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May 27, 2010
2335-12C, L-28912

Mr. Richard Stanton
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-225
Berkeley, CA 94720

RE: Geotechnical Investigation Report Supplement
Central Plant
General Purpose Laboratory at B25 Site
Lawrence Berkeley National Laboratory
Berkeley, California
(Subcontract No. 6859200)

Dear Mr. Stanton:

This supplement presents the results of a geotechnical investigation by Alan Kropp & Associates, Inc. (AKA) for the proposed central plant southwest of the future General Purpose Laboratory (GPL). We are currently providing services on this project under Lawrence Berkeley National Laboratory (LBNL) Architect-Engineer Subcontract No. 6859200, Modification No. 4.

This geotechnical letter report supplements our April 2, 2010 geotechnical investigation report for the GPL and relates to features shown on the 100% Design Development (DD) drawings prepared by RMW Architecture & Interiors. The approximate locations of the features discussed are shown on the attached Supplemental Investigation Site Plan, Figure 1.

INTRODUCTION

The GPL will be located at the site currently occupied by Building 25, which will be demolished prior to the construction of the project. As shown on the 100% DD drawings, the GPL will be a three-story building situated on a nearly level building pad with a ground floor level at or near the elevation of the existing ground surface. The approximate location of the GPL is indicated (in yellow) on Figure 1.

As currently envisioned, the central plant would be located about 30 feet southwest of the GPL. The approximate footprint of the proposed central plant building is shown (in green) on Figure 1. The proposed site for the central plant building generally slopes down towards the southwest at a gradient of about 3:1 (horizontal to vertical). The 100% DD drawings show the central plant building sited on a split-level pad with the upper (eastern) half of the pad about 8 feet higher than the lower (western) half of the pad. Various retaining walls are planned at the transition between the two levels of pad and the adjacent sloping grades. Sheet C4 of the 100% DD drawings shows a retaining wall bordering the south side of the central plant (shown in green on Figure 1) that is about 15 feet high at the southwest corner of the upper-level pad. Sheet A5.1.1 of

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the 100% DD drawings shows the central plant building as a one-story structure measuring about 40 by 80 feet, in maximum plan dimensions. The building is shown on Sheet S2.2.1 as supported on spread footings.

This supplement focuses upon the localized area outlined in red on Figure 1. The primary purpose of our supplemental geotechnical investigation was to document the geotechnical conditions present within the study area and provide geotechnical conclusions and recommendations for the proposed central plant. The scope of our services included:

- Reviewing existing geotechnical and geologic information;
- Characterizing subsurface conditions;
- Performing geotechnical engineering analyses;
- Developing geotechnical engineering recommendations; and
- Preparing this geotechnical investigation report supplement.

Please note that it was not a purpose of this study to discuss chemical constituents in the onsite soil or groundwater, or to provide recommendations pertaining to soil handling/disposal, or other environmental aspects of the proposed work.

METHODS OF INVESTIGATION

We investigated subsurface conditions in the vicinity of the planned central plant by: (1) reviewing existing data from previous borings drilled within the study area; (2) drilling two new exploratory borings (AKA-5 and AKA-6); and (3) correlating the data obtained from the borings with geologic observations made within an exploratory trench (Trench T-1), which was excavated in 2009 by William Lettis & Associates, Inc. (WLA) across the planned central plant building site. The approximate locations of Trench T-1 and known borings in the site vicinity are shown on Figure 1.

Our April 2, 2010 geotechnical investigation report for the GPL includes appendices containing logs of previous borings by others, five of which are within our current study area. Borings HMLA (1966) 12 and 13 were drilled by Harding Miller Lawson & Associates (HMLA) as part of a geotechnical investigation for the Omnitron, a project that was never built. Borings MW25-95-5, MW25-98-10 and SB25-95-4 were drilled by LBNL's Environmental Health & Safety (EH&S) division as part of onsite geologic characterization and monitoring well installation activities. Logs of these five borings are in Appendix B and C of our April 2, 2010 geotechnical investigation report for the GPL.

Borings AKA-5 and AKA-6 were drilled in April 2010 to depths of approximately 40½ feet and 34 feet (respectively) using a truck-mounted drill rig equipped with continuous flight augers. An AKA engineer supervised the drilling of both borings, logged the soils and bedrock encountered, and obtained samples of the subsurface materials for subsequent evaluation. Samples were obtained using a 2-inch outside diameter (O.D.) Standard Penetration Test (SPT) sampler without liners and a 3-inch O.D. Modified California sampler with liners. Both samplers were advanced with a standard 140-pound hammer falling 30 inches using a rope and cathead system. Following drilling, we measured the depth to groundwater in Boring AKA-5 and noted the absence of free groundwater in Boring AKA-6; Boring AKA-5 was left open for several days so that a second groundwater depth measurement could be made. Following our groundwater depth measurements, the borings were backfilled to near the ground surface with grout. The location and elevation of the borings were later surveyed by Bates & Bailey Land Surveyors, Inc. (B&B) of Berkeley, California, an LBNL subcontractor.

Soil and rock samples were examined in our laboratory to check field classifications and to select suitable specimens for laboratory testing. Soils were classified in general accordance with ASTM D2487, which is described on the attached Key to Exploratory Boring Logs (Figure 2). Rock materials were evaluated and described in general accordance with the Physical Properties Criteria for Rock Descriptions (Figure 3). John Baldwin (C.E.G.) of WLA assisted in the geologic classification of materials obtained from the borings. Geotechnical laboratory tests performed for this study consisted of Moisture Content (ASTM D-2216), Dry Density (ASTM D-2937) and Atterberg Limits determinations (ASTM D-4318) involving soil plasticity. The logs of Borings AKA-5 and AKA-6 are attached and include material descriptions, sampler blow counts, laboratory test results, and groundwater depth information (where encountered). Also attached are logs of Boring AKA-2 (drilled by AKA in 2009) and Trench T-1 (adapted from the more detailed oversized version presented in WLA, 2009).

When referring to the attached boring logs, please note that the logs depict subsurface conditions only at the specific boring locations on the date that the boring was drilled. The passage of time may result in changes in the subsurface conditions. In addition, the sampler blow counts presented on the logs are field values obtained using the specific sampler and hammer combination indicated. Care should be exercised in making comparisons of sampler blow counts between borings or with published data (blow counts obtained using the Modified California sampler are higher than what would be obtained using an SPT sampler under the same conditions).

SURFACE CONDITIONS

Figure 4 presents two photographs that show the proposed site of the central plant. In the top photograph (facing northwest), Buildings 41 and 4 can be seen in the upper right. In the bottom photograph (facing southeast) Building 28 can be seen near the center of the picture. Building 25 is not shown on either photograph but is located to the left of the lower photograph on Figure 4.

