SECTION 2. SITE CHARACTERIZATION

2.1 Regional Geology

The Island of Oahu is composed largely of weathered remnants of the Waianae and Koolau shield volanoes. The older Waianae Volcano forms the bulk of the western third of the island while the younger Koolau Volcano forms the majority of the eastern two-thirds of the island. Waianae became extinct while Koolau was still active and its eastern flank is partially buried below Koolau lavas in central Oahu. The Waianae and Koolau volcanic shields were built during the late Pliocene Epoch and the early Pleistocene Epoch by thin bedded basaltic lava flows. The main shield-building activities ceased approximately 2.5 to 3.5 million years ago. The proposed highway rehabilitation project is located on the southeastern portion of Koolau. The base of the stratigraphic section in this area is Koolau Basalt.

Following the main shield building activities, erosion began to dissect the volcanic domes starting with the establishment of drainageways that expanded to become deep amphitheater-headed valleys. On the leeward side of the Koolau dome, these valleys became the major valleys that we see today, such as Manoa, Nuuanu and Halawa. The windward side of the dome receives much more precipitation and experiences a greater rate of erosion causing the windward facing valleys to coalesce and form a cliff face now referred to as the Pali.

During the Pleistocene Epoch (Ice Age), many sea level changes occurred as a result of widespread glaciation in the continental areas of the world. As the great continental glaciers accumulated, the level of the ocean fell since there was less water available to fill the oceanic basins. Conversely, as the glaciers receded, or melted, global sea levels rose because more water was available. The land mass of Oahu remained essentially stable during these changes and the fluctuations were eustatic in nature. These glacio-eustatic fluctuations resulted in stands of the sea which were both higher and lower relative to present sea level on Oahu.

The higher sea level stands caused the accumulation of terrigenous sediments in the valleys. The lower sea stands caused streams to erode into the sediments in the valley floors. About 15,000 years ago, a relatively rapid rise in sea level occurred. During that rise, portions of the deep valleys were drowned. In the last 10,000 years or so, sea level has adjusted to its present stand.

The soils and rocks within the highway alignment may be grouped into several major stratigraphic units. The engineering characteristics of these units appear to be reasonably consistent. These soil units are listed below in the general order of geologic age, beginning with the youngest and ending with the oldest unit:

1. Recent Alluvium (Ra)
2. Older Alluvium (Qa)
3. Koolau Basalt (Tkb)

Based on our review of the available data and the borings drilled and sampled for the current exploration effort, the following discussions summarize the general characteristics of the materials encountered along the highway alignment under consideration for this project:

Recent Alluvium (Ra)

The Recent Alluvium consists mainly of very soft to medium stiff, brown to dark brown clayey silt and organic silt with varying amounts of sand and infrequent pockets of gravel and cobbles.

The soils assigned to this unit are generally considered to be poorly to very poorly suited for use as support for foundation loads, due to their low in situ strength characteristics and the tendency for settlement to occur in structures overlying soils of this unit.

Older Alluvium (Qa)

The Older Alluvium is assigned the position of being the second oldest unit in the stratigraphic column of the project area. This unit generally overlies the Koolau Basalt and consists of terrigenous sediments which have been transported by stream action from the upper reaches of the streams. The materials consist mainly of very stiff to hard brown clayey silts and silty clays. Gravel lenses representing buried stream channels are sometimes encountered. Portions of the Older Alluvium unit contain some weathered basalt boulders and cobbles.

The Older Alluvium materials generally exhibit high strength which leads to a relatively high bearing capacity. Frequently, these materials show a moderate to high shrink/swell potential; however, this is not considered a constraint for the type of structural elements (light poles) planned for this project.

Koolau Basalt (Tkb)

The Koolau Basalt is the oldest geologic unit within the highway alignment. It generally consists of interbedded pahoehoe and a'a flows of basaltic lavas and may have a mantle of cobbles and bounders, or residual soil overlying the top of the rock. It is anticipated that various types of volcanic rock sub-components, such as clinker layers and lava tubes, could also be encountered.

Structurally, the Koolau Basalt and its residual soils are among the strongest of all the units encountered within the project limits. Therefore, the basalt and related residual soils and saprolites make excellent bearing formations due to their high strength characteristics in an undisturbed state.

2.2 Existing Site/Pavement Conditions

Pali Highway (Hawaii Route 61) is a major thoroughfare connecting downtown Honolulu with the windward side of Oahu with a total length of approximately 20.8 miles. The highway generally starts at the intersection with Beretania Street in downtown Honolulu, traverses up Nuuanu Valley and the residential neighborhood of Nuuanu, passes through the Nuuanu Pali Tunnels, and descends to the major windward communities of Kaneohe and Kailua, terminating at the intersection with Hamakua Drive in Kailua. The approximate limits for this pavement rehabilitation project generally extend between about Waokanaka Street (Sta. 26+88.3 or Mile Post 2.64) in Honolulu and Kamehameha Highway (Sta. 203+55.26 or Mile Post 7.68) in Kaneohe as shown on the General Site Plan, Plate 2.

This portion of the Pali Highway was constructed in the 1950s and has gone through various phases of upgrading through the years. The existing highway within the project limits is generally a four-lane divided highway (two lanes of traffic in each direction separated by a concrete median) with turn lanes at the intersection with Old Pali Road. The highway has an additional right lane with concrete pavements extending from Waokanaka Street to Nuuanu Pali Drive in the outbound direction. In addition, the highway widened from two to four lanes (including turn lanes) in the outbound direction near the intersection with Kamehameