July 14, 2020

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Report of Geotechnical Exploration and Slope Stability Analyses
Allen Street – Slope Failure
Sylva, North Carolina
KEG Project No. JA20-4021-01

Mr. Scott:

Kessel Engineering Group, PLLC (KEG) is pleased to present this report of geotechnical exploration and slope stability analyses of the slope failure area located along a portion of Allen Street in Sylva, North Carolina. The following executive summary provides an overview of the significant geotechnical issues for this project. The summary should not be relied upon exclusively. Specific geotechnical design parameters with a detailed discussion of applications and limitations are provided in the attached report.

EXECUTIVE SUMMARY

The project site is located at the south end of Bryson Park on Chipper Curve Road and consists of the sloped property located between Chipper Curve Road and Allen Street, and is adjacent the residential property located at 527 Allen Street. A slope failure occurred in late April / early May 2020 and extended from Allen Street to the south end of Bryson Park. Significant vertical scarps were observed at the top of the failure area within Allen Street, and seepage and pavement knuckling were observed at the toe of the failure.

A total of nine soil test borings (B-1 to B-9) were performed at the site and typically encountered surficial fill soils underlain by residual soils, partially weathered rock, and refusal materials. The existing fill soils typically consisted of very loose to loose silty sands and very soft to soft sandy silts. Residual soils consisted of very loose to very dense silty sands and soft to stiff sandy silts. PWR and refusal materials were encountered in six of the nine borings. Groundwater was encountered in each of the soil test borings performed during this exploration, and stabilized groundwater measurements were taken at six piezometer locations. Laboratory testing on undisturbed and bulk samples was performed and included consolidated undrained (CU) triaxial shear testing, standard Proctor testing, grain size distribution testing, and natural moisture contents.

Slope stability analyses indicate that contributing factors to the observed slope failure were likely a combination of relatively shallow groundwater elevations, relatively weak near-surface residual soils, and significant precipitation events. Remedial measures for the existing slope should include installation of a system of horizontal drains to lower the groundwater table within the slope, as well as the installation of soil nails or ground anchors to permanently stabilize the already mobilized materials. The implementation of conventional stabilization measures such as site retaining walls or rock buttresses is not recommended due to the presence of weaker near-surface residual soils.

We appreciate the opportunity to offer our professional geotechnical services on this project. Please contact us with questions regarding this report or if we may be of further assistance.

Sincerely,
KESSEL ENGINEERING GROUP, PLLC (NC Firm License No. P-0420)

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TABLE OF CONTENTS

SCOPE OF EXPLORATION

The purpose of this exploration was to determine general subsurface conditions in the slope failure area in order to develop general geotechnical recommendations for slope remediation. This geotechnical exploration was performed in general accordance with our *Proposal for Geotechnical Exploration*, KEG Proposal No. PA20-3389-01.

PROJECT INFORMATION AND SITE OBSERVATIONS

Initial project information was gathered during an April 30, 2020 site visit attended by Mr. Jake Scott (Town of Sylva), several members of TWSA (Tuckaseigee Water and Sewer Authority), and our Mr. Ian Johnson, P.E. Additional information has been gathered during subsequent onsite visits by Mr. Johnson and telephone and email correspondences with Mr. Scott. We have also been provided with the following digital document: *Topographic Survey prepared for: Town of Sylva*, by Alliance Land Surveying, P.C., dated 06/16/2020, and showing the approximate property boundaries, existing topographic contours, and boring locations.

The project site is located at the south end of Bryson Park on Chipper Curve Road and consists of the sloped property located between Chipper Curve Road and Allen Street (see Figure 1). The property is located adjacent and below the single-family home located at 527 Allen Street. The sloped area between the two roads has a total height difference on the order of 38 feet and consists of a relatively flat area just above Chipper Curve Road and another relatively flat bench approximately mid-slope. The mid-slope bench runs along the slope and serves as an access road to an existing TWSA sewer line and several manholes. The subject slope is heavily-vegetated with underbrush/vines and has sporadic larger trees. Chipper Curve Road is a two-lane NCDOT maintained road, and Allen Street is a single-lane paved road maintained by the Town of Sylva. A water line owned by TWSA is located within Allen Street. The slope failure area does not appear to extend to Chipper Curve Road. Based on our review of the provided topographic survey, the slope failure area has an overall height of approximately 28 to 32 feet, with an overall inclination of approximately 2.4H:1V (horizontal:vertical). Localized areas of the slope associated with construction of the east side/shoulder of Allen Street are on the order of 1.6H:1V. We understand from anecdotal evidence that slope failures have occurred along sections of Allen Street for several decades.

Slope Failure Observations: April 30, 2020

The subject slope failure formed in late April, 2020 after a heavy precipitation event. The slope failure initialized with tension cracking within Allen Street near/adjacent the residential property at 527 Allen Street (see Photo 1). A bowl-shaped series of tension crack formed through the roadway pavements, was approximately 100 to 110 feet wide within Allen Street, and exhibited vertical displacements (scarps) on the order of 8 to 12 inches at the time of our site visit. Shallow ponded water was observed in the grassed shoulder area near the rear/west of the tension cracks. The lower bound of the slope failure area extended to the driveway access area at Bryson Park located off Chipper Curve Road. Minor knuckling of a portion of the driveway asphalt was observed during this site visit, and water seepage was also observed exiting the toe of the slope (see Photo 2). The grassed area to the south of the Bryson Park driveway was also wet with water seepage.

Photo 1: Slope Failure Area observed within Allen Street, facing north. Photo dated 04/30/2020.

Photo 2: Slope Failure Area observed from Chipper Curve Road, facing west. Photo dated 04/30/2020.

Slope Failure Observations: May 5, 2020

Additional movement of the failure zone took place between our April 30, 2020 and May 5, 2020 site visits. This movement included additional cracking of the asphalt in Allen Street (see Photo 3) as well as dropping of the failure zone to a total scarp height of approximately 2 feet (see Photo 4). The tension crack extended up the fill slope supporting the driveway for the residential property at 527 Allen Street (see Photo 5). During our site visit, we also observed significant water flowing (several gallons per minute) out of a shallow excavation near the north end of the failure area within Allen Street (see Photo 6). Based on conversations with Mr. Scott, we understand this was likely the result of a rupture in the TWSA water main, and was subsequently cut off in the following days. Severe knuckling of a portion of the driveway asphalt at Bryson Park at the base of the failure area was observed during this site visit, and water seepage was also observed exiting the toe of the slope (see Photos 7, 8). The grassed area to the south of the driveway also continued to be very wet with seepage.

Photo 3: Slope Failure Area observed within Allen Street, facing south. Photo dated 05/06/2020.

Photo 4: Approx. 2 feet vertical scarp on south edge of failure at Allen Street. Photo dated 05/06/2020.

Photo 5: Extension of tension cracking up adjacent slope at 527 Allen Street. Photo dated 05/06/2020.

Photo 6: Water flowing near north end of failure within Allen Street. Photo dated 05/06/2020.

Photo 7: Slope Failure Area observed at Bryson Park entrance, facing west. Photo dated 05/06/2020.

Photo 8: Slope Failure Area observed at Bryson Park entrance, facing west. Photo dated 05/06/2020.

Slope Failure Observations: May 10, 2020

A tension crack was observed along the north end of the failure zone within the mid-slope bench (see Photo 9). Additional significant movement of the failure area was not observed during this site visit, and the surface of the pavement at the base of the failure at the Bryson Park driveway was essentially dry.

Photo 9: Tension crack observed within mid-slope bench, north end of failure. Photo dated 05/10/2020.

SITE GEOLOGY

The project site is located in the Blue Ridge Physiographic Province. The bedrock in this region is a complex crystalline formation that has been faulted and contorted by past tectonic movements. The rock has weathered to residual soils which form the mantle for the hillsides and hilltops. The typical residual soil profile in areas not disturbed by erosion or grading consists of clayey soils near the surface where weathering is more advanced, underlain by sandy silts and silty sands.

The boundary between soil and rock is not sharply defined and there is often a transitional zone, termed "partially weathered rock" overlying the parent bedrock. Partially weathered rock (PWR) is defined, for engineering purposes, as residual material with a standard penetration resistance in excess of 100 blows per foot. Weathering is facilitated by fractures, joints, and the presence of less resistant rock types. Consequently, the profile of the partially weathered rock is irregular even over short horizontal distances. Also, it is not unusual to find lenses and boulders of hard rock and/or zones of partially weathered rock within the soil mantle, well above the general bedrock level.

Refusal materials encountered in some of the borings performed during this exploration are those materials which are sufficiently hard to prevent the vertical advancement of the soil test boring auger. Refusal may result from very dense soils, partially weathered rock, boulders, lenses, ledges, or layers of relatively hard rock underlain by partially weathered rock or residual soil; refusal may also represent the surface of relatively continuous bedrock. Core drilling procedures are required to penetrate refusal materials and to determine their character and continuity. Core drilling was beyond the scope of this exploration.

FIELD EXPLORATION

The site was explored by performing nine (9) soil test borings (B-1 to B-9) at the approximate locations as indicated on the attached Field Exploration Plan (see Figure 2). Borings were located in the field by our Mr. Ian Johnson, P.E. Borings B-1 to B-5 were located within Allen Street at the upper bound of the failure area. Borings B-1 and B-5 were located just to the north and south of the failure zone, respectively, and borings B-2 to B-4 were located within the failure zone. Borings B-6 and B-7 were located along the TWSA access road/bench located approximately mid-slope, and borings B-8 and B-9 were located near the base of the failure area at the Bryson Park access driveway area.

The soil test borings were performed by utilizing a GeoProbe 7822 DT ATV drill rig. Borings were advanced by mechanically twisting a continuous flight steel auger into the soil. Soil sampling and penetration testing were performed in general accordance with ASTM D 1586. At assigned intervals, soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings and then driven an additional 12 inches with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final 12 inches was recorded and is designated the "penetration resistance." The penetration resistance, once properly evaluated, is an index to the strength of the soil. Representative portions of the soil samples, thus obtained, were placed in plastic bags and transported to the laboratory. In the laboratory, the samples were examined to verify the field classifications made by the driller. The boreholes were backfilled with the soil cuttings brought to the surface by the augers. Due to the damage in the roadway from the failure area and utility excavations, the boreholes were not capped with an asphalt cold patch mixture. In addition to bag samples, bulk samples and undisturbed samples were also gathered in order to perform additional laboratory testing. Prior to removing the augers, piezometers were installed at selected borings (B-1, B-2, B-4, B-5, B-6, B-9) to gather information about stabilized ground water elevations.

Soil descriptions and penetration resistances are tabulated on the attached Boring Logs. Top of boring elevations were estimated by referencing the topographic information from the provided plan. The boring locations and elevations shown in the appendix should be considered approximate.

LABORATORY TESTING

A total of six (6) undisturbed specimens (Shelby tubes) were gathered form the project site. Triaxial shear testing (consolidated undrained conditions) was performed on three (3) selected undisturbed specimens by our subcontractor testing agency. Grain size distribution testing was performed on undisturbed specimens after triaxial shear testing was completed. (2) bulk samples were also tested for their compaction characteristics as well as grain size distributions. The selected samples were non-plastic. A summary of important laboratory testing results is provided in Table 1 below. Complete results of laboratory testing are provided in the Appendix of this report.

TABLE 1
LABORATORY TEST RESULTS

Boring No.	Sample Depth (ft)	Sample Type* (ft)	Sample Strata	Maximum Dry Density per ASTM D-698 (pcf)	Optimum Moisture Content per ASTM D-698 (%)	Effective Friction Angle, ϕ' (degrees)	Effective Cohesion, C', (psf)	Natural Moisture Content (%)	Percent Passing No. 200 Sieve (%)	USCS Classi-ficiation**
B-1	11 to 13	UD	Fill	-	-	32.4	220	16.7	41.1	SM
B-2	1 to 20	BK	Fill / Residuum	110.9	15.6	-	-	19.6	47.3	SM
B-2	16 to 18	UD	Residuum	-	-	26.3	310	36.6	47.3	SM
B-7	16 to 18	UD	Residuum	-	-	27.8	230	28.2	58.7	ML
B-8	1 to 20	BK	Fill / Residuum	104.8	18.2	26.5	-	-	51.1	ML

- Test not performed
* UD = Undisturbed sample (Shelby Tube); BK = Bulk sample
** SM = Silty Sand; ML = sandy silt; tested samples were non-plastic.

SUBSURFACE CONDITIONS

Borings at Allen Street: B-1 to B-5

Soil test borings performed at these locations encountered existing fill soils at the ground surface. The existing fill consisted of very soft to soft sandy silts (ML) and very loose to loose silty sands (SM). Existing fill was noted as being slightly moist to wet, and contained trace to moderate mica content. The existing fill extended to depths of approximately 17 feet deep just north of the failure zone (B-1) and approximately 3 feet deep just south of the failure zone (B-5). Within the failure zone (B-2 to B-4), existing fill extended to depths of 8 to 12 feet below existing grade. Existing fill encountered in borings B-2 to B-4 had pockets exhibiting very low blow counts ($N \leq 2$) as well as weight-of-hammer (WOH) material. Existing fill was underlain by residual soils.

Residual soils encountered by these borings typically consisted of firm to stiff silts (ML) within the upper 12 to 22 feet underlain by loose to very dense silty sands (SM). Residual soils contained varying amounts of mica. Partially weathered rock (PWR) was encountered in borings B-2, B-3, and B-5 at depths of approximately 32 to 42 feet below the existing ground surface. Refusal materials were encountered in soil test borings B-1, B-2, B-3, and B-5 at depths of approximately 37.4 to 46.6 feet below the existing ground surface. Boring B-4 extended to its assigned termination depth of 50 feet.

Borings at Mid-Slope Bench: B-6, B-7

Soil test borings performed at these locations encountered existing fill soils at the ground surface underlain by residual soils. The existing fill consisted of soft to firm sandy silts (ML) and very loose silty sands (SM). Existing fill at B-7 was noted as being moist, very micaceous, and containing trace topsoil. The existing fill at these borings extended to depths of approximately 3 to 5.5 feet below existing grade.

Residual soils encountered by these borings typically consisted of soft to firm sandy silts (ML) within the upper 12 to 17 feet below existing grade underlain by loose to very firm silty sands (SM). Residual soils were generally noted as being moist. Partially weathered rock (PWR) was encountered in borings B-6 and B-7 at depths of approximately 27 feet below the existing ground surface. Both borings extended to their assigned termination depths of 30 feet.

Borings at Base of Slope: B-8, B-9

Soil test borings performed at these locations encountered existing fill soils at the ground surface underlain by residual soils. The existing fill consisted of very loose to loose silty sands (SM). The existing fill at these borings extended to depths of approximately 3 to 5.5 feet below existing grade.

Residual soils encountered by these borings typically consisted of soft sandy silts (ML) and loose to very dense silty sands (SM). Residual soils in B-9 were noted as being very micaceous. Partially weathered rock (PWR) was encountered in borings B-9 at a depth of approximately 17 feet below the existing ground surface. Refusal materials were encountered in soil test borings B-8 and B-9 at depths of approximately 22.1 and 18.2 feet below the existing ground surface, respectively.

A summary of subsurface conditions encountered by the soil test borings is provided below in Table 2.