The photographs presented on Figure 4 show the sloping lawn area upon which the proposed central plant would be sited. The approximate southwestern limit of the project approximately coincides with the edge of the grassy area shown on the left-hand side of the upper photograph (Figure 4). This is approximately the location of the planned downslope retaining wall bordering the south side of the central plant, which is shown in green on the Site Plan (Figure 1). The trees located southwest of the grassy lawn area are situated near the top of a much steeper southwest-facing slope within which an area of geologic instability has previously been mapped by WLA (also shown on Figure 1). Pavement markings present at the time of our investigation indicate that there are utility lines buried within the site area, including a high-pressure natural gas (HPNG) line that crosses the site near the location of Trench T-1.

GEOLOGIC CONDITIONS

The study area is situated along the western side of a ridgeline underlain by resistant volcanic rock of the Moraga Formation. Previous grading to construct the relatively level pad upon which Building 25 is situated included lowering grades (by cutting) in the north and raising grades (by filling) in the south. The subsurface materials present in the current study area, located southwest of Building 25, include fill, natural soil and rock. A recent geologic study (WLA 2009) indicates that the rock materials upon which Building 25 is situated are considered geologically stable; in this report, we refer to these rock materials as bedrock.

As discussed in our April 2, 2010 geotechnical investigation report for the GPL, the project site is not located within an Alquist-Priolo Earthquake Fault Zone, and the references that we reviewed indicate the closest mapped active fault (the Hayward fault) is more than 1/4 mile away. WLA's previous geologic study also included excavating and logging Trench T-1, the location of which is within the planned footprint of the proposed central plant building. In general, the trench exposed a mature soil profile developed on weathered bedrock. Trench T-1 exposed several shear zones within the bedrock, but the shear zones do not offset or deform overlying soils estimated to be at least 8,000 years old. Based on this information, we consider the overall risk of surface fault rupture at the site to be low.

Previous studies (e.g. HLA 1982 and WLA 2009) note that a small area of localized landsliding exists downslope of Building 41 and the proposed central plant building site. The approximate limits of this area, as mapped by WLA (2009), are shown on Figure 1. WLA (2009) also cautions that the areas southwest of Building 25 should not be developed without further characterizing the upslope limits of this known area of local instability. As part of this study for the central plant, we: (1) observed conditions on the slope in and around the area of mapped instability; and (2) reviewed and interpreted stereo-paired aerial photographs taken before and after the Building 25 area was developed. During our reconnaissance, we noted that the areas outside the area of instability mapped by WLA appeared generally unaffected by past landsliding and that there appeared to be no evidence of recent slope instability in the area of the planned central plant project.

Our review of historic aerial photography generally showed that a small landslide existed on the slope in 1939 at approximately the same location as the area of instability mapped by WLA in 2009. To accurately locate this feature, we compared the predevelopment aerial photographs taken in 1939 with similar photographs taken in 1947 after the Building 25 area was developed. The results of this analysis generally showed that: (1) the mapped area of instability shown on Figure 1 is similar in size and location to the landslide feature seen on the 1939 photographs; and (2) there were no obvious geomorphic features present in 1939 that would indicate that the area of the proposed central plant site was/is geologically unstable.

SUBSURFACE CONDITIONS

Bedrock Conditions

The bedrock materials present in the project vicinity consist of Moraga Volcanics (including andesite and tuff or agglomerate breccias) and Orinda Formation (including siltstone, sandstone, claystone and conglomerate). The bedrock layers that exist within the Moraga Formation are highly variable and include materials that are harder and more resistant than the Orinda Formation. The borings drilled within the study area encountered varying thicknesses of soil directly overlying bedrock. Interpreted bedrock depths are summarized in the table that follows together with the corresponding "top of bedrock" elevation. A map depicting interpreted elevation contours of the top of the bedrock surface is presented on Figure 5.

Interpreted Top of Bedrock Depth/Elevation

Boring No.	Surface Elevation (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock (feet)	Top of Bedrock Description
AKA-5	917.5	5.5	912.0	Volcanics
AKA-6	925.0	8.0	917.0	Volcanics
AKA-2 (2009)	933.4	3.5	929.9	Moraga Volcanics
HMLA (1966) 12	922	8	914	Orinda (siltstone)
HMLA (1966) 13	933	7	926	Moraga (basalt)
MW25-95-5	933.24	~0	933.2	Moraga (andesite)
MW25-98-10	935	~4	931	Moraga (andesite)
SB25-95-4	935	~3	~932	Moraga

The logs of Borings AKA-5 and AKA-6 are attached at the end of this report together with a Simplified Trench Log depicting the subsurface profile at the location of Trench T-1, as interpreted by WLA (2009). The simplified log generally shows that bedrock is about 7 to 10 feet deep at the location of Trench T-1.

The bedrock materials at the site are directly overlain by soils comprised of bedrock materials that have weathered in place (residual soil). The transition from residual soil to bedrock can be gradual, therefore the interpreted depths of bedrock presented in this report and the attachments should be considered approximate.

Soil Conditions

Within the study area, the soils that overlie rock vary in thickness and fill materials are locally present. Where encountered, the fill materials were relatively thin (less than about 4 feet thick); fill was not encountered in Borings AKA-5 or AKA-6, which were drilled along the southern side of the proposed central plant site. In most cases, the fill materials shown on the attached logs overlie natural soil deposits; however, at the location of AKA-2, natural soils appear not to be present as the fill materials shown on the log directly overlie volcanics (bedrock).

We performed Atterberg Limits determinations on samples of soil from Borings AKA-5 and AKA-6 to evaluate the plasticity and expansion potential of the onsite soil materials. The results of our laboratory Atterberg Limits determinations are presented on the attached boring logs and are summarized in the following table.

Atterberg Limits Test Results

Boring No.	Approximate Depth of Sample (feet)	Liquid Limit	Plasticity Index (PI)	Soil Classification
AKA-5	4 – 4.5	77	56	Fat Clay (CH)
AKA-6	6 – 6.5	65	46	Fat Clay (CH)

Onsite soils having a PI of 15 or less are generally considered to have a sufficiently low expansion potential to be used as non-expansive fill.

Groundwater Conditions

Groundwater was measured at a depth of 38 feet in Boring AKA-5 shortly after the completion of drilling; about three days later, groundwater was measured in Boring AKA-5 at a depth of 31 feet (about Elevation +886.5). Boring AKA-6 did not encounter groundwater during drilling and was grouted shortly after drilling was complete. Previous data and interpretations developed by LBNL's EH&S Division generally indicate that groundwater can be present beneath the site above the contact between the Moraga Formation (which can be highly permeable) and the underlying Orinda Formation (which is typically less permeable). This contact was encountered at a depth of about 29 feet (Elevation +888.5) in Boring AKA-5 and is interpreted to be below the bottom of Boring AKA-6 at a depth greater than 34 feet (below Elevation +891 feet).

