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PRELIMINARY GEOTECHNICAL ENGINEERING STUDY
WATERMARK AT COLORADO SPRINGS
AKERS DRIVE APARTMENTS
NWC OF CONSTITUTION AVE & MARKSHEFFEL RD
COLORADO SPRINGS, COLORADO

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SUMMARY

1. Beneath a layer of topsoil (root zone), the generalized subsurface profile encountered in the borings consisted of a combination of granular and cohesive overburden soils underlain by claystone and sandstone bedrock. Man-placed fill was encountered in one of the borings. Considering the wide spacings of the borings drilled for this study, it is possible for existing fill to be present elsewhere on site. Swell-consolidation tests indicate the tested samples of clay varied from having a nil to high swell potential to a low potential for compression, when wetted under a 1,000 psf surcharge.
2. Groundwater was not encountered at the time of drilling. When the borings were checked 8 to 9 days later, groundwater was encountered in one of the borings at a depth approximately 25.1 feet. Fluctuations in the water level may occur with time, particularly during wetter seasons and after precipitation events.
3. Considering the data obtained from the field and laboratory studies and the nature of the proposed construction, it is our opinion that a shallow foundation system with a partial overexcavation of the underlying expansive materials, and complete overexcavation of any existing fill would perform adequately if the recommendations provided in this report are followed. The risk for excessive foundation movements is estimated to be relatively low for a shallow foundation system supported by nonexpansive material. The use of a post-tensioned slab foundation will result in the reduced risk of associated distress from foundation movement as compared to a conventional spread footing foundation system, given the foundation systems ability to be rigid and withstand differential movements. Foundation recommendations included in this report include post tensioned (PT) slabs and spread footings based on our understanding of the owner's preferences.
4. The on-site soils and sandstone bedrock will be suitable for reuse as nonexpansive structural fill, including for compacted fill beneath foundations, exterior flatwork and pavements. The existing fill encountered is also suitable for reuse, minus any deleterious materials. Claystone should be considered unsuitable for use as structural fill. Overlot grading compaction specification recommendations are included in the report.
5. We recommend drive lanes be constructed with 7 inches of full-depth asphalt pavement or a composite section consisting of 5 inches of asphalt over 7 inches of aggregate base course. We recommend parking stalls and other areas restricted to auto traffic be constructed with 6 inches of full-depth asphalt pavement or a composite section consisting of 4 inches of asphalt over 7 inches of base course. We recommend trash collection areas and other areas that may have concentrated truck turning movements be paved with a 6-inch thick portland cement concrete pavement section.

PURPOSE OF STUDY

This report presents the results of a preliminary geotechnical engineering study for the proposed apartment development in Colorado Springs, Colorado. The study was conducted for the purpose of developing preliminary recommendations for site grading, foundations and pavements. The project site is shown on the attached Fig. 1. The study was performed in accordance with our Proposal No. C20-163R, dated August 4, 2020.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and preliminary recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to the proposed construction are included in the report. Once details regarding the proposed construction have been finalized, to include the site layout and planned grading, additional study with supplemental field exploration and lab testing will be required to develop a report with final recommendations. It should be noted that even if the proposed construction does not change from that described herein, it is still possible for the recommendations to change if the supplemental field and lab data significantly differs.

PROPOSED CONSTRUCTION

We understand the proposed construction will include nine separate three-story apartment buildings, a clubhouse with pool, a rental office, and potential garage pods or covered parking areas. Paved access roadways and parking stalls will also be constructed throughout the site. The preliminary site layout plan provided (dated 7/28/20) is shown on Fig. 1. The planned site grading had not been determined at the time of our study; however, we have assumed it would be relatively minor, with cuts and fills on the order of approximately 2 to 4 feet or less. If the proposed construction varies significantly from that described above or depicted herein, we should be notified to reevaluate the recommendations provided herein.

SITE CONDITIONS

The subject site consists of vacant, undeveloped land, bound by Akers Drive to the west, Constitution Avenue to the south, and Marksheffel Road to the east. Additional vacant land and commercial development is located to the north. The site slopes gently down to the southeast, and there was roughly 25 feet of elevation different across the property. The site appeared relatively undisturbed; however, review of historic aerial photographs indicates some potential site grading and unknown land use occurred in the 1970's and 80's. The site was vegetated with natural grasses, weeds, yucca, and cacti. There were some deciduous trees along the south property line.

FIELD EXPLORATION

The field exploration of subsurface conditions consisted of drilling a total of 18 borings at the approximate locations shown on Fig. 1. The borings were drilled on August 24 and 25, 2020. The locations of the borings were approximated using a handheld GPS unit, and the elevations were measured using a hand level. The boring logs are presented on Figs. 2 thru 4, and corresponding legend and notes are presented on Fig. 5.

The borings were drilled with 4-inch diameter continuous flight augers and were logged by a representative of Kumar & Associates, Inc. Samples of the soils and bedrock were taken with a 2-inch I.D. California sampler. The sampler was driven into the various strata with blows from a 140-pound hammer falling 30 inches. Penetration resistance values, when properly evaluated, provide an indication of the relative density or consistency of the soils. Depths at which the samples were taken and the penetration resistance values are shown on the boring logs.

LABORATORY TESTING

Samples obtained from the exploratory borings were visually classified in the laboratory by the project engineer and samples were selected for laboratory testing. Laboratory testing included index property tests such as in-situ moisture content and dry unit weight, grain size analysis, and Atterberg limits. Additional testing included in-situ swell-consolidation and concentration of water soluble sulfates. The testing was conducted in general accordance with recognized test procedures, primarily those of the American Society for Testing of Materials (ASTM). Results of the laboratory testing program are shown on Figs. 2 thru 4, and 6 thru 16, and are summarized on Table I.

SUBSURFACE CONDITIONS

Beneath a layer of topsoil (root zone), the generalized subsurface profile encountered in the borings consisted of a combination of granular and cohesive overburden soils, underlain by claystone and sandstone bedrock. Man-placed fill was encountered in one of the borings. Given the wide spacings of the borings drilled for this study, it is possible for existing fill to be present elsewhere on site. The following subsurface descriptions are of a generalized nature to highlight the soil and bedrock types encountered in the borings drilled for this study. The boring logs should be reviewed for more detailed information.

Existing Fill: In Boring 11, man-placed fill was encountered to an approximate depth of 7 feet. The fill consisted of a mixture of clayey sand (SC) and sandy silty clay (CL-ML), and appeared to consist of reworked on-site soils. Due to the similarity of the natural soil and fill materials, it was not possible to clearly differentiate between fill and native soils. The fill was slightly moist to moist, and light brown to brown in color. Our study did not determine the exact lateral or vertical extent of the fill. Swell-consolidation test results presented on Fig. 9 indicate the tested sample of sandy silty clay fill had a low swell potential when wetted under a 1,000 psf surcharge.

Native Granular Soils: The native granular soils encountered were grouped as follows: clayey sand (SC) with silty-clayey sand (SM-SC), and poorly to well-graded sand with silt (SP-SM, SW-SM) with silty sand (SM) and occasional gravel. These soils were encountered in 17 of the 18 borings, beginning at depths ranging from near surface (below topsoil layer) to 10 feet, and extending to depths ranging from 4 to 22 feet in 10 of the borings, and to the maximum 15 to 30-foot depths explored in seven of the borings. The native granular soils were slightly moist to very moist, and tan to brown in color. Sampler penetration blow counts indicate the granular soils are generally medium dense to very dense. The exception was Boring 9 at a depth of 9 feet, where the granular soils were very loose (blow count of 3).

Native Clay Soils: Native lean clay (CL) soil with varied amounts of sand were encountered in 15 of the 18 borings. These soils were encountered beginning at depths ranging from near surface (below topsoil layer) to 13 feet, and extending to depths ranging from 4.5 feet to 26 feet in 13 of the borings, and to the maximum 20-foot depth explored in two of the borings. The native clay soils were slightly moist to moist, and brown, dark brown, and gray in color. Sampler penetration blow counts indicate the clay soils are medium stiff to hard in consistency. Swell-consolidation test results presented on Figs. 6 thru 10 indicate the tested samples of clay varied from having a nil to high swell potential to a low potential for compression, when wetted under a 1,000 psf surcharge.

Bedrock: Sandstone and/or claystone bedrock was encountered in 9 of the borings, beginning at depths of 9 to 26 feet, and extending to the maximum 15 to 30-foot depths explored. In two of these borings, the upper few feet of claystone was weathered. The sandstone was poorly cemented, moist and brown in color. The claystone was slightly moist to moist, and brown to gray in color. Sampler penetration blow counts indicate the non-weathered bedrock is hard to very hard, and the weathered claystone is very stiff to hard. Swell-consolidation testing was not performed on the claystone due to the depth encountered, however, based on our experience in the area, we recognize that it typically has a similar potential for swell as the tested overburden clay soils.

Groundwater: Groundwater was not encountered at the time of drilling. When the borings were checked 8 to 9 days later, groundwater was encountered in Boring 8 at an approximate depth of 25.1 feet. Fluctuations in the water level may occur with time, particularly during wetter seasons and after precipitation events. The borings were backfilled with auger cuttings upon completion of water level measurements.

GEOTECHNICAL ENGINEERING CONSIDERATIONS

The site subsurface conditions generally consist of variable depths of granular and clay overburden soils underlain by sandstone and claystone bedrock. Existing fill was encountered in one of the borings. The existing fill and the expansive clay and claystone materials are considered unsuitable as discussed in the paragraphs that follow. Shallow foundations (PT-slab and spread footings) and slabs placed directly on or near these materials can experience differential movement or excessive settlement (in the case of existing fill) causing distress if the materials are subjected to changes in moisture content. The natural granular soils and sandstone encountered are considered suitable for support of shallow foundations and slabs.

Existing fill: As discussed, it appears that previous land usage has occurred on the site, and it is unclear as to the extent of site grading that may have occurred. Existing fill was encountered in one of the borings, and sampler penetration blow counts suggest the fill is relatively compact. Given the unknown history of the fill, it is our opinion that it should be considered unsuitable for support of the proposed development unless documentation is available stating the site fills were properly controlled to the compaction criteria presented in this report. Foundations, floor slabs and pavements placed on uncontrolled fill can experience large total and differential movement resulting structural distress, particularly if debris or loose zones are present within the existing fill zone. We recommend the existing fill, where present in these areas, be overexcavated, moisture conditioned, and placed back properly compacted. The intent of this recommendation is to provide a low risk of settlement more than about 1 inch. Based on the properties of the existing fill encountered, it is our opinion it would be suitable for reuse as structural fill if it is processed and moisture conditioned.

Expansive Soil/Bedrock Considerations: Clay overburden soil varied from having a nil to high swell potential to a low potential for compression, and was encountered in several of the borings within the assumed elevation of construction. With the given conditions, the foundation option which would allow for the least amount of risk of overall movement would be to support the structures with a deep foundation system end bearing in the underlying bedrock and to use a structurally supported floor. However, bedrock was not encountered in many of the borings within the 20 to 30-foot depths explored, suggesting that a deep foundation may be a cost prohibitive option for portions of the site. Additional field exploration would be required to develop criteria for a deep foundation option.

Considering the data obtained from the field and laboratory studies and the nature of the proposed construction, it is expected that a shallow foundation system with a partial overexcavation of the underlying expansive materials would perform adequately if the recommendations provided in this

report are followed. The risk for excessive foundation movements is estimated to be relatively low for a shallow foundation system supported by nonexpansive material. It is anticipated that providing separation from the expansive materials with a zone of nonexpansive fill will result in a low risk of swell-related heave of about 1-1/2 inches or less unless extreme wetting of the subgrade occurs.

The use of a post-tensioned slab foundation will result in the reduced risk of associated distress from foundation movement as compared to a conventional spread footing foundation system, given the foundation systems ability to be rigid and withstand differential movements. As requested, the foundation recommendations that follow include PT-slabs and spread footings based on our understanding of the owner's preferences.

Acceptable performance of a PT-slab or spread footing foundation will rely on maintaining a relatively stable moisture content, and minimizing water infiltration into the underlying expansive clay by providing good surface and subsurface drainage, and using prudent landscaping and irrigation practices. The use of PT slab foundations or spread footing foundations with slab-on-grade floors should only be considered if the owner understands and accepts the risk of distress resulting from some foundation movement even though mitigation measures are used to reduce the potential for building and foundation distress resulting from ground heave.

Potential Heave: The following discussion presents estimates of ground heave to aid in the decision making process for selecting a depth of subgrade preparation. The risk of ground heave and its effect on the foundation can be reduced by providing a zone of compacted nonexpansive fill directly beneath foundations and floor slabs. Heave estimate calculations can be useful in evaluating the relative effectiveness of varying the thickness of this prepared fill zone. However, such calculations cannot address the uncertainty in the potential depth and degree of wetting or drying that may occur beneath the buildings or the variable swell potential across the site.

We have performed calculations for a range of scenarios of depth of wetting and overexcavation and backfill combinations to demonstrate the potential for ground heave if the expansive materials beneath the buildings should be thoroughly wetted to a significant depth, including below the depth of the prepared fill zone. Fills should consist of the on-site soils, sandstone bedrock or similar imported nonexpansive materials. The following table presents estimates of potential heave based on the results of swell-consolidation tests using test and analysis methods generally accepted in the Colorado Front Range. Both depth of wetting and depth of the prepared nonexpansive fill were considered as variables in the analysis.

Calculated Ground Heave (in.)			
ALTERNATIVE	Assumed Depth of Wetting (ft.)		
	5 ft	10 ft	15 ft
No Treatment	2.7	4.3	5.7
3' Overexcavation	0.8	2.4	3.7
4' Overexcavation	0.3	1.9	3.3
5' Overexcavation	0	1.6	2.9

The heave estimate calculations demonstrate that significant heave should be expected if thorough wetting of the expansive materials below the bottom of the prepared fill zone occurs, particularly if wetting extends to significant depths. However, our experience indicates the natural materials underlying the foundations on the large majority of sites with similar subsurface conditions do not experience extreme moisture increases to significant depth provided that good surface and subsurface drainage is designed, constructed and maintained, and that good irrigation practices are followed. The risk could be further reduced by eliminating landscape irrigation within about 15 to 20 feet of the buildings and limiting irrigation elsewhere on site. Wetting can also occur as a result of unforeseeable influences such as plumbing leaks or breaks, or adverse surface or subsurface drainage from adjacent future developments.

With proper site preparation, PT slabs, and shallow spread footing foundations with slab-on-grade floors should be feasible. Proper site preparation should include complete removal of topsoil and organic materials, and existing non-engineered fills where present within the proposed building footprints and beneath other structures, down to the natural soils or bedrock and replacement with nonexpansive structural fill. Any clay or claystone bedrock encountered within 5 feet of the base of spread footing foundations and floor slabs and within 4 feet of PT slab foundations (as referenced from the bottom the lowest portion of the foundation element/rib) should be removed and replaced with a suitable structural fill. The approximate limits of overexcavation should be evaluated once the site layout and proposed grading have been determined.

The on-site native soils and sandstone bedrock will be suitable for reuse as nonexpansive fill, including structural fill beneath foundations, exterior flatwork, pool and pavements. The existing fill encountered is also suitable for reuse, minus any deleterious materials. The "Site Grading and Earthwork" section of the report provides additional discussion.

FOUNDATION RECOMMENDATIONS

PT-Slab Foundations: We assume the PT-slab foundation will be designed in accordance with the Post-Tensioning Institute's (PTI) publication "Design of Post-Tensioned Slabs-On-Ground (Third Edition, 2004)" with the 2008 supplement. The design method is empirical and was developed in other parts of the country based on assumptions relating clay mineralogy and climate to the soil swell characteristics. Using the PTI design procedure, the PT-slab foundations are designed for differential uplift and settlement of the slab edges, relative to the slab center, caused by seasonal swelling and shrinking cycles of the clay soils supporting the slab.

The PTI design method does not take into account the swell characteristics of highly overconsolidated clay materials, including soils found along the Colorado front range, which are prone to swell but are rarely observed to shrink. Nor does the method use direct measurement of the material swell characteristics, as is routinely done for foundation design in the Colorado front range area. However, our experience indicates that PT-slabs designed using the PTI design methods perform well when the slabs are supported on a layer of fill consisting of on-site or imported moisture-conditioned materials. Because the thickness of the moisture-conditioned fill generally does not extend to the anticipated depth of potential wetting and uplift, the remaining untreated expansive materials have the potential to cause uplift. However, the contribution of the remaining deeper expansive materials to differential uplift is considered to be significantly less than the shallower materials.

The design and construction criteria presented below should be observed for a PT-slab foundation. The construction details should be considered when preparing project documents.

1. We recommend that PT-slab foundations be supported on the native granular soils, sandstone bedrock, or properly compacted nonexpansive fill. Clay or claystone encountered within 4 feet of the base of the foundation should be removed and replaced with suitable structural fill in accordance with the criteria presented in the "Site Grading and Earthwork" section of the report. The base of the foundation should be defined as the bottom of the lowest element of the PT-slab (the bottom of the foundation ribs would be considered the lowest point).
2. Any areas of existing fill, loose or soft material encountered within the foundation excavation should be removed and replaced with structural fill meeting the material and placement requirements outlined in the "Site Grading and Earthwork" section of this report. New

structural fill should extend down from the edges of the foundations at a 1 horizontal to 1 vertical projection.