TABLE 2A
SUMMARY OF SUBSURFACE CONDITIONS ENCOUNTERED BY SOIL TEST BORINGS
(MEASURED IN FEET BELOW THE EXISTING GROUND SURFACE)

Soil Test Boring No.	General Location*	**Existing Fill**		**Residuum**				Refusal Depth (feet)
		V. Loose to Loose SANDS / V. Soft to Soft SILTS (feet)	Firm to Stiff SILTS / Firm to V. Firm SANDS (feet)	Firm to Stiff SILTS (feet)	Very Loose to Loose SANDS (feet)	Firm to Very Dense SANDS (feet)	PWR (feet)	
B-1	Allen Street - N. of Scarp Zone	0 to 17	-	17 to 22	-	22 to 38.1	-	38.1
B-2	Allen Street - N. Side within Scarp Zone	0 to 12	-	12 to 22	-	22 to 32	32 to 37.4	37.4
B-3	Allen Street - Approx. Center within Scarp Zone	0 to 12	-		12 to 17	17 to 42	42 to 46.6	46.6
B-4	Allen Street - S. Side within Scarp Zone	0 to 8	-	8 to 12	-	12 to 50	-	50 (t)
B-5	Allen Street - S. of Scarp Zone	0 to 3	-	-	3 to 5.5	5.5 to 32	32 to 42.3	42.3
B-6	Mid-Slope Access Bench - N. Side	0 to 3	-	3 to 12**	12 to 17	17 to 27	27 to 30	30 (t)
B-7	Mid-Slope Access Bench - S. Side	3 to 5.5	0 to 3	8 to 17	5.5 to 8, 17 to 27	-	27 to 30	30 (t)
B-8	Base of Slope - Green Area S. of Park Driveway	0 to 5.5	-	8 to 12	5.5 to 8	12 to 22.1	-	22.1
B-9	Base of Slope - Within Park Driveway	0 to 3	-	-	3 to 12	12 to 17	17 to 18.2	18.2

- Not encountered in soil test boring / not applicable.
*See Figure 2 for approximate locations.
** Soft residual silts encountered in B-6 at depths of approx. 3 to 5.5 feet.
(t) = boring terminated

Groundwater

Groundwater measurements were taken by the drillers at the time of boring, and groundwater was encountered in each of the borings. Piezometer standpipes were installed in six of the boring locations (B-1, B-2, B-4, B-5, B-6, B-9), and stabilized groundwater measurements (approx. 1 week, 2 weeks, and 6 weeks after boring) were performed at each of these boring locations. Long-term groundwater measurements taken weeks after boring were typically consistent with stabilized elevations at each location. A summary of groundwater conditions encountered by the soil test borings is provided below in Table 2B. Groundwater levels may fluctuate several feet with seasonal and rainfall variations. Normally, the highest groundwater levels occur in late winter and spring and the lowest levels occur in late summer and fall.

TABLE 2B
SUMMARY OF GROUNDWATER DEPTHS ENCOUNTERED BY SOIL TEST BORINGS
(MEASURED IN FEET BELOW THE EXISTING GROUND SURFACE)

Soil Test Boring No.	General Location*	Boring Depth** (feet)	Groundwater Depths			
			Time of Boring (feet)	±1 Week after Boring (feet)	±2 Weeks after Boring (feet)	±6 Weeks after Boring (feet)
B-1	Allen Street - N. of Scarp Zone	38.1	22.0	18.0	18.5	19.2
B-2	Allen Street - N. Side within Scarp Zone	37.4	21.1	15.5	15.7	16.5
B-3	Allen Street - Approx. Center within Scarp Zone	46.6	19.2	No Piezometer Installed		
B-4	Allen Street - S. Side within Scarp Zone	50.0	23.3	13.7	13.4	14.1
B-5	Allen Street - S. of Scarp Zone	42.3	22.6	16.2	15.8	16.5
B-6	Mid-Slope Access Bench - N. Side	30.0	16.2	7.0	8.0	8.7
B-7	Mid-Slope Access Bench - S. Side	30.0	15.3	No Piezometer Installed		
B-8	Base of Slope - Green Area S. of Park Driveway	22.1	18.7	No Piezometer Installed		
B-9	Base of Slope - Within Park Driveway	18.2	12.3	9.9	9.0	9.6

*See Figure 2 for approximate locations.
**Borings B-4, B-6, B-7 extended to assigned termination depths. Other borings encountered refusal materials.

The above descriptions provide a summary of the subsurface conditions encountered by the soil test borings. The attached logs contain information recorded at each boring location. The logs represent our interpretation of the field logs based on examination of the field samples. The lines designating the interfaces between various strata represent approximate boundaries. The transition between strata may be gradual. It should be noted the soil conditions may vary between boring locations, and that elevations should be considered approximate.

ANALYSES AND DESIGN RECOMMENDATIONS

Slope Stability Analyses

Slope stability analyses were conducted by Spencer's limit equilibrium method using SLOPE/W software developed by Geo-Slope International. Slope stability analyses were utilized to approximate the existing observed failure mechanism and to develop general geotechnical recommendations for slope stabilization and repair. The soil strength parameters used in the analyses were estimated based on the results of laboratory testing and our experience on similar projects. Cohesion parameters for existing fill and residual soils were back-calculated in order to develop the approximate slope failure mechanism geometries observed in the field. These back-calculations led to a reduction of cohesion values from the laboratory determined values, which would be anticipated along the slip plane surface. Our analyses utilized stabilized groundwater phreatic surface conditions observed during our exploration and noted in Table 2B, as well as the observance of seepage water exiting at the toe of the slope during our site visits in the general vicinities of B-8 and B-9.

The following values were utilized for existing fill soils: effective cohesion c' = 10 psf, effective friction angle φ' = 27 degrees, total unit weight, γ_t = 125 pcf. The following values were utilized for soft/loose residual soils: effective cohesion c' = 10 psf, effective friction angle φ' = 26.3 degrees, total unit weight, γ_t = 120 pcf. The following values were utilized for firm or better residual soils: effective cohesion c' = 100 psf, effective friction angle φ' = 32 degrees, total unit weight, γ_t = 125 pcf. The following values were utilized for PWR: effective cohesion c' = 250 psf, effective friction angle φ' = 40 degrees, total unit weight, γ_t = 135 pcf. Shear strength parameters utilized for PWR were estimated based on our experience with similar materials.

Based on our experience, the most likely type of slope failure for these conditions would be a circular failure arc. The minimum factor of safety (FS) generally recommended for long-term slope stability is 1.3 or greater. Generally, a FS $\geq$ 1.5 is required for critical slopes retaining infrastructure (such as roadways). A factor of safety FS $\leq$ 1.0 is indicative of failure. Back-calculations utilized to help approximate cohesion parameters for existing fill and residual soils at the site assumed a FS $\approx$ 1.0.

Until remedial recommendations are implemented, the existing slope configuration will likely continue to have a factor of safety FS $\approx$ 1.0, meaning that it is potentially unstable. Additional instability may take place at the project slope, especially during or after periods of sustained and significant precipitation events. Access to areas below the slope should be prevented as much as possible to reduce the likelihood of loss of life and/or property in the event of a subsequent failure prior to implementation of remedial recommendations. Additionally, new signs of structural distress within the adjacent residential property at 527 Allen Street may warrant vacating the structure until repairs are implemented.

Conclusions and General Recommendations for Repair

It is our opinion that the existing failure was likely triggered by a combination of a relatively high groundwater table, significant recent precipitation events, and a relatively weak strata of near-surface residual soils. The possible breakage of the water line within Allen Street may have contributed to a portion of the movement; however, we are unable to conclude if the breakage occurred before or after the slope failure, and therefore whether discharged water from the possible breakage contributed to triggering the initial movement.

Groundwater and Surface Water Control

It is our opinion that that long-term repair of the existing slope failure area must incorporate a means of lowering the existing groundwater table elevation within the slope. Furthermore, the groundwater elevation within the slope should be maintained such that it does not rise during future periods of significant rainfall and trigger another slope failure.

The implementation of any remedial design should incorporate the installation of horizontal drains to effectively remove groundwater from the slope. The number, size, spacing, and location of horizontal drains should be designed by a licensed Professional Engineer to adequately remove groundwater from the area. At a minimum, we recommend that horizontal drains be installed at or near the base of the slope (at the general Bryson Park elevation) and also approximately midslope (i.e., along the length of the access road). Groundwater gathered by the horizontal drain systems should be removed from the slope area by permanent piping.

We recommend that horizontal drains be installed at sufficient lengths and frequency such that the groundwater table is lowered to a depth of at least 20 feet below existing grade along the slope profile (i.e., within the Allen Street and mid-slope bench footprints), or roughly 6 to 11 feet deeper than its present depth in these areas. We do not anticipate that installation of horizontal drains will significantly lower the groundwater elevation at the toe of the slope failure (Bryson Park area). Permanent piezometers should be installed and regularly observed to confirm that horizontal drains are maintaining the groundwater elevation as described. Site grading should be performed that surface water does not pool in locations within, adjacent, or at the toe of the slope. This also should include positive drainage away from the small roadway shoulder to the west of Allen Street and at the mid-slope bench.

Soil Nailing / Ground Anchors

Proper installation of horizontal drains will significantly improve the factor of safety for global slope stability of the site. However, based on our analyses, installation of horizontal drains will not increase the slope stability factor of safety to industry standards for critical slopes (FS ≥ 1.5), and localized failures (e.g., along the fill slope from Allen Street to the mid-slope bench) may continue to occur. Such failures would likely impact future serviceability of the roadway and underground public utilities in the area in a similar manner to the current failure. It is our experience that unreinforced, permanent fill slopes (such as those supporting Allen Street in the slope failure area) that are benched into a suitable foundation and adequately compacted should be constructed at 2H:1V slope configurations, or flatter, in order to maintain long-term stability.

Because of the presence of weaker near-surface residual soils (N-values < 7) within the upper approximate 10 feet at the base of the slope failure area (vicinity of B-8, B-9), as well within the upper approximate 15 feet at the mid-slope bench (vicinity of B-6, B-7), the use of conventional means to stabilize localized failures is not recommended. Conventional means such as site retaining walls or rock buttresses would increase loading on these weaker residual soils and likely result in additional localized failures. Furthermore, because the slope has an overall inclination of approximately 2.4H:1V, it is unlikely that additional grading measures are feasible or would provide significant gains to slope stability.

It is therefore our opinion that a soil nail / ground anchor system would likely provide the best option for long-term stabilization of the existing slope. Soil nails are used to create a mass of soil which then behaves as a gravity system to resist lateral earth pressures. The soil nail system should take the global stability of the site and potential traffic loading into account. Soil nailing will have the advantage of being able to be constructed without removing large sections of the existing roadway; however, care must be taken to avoid existing utilities during installation thereof. Easements may be required where soil nails extend beyond adjacent property lines.

Soil nailing is a method of earth reinforcement which can be constructed with equipment reaching over the edge of the slope from above, from the mid-slope bench, and from the base of the slope at the Bryson Park elevation. Soil nailing consists of drilling holes at a determined pattern through the slope face and into suitable residual materials, after which the hole is grouted with a steel member in place. The steel member is connected to the facing material (typically a steel matting) and tensioned in order to retain the soil mass. At a minimum, we recommend that the slope section between Allen Street and the mid-slope bench be nailed. However, it is likely that stabilization will be required at the lower slope section between the mid-slope bench and Bryson Park as well (this could likely be performed at a later date if additional movement/instability is detected).

Given the existing slope inclinations, we anticipate that soil nail systems can be installed such that a shotcrete facing is not required, and vegetation can be grown on the slope face. A steel Tecco mesh facing may be required. The soil nail specialty contractor should determine a final design inclination and whether a vegetative facing is feasible given the site and soil conditions.

Soil nail / ground anchor designs must take the global stability of the site into account. We recommend a minimum global stability factor of safety of FS = 1.5 for the proposed soil nail system. Soil nail systems should be designed by a Professional Engineer licensed in the state of North Carolina and constructed by a specialty contractor specializing in soil nailing.

After remedial repair work associated with soil nail construction has been completed, the roadway stonebase and asphalt sections at Allen Street and the Bryson Park access driveway could then be reconstructed. Shallow ground improvement measures (such as utilization of biaxial geogrid for stabilization) may be required where very soft existing fill soils (such as at B-2, B-3, and B-4) were encountered within approximately 3 to 4 feet of final pavement elevation.

Construction Sequencing

We recommend that construction take place such that groundwater control is first implemented. Soil nailing / ground anchors utilized to stabilize the already-mobilized materials and to control future failures could then be installed along the face of the slope.

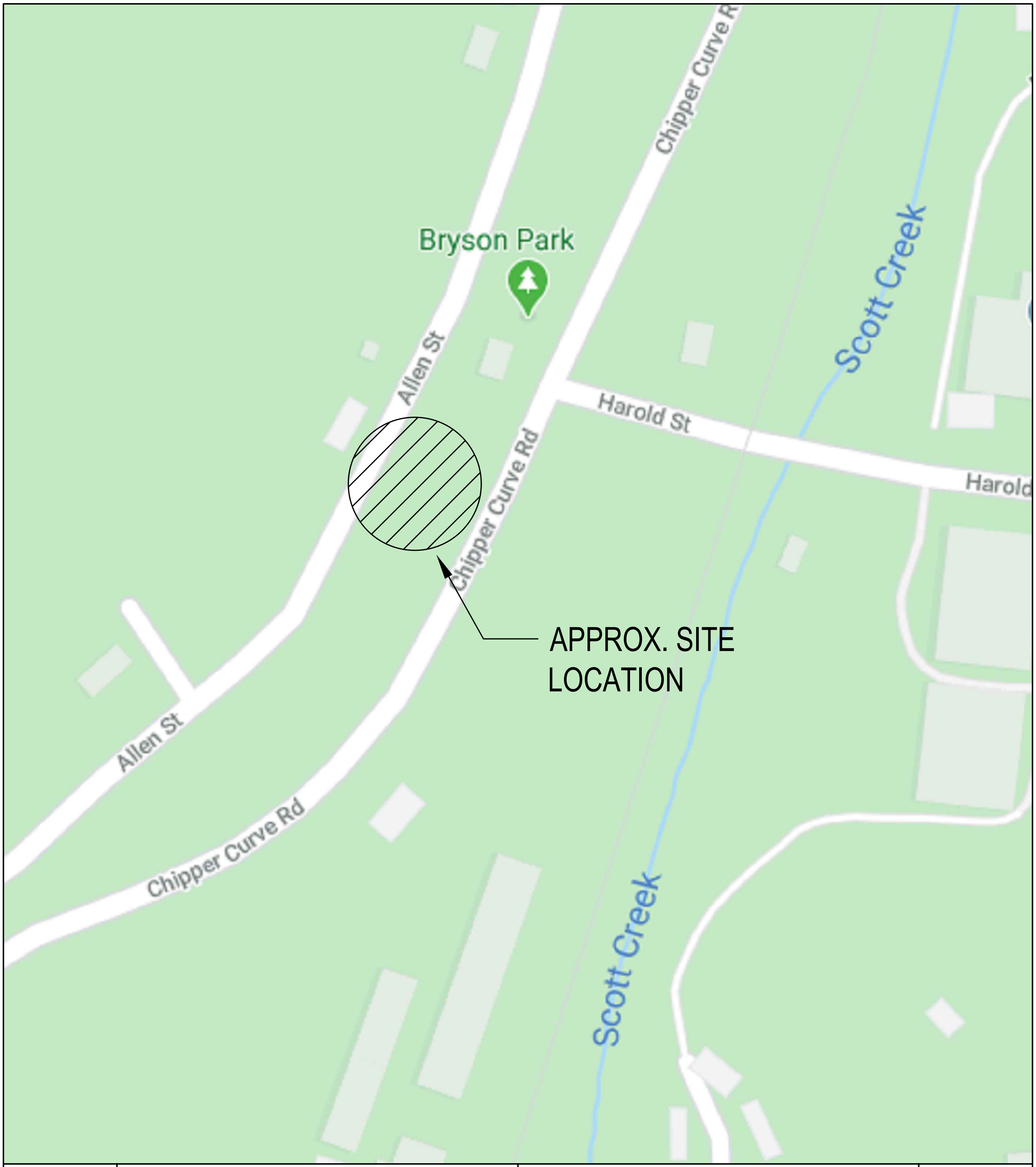
SPECIFICATIONS REVIEW

We recommend that we be retained to make a review of the earthwork plans and specifications prepared from the recommendations presented in this report. We would then suggest any modifications so that our recommendations are properly interpreted and implemented. An additional fee would apply for review of plans and specifications.