DISCUSSION AND CONCLUSIONS

Past Site Performance

In general, it appears that the site of the proposed central plant has remained stable over the 70+ years since the 1939 aerial photographs were taken. The reports and other information that we reviewed did not include any information or data that would suggest that the site has experienced slope movements or deformations in the past. Neither the onsite trench (Trench T-1) nor the borings (AKA-5 and AKA-6) revealed any obvious indicators in the subsurface that would suggest that the site, in its current condition, is geologically unstable. The previously-mapped area of instability on the slope south of the site appears not to have increased substantially in size relative to what can be seen on the 1939 aerial photographs, and does not underlie any of the planned central plant improvements.

High Plasticity Soils

The results of Atterberg Limits determinations performed for this study indicate that the soil materials at the site include clays that are highly plastic, and therefore highly expansive (expansive soils shrink and swell in response to changes in moisture content). In Borings AKA-5 and AKA-6, highly plastic clays extend to depths of 5.5 and 8 feet, respectively, and directly overlie bedrock.

Expansive soils have the potential to damage improvements that are supported directly upon them unless appropriately mitigated. Footings, grade beams, pier caps and concrete slabs will be subjected to uplift pressures unless: (1) non-expansive material underlies them; or (2) they are not in direct contact with the ground. In this report, we recommend that a compacted non-expansive fill layer at least 18 inches thick be placed beneath foundation elements and slabs that are to be in contact with the ground surface to mitigate expansive soil effects. Alternatively, a vertical space (void) of 6 inches or more will be adequate to mitigate the potentially adverse effects of underlying expansive soils. For structural concrete elements, a suitable void can be created by forming the bottom of the element or through the use of bio-degradable cardboard cells made expressly for this purpose. Styrofoam blocks or other rigid non-degradable supports are <u>not</u> considered appropriate for this use.

Slope Stability Considerations

The proposed central plant site is located adjacent to a southwest-facing slope, portions of which are inclined as steep as about 1.5 to 1 (horizontal to vertical). Although the area of the central plant site appears to have remained stable over the past 70+ years, past development activities in this area have not included placing thick fills or constructing high retaining walls in close proximity to the top of the slope. Such activities would have the potential to substantially increase vertical loads (driving forces) and decrease current factors of safety against slope instability. This decrease in slope stability could be exacerbated by the presence of the plastic clays that overlie the bedrock surface in this area.

In this report, we recommend that thick fills not be placed in association with the development of the central plant site. Although it is possible for us to envision founding new fills at the site directly upon bedrock after overexcavating and removing the highly-plastic clays, this approach is problematic for several reasons: (1) the mature trees that exist at the top of the slope along the southern site margin would make deep excavations in this area difficult (due to roots and the inability to "lay back" temporary excavation slopes) or the trees would need to be removed (which is not currently planned); (2) relatively large volumes of expansive soil materials would be excavated that may require offsite disposal (in the event that georeinforcement is used to create a stable fill pad); and (3) thick fills would still place significant new loads on the underlying bedrock materials, thereby decreasing their stability. Perhaps most importantly, issues involving the stability of the underlying bedrock could be difficult to resolve, and would likely require additional geologic investigations (e.g. borings, trenches and/or test pits) to further characterize shear zones and other geologic discontinuities that might provide a plane of weakness along which sliding could occur.

Foundation Support

In general, we conclude that it would be generally feasible to construct the new central plant at the location shown on the 100% DD drawings, provided that the building and adjacent improvements are structurally supported on drilled pier foundations supported in bedrock. The drilled piers would be designed to gain support through skin friction in the bedrock materials that underlie the site at depth; in this report, we recommend that skin friction in soil and end bearing be neglected when evaluating the axial capacity of drilled piers. Drilled pier foundations designed and constructed in accordance with the recommendations presented in this report should experience very little (less than about ½ an inch) settlement under the applied loads.

As noted above, we recommend that deep fills not be placed at the site to raise grades; consequently, driveway and walkway areas that are significantly higher in elevation than the current site grades will need to be structurally supported. We judge that thinner fills (less than about 4 feet thick) can reasonably be placed at the site, especially in the upslope areas that are not directly adjacent to the steep slope at the site's southern margin. Similarly, low (less than about 4 feet high) site retaining walls can reasonably be constructed at the site, provided that they are not directly adjacent to the steep slope at the site's southern margin. In these cases, low retaining walls can be supported on spread footings that are underlain by at least 18 inches of non-expansive materials.

SUPPLEMENTAL RECOMMENDATIONS

This section presents supplemental geotechnical recommendations for drilled pier foundations to support the central plant building and adjacent improvements. We anticipate that a variety of factors will need to be considered and evaluated prior to developing a final design. We should be consulted as designs are being developed in order to augment or revise our geotechnical recommendations, if necessary, to suit the project. The recommendations presented in the sections that follow supplement the recommendations presented in our April 2, 2010 geotechnical investigation report for the GPL.

Structural Support Recommendations

This section provides recommendations for drilled piers that are founded in bedrock. Foundation piers should be spaced no closer than three pier diameters, center-to-center. Piers at closer spacings may have a reduced compressive capacity due to group effects and would need to be evaluated on an individual basis. Drilled pier groups should be structurally tied together at their tops by grade beams or a thickened structural concrete slab. Grade beams and structurally supported slabs should be underlain by at least 18 inches of non-expansive fill to mitigate potential expansive soil uplift effects. Alternatively, a 6-inch minimum vertical space (void) could be provided between the ground surface and overlying structural elements.

The axial capacity of drilled piers can be evaluated using an allowable skin friction value of 1,200 psf in bedrock. This skin friction value can be increased by one third for total compressive loads, including wind and/or seismic, but should not be increased for uplift loads. We recommend that skin friction in soil be ignored in evaluating drilled pier axial capacity. We further recommend that any contribution to axial capacity from end bearing in bedrock be ignored due to difficulties associated with obtaining and/or assuring a clean bearing surface at the bottom of the pier holes. Drilled piers should extend at least 10 feet into bedrock, regardless of load. For design purposes, the elevation of bedrock can be estimated using the bedrock contours shown on Figure 5.

Resistance to lateral loads can be provided by passive pressures acting against the below-grade portions of the drilled piers. Passive resistance can be applied over two (horizontal) pier diameters. Passive resistance in soil can be evaluated using an equivalent fluid pressure of 300 pounds per cubic foot (pcf). Passive resistance in bedrock can be evaluated using the truncated triangular distribution described below:

- Starting at the top of bedrock, a passive resistance value of 1,000 psf can be used; and
- Passive resistance in bedrock can be assumed to increase at a rate of 350 psf per foot of depth.