3. PT-slab foundations bearing on compacted suitable fill material placed as recommended herein should be designed for a maximum allowable bearing pressure of 2,500 psf.
4. Based on the method in PTI's Third Edition, the PT-slabs should be designed using the following criteria:

Criteria	Center Lift	Edge Lift
Moisture variation (e_m) (ft.)	5.3	2.6
Differential swell (y_m) (in.)	0.19	0.43

5. The parameters used to calculate these values include a soil suction (pF) of 3.9 and a Mineral Classification of Zone III. These parameters were selected from the PTI design manual based on soil index parameters; they are not actual measurements or estimates of soil suction and soil moisture distributions across the site.
6. PT-slab beam elements around the slab perimeters and beneath unheated areas should be provided with adequate soil cover above their bearing elevation for frost protection. A cover of at least 30 inches is typically used in this area.
7. Once the building pad area has been prepared as described above, it should be protected from excessive wetting or drying until after the foundation has been completed.
8. Proper construction is essential for the adequate performance of a PT-slab foundation. We recommend a contractor experienced in PT-slab construction in this area be retained.
9. A representative of the geotechnical engineer should confirm proper subgrade preparations have been met prior to placing foundation formwork. Loose or disturbed material should be removed from the slab subgrade prior to placement of concrete. Placement of structural fill should be observed and tested by a representative of the geotechnical engineer. In addition, representatives of the geotechnical and/or structural engineer should check reinforcement placement immediately prior to concrete placement.

Spread Footings: As discussed previously, it is our opinion that the proposed buildings may be founded on spread footings bearing on the native granular soils, sandstone or properly compacted structural fill. Existing fill and expansive clay and claystone materials will require overexcavation as discussed in the "Site Grading and Earthwork" section. The design and construction criteria presented below should be observed for a spread footing foundation system. The construction details should be considered when preparing project documents.

1. We recommend that spread footing foundations be supported on the native granular soils, sandstone bedrock, or properly compacted nonexpansive fill. Clay or claystone encountered within 5 feet of the foundation bearing elevation should be removed and replaced with structural fill in accordance with the criteria presented in the "Site Grading and Earthwork" section of the report.
2. Any areas of existing fill, loose or soft material encountered within the foundation excavation should be removed and replaced with structural fill meeting the material and placement requirements outlined in the "Site Grading and Earthwork" section of this report. New structural fill should extend down from the edges of the foundations at a 1 horizontal to 1 vertical projection.
3. Footings supported on the native granular materials or properly compacted structural fill as recommended herein should be designed for an allowable soil bearing pressure of 2,500 psf.
4. The footings for buildings in areas requiring overexcavation of the clay or claystone should also be designed for a minimum dead load pressure of 800 psf. In order to satisfy the minimum dead load pressure and minimum footing width criteria, it may be necessary to concentrate loads by using a grade beam and pad or similar foundation design. If this system is used, a void should be provided beneath the grade beams between pads. Wall-on-grade construction is not acceptable to achieve the minimum dead load.
5. Spread footings should have a minimum footing width of 16 inches for continuous footings and of 24 inches for isolated pads.

6. Exterior footings and footings beneath unheated areas should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of foundations at least 30 inches below the exterior grade is typically used in this area.
7. Criteria for the lateral resistance of a spread footing placed on native granular materials or properly compacted structural fill is presented in the "Foundation Walls & Retaining Structures" section of this report.
8. Continuous foundation walls should be reinforced top and bottom to span an unsupported length of at least 10 feet.
9. Granular foundation soils should be densified with a smooth vibratory compactor prior to placement of formwork and reinforcing steel.
10. A representative of the geotechnical engineer should confirm proper subgrade preparations have been met prior to placing foundation formwork. Loose disturbed material should be removed from the foundation subgrade prior to placement of concrete. Placement of structural fill should be observed and tested by a representative of the geotechnical engineer. In addition, representatives of the geotechnical and/or structural engineer should check reinforcement placement immediately prior to concrete placement.

SITE SEISMIC CRITERIA

Using estimated shear wave velocities for the subgrade materials encountered based on standard penetration testing, calculations indicate a design Site Class D per the International Building Code (IBC). Based on the subsurface profile and the anticipated ground conditions, liquefaction is not a design consideration.

FLOOR SLABS

The native granular soils, sandstone bedrock, or reconditioned fill are suitable to support light to moderately loaded slab-on-grade construction. Where shallow expansive clay or claystone is present near the proposed floor slab elevation, floor slabs will present a difficult problem because sufficient dead load cannot be imposed on them to resist the uplift pressure generated when the materials are wetted and expand. The most positive method to avoid damage as a result of floor slab movement is to construct a structural floor above a well-ventilated crawl space. Based on the moisture-volume change characteristics of the materials encountered, we believe slab-on-ground construction may be

used in conjunction with buildings that will utilize spread footing foundations, provided the risk of distress resulting from slab movement is accepted by the owner. The “Geotechnical Considerations” section discusses the anticipated movement potential.

The following measures should be taken to reduce the damage which could result from movement should the underslab materials be subjected to moisture changes.

1. Existing fill, clay and claystone, where encountered below the floor slab, should be overexcavated and replaced with suitable nonexpansive fill per the depths and criteria presented in the “Site Grading and Earthwork” section of the report.
2. Floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement.
3. Applicable for buildings that will require overexcavation of clay or claystone, interior non-bearing partitions resting on floor slabs should be provided with slip joints at the bottoms so that, if the slabs move, the movement cannot be transmitted to the upper structure. This detail is also important for wallboards, stairways and door frames. Slip joints which will allow at least 2 inches of vertical movement are recommended.
4. Floor slabs should not extend beneath exterior doors or over foundation grade beams, unless saw cut at the beam after construction.
5. Floor slab control joints should be used to reduce damage due to shrinkage cracking. The appropriate joint spacing is dependent on slab thickness, concrete aggregate size and slump, and should be consistent with recognized guidelines such as those of the Portland Cement Association (PCA) or American Concrete Institute (ACI). The joint spacing and any requirements for slab reinforcement should be established by the designer based on experience and the intended slab use.
6. If moisture-sensitive floor coverings will be used, mitigation of moisture penetration into the slabs, such as by use of a vapor barrier, may be required. If an impervious vapor barrier membrane is used, special precautions will be required to reduce potential differential curing problems which could cause the slabs to warp. Section 302.1R of the ACI Manual of Concrete Practice addresses this topic.

7. All plumbing lines should be tested before operation. Where plumbing lines or other slab protrusions enter through the floor, a positive bond break should be provided. Flexible connections should be provided for slab-bearing mechanical equipment.

The precautions and recommendations itemized above will not prevent the movement of floor slabs if the underlying expansive materials are subjected to alternate wetting and drying cycles. However, the precautions should reduce the damage if such movement occurs.

FOUNDATION WALLS AND RETAINING STRUCTURES

Foundation walls and retaining structures which are laterally supported and can be expected to undergo only a moderate amount of deflection should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 55 pcf for backfill consisting of the on-site granular soils, or 50 pcf if a imported CDOT Class I structural backfill is used. Cantilevered retaining structures which can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 45 pcf for backfill consisting of the on-site granular soils, or 40 pcf for CDOT Class I structural backfill.

All foundation and retaining structures should be designed for appropriate hydrostatic and surcharge pressures such as adjacent buildings, traffic, construction materials and equipment. The pressures recommended above assume drained conditions behind the walls and a horizontal backfill surface. The buildup of water behind a wall or an upward sloping backfill surface will increase the lateral pressure imposed on a foundation wall or retaining structure.

The lateral resistance of a foundation or retaining wall footing placed on undisturbed native granular soils or properly compacted structural fill material will be a combination of the sliding resistance of the foundation on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings may be calculated based on an allowable coefficient of friction of 0.3. Passive pressure against the sides of the footings may be calculated using an allowable equivalent fluid unit weight of 180 pcf.

The onsite soils, minus any clay soils or claystone, are suitable for use as wall backfill. Imported granular wall back fill, if used, should meet the requirements of a CDOT Class I structural backfill with less than 20% passing the No. 200 sieve. Proposed material should be approved by the geotechnical engineer prior to use.

The granular backfill behind foundation and retaining walls should be sloped from the base of the wall at an angle of at least 45 degrees from the vertical. Backfill should be placed in uniform lifts and compacted to the criteria presented in the "Site Grading and Earthwork" section of the report. Care should be taken not to overcompact the backfill since this could cause excessive lateral pressure on the walls. Some settlement of deep foundation wall backfills will occur even if the material is placed properly.

EXTERIOR FLATWORK

The following discussion applies to areas where shallow expansive clay or claystone is present near the proposed foundation, floor slab, pavement or pool grades. The limits should be evaluated once the site layout and proposed grading have been determined.

It is extremely important that exterior flatwork and pavements be isolated from the building foundations and other structures. Many problems associated with expansive materials are related to ineffective isolation between pavements and exterior slabs relative to foundation-supported components of structures. Careful design detailing is necessary at locations such as exterior stairway landings and entry points.

We recommend subgrade preparation beneath exterior flatwork immediately adjacent to the buildings and pool, and within a 10-foot zone around the perimeter of the buildings and pool including sidewalks and patio areas, where reduction of heave potential is considered critical be done to the same requirement of overexcavation required for the structure, including depth of overexcavation and backfilling with compacted fill.

In pavement areas, we recommend the clay and claystone materials be removed and replaced with nonexpansive fill where encountered within 2 feet of the pavement grade. If the client can tolerate a greater risk of movement, subgrade preparation for exterior flatwork may be done as per the pavement subgrade requirements. Reference the "Pavement Design" section of this report for additional discussion. Proper surface drainage measures as recommended in "Surface Drainage" section of this report are also critical to reducing moisture or frost-related movement.

Upward heave-related movement or settlement of fill of exterior flatwork adjacent to the building or pool may result in adverse drainage conditions with runoff directed toward the structure. In addition, upward movement of exterior flatwork may restrict movement of outward swinging doors. Site grading and drainage design should consider those possibilities, particularly at entryways. Positive drainage and grades should be maintained throughout the life of the facility.

WATER SOLUBLE SULFATES

The concentration of water soluble sulfates measured in samples of the on-site soils obtained from the borings ranged from less than 0.01% to approximately 0.03%. These concentrations of water soluble sulfates represent Class 0 severity exposures to sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of Class 0, Class 1, Class 2, and Class 3 severity exposure as presented in ACI 201. Based on the laboratory data and our experience, we believe special sulfate resistant cement will not be required for concrete exposed to the on-site soils. Concrete containing Type I or I/II cement is commonly used in the area, and is recommended for this project due to its availability.

SWIMMING POOL

Boring 1 was drilled in the vicinity of pool area, and encountered granular soil types to a depth of 13 feet, followed by clay and claystone. The granular soils are considered to be suitable for the proposed construction. Any clay or claystone encountered within 5 feet of the pool will require overexcavation and replacement with nonexpansive fill as described below. Proper design and construction of below-ground pool structures is critical to their satisfactory performance. Based on the subsurface conditions, we suggest the following precautions be taken in the design and construction of the proposed pool.

1. The pool should be designed and constructed to withstand some differential movement without serious cracking.
2. Clay and claystone encountered within 5 feet beneath the pool bottom should be removed and replaced with a suitable nonexpansive fill, compacted in accordance with the "Site Grading and Earthwork" section of this report. The determined overexcavation depth should be uniform within the pool footprint to reduce the potential for excessive differential settlements. The overexcavation limits should also follow the criteria discussed in the "Exterior Flatwork" section of the report, as applicable for the deck and any adjacent flatwork.
3. A minimum 6-inch free-draining gravel layer above a bituminous liner or equivalent impermeable membrane should be placed beneath the pools. The drainage layer should slope to a drain line or collection point from which water can be removed by pumping or gravity drainage. The pool should be designed to resist hydrostatic uplift forces. The pool designer should determine the suitability/ requirements of any underdrain systems.

4. A water-tight joint should be provided between the pool and deck so that water splashed from the pool will not infiltrate into the pool backfill soils. The deck should be properly maintained, including sealing of cracks which develop on the deck while the pool is in service, to mitigate water infiltration.
5. The pool deck and adjoining area should be sloped to drain away from the pool and to minimize ponding and infiltration of moisture into the subsoils. Lawn irrigation should be kept to a minimum adjacent to the pool. Landscape not requiring irrigation may be considered as an alternative to lawn in areas surrounding the pool.

The above measures will not eliminate the risk of damage to the pool and deck due to movement of subgrade materials, but should reduce the amount of subsurface materials becoming wetted, which should help reduce potential movement due to wetting of the subgrade materials.

UNDERDRAIN SYSTEM

For Below Grade Space: Based on our understanding that there will be no basement or below grade space, it is our opinion an underdrain system will not be necessary for the apartment buildings and other on-site buildings. If the proposed construction differs from our assumptions, we should be consulted to reevaluate the recommendations for an underdrain in these areas.

For Building Pads Requiring Overexcavation: Depending on the final site layout and grading, for buildings that will require overexcavation of the expansive clay or claystone materials, the base of the fill zone may require an underdrain system. If the overexcavation is limited to only a portion of the building footprint, or if the remaining thickness of native clay is limited below the overexcavation zone, it is our opinion an underdrain would not be necessary. This should be evaluated as part of the final design.

SURFACE DRAINAGE

Proper surface drainage is very important for acceptable performance of the buildings during construction and after the construction has been completed. Drainage recommendations provided by local, state and national entities should be followed based on the intended use. The following recommendations should be used as guidelines and changes should be made only after consultation with the geotechnical engineer.

1. Excessive wetting or drying of foundation and slab subgrades should be avoided during construction.
2. The prepared subgrade will have an increased swell potential if it is allowed to dry between completion of the subgrade preparation and when it is covered with concrete and/or backfilled. We recommend the surface of the subgrade be protected with a loose soil layer to reduce drying. Subgrade that is exposed for extended periods of time should be scarified, moisture conditioned and removed/recompacted as necessary prior to placement of concrete.
3. The ground surface surrounding the exterior of the buildings and other structures should be sloped to drain away from the foundations in all directions. We recommend a minimum slope of 12 inches in the first 10 feet in unpaved areas. Site drainage beyond the 10-foot zone should be designed to promote runoff and reduce infiltration. A minimum slope of 3 inches in the first 10 feet is recommended in the paved areas. These slopes may be changed as required for handicap access points in accordance with the Americans with Disabilities Act.
4. Ponding of water should not be allowed in backfill material or in a zone within 10 feet of foundations or foundation walls, whichever is greater.
5. Roof downspouts and drains should discharge well beyond the limits of all backfill.
6. Lawn sprinkler heads and landscaping which requires typical irrigation should be located at least 10 feet from foundations. Irrigation schemes are available which allow placement of lightly irrigated landscape near foundations in moisture sensitive soil areas. Drip irrigation heads with main lines located at least 10 feet from the foundations are acceptable provided irrigation quantities are limited.
7. Plastic membranes should not be used to cover the ground surface adjacent to foundation walls. A pervious geotextile may be used to inhibit weed growth.
8. Raised landscape edging should have periodic openings to prevent ponding of water.

9. If the nearby ground surface slopes towards a building, we recommend a swale be constructed to intercept and redirect surface runoff around and away from the building. The swale should be located a minimum of 10 feet from the foundation, and should be graded at a minimum 2% slope.

PAVEMENT DESIGN

Subgrade Materials: Based on the results of the field exploration and laboratory testing programs, the pavement subgrade materials encountered at the site classify as A-1-a, A-1-b, A-2-4, A-4, A-6 and A-7-6 with group indices ranging from 0 to 20 in accordance with the American Association of State Highway and Transportation Officials (AASHTO) soil classification system. An R-value of 5 and a resilient modulus value of 3,025 psi were assumed for design of flexible pavements, and a subgrade modulus of 50 pci was assumed for design of rigid pavements. The pavement design has also assumed any clay and claystone materials encountered within 2 feet of pavement grade would be removed and replaced with suitable nonexpansive fill.

Design Traffic: We have not been provided with site specific traffic numbers for the planned pavement areas. For pavement thickness design calculations, we have assumed an equivalent 18-kip daily load application (EDLA) of 15 for drive lanes subject to vehicle traffic and infrequent moderate to heavy vehicles, such as fire trucks and trash trucks, and an EDLA of 5 for the parking stalls restricted to automobile traffic. If it is determined that actual traffic is significantly different, we should be contacted to reevaluate the pavement thickness design.

Pavement Sections: Asphalt pavement sections were determined in accordance with the 1993 AASHTO pavement design procedures. Based on this procedure, we recommend drive lanes be constructed with 7 inches of full-depth asphalt pavement or a composite section consisting of 5 inches of asphalt over 7 inches of aggregate base course. We recommend parking stalls restricted to auto traffic be constructed with 6 inches of full-depth asphalt pavement or a composite section consisting of 4 inches of asphalt over 7 inches of base course.

