be re-vegetated as soon as possible to reduce the potential for erosion problems. Surface drainage should be designed to direct water away from slope faces and to prevent ponding adjacent to slopes.

The on-site soils or approved low volume change import materials can be used for site grading fill. The properties of the fill will affect the performance of foundations, slabs-on-grade and pavements. Full-time observation and testing of engineered fills should be performed by the geotechnical engineer.

The fill should be placed in thin, loose lifts and compacted. Considerable processing such as moisture addition and uniform mixing of dry soils should be anticipated and will be important for fill placement. Fill comprised of the on-site clays and clayey sands should be moisture conditioned between 0 to 3 percent above optimum moisture content, while fill comprised of the on-site sands should be moisture conditioned between 2 percent below to 2 percent above the optimum moisture content. Fill should be compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698). If fill depths exceed about 8 feet, modifications to fill placement and compaction criteria may be needed. Detailed placement and compaction requirements for site grading fill, subgrade preparation and structure backfill can be provided following design-level geotechnical explorations.

4.3 Excavation/Utility Construction

We believe the soils encountered in our exploratory borings can be excavated with conventional, heavy-duty excavation equipment. Groundwater seepage is not expected for excavations on the order of about 15 feet, or less, below existing ground surface. However, if seepage occurs or rain or snow-melt water accumulates in the excavation, it should be removed as soon as possible.

Trench backfill should consist of the on-site soils or approved imported materials. Utility trench backfill should be moisture conditioned as outlined above and compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698). In-place moisture contents of the site soils indicate considerable processing such as moisture addition and uniform mixing of dry soils will be needed for proper backfill placement.

The individual contractor(s) should be made responsible for designing and constructing stable, temporary excavations in order to maintain stability of the excavation sides and bottom as well as any adjacent structures, utilities or pavements. Excavations should be sloped or shored in the interest of safety following local, and federal regulations, including current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. If any excavation, including a utility trench, is extended to a depth of more than 20 feet, it will be necessary to have the side slopes designed by a professional engineer. As a safety measure, it is suggested that vehicles and soil piles be kept to a minimum lateral distance from the crest of the slope equal to no less than the slope height.

The soils to be penetrated by the proposed excavations may vary significantly across the site. The preliminary soil classifications are based solely on the materials encountered in widely

spaced exploratory test borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, we recommend that we be contacted immediately to evaluate the conditions encountered.

4.4 Foundations

Foundation selection will be dependent upon the type of construction planned (i.e. basement, crawl space or slab-on-grade), foundation loading conditions and geometry, building specific geotechnical conditions and final site grading configurations. Additional geotechnical exploration and laboratory testing will be necessary on the site in order to more accurately define swell and/or collapse/settlement potential and to develop specific foundation recommendations and design parameters after final building locations, site grading and type of construction have been determined.

Expansive clays and collapse/settlement-prone soils are present on this site and will present a greater than normal risk of excessive differential movement and damage to shallow foundations. Drilled piers socketed into bedrock are often used for support of structures where moisture-sensitive soils such as those found on this site are present in order to control post-construction foundation movement. However, depth to bedrock on the site would result in pier lengths on the order of about 40 to 45 feet, or more. Furthermore, groundwater conditions and caving sand/gravel indicate the need for temporary casing during pier installation. Constructing long piers and temporary casing would be necessary for this site and would be costly. We believe installation of drilled piers are not practical or cost effective for this project.

Based on preliminary data and the type of construction planned, it appears buildings could be supported on spread footings along with conventional concrete slabs-on-grade or post-tensioned slab-on-ground (PTSOG) foundations bearing on a uniform zone of modified (over-excavated, moisture conditioned and re-compacted) on-site soils provided some movement can be accepted. The ground modification technique involves over-excavation below building footprints to a specified depth or elevation, moisture conditioning the same material and re-working the soil to provide a zone of low swelling and well compacted fill. The success of the ground modification process is highly dependent on the earthwork contractor's experience and procedures. Thorough processing of the soils, addition of significant amounts of water, and proper compaction are required. Full-time observation and testing is required to verify the process is completed properly.

4.4.1 Shallow Foundations

Swell-consolidation testing indicates the overburden sands and clays have variable swell and/or collapse/settlement potential when wetted and these conditions will present a risk of differential movement and damage to shallow foundations. To provide more uniform support and to reduce

soil movements related to the expansive clays and collapse/settlement prone soils, some ground modification below the building footprints should be expected for this site.

Based on preliminary data we believe, spread footings or other shallow foundations, such as post-tensioned slabs-on-ground (PTSOG), bearing on a zone of modified (over-excavated, moisture conditioned and recompacted) on-site soils or approved imported materials could be considered for support of the buildings provided the owner is willing to accept some movement.

The final recommended depth of over-excavation below shallow foundations cannot be precisely determined without more closely spaced borings in each building and additional laboratory testing. Preliminary data suggests over-excavation and recompaction on the order of about 5 to 12 feet, or more, below the existing ground surface may be necessary. We normally recommend the bottom of over-excavated areas extend at least 5 feet, and preferably more, beyond building footprints at the limits of the excavation to ensure foundation elements are constructed over moisture conditioned, compacted fill.

Shallow foundations bearing on an appropriate thickness of modified on-site soils (moisture conditioned and recompacted materials) may be preliminarily evaluated using a maximum allowable soil bearing pressure in the range of 1,500 to 2,500 pounds per square foot (psf). Conventional spread footings (if used) will likely need to be sized to maintain minimum dead-load pressure on the soil.

It should be recognized the over-excavation process will not eliminate swell/settlement and movement potential of the soils at the site. The risk of foundation (and slab) movements can be mitigated but not eliminated by careful design, construction and maintenance procedures. We believe the ground modification process will help control risk of foundation and slab damage and allow construction to proceed with normal risk.

4.5 Floor Slabs

Swell-consolidation tests indicate the clay and sand soils likely to influence floor slab performance have variable engineering properties. Some of the clays are expansive while other clay/sand samples showed collapse/settlement potential when wetted. Based on preliminary data, we estimate heave of up to about 3 inches, or more, due wetting of the expansive clays is possible, while settlement due to collapsible soil of up to about 2 inches is possible. Consequently, ground modification below slabs as discussed in the **Foundations** section of this report should be anticipated on this site in order to reduce movement and enhance performance of floor slabs.

After proper over-excavation/ground modification has been completed below buildings, we believe slab-on-grade floors could be used on the site provided some movement can be accepted. For this site and assuming engineered fill below the building footprints consists of properly

moisture conditioned and compacted on-site soils, we estimate slab movement could be on the order of about 1 inch, or more. For PTSOG construction, the foundations are structurally integral with the floor and should perform better than spread footings and conventional slab-on-grade floors for the soil conditions encountered on the site. If slab movement must be reduced or cannot be accepted, the use of select imported soils could be used below the floor or a structural floor system supported independent of the ground could be considered.

Because of the variability of the engineering properties of the overburden soils on the site, building specific geotechnical explorations should be conducted to more thoroughly define swell and collapse/settlement potential and to evaluate risk associated with slab-on-grade construction.

4.6 Basements

We understand basement construction is not planned for any of the buildings, except possibly for some of the single-unit structures. Crawl-space construction is not likely for the project. Groundwater was measured in the test borings in May of 2008 at depths of about 19 to 20 feet below existing ground surface. Based on the preliminary data, it appears full-depth basement construction could be considered on the site.

Our experience indicates surface water from precipitation, snowmelt and surface irrigation frequently flows through relatively permeable backfill adjacent to the building and collects on the surface of less permeable soils occurring at the bottom of the excavation. To reduce the likelihood water pressure will develop outside foundation walls and the risk of accumulation of water at the basement floor level, installation of perimeter foundation drains will be necessary around all basement areas (if used).

In general, the drain trench and pipe should be constructed around the exterior perimeter of the basement foundation, and sloped at a minimum 1 percent (⅛” drop per foot of drain) to a suitable outlet, such as an underdrain system (if available), a positive gravity outfall or to a sump where water can be removed by pumping. Site specific foundation drainage details can be provided following design level geotechnical explorations.

4.7 Pavements

Assuming only minor cuts are planned for site development, we anticipate clayey sands and sandy clays or site grading fill comprised of these or similar materials will support pavements on the site. Testing and our experience in the area indicates the subgrade soils typically classify as A-6, A-4 and A-2-6 soils according to the American Association of State Highway and Transportation Officials (AASHTO) classification system. Soil classification tests and our experience indicate the near surface soils generally offer fair to poor pavement support.

Preliminary data indicates expansive clays will likely be encountered at or near pavement subgrade on portions of the site and depending upon final grading. Pavements supported directly on expansive soils will move and crack to some degree and could create a maintenance problem and provide poor performance and serviceability. To reduce risk of movement and enhance pavement performance, subgrade modification/swell mitigation should be anticipated on portions of the site. Swell mitigation would likely involve over-excavation, moisture treatment and recompaction of the upper 2 to 3 feet of the expansive subgrades. Chemical treatment of subgrade soils with lime and/or fly ash may also be an acceptable method of swell mitigation. It should be recognized that even if swell mitigation is performed some pavement distress and cracking should be anticipated.

The preliminary pavement thicknesses presented are based on minimum 18-kip equivalent daily load application (EDLA) values of 3 to 5 for car parking areas only and 10 to 15 for truck access and drive lanes. For planning purposes and preliminary cost estimating, we anticipate the pavement section for car parking areas would consist of around 5½ to 6 inches of full-depth asphalt. For truck access/drive lane areas, we anticipate the pavement section would consist of around 6½ to 7½ inches of full-depth asphalt.

A detailed subgrade evaluation and pavement thickness design should be completed during design level geotechnical exploration. The final design will account for actual traffic type and volume and variations in pavement subgrade soils which may occur in cut/fill sections required to bring the site to construction grade and within the actual pavement areas.

4.8 Soluble Sulfate Test Results (Concrete)

Soluble sulfate concentrations were measured for samples of the soil that will likely be in contact with project concrete. The sulfate concentrations measured in the samples varied from 0.020 to 0.12 percent. Sulfate concentrations in the range of 0.1 to less than 0.2 percent indicate Class 1 exposure to sulfate attack for concrete in contact with the subsoils, according to the American Concrete Institute (ACI) *Guide to Durable Concrete*.

Based on preliminary data, it appears concrete should be designed for Class 1 sulfate exposure. ACI recommends the use of Type II cement (or equivalent) and a maximum water-cement ratio of 0.50 for project concrete in contact with the on-site soils. Sulfate exposure should be more thoroughly defined during design-level geotechnical exploration.

4.9 Grading and Drainage

Proper drainage and surface water management is important to the performance of foundations, floor slabs, pavements and other site improvements, regardless of swell potential. The following drainage considerations are considered good practice for any site and should be planned for and implemented where applicable and/or to the extent possible.

Grades must be adjusted to provide positive drainage away from buildings, pavements and other site features during construction and maintained throughout the life of the proposed development. Maintenance of surface drainage is imperative subsequent to construction and becomes the responsibility of the owner.

Landscaped irrigation adjacent to the foundation system and other site improvements should be minimized. Plants placed close to foundation walls should be limited to those with low moisture requirements. The importance of proper irrigation practices cannot be over emphasized. Irrigation should be limited to the minimum amount needed to maintain vegetation; application of more water will increase likelihood of slab, pavement and foundation movements.

Normally, we recommend constructed slopes of about 12 inches in the first 10 feet in landscaped areas around each building, where practical. Between structures or other site improvements which are less than 20 feet apart, the slope should be at least 10 percent to the swale used to convey water out of these areas. The ground surface should be sloped in such a manner that water will not pond between or adjacent to structures, pavements and other site improvements. Drainage swales, open area drains and/or sidewalk chases may also be needed to facilitate drainage.

Planters located adjacent to structure should be self-contained. Sprinkler mains and spray heads should not be installed or allowed to discharge within 5 feet of foundation walls. Roof drains should discharge on pavements or be extended away from the structure well beyond the limits of the backfill zone through the use of splash blocks or downspout extensions. Generally speaking, downspouts should not be buried and extended below grade, as these systems can be difficult to monitor and maintain.

4.10 Recommended Additional Investigations/Engineering Services

Based on the results of this preliminary geotechnical study and our understanding of the proposed development, we recommend the following engineering services be performed:

- Review of preliminary and final site grading plans by our firm to further evaluate possible geotechnical concerns.

- Additional geotechnical exploration on the site (including borings in each building), laboratory testing and preparation of a design-level geotechnical engineering report once final building locations, actual foundation loads and site grading have been established.

- Construction testing and observation during site development and building or pavement construction, including compaction testing of site grading fill, utility trench and structure backfill, pavements and foundation construction observations.

5.0 GENERAL COMMENTS

Terracon should be retained to review preliminary and final design plans and specifications so comments can be made regarding interpretation and implementation of our preliminary geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from widely spaced borings performed at the indicated locations, time and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction, weather or time. The nature and extent of such variations and their impact on development may not become evident until design level explorations are completed or during or after construction. If variations appear, we should be notified so that further evaluation and supplemental recommendations can be provided. The recommendations and information presented in this report are intended for planning and preliminary design purposes only and should not be relied upon for final design. Design-level geotechnical explorations will be required on the site in order to design and construct foundations, floor slabs and pavements.

The scope of services for this report does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as described in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION

Field Exploration Description

Exploratory test borings were previously drilled at the site in April of 2003 and May of 2008. These borings were drilled and sampled to depths of about 20 to 50 feet at the approximate locations shown on the Boring Location Plan, Exhibit A-2. Borings were advanced with a truck-mounted drilling rig, utilizing 4-inch diameter solid stem auger.

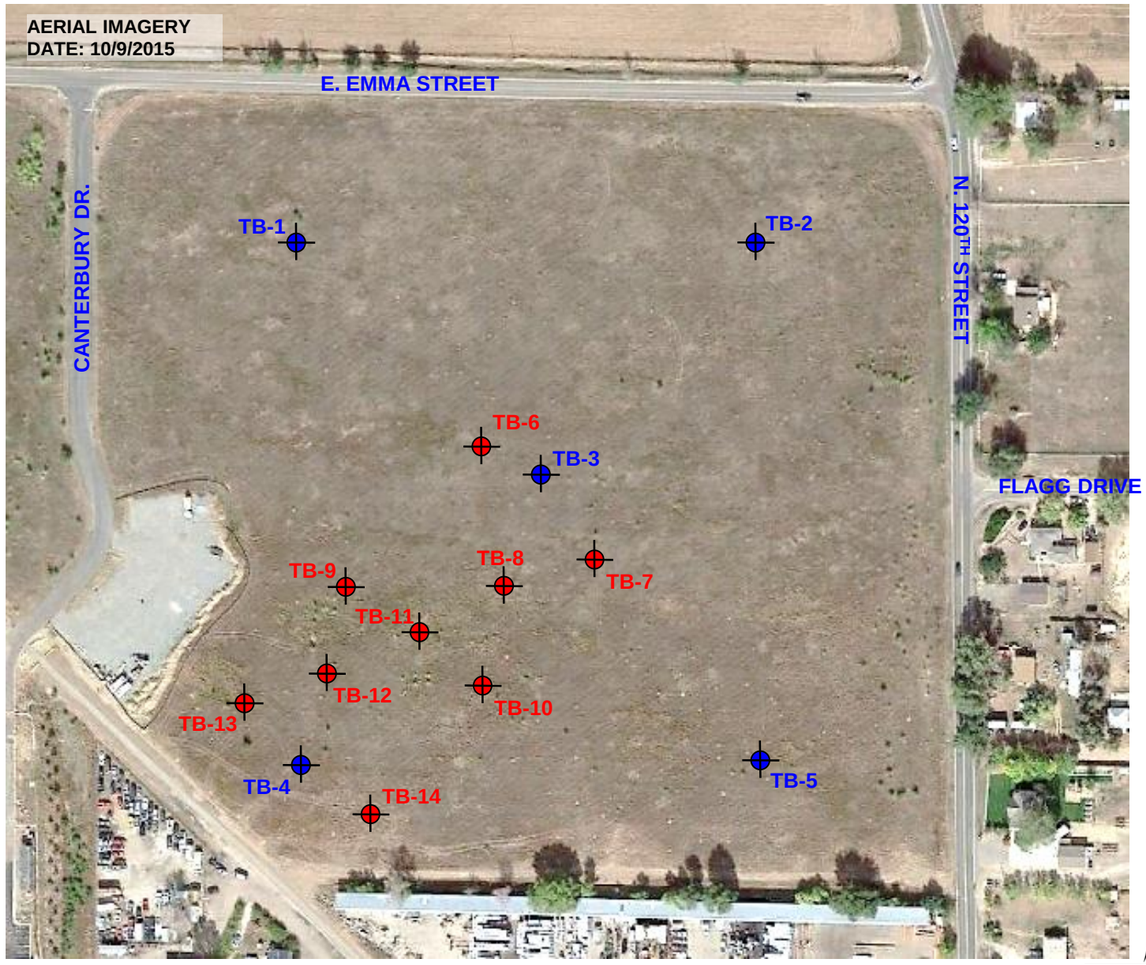
The borings were located in the field by pacing or by measurements with a mechanical surveying wheel using property boundaries and/or existing site features as a reference. Right angles for locating the borings were estimated. Elevations of borings were not surveyed and the logs are drawn to depth. The latitude and longitude coordinates of the boring locations were obtained by locating the borings on Google Earth and recording the values. The accuracy of these coordinates is typically about +/- 25 feet. The accuracy of boring locations should only be assumed to the level implied by the methods used.

A geotechnical engineer recorded lithologic logs of each boring during the drilling operations. At selected intervals, samples of the subsurface materials were taken by means of driving a standard split-spoon or 2.5-inch O.D. modified California barrel sampler. Penetration resistance measurements were obtained by driving the split-spoon or California barrel into the subsurface materials with a 140-pound hammer falling 30 inches. The penetration resistance value, when properly interpreted, is a useful index in estimating the consistency, relative density, or hardness of the materials encountered.

Groundwater levels were recorded in each boring at the time of site exploration and 1 to 2 days after completion of drilling. After the groundwater levels were checked, the borings were backfilled with on-site soils (auger cuttings).

An automatic SPT hammer was used to advance the split-spoon and/or California barrel sampler in borings TB-1 through 5. A conventional safety hammer operated with a cathead and rope was used to advance the sampler in the rest of the borings performed on the site. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between penetration values and soil properties are based on the lower efficiency cathead and rope method. This higher efficiency affects the penetration resistance blow count value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

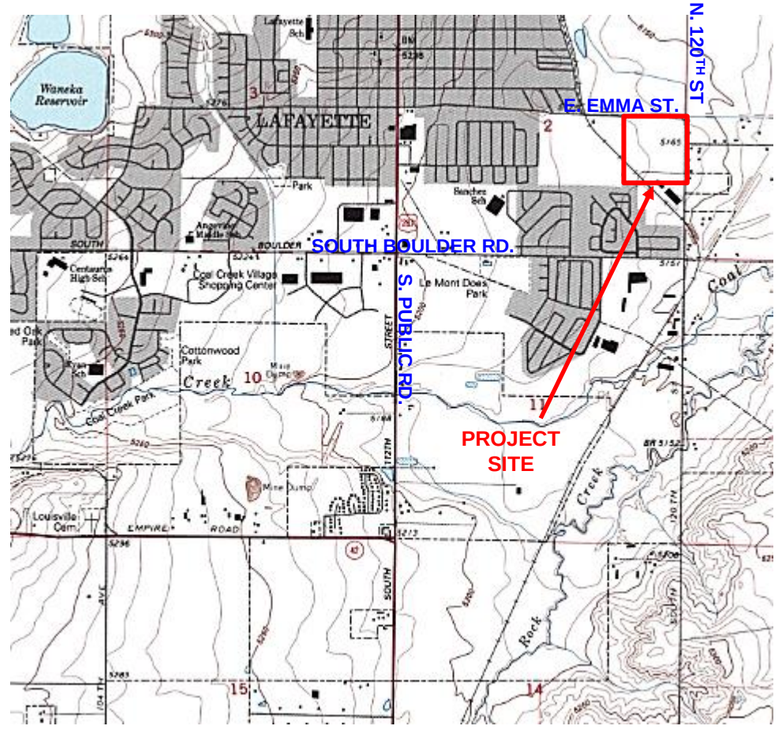
The penetration test provides a reasonable indication of the in-place density of sandy type materials, but only provides an indication of the relative stiffness of cohesive materials since the blow count in these soils may be affected by the soils moisture content. In addition, considerable care should be exercised in interpreting the penetration values in gravelly soils, particularly where the size of the gravel particle exceeds the inside diameter of the sampler.



N

0’ 100’ 200’

APPROX. GRAPHIC SCALE



VICINITY MAP
N.T.S.