BASIS OF RECOMMENDATIONS

Our evaluation of the existing slope conditions has been based on our understanding of the project information, the provided topographic information, and data obtained in our exploration as well as our experience on similar projects. The general subsurface conditions utilized in our slope stability analyses have been based on interpolation of the subsurface data between the widely spaced soil test borings. Subsurface conditions between the borings may differ. If the project information is incorrect, please contact us so that our recommendations can be reviewed. The discovery of site or subsurface conditions during construction which deviate from the data obtained in this exploration should be reported to us for our evaluation. The assessment of site environmental conditions for presence or absence of pollutants in the soil, rock and ground water of the site was beyond the scope of this exploration. The assessment of slopes not described in this report, including other slope areas along Allen Street and the slope extending uphill and to the west of the residential property located at 527 Allen Street, was beyond our current scope of services.

APPENDIX



SITE LOCATION PLAN
KEG PROJECT NO. JA20-4021-01
DATE: 07-14-2020

ALLEN STREET SLOPE FAILURE
SYLVA, NORTH CAROLINA

FIGURE
1

N

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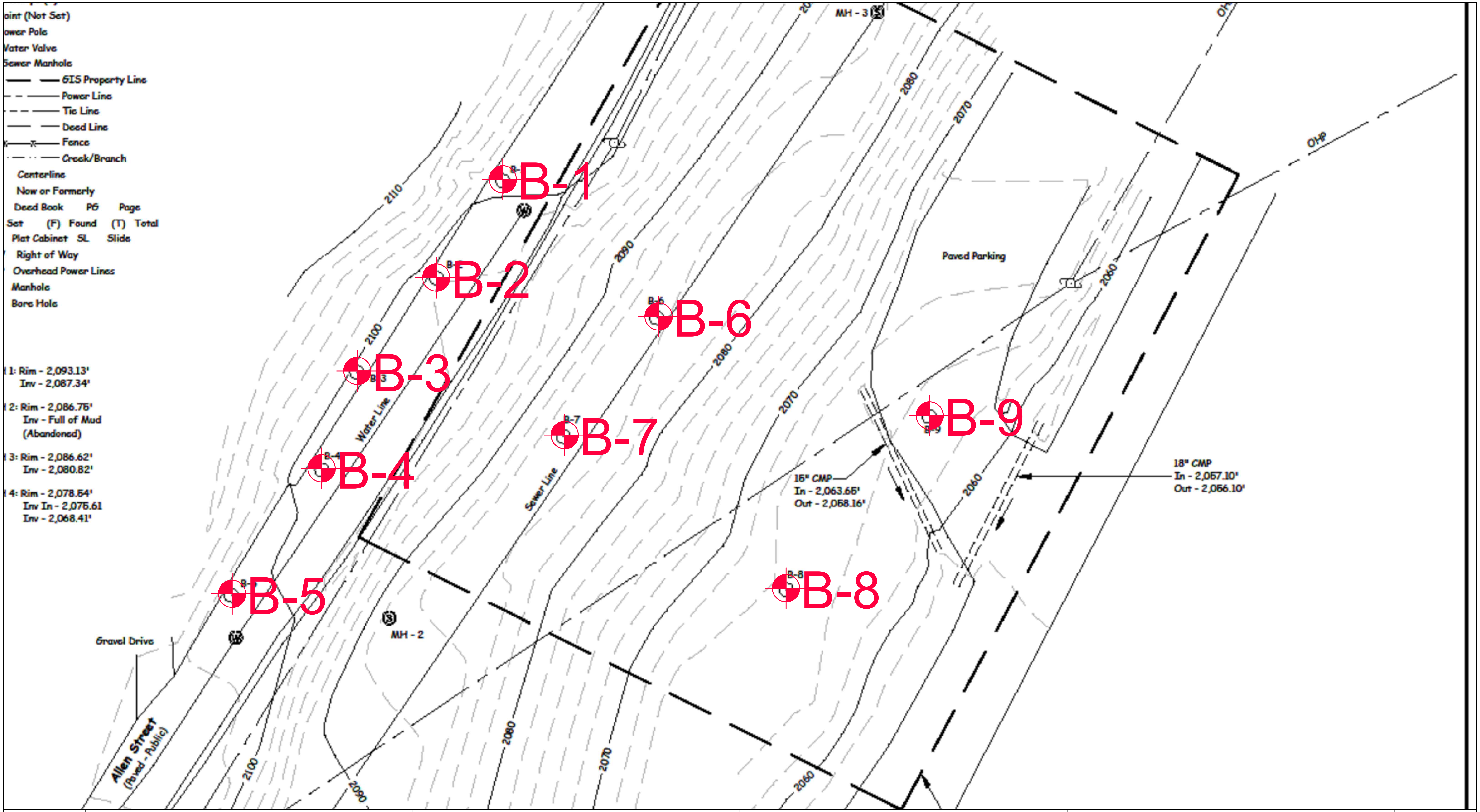
582 HENDERSONVILLE ROAD SUITE ONE | ASHEVILLE NC 28803 | P:[828] 277-6351 | F:[828] 277-6355
WWW.THEKESSELGROUP.COM



N

KESSEL ENGINEERING GROUP

ALLEN STREET SLOPE FAILURE
SYLVA, NORTH CAROLINA

KEG PROJECT NO. JA20-4021-01

FIELD EXPLORATION PLAN DATE: 07-14-2020

REFERENCE: Topographic Survey prepared for: Town of Sylva, by Alliance Land Surveying, P.C., dated 06/16/2020

0' 10' 20' 40'

SCALE: 1" = 20'-0"

FIGURE
2

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FIELD EXPLORATION AND LABORATORY TEST PROCEDURES

SOIL TEST BORINGS

The soil test borings were advanced by mechanically twisting a continuous flight steel auger into the soil. Soil sampling and penetration testing were performed in general accordance with ASTM D 1586. At assigned intervals, soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings and then driven an additional 12 inches with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final 12 inches was recorded and is designated the "penetration resistance." The penetration resistance, once properly evaluated, is an index to the strength of the soil and foundation supporting capability. Representative portions of the soil samples, thus obtained, were placed in plastic bags and transported to the laboratory. In the laboratory, the samples were examined to verify the field classifications made by the driller. Soil descriptions and penetration resistances are tabulated on the attached Boring Logs.

UNDISTURBED SAMPLING

Split-barrel samples are suitable for visual examination and classification tests but are not sufficiently intact for quantitative laboratory tests. Therefore, relatively undisturbed samples were obtained in selected soil test borings by drilling to the desired depth and hydraulically forcing a section of 3-inch O.D., 16-gauge steel tubing into the soil. The sampling procedure is described by ASTM D 1587. Together with the encased soil, each tube was carefully removed from the ground, made airtight and transported to the laboratory. The location of gathered undisturbed samples is indicated on the attached Boring Logs.

CONSOLIDATED – UNDRAINED TRIAXIAL SHEAR TESTING

Consolidated undrained triaxial compression tests with pore pressure measurements were performed on three undisturbed soil samples. The extruded samples were encased in rubber membranes. Each was then placed in a compression chamber and confined by all-around water pressure. An increasing axial load was then applied until the sample failed in shear. The test results are presented in the form of Stress-Strain Curves and Mohr Diagrams on the accompanying Triaxial Compression Test Reports. The results are presented in the Table 1 of the attached Report.

LABORATORY COMPACTION TESTING

Two representative samples of the onsite soils were collected, placed in buckets and transported to the laboratory for compaction testing. Standard Proctor compaction testing (ASTM D 698) was performed to determine the compaction characteristics including maximum dry density and optimum moisture content. Test results are presented on the attached Compaction Test Reports and in Table 1 of the attached Report.

NATURAL MOISTURE CONTENT

The natural moisture content of selected samples was determined in accordance with ASTM D 2216. The moisture content of the soil is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the soil particles. The results are presented in the Table 1 of the attached Report.

PERCENT FINES

The percentage of fine-grained particles present in the selected samples was determined by passing the sample through a No. 200 mesh sieve. The percent by weight passing the sieve is the percentage of fines or the portion of the sample in the silt and clay size range. These tests were conducted in accordance with ASTM D 1140. The results are shown on the lower right hand corner of the attached Compaction Test Reports and Table 1 of the attached Report.

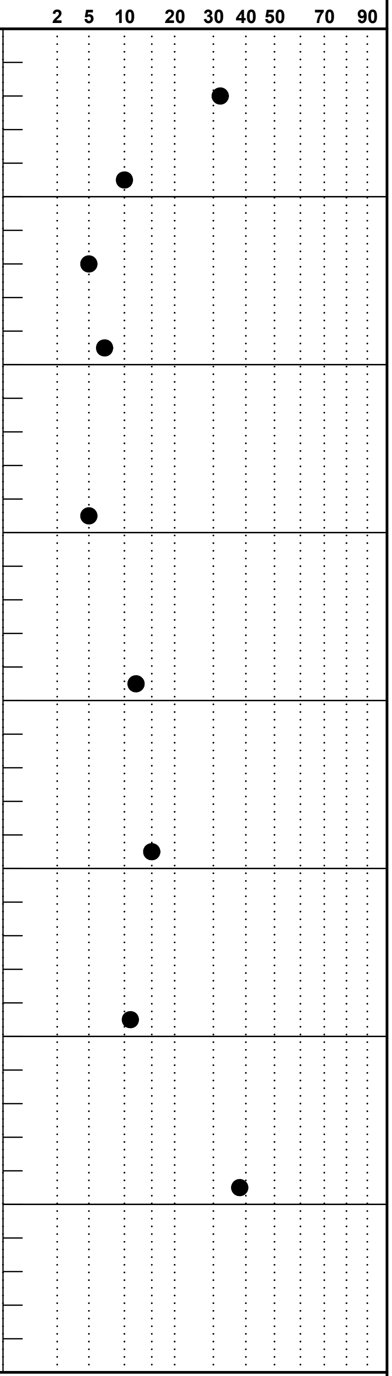
SOIL TEST BORING LOGS (B-1 TO B-9)

KESSEL ENGINEERING GROUP

SOIL TEST BORING NO. B-1

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-11-20 END: 5-11-20
LOCATION: See Figure 2
ELEVATION: 2101 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL ▽ 22.0 ft AFTER 192 HOURS: ▼ 18 ft CAVING> ▨ 20.4 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT	
2100	Loose, Brown, Silty, Fine to Coarse SAND with Gravel (Fill)		☒	9 24 8	N = 32
5			☒	9 7 3	N = 10
2095	Loose, Reddish Brown, Slightly Moist to Wet, Silty, Fine to Coarse SAND with Trace Gravel (Fill) Undisturbed Sample between 11 and 13 feet.		☒	10 2 3	N = 5
10			☒	5 3 4	N = 7
2090					
15			☒	5 2 3	N = 5
2085					
20	Stiff, Reddish Brown, Slightly Micaceous, Slightly Moist, Sandy, Clayey SILT (Residuum)		☒	5 7 5	N = 12
2080					
25	Firm, Dark Brown to Light Brown, Micaceous, Silty, Fine SAND		☒	5 7 8	N = 15
2075					
30			☒	4 4 7	N = 11
2070					
35	Dense, Tan with White, Micaceous, Silty, Fine to Medium SAND		☒	6 12 26	N = 38
2065					
	Auger refusal encountered at 38.1 feet. Groundwater encountered at 22 feet at time of boring and 18 feet 8 days after boring. Borehole caved at 20.4 feet at time of boring				

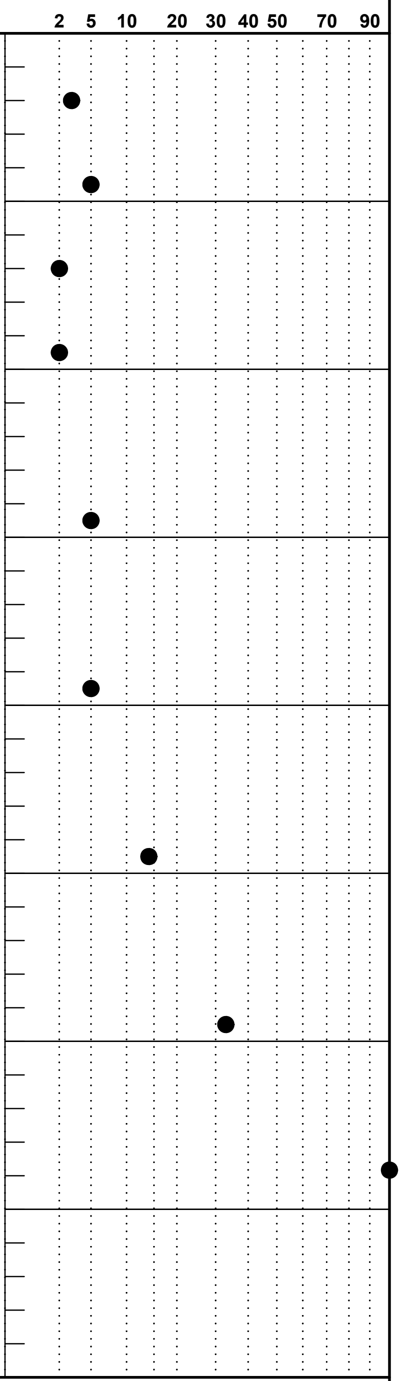


SOIL TEST BORING NO. B-1
Sheet 1 of 1

SOIL TEST BORING NO. B-2

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-11-20 END: 5-11-20
LOCATION: See Figure 2
ELEVATION: 2099 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL▽ 21.1 ft AFTER 192 HOURS:▼ 15.5 ft CAVING>▨ 19 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SAMPLES		STANDARD PENETRATION RESULTS BLOWS/FOOT
	Very Loose and Loose, Reddish Brown with Brown, Micaceous, Slightly Moist, Silty, Fine to Medium SAND (Fill)	4 2 1	N = 3	
2095 / 5		1 2 3	N = 5	
		1 1 1	N = 2	
2090 / 10		2 1 1	N = 2	
2085 / 15	Firm, Reddish Brown, Micaceous, Moist, Sandy SILT (Residuum) Undisturbed Sample between 16 and 18 feet.	WOH 2 3	N = 5	
2080 / 20		2 2 3	N = 5	
2075 / 25	Firm, Brown with White, Slightly Micaceous, Silty, Fine to Medium SAND	3 5 9	N = 14	
2070 / 30	Dense, Tan and Orange, Slightly Micaceous, Silty, Fine to Medium SAND	5 12 21	N = 33	
2065 / 35	PARTIALLY WEATHERED ROCK with No Sample Recovery	37 50/2	N = 50/2	
2060	Auger refusal encountered at 37.4 feet. Groundwater encountered at 21.1 feet at time of boring and 15.5 feet 8 days after boring. Borehole caved at 19 feet at time of boring.			