We recommend trash collection areas and other areas that may have concentrated truck turning movements be paved with a 6-inch thick portland cement concrete pavement section. The use of a flexible pavement in these areas could result in pavement fatigue cracking and/or rutting/shoving of the pavement due to the concentrated wheel loads. A 6-inch portland cement concrete pavement section may also be considered in lieu of an asphalt pavement section for other pavements in the development.

Subgrade Preparation: Fill placed for support of pavements should meet the material and compaction requirements for structural fill presented in the "Site Grading and Earthwork" section of this report.

To reduce the potential magnitude of pavement heave and distress caused by swelling of the clays and shallow claystone bedrock, we recommend these materials be removed and replaced with nonexpansive fill where encountered within 2 feet of the pavement grade. At the base of the overexcavation, the entire subgrade area should be overexcavated scarified to a depth of 12 inches, moisture conditioned as necessary, and compacted to 95% of the standard Proctor (ASTM D698) maximum dry density. Increasing the depth of moisture conditioning would further reduce the magnitude of potential movements.

The pavement subgrade should be proofrolled with a heavily loaded pneumatic-tired vehicle or a heavy, smooth drum roller compactor. Pavement design procedures assume a stable subgrade. Areas that deform excessively under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to paving.

Drainage: The collection and diversion of surface drainage away from paved areas is extremely important to the satisfactory performance of pavement. Drainage design should provide for the removal of water from paved areas and prevent the wetting of the subgrade soils.

Pavement Materials: The asphalt pavement should consist of a bituminous material which meets the requirements of the Pikes Peak Region Asphalt Paving Specifications. Given the assumed traffic loading, we recommend the mix have a binder grade of PG 58-28 or PG 64-22, and a design gyrations (Ndes) of 75. In the event that a PG 64-22 asphalt binder is used in the mix, the asphalt section will provide adequate structural support but will be subject to a higher potential for low temperature related transverse cracking. The mix grading should consist of a Grading S for the lower lifts, and a grading SX for the top lift. Grading S may also be acceptable for the top lift.

Aggregate base course should be a Class 6 material conforming to the requirements presented in Section 703.03 of the CDOT Standard Specifications for Road and Bridge Construction.

Concrete pavement should meet the requirements of a Class P Mix, per Section 601 of the CDOT Standard Specifications, and should be based on a mix design established by a qualified engineer. The concrete should contain transverse joints not greater than 12 to 15 feet on centers and

longitudinal joints no greater than 14 feet. The joints should be hand formed, sawed or formed by premolded filler. The joints should be at least 1/4 of the slab thickness. Expansion joints should be provided at the end of each construction sequence and between the concrete slab and adjacent structures. Expansion joints where required, should be filled with a 1/2 inch-thick asphalt impregnated fiber. Concrete should be cured by protecting against loss of moisture, rapid temperature changes and mechanical injury for at least three days after placement. The concrete sections presented above are assumed to be unreinforced. Providing dowels at construction joints would help reduce the risk of differential movements between panel sections. Providing a grid mat of deformed rebar or welded wire mesh within the concrete pavement section would assist in mitigating corner breaks and differential panel movements. If a rebar mat is installed, we recommend that the bars be placed in the lower half of the pavement section. Also, if reinforcing is used, we have commonly seen No. 4 rebar placed at 24-inch center in each direction, however, we recommend that a structural engineer evaluate the placement and spacing of rebar if needed.

Maintenance: Periodic maintenance of paved areas is critical to achieve the design life of the pavement. Crack sealing should be performed annually as new cracks appear. Chip seals, fog seals, or slurry seals applied at approximate intervals of 3 to 5 years are usually necessary for asphalt. As conditions warrant, it may be necessary to perform patching and overlay at approximate 10-year intervals.

SITE GRADING AND EARTHWORK

Temporary Excavations: We recommend temporary excavation slopes be constructed in accordance with OSHA regulations. In accordance with OSHA criteria, the on-site native granular soils and existing fill should be considered a Type C soil due to the variability of material properties. The native clay soils classify as a Type B material, however, considering the intermittent occurrence of the clays, we recommend the overburden soils as a whole be considered a Type C material. The sandstone and claystone should be considered a Type B material. Temporary unretained excavations should have slopes no steeper than 1.5:1 (H:V) in Type C soils and 1:1 in Type B materials. A properly braced excavation or the use of a trench box should be used where the indicated unretained slopes cannot be accommodated. Flatter slopes will be required where groundwater seepage is encountered. OSHA regulations require that excavations greater than 20 feet in depth be designed by a professional engineer. If soils different from those indicated in this report are encountered, the OSHA soil type may vary and the required cut slopes may need to be adjusted. A contractor's competent person should make decisions regarding cut slopes.

Excavated slopes may soften or loosen due to construction traffic and erode from surface runoff. Measures to keep surface runoff from excavation slopes, including diversion berms, should be considered.

Excavation Considerations: In our opinion, the overburden soils and near surface bedrock encountered in the exploratory borings drilled for this study can be excavated with heavy-duty construction equipment with rippers. It is possible that localized, harder lenses of bedrock may be encountered within the excavation in portions of the site, and in particular confined excavations such as trench cuts. If harder rock is encountered, hydraulic chiseling may be required. Based on the subsurface conditions encountered, we do not anticipate dewatering to be necessary during construction.

Cut and Fill Slopes: Permanent cut and fill slopes should not be steeper than 3:1 (horizontal to vertical). Slopes will generally be stable at 2:1; however, 2:1 slopes will be prone to increased surface erosion and it will be difficult to maintain vegetation on them. The risk of slope instability will be significantly increased if seepage is encountered in cuts. If seepage is encountered in permanent excavations, an investigation should be conducted to determine if the seepage will adversely affect the cut stability.

Good surface drainage should be provided for all permanent cuts and fills to direct the surface runoff away from the slope faces. Permanent cut and fill slopes and other stripped areas should be protected against erosion by revegetation or other means. Fills should be benched into hillsides exceeding 4 horizontal to 1 vertical. Site grading should be planned to provide positive surface drainage away from all building and pavement areas.

No formal stability analyses were performed to evaluate the slopes recommended above. Published literature and our experience with similar cuts and fills indicate the recommended slopes should have adequate factors of safety. If a detailed stability analysis is required, we should be notified.

Fill Material: Unless specifically modified in the preceding sections of this report, the following recommended material and compaction requirements are presented for structural fills on the project site. A geotechnical engineer should evaluate the suitability of all proposed fill materials for the project prior to placement.

1. *Nonexpansive Structural Fill:* With proper moisture conditioning, the on-site native granular soils, clay soils, and sandstone bedrock will be suitable for reuse as nonexpansive fill, including structural fill beneath foundations, exterior flatwork, pool and pavements. The existing fill encountered is also suitable for reuse, minus any deleterious materials. Claystone should be considered unsuitable for use as structural fill. New fill should extend down from the edge of footings at a minimum 1:1 horizontal to vertical projection.

Imported structural fill, if required, should consist of nonexpansive soil material having a maximum of 50% passing the No. 200 sieve, and a maximum plasticity index of 15. (We recognize that some of the tested samples of the onsite soils do not meet these specifications; however, given the properties, it is our opinion they would be acceptable for reuse as structural fill, if properly moisture conditioned.) Import fill source materials not meeting the above liquid limit and plasticity index criteria may be acceptable (provided the minimum percentage passing the No. 200 sieve is satisfied) if the swell potential when remolded to 98% of the ASTM D 698 (standard Proctor) maximum dry density at optimum moisture content under a 200 psf surcharge pressure does not exceed 1%. Evaluation of potential sources would then require determination of laboratory moisture-density relationships and swell consolidation tests on remolded samples, thereby adding time and cost to evaluate proposed fill materials.

2. *Reuse of Claystone Bedrock:* The claystone will be expansive when placed in a compacted condition and are not suitable for use as nonexpansive fill. Placement of excavated claystone should be limited to nonstructural areas such as landscape areas to the extent practical. If necessary elsewhere, placement of these materials should be limited to deeper fills, and placed at depths 5 feet or greater from the base of foundation in building/structure locations, and 2 feet or greater in pavement areas. Claystone placed as fill should only be used if it is processed into a soil like material, with a maximum particle size of 2 inches.
3. *Utility Trench Backfill:* Materials excavated from the utility trenches may be used for trench backfill above the pipe zone fill provided they do not contain unsuitable material or particles larger than 4 inches.

4. *Material Suitability:* All fill material should be free of vegetation, brush, sod, trash and debris, and other deleterious substances, and should not contain rocks or lumps having a diameter of more than 6 inches.
5. *Subgrade Preparation:* The ground surface shall be stripped of vegetation/organics prior to fill placement. The resulting ground surface should be scarified to a depth of 12 inches, moisture conditioned as necessary, and compacted in a manner specified below for the subsequent layers of fill. Loose or unstable soils shall be removed, where present, in order to provide a stable platform prior to placement of fill.
6. *Existing Fill:* Existing fill was encountered in one of borings (Boring 11) to an approximate depth of 7 feet. Any existing fill encountered should be considered unsuitable for support of foundations, floor slabs, retaining walls and pavements, unless documentation can be provided stating it was properly compacted. We recommend the existing fill, where present in these areas, be overexcavated, moisture conditioned, and placed back properly compacted.
7. *Overexcavation of Expansive Clay and Claystone:* We recommend the expansive clays and claystone bedrock be overexcavated and replaced with a nonexpansive structural fill where present within 5 feet of the bottom of spread footing foundations, floor slabs and the pool. For PT slab foundations, we recommend a 4-foot overexcavation, as referenced from the bottom the lowest portion of the foundation element/rib. As discussed in the "Exterior Flatwork" section, the overexcavation zone should also extend 10 feet beyond each building where exterior flatwork is located, including sidewalks and patio areas, and where reduction of heave potential is considered critical. Depending on the amount of site grading planned, partial or no overexcavation may be applicable provided there is adequate separation between the foundation bearing elevation and the expansive materials. For pavement areas and other areas with movement sensitive exterior flatwork, we recommend a minimum 2-foot overexcavation and replacement. The anticipated areas that may require overexcavation should be evaluated during the final study once the site layout and proposed grading has been determined. It is expected that once grading and excavations begin, we are present on site to observe test pits and assist the contractor in determining the limits of overexcavation that will be required.

Compaction Requirements: A representative of the geotechnical engineer should observe fill placement operations on a full-time basis. We recommend the following minimum compaction criteria be used on the project.

Area	Percentage of Standard Proctor Maximum Dry Density (ASTM D 698)
Building Pads and all areas with fill depths greater than 10 feet	100%
Floor Slab Subgrade	98%
Foundation Wall Backfill	95%
Swimming Pool Subgrade	98%
Beneath Pavement Areas/Exterior Flatwork/Utility Trenches	95%
Retaining Wall Subgrade	98%
Retaining Wall Backfill	95%
Landscape and Other Misc. Overlot Fill Areas	95%
Compaction of granular soils should be achieved at a moisture content within +/- 2% of the optimum. Clay and claystone materials should be placed at a moisture content within 0% to +4% of the optimum.	

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in our report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction.

We recommend that Kumar & Associates, Inc. be retained to provide construction observation and testing services to document that the intent of this report and the requirements of the plans and specifications are being followed during construction. This will allow us to identify possible variations in subsurface conditions from those encountered during this study and to allow us to re-evaluate our recommendations, if needed. We will not be responsible for implementation of the recommendations presented in this report by others, if we are not retained to provide construction observation and testing services.

LIMITATIONS

This study has been conducted for exclusive use by the client for preliminary geotechnical related design and construction criteria for the project. The conclusions and recommendations submitted in

this report are based upon the data obtained from the exploratory borings at the locations indicated on Fig. 1 or as described in the report, and the proposed type of construction. This report may not reflect subsurface variations that occur, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

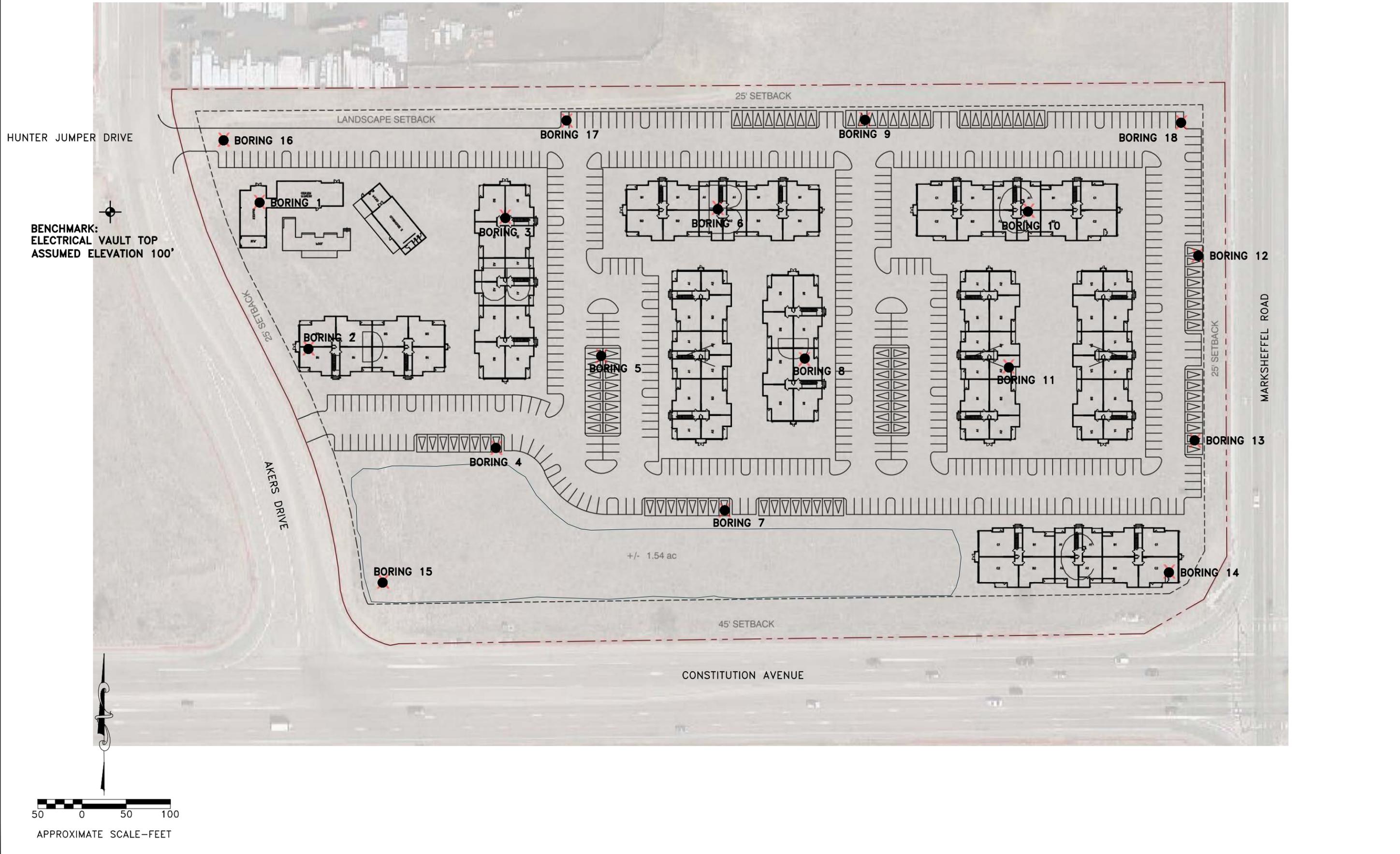
The scope of services for this project does not include identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

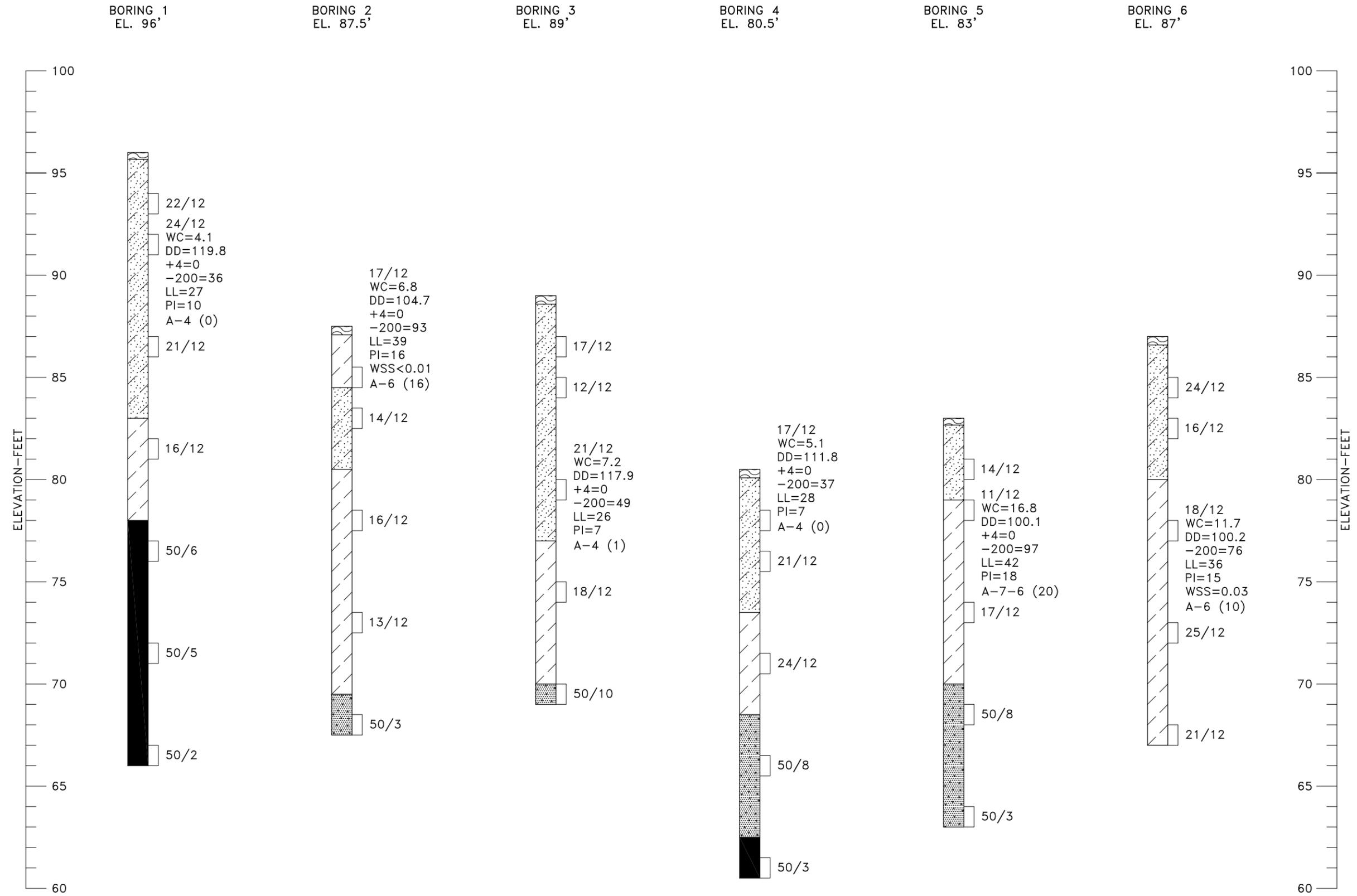
Swelling soils occur on this site. Such materials are stable at their natural moisture content but will undergo high volume changes with changes in moisture content. The extent and amount of perched water beneath the building site as a result of area irrigation and inadequate surface drainage is difficult, if not impossible, to foresee.

