Kumar & Associates, Inc.®
Geotechnical and Materials Engineers
and Environmental Scientists

5020 County Road 154
Glenwood Springs, CO 81601
phone: (970) 945-7988
fax: (970) 945-8454
email: kaglenwood@kumarusa.com
www.kumarusa.com

An Employee Owned Company

Office Locations: Denver (HQ), Parker, Colorado Springs, Fort Collins, Glenwood Springs, and Summit County, Colorado

SUBSOIL STUDY
FOR FOUNDATION DESIGN
PROPOSED RESIDENCE
LOT 14, SHIELD-O-TERRACES
51 SHIELD O ROAD
PITKIN COUNTY, COLORADO

PROJECT NO. 19-7-661

NOVEMBER 14, 2019

PREPARED FOR:

DAVID ECKELBERGER
772 N. HUMBOLT STREET
DENVER, COLORADO 80218
dave.eckel@gmail.com

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PURPOSE AND SCOPE OF STUDY

This report presents the results of a subsoil study for a proposed residence to be located on Lot 14, Shield-O-Terraces, 51 Shield O Road, Pitkin County, Colorado. The project site is shown on Figure 1. The purpose of the study was to develop recommendations for the foundation design. The study was conducted in accordance with our proposal for geotechnical engineering services to Dave Eckelberger dated October 31, 2019. Hepworth-Pawlak Geotechnical, Inc. (now Kumar & Associates), previously performed percolation testing at the subject site and presented the results in a report dated October 31, 2006, Job No. 106 0902.

A field exploration program consisting of exploratory borings was conducted to obtain information on the subsurface conditions. Samples of the subsoils obtained during the field exploration were tested in the laboratory to determine their classification, compressibility or swell and other engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations for foundation types, depths and allowable pressures for the proposed building foundation. This report summarizes the data obtained during this study and presents our conclusions, design recommendations and other geotechnical engineering considerations based on the proposed construction and the subsurface conditions encountered.

PROPOSED CONSTRUCTION

The proposed residence will be a two story wood frame structure over possible basement or crawlspace with attached garage. Ground floor will be slab-on-grade for the garage and possible basement and structural over crawlspace for no-basement areas. Grading for the structure is assumed to be relatively minor with cut depths between about 3 to 12 feet. We assume relatively light foundation loadings, typical of the proposed type of construction.

If building loadings, location or grading plans change significantly from those described above, we should be notified to re-evaluate the recommendations contained in this report.

SITE CONDITIONS

The subject site was vacant at the time of our field exploration. There is a well near the east corner of the building envelope. The ground surface is gently sloping down to the northeast in the building area and very steep on the hillside above and below the building area.

FIELD EXPLORATION

The field exploration for the project was conducted on November 7, 2019. Two exploratory borings were drilled at the locations shown on Figure 1 to evaluate the subsurface conditions. The borings were advanced with 4 inch diameter continuous flight augers powered by a truck-mounted CME-45B drill rig. The borings were logged by a representative of Kumar & Associates, Inc.

Samples of the subsoils were taken with 1⅜ inch and 2 inch I.D. spoon samplers. The samplers were driven into the subsoils at various depths with blows from a 140 pound hammer falling 30 inches. This test is similar to the standard penetration test described by ASTM Method D-1586. The penetration resistance values are an indication of the relative density or consistency of the subsoils. Depths at which the samples were taken and the penetration resistance values are shown on the Logs of Exploratory Borings, Figure 2. The samples were returned to our laboratory for review by the project engineer and testing.

SUBSURFACE CONDITIONS

Graphic logs of the subsurface conditions encountered at the site are shown on Figure 2. The subsoils consist of about 1 foot of topsoil overlying stiff sandy clay soils to a depth of 4 feet. Underlying the sandy clay soils, relatively dense, sandy clay and gravel was encountered to a depth of 6 feet in Boring 1 and 7 feet in Boring 2, further underlain by dense clayey, silty sand and gravel with cobbles and probable boulders to the maximum drilled depth of 16½ feet. Drilling in the dense granular soils with auger equipment was difficult due to the cobbles and boulders and drilling refusal was encountered in the deposit.

Laboratory testing performed on samples obtained from the borings included natural moisture content and gradation analyses. Results of swell-consolidation testing performed on a relatively undisturbed drive sample of the sand and clay soils, presented on Figure 4, indicate low to moderate compressibility under conditions of loading and wetting. Results of gradation analyses performed on small diameter drive samples (minus 1½-inch fraction) of the deeper coarse granular subsoils are shown on Figure 5. The laboratory testing is summarized in Table 1.