The above passive resistance values include a factor of safety of at least 2. For design purposes, the elevation of the top of bedrock can be estimated using the interpreted bedrock elevation contours shown on Figure 5. We recommend that the upper foot of soil be ignored in calculating passive resistance unless the surface of the soil adjacent to the pier is confined by pavement or a concrete slab-on-grade.

Holes for drilled piers should be drilled straight and plumb (within 1 percent of vertical) and should be cleaned of loose soil and rock fragments. We judge that the holes can likely be drilled using heavy auger drilling equipment; however, zones of relatively hard rock could be encountered. The contractor should be prepared to utilize suitable hard rock drilling techniques, if necessary. If water accumulates in the holes, it should be removed by pumping or bailing prior to concrete placement unless tremie methods are used.

Concrete placement should start as soon as possible after the drilling and cleanout is complete. In all cases, holes for drilled piers should be concreted on the day they are drilled. Following placement of the reinforcing steel, holes should be concreted from the bottom up in a single operation. If water is present in the hole, the tremie pipe should be constantly maintained at least 5 feet below the surface of the concrete during casting of the pier. As the concrete is placed, any casing used to stabilize the hole should be withdrawn and the casing should be maintained not more than 5 feet or less than 1 foot below the surface of the concrete as it is withdrawn.

Drilled piers should be installed by a qualified drilling contractor. AKA should observe during drilling to confirm that subsurface conditions are as anticipated and observe the various geotechnical aspects of construction to check conformance with the intent of our recommendations.

LIMITATIONS AND CLOSURE

This report has been prepared for the exclusive use of LBNL and their consultants for specific application to the GPL central plant project in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

In this report, we present design concepts that we developed based on our current understanding of the site conditions and project requirements. Future concepts developed by the design team may vary appreciably from those presented in this report. In our judgment, it is essential that we be consulted as final designs are being developed in order to: (1) check conformance with the intent of our geotechnical recommendations; and (2) identify any aspects of the design that would require that the conclusions of this report be modified (in writing).

The findings of this report are valid as of the present date. However, the passing of time will likely change the conditions of the existing property due to natural processes or the works of man. In addition, due to legislation or the broadening of knowledge, changes in applicable or appropriate standards may occur. Accordingly, the findings of this report may be invalidated, wholly or partly, by changes beyond our control. Therefore, this report should not be relied upon after a period of three years without being reviewed by this office.

Should you have questions or comments concerning our findings, the geotechnical design concepts discussed, or our recommendations, please do not hesitate to call.

Very truly yours,

ALAN KROPP & ASSOCIATES, INC.

Dona K Mann

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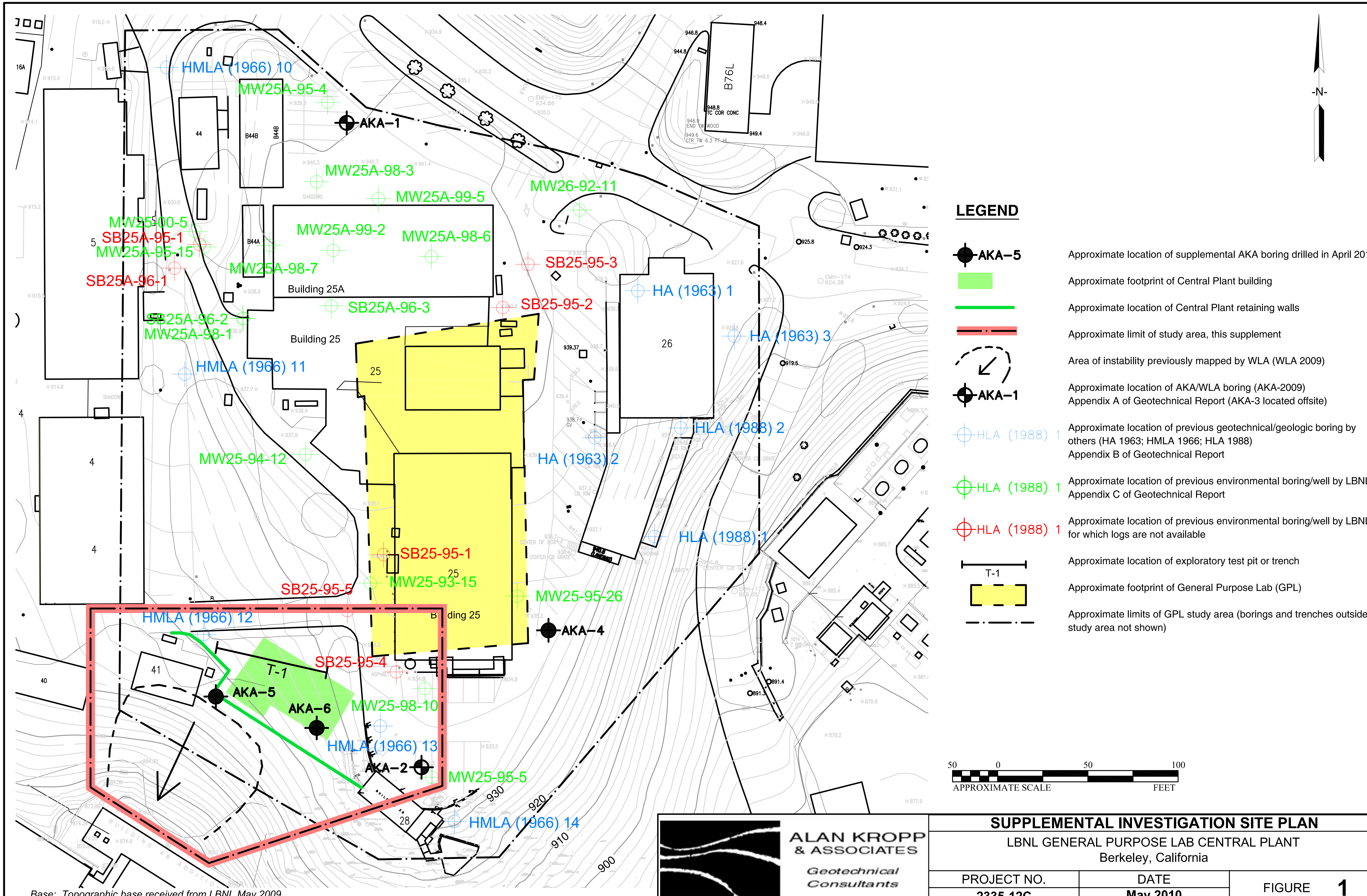
Attachments:
Figure 1 Supplemental Investigation Site Plan
Figure 2 Key to Exploratory Boring Logs
Figure 3 Physical Properties Criteria for Rock Descriptions
Figure 4 Site Photographs
Figure 5 Bedrock Surface Contour Map
Logs of Borings AKA-5 and AKA-6
Log of Boring AKA-2 (2009)
Simplified Log of Trench T-1