The recommendations presented in this report are based on current theories and experience of our engineers on the behavior of swelling soil in this area. Standards of practice in this area evolve over time. The owner should be aware that there is a risk in constructing a building in an expansive soil area. Following the recommendations given by a geotechnical engineer, careful construction practice and prudent maintenance by the owner can, however, decrease the risk of foundation movement due to expansive soils.

DPC:bj

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BORING 7
EL. 78'

BORING 8
EL. 81.5'

BORING 9
EL. 85.5'

BORING 10
EL. 82'

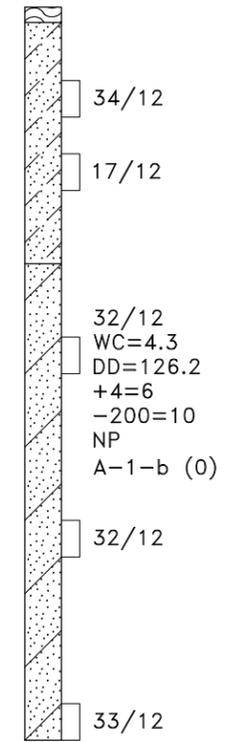
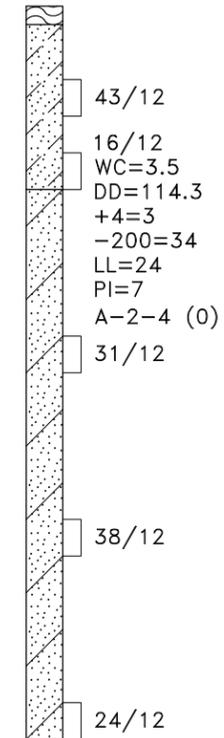
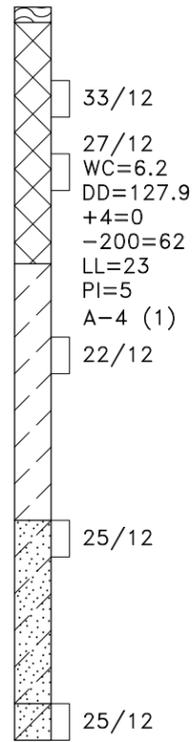
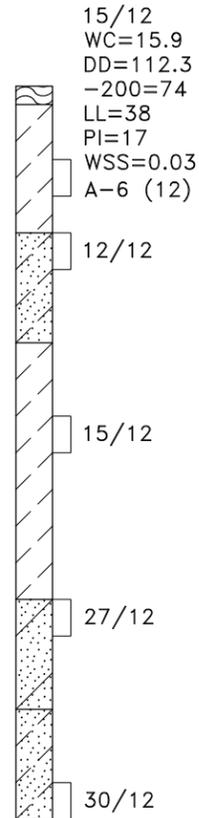
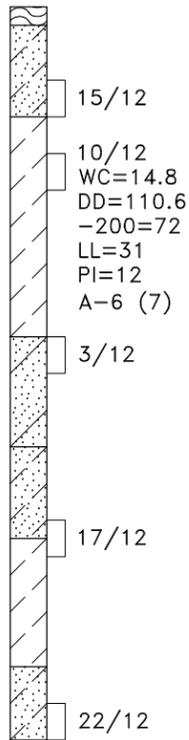
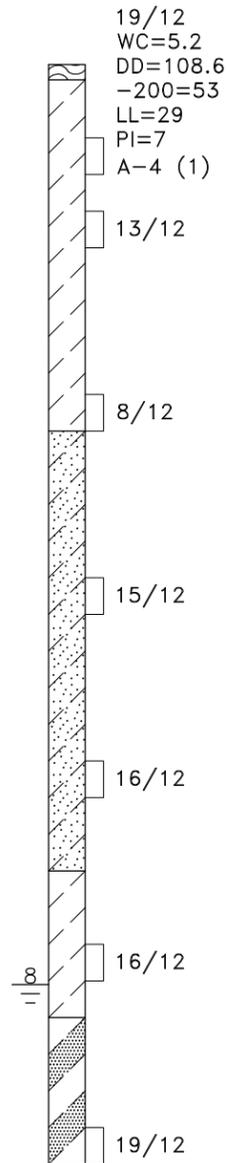
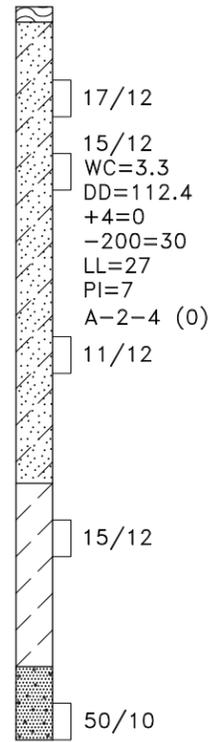
BORING 11
EL. 79'

BORING 12
EL. 82'

BORING 13
EL. 79'

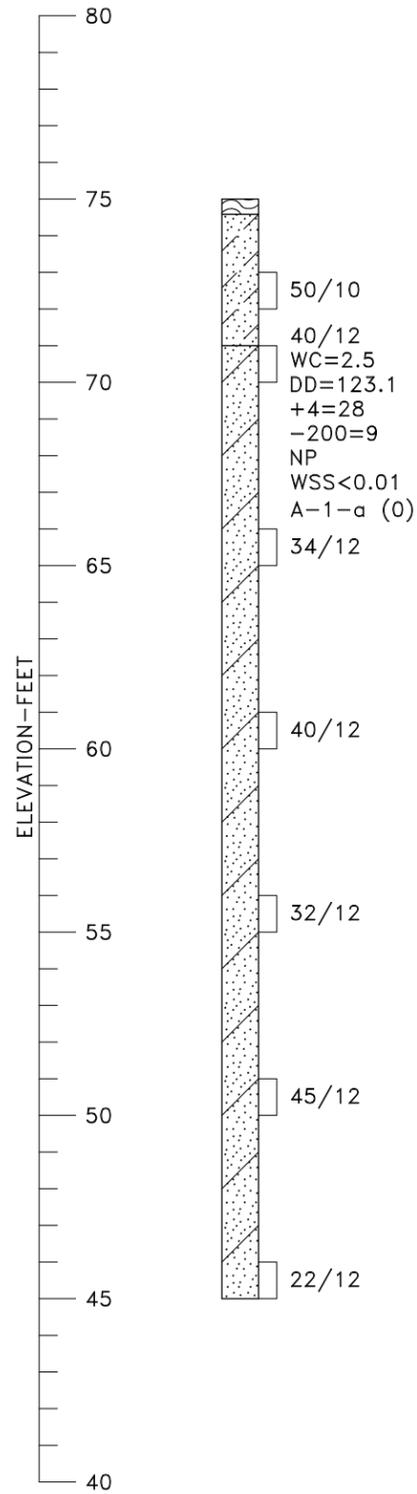
ELEVATION - FEET

ELEVATION - FEET

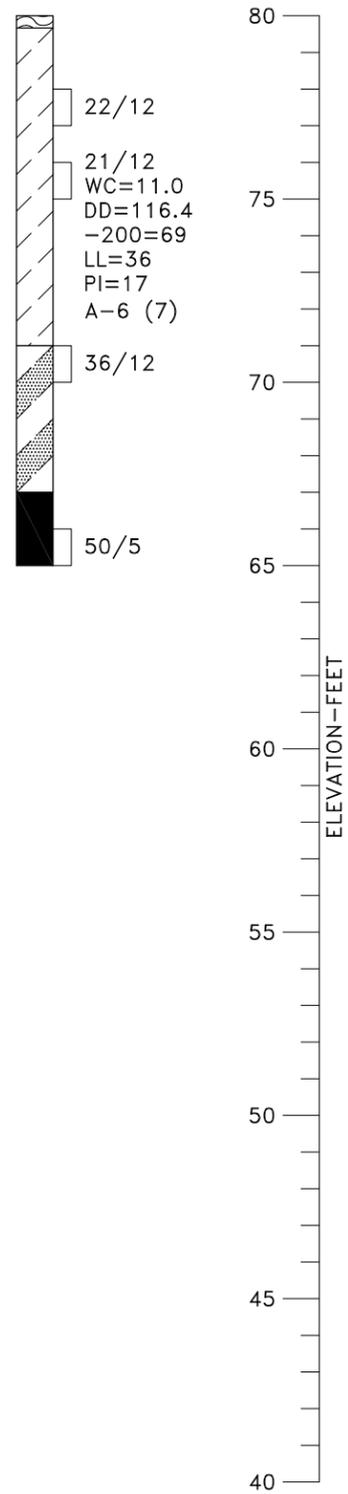


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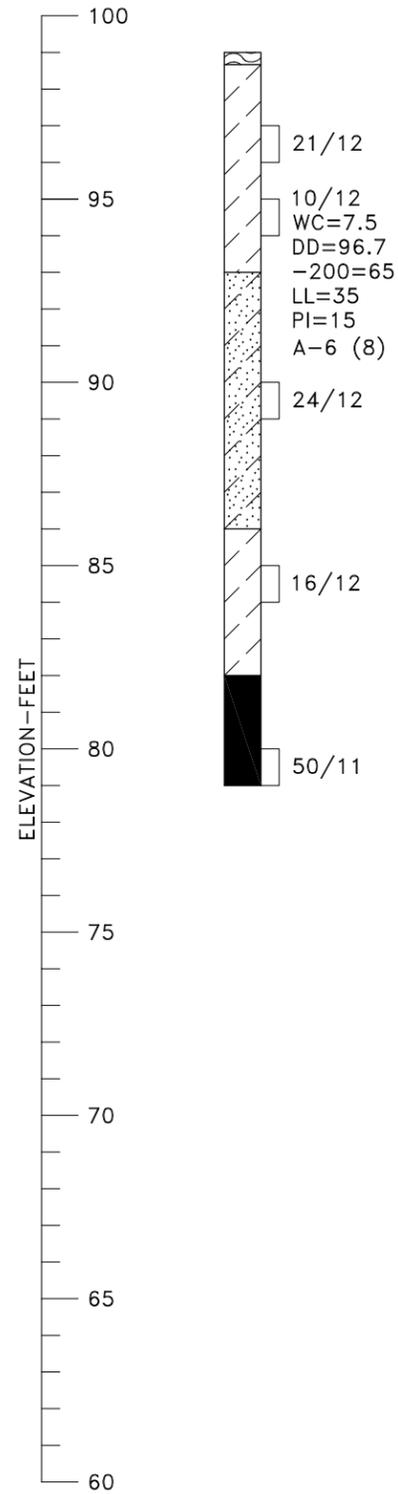
BORING 14
EL. 75'



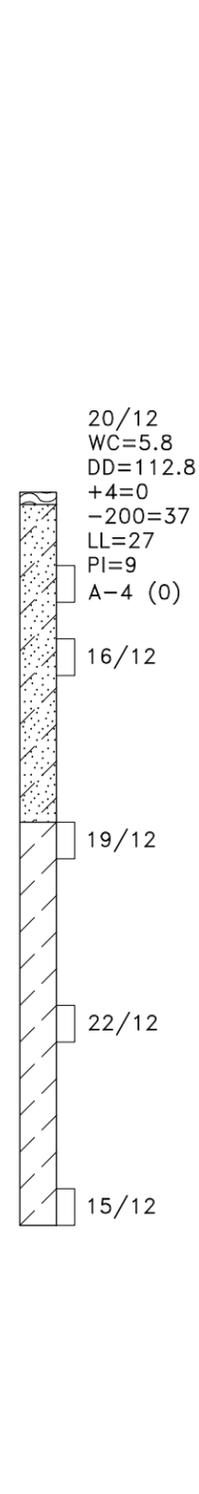
BORING 15
EL. 80'



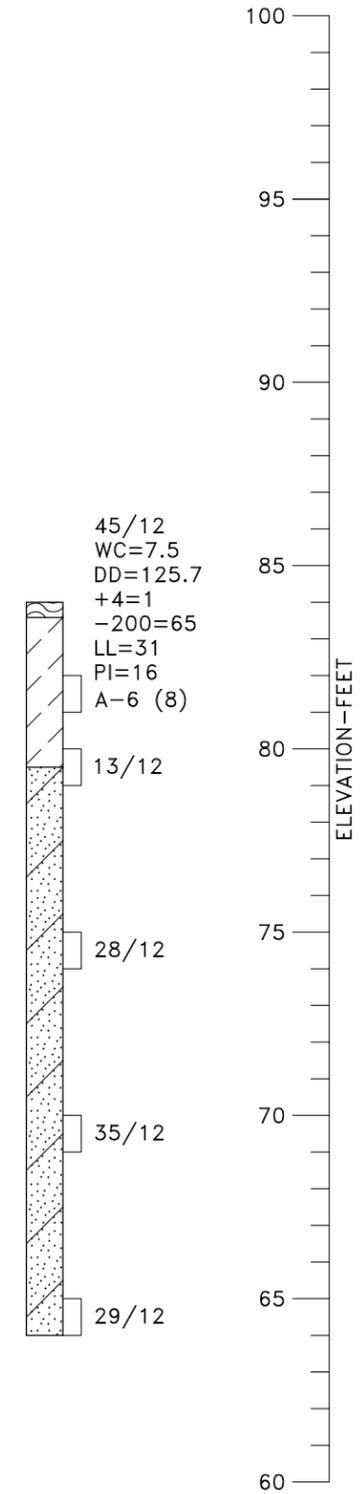
BORING 16
EL. 99'



BORING 17
EL. 87'



BORING 18
EL. 84'