No free water was encountered in the borings at the time of drilling and the subsoils were slightly moist.

FOUNDATION BEARING CONDITIONS

The subsoils encountered at the site possess low to moderate bearing capacity and typically low compressibility potential mainly when wetted. At assumed excavation depths we expect crawlspace excavations to expose sandy clay or gravely sand and clay and basement excavations to expose clayey sand and gravel. Spread footings should be feasible for foundation support of the building with a risk of movement due to variable bearing conditions. Once the foundation excavation is complete a representative of the geotechnical engineer should observe the exposed fill prior to concrete placement to evaluate bearing conditions.

DESIGN RECOMMENDATIONS

FOUNDATIONS

Considering the subsurface conditions encountered in the exploratory borings and the nature of the proposed construction, we recommend the building be founded with spread footings bearing on the natural soils.

The design and construction criteria presented below should be observed for a spread footing foundation system.

1) Footings placed on the undisturbed natural granular soils should be designed for an allowable bearing pressure of 2,000 psf for the sandy clay and gravelly sand and clay and 3,000 psf for footings bearing entirely on the deeper clayey sand and gravel. Based on experience, we expect settlement of footings designed and constructed as discussed in this section will be about 1 inch or less.
2) The footings should have a minimum width of 18 inches for continuous walls and 2 feet for isolated pads.

3) 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 42 inches below exterior grade is typically used in this area.

4) Continuous foundation walls should be reinforced top and bottom to span local anomalies such as by assuming an unsupported length of at least 10 feet. Foundation walls acting as retaining structures should also be designed to resist lateral earth pressures as discussed in the "Foundation and Retaining Walls" section of this report.

5) Topsoil and any loose disturbed soils should be removed and the footing bearing level extended down to the relatively dense natural granular soils. The exposed soils in footing area should then be moistened and compacted. If water seepage is encountered, the footing areas should be dewatered before concrete placement.

6) A representative of the geotechnical engineer should observe all footing excavations prior to concrete placement to evaluate bearing conditions.

FOUNDATION AND RETAINING WALLS

Foundation walls and retaining structures which are laterally supported and can be expected to undergo only a slight amount of deflection should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of at least 50 pcf for backfill consisting of the on-site soils. Cantilevered retaining structures which are separate from the residence and 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 at least 40 pcf for backfill consisting of the on-site soils.

All foundation and retaining structures should be designed for appropriate hydrostatic and surcharge pressures such as adjacent footings, 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. An underdrain should be provided to prevent hydrostatic pressure buildup behind walls.

Backfill should be placed in uniform lifts and compacted to at least 90% of the maximum standard Proctor density at a moisture content near optimum. Backfill in pavement and walkway areas should be compacted to at least 95% of the maximum standard Proctor density. Care should be taken not to overcompact the backfill or use large equipment near the wall, since this could cause excessive lateral pressure on the wall. Some settlement of deep foundation wall backfill should be expected, even if the material is placed correctly, and could result in distress to facilities constructed on the backfill.

The lateral resistance of foundation or retaining wall footings will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings can be calculated based on a coefficient of friction of 0.40. Passive pressure of compacted backfill against the sides of the footings can be calculated using an equivalent fluid unit weight of 375 pcf. The coefficient of friction and passive pressure values recommended above assume ultimate soil strength. Suitable factors of safety should be included in the design to limit the strain which will occur at the ultimate strength, particularly in the case of passive resistance. Fill placed against the sides of the footings to resist lateral loads should be a granular material compacted to at least 95% of the maximum standard Proctor density at a moisture content near optimum.

FLOOR SLABS

The natural on-site soils, exclusive of topsoil, are suitable to support lightly loaded slab-on-grade construction. To reduce the effects of some differential movement, floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement. Floor slab control joints should be used to reduce damage due to shrinkage cracking. The requirements for joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use. A minimum 4 inch layer of free-draining gravel should be placed beneath basement level slabs to facilitate drainage. This material should consist of minus 2-inch aggregate with at least 50% retained on the No. 4 sieve and less than 2% passing the No. 200 sieve.

All fill materials for support of floor slabs should be compacted to at least 95% of maximum standard Proctor density at a moisture content near optimum. Required fill can consist of the on-site granular soils devoid of vegetation, topsoil and oversized rock.