HMLA (1966) 10
MW25A-95-4
AKA–1
MW25A-98-3
MW25A-99-5
MW26-92-11
MW25-00-5
SB25A-95-1
MW25A-95-15
SB25A-96-1
MW25A-99-2
MW25A-98-6
MW25A-98-7
SB25-95-3
Building 25A
SB25-95-2
HA (1963) 1
SB25A-96-3
SB25A-96-2
MW25A-98-1
Building 25
HA (1963) 3
HMLA (1966) 11
25
26
HLA (1988) 2
MW25-94-12
HA (1963) 2
HLA (1988) 1
SB25-95-1
MW25-93-15
SB25-95-5
MW25-95-26
HMLA (1966) 12
Building 25
AKA–4
41
T-1
SB25-95-4
AKA–5
AKA–6
MW25-98-10
HMLA (1966) 13
AKA–2
MW25-95-5
28
HMLA (1966) 14
930
920
910
900
44
B44B
B44A
B76L
16A
40
4
-N-
LEGEND
AKA–5 Approximate location of supplemental AKA boring drilled in April 2010
Approximate footprint of Central Plant building
Approximate location of Central Plant retaining walls
Approximate limit of study area, this supplement
Area of instability previously mapped by WLA (WLA 2009)
AKA–1 Approximate location of AKA/WLA boring (AKA-2009) Appendix A of Geotechnical Report (AKA-3 located offsite)
HLA (1988) 1 Approximate location of previous geotechnical/geologic boring by others (HA 1963; HMLA 1966; HLA 1988) Appendix B of Geotechnical Report
HLA (1988) 1 Approximate location of previous environmental boring/well by LBNL Appendix C of Geotechnical Report
HLA (1988) 1 Approximate location of previous environmental boring/well by LBNL for which logs are not available
T-1 Approximate location of exploratory test pit or trench
Approximate footprint of General Purpose Lab (GPL)
Approximate limits of GPL study area (borings and trenches outside study area not shown)
50 0 50 100
APPROXIMATE SCALE FEET
Base: Topographic base received from LBNL May 2009.
ALAN KROPP & ASSOCIATES
Geotechnical Consultants
SUPPLEMENTAL INVESTIGATION SITE PLAN
LBNL GENERAL PURPOSE LAB CENTRAL PLANT
Berkeley, California
PROJECT NO. 2335-12C
DATE May 2010
FIGURE 1

SOIL CLASSIFICATION CHART

PRIMARY DIVISIONS			SECONDARY DIVISIONS: CRITERIA *	GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS MORE THAN 50% RETAINED ON NO.200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	Cu ≥ 4 AND 1 ≤ Cc ≤ 3 *A*	GW	Well-graded gravel
			Cu < 4 AND/OR 1 > Cc > 3	GP	Poorly-graded gravel
		GRAVELS WITH FINES - MORE THAN 12% FINES	FINES CLASSIFY AS ML OR MH	GM	Silty gravel
			FINES CLASSIFY AS CL OR CH	GC	Clayey gravel
	SANDS 50% OR MORE OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	Cu ≥ 6 AND 1 ≤ Cc ≤ 3	SW	Well-graded sand
			Cu < 6 AND/OR 1 > Cc > 3	SP	Poorly-graded sand
		SANDS WITH FINES - MORE THAN 12% FINES	FINES CLASSIFY AS ML OR MH	SM	Silty sand
			FINES CLASSIFY AS CL OR CH	SC	Clayey sand
FINE-GRAINED SOILS 50% OR MORE PASSES THE NO.200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50%	INORGANIC	PI > 7 AND PLOTS ON OR ABOVE "A" LINE	CL	Lean clay
			PI < 4 OR PLOTS BELOW "A" LINE	ML	Silt
		ORGANIC	LIQUID LIMIT - OVEN DRIED / LIQUID LIMIT - NOT DRIED < 0.75	OL	Organic Clay & Organic Silt
	SILTS AND CLAYS LIQUID LIMIT 50% OR MORE	INORGANIC	PI PLOTS ON OR ABOVE "A" LINE	CH	Fat clay
			PI PLOTS BELOW "A" LINE	MH	Elastic silt
		ORGANIC	LIQUID LIMIT - OVEN DRIED / LIQUID LIMIT - NOT DRIED < 0.75	OH	Organic Clay & Organic Silt
	HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR	PT	Peat

REFERENCE: Unified Soil Classification System (ASTM D 2487-06)

* Criteria may be done on visual basis, not necessarily based on lab testing

A – $C_u = D_{60}/D_{100}$ & $C_c = (D_{30})^2 / (D_{10} \times D_{60})$

GRAIN SIZES

U. S. STANDARD SERIES SIEVE: 200, 40, 10, 4 — CLEAR SQUARE SIEVE OPENINGS: 3/4", 3", 12"

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

ABBREVIATIONS

INDEX TESTS

- LL - Liquid Limit (%) (ASTM D 4318-05)
- PI - Plasticity Index (%) (ASTM D 4318-05)
- -200 - Passing No. 200 Sieve (%) (ASTM D 1140-00)

STRENGTH TESTS

- PP - Field Pocket Penetrometer test of unconfined compressive strength (tsf)
- TV - Field Torvane test of shear strength (psf)
- UC - Laboratory unconfined compressive strength (psf) (ASTM D 2166-06)
- TXUU - Laboratory unconsolidated, undrained triaxial test of undrained shear strength (psf) (ASTM D 2850-03a)

MISCELLANEOUS

- ATOD - At time of drilling
- psf/tsf - pounds per square foot / tons per square foot
- psi - pounds per square inch (indicates relative force required to advance Shelby tube sampler)

SYMBOLS

- Standard Penetration Test Split Spoon (2-inch O.D.)
- Modified California Sampler (3-inch O.D.)
- Thin-walled Sampler Tube (either Pitcher or Shelby) (3-inch O.D.)
- Rock Core
- Bag Sample
- Groundwater Level

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KEY TO EXPLORATORY BORING LOGS

LBNL GENERAL PURPOSE LAB CENTRAL PLANT
Berkeley, California

PROJECT NO.	DATE	FIGURE 2
2335-12C	**May 2010**	

CONSOLIDATION OF SEDIMENTARY ROCKS; usually determined from unweathered samples. Largely dependent on cementation.