LEGEND:

- APPROXIMATE LOCATION OF TEST BORING DRILLED ON MAY 21 & 22, 2008
- APPROXIMATE LOCATION OF TEST BORING DRILLED ON APRIL 2, 2003

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager:	ESW
Drawn by:	GMM
Checked by:	ESW
Approved by:	ESW

Project No.	22175065
Scale:	1” = 200’ +/-
File Name:	22175065 BLP
Date:	6/23/2017

Terracon
Consulting Engineers & Scientists
1242 Bramwood Place Longmont, Colorado 80501
PH. (303) 776-3921 FAX. (303) 776-4041

BORING LOCATION PLAN

BCHA LAFAYETTE PROPERTY – AFFORDABLE HOUSING
BOULDER COUNTY HOUSING AUTHORITY
SW CORNER OF E. EMMA STREET AND N. 120TH STREET
LAFAYETTE, COLORADO

EXHIBIT

A-2

BORING LOG NO. TB-1

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, red brown, stiff/medium dense, calcareous, porous soil structure	5			18/12"	-0.5/500		6	95		
	7.0 **SANDY LEAN CLAY (CL)**, brown, beige, orange brown, stiff, slightly calcareous, with SILTY SAND layers	10			11/12"	-0.1/1000		13	113		
		15			11/12"		2020	16	106		
	18.0 **SILTY to CLAYEY SAND with GRAVEL (SC, SM, SC-SM)**, brown, orange brown, red brown, medium dense, fine to medium grained	20			21/12"			6			
	20.0 ***Boring Terminated at 20 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 4/3/2003

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling

Dry at 19.5 feet when checked on 4/3/2003

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 4/2/2003	Boring Completed: 4/2/2003
Drill Rig: Mobile B-57	Driller: KING
Project No.: 22175065	Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-2

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, red brown, stiff/loose, calcareous, porous soil structure	5			14/12"	-0.5/500		7	98	27-15-12	34
	8.0 **SANDY LEAN CLAY (CL)**, brown, olive brown, stiff, with SILTY SAND layers	10			13/12"			9	108		
	15.0 **SILTY to CLAYEY SAND with GRAVEL (SC, SM, SC-SM)**, beige, orange brown, red brown, medium dense, fine to coarse grained, occasional COBBLES	15			15/12"	+0.4/1000		15	115		
		20	▽		34/12"			5			
		25			25/12"			10			
	35.0 ***Boring Terminated at 35 Feet***	30									
		35									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 4/3/2003

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *21 feet after completion of drilling*

▽ *20.5 feet when checked on 4/3/2003*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 4/2/2003 | Boring Completed: 4/2/2003

Drill Rig: Mobile B-57 | Driller: KING

Project No.: 22175065 | Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-3

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, orange brown, beige, red brown, stiff/medium dense, calcareous, porous soil structure										
	6.0 **SANDY LEAN CLAY (CL)**, silty, red brown, beige, rust, grey, stiff to very stiff, trace fine GRAVEL with depth	5			18/12"	-0.4/500		8	99		
		10			18/12"	+0.1/500		7	106	29-15-14	55
		15			14/12"		4340	14	112		
	17.0 **SILTY to CLAYEY SAND with GRAVEL (SC, SM, SC-SM)**, brown, orange brown, red brown, medium dense, fine to medium grained, occasional COBBLES	20	▽		16/12"			10			
	24.5 **LEAN to FAT CLAY with SAND (CL/CH)**, mottled olive-grey, rust, stiff.	25	▽		12/12"			21			
	26.5 **SILTY to CLAYEY SAND with GRAVEL (SC, SM, SC-SM)**, brown, orange brown, red brown, fine to coarse grained, occasional COBBLES	30									
		35									
	37.0 **CLAYSTONE/SILTSTONE/SANDSTONE**, interbedded, grey, rust, olive-brown	40									
	40.0 ***Boring Terminated at 40 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 4/3/2003

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *22 feet after completion of drilling*

▽ *20.5 feet when checked on 4/3/2003*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 4/2/2003	Boring Completed: 4/2/2003
Drill Rig: Mobile B-57	Driller: KING
Project No.: 22175065	Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-4

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SILTY to CLAYEY SAND (SC/SM), interlayered, brown, red brown, very loose, fine grained	5			4/12"			5			
	7.0 **SILTY, CLAYEY SAND (SC-SM)**, brown, light brown, medium dense, fine grained	10			16/12"	-2.8/1000		4	102		
	12.0 **SANDY LEAN CLAY (CL)**, brown, beige, rust brown, stiff, with SILTY SAND layers	15			11/12"	-0.1/1000		16	110		
	19.0 **SILTY to CLAYEY SAND (SC, SM, SC-SM)**, trace GRAVEL, brown, rust, grey, loose, fine to medium grained	20	▽		10/12"			16			
	21.0 **SAND with SILT and GRAVEL (SP-SM, SW-SM)**, brown, red brown, dense, fine to coarse grained, occasional CLAY lenses, trace COBBLES, poorly to well graded		▽								
	25.0 ***Boring Terminated at 25 Feet***	25			31/12"			10			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 4/3/2003

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *22 feet after completion of drilling*

▽ *19.5 feet when checked on 4/3/2003*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 4/2/2003	Boring Completed: 4/2/2003
Drill Rig: Mobile B-57	Driller: KING
Project No.: 22175065	Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-5

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, red brown, stiff/medium dense, calcareous, porous soil structure	5			18/12"			8	93		
	7.0 **SILTY to CLAYEY SAND (SC/SM)**, interlayered, brown, red brown, beige, medium dense, fine grained, with SANDY CLAY lenses	10			21/12"	-0.4/500		5	107		
	14.0 **SILTY to CLAYEY SAND with GRAVEL (SC, SM, SC-SM)**, brown, orange brown, red brown, medium dense to loose, fine to medium grained, intermittent CLAY lenses	15			21/12"			6			
	20.0 ***Boring Terminated at 20 Feet***	20			11/12"			18			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 4/3/2003

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling

Dry at 19.5 feet when checked on 4/3/2003

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 4/2/2003 | Boring Completed: 4/2/2003

Drill Rig: Mobile B-57 | Driller: KING

Project No.: 22175065 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-6

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, hard/medium dense, calcareous	5			43/12"	+2.0/500		8	111		
		10			45/12"	+1.7/1000		9	114		
	12.0 **SILTY SAND and SILTY, CLAYEY SAND (SM, SC-SM)**, interlayered, brown, rust, beige, tan, medium dense, fine to medium grained	15			37/12"			5	107		
	17.0 **SANDY LEAN CLAY to CLAYEY SAND (CL, SC)**, brown, beige, rust, very stiff/medium dense, fine to medium grained, occasional GRAVEL, with SILTY SAND lenses	20	▽		20/12"			22	105		
	22.0 **SAND with SILT and GRAVEL (SP-SM)**, rust, brown, beige, medium dense to dense, fine to coarse grained, poorly graded, occasional COBBLES	25			34/12"						
		30			50/9"			7			
		35									
	38.0 **CLAYSTONE/SILTSTONE**, grey, rust, olive-brown, beige, very hard	40			50/6"						
		45			50/2"						
	50.0	50			30/0"						
	Boring Terminated at 50 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *20 feet after completion of drilling*

▽ *20 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/21/2008	Boring Completed: 5/21/2008
Drill Rig: Deidrich D-55	Driller: DAKOTA
Project No.: 22175065	Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-7

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, tan, stiff to very stiff/loose to medium dense, calcareous				12/12"			9			
		5			26/12"	-0.9/500		4	105		
		10			18/12"	+1.4/1000		10	112		
	12.0 **SILTY SAND (SM)**, brown, rust, beige, tan, medium dense, fine to medium grained										
		15			32/12"	-0.3/1000		10	112		
	19.0 **SILTY SAND with GRAVEL (SM)**, brown, rust, beige, olive-brown, dense, fine to medium grained	20	▽		50/8"			5			
	24.0 **SAND with SILT and GRAVEL (SP-SM)**, rust, brown, beige, grey, loose to medium dense, fine to coarse grained, poorly graded, with CLAY lenses	25			9/12"						
		30			29/12"			12			
		35			35/12"			14			
	39.0 **CLAYSTONE/SILTSTONE**, grey, rust, olive-brown, beige, very hard	40			50/5"						
		45			50/3"						
	50.0	50			50/2"						
	Boring Terminated at 50 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *22 feet after completion of drilling*

▽ *20 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/21/2008	Boring Completed: 5/21/2008
Drill Rig: Deidrich D-55	Driller: DAKOTA
Project No.: 22175065	Exhibit: A-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-8

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, tan, very stiff/medium dense, calcareous				26/12"	+6.1/250		9	120		
		5			22/12"			7	112		
	7.0 **SANDY LEAN CLAY (CL)**, brown, rust, grey, very stiff to hard, with SILTY SAND layers, varies to LEAN CLAY with SAND				25/12"	+1.1/1000		7	129		
		10									
					26/12"		10600	20	110		
		15									
	18.0 **SAND with SILT and GRAVEL (SP-SM)**, rust, brown, beige, grey, medium dense, fine to coarse grained, poorly graded, with CLAY lenses				26/12"			15	115		
		20									
					16/12"			23			
		25									
	30.0 ***Boring Terminated at 30 Feet***	30			22/12"			21			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

20 feet after completion of drilling

19 feet when checked on 5/23/2008

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/22/2008	Boring Completed: 5/22/2008
Drill Rig: Deidrich D-55	Driller: DAKOTA
Project No.: 22175065	Exhibit: A-10

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-9

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, very stiff to hard/medium dense, calcareous				29/12"	+5.1/250		9	121		
		5			31/12"		11800	5	109		
					42/12"	-0.4/1000		5	108		
	11.0 **LEAN CLAY with SAND (CL)**, brown, grey, rust, very stiff	10									
	15.0				29/12"		6600	18	107		
	17.0 **SILTY SAND (SM)**, rust, brown, beige, grey, fine to coarse grained, with CLAY lenses	15									
	SAND with SILT and GRAVEL (SP-SM), rust, brown, beige, grey, medium dense to dense, fine to coarse grained, poorly graded, with CLAY lenses		▽		47/12"			10		NP	8
		20									
					50/11"						
		25									
	30.0										
	Boring Terminated at 30 Feet	30			27/12"			18			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19 feet after completion of drilling*

▽ *19 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/22/2008	Boring Completed: 5/22/2008
Drill Rig: Deidrich D-55	Driller: DAKOTA
Project No.: 22175065	Exhibit: A-11

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-10

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, stiff to very stiff/medium dense, calcareous				29/12"			10	114		
		5			18/12"	+0.7/500		6	116		
	8.0 **LEAN CLAY with SAND (CL)**, brown, beige, rust, hard, slightly calcareous	10			40/12"	+2.3/1000		12	122		
	12.0 **SANDY LEAN CLAY (CL)**, brown, rust, olive-brown, very stiff, with SILTY SAND layers, trace GRAVEL	15			22/12"		7000	13	120		
		20	▽		22/12"			15	115		
	23.0 **LEAN to FAT CLAY with SAND (CL/CH)**, mottled olive-grey, rust, brown, stiff.										
	25.0 **SILTY SAND (SM)**, trace GRAVEL, brown, rust, beige, grey, loose, with CLAY lenses.	25			14/12"						
	30.0 ***Boring Terminated at 30 Feet***	30			9/12"						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19 feet after completion of drilling*

▽ *19.5 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/22/2008	Boring Completed: 5/22/2008
Drill Rig: Deidrich D-55	Driller: DAKOTA
Project No.: 22175065	Exhibit: A-12

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-11

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, tan, very stiff to hard/medium dense, calcareous, slightly porous	5			22/12"		11900	13	96		
	7.0 **LEAN CLAY with SAND (CL)**, brown, beige, rust, very stiff to hard	10			40/12"	+5.5/1000		12	120	43-16-27	79
		15			28/12"	+0.3/1000		15	117		
	16.0 **SANDY LEAN CLAY to CLAYEY SAND (CL, SC)**, interlayered, brown, beige, rust, grey, stiff to very stiff/loose to medium dense, with SILTY SAND lenses and GRAVEL	20	▽		22/12"	+0.1/1000		20	111		
		25			15/12"						
		30			11/12"						
	32.0 **CLAYSTONE/SILTSTONE**, grey, rust, olive-brown, beige, medium hard to very hard	35			50/11"						
		40			50/1"						
		45			50/2"						
	50.0	50			50/2"						
	Boring Terminated at 50 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19 feet after completion of drilling*

▽ *19 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/21/2008 | Boring Completed: 5/21/2008

Drill Rig: Deidrich D-55 | Driller: DAKOTA

Project No.: 22175065 | Exhibit: A-13

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-12

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, very stiff to hard/medium dense, calcareous	5			20/12"		9100	8	110		
	7.0 **SANDY LEAN CLAY (CL)**, brown, rust, grey, very stiff, with SILTY SAND layers	10			35/12"	+4.8/1000		13	124		
		15			23/12"	+0.1/1000		11	115		
	17.0 **SILTY SAND (SM)**, trace GRAVEL, rust, brown, beige, grey, medium dense, varies to SILTY, CLAYEY SAND, fine to medium grained	20	▽		36/12"			20	108		
	22.0 **SAND with SILT and GRAVEL (SP-SM)**, rust, brown, beige, grey, medium dense, fine to coarse grained, poorly graded, with CLAY lenses	25			26/12"			21			
	30.0 ***Boring Terminated at 30 Feet***	30			26/12"			21			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19 feet after completion of drilling*

▽ *19 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/22/2008 | Boring Completed: 5/22/2008

Drill Rig: Deidrich D-55 | Driller: DAKOTA

Project No.: 22175065 | Exhibit: A-14

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-13

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, very stiff/medium dense, calcareous	5			25/12"			6	104		
		10			30/12"	-0.2/500		5	113		
	11.0 **SANDY LEAN CLAY (CL)**, brown, rust, olive-brown, stiff, with SILTY SAND layers	15			16/12"	+0.1/1000		17	113		
		20	▽		14/12"			23			
	22.0 **SAND with SILT and GRAVEL (SP-SM)**, rust, brown, beige, grey, medium dense, fine to coarse grained, poorly graded, with SILTY SAND lenses	25			30/12"						
		30									
	32.0 **CLAYSTONE/SILTSTONE**, grey, rust, olive-brown, beige, very hard	35			50/2"			15			
		40			50/2"						
	45.0 ***Boring Terminated at 45 Feet***	45			30/0"						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19 feet after completion of drilling*

▽ *19 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/21/2008	Boring Completed: 5/21/2008
Drill Rig: Deidrich D-55	Driller: DAKOTA
Project No.: 22175065	Exhibit: A-15

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

BORING LOG NO. TB-14

PROJECT: BCHA Lafayette Property - Affordable Housing

CLIENT: Boulder County Housing Authority
Boulder, CO

SITE: SW Corner of E. Emma St. & N. 120th St.
Lafayette, Colorado

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **VEGETATIVE SOIL LAYER**, CLAYEY soil with light vegetation and root penetration										
	SANDY LEAN CLAY to CLAYEY SAND (CL/SC), interlayered, brown, beige, rust, very stiff to hard/medium dense, calcareous										
	8.0				20/12"		13550	7	109		
	LEAN CLAY with SAND (CL), brown, beige, rust, very stiff to hard, slightly calcareous	5									
					46/12"	+5.5/500		11	124		
		10									
					32/12"		11400	20	107		
	17.0	15									
	SILTY to CLAYEY SAND (SM, SC-SM), beige, grey, medium dense, fine to medium grained		▽								
		20			22/12"			20	109		
	23.0										
	SAND with SILT and GRAVEL (SP-SM), rust, brown, beige, medium dense, fine to coarse grained, poorly graded, with CLAY lenses	25			25/12"						
	28.0										
	LEAN to FAT CLAY with SAND (CL/CH), mottled olive-grey, rust, brown, very stiff, trace fine GRAVEL.	30			29/12"						
	32.0										
	SAND with SILT and GRAVEL (SP-SM), rust, brown, beige, medium dense, fine to coarse grained, poorly graded	35			30/12"			12			
	38.0										
	CLAYSTONE/SILTSTONE, grey, rust, olive-brown, beige, very hard	40			50/4"	+2.9/1000		16	116		
		45			50/2"						
	50.0	50			50/2"						
	Boring Terminated at 50 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
4-inch diameter solid flight auger

Abandonment Method:
Boring backfilled with soil cuttings after groundwater measurement on 5/23/2008

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19 feet after completion of drilling*

▽ *19.5 feet when checked on 5/23/2008*

Terracon
1242 Bramwood Pl
Longmont, CO

Boring Started: 5/21/2008	Boring Completed: 5/21/2008
Drill Rig: Deidrich D-55	Driller: DAKOTA
Project No.: 22175065	Exhibit: A-16

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 22175065 BCHA LAFAYETTE PR.GPJ TERRACON_DATATEMPLATE.GDT 7/5/17

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field explorations were returned to the laboratory for observation by the project geotechnical engineer and were visually classified in general accordance with the Unified Soil Classification System described in Appendix C. Samples of bedrock were classified in accordance with the general notes for Rock Classification.

After sample review by the project engineer, an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Following completion of the laboratory testing, the field and visual descriptions were confirmed or modified as necessary, and Logs of Borings were prepared. These logs are presented in Appendix A.

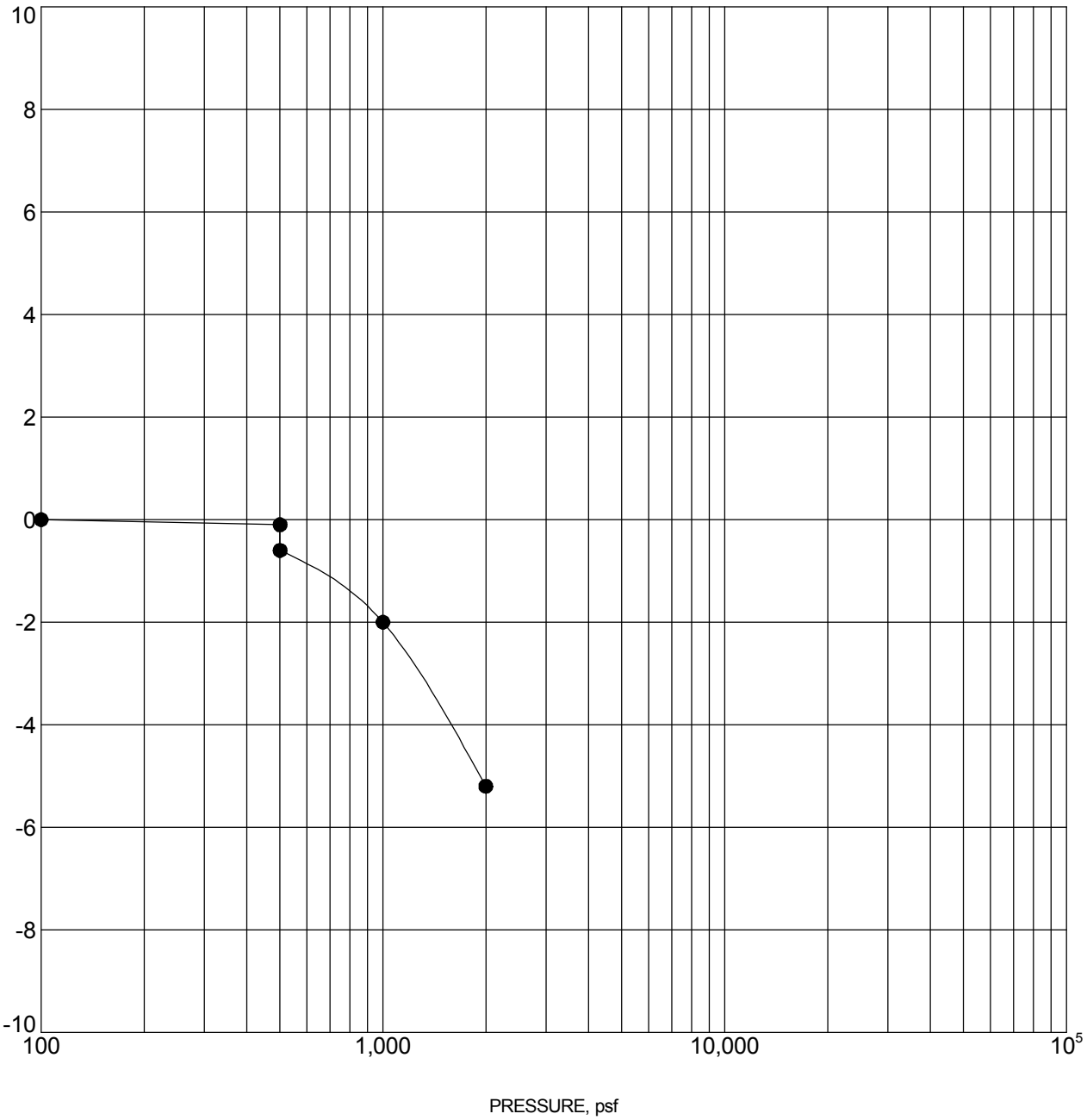
Selected samples were tested for the following physical and/or engineering properties:

- Water Content
- Dry Unit Weight
- Unconfined Compressive Strength
- Swell-Consolidation Potential
- Atterberg Limits
- Percent Fines/Grain Size
- Water Soluble Sulfate Content

Laboratory test results are indicated on the boring logs included in Appendix A and presented in depth in Appendix B. The test results were used for the geotechnical engineering evaluation and the development of preliminary recommendations for project planning. Laboratory tests were performed in general accordance with applicable local standards or other accepted standards. Procedural standards noted in this report are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. Classification was by visual-manual procedures. Selected samples were further classified using the results of Atterberg limit testing. The Atterberg limit test results are also provided in Appendix B.