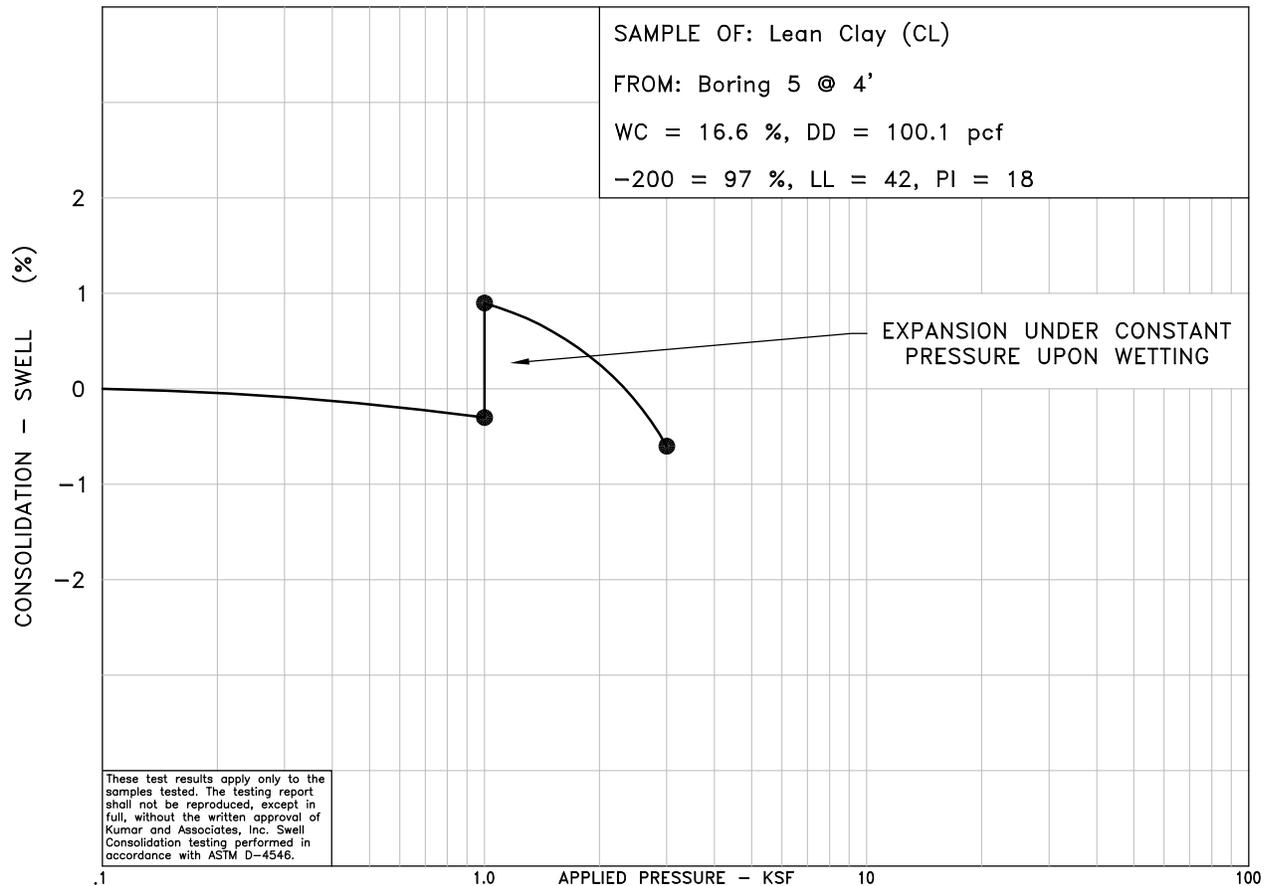
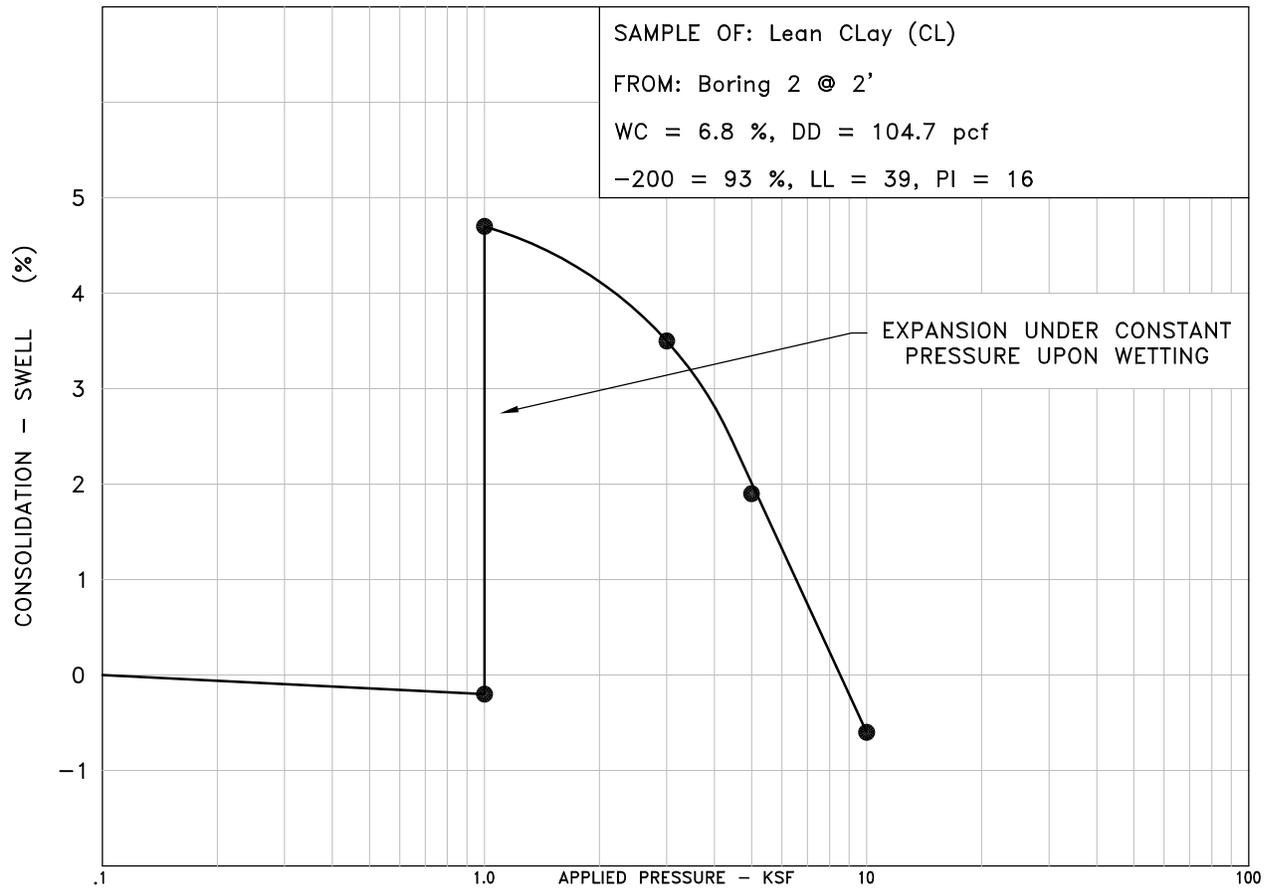
LEGEND

-  TOPSOIL.
-  FILL: CLAYEY SAND (SC) AND SANDY-SILTY CLAY (CL-ML), SLIGHTLY MOIST TO MOIST, LIGHT BROWN TO BROWN.
-  CLAYEY SAND (SC) AND SILTY-CLAYEY SAND (SC-SM), MEDIUM DENSE TO VERY DENSE, SLIGHTLY MOIST TO MOIST, TAN TO BROWN.
-  LEAN CLAY WITH VARIED AMOUNTS OF SAND (CL), WITH OCCASIONAL CLAYEY SAND (SC) LAYERS, MEDIUM STIFF TO HARD, SLIGHTLY MOIST TO MOIST, BROWN, DARK BROW AND GRAY.
-  POORLY TO WELL GRADED SAND WITH SILT (SP-SM, SW-SM), AND SILTY SAND (SM), WITH OCCASIONAL GRAVEL, VERY LOOSE TO DENSE, MOIST TO VERY MOIST, TAN TO BROWN.
-  SANDSTONE BEDROCK, POORLY CEMENTED, HARD TO VERY HARD, MOIST, BROWN.
-  WEATHERED CLAYSTONE BEDROCK, VERY STIFF TO HARD, SLIGHTLY MOIST TO MOIST, BROWN TO GRAY.
-  CLAYSTONE BEDROCK, SANDY, HARD TO VERY HARD, SLIGHTLY MOIST TO MOIST, BROWN TO DARK BROWN, AND GRAY TO DARK GRAY.
-  DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLE.
-  DISTURBED BULK SAMPLE.
- 22/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 22 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.
- $\frac{8}{1}$ DEPTH TO WATER LEVEL AND NUMBER OF DAYS AFTER DRILLING MEASUREMENT WAS MADE.

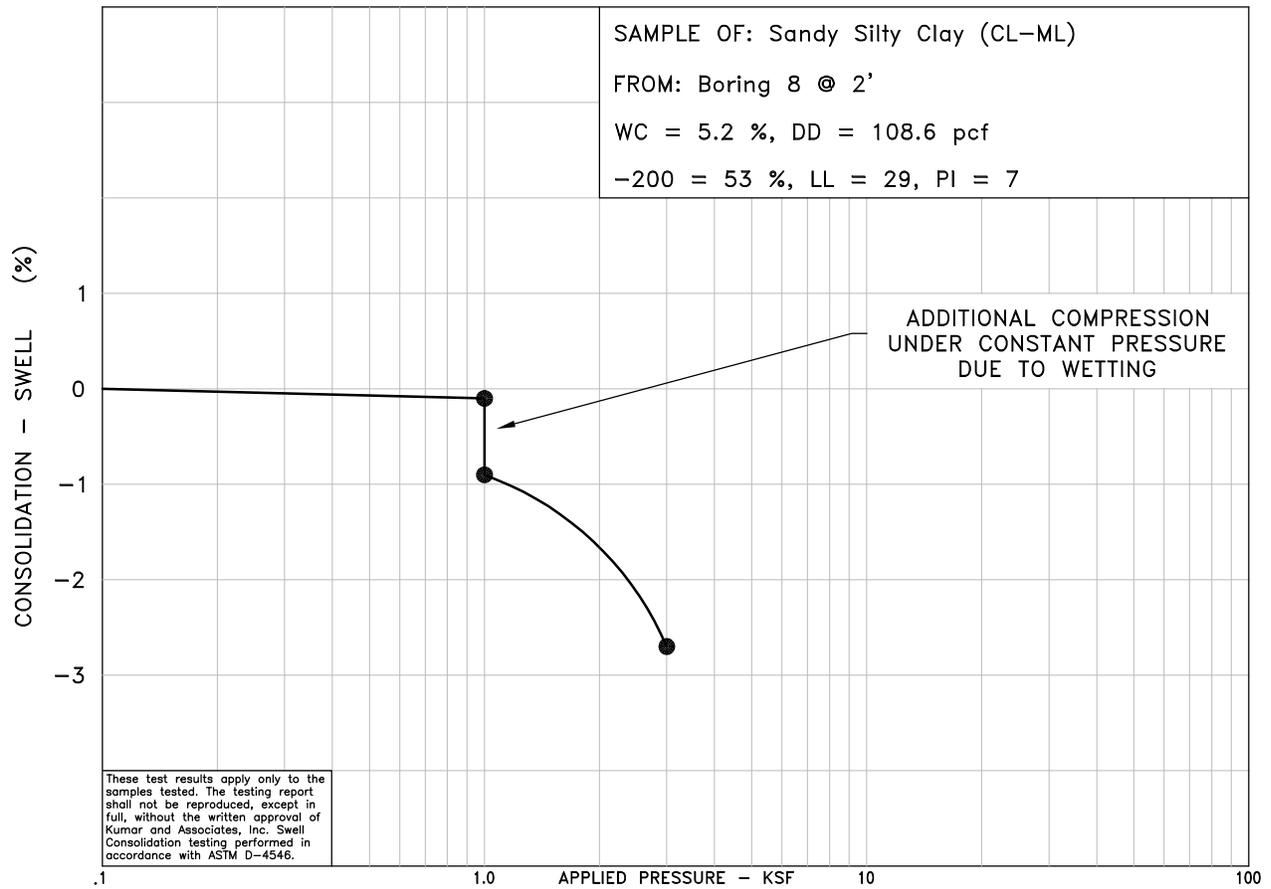
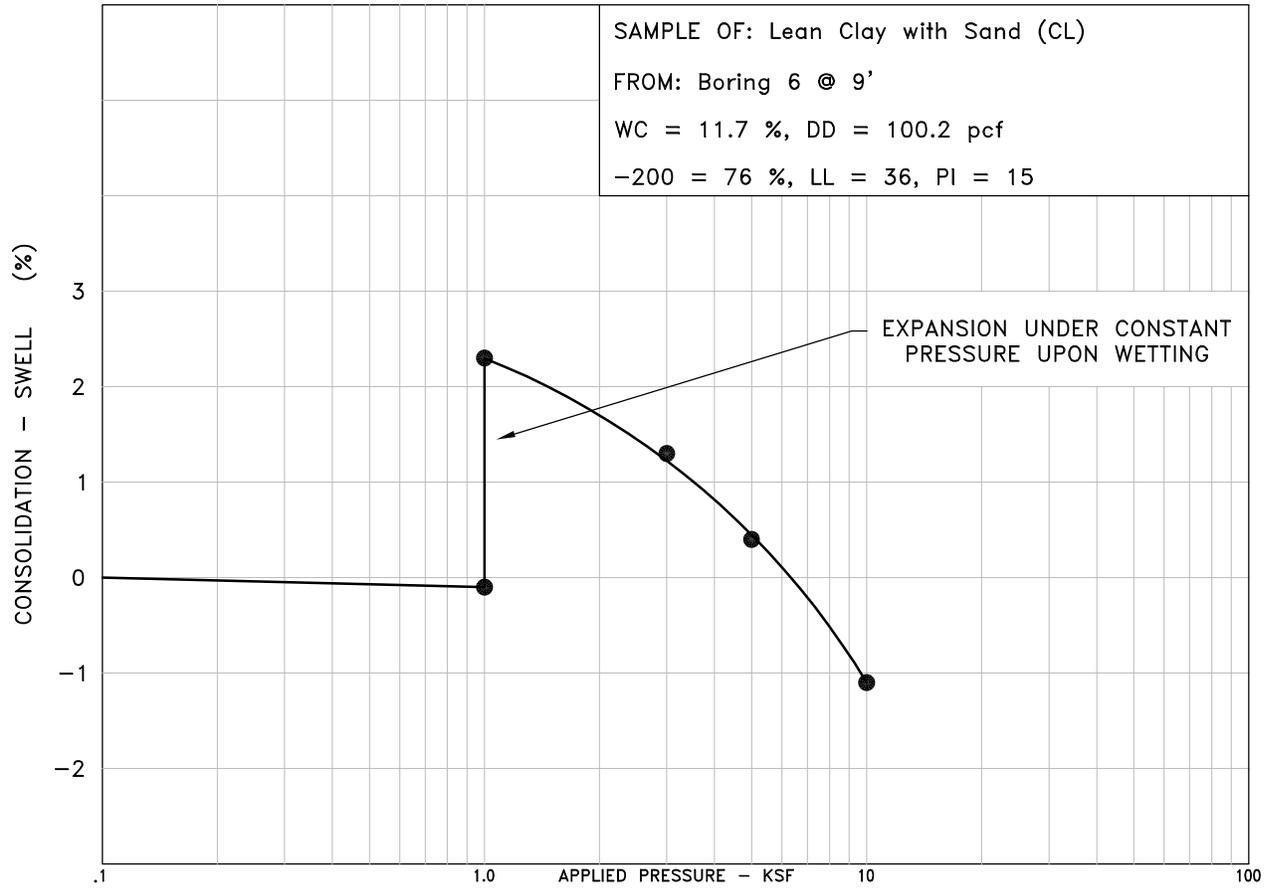
NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON AUGUST 24 AND 25, 2020 WITH A 4-INCH-DIAMETER CONTINUOUS-FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE APPROXIMATED USING A HANDHELD GPS UNIT.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE MEASURED BY HAND LEVEL AND REFER TO THE BENCHMARK ON FIG. 1.
4. THE EXPLORATORY BORING LOCATIONS AND ELEVATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
6. GROUNDWATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
7. LABORATORY TEST RESULTS:
 WC = WATER CONTENT (%) (ASTM D2216);
 DD = DRY DENSITY (pcf) (ASTM D2216);
 +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D6913);
 -200 = PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
 LL = LIQUID LIMIT (ASTM D4318);
 PI = PLASTICITY INDEX (ASTM D4318);
 NP = NON-PLASTIC (ASTM D 4318);
 WSS = WATER SOLUBLE SULFATES (%) (CP-L 2103);
 A-4 (0) = AASHTO CLASSIFICATION (GROUP INDEX) (AASHTO M145).