UNDERDRAIN SYSTEM

Although free water was not encountered during our exploration, it has been our experience in the area that local perched groundwater can develop during times of heavy precipitation or seasonal runoff. Frozen ground during spring runoff can create a perched condition. We recommend below-grade construction, such as retaining walls, crawlspace and basement areas, be protected from wetting and hydrostatic pressure buildup by an underdrain system.

The drains should consist of drainpipe placed in the bottom of the wall backfill surrounded above the invert level with free-draining granular material. The drain should be placed at each level of excavation and at least 1 foot below lowest adjacent finish grade and sloped at a minimum 1% to a suitable gravity outlet. Free-draining granular material used in the underdrain system should contain less than 2% passing the No. 200 sieve, less than 50% passing the No. 4 sieve and have a maximum size of 2 inches. The drain gravel backfill should be at least 1½ feet deep. An impervious membrane such as 20 mil PVC should be placed beneath the drain gravel in a trough shape and attached to the foundation wall with mastic to prevent wetting of the bearing soils.

SURFACE DRAINAGE

The following drainage precautions should be observed during construction and maintained at all times after the residence has been completed:

1) Inundation of the foundation excavations and underslab areas should be avoided during construction.
2) Exterior backfill should be adjusted to near optimum moisture and compacted to at least 95% of the maximum standard Proctor density in pavement and slab areas and to at least 90% of the maximum standard Proctor density in landscape areas.
3) The ground surface surrounding the exterior of the building should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 12 inches in the first 10 feet in unpaved areas and a minimum slope of 3 inches in the first 10 feet in paved areas. Free-draining wall backfill should be capped with about 2 feet of the on-site soils to reduce surface water infiltration.
4) Roof downspouts and drains should discharge well beyond the limits of all backfill.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering principles and practices in this area at this time. We make no warranty either express or implied. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated on Figure 1, the proposed type of construction and our experience in the area. Our services do not include determining the presence, prevention or possibility of mold or other biological contaminants (MOBC) developing in the future. If the client is concerned about MOBC, then a professional in this special field of practice should be consulted. Our findings include interpolation and extrapolation of the subsurface conditions identified at the exploratory borings and variations in the subsurface conditions may not become evident until excavation is performed. If conditions encountered during construction appear different from those described in this report, we should be notified so that re-evaluation of the recommendations may be made.

This report has been prepared for the exclusive use by our client for design purposes. We are not responsible for technical interpretations by others of our information. As the project evolves, we should provide continued consultation and field services during construction to review and monitor the implementation of our recommendations, and to verify that the recommendations have been appropriately interpreted. Significant design changes may require additional analysis or modifications to the recommendations presented herein. We recommend on-site observation of excavations and foundation bearing strata and testing of structural fill by a representative of the geotechnical engineer.

Respectfully Submitted,

Kumar & Associates, Inc.

James H. Parsons, E.I.