SWELL CONSOLIDATION TEST



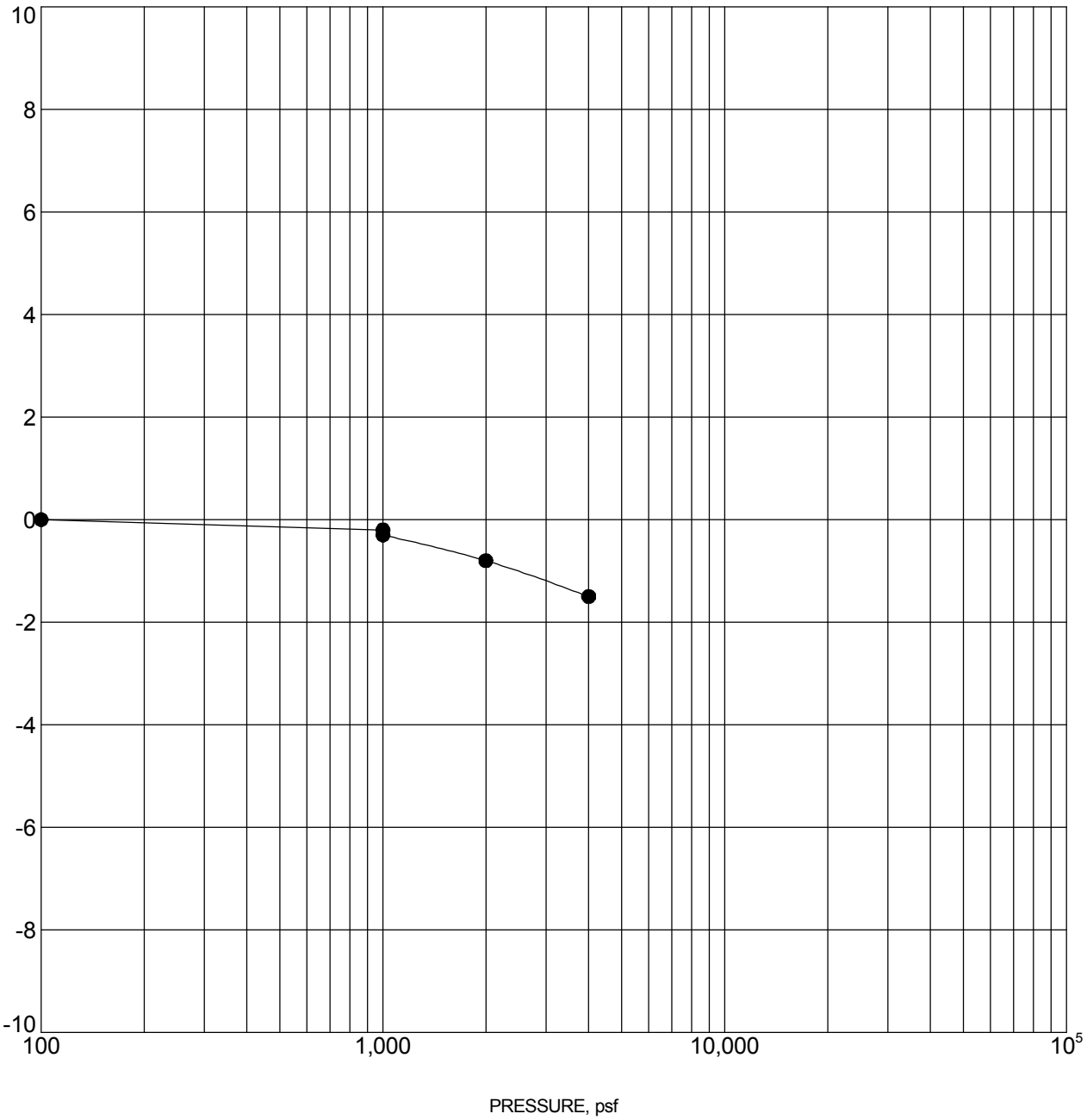
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-1	4 - 5 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	95	6

NOTES: Sample exhibited 0.5 percent compression upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-1	9 - 10 ft	SANDY LEAN CLAY (CL)	113	13

NOTES: Sample exhibited 0.1 percent compression upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

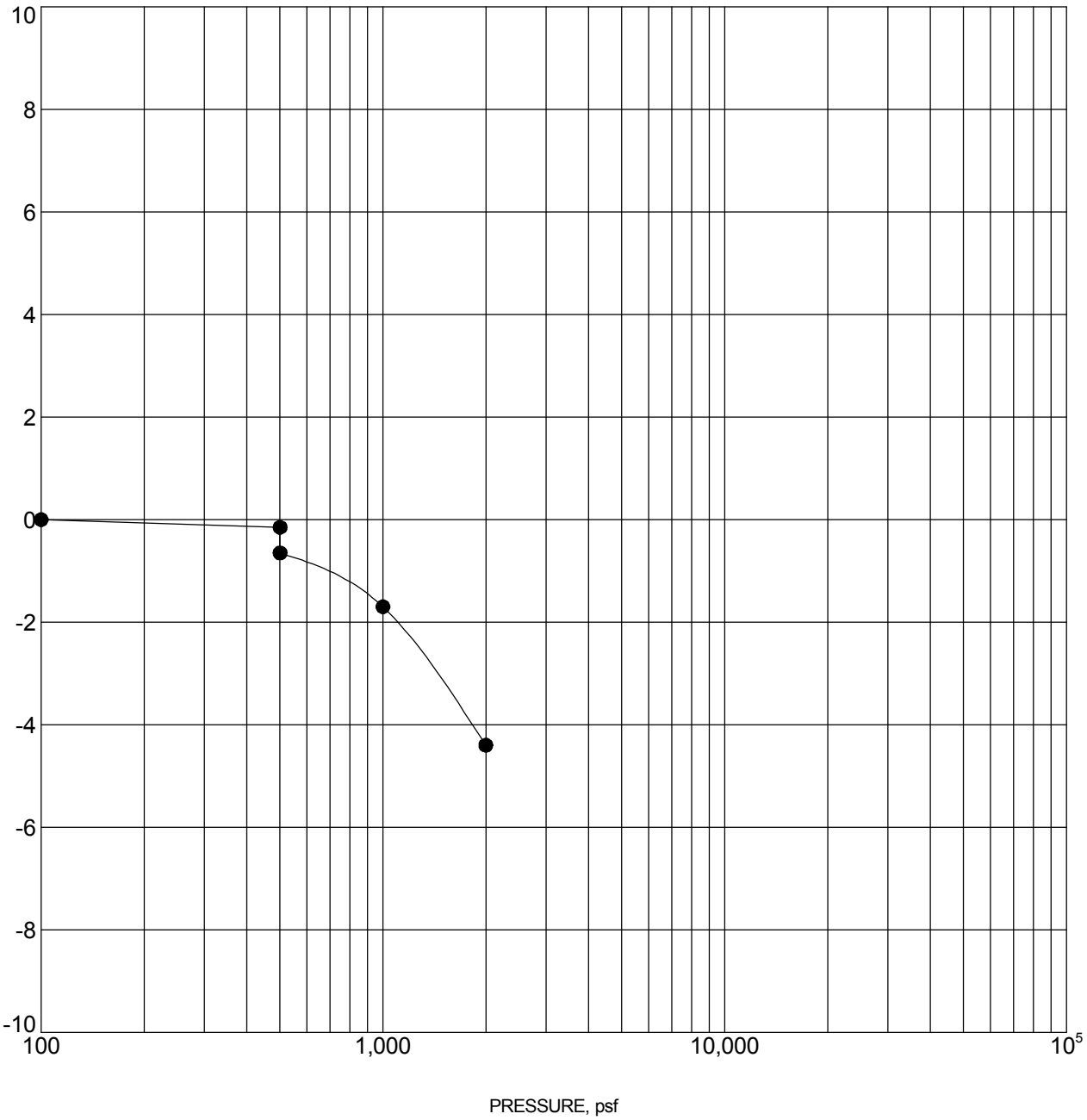
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



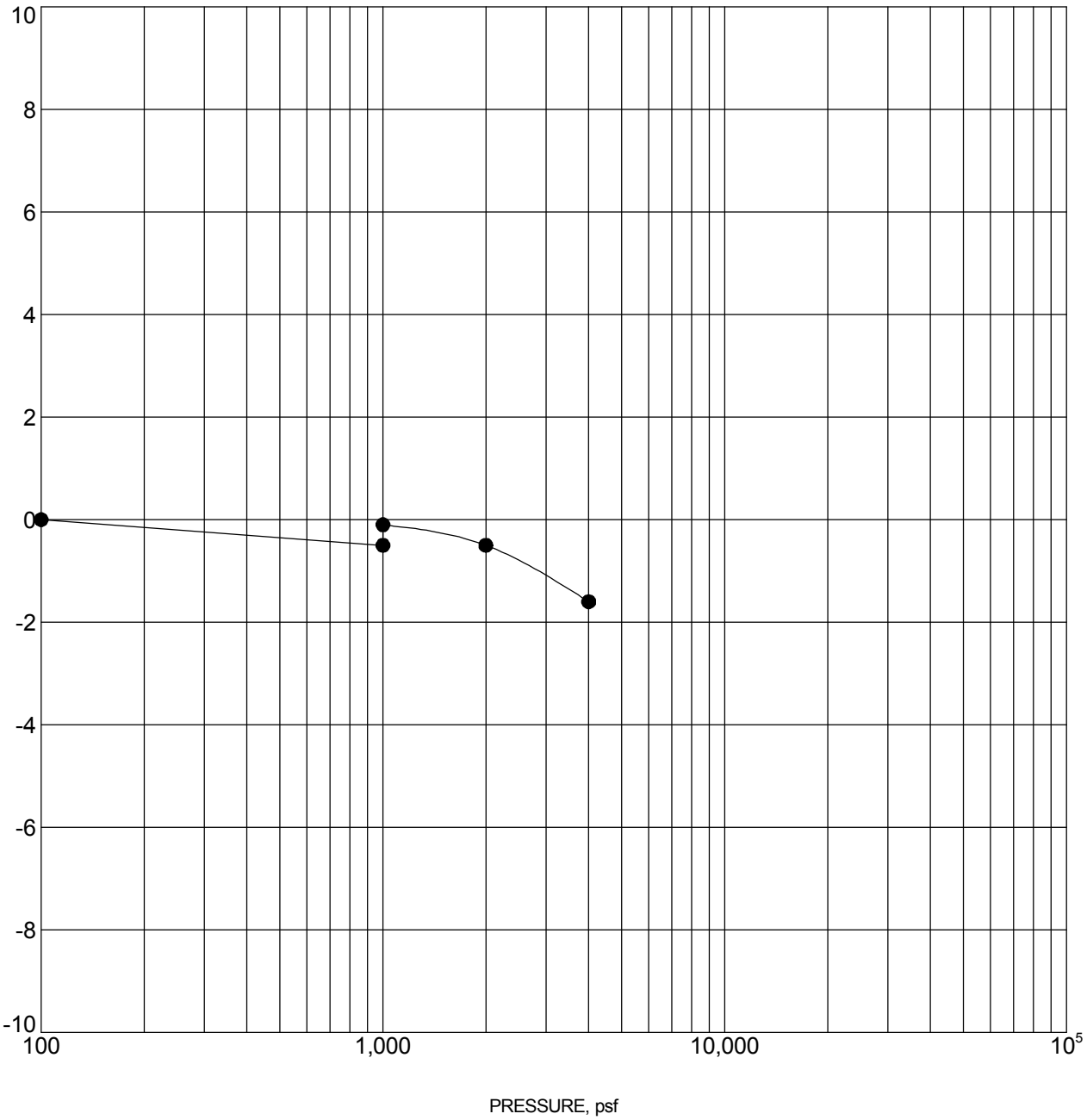
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-2	4 - 5 ft	CLAYEY SAND(SC)	98	7

NOTES: Sample exhibited 0.5 percent compression upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-4

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
● TB-2	14 - 15 ft	SANDY LEAN CLAY (CL)	115	15

NOTES: Sample exhibited 0.4 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

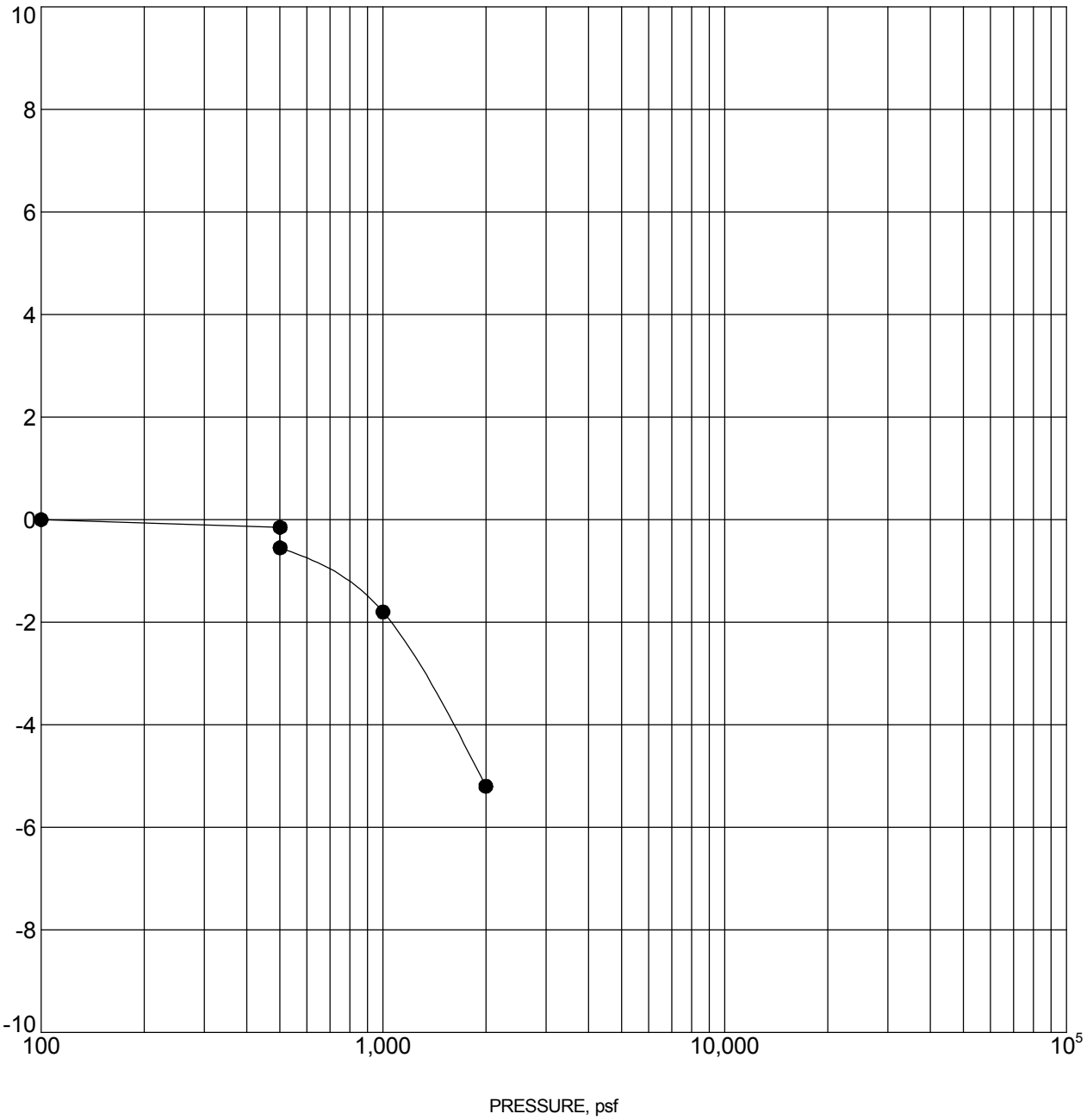
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-5

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



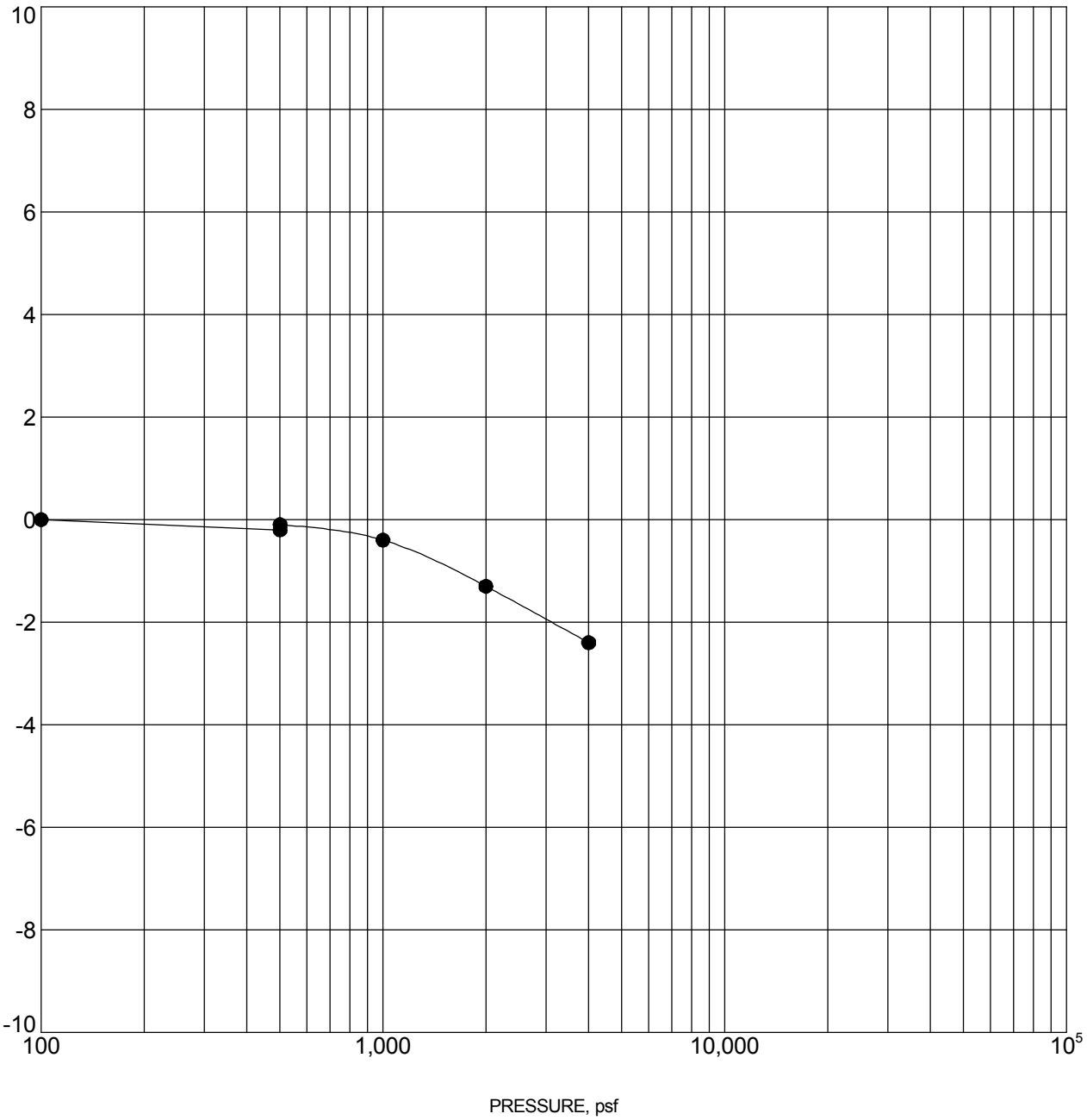
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-3	4 - 5 ft	SANDY LEAN CLAY (CL)	99	8

NOTES: Sample exhibited 0.4 percent compression upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-6

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-3	9 - 10 ft	SANDY LEAN CLAY(CL)	106	7

NOTES: Sample exhibited 0.1 percent expansion upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