SOIL TEST BORING NO. B-2
Sheet 1 of 1

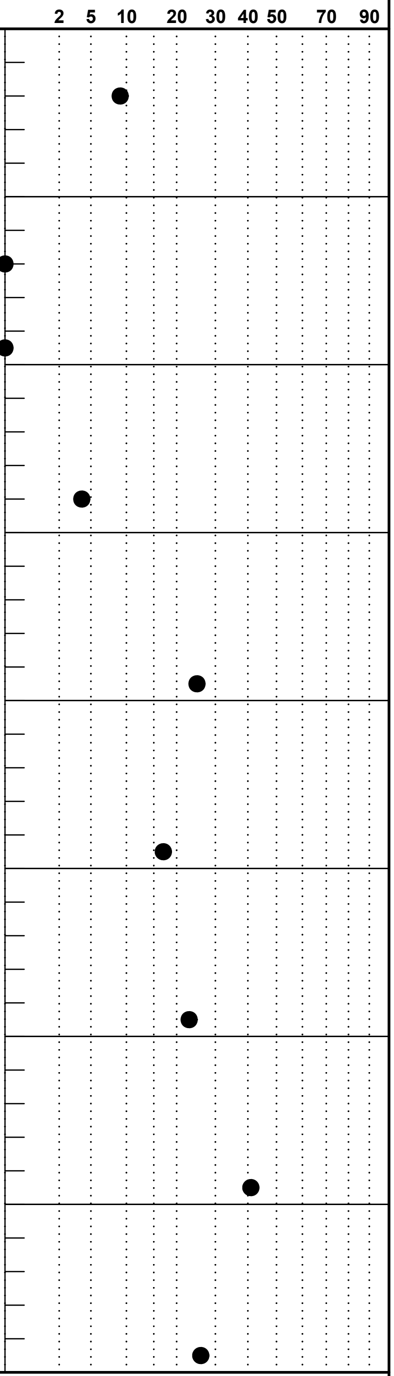
KESSEL ENGINEERING GROUP

SOIL TEST BORING NO. B-3

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-11-20 END: 5-11-20
LOCATION: See Figure 2
ELEVATION: 2100 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL: ∇ 19.2 ft AFTER 24 HOURS: ▼ ________ CAVING> ▨ 23.6 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES	BLOWS	N
	Loose, Dark Gray with Tan, Silty, Fine SAND (Fill)	░	☒	2 3 6	N = 9
2095 — 5	Very Soft, Micaceous, Moist, Sandy, Clayey SILT with Trace Gravel (Fill)	▥	☒	1 WOH	N = WOH
			☒	WOH	N = WOH
2090 — 10			☒	WOH	N = WOH
2085 — 15	Very Loose, Orangish Brown, Micaceous, Slightly Moist, Silty, Fine SAND (Residuum) Undisturbed Sample between 11 and 13 feet.	░	☒	1 2 2	N = 4
2080 — 20	Very Firm, Black, Very Micaceous, Silty, Fine SAND	░	☒	7 11 14	N = 25
2075 — 25	Firm to Very Firm, Light Gray with White and Black, Slightly Micaceous, Silty, Fine to Medium SAND	░	☒	4 7 10	N = 17
2070 — 30			☒	10 10 13	N = 23
2065 — 35	Dense to Very Firm, Orangish White with Gray, Silty, Fine SAND	░	☒	14 18 23	N = 41
			☒	10 11 15	N = 26

STANDARD PENETRATION RESULTS BLOWS/FOOT



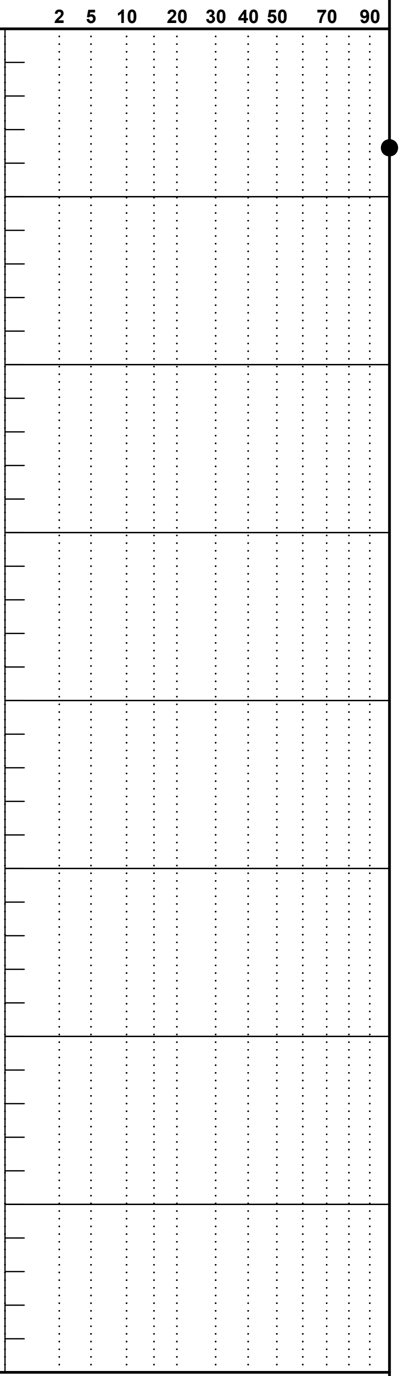
SOIL TEST BORING NO. B-3
Sheet 1 of 2

SOIL TEST BORING NO. B-3

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-11-20 **END:** 5-11-20
LOCATION: See Figure 2
ELEVATION: 2100 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL: ▽ 19.2 ft **AFTER 24 HOURS:** ▼ **CAVING>** ▨ 23.6 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES		
	Dense to Very Firm, Orangish White with Gray, Silty, Fine SAND				
	PARTIALLY WEATHERED ROCK which sampled as Gray, Silty, Fine to Medium SAND			50/1	N = 50/1
2055 — 45					
	Auger refusal encountered at 46.6 feet. Groundwater encountered at 19.2 feet at time of boring. Borehole caved at 23.6 feet at time of boring.				
2050 — 50					
2045 — 55					
2040 — 60					
2035 — 65					
2030 — 70					
2025 — 75					

STANDARD PENETRATION RESULTS BLOWS/FOOT



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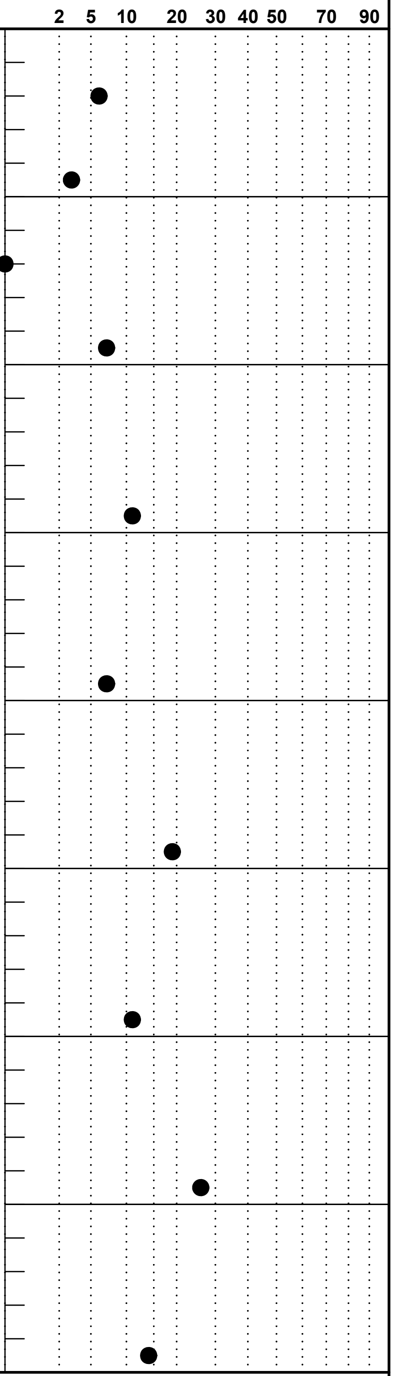
SOIL TEST BORING NO. B-4

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 END: 5-12-20
LOCATION: See Figure 2
ELEVATION: 2099 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL▽ 23.3 ft AFTER 168 HOURS:▼ 13.7 ft CAVING>▨ 24.2 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT
	Loose, Light Gray with White, Slightly Micaceous, Silty, Fine SAND (Fill)	1 3 3	N = 6
2095 5	Very Soft, Brown, Micaceous, Moist, Sandy SILT (Fill)	2 1 2	N = 3
		WOH 2	N = 2
2090 10	Firm, Reddish Brown, Slightly Moist, Micaceous, Sandy SILT (Residuum)	2 3 4	N = 7
2085 15	Firm, Brown, Micaceous, Silty, Fine to Medium SAND	3 5 6	N = 11
2080 20		3 3 4	N = 7
2075 25		4 8 11	N = 19
2070 30		3 3 8	N = 11
2065 35	Very Firm to Firm, White with Gray, Silty, Fine to Coarse SAND with Quartz Fragments	4 9 17	N = 26
2060		4 7 7	N = 14

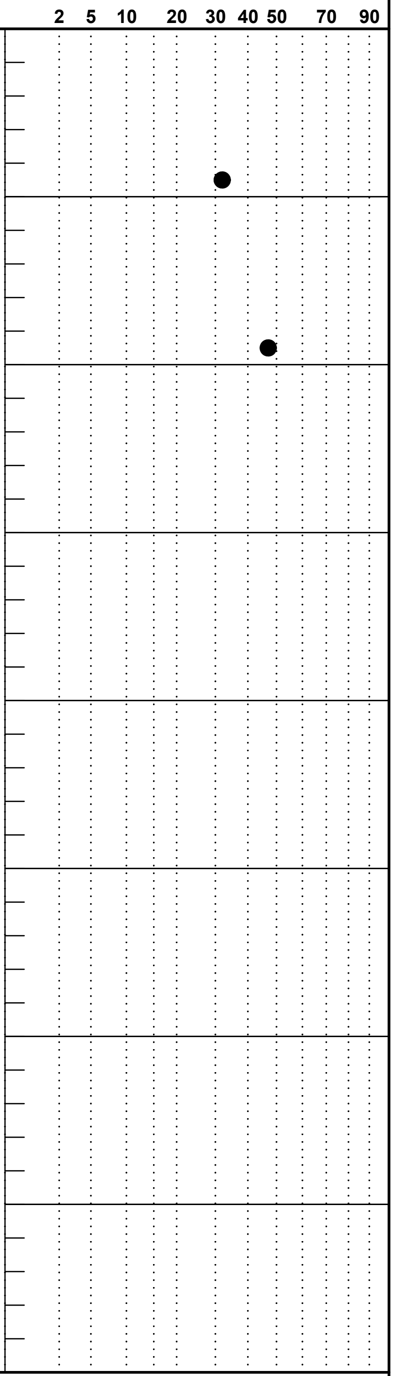


SOIL TEST BORING NO. B-4
Sheet 1 of 2

SOIL TEST BORING NO. B-4

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 **END:** 5-12-20
LOCATION: See Figure 2
ELEVATION: 2099 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL:▽ 23.3 ft **AFTER 168 HOURS:**▼ 13.7 ft **CAVING>**▨ 24.2 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT	
	Very Firm to Firm, White with Gray, Silty, Fine to Coarse SAND with Quartz Fragments				
2055 / 45	Dense, Light Brown, Slightly Micaceous, Silty, Fine to Medium SAND		☒	9 13 19	N = 32
2050 / 50			☒	9 15 32	N = 47
2045 / 55 2040 / 60 2035 / 65 2030 / 70 2025 / 75 2020	Boring terminated at 50.0 feet. Groundwater encountered at 23.3 feet at time of boring and 13.7 feet 7 days after boring. Borehole caved at 24.2 feet at time of boring.				



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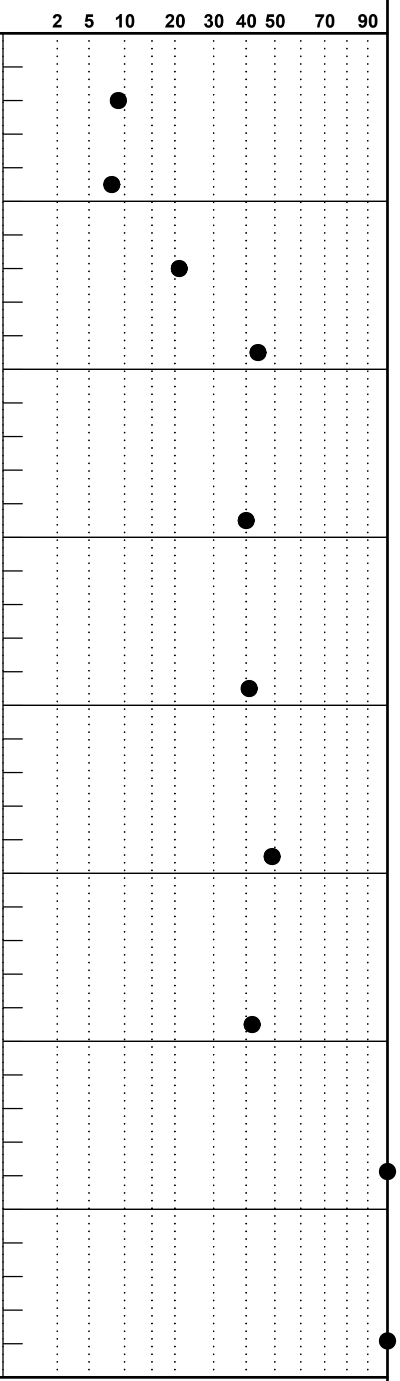
SOIL TEST BORING NO. B-5

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 END: 5-12-20
LOCATION: See Figure 2
ELEVATION: 2102 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL▽ 22.6 ft AFTER 168 HOURS:▼ 16.2 ft CAVING> 24.1 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT
2100	Loose, Dark Brown, Micaceous, Silty, Fine to Medium SAND (Fill)	4 6 3	N = 9
5	Loose, Brown with White, Silty, Fine to Medium SAND (Residuum)	3 4 4	N = 8
2095	Very Firm, Black and White, Very Slightly Micaceous, Silty, Fine to Medium SAND	6 9 12	N = 21
10	Dense, Black, White and Orangish Brown, Silty, Fine to Medium SAND with Very Wet Split Spoon Sample at 23.5 to 25 feet Undisturbed Sample between 13 and 15 feet.	6 23 21	N = 44
2090			
15		11 13 27	N = 40
2085			
20		12 18 23	N = 41
2080			
25		8 21 28	N = 49
2075			
30		10 19 23	N = 42
2070	PARTIALLY WEATHERED ROCK which sampled as Gray, Very Wet, Silty, Fine SAND	26 50/3	N = 50/3
35			
2065	PARTIALLY WEATHERED ROCK which sampled as Brown, Black and White, Slightly Micaceous, Silty, Fine to Medium SAND	21 50/4	N = 50/4



SOIL TEST BORING NO. B-5

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 **END:** 5-12-20
LOCATION: See Figure 2
ELEVATION: 2102 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL: ∇ 22.6 ft **AFTER 168 HOURS:** ▼ 16.2 ft **CAVING>** ▨ 24.1 ft

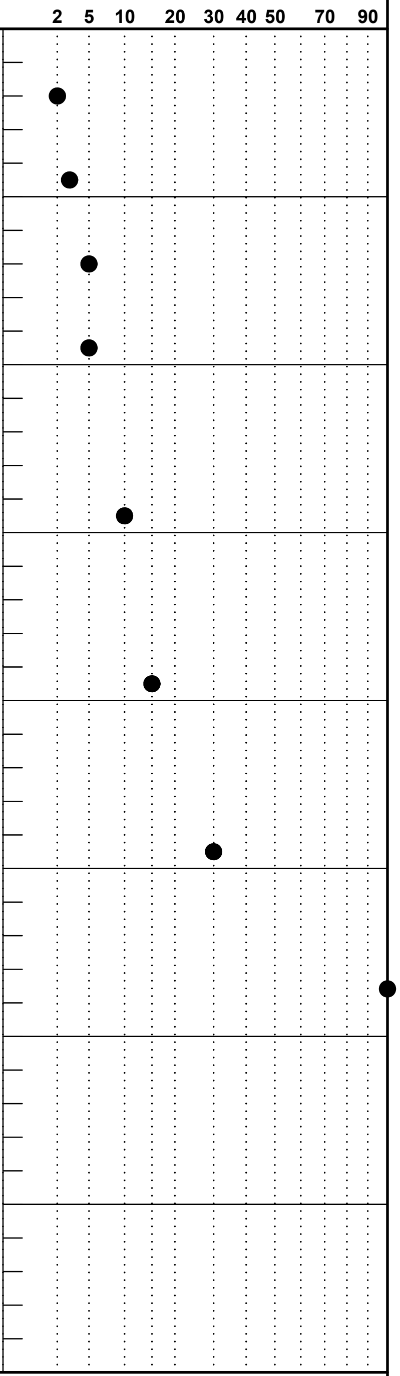
ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT 2 5 10 20 30 40 50 70 90
2060	PARTIALLY WEATHERED ROCK which sampled as Brown, Black and White, Slightly Micaceous, Silty, Fine to Medium SAND	▨		
45	Auger refusal encountered at 42.3 feet. Groundwater encountered at 22.6 feet at time of boring and 16.2 feet 7 days after boring. Borehole caved at 24.1 feet at time of boring.			
2055				
50				
2050				
55				
2045				
60				
2040				
65				
2035				
70				
2030				
75				
2025				