- **U** = unconsolidated
- **P** = poorly consolidated
- **M** = moderately consolidated
- **W** = well consolidated

BEDDING OF SEDIMENTARY ROCK

Splitting Property	Thickness	Stratification
Massive	Greater than 4.0 feet	Very thick-bedded
Blocky	2.0 to 4.0 feet	Thick-bedded
Slabby	0.2 to 2.0 feet	Thin-bedded
Flaggy	0.05 to 0.2 feet	Very thin-bedded
Shaly or platy	0.01 to 0.05 feet	Laminated
Papery	Less than 0.01 feet	Thinly laminated

FRACTURING

Intensity	Size of Pieces in Feet
Very little fractured	Greater than 4.0 feet
Occasionally fractured	1.0 to 4.0 feet
Moderately fractured	0.5 to 1.0 feet
Closely fractured	0.1 to 0.5 feet
Intensely fractured	0.05 to 0.1 feet
Crushed	Less than 0.05 feet

HARDNESS

1. **Soft** - Reserved for plastic material alone.
2. **Low Hardness** - Can be gouged deeply or carved easily by a knife blade.
3. **Moderately Hard** - Can be readily scratched by a knife blade; scratch leaves a heavy trace of dust and is readily visible after the powder has been blown away.
4. **Hard** - Can be scratched by a knife blade with difficulty; scratch produces little powder and is often faintly visible.
5. **Very Hard** - Cannot be scratched by a knife blade; leaves a metallic streak

STRENGTH

1. **Plastic** - Very low strength.
2. **Friable** - Crumbles easily by rubbing with fingers.
3. **Weak** - An unfractured specimen of such material will crumble under light hammer blows.
4. **Moderately Strong** - Specimen will withstand a few heavy hammer blows before breaking.
5. **Strong** -Specimen will withstand a few heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.
6. **Very Strong** -Specimen will resist heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.

WEATHERING - the physical and chemical disintegration and decomposition of rocks and minerals by natural processes such as oxidation, reduction, hydration, solution, carbonation, and freezing and thawing.

- D. **Deep** - Moderate to complete mineral decomposition; extensive disintegration; deep and thorough discoloration; many fractures, all extensively coated or filled with oxides, carbonates and/or clay or silt.
- M. **Moderate** - Slight change or partial decomposition of minerals; little disintegration; cementation little to unaffected. Moderate to occasionally intense discoloration. Moderately coated fractures.
- L. **Little** - No megascopic decomposition of minerals; little or no effect on normal cementation. Slight and intermittent, or localized discoloration. Few stains on fracture surfaces.
- F. **Fresh** - Unaffected by weathering agents. No disintegration or discoloration. Fractures usually less numerous than joints.

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PHYSICAL PROPERTIES CRITERIA FOR ROCK DESCRIPTIONS

LBNL GENERAL PURPOSE LAB CENTRAL PLANT
Berkeley, California

PROJECT NO.	DATE	FIGURE 3
2335-12C	**May 2010**	

Looking Northwest toward Buildings 41 and 4 (in distance)

Looking Southeast toward Building 28 (in distance)

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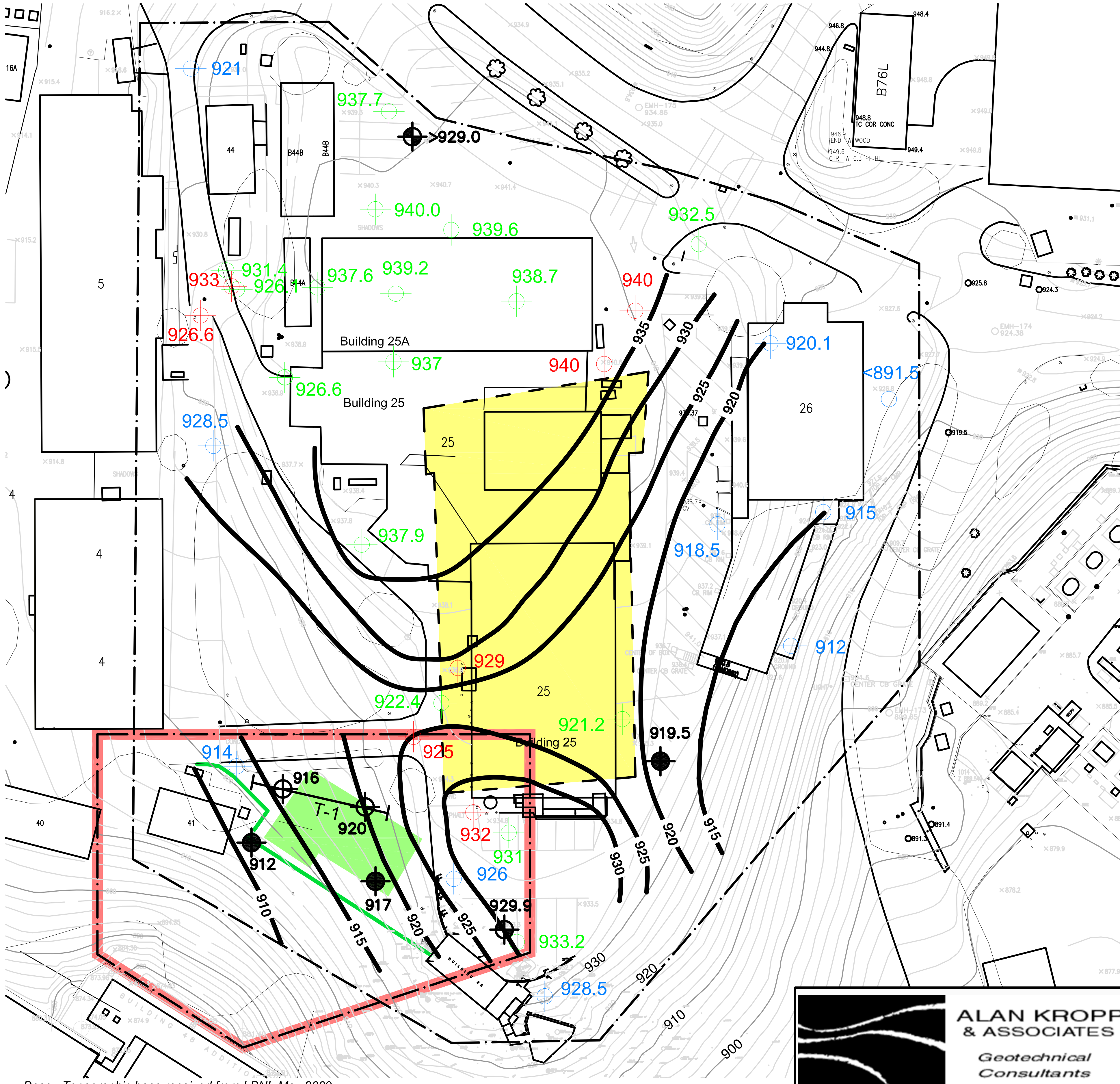
SITE PHOTOGRAPHS		
LBNL GENERAL PURPOSE LAB CENTRAL PLANT Berkeley, California		
PROJECT NO.	DATE	FIGURE 4
2335-12C	**May 2010**	



Base: *Topographic base received from LBNL May 2009.*

LEGEND

- Approximate footprint of Central Plant building
- Approximate location of Central Plant retaining walls
- Approximate limit of study area, this supplement
- 936 — Bedrock surface elevation reported on log of boring (in feet)
- 935 — Interpreted bedrock surface contours (elevation in feet)
- Approximate footprint of General Purpose Lab (GPL)
- Approximate limits of GPL study area (borings and trenches outside study area not shown)

NOTE: Bedrock surface elevation contours are interpreted based on data from existing borings and should be considered approximate.