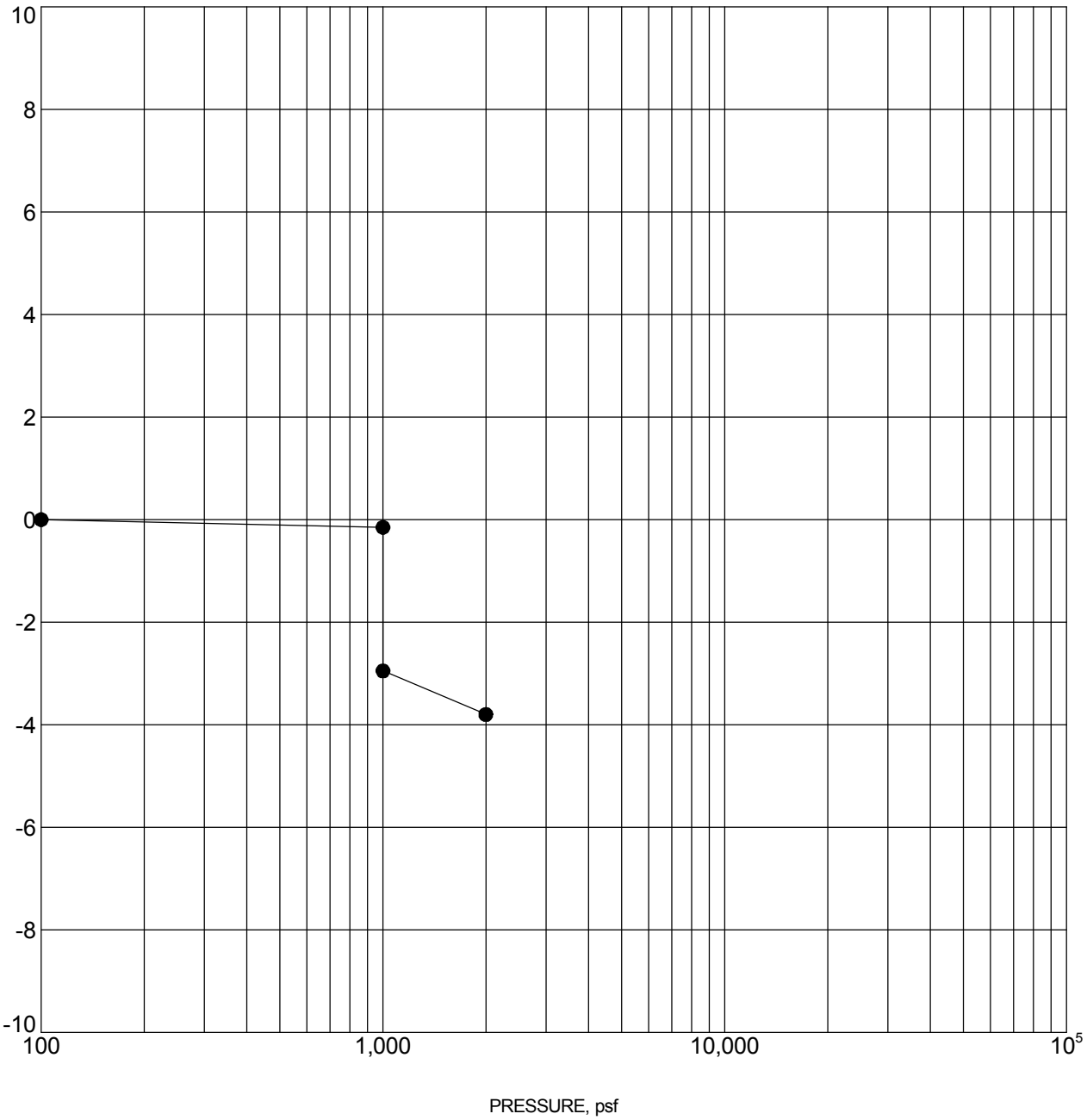
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-7

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



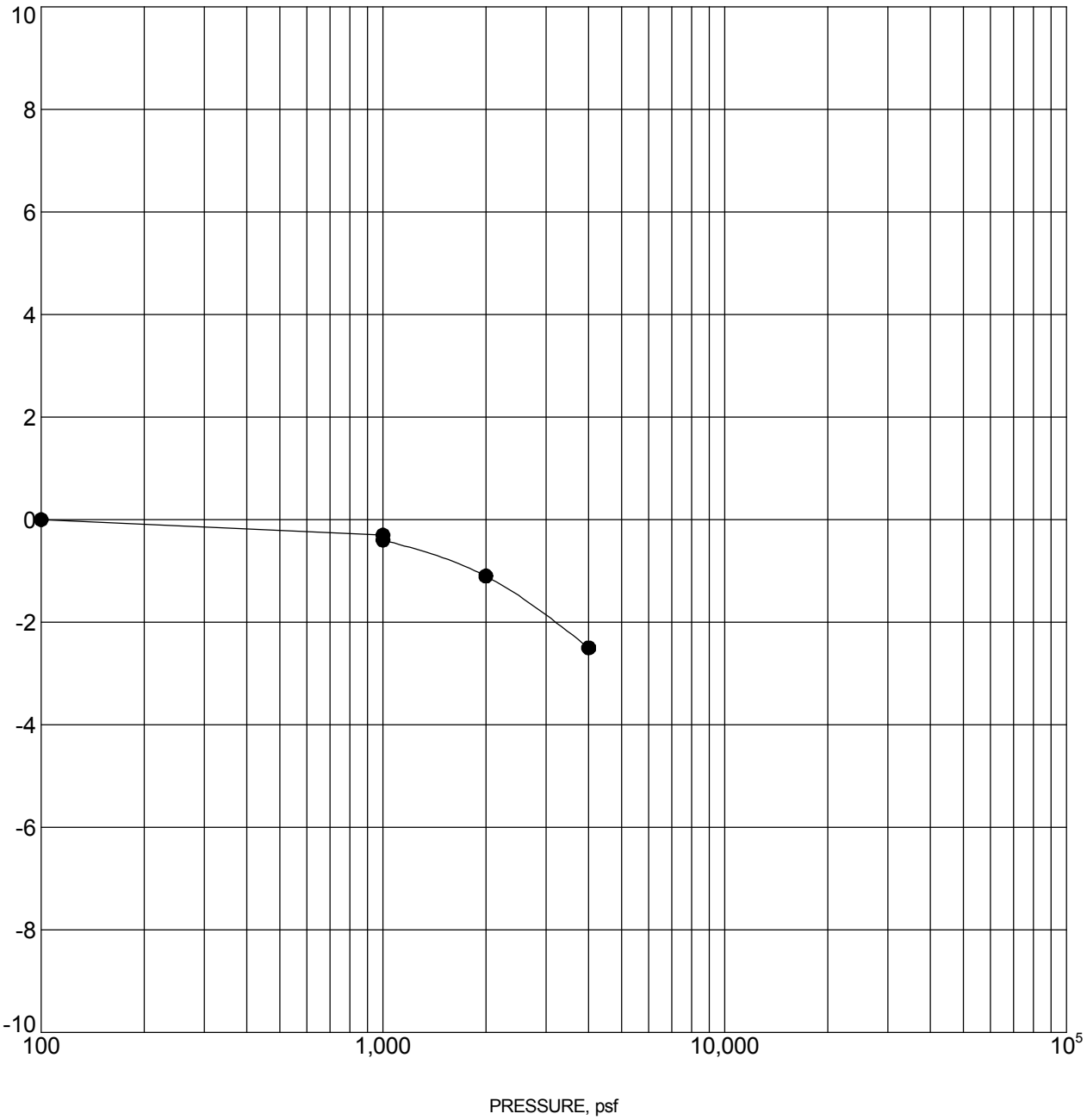
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-4	9 - 10 ft	SILTY to CLAYEY SAND (SC/SM)	102	4

NOTES: Sample exhibited 2.8 percent compression upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-8

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



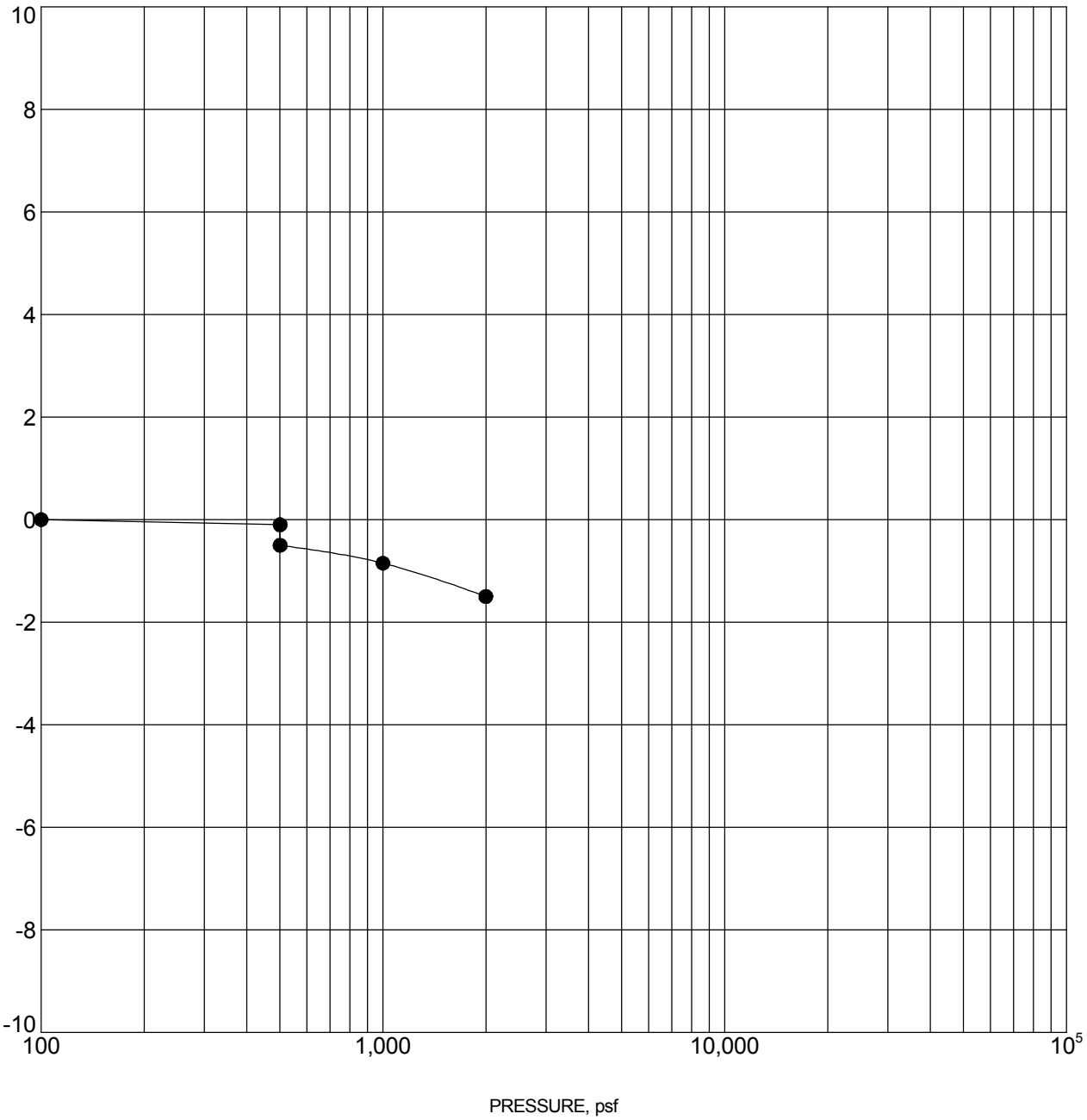
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-4	14 - 15 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	110	16

NOTES: Sample exhibited 0.1 percent compression upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-9

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



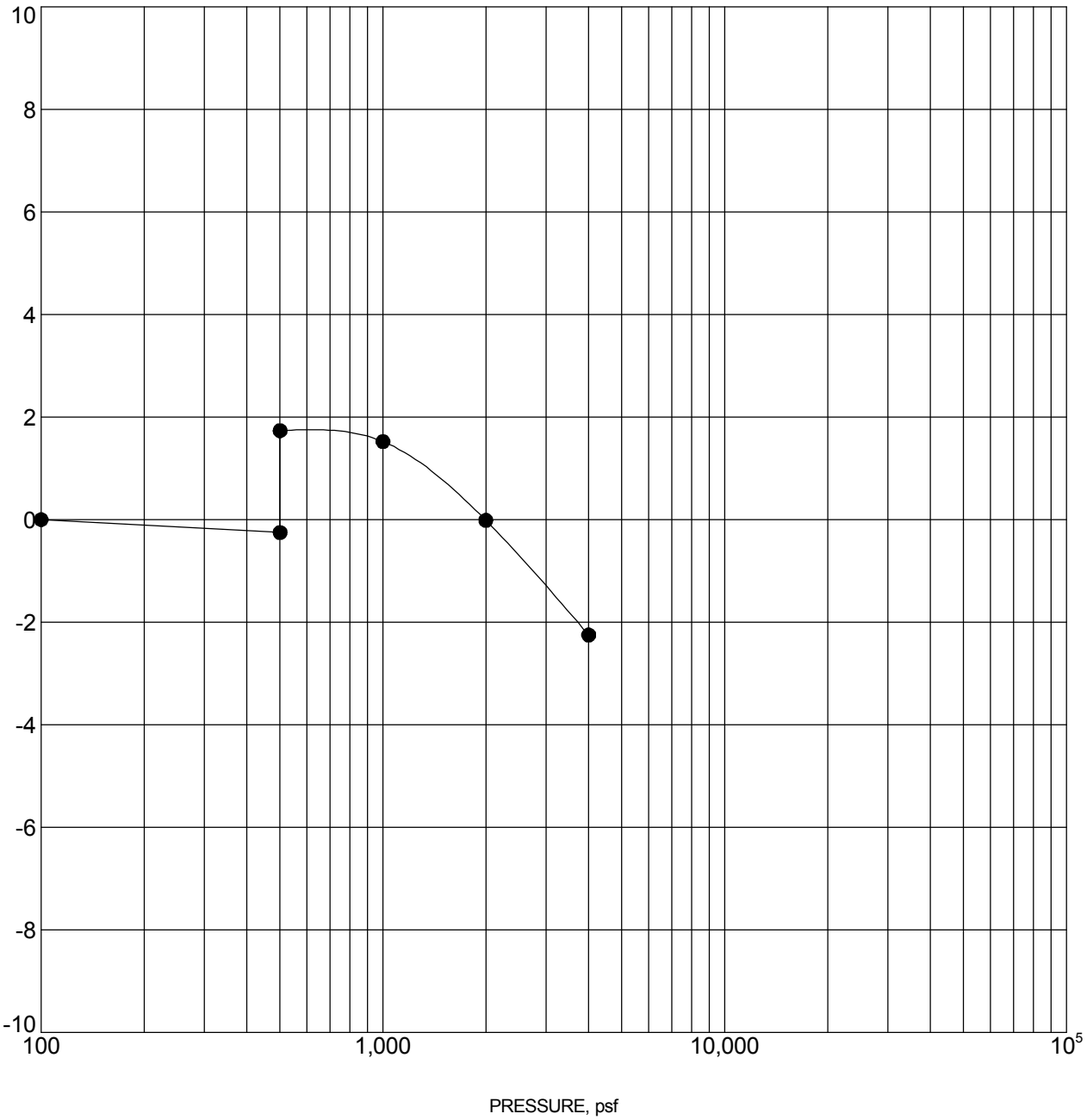
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-5	9 - 10 ft	SILTY, CLAYEY SAND (SC-SM)	107	5

NOTES: Sample exhibited 0.4 percent compression upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-10

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



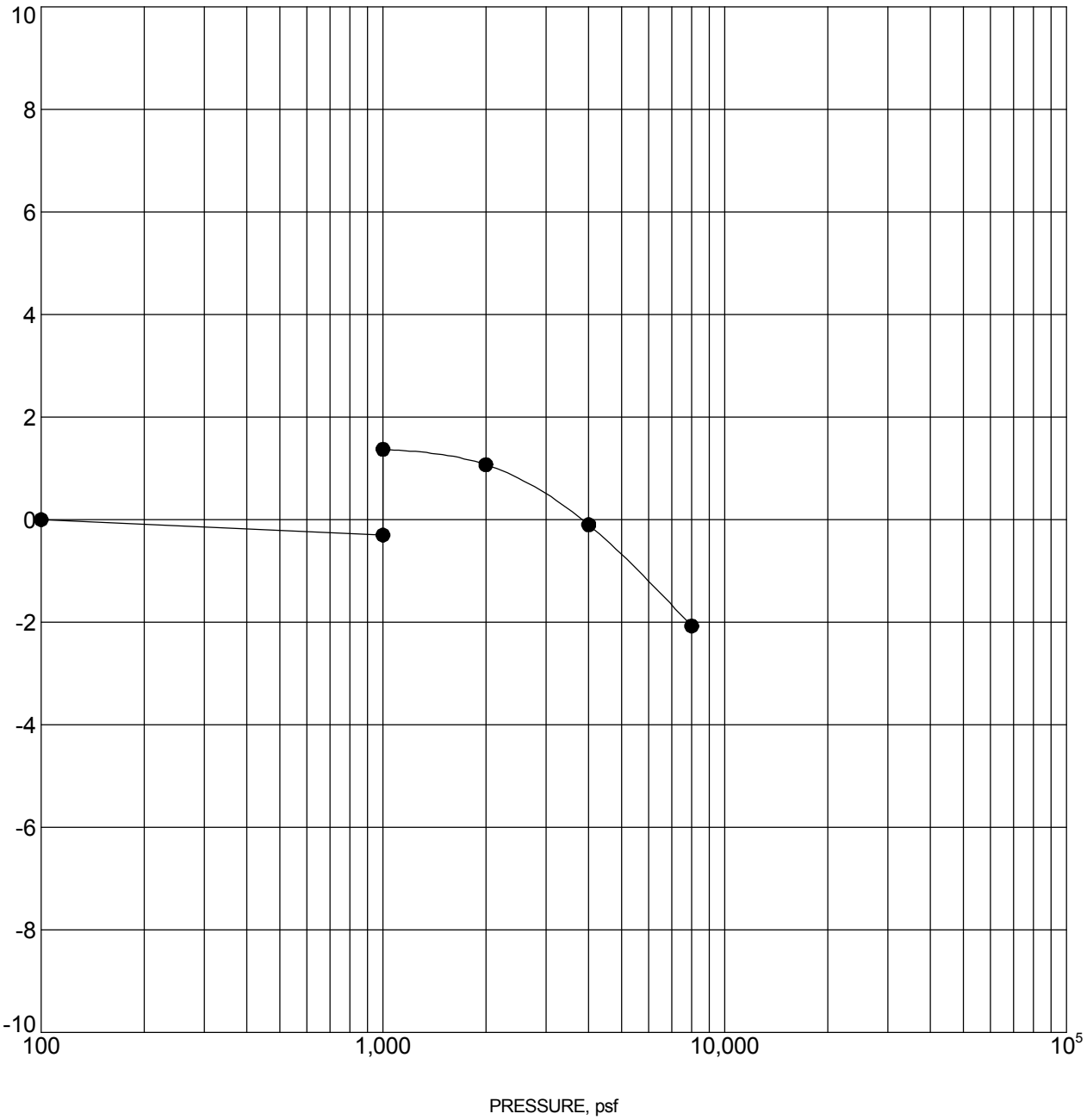
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-6	4 - 5 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	111	8

NOTES: Sample exhibited 2.0 percent expansion upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-11