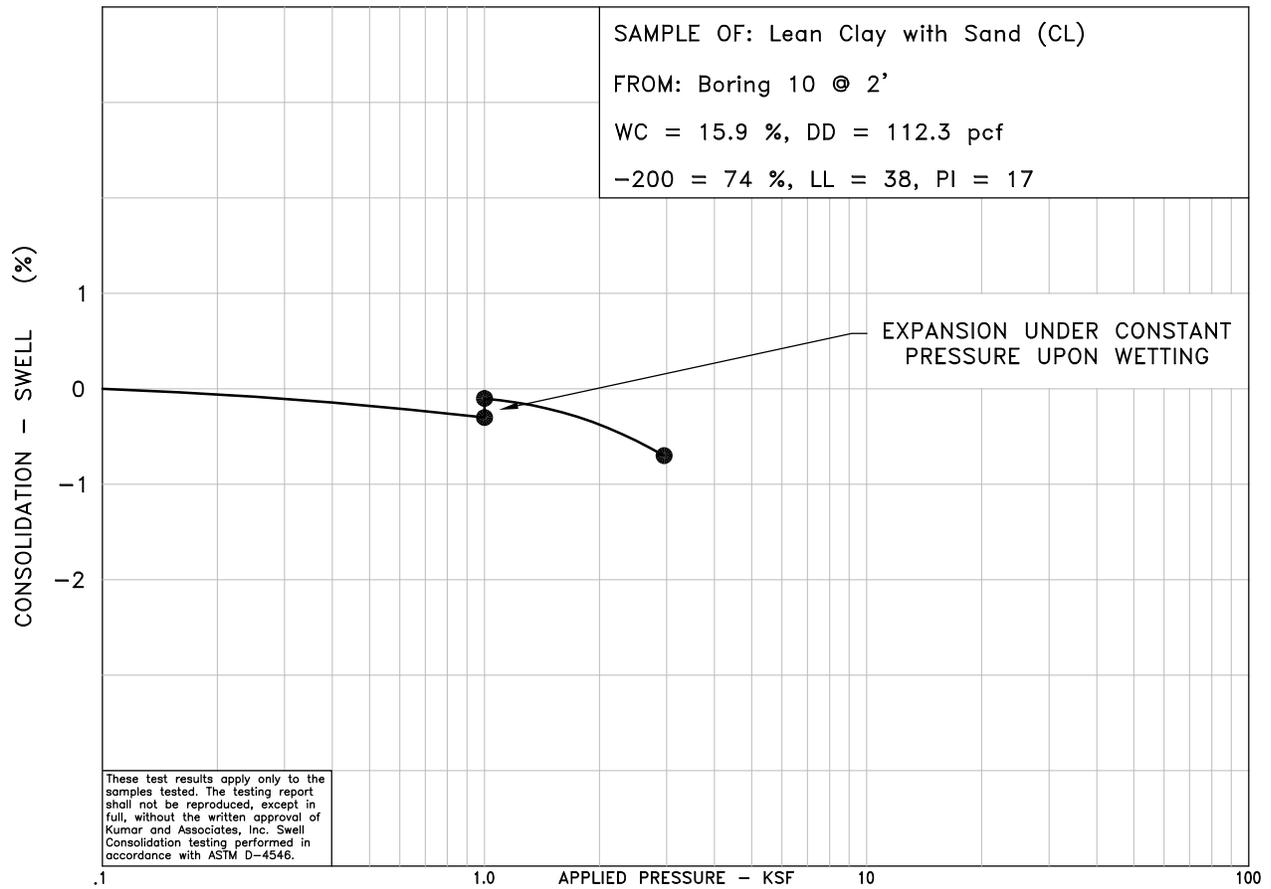
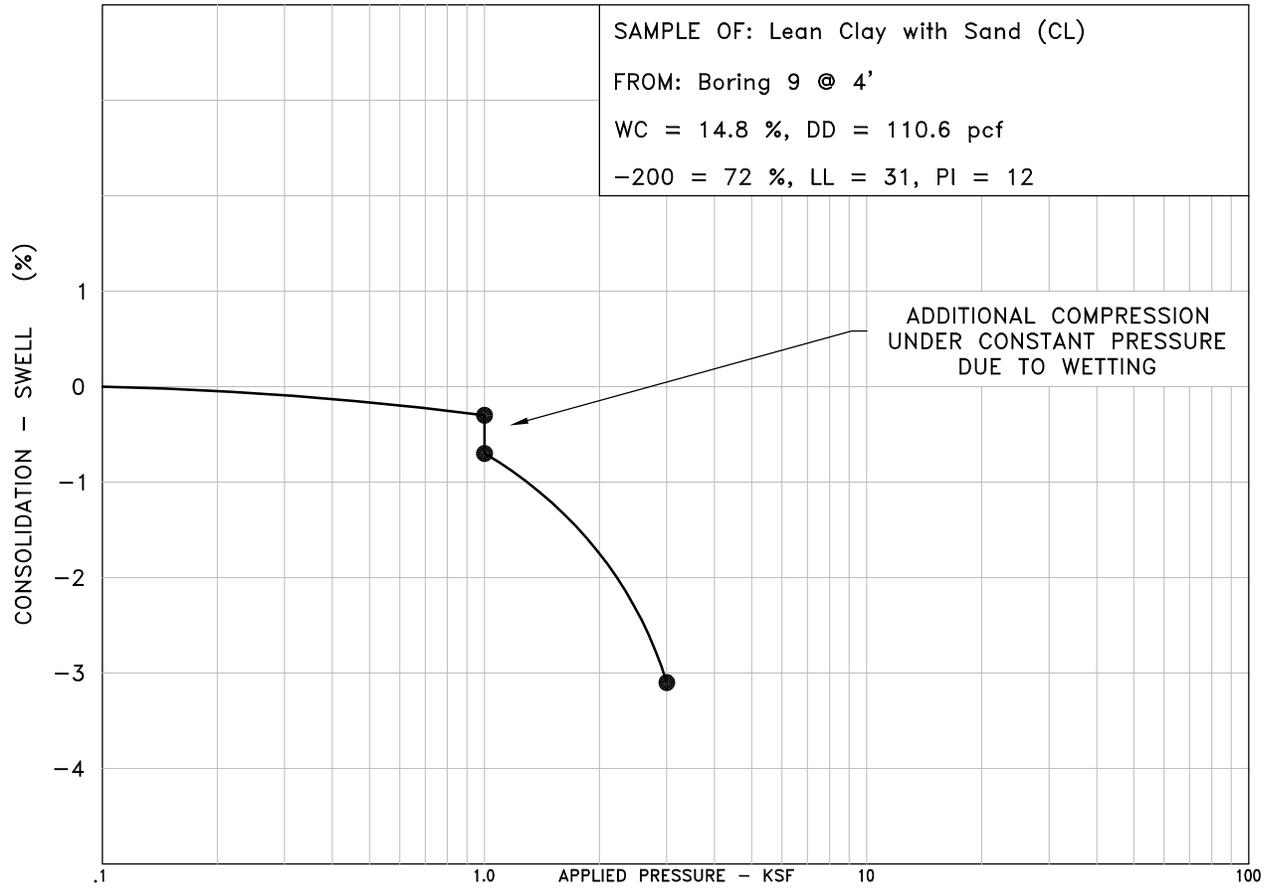
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VA\Projects\2020\20-2-194 Watermark at Colorado Springs-Akers Drive\Drafting\202194-06 to 10.dwg



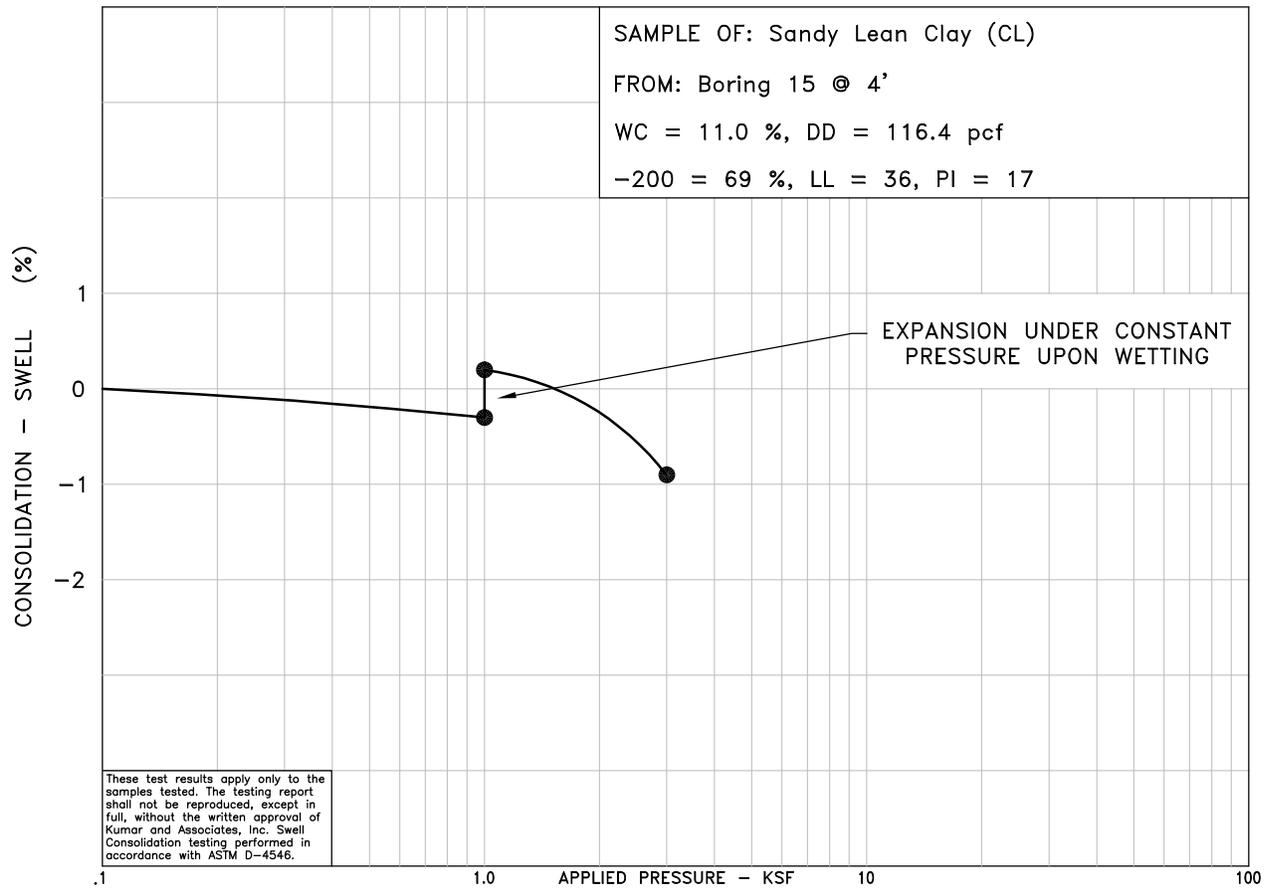
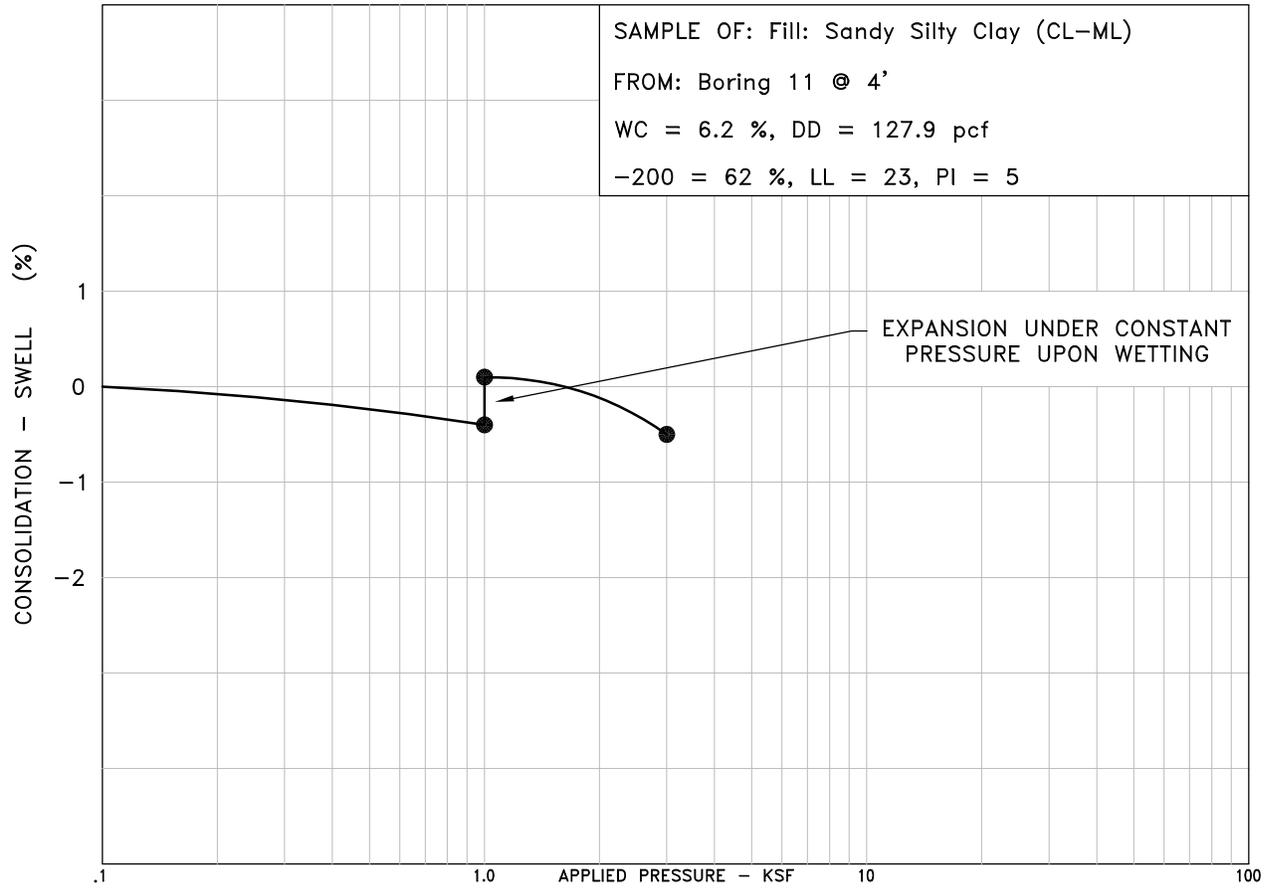
These test results apply only to the samples tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Swell Consolidation testing performed in accordance with ASTM D-4546.



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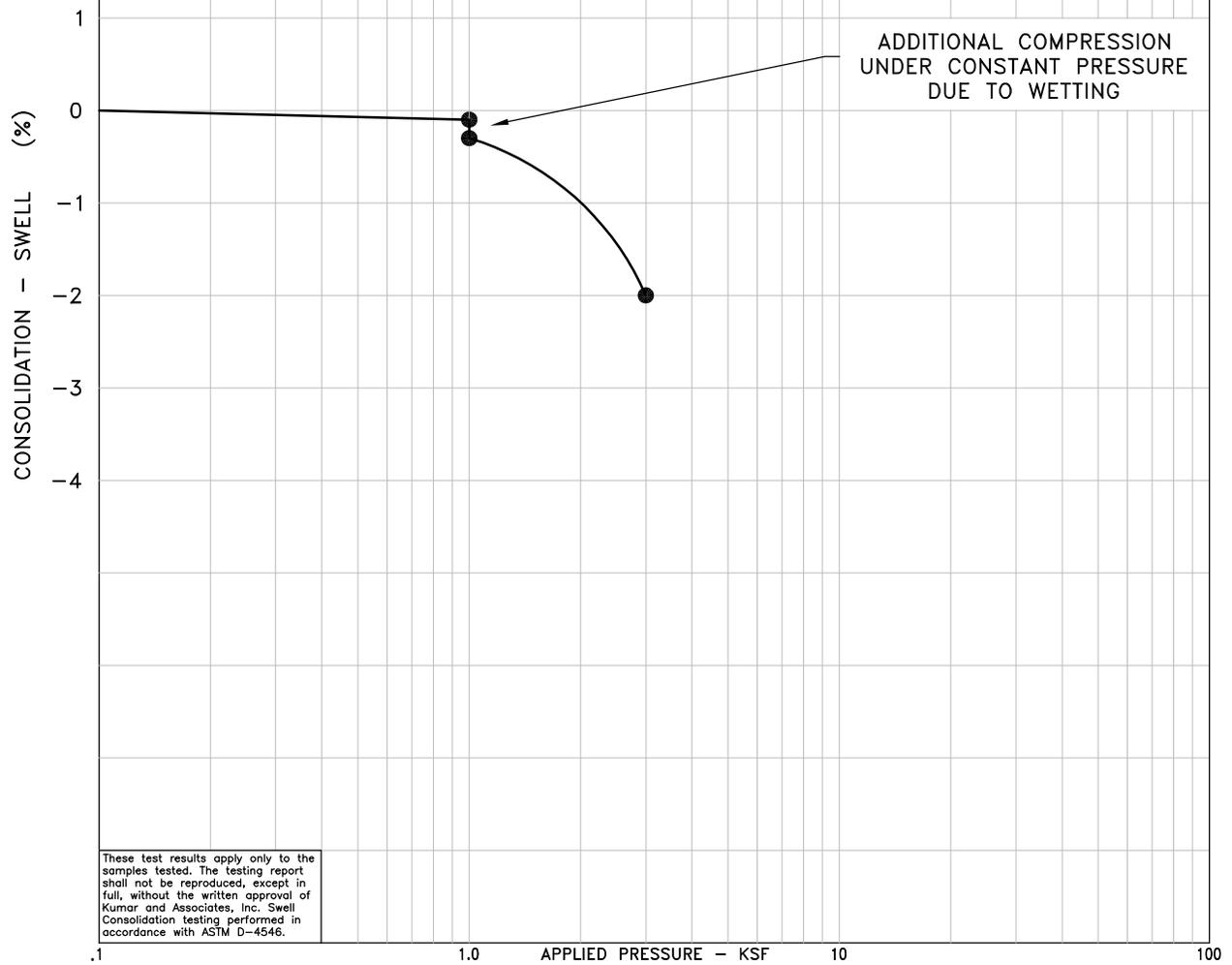