KESSEL ENGINEERING GROUP

SOIL TEST BORING NO. B-6

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 END: 5-12-20
LOCATION: See Figure 2
ELEVATION: 2085 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL: ▽ 16.2 ft AFTER 168 HOURS: ▼ 7 ft CAVING> ▨ 17 ft

ELEVATION/ DEPTH (FT)		DESCRIPTION	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT	
		Very Loose, Gray, Moist, Silty, Fine to Medium SAND (Fill)			
			☒	3 1 1	N = 2
		Soft to Firm, Reddish Brown, Very Slightly Micaceous, Moist, Sandy, Clayey SILT (Residuum)			
			☒	1 1 2	N = 3
2080	5				
	▼		☒	2 2 3	N = 5
			☒	2 2 3	N = 5
2075	10				
		Loose, Reddish Brown, Very Slightly Micaceous, Silty, Fine to Medium SAND			
			☒	3 4 6	N = 10
2070	15				
	▽				
	▨	**Firm to Very Firm, Tan, Very Micaceous, Slightly Moist, Silty, Fine SAND**			
			☒	4 7 8	N = 15
2065	20				
			☒	10 12 18	N = 30
2060	25				
		PARTIALLY WEATHERED ROCK which sampled as Tan with Gray, Very Micaceous, Silty, Fine SAND			
			☒	50/2	N = 50/2
2055	30	**Boring terminated at 30.0 feet. Groundwater encountered at 16.2 feet at time of boring and 7 feet 7 days after boring. Borehole caved at 17 feet at time of boring.**			
2050	35				



SOIL TEST BORING NO. B-6
Sheet 1 of 1

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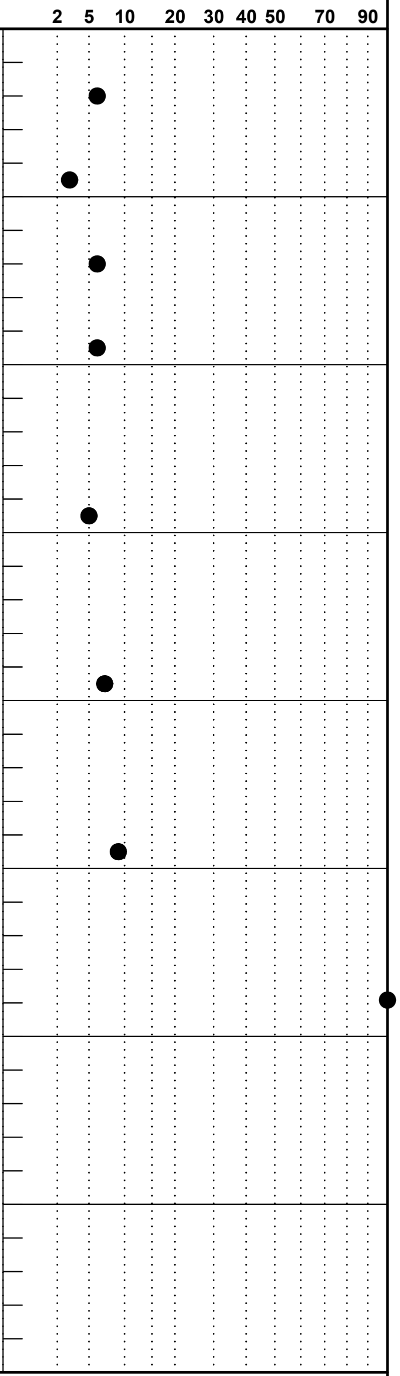
SOIL TEST BORING NO. B-7

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 END: 5-12-20
LOCATION: See Figure 2
ELEVATION: 2085 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL▽ 15.3 ft AFTER 24 HOURS:▼ CAVING> 15.8 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT	
	Firm to Soft, Brown, Very Micaceous, Moist, Sandy SILT with Trace Topsoil (Fill)		☒	2 3 3	N = 6
			☒	1 2 1	N = 3
2080—5					
	Loose, Brown, Micaceous, Slightly Moist, Silty, Fine SAND (Residuum)		☒	2 3 3	N = 6
	Firm, Brown, Micaceous, Very Moist, Sandy SILT Undisturbed Sample between 16 and 18 feet.		☒	2 3 3	N = 6
2075—10					
			☒	2 2 3	N = 5
2070—15 ▽					
	Loose, Brown, Very Slightly Micaceous, Very Slightly Moist to Moist, Silty, Fine to Medium SAND		☒	3 3 4	N = 7
2065—20					
			☒	2 4 5	N = 9
2060—25					
	PARTIALLY WEATHERED ROCK which sampled as Tan and Brown, Very Micaceous, Silty, Fine SAND		☒	11 50/4	N = 50/4
2055—30	Boring terminated at 30.0 feet. Groundwater encountered at 15.3 feet at time of boring. Borehole caved at 15.8 feet at time of boring.				
2050—35					



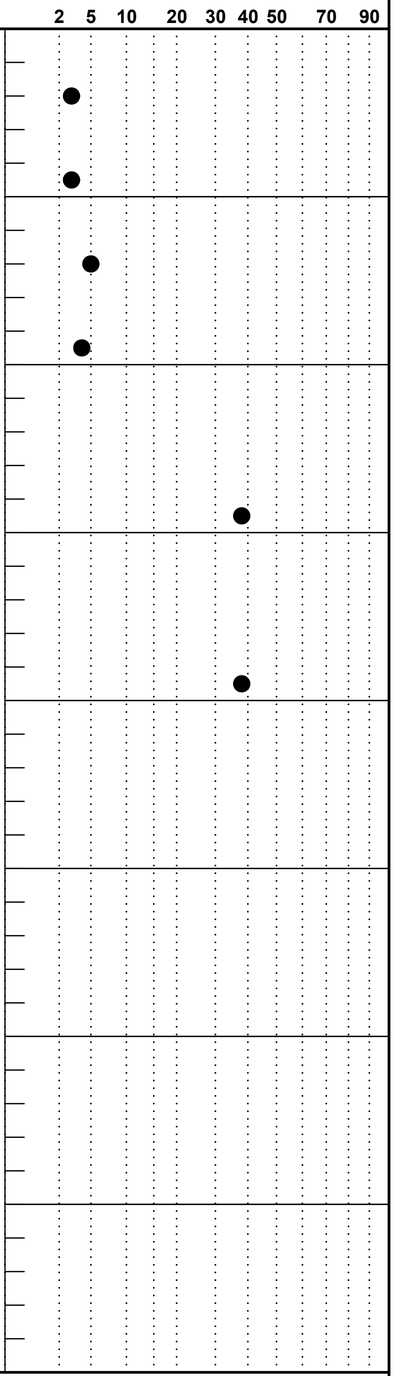
SOIL TEST BORING NO. B-7
Sheet 1 of 1

KESSEL ENGINEERING GROUP

SOIL TEST BORING NO. B-8

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 END: 5-12-20
LOCATION: See Figure 2
ELEVATION: 2065 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL▽ 18.7 ft AFTER 24 HOURS:▼ CAVING>▨

ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES	STANDARD PENETRATION RESULTS BLOWS/FOOT
	Very Loose, Brown, Micaceous, Very Moist, Silty, Fine to Coarse SAND (Fill)	▨	☒	3 2 1 N = 3
			☒	2 1 2 N = 3
2060 — 5				
	Loose, Brown, Micaceous, Silty, Fine SAND (Residuum)	▨	☒	2 2 3 N = 5
	Soft, Brown, Very Wet, Sandy SILT		☒	3 2 2 N = 4
2055 — 10				
	Dense, Brown with White, Silty, Fine to Coarse SAND Undisturbed Sample between 11 and 13 feet.	▨	☒	2 18 20 N = 38
2050 — 15				
	Dense, Light Brown, Silty, Fine to Coarse SAND with Partially Weathered Rock Fragments	▨	☒	15 20 18 N = 38
▽				
2045 — 20				
	Auger refusal encountered at 22.1 feet. Groundwater encountered at 18.7 feet at time of boring.			
2040 — 25				
2035 — 30				
2030 — 35				

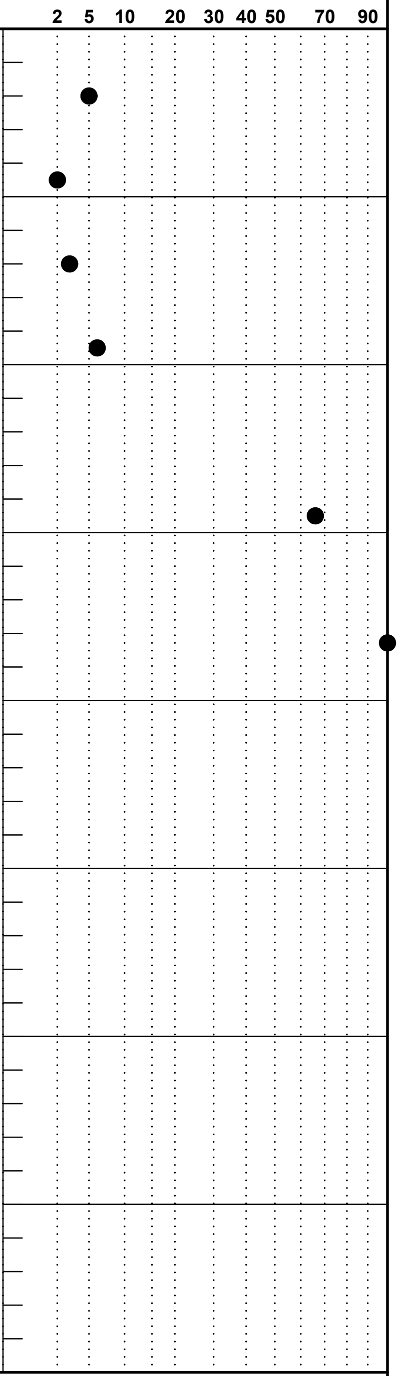


KESSEL
ENGINEERING
GROUP

SOIL TEST BORING NO. B-9

PROJECT: Allen Street Slope Failure
PROJECT NO.: JA20-4021-01
CLIENT: Town of Sylva
DATE START: 5-12-20 **END:** 5-12-20
LOCATION: See Figure 2
ELEVATION: 2063 (feet)
DRILLER: EDPS
LOGGED BY: I. Johnson
DRILLING METHOD: Hollow Stem Auger
DEPTH TO - WATER> INITIAL:▽ 12.3 ft **AFTER 168 HOURS:▼** 9.9 ft **CAVING>▨** 6.3 ft

ELEVATION/ DEPTH (FT)	DESCRIPTION	SOIL TYPE	SAMPLES		STANDARD PENETRATION RESULTS BLOWS/FOOT
2060	Loose, Brown, Micaceous, Silty, Fine to Coarse SAND with Trace Asphalt Fragments (Fill)		☒	2 3 2	N = 5
5 2055	Very Loose, Tan, Very Micaceous, Slightly Moist to Very Wet, Silty, Fine to Coarse SAND (Residuum)		☒ ☒	2 1 1 1 1 2	N = 2 N = 3
10	Loose, Tan, Very Micaceous, Silty, Fine SAND		☒	3 4 2	N = 6
2050 15	Very Dense, Tan, Very Micaceous, Very Wet, Silty, Fine SAND		☒	28 46 20	N = 66
	PARTIALLY WEATHERED ROCK with No Sample Recovery				
2045 20 2040 25 2035 30 2030 35 2025	Auger refusal encountered at 18.2 feet. Groundwater encountered at 12.3 feet at time of boring and 9.9 feet 7 days after boring. Borehole caved at 6.3 feet at time of boring.			50/2	N = 50/2



SOIL TEST BORING NO. B-9
Sheet 1 of 1

KEY TO SOIL CLASSIFICATIONS AND CONSISTENCY DESCRIPTIONS

SANDS

Penetration Resistance* Blows per Foot	Relative Density
0 to 4	Very Loose
5 to 10	Loose
11 to 20	Firm
21 to 30	Very Firm
31 to 50	Dense
over 50	Very Dense

Particle Size Identification

Boulder: Greater than 300 mm
Cobble: 75 to 300 mm
Gravel:
Coarse - 19 to 75 mm
Fine - 4.75 to 19 mm
Sand:
Coarse - 2 to 75 mm
Medium - 0.425 to 2 mm
Fine - 0.075 to 0.425 mm
Silts & Clay: Less than 0.075 mm

SILTS and CLAYS

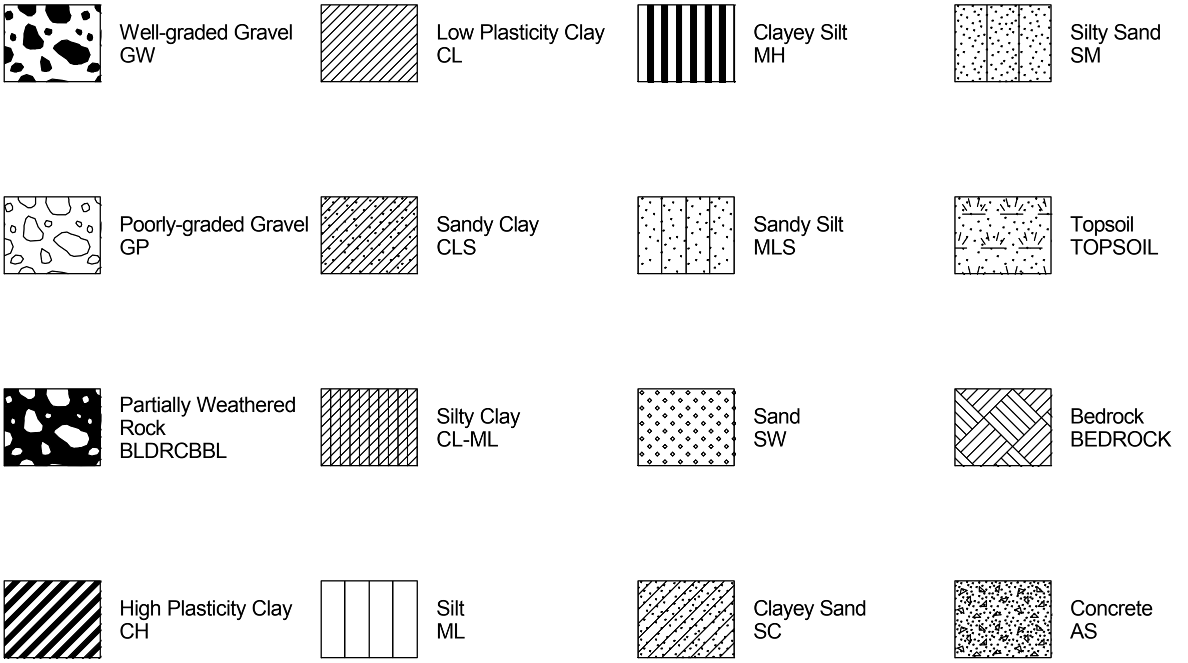
Penetration Resistance* Blows per Foot	Consistency
0 to 2	Very Soft
3 to 4	Soft
5 to 8	Firm
9 to 15	Stiff
16 to 30	Very Stiff
31 to 50	Hard
over 50	Very Hard