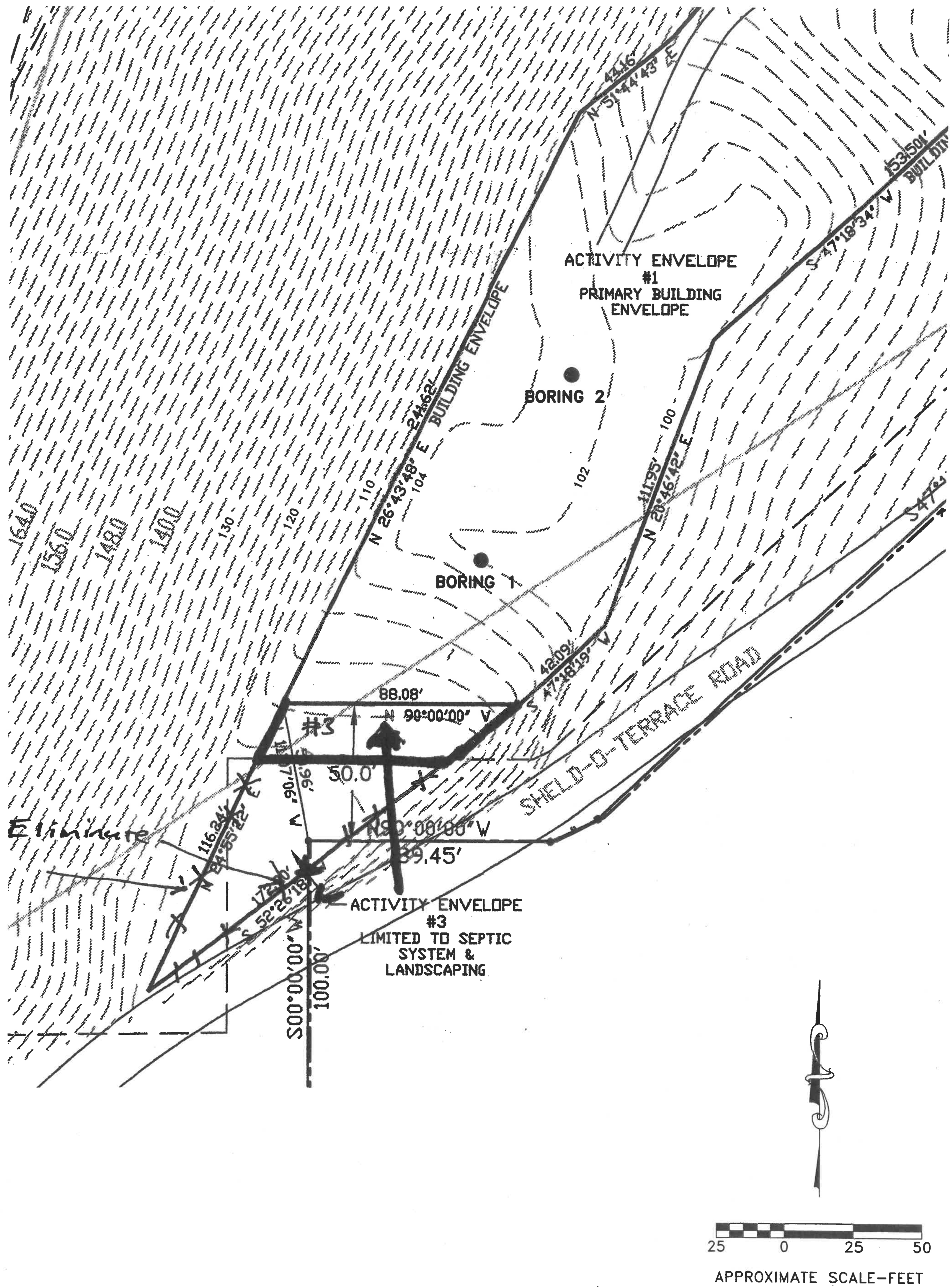
Reviewed by:

COLORADO LICENSED PROFESSIONAL ENGINEER DANIEL E. HARDIN 24443 6/19/19

Daniel E. Hardin, P.E.

JHP/kac

cc: Glenn Rappaport - (grappa@blackshack.net)



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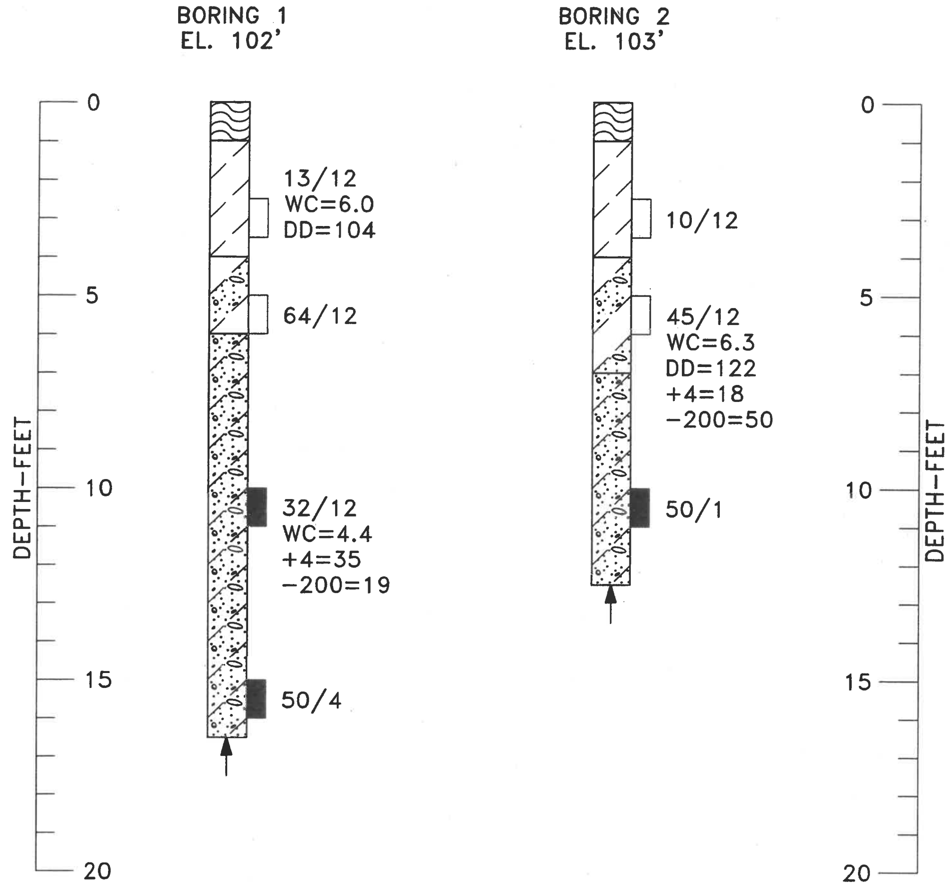
19-7-661	Kumar & Associates	LOCATION OF EXPLORATORY BORINGS	Fig. 1