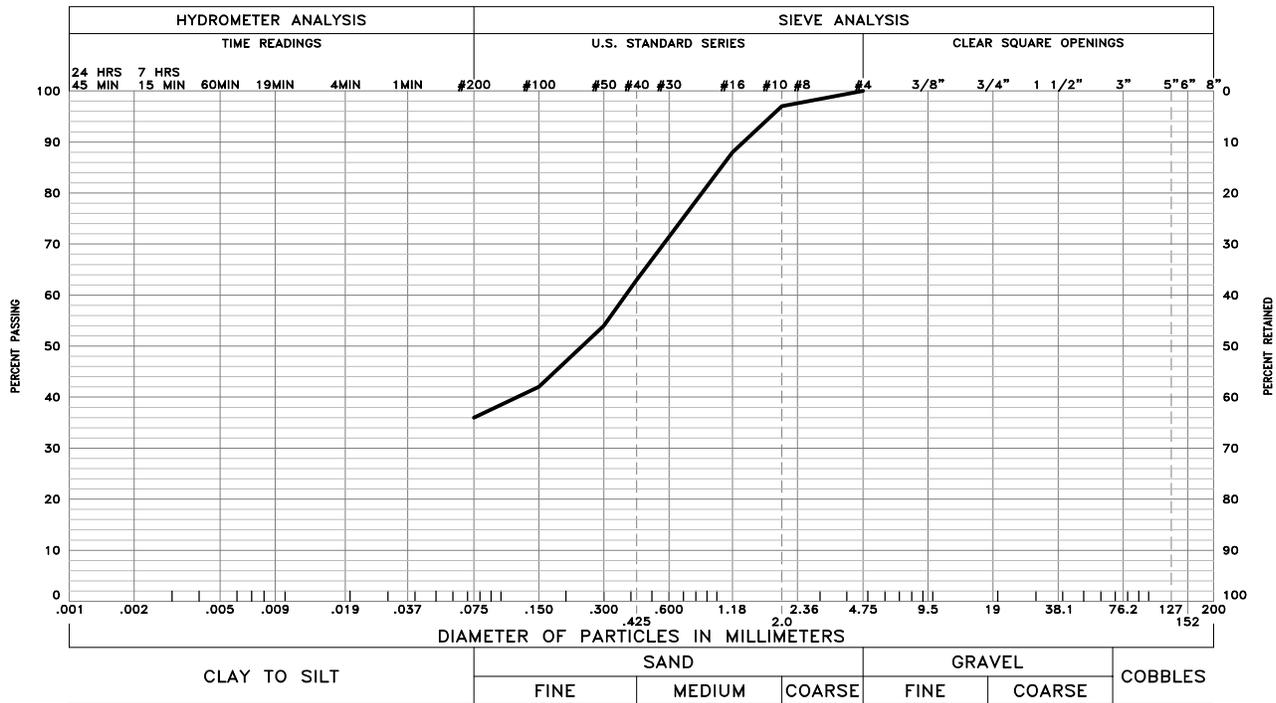
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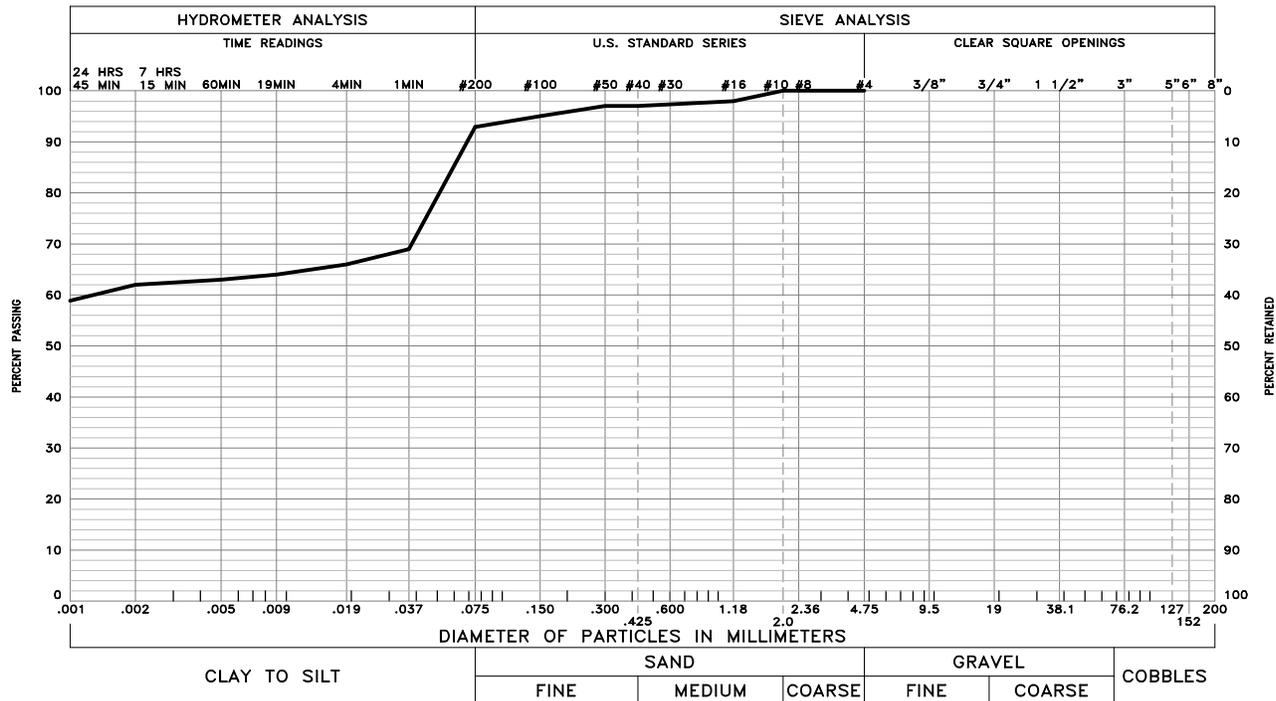
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SAMPLE OF: Sandy Lean Clay (CL)
 FROM: Boring 16 @ 4'
 WC = 7.5 %, DD = 96.7 pcf
 -200 = 65 %, LL = 35, PI = 15



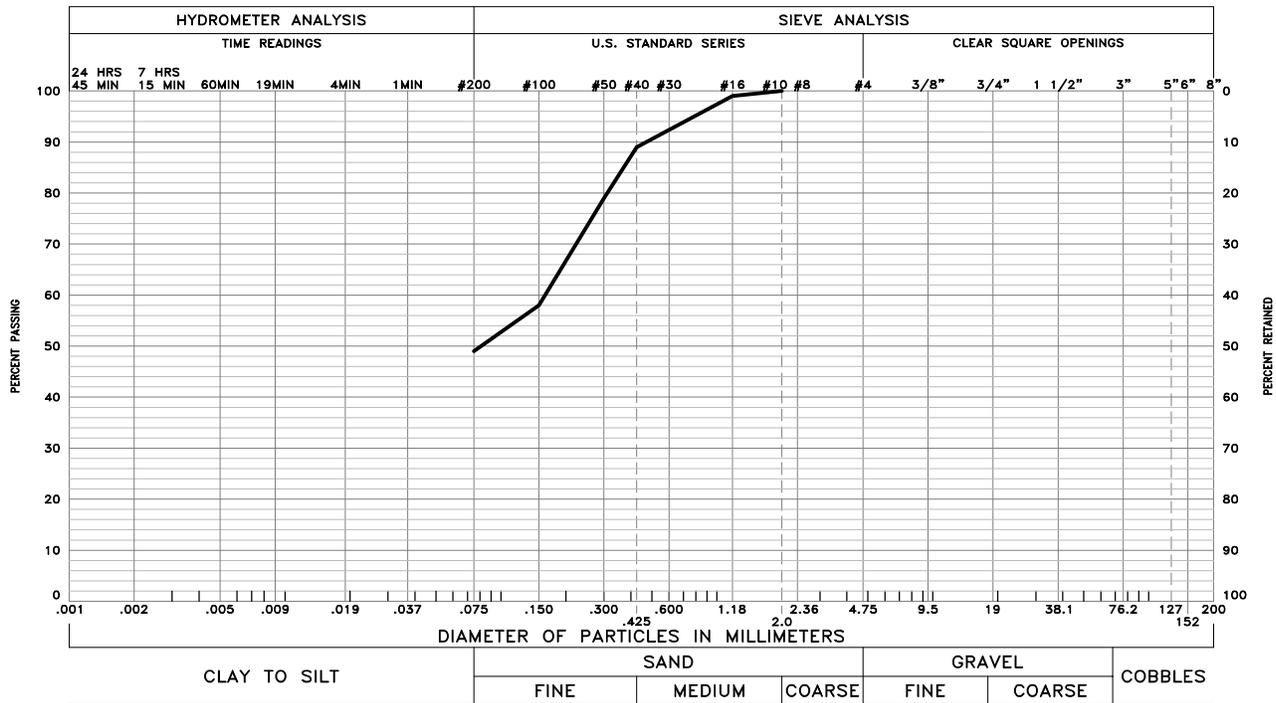


GRAVEL 0 % SAND 64 % SILT AND CLAY 36 %
 LIQUID LIMIT 27 PLASTICITY INDEX 10
 SAMPLE OF: Clayey Sand (SC) FROM: Boring 1 @ 4'



GRAVEL 0 % SAND 7 % SILT AND CLAY 93 %
 LIQUID LIMIT 39 PLASTICITY INDEX 16
 SAMPLE OF: Lean Clay (CL) FROM: Boring 2 @ 2'

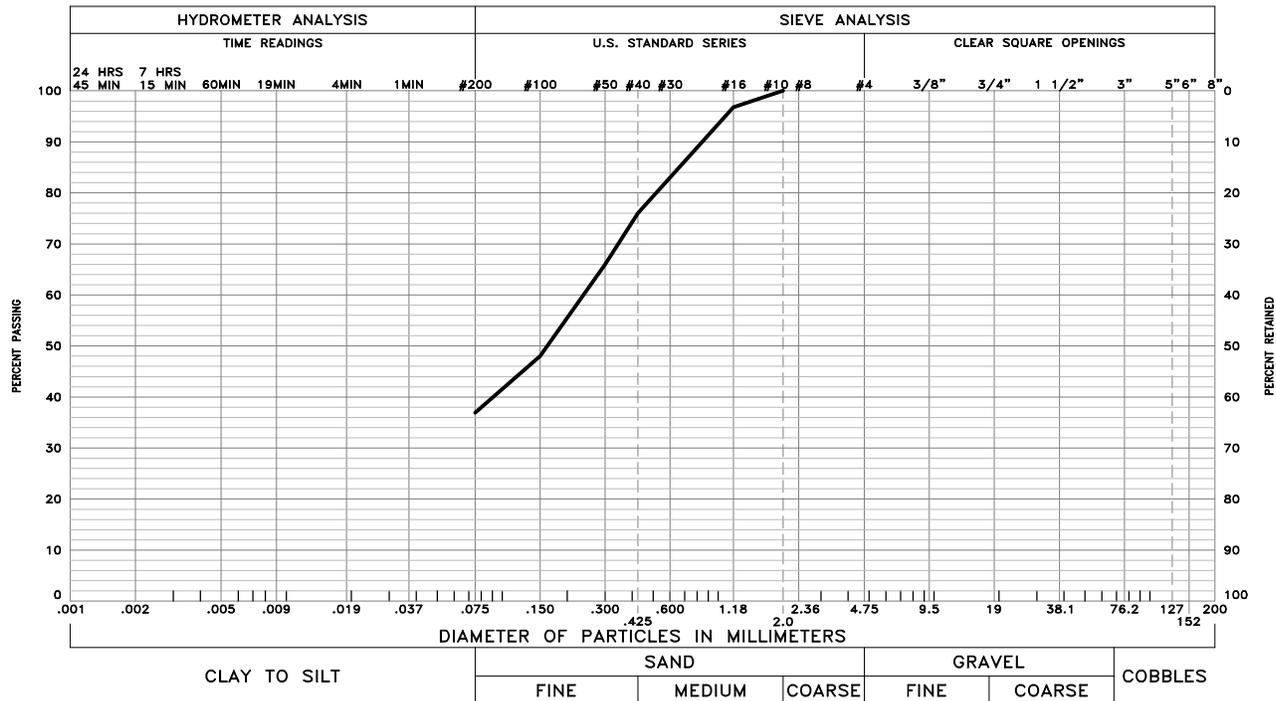
These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.



GRAVEL 0 % SAND 51 % SILT AND CLAY 49 %

LIQUID LIMIT 26 PLASTICITY INDEX 7

SAMPLE OF: Silty Clayey Sand (SC-SM) FROM: Boring 3 @ 9'

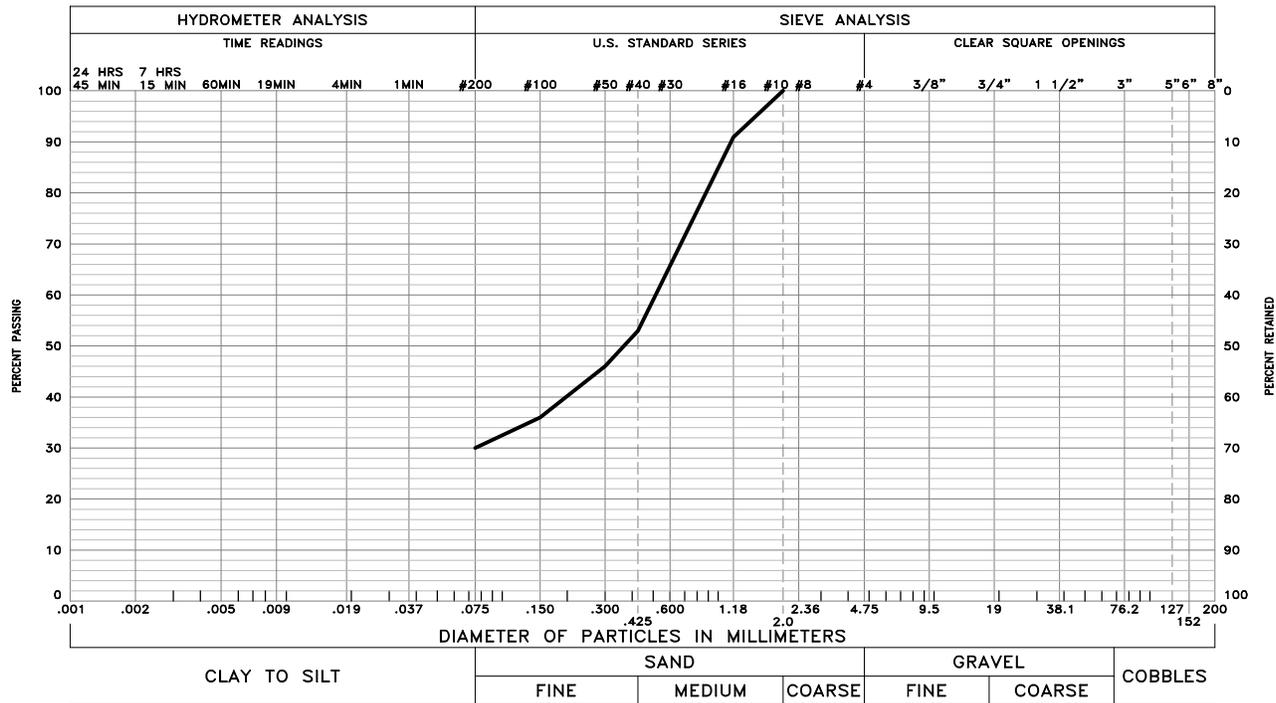
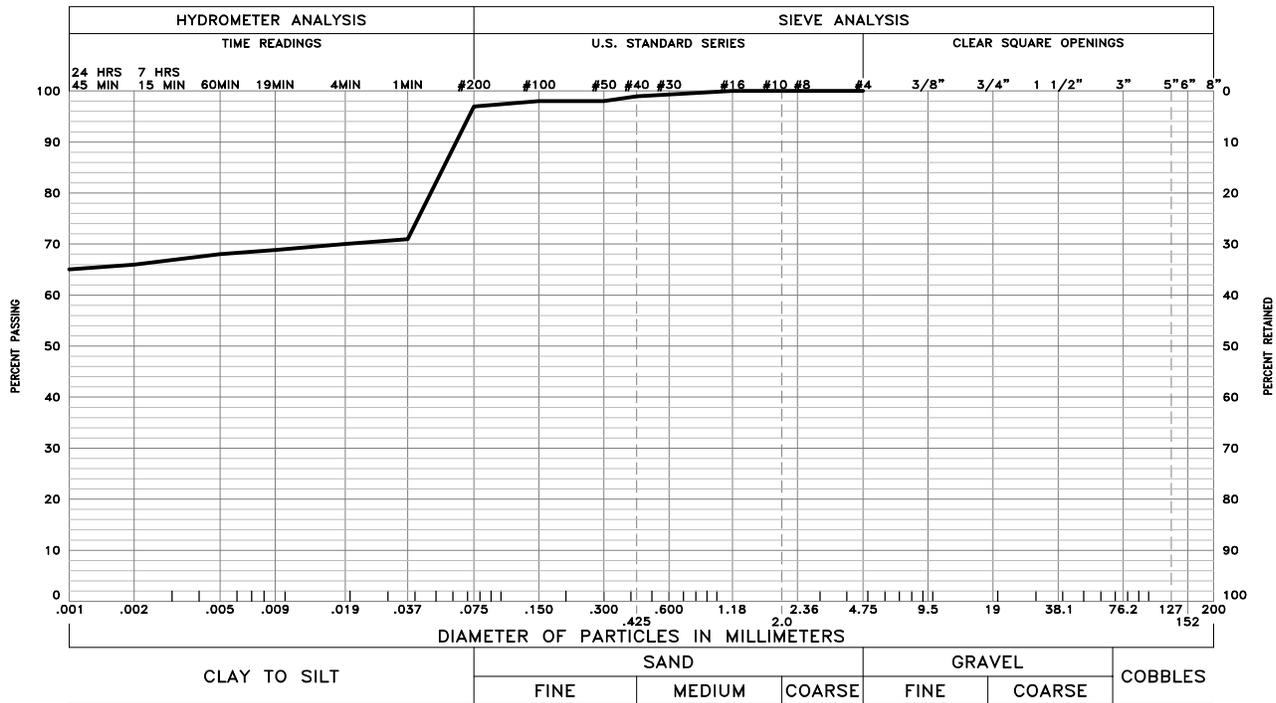