50 0 50 100
APPROXIMATE SCALE FEET

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BEDROCK SURFACE CONTOUR MAP		
LBNL GENERAL PURPOSE LAB CENTRAL PLANT Berkeley, California		
PROJECT NO. **2335-12C**	DATE **May 2010**	FIGURE **5**

DRILL RIG: B-24, Solid Flight Auger	SURFACE ELEVATION: 917.5 feet (see notes)	LOGGED BY: DI
DEPTH TO GROUNDWATER: 31 feet (see notes)	BORING DIAMETER: 4 inches	DATE DRILLED: 4/16/10

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
CLAY, Lean - with silt and sand, dry to moist	Dark Gray	Stiff	CL	1					
CLAY, Fat - with silt, trace coarse sand, dry to moist	Dark Reddish Brown to Dark Brown	Very Stiff	CH	2, 3, 4, 5		[27]			PP = 1.75 tsf LL = 77 PI = 56 -200 = 81%
VOLCANICS - deeply weathered, friable to weak, soft to low hardness, with angular fragments of weathered andesite	Reddish Brown to Grayish Brown		BED ROCK	6		30	18.4		
				7, 8, 9		[50/6"]	10.5		
	Reddish Brown with some Very Dark Gray			10		50/6"			
				11, 12, 13					
-plastic to friable	Mottled Reddish Brown, Grayish Brown and Very Dark Gray			14, 15		23	14.5		
				16, 17, 18, 19					

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DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
VOLCANICS - deeply weathered, friable to weak, low hardness, with angular fragments of weathered andesite	Reddish Brown with some Very Dark Gray		BED ROCK			41	14.5		
				21					
				22					
-23' harder drilling				23					
-no recovery in sample barrel				24		50/3"			
				25					
				26					
				27					
				28					
-29' drilling is smoother									
SILTSTONE - deeply weathered, friable, low hardness	Gray		BED ROCK	29					
				30		40	9.1		
				31					▼ (3 days after drilling)
				32					
				33					
				34					
				35					
				36					
				37					
				38					∇ (ATOD)
				39					
				40					
				41		31			

Bottom of boring at 41.5 feet.

(Continued on Next Page)

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EXPLORATORY BORING LOG
LBNL GENERAL PURPOSE LAB CENTRAL PLANT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12C	**May 2010**	**2 of 3**	**AKA-5**

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS

(Continued from Previous Page)

NOTES:

1. Groundwater was encountered at approximately 38 feet at the time of drilling and was at a depth of about 31 feet 3 days after drilling was complete. (See report for discussion.)
2. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
3. Penetration resistance values (blow counts) enclosed in brackets ([ ]) were recorded with a 3.0-inch O.D. Modified California sampler; these are not standard penetration resistance values.
4. Boring location levations were surveyed by LBNL subcontractor.
5. Approximate unconfined compressive strength values were recorded in the field using a pocket penetrometer. These values are shown on the logs and are preceded by the symbol "PP".

DRILL RIG: B-24, Solid Flight Auger	SURFACE ELEVATION: 925 feet (see notes)	LOGGED BY: DI
DEPTH TO GROUNDWATER: (see notes)	BORING DIAMETER: 4 inches	DATE DRILLED: 4/16/10

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
CLAY, Lean - with silt and sand (fine to coarse grained), dry to moist	Dark Gray to Dark Reddish Brown	Stiff	CL	1 2 3					
CLAY, Fat - with silt, trace coarse sand, dry to moist	Dark Reddish Brown	Stiff to Very Stiff	CH	4 5 6 7		[23]	26.1	89	PP = 2.5 tsf LL = 65 PI = 46 -200 = 76%
VOLCANICS - deeply weathered, friable, soft to low hardness, with angular fragments of weathered andesite	Reddish Brown to Dark Gray		BED ROCK	8 9					
	Reddish Brown with some Brown and Yellowish Brown			10 11 12 13 14		[39]	16.8	103	
	Dark Reddish Brown with some Gray and Very Dark Gray			15 16 17 18 19		[67]	15.5		

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EXPLORATORY BORING LOG
LBNL GENERAL PURPOSE LAB CENTRAL PLANT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12C	**May 2010**	**1 of 2**	**AKA-6**

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
VOLCANICS - deeply weathered, friable, low hardness, with angular fragments of weathered andesite	Mottled Gray, Olive Gray and Reddish Brown		BED ROCK	21					
						[90]	17.8		
				22					
				23					
				24					
-friable to weak	Mottled Gray and Reddish Brown			25					
				26					
						41	13.7		
				27					
				28					
				29					
				30					
				31					
				32					
				33					
				34		50/6"			

Bottom of boring at 34.0 feet.

NOTES:

1. No groundwater was encountered at the time of drilling and the boring was backfilled immediately after drilling. (See report for discussion.)
2. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
3. Penetration resistance values (blow counts) enclosed in brackets ([ ]) were recorded with a 3.0-inch O.D. Modified California sampler; these are not standard penetration resistance values.
4. Boring location levations were surveyed by LBNL subcontractor.
5. Approximate unconfined compressive strength values were recorded in the field using a pocket penetrometer. These values are shown on the logs and are preceded by the symbol "PP".

DRILL RIG: Fraste Multidrill XL, Rotary Wash	SURFACE ELEVATION: 929.9 (see notes)	LOGGED BY: SS
DEPTH TO GROUNDWATER: (see notes)	BORING DIAMETER: 4 7/8 inches	DATE DRILLED: 5/19/09

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
Asphalt Concrete - 2-inches									
GRAVEL, Poorly Graded - sandy, well compacted, no plasticity, dry (Road Aggregate Base) FILL	Light Brown	Medium Dense	GP	1 2 3					
VOLCANICS - Rhyolite, moderately weathered, weak, breaks into indiscernable rubble during drilling, dry	Yellowish Brown		BED ROCK	4 5 6	X	[30]/3"			
				7 8 9 10	X	[50]/3"			
				11 12 13 14 15 16	X	[50]/4.5"			
				17 18 19					

(Continued on Next Page)

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
-Andesite, moderately weathered, weak	Yellowish Brown		BED ROCK			[50]/3"			
				21					
				22					
				23					
				24					
				25					
				26					
				27					
				28					
				29					
				30					
				31					
				32					
-Rhyolite, with mineralization, hard, fractured, with weak granular weathered rock matrix	Grayish Green with Red			33					
				34		83			
				35					
				36					
				37					
				38					
				39		75			
				40					
				41					
				42					