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



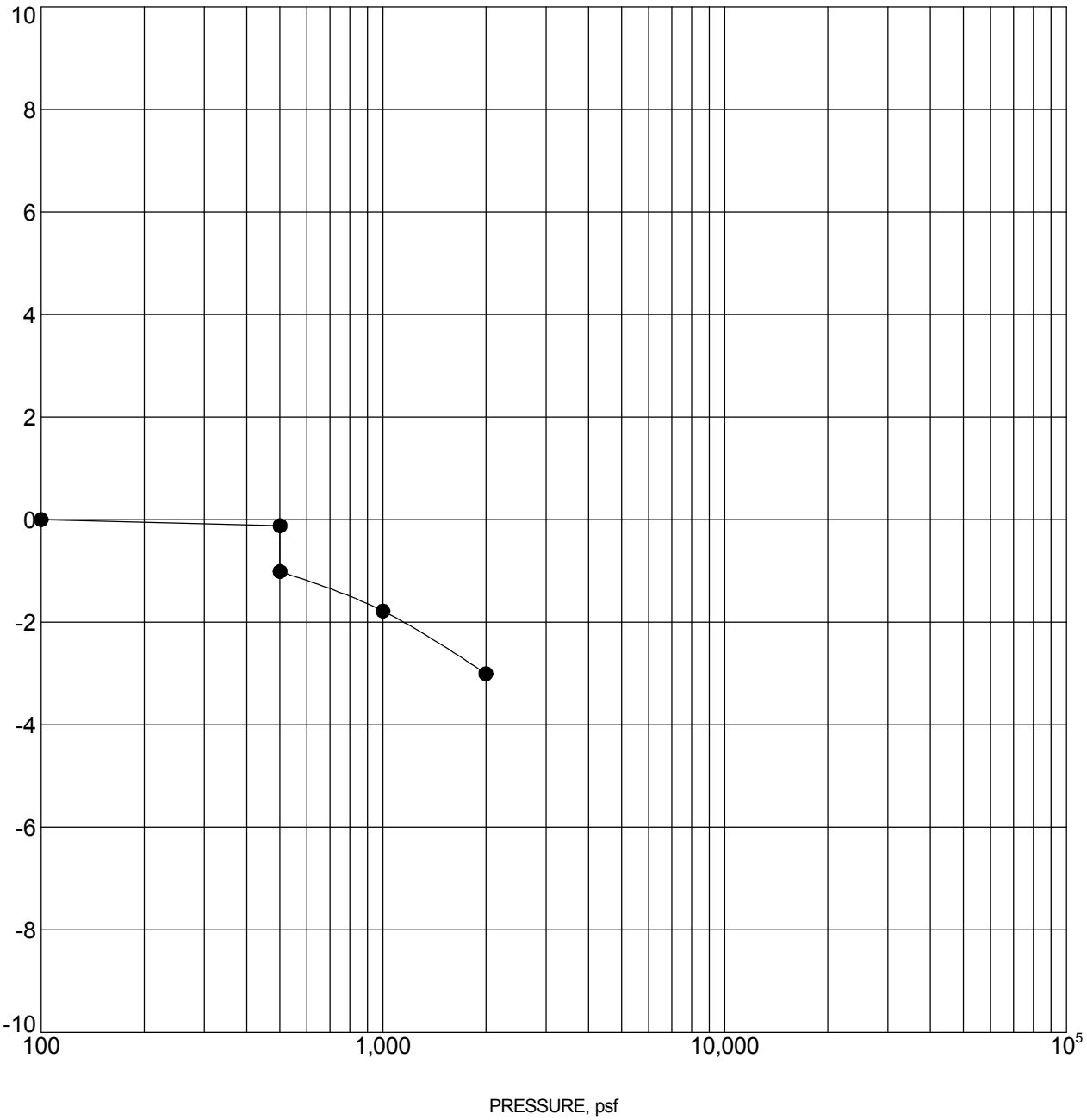
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-6	9 - 10 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	114	9

NOTES: Sample exhibited 1.7 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-12

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



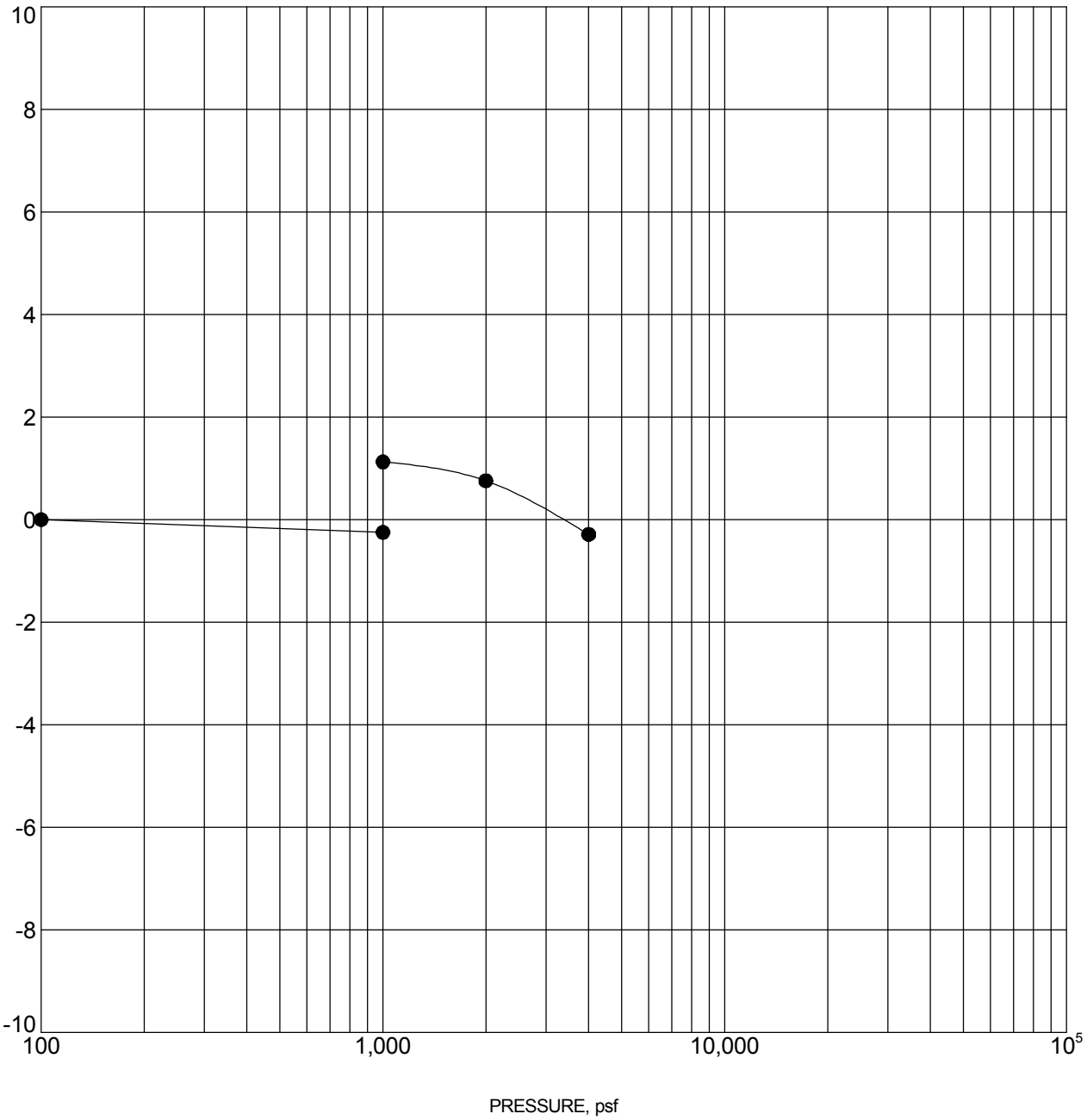
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-7	5 - 6 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	105	4

NOTES: Sample exhibited 0.9 percent compression upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-13

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



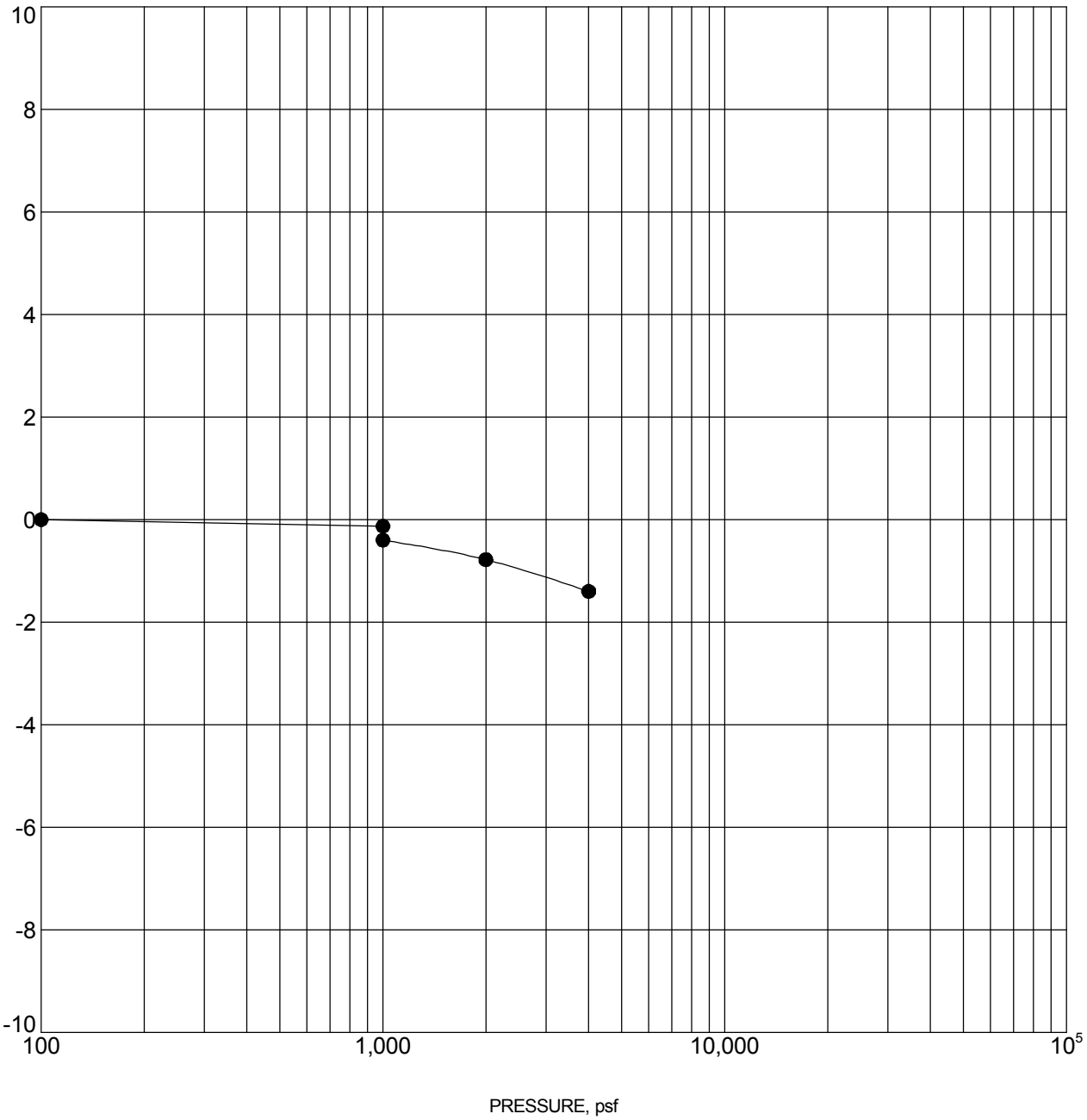
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-7	9 - 10 ft	SANDY LEAN CLAY (CL)	112	10

NOTES: Sample exhibited 1.4 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-14

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



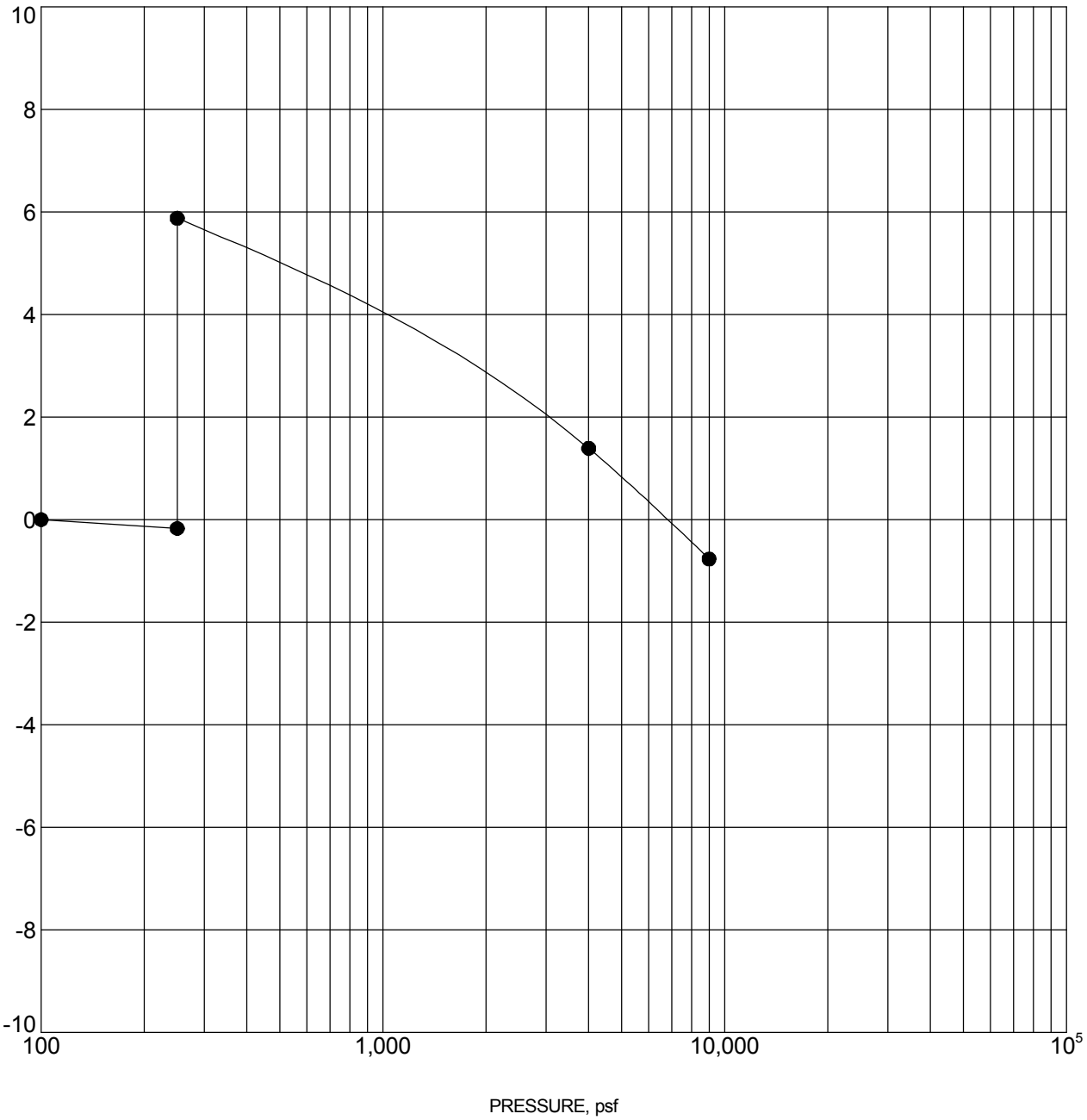
Specimen Identification		Classification	γ_d, pcf	WC, %
●	TB-7 14 - 15 ft	SILTY SAND (SM)	112	10

NOTES: Sample exhibited 0.3 percent compressing upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-15

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



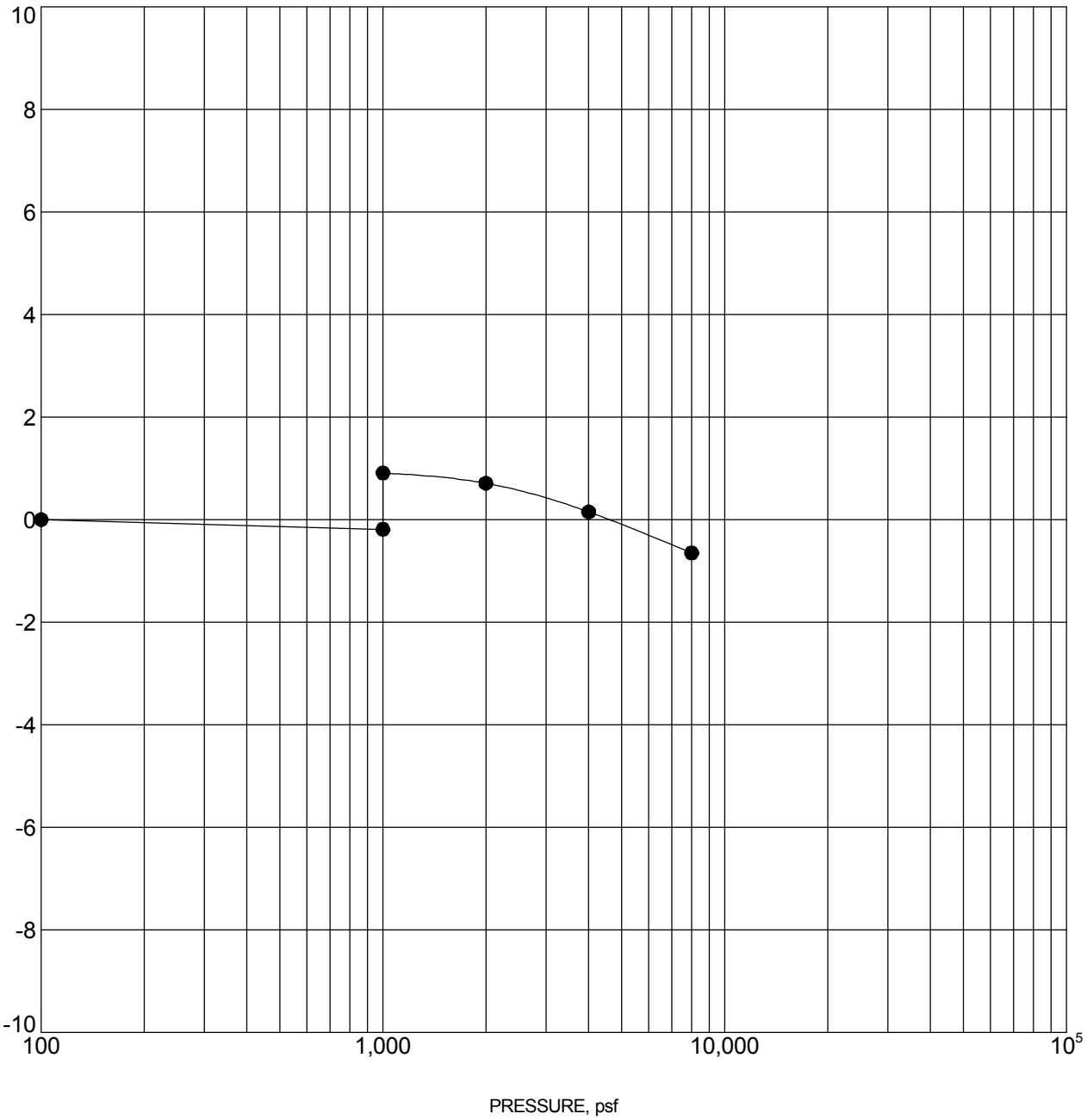
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-8	2 - 3 ft	SANDY LEAN CLAY (CL)	120	9

NOTES: Sample exhibited 6.1 percent expansion upon wetting under an applied pressure of 250 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-16

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



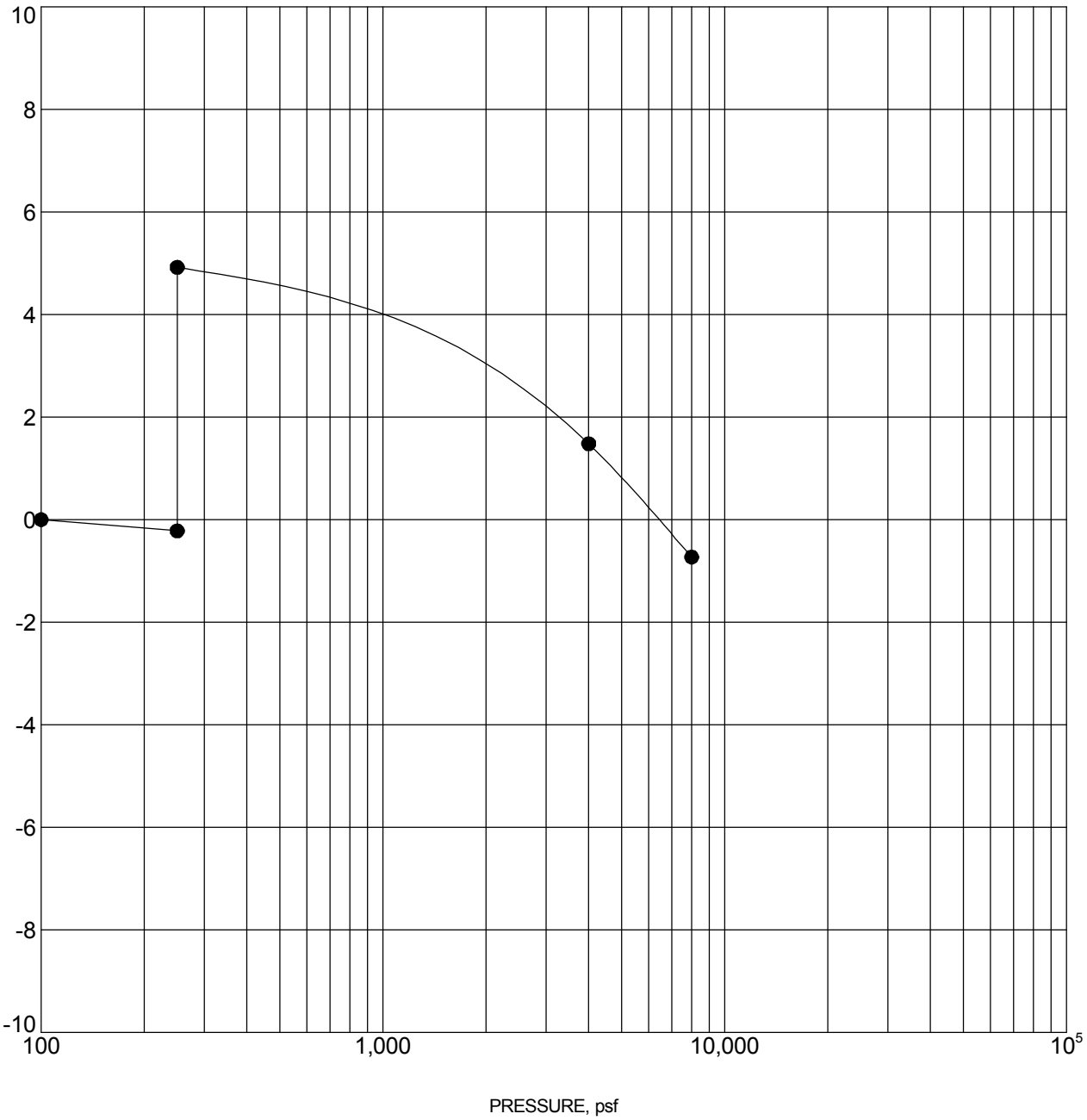
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-8	9 - 10 ft	SANDY LEAN CLAY (CL)	129	7