GRAVEL 0 % SAND 63 % SILT AND CLAY 37 %

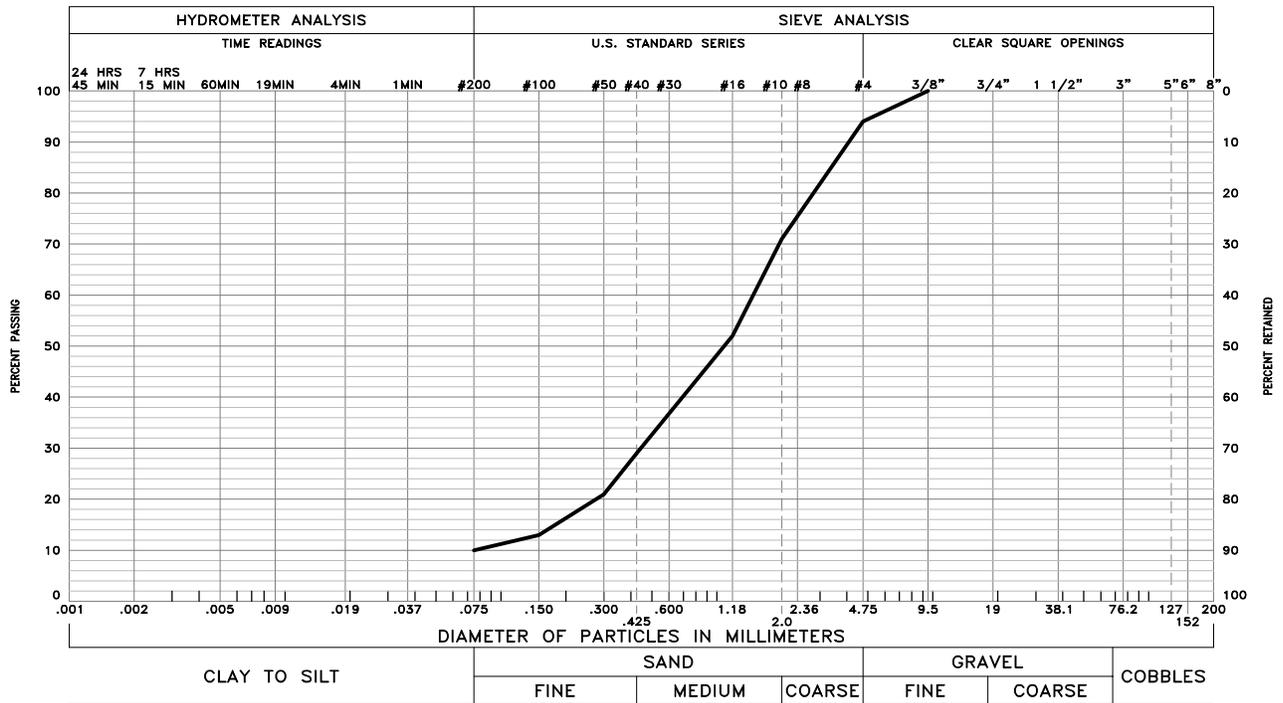
LIQUID LIMIT 28 PLASTICITY INDEX 7

SAMPLE OF: Silty Clayey Sand (SC-SM) FROM: Boring 4 @ 2'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.



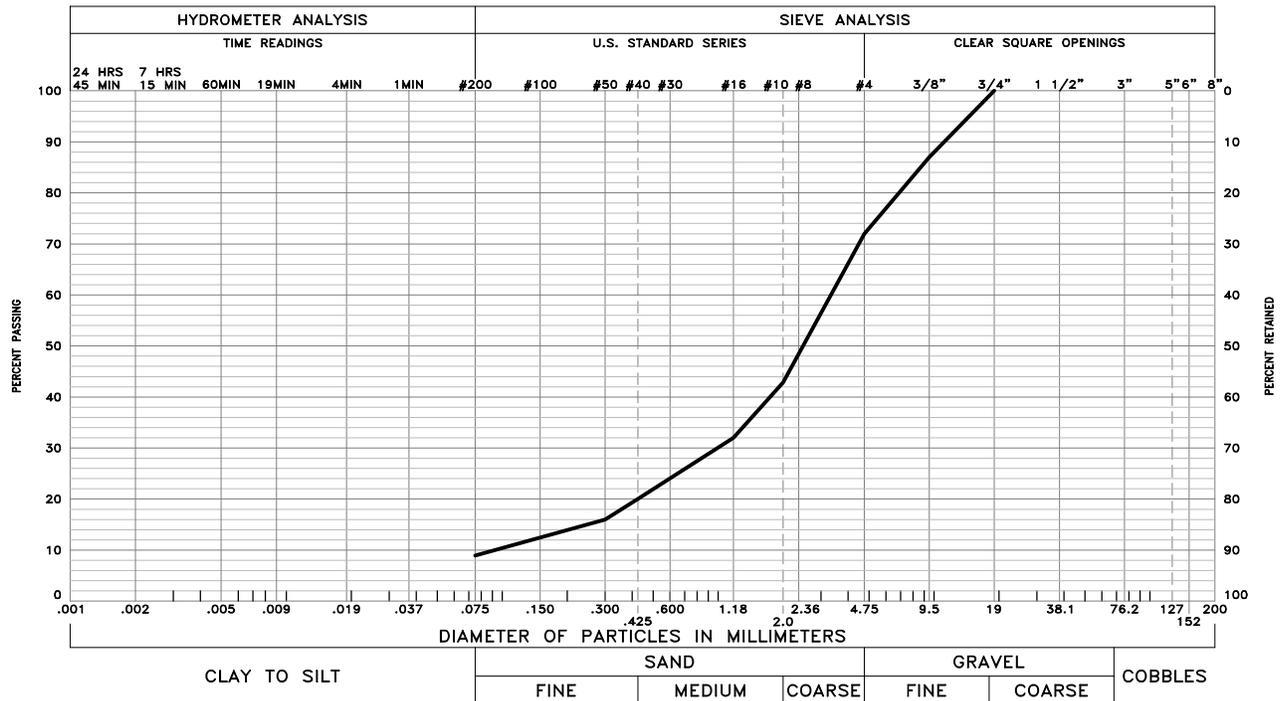
These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.



GRAVEL 6 % SAND 84 % SILT AND CLAY 10 %

LIQUID LIMIT PLASTICITY INDEX NP

SAMPLE OF: Well Graded Sand with Silt (SW-SM) FROM: Boring 13 @ 9'

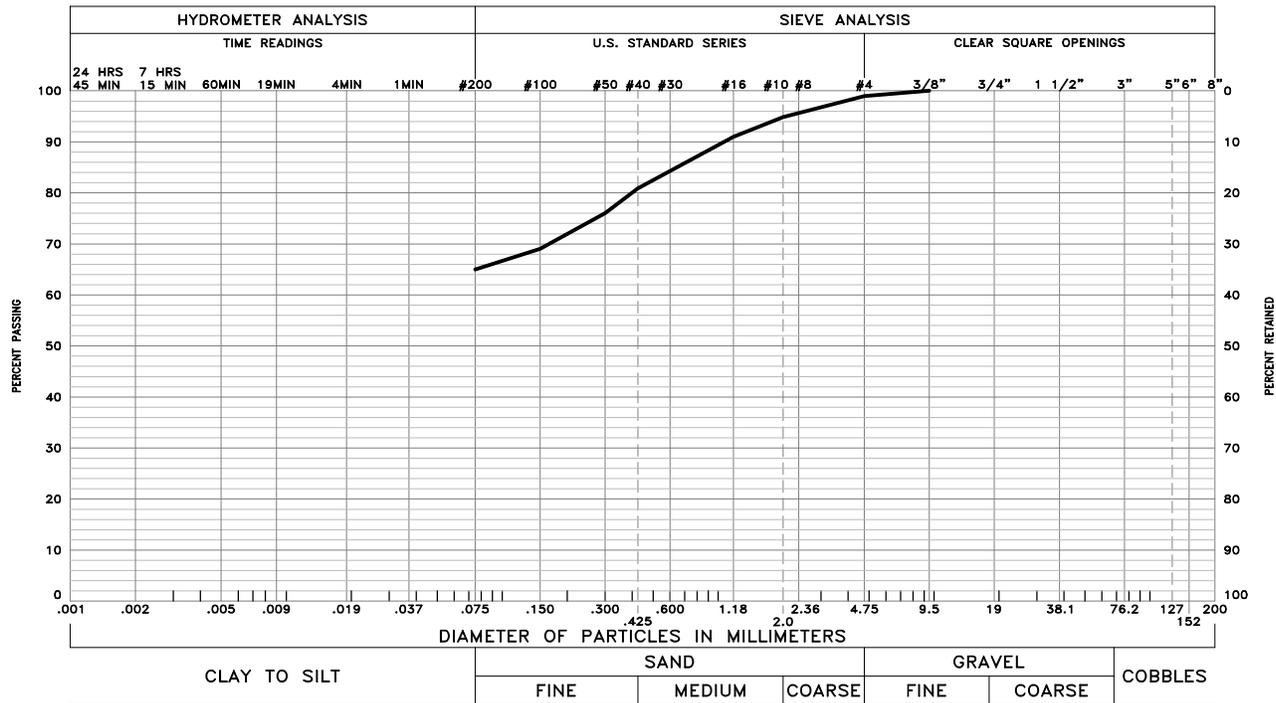
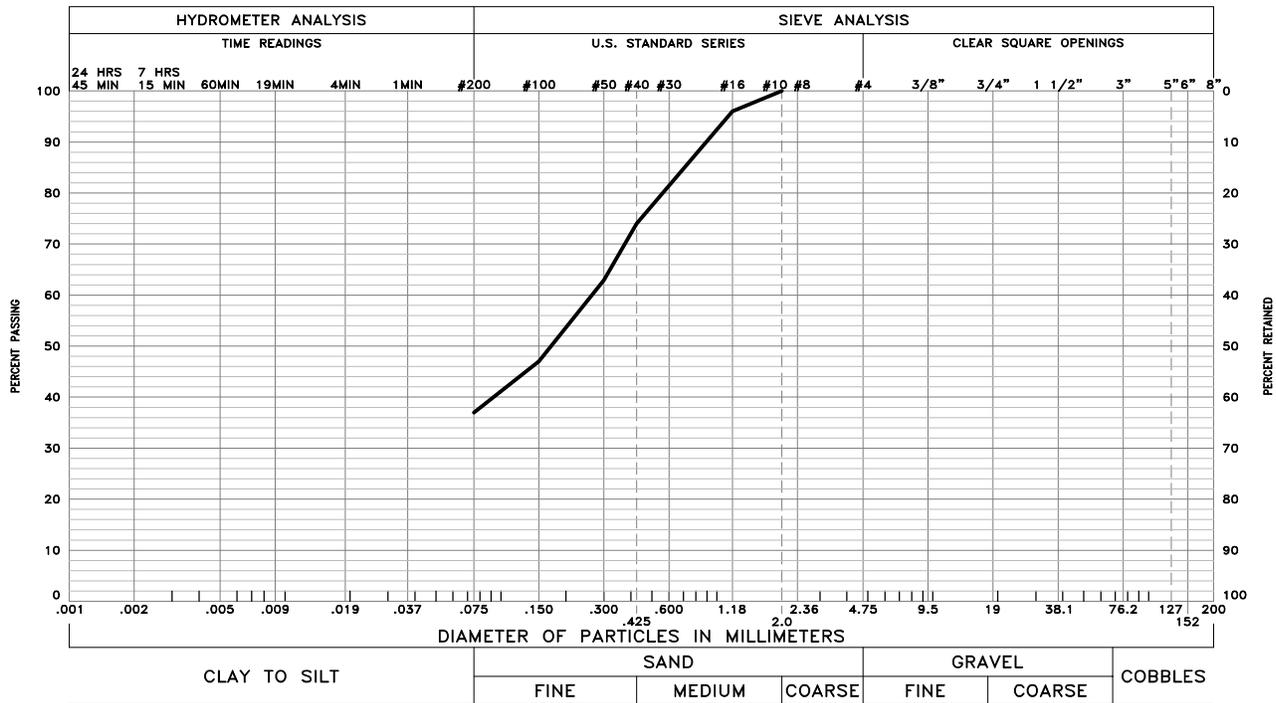


GRAVEL 28 % SAND 63 % SILT AND CLAY 9 %

LIQUID LIMIT PLASTICITY INDEX NP

SAMPLE OF: Well Graded Sand with Silt and Gravel (SW-SM) FROM: Boring 14 @ 4'

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Kumar and Associates, Inc.

**TABLE I
SUMMARY OF LABORATORY TEST RESULTS**

Project No.: 20-2-194

Project Name: Watermark Apartments - Akers Drive, Colorado Springs, CO

Date Sampled: 8/24/2020 and 8/25/2020

Date Received: 8/24/2020 and 8/25/2020

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	PERCENT PASSING 0.002 mm	ATTERBERG LIMITS		WATER SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (Group Index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH (ft)				GRAVEL (%)	SAND (%)			LIQUID LIMIT	PLASTICITY INDEX			
1	4	9/2/20	4.1	119.8	0	64	36		27	10		A-4 (0)	Clayey Sand (SC)
2	2	9/2/20	6.8	104.7	0	7	93	62	39	16	<0.01	A-6 (16)	Lean Clay (CL)
3	9	9/2/20	7.2	117.9	0	51	49		26	7		A-4 (1)	Silty Clayey Sand (SC-SM)
4	2	9/2/20	5.1	111.8	0	63	37		28	7		A-4 (0)	Silty Clayey Sand (SC-SM)
5	4	9/2/20	16.6	100.1	0	3	97	66	42	18		A-7-6 (20)	Lean Clay (CL)
6	9	9/2/20	11.7	100.2			76		36	15	0.03	A-6 (10)	Lean Clay with Sand (CL)
7	4	9/2/20	3.3	112.4	0	70	30		27	7		A-2-4 (0)	Silty Clayey Sand (SC-SM)
8	2	9/2/20	5.2	108.6			53		29	7		A-4 (1)	Sandy Silty Clay (CL-ML)
9	4	9/2/20	14.8	110.6			72		31	12		A-6 (7)	Lean Clay with Sand (CL)
10	2	9/2/20	15.9	112.3			74		38	17	0.03	A-6 (12)	Lean Clay with Sand (CL)
11	4	9/2/20	6.2	127.9	0	38	62	38	23	5		A-4 (1)	Fill: Sandy Silty Clay (CL-ML)

Kumar and Associates, Inc.

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Project No.: 20-2-194

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SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	PERCENT PASSING 0.002 mm	ATTERBERG LIMITS		WATER SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (Group Index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH (ft)				GRAVEL (%)	SAND (%)			LIQUID LIMIT	PLASTICITY INDEX			
12	4	9/2/20	3.5	114.3	3	63	34		24	7		A-2-4 (0)	Silty Clayey Sand (SC-SM)
13	9	9/2/20	4.3	126.2	6	84	10			NP		A-1-b (0)	Well Graded Sand with Silt (SW-SM)
14	4	9/2/20	2.5	123.1	28	63	9			NP	<0.01	A-1-a (0)	Well Graded Sand with Silt and Gravel (SW-SM)
15	4	9/2/20	11.0	116.4			69		36	17		A-6 (7)	Sandy Lean Clay (CL)
16	4	9/2/20	7.5	96.7			65		35	15		A-6 (8)	Sandy Lean Clay (CL)
17	2	9/2/20	5.8	112.8	0	63	37		27	9		A-4 (0)	Clayey Sand (SC)
18	2	9/2/20	7.5	125.7	1	34	65		31	16		A-6 (8)	Sandy Lean Clay (CL)