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DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
	Grayish Green with Red		BED ROCK	43		50/4.5"			
				44					
				45					
				46					
				47					
-clay lined fractures mixed with volcanic rock blocks, not continuous, brownish with manganese staining				48					
				49		72			
-Andesite, volcanics, very fine grained (Basalt?)	Greenish Brown			50		50/5"			
				51					
				52					
				53					
				54					
				55					
				56					
				57					
				58					
				59		50/5"			
				60					
				61					
				62					
				63		50/4.5"			
				64					
-Rhyolite, with mineralization, volcanics (Basalt?)				65					

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DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
	Greenish Brown		BED ROCK	66					
				67					
-hard, heavily weathered volcanics (Basalt?)	Black			68		50/4.5"			
				69					
				70					
				71					
				72					
-0.2 to 0.1 foot pieces of subangular clasts of fractured volcanic Basalt from 72.5 to 74 feet				73		50/3.5"			
				74					
				75					
				76					
				77					
-weathered with iron oxide zones along fractures, no continuous clay seams, fractured Basalt 0.2 to 0.3 foot diameter, moist to wet				78					
				79		68			
-becomes more competent with depth, larger fracturing blocks, no thick or laterally continuous clay seams				80					
				81					
				82					
				83					
				84					
-Andesite, tuffacious in spots, flecks of Basalt, deeply weathered, quartz veins, Rhyolite, larger clasts than above	Dark Grayish Brown with Reddish Overtone			85					
				86					
				87					
-more competent, fine grained				88					

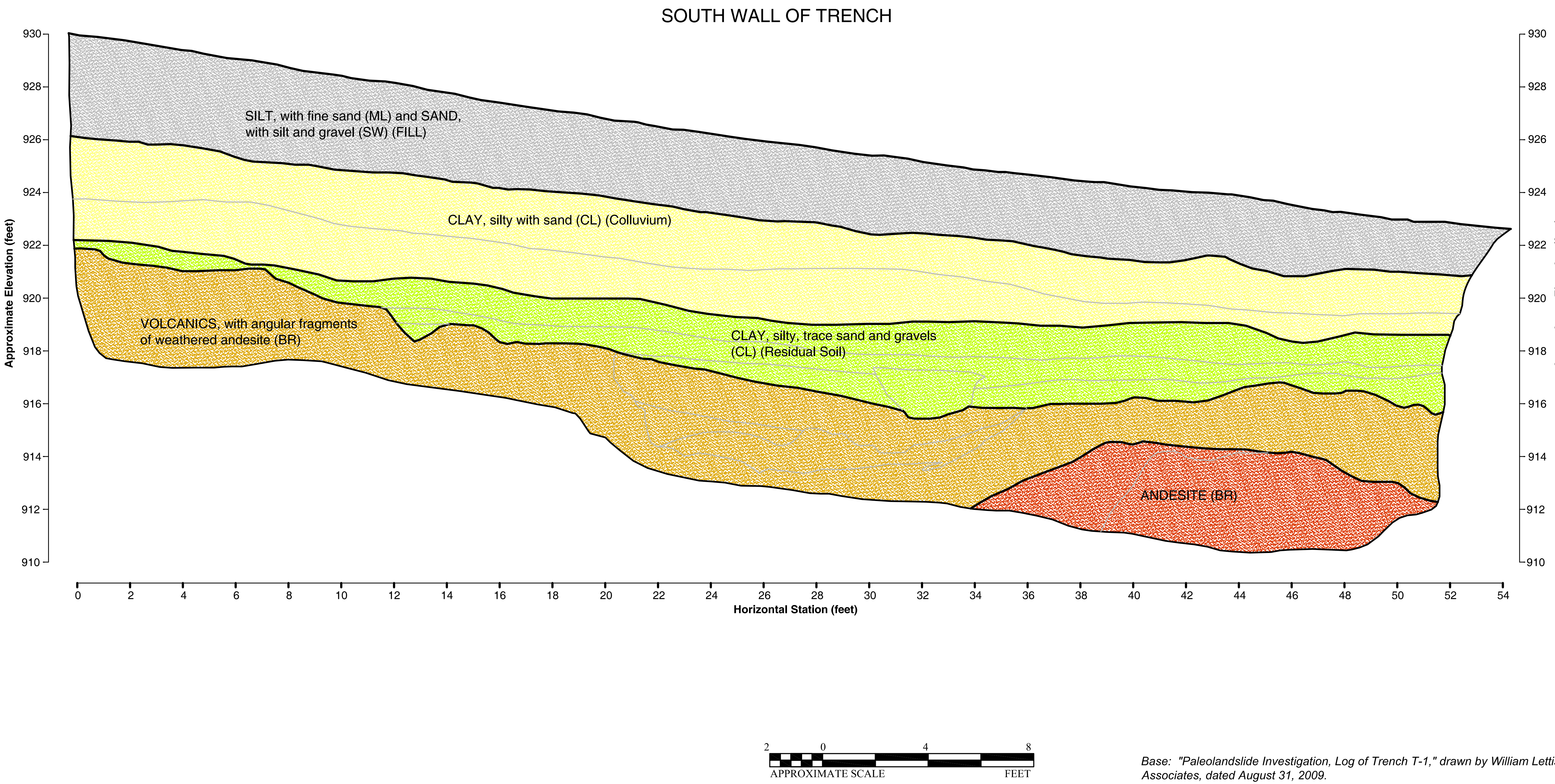
(Continued on Next Page)

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
-becomes fractured and brecciated, smaller clasts -deeply weathered	Dark Grayish Brown with Reddish Overtone		BED ROCK	89 90 91					
SILTSTONE/CLAYSTONE - with volcanic gravels	Reddish Brown		BED ROCK	92					
SILTSTONE - little weathering, weak, slightly fractured -competent and hard -massive	Dark Bluish Gray Greenish Gray		BED ROCK	93 94 95 96 97 98 99 100 101 102					
CLAYSTONE - friable to weak, moderately fractured along planes, some harder clasts of calcite	Bluish Gray		BED ROCK	103 104 105 106					

Bottom of boring at 106.2 feet.

NOTES:

1. Groundwater levels were obscured due to rotary was drilling method (See report for discussion).
2. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
3. Penetration resistance values (blow counts) enclosed in brackets ([ ]) were recorded with a 3.0-inch O.D. Modified California sampler; these are not standard penetration resistance values.
4. Elevations were determined from survey performed by LBNL subcontractor.



Base: "Paleolandslide Investigation, Log of Trench T-1," drawn by William Lettis & Associates, dated August 31, 2009.

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SIMPLIFIED TRENCH LOG

LBNL GENERAL PURPOSE LAB CENTRAL PLANT
Berkeley, California

PROJECT NO.	DATE	TRENCH NO.
2335-12C	**May 2010**	**T-1**