NOTES: Sample exhibited 1.1 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-17

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



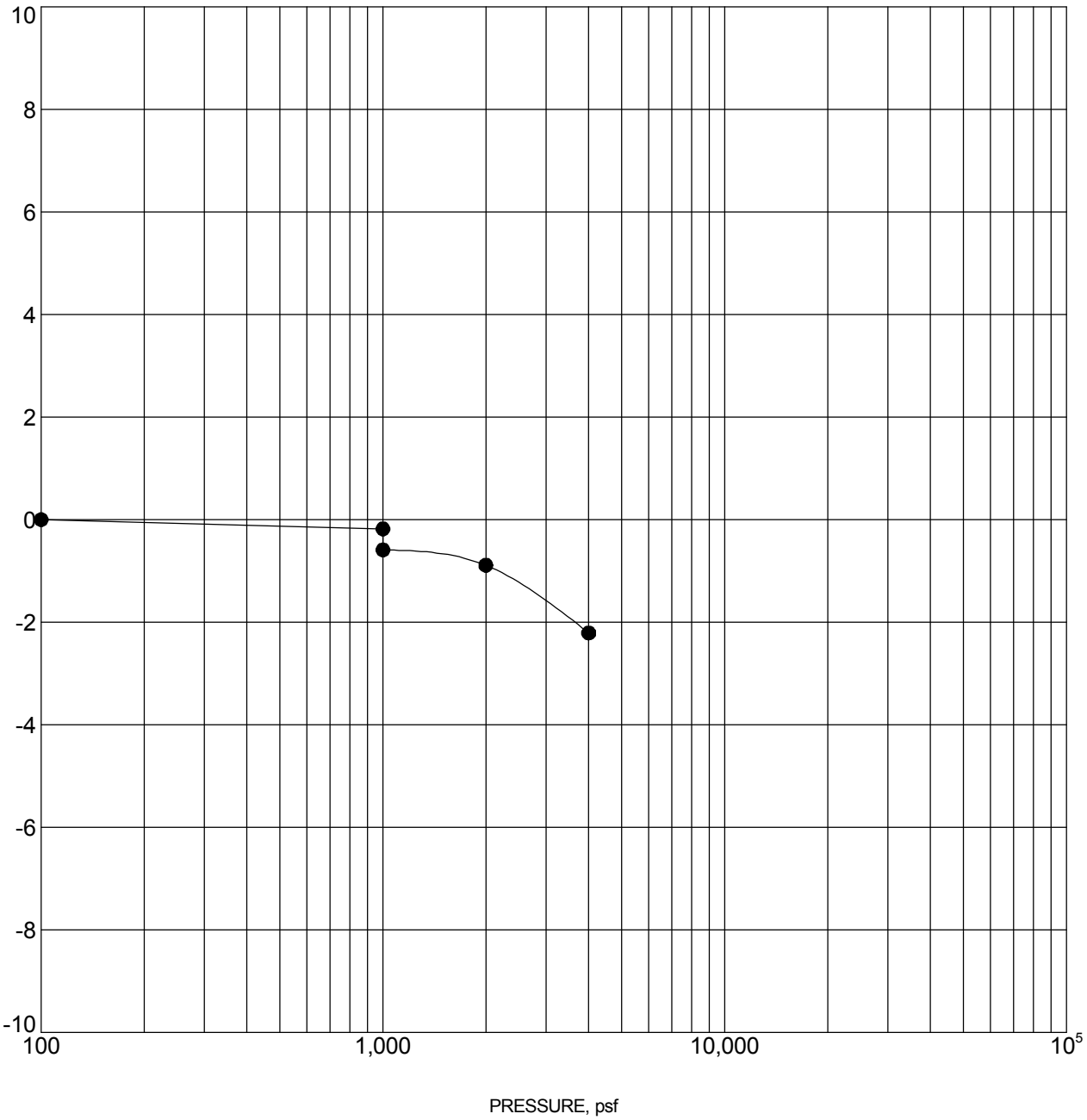
Specimen Identification		Classification	γ_d, pcf	WC, %
● TB-9	2 - 3 ft	SANDY LEAN CLAY (CL)	121	9

NOTES: Sample exhibited 5.1 percent expansion upon wetting under an applied pressure of 250 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-18

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-9	9 - 10 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	108	5

NOTES: Sample exhibited 0.4 percent compression upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

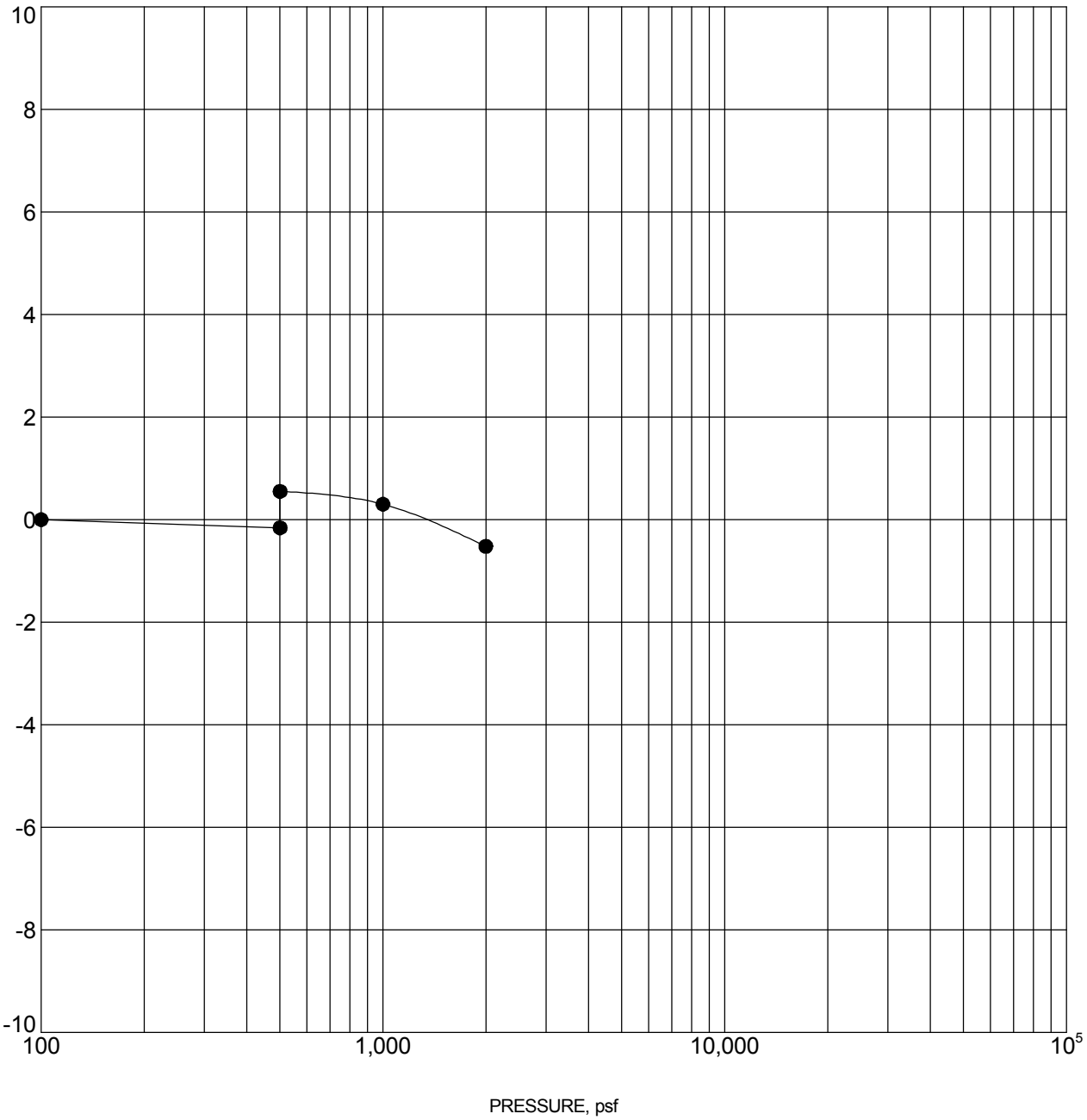
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-19

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



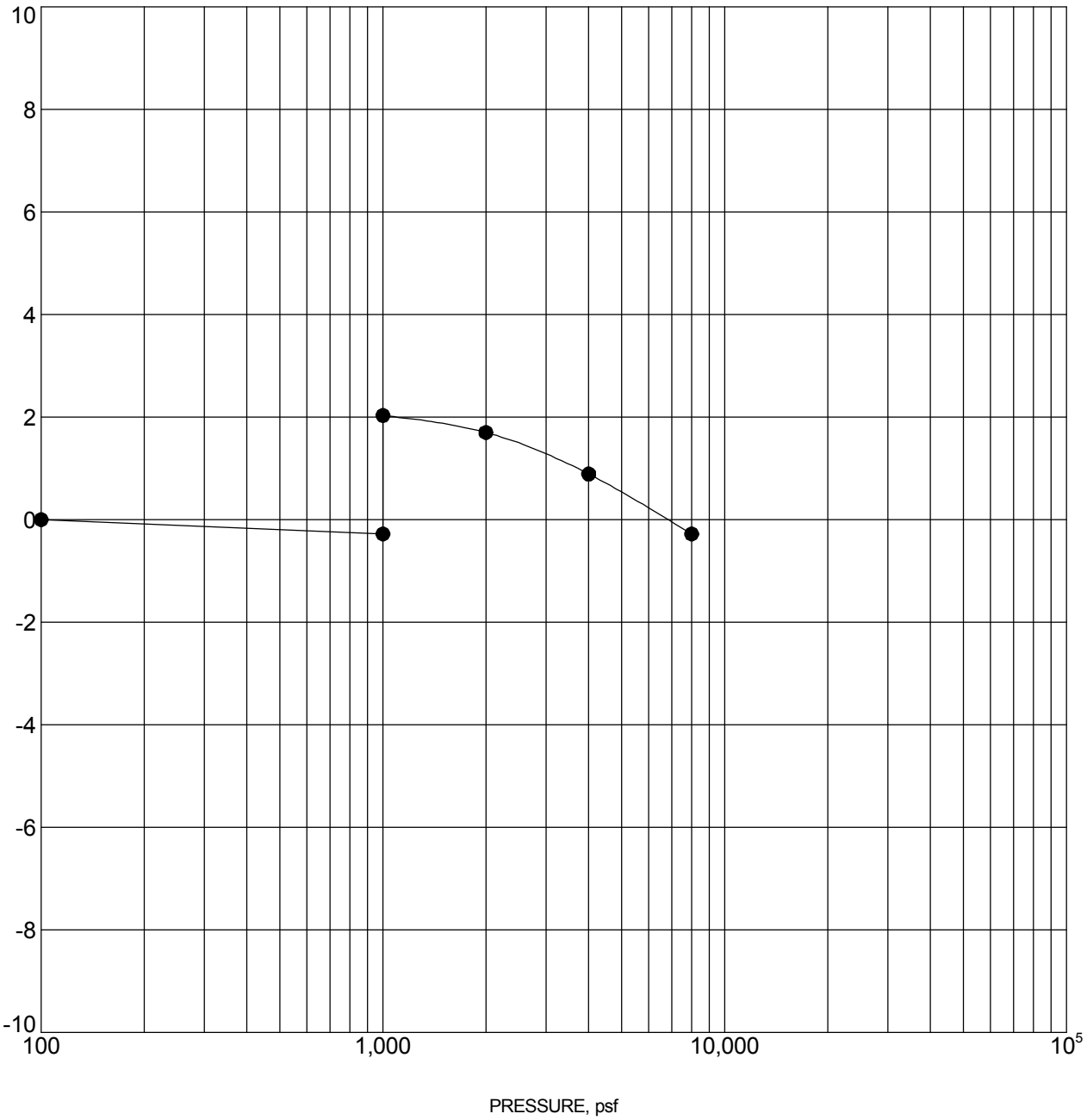
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-10	5 - 6 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	116	6

NOTES: Sample exhibited 0.7 percent expansion upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-20

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



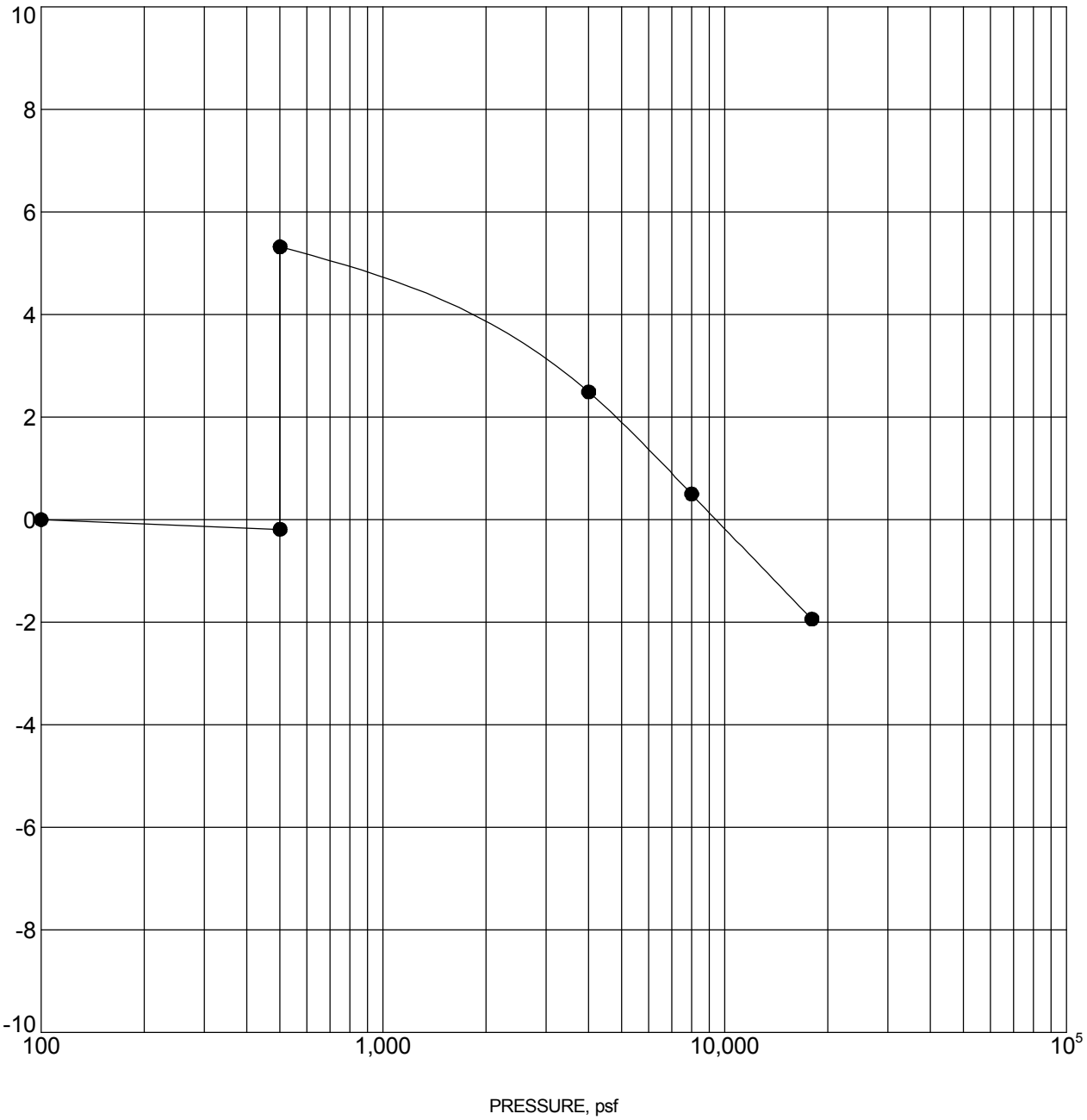
Specimen Identification		Classification	γ_d, pcf	WC, %
●	TB-10 9 - 10 ft	LEAN CLAY with SAND (CL)	122	12

NOTES: Sample exhibited 2.3 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-21

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



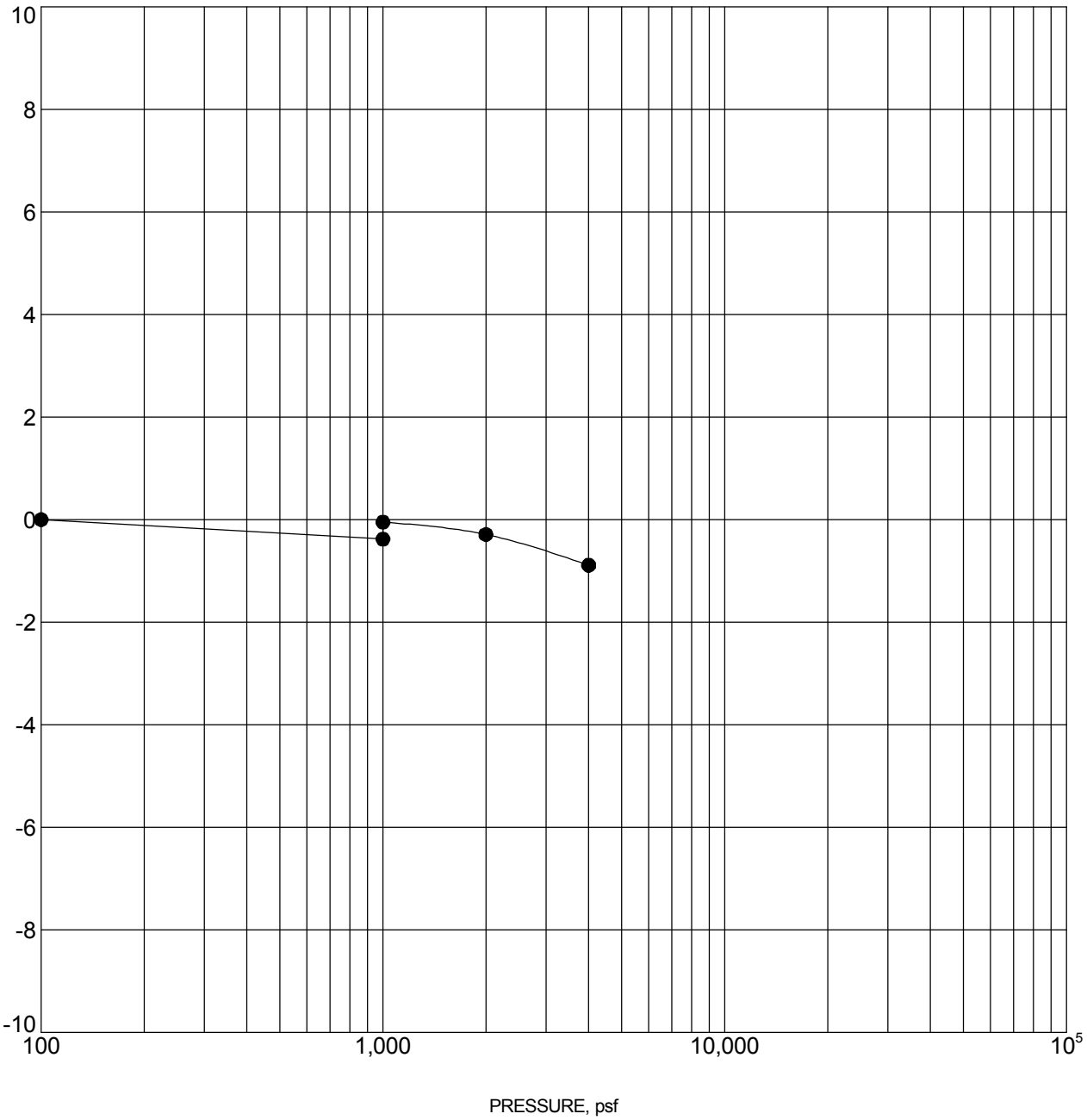
Specimen Identification		Classification	γ_d, pcf	WC, %
● TB-11	9 - 10 ft	LEAN CLAY with SAND (CL)	120	12