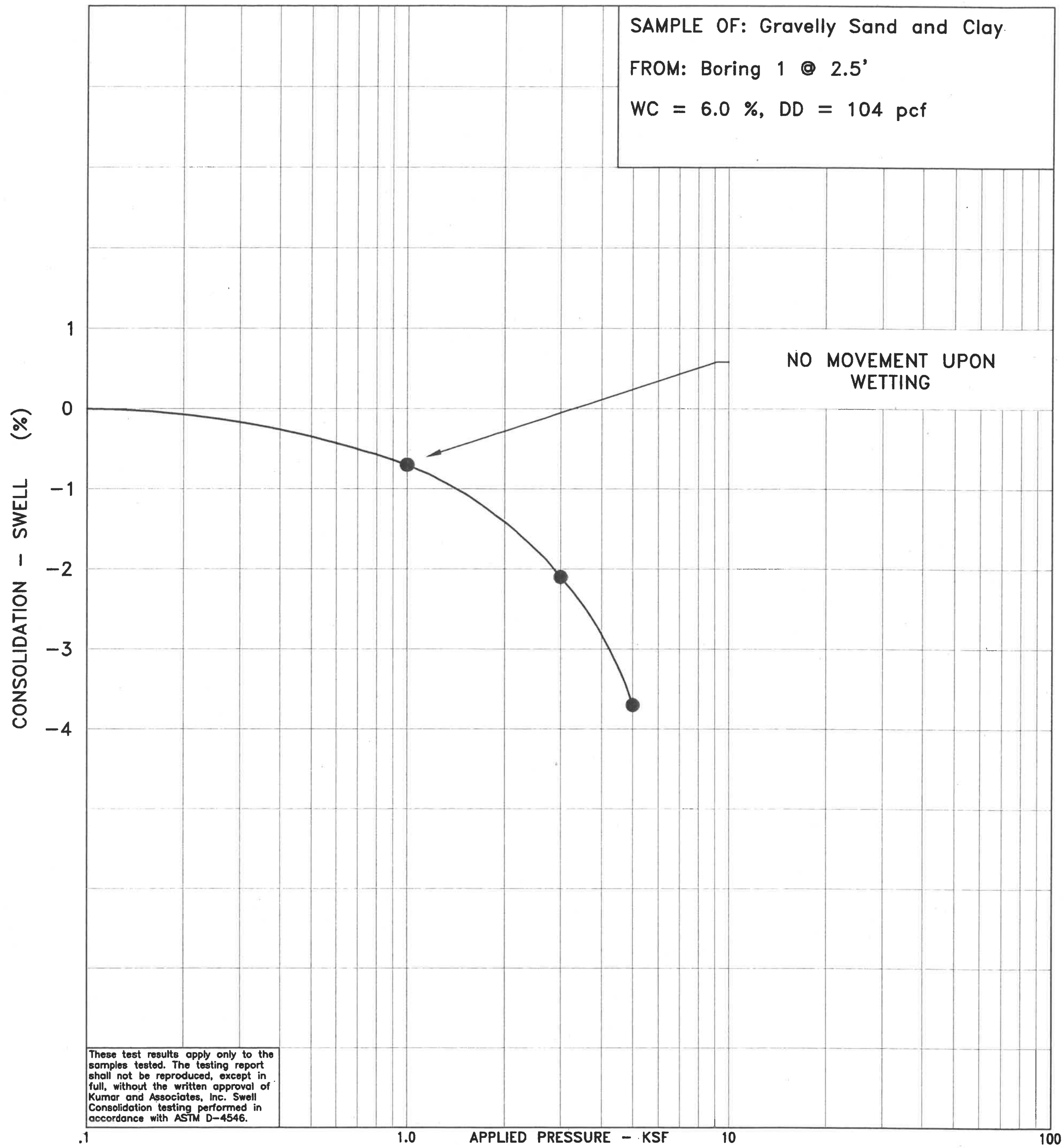
19-7-661	Kumar & Associates	LOGS OF EXPLORATORY BORINGS	Fig. 2