* ASTM D 1586

KEY TO DRILLING SYMBOLS

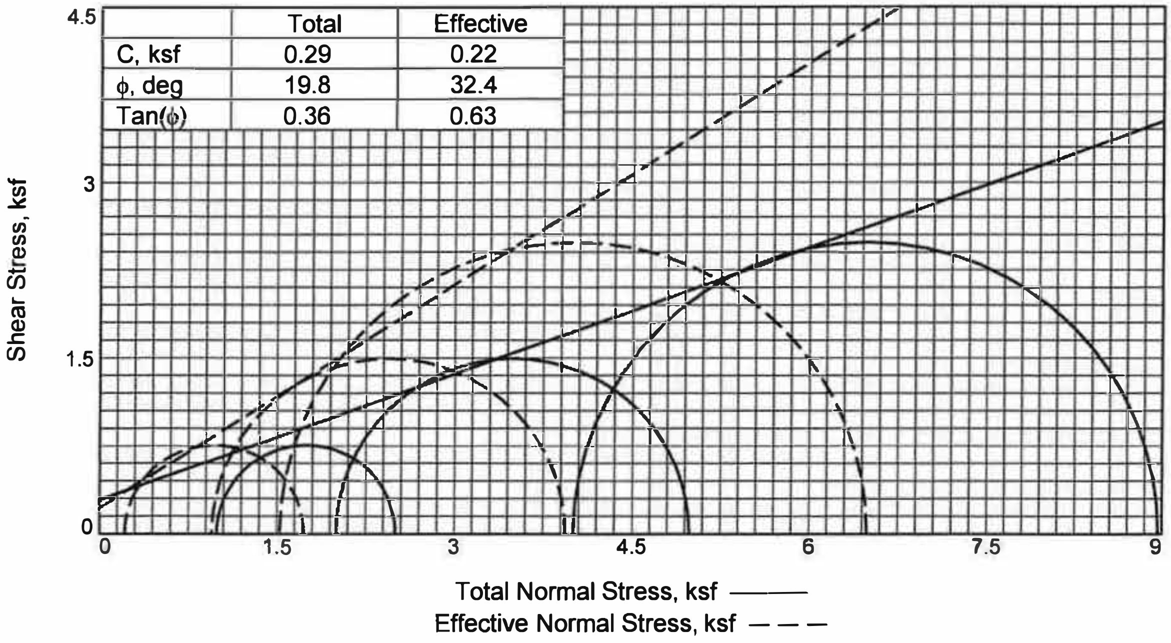
✋	Grab Sample
☒	Split Spoon Sample
☐	Undisturbed Sample
▽	Groundwater Table at Time of Drilling
▼	Groundwater Table 24 Hours after Completion of Drilling

KEY TO SOIL CLASSIFICATIONS

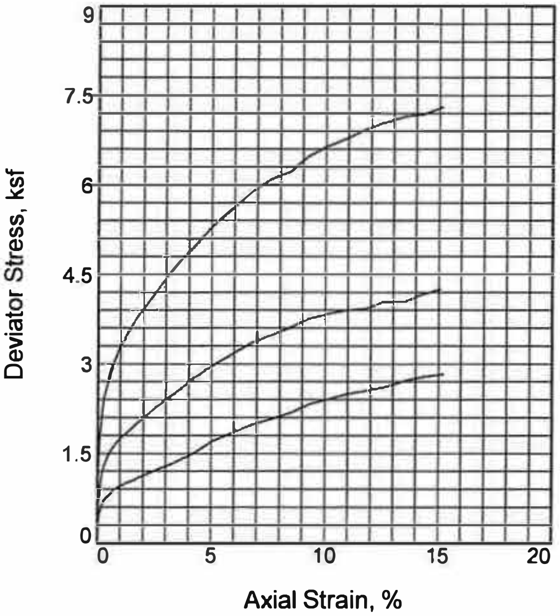


LABORATORY TEST RESULTS

1. Undisturbed Sample Nos. B-1, B-2, B-7
    a. Triaxial Shear Test Report No. TX B-1
    b. Triaxial Shear Test Report No. TX B-2a
    c. Triaxial Shear Test Report No. TX B-7
2. Particle Size Distribution Reports
    a. Particle Size Distribution Report PS B-1
    b. Particle Size Distribution Report PS B-2a
    c. Particle Size Distribution Report PS B-2b
    d. Particle Size Distribution Report PS B-7
    e. Particle Size Distribution Report PS B-8
3. Compaction Test Reports
    a. Compaction Test Report STD B-2b
    b. Compaction Test Report STD B-8



	Total	Effective
C, ksf	0.29	0.22
ϕ, deg	19.8	32.4
Tan(ϕ)	0.36	0.63



	Sample No.	1	2	3
Initial	Water Content, %	18.2	15.6	16.3
	Dry Density, pcf	101.1	114.8	110.4
	Saturation, %	73.6	90.0	83.5
	Void Ratio	0.6676	0.4676	0.5270
	Diameter, in.	2.865	2.865	2.865
	Height, in.	5.981	6.040	6.002
At Test	Water Content, %	18.2	15.9	16.1
	Dry Density, pcf	113.1	117.8	117.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.4901	0.4306	0.4344
	Diameter, in.	2.720	2.845	2.790
	Height, in.	5.931	5.972	5.945
	Strain rate, %/min.	0.07	0.07	0.07
	Back Pressure, psi	70.00	70.00	70.00
	Cell Pressure, psi	76.90	83.90	97.80
	Fail. Stress, ksf	1.51	2.98	4.97
	Total Pore Pr., ksf	10.86	11.13	12.56
	Ult. Stress, ksf			
	Total Pore Pr., ksf			
	$\bar{\sigma}_1$ Failure, ksf	1.73	3.94	6.49
	$\bar{\sigma}_3$ Failure, ksf	0.22	0.95	1.53

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: Dark Brown Micaceous Silty Sand

Assumed Specific Gravity= 2.70

Remarks:

Client: Kessel Engineering Group

Project: Allen Street Slope Failure
Town of Sylva

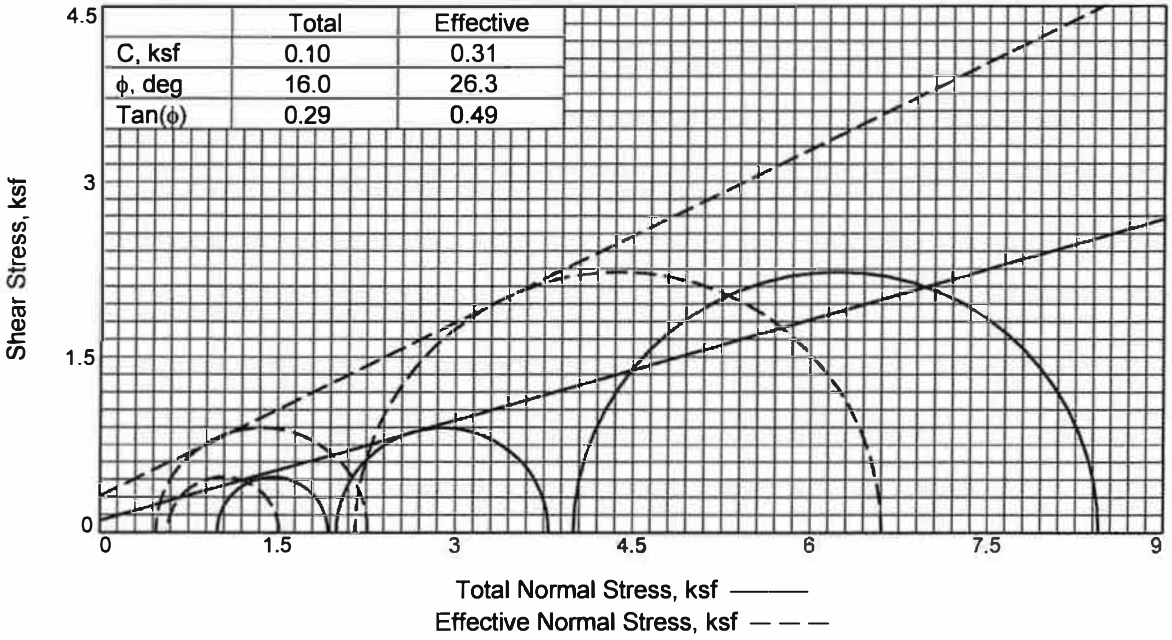
Location: B-1 UD @ 11'-13'

Proj. No.: JA20-4021-01 **Date Sampled:** 06-02-20

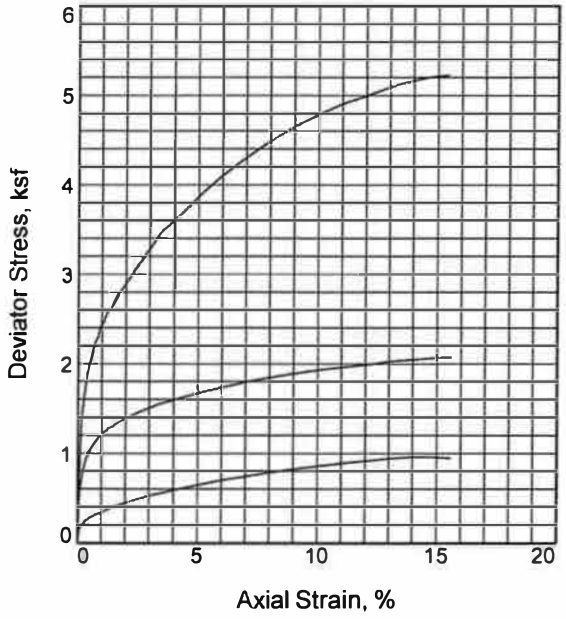
TRIAXIAL SHEAR TEST REPORT
Summit Engineering
Ft. Mill, South Carolina

Figure TX B-1

Tested By: FG



	Total	Effective
C, ksf	0.10	0.31
ϕ, deg	16.0	26.3
Tan(ϕ)	0.29	0.49



	Sample No.	1	2	3
Initial	Water Content, %	41.5	39.4	29.0
	Dry Density, pcf	78.2	79.3	93.8
	Saturation, %	96.8	94.4	98.1
	Void Ratio	1.1567	1.1265	0.7969
	Diameter, in.	2.865	2.860	2.865
	Height, in.	5.925	5.980	5.957
At Test	Water Content, %	34.7	32.3	24.7
	Dry Density, pcf	87.0	90.0	101.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.9382	0.8721	0.6672
	Diameter, in.	2.748	2.730	2.787
	Height, in.	5.788	5.779	5.842
	Strain rate, %/min.	0.07	0.07	0.07
	Back Pressure, psi	70.00	70.00	70.00
	Cell Pressure, psi	76.90	83.90	97.80
	Fail. Stress, ksf	0.94	1.79	4.45
	Total Pore Pr., ksf	10.50	11.61	11.92
	Ult. Stress, ksf			
	Total Pore Pr., ksf			
	$\bar{\sigma}_1$ Failure, ksf	1.52	2.27	6.61
	$\bar{\sigma}_3$ Failure, ksf	0.58	0.48	2.16

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: Light Brown Silty Sand

Assumed Specific Gravity= 2.70

Remarks:

Figure TX B-2a

Client: Kessel Engineering Group

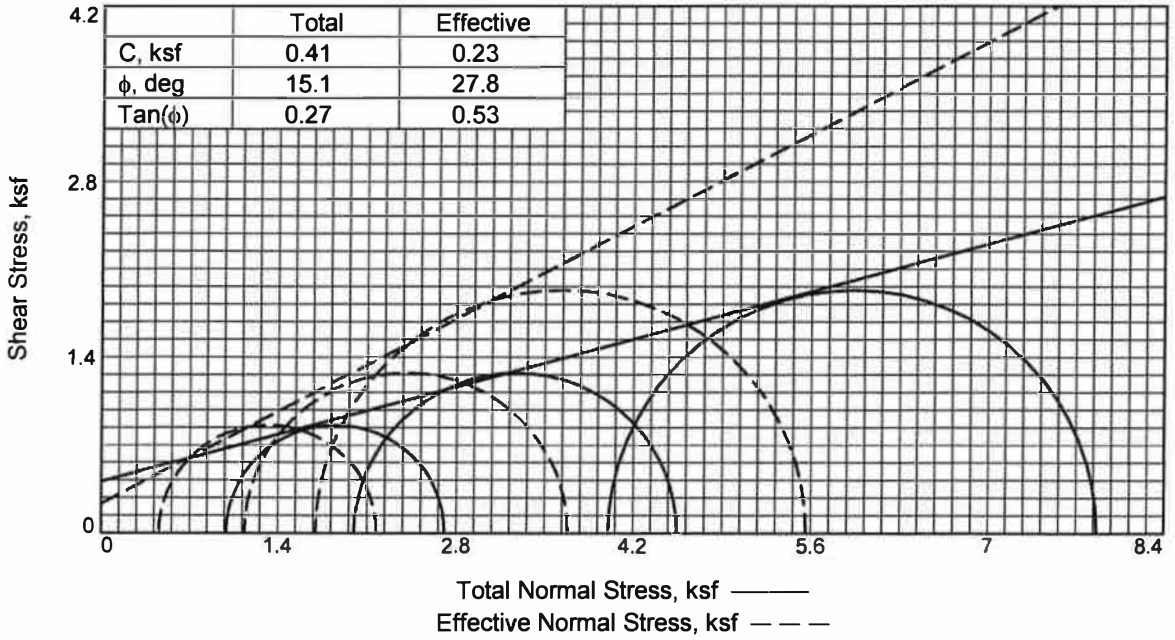
Project: Allen Street Slope Failure
Town of Sylva

Location: B-2 UD @ 16'-18'

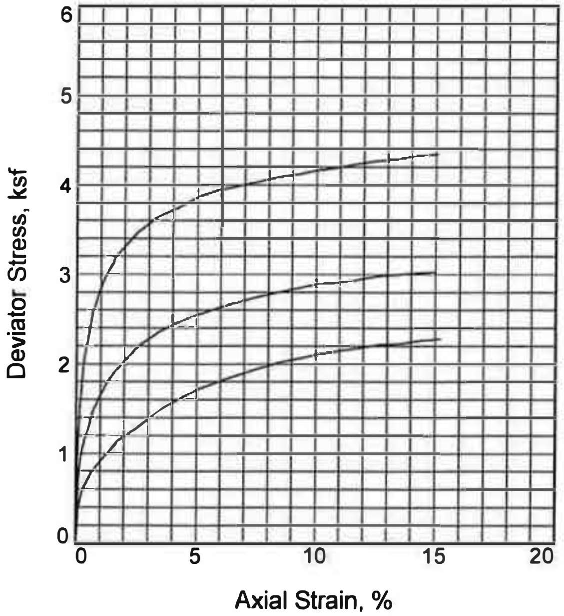
Proj. No.: JA20-4021-01 **Date Sampled:** 05-27-20

TRIAXIAL SHEAR TEST REPORT
Summit Engineering
Ft. Mill, South Carolina

Tested By: FG



	Total	Effective
C, ksf	0.41	0.23
ϕ, deg	15.1	27.8
Tan(ϕ)	0.27	0.53



	Sample No.	1	2	3
Initial	Water Content, %	26.5	26.9	31.3
	Dry Density, pcf	98.5	98.1	92.0
	Saturation, %	100.7	101.1	101.6
	Void Ratio	0.7114	0.7176	0.8328
	Diameter, in.	2.864	2.864	2.865
	Height, in.	5.962	6.033	6.061
At Test	Water Content, %	25.9	25.8	33.6
	Dry Density, pcf	99.1	99.3	88.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.7004	0.6973	0.9063
	Diameter, in.	2.863	2.856	2.936
	Height, in.	5.928	5.997	6.003
	Strain rate, %/min.	0.07	0.07	0.07
	Back Pressure, psi	70.00	70.00	70.00
	Cell Pressure, psi	76.90	83.90	97.80
	Fail. Stress, ksf	1.72	2.55	3.86
	Total Pore Pr., ksf	10.61	10.94	12.38
	Ult. Stress, ksf			
	Total Pore Pr., ksf			
	$\bar{\sigma}_1$ Failure, ksf	2.18	3.68	5.56
	$\bar{\sigma}_3$ Failure, ksf	0.46	1.14	1.70

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: Red-Brown Clayey Sandy Silt

Assumed Specific Gravity= 2.70

Remarks:

Figure TX B-7

Client: Kessel Engineering Group

Project: Allen Street Slope Failure
Town of Sylva

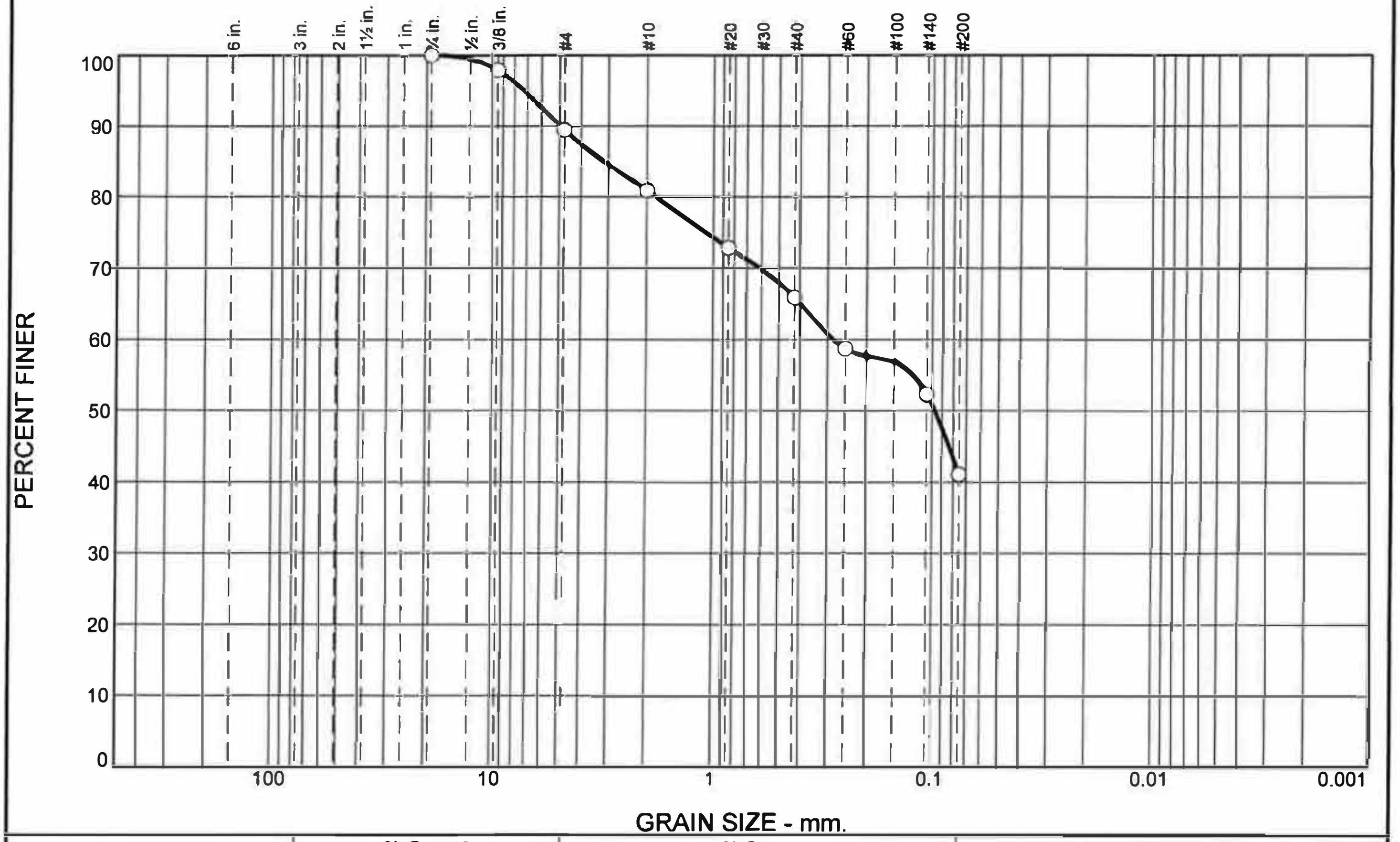
Location: B-7 UD @ 16'-18'

Proj. No.: JA20-4021-01 **Date Sampled:** 06-04-20

TRIAXIAL SHEAR TEST REPORT
Summit Engineering
Ft. Mill, South Carolina

Tested By: FG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	10.5	8.6	15.0	24.8	41.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.75	100.0		
0.375	97.9		
#4	89.5		
#10	80.9		
#20	72.9		
#40	65.9		
#60	58.7		
#140	52.4		
#200	41.1		

* (no specification provided)

Material Description

Dark Brown Micaceous Silty Sand

Atterberg Limits

PL=
LL=
PI=

Coefficients

D_{90}= 4.9351
D_{85}= 3.1200
D_{60}= 0.2830
D_{50}= 0.0971
D_{30}=
D_{15}=
D_{10}=
C_u=
C_c=

Classification

USCS = SM
AASHTO=

Remarks

Location: B-1 UD @ 11'-13'

Date: 06-02-20

Summit Engineering

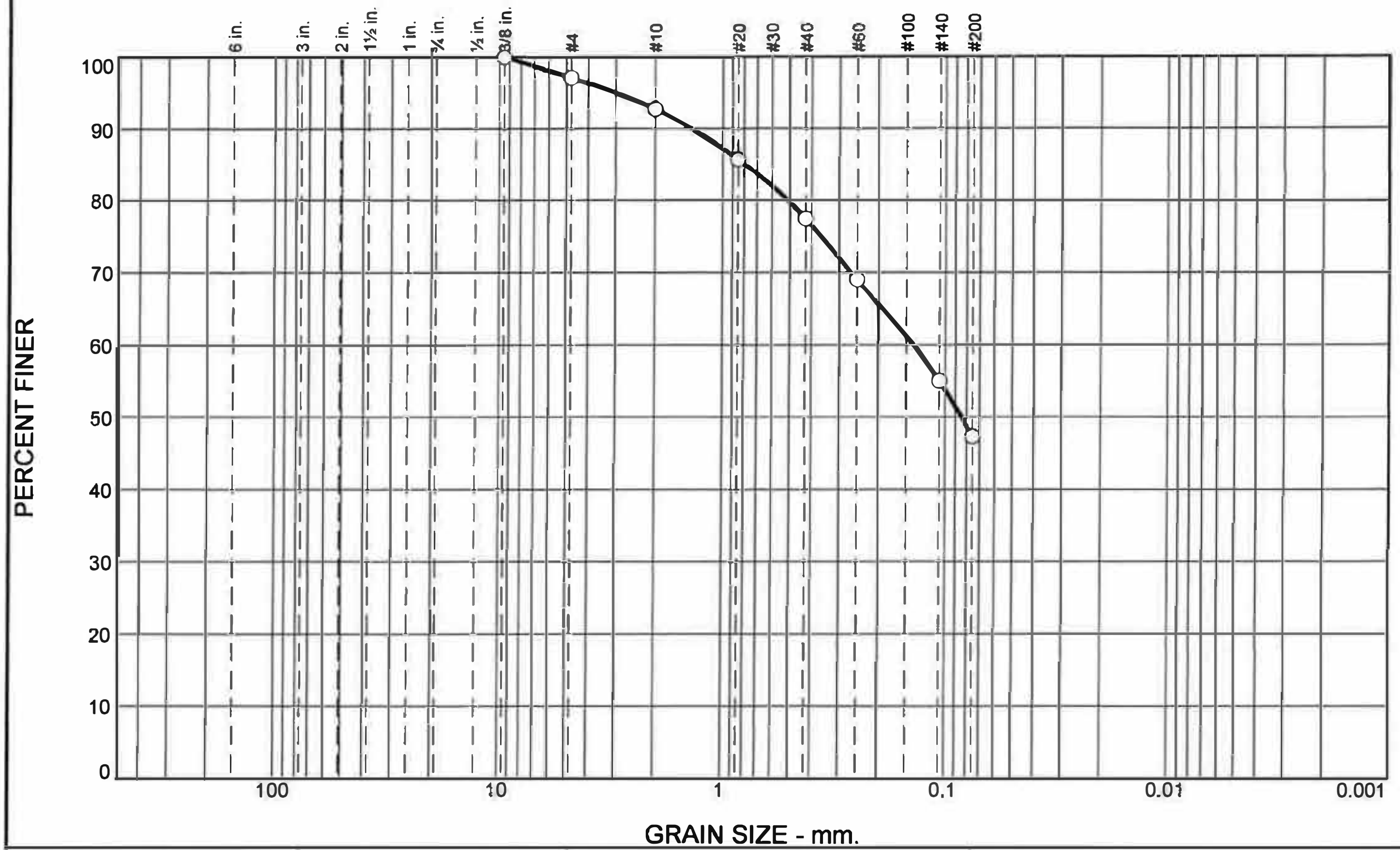
Ft. Mill, South Carolina

Client: Kessel Engineering Group
Project: Allen Street Slope Failure
Town of Sylva
Project No: JA20-4021-01

FIGURE: PS B-1

Tested By: FG
Checked By: MH

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.0	4.3	15.2	30.2	47.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.375	100.0		
#4	97.0		
#10	92.7		
#20	85.7		
#40	77.5		
#60	69.0		
#140	55.0		
#200	47.3		

* (no specification provided)

Material Description

Light Brown Silty Sand

Atterberg Limits

PL=
LL=
PI=

Coefficients

D_{90}= 1.3701
D_{85}= 0.7909
D_{60}= 0.1393
D_{50}= 0.0843
D_{30}=
D_{15}=
D_{10}=
C_u=
C_c=

Classification

USCS= SM
AASHTO=

Remarks

Location: B-2a UD @ 16'-18'

Date: 05-27-20

Summit Engineering

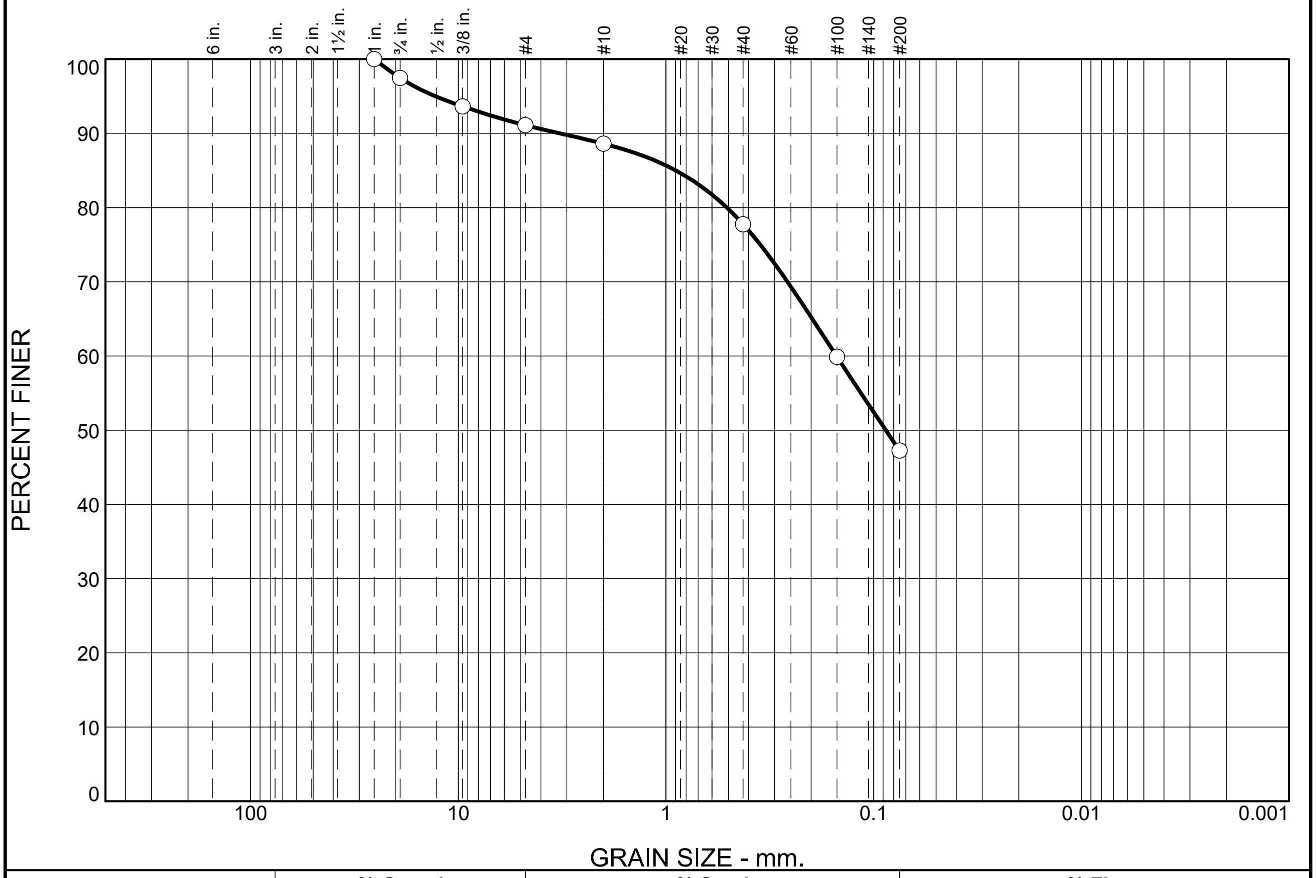
Ft. Mill, South Carolina

Client: Kessel Engineering Group
Project: Allen Street Slope Failure
Town of Sylva
Project No: JA20-4021-01

Figure PS B-2a

Tested By: FG
Checked By: MH

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.5	6.4	2.5	10.8	30.5	47.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	97.5		
3/8"	93.6		
#4	91.1		
#10	88.6		
#40	77.8		
#100	59.9		
#200	47.3		

* (no specification provided)

Material Description

Brown, Silty, Fine to Coarse SAND with Gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 3.2443 D_{85}= 0.8972 D_{60}= 0.1510
D_{50}= 0.0874 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= -

Remarks

Boring B-2

Source of Sample: Onsite **Depth:** 1' - 20'
Sample Number: B-2b

Date: 5/25/20

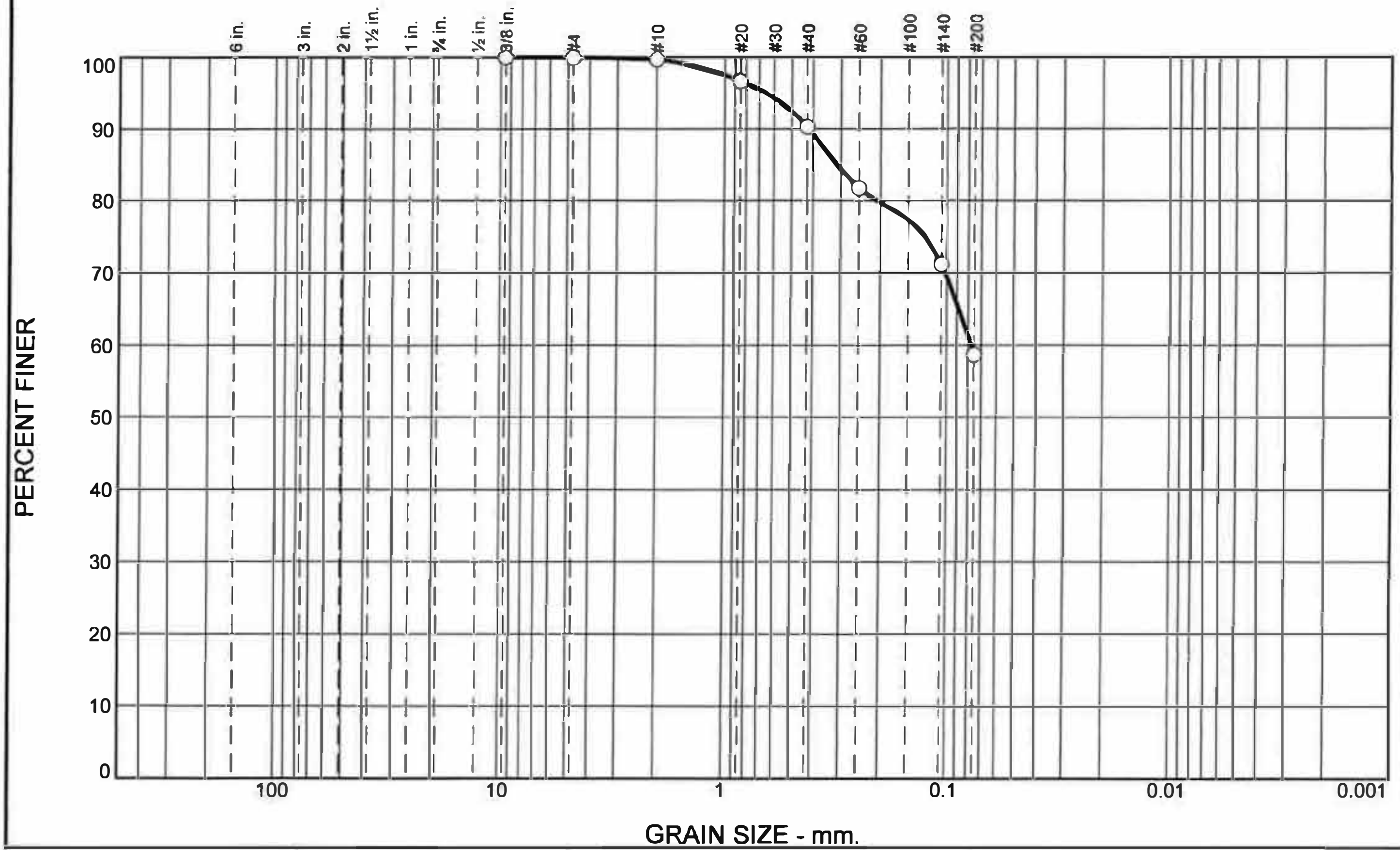
Kessel Engineering Group

Asheville, NC

Client: Town of Sylva
Project: Allen Street Slope Failure
Project No: JA20-4021-01 **Figure** PS B-2b