NOTES: Sample exhibited 5.5 percent expansion upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-22

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
●	TB-11 14 - 15 ft	LEAN CLAY with SAND (CL)	117	15

NOTES: Sample exhibited 0.3 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

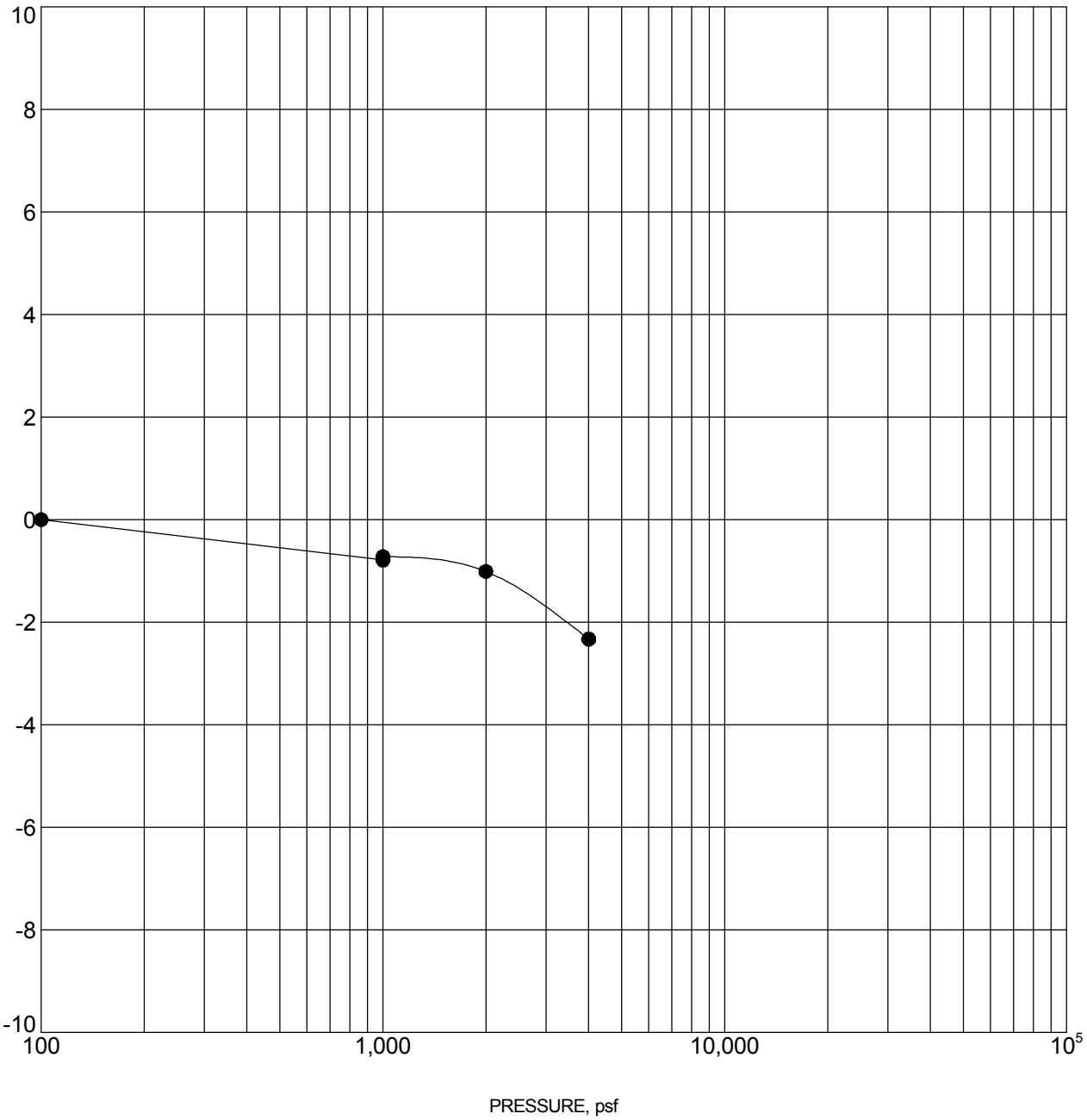
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-23

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
●	TB-11 19 - 20 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	111	20

NOTES: Sample exhibited 0.1 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

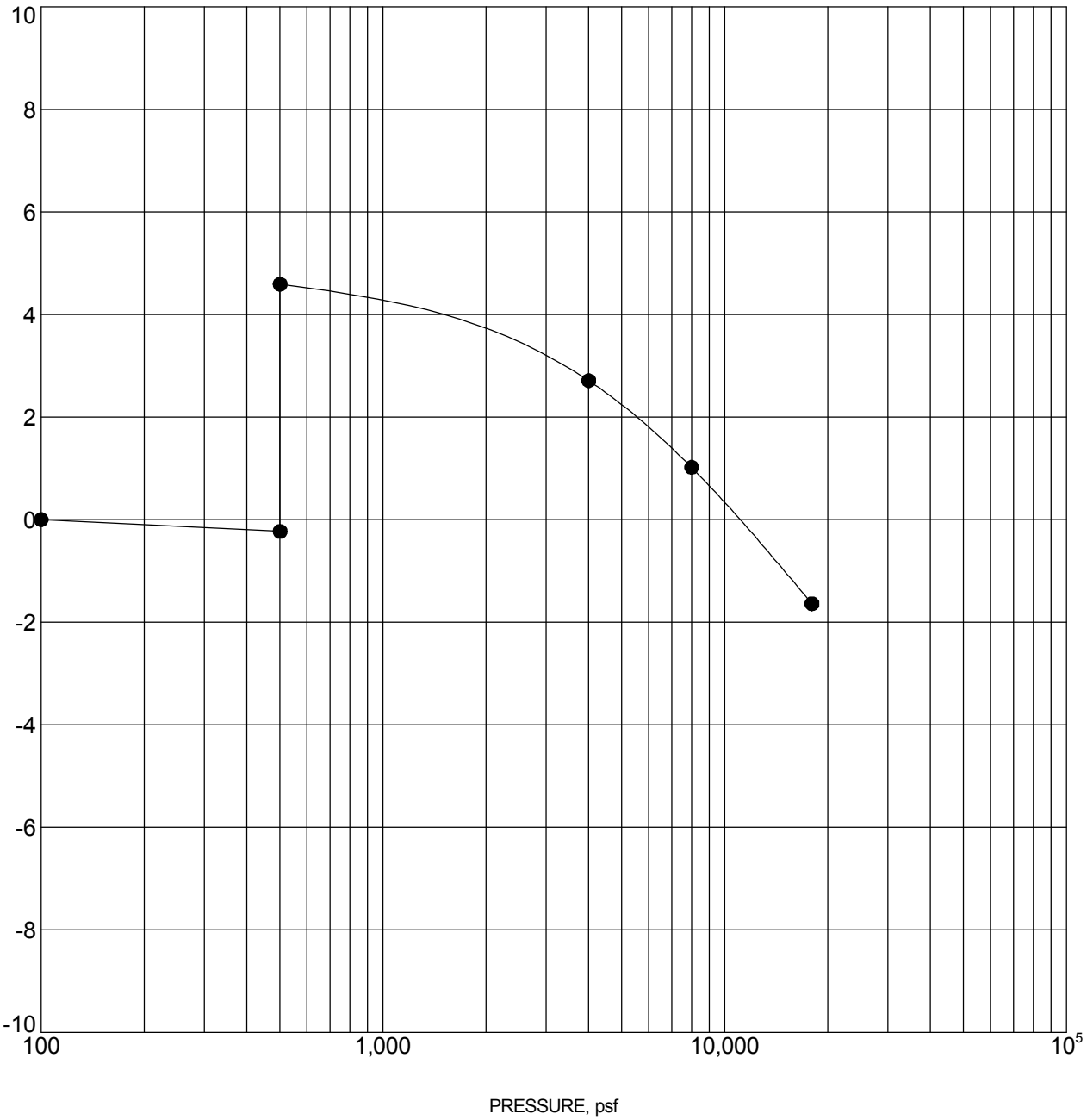
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-24

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



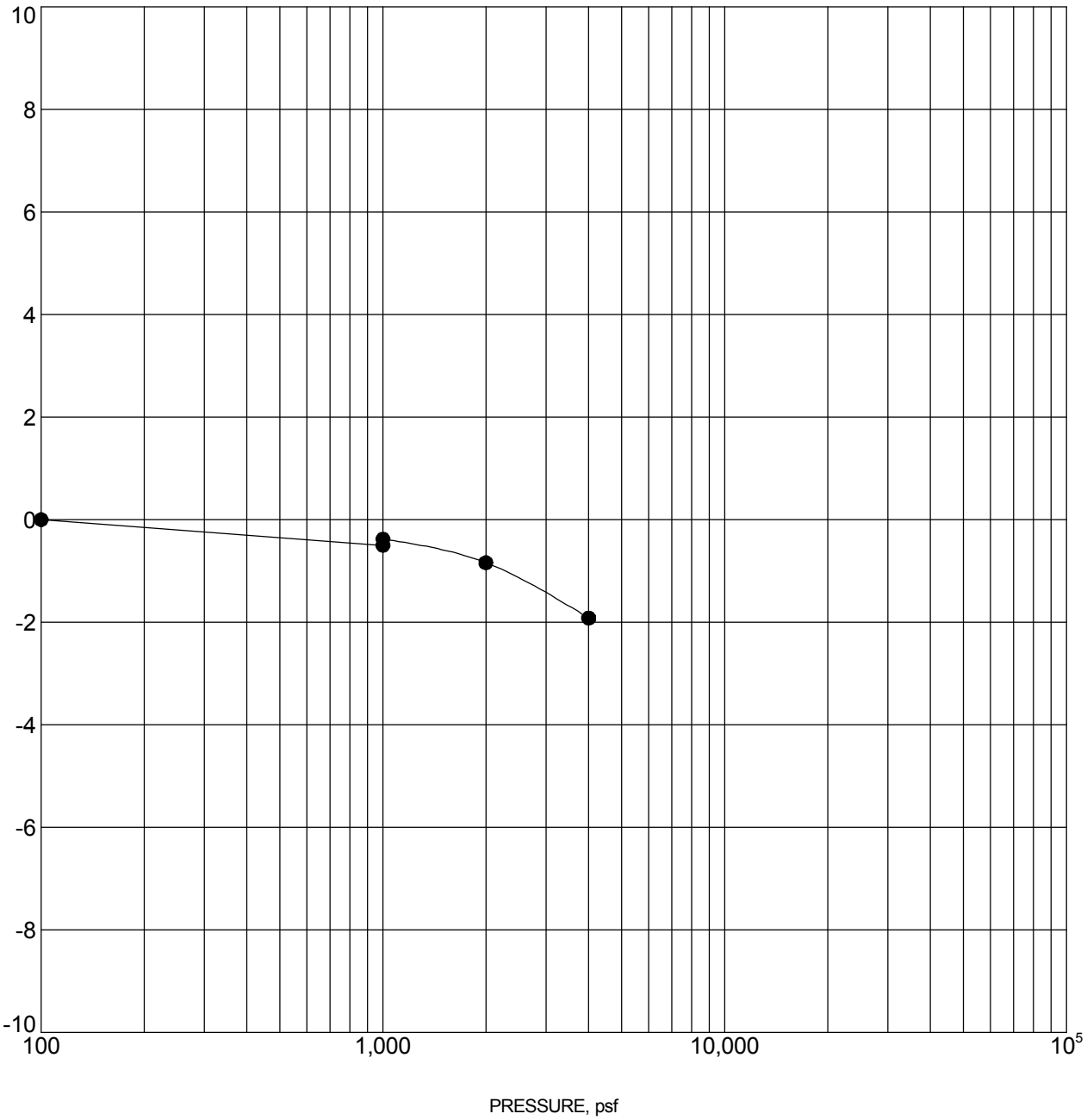
Specimen Identification		Classification	γ_d, pcf	WC, %
● TB-12	9 - 10 ft	SANDY LEAN CLAY (CL)	124	13

NOTES: Sample exhibited 4.8 percent expansion upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-25

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
●	TB-12 14 - 15 ft	SANDY LEAN CLAY (CL)	115	11

NOTES: Sample exhibited 0.1 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

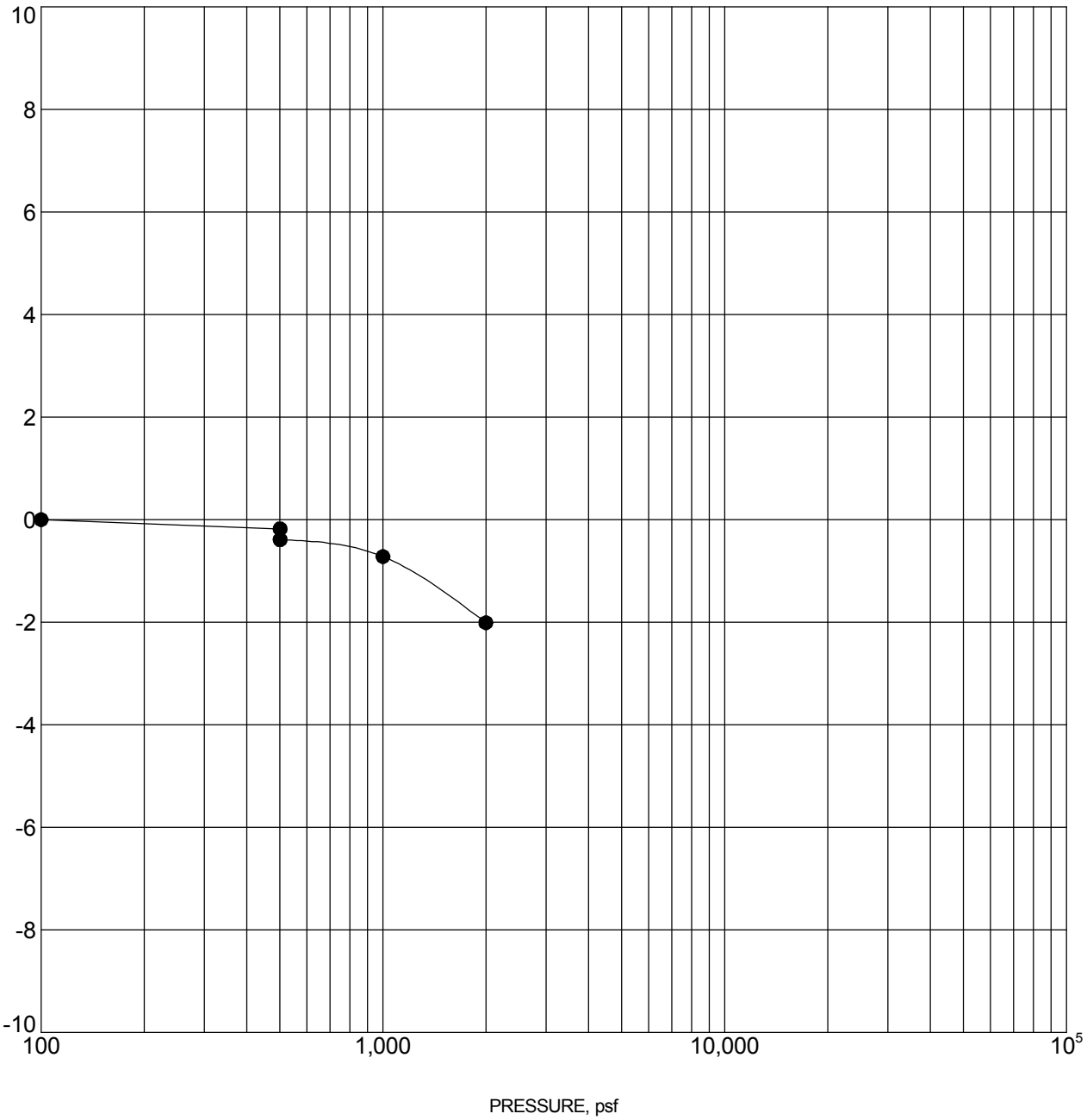
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-26

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
● TB-13	9 - 10 ft	SANDY LEAN CLAY to CLAYEY SAND (CL/SC)	113	5

NOTES: Sample exhibited 0.2 percent compression upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

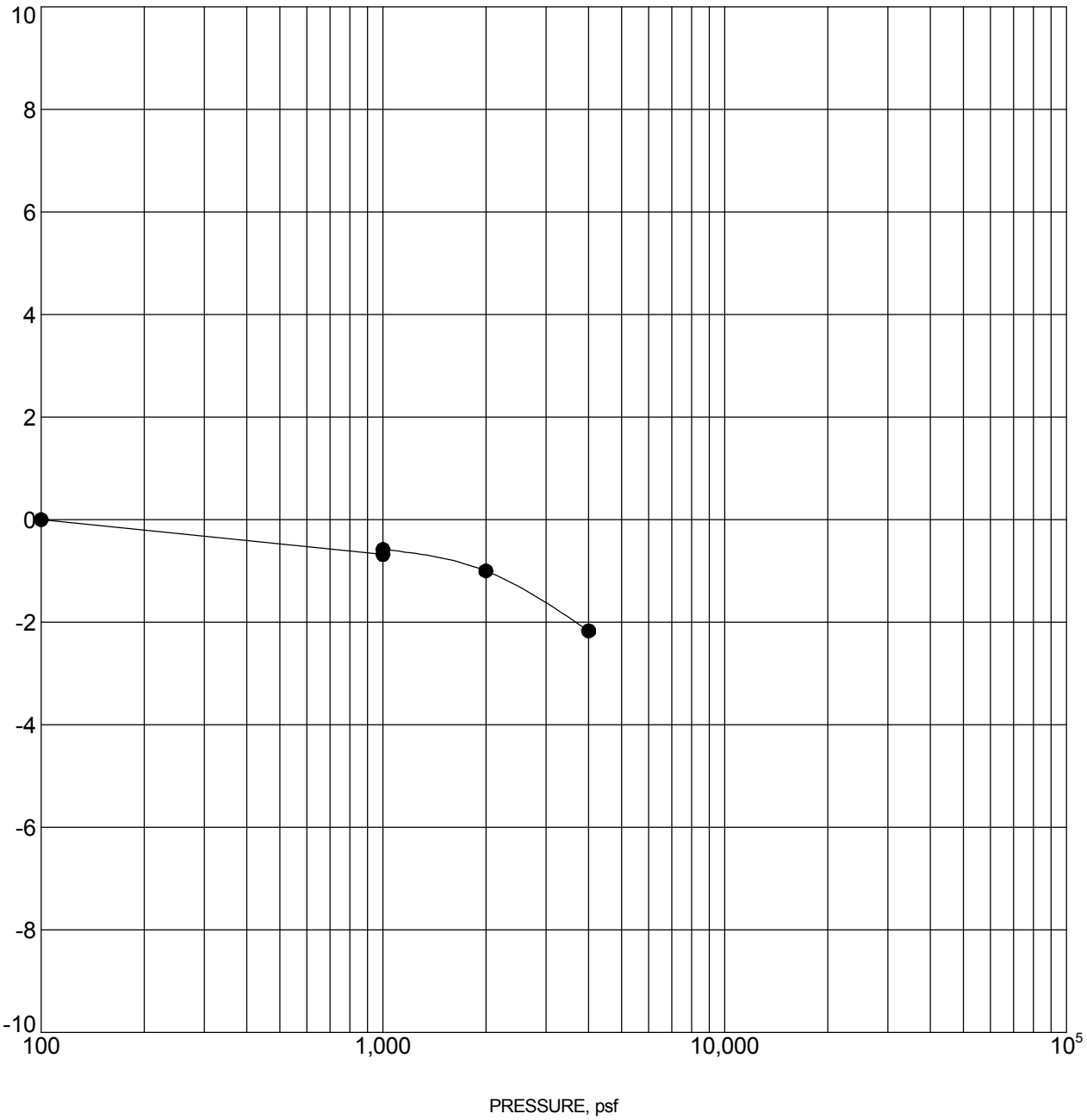
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-27

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
●	TB-13 14 - 15 ft	SANDY LEAN CLAY (CL)	113	17

NOTES: Sample exhibited 0.1 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