LEGEND

- TOPSOIL; ORGANIC SILT AND CLAY, SANDY, FIRM, MOIST, DARK BROWN.
- CLAY (CL); SANDY, STIFF, SLIGHTLY MOIST, MIXED BROWN.
- CLAY AND GRAVEL (CL-GC); SANDY, SCATTERED COBBLES, DENSE, SLIGHTLY MOIST, MIXED BROWN.
- GRAVEL AND SAND (GC-SC); CLAYEY SILT, COBBLES, PROBABLE BOULDERS, DENSE, SLIGHTLY MOIST, MIXED BROWN.
- DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLE.
- DRIVE SAMPLE, 1 3/8-INCH I.D. SPLIT SPOON STANDARD PENETRATION TEST.
- 13/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 13 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.
- ↑ PRACTICAL AUGER REFUSAL.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON NOVEMBER 7, 2019 WITH A 4-INCH-DIAMETER CONTINUOUS-FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE OBTAINED BY INTERPOLATION BETWEEN CONTOURS ON THE SITE PLAN PROVIDED.
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 WAS NOT ENCOUNTERED IN THE BORINGS AT THE TIME OF DRILLING.
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).



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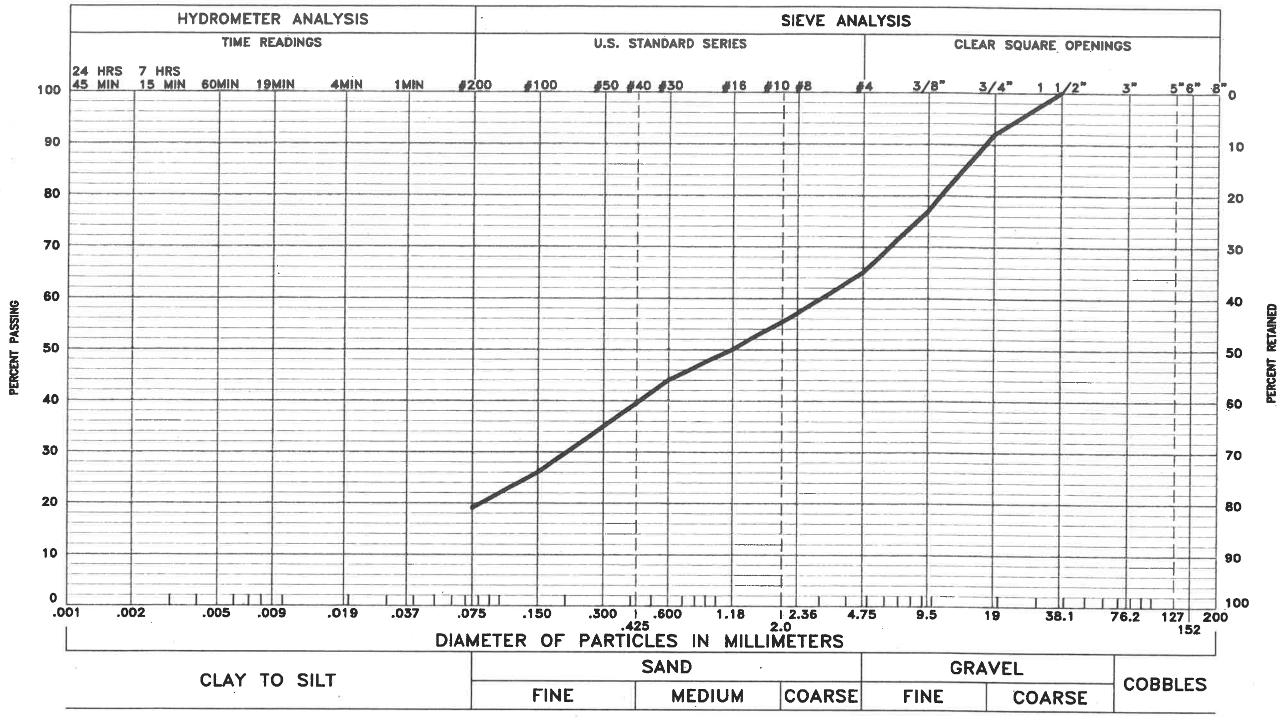
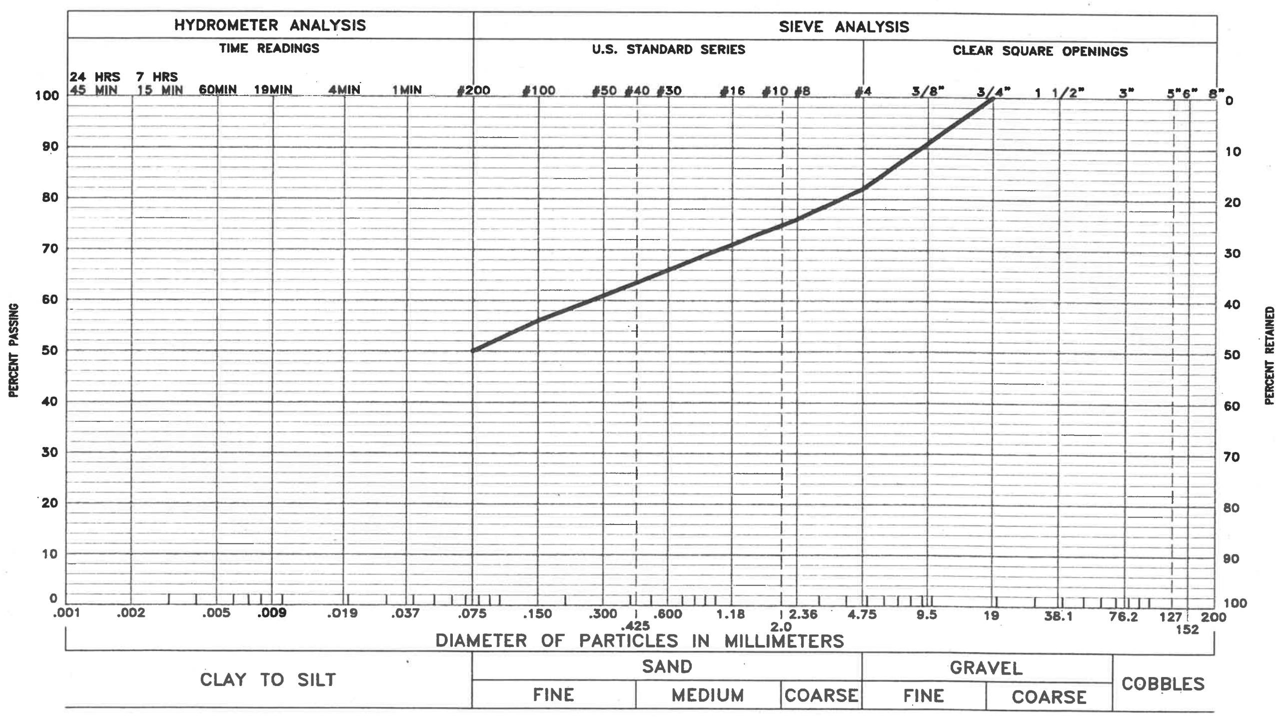
19-7-661	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULT	Fig. 4



GRAVEL 35 % SAND 46 % SILT AND CLAY 19 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Clayey Sand and Gravel FROM: Boring 1 @ 10'



GRAVEL 18 % SAND 32 % SILT AND CLAY 50 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Gravelly Sand and Clay FROM: Boring 2 @ 5'

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.

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19-7-661	Kumar & Associates	GRADATION TEST RESULTS	Fig. 5

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

Project No. 19-7-661

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH		SOIL TYPE
BORING	DEPTH (ft)	(%)	(pcf)	GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTIC INDEX (%)	(psf)		
1	2½	6.0	104								Gravely sand and Clay
	10	4.4		35	46	19					Clayey Sand and Gravel
2	5	6.3	122	18	32	50					Gravely Sand and Clay