Tested By: IJ/LB **Checked By:** IJ

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.3	9.4	31.6	58.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.375	100.0		
#4	100.0		
#10	99.7		
#20	96.7		
#40	90.3		
#60	81.8		
#140	71.2		
#200	58.7		

* (no specification provided)

Material Description

Red-Brown Clayey Sandy Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.4167 D_{85}= 0.3107 D_{60}= 0.0775

D_{50}= D_{30}= D_{15}=

D_{10}= C_u= C_c=

Classification

USCS=ML AASHTO=

Remarks

Location: B-7 UD @ 16'-18'

Date: 06-04-20

Summit Engineering

Ft. Mill, South Carolina

Client: Kessel Engineering Group

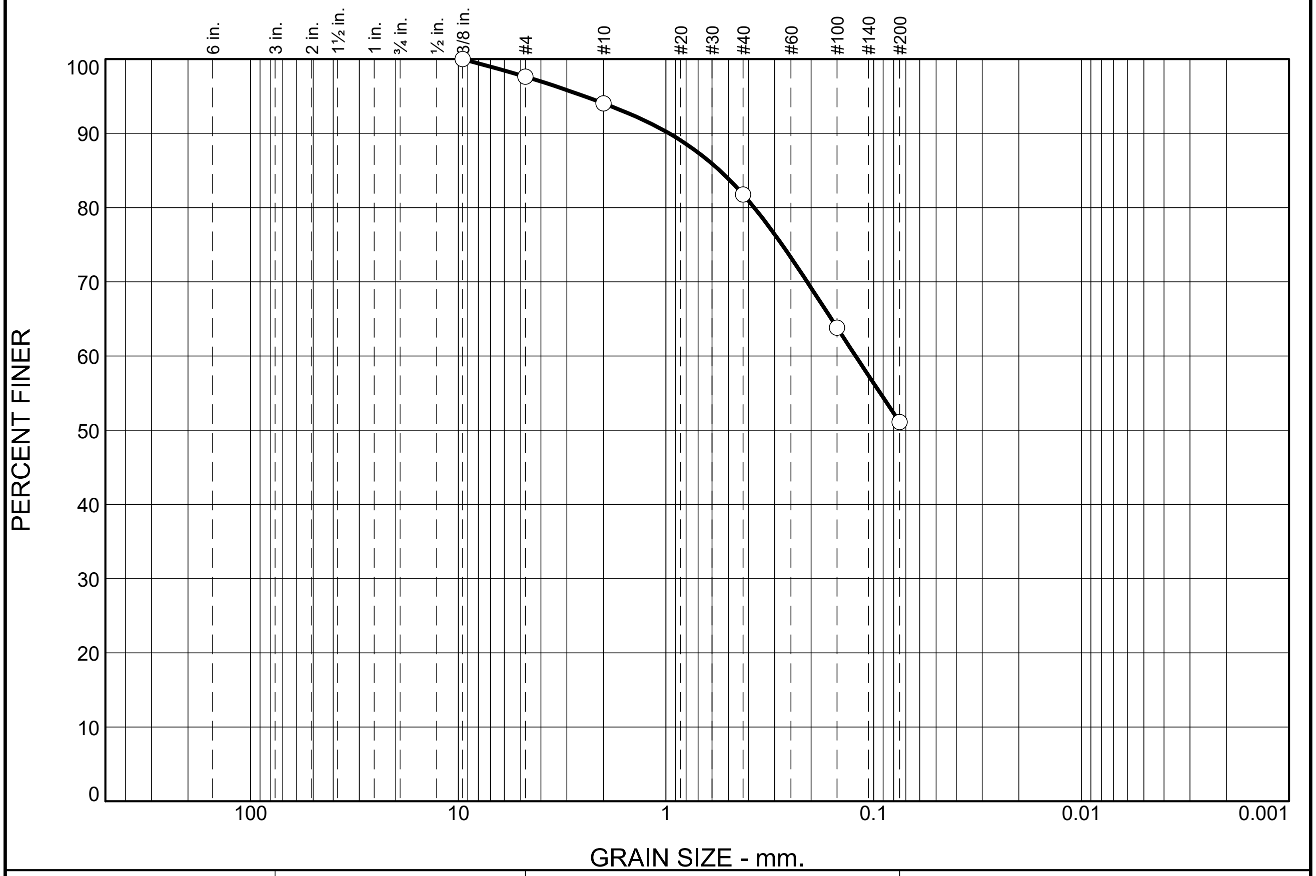
Project: Allen Street Slope Failure
Town of Sylva

Project No: JA20-4021-01

Figure PS B-7

Tested By: FG **Checked By:** MH

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.4	3.6	12.2	30.7	51.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	97.6		
#10	94.0		
#40	81.8		
#100	63.8		
#200	51.1		

* (no specification provided)

Material Description

Brown, Sandy SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.9656 D_{85}= 0.5515 D_{60}= 0.1221
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= -

Remarks

Boring B-8

Source of Sample: Onsite **Depth:** 1' - 20'
Sample Number: B-8 **Date:** 5/25/20

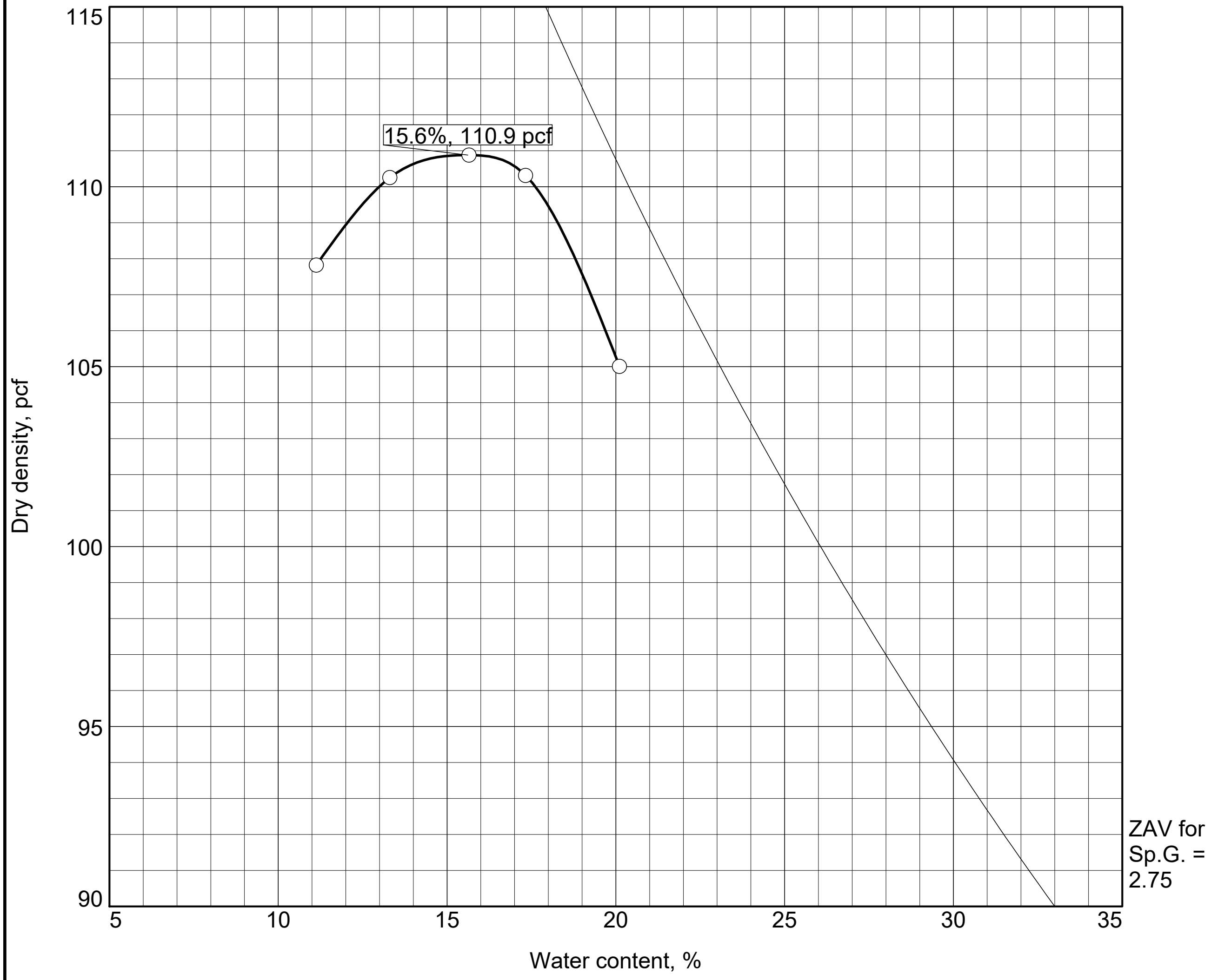
Kessel Engineering Group

Asheville, NC

Client: Town of Sylva
Project: Allen Street Slope Failure
Project No: JA20-4021-01 **Figure** PS B-8

Tested By: IJ/LB **Checked By:** IJ

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
1' - 20 '	SM	-	19.6	-		NP	6.4	47.3

TEST RESULTS

Maximum dry density = 110.9 pcf

Optimum moisture = 15.6 %

MATERIAL DESCRIPTION

Brown, Silty, Fine to Coarse SAND with Gravel

Project No. JA20-4021-01 **Client:** Town of Sylva

Project: Allen Street Slope Failure

Date: 5/25/20

○ **Source of Sample:** Onsite **Sample Number:** B-2b

Kessel Engineering Group

Asheville, NC

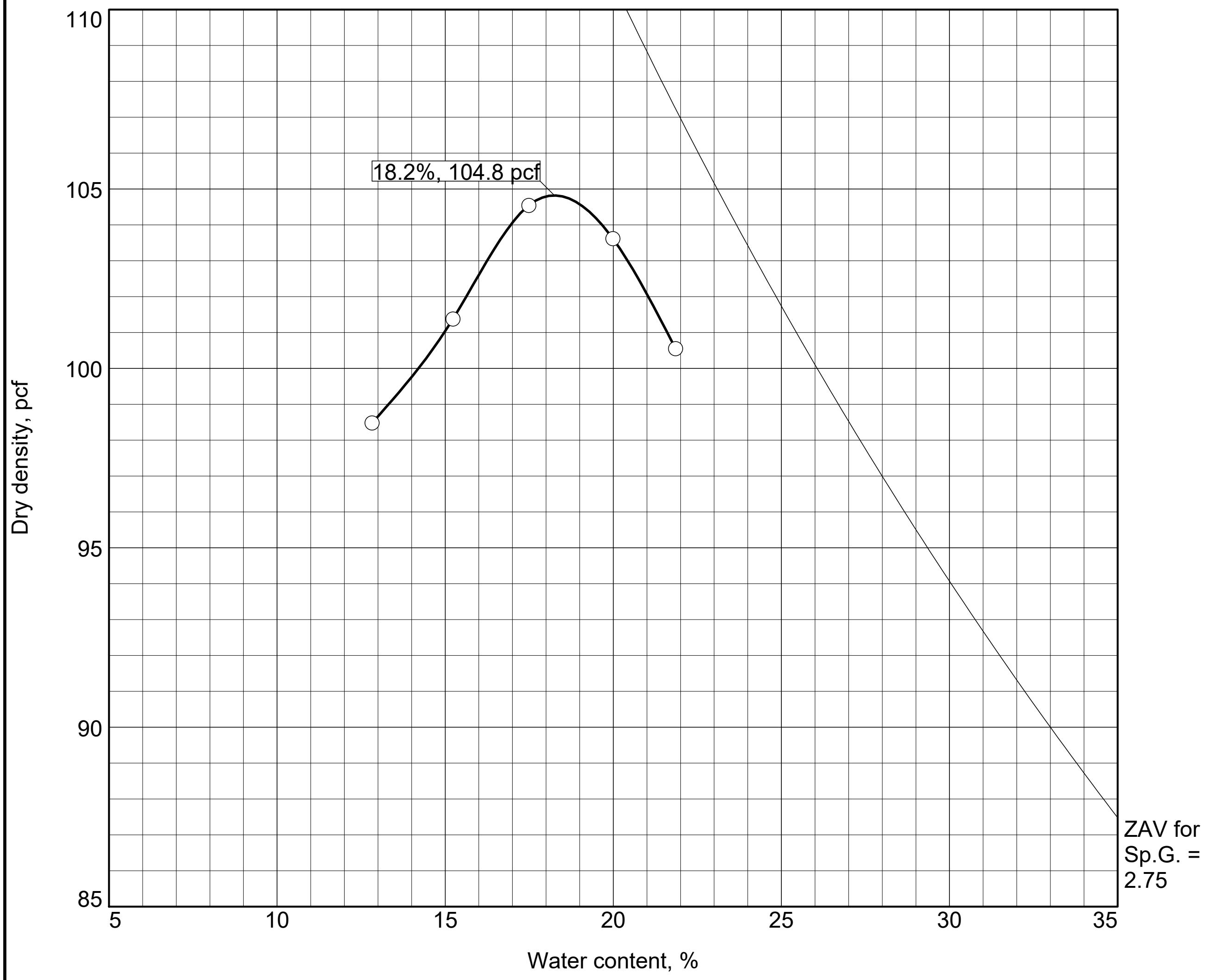
Remarks:

Standard Manual Rammer
Sampled at Boring B-2

Figure STD B-2b

Tested By: IJ/LB **Checked By:** IJ

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
1' - 20'	SM	-	26.5	-		NP	0.0	51.1

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 104.8 pcf Optimum moisture = 18.2 %	Brown, Sandy SILT

Project No. JA20-4021-01 **Client:** Town of Sylva

Project: Allen Street Slope Failure

Date: 5/25/20

○ **Source of Sample:** Onsite **Sample Number:** B-8

Kessel Engineering Group

Asheville, NC

Remarks:

Standard Manual Rammer
Sampled at Boring B-8

Figure STD B-8

Tested By: IJ/LB **Checked By:** IJ