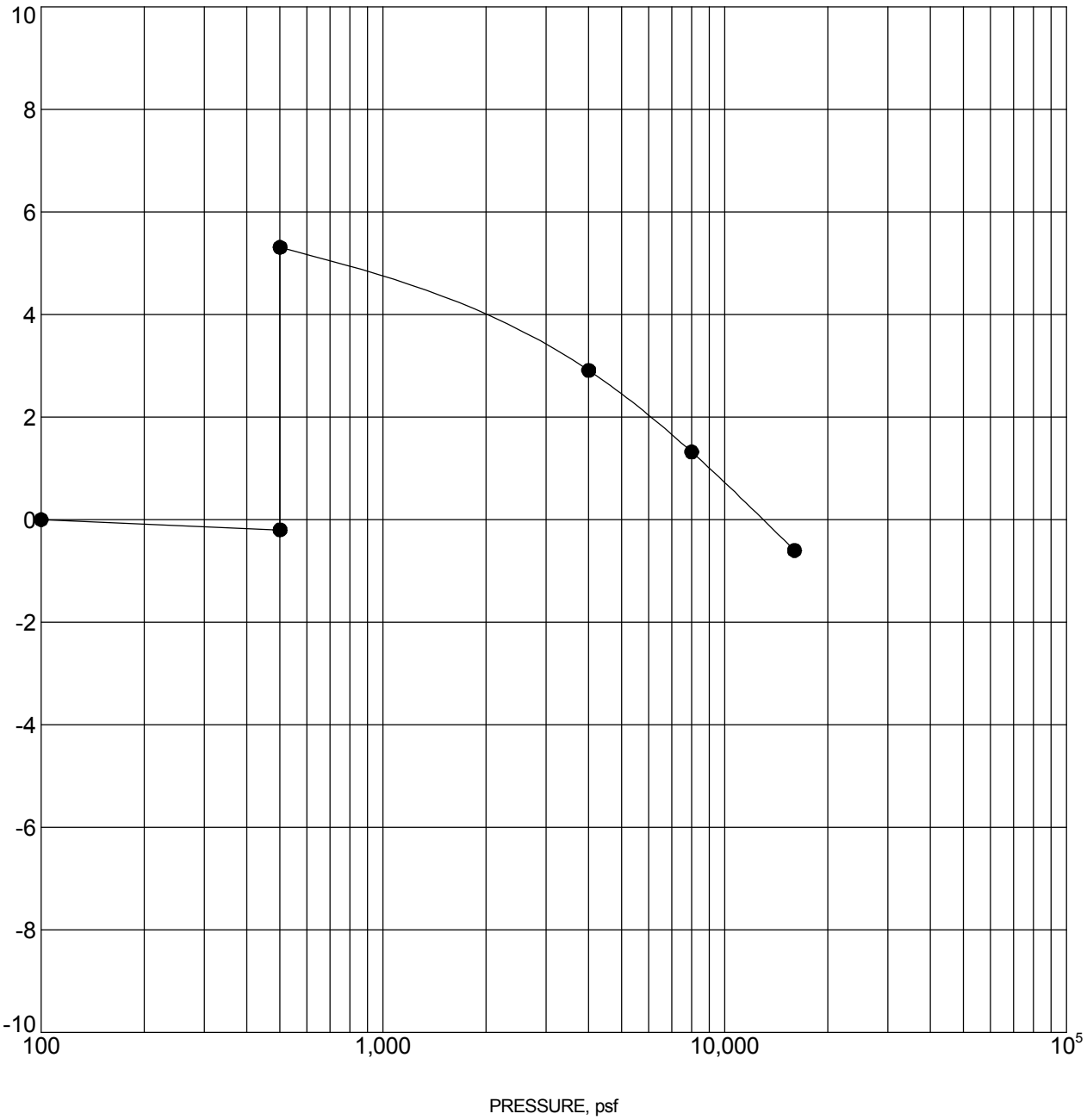
PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-28

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



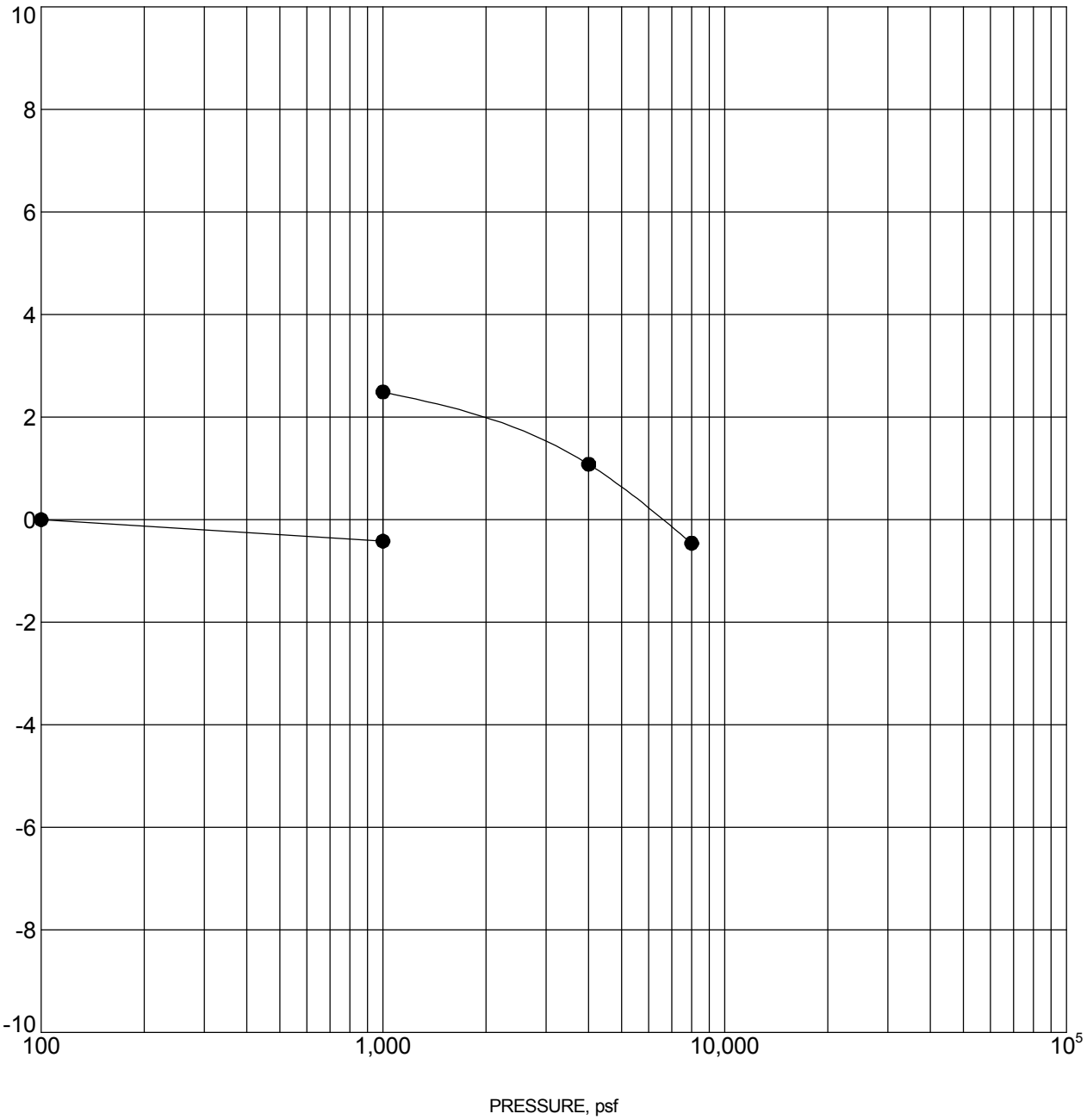
Specimen Identification			Classification	γ_d, pcf	WC, %
●	TB-14	9 - 10 ft	LEAN CLAY with SAND (CL)	124	11

NOTES: Sample exhibited 5.5 percent expansion upon wetting under an applied pressure of 500 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing	Terracon 1242 Bramwood Pl Longmont, CO	PROJECT NUMBER: 22175065
SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado		CLIENT: Boulder County Housing Authority Boulder, CO
		EXHIBIT: B-29

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
●	TB-14 39 - 40 ft	CLAYSTONE/SILTSTONE	116	16

NOTES: Sample exhibited 2.9 percent expansion upon wetting under an applied pressure of 1,000 psf.

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

PROJECT NUMBER: 22175065

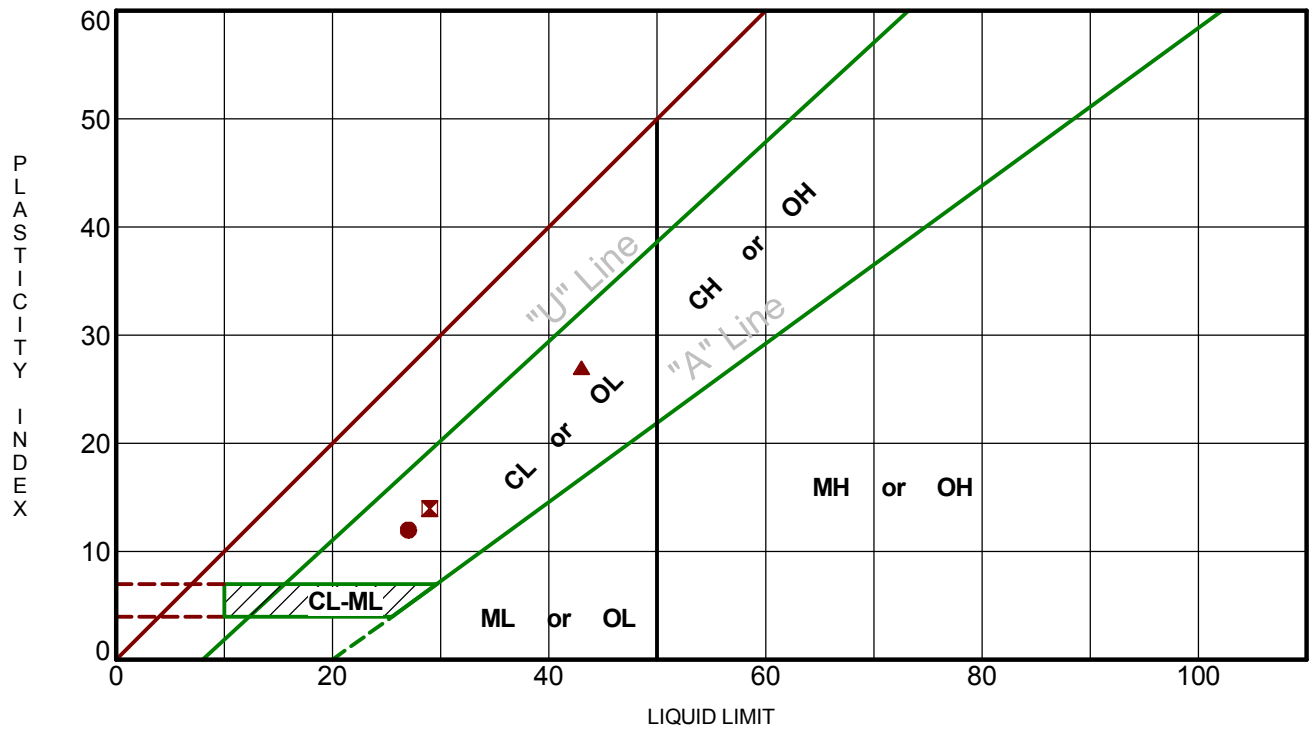
CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-30

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS-NO ASTM 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2012.GDT 6/28/17

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● TB-2	4 - 5	27	15	12	34	SC	CLAYEY SAND
⊠ TB-3	9 - 10	29	15	14	55	CL	SANDY LEAN CLAY
▲ TB-11	9 - 10	43	16	27	79	CL	LEAN CLAY with SAND (CL)

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

PROJECT NUMBER: 22175065

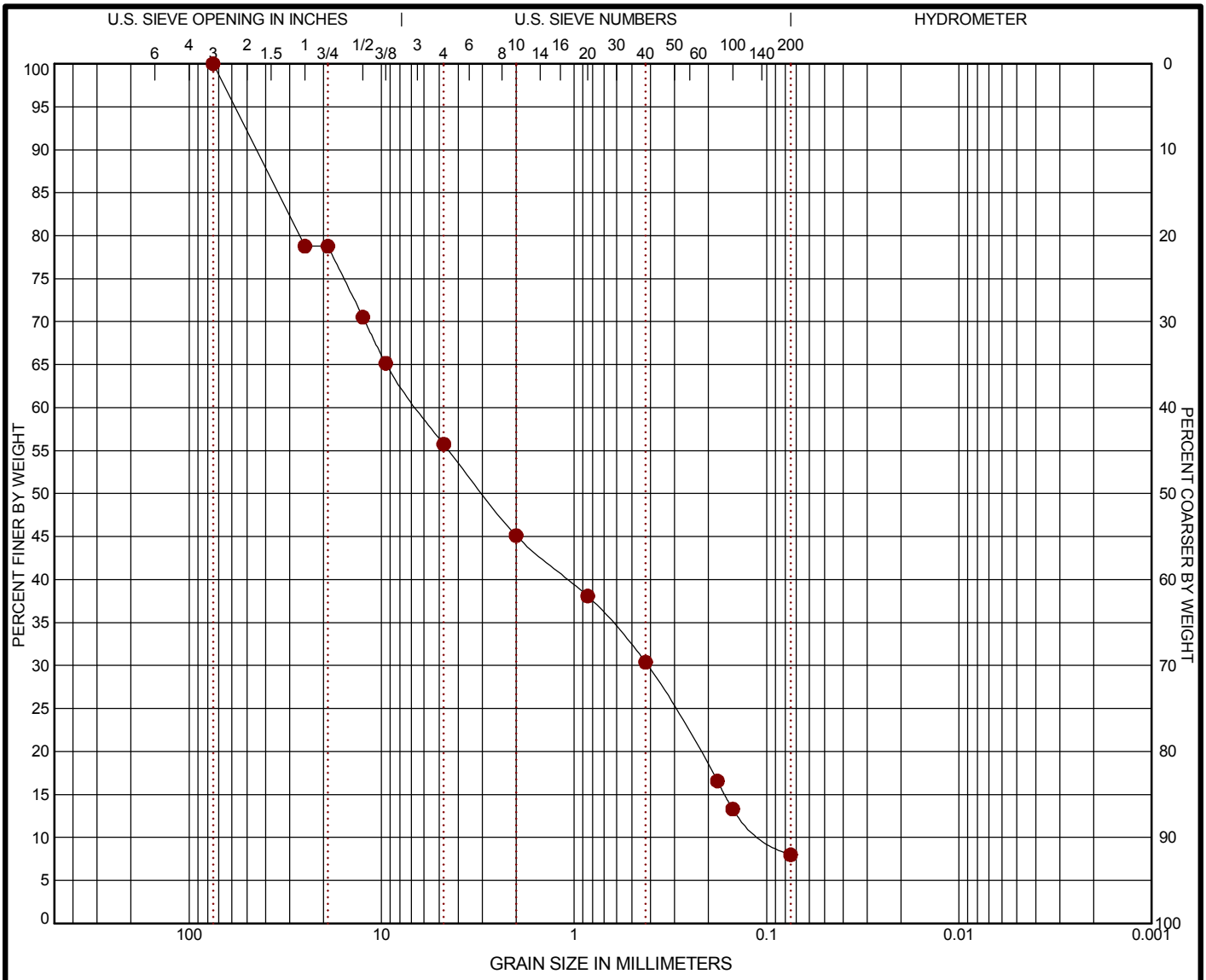
CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-31

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 22175065 BCHA LAFAYETTE PR.GPJ TERRACON2015.GDT 6/28/17

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**TB-9**	**19 - 20**	**0.0**	**44.2**	**47.8**		**8.0**		**SP-SM**

	GRAIN SIZE
●	
D_{60}	**6.495**
D_{30}	**0.415**
D_{10}	**0.097**
	COEFFICIENTS
C_C	**0.27**
C_U	**66.63**

SIEVE (size)	PERCENT FINER		
	●		

SOIL DESCRIPTION

● POORLY GRADED SAND with SILT and GRAVEL (SP-SM)

REMARKS

●

PROJECT: BCHA Lafayette Property - Affordable Housing

SITE: SW Corner of E. Emma St. & N. 120th St. Lafayette, Colorado

Terracon
1242 Bramwood Pl
Longmont, CO

PROJECT NUMBER: 22175065

CLIENT: Boulder County Housing Authority Boulder, CO

EXHIBIT: B-32

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 22175065 BCHA LAFAYETTE PR.GPJ 35159097 - ATTERBERG ISSUE.GPJ 6/28/17

APPENDIX C

SUPPORTING DOCUMENT

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING


Auger


Split Spoon


Shelby Tube


Macro Core


Ring Sampler


Rock Core


Grab Sample


No Recovery

WATER LEVEL


Water Initially Encountered


Water Level After a Specified Period of Time


Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance				BEDROCK		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Ring Sampler Blows/Ft.	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)
Very Loose	0 - 3	0 - 5	Very Soft	less than 500	0 - 1	< 3	< 24	< 20	Weathered
Loose	4 - 9	6 - 14	Soft	500 to 1,000	2 - 4	3 - 5	24 - 35	20 - 29	Firm
Medium Dense	10 - 29	15 - 46	Medium-Stiff	1,000 to 2,000	4 - 8	6 - 10	36 - 60	30 - 49	Medium Hard
Dense	30 - 50	47 - 79	Stiff	2,000 to 4,000	8 - 15	11 - 18	61 - 96	50 - 79	Hard
Very Dense	> 50	≥ 80	Very Stiff	4,000 to 8,000	15 - 30	19 - 36	> 96	>79	Very Hard
			Hard	> 8,000	> 30	> 36			

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

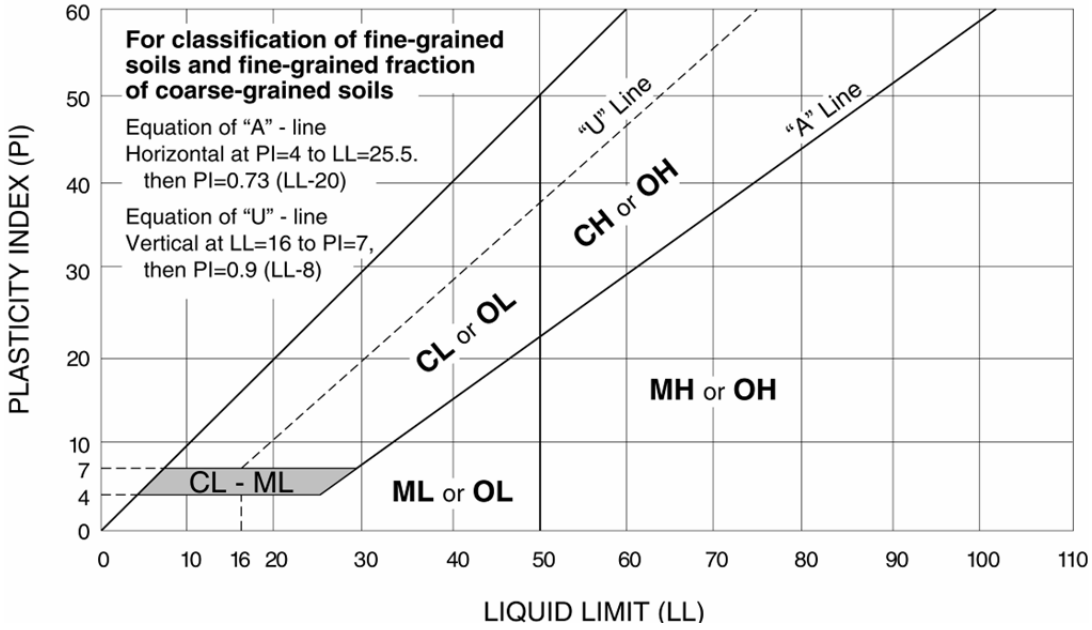
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

Exhibit C-2

ROCK CLASSIFICATION

(Based on ASTM C-294)

Sedimentary Rocks

Sedimentary rocks are stratified materials laid down by water or wind. The sediments may be composed of particles or pre-existing rocks derived by mechanical weathering, evaporation or by chemical or organic origin. The sediments are usually indurated by cementation or compaction.

Chert Very fine-grained siliceous rock composed of micro-crystalline or cyrptocrystalline quartz, chalcedony or opal. Chert is various colored, porous to dense, hard and has a conchoidal to splintery fracture.

Claystone Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Soft massive and may contain carbonate minerals.

Conglomerate Rock consisting of a considerable amount of rounded gravel, sand and cobbles with or without interstitial or cementing material. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other materials.

Dolomite A fine-grained carbonate rock consisting of the mineral dolomite [$CaMg(CO_3)_2$]. May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

Limestone A fine-grained carbonate rock consisting of the mineral calcite ($CaCO_3$). May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

Sandstone Rock consisting of particles of sand with or without interstitial and cementing materials. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other material.

Shale Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Shale is hard, platy, or fissile and may be gray, black, reddish or green and may contain some carbonate minerals (calcareous shale).

Siltstone Fine grained rock composed of or derived by erosion of silts or rock containing silt. Siltstones consist predominantly of silt sized particles (0.0625 to 0.002 mm in diameter) and are intermediate rocks between claystones and sandstones and may contain carbonate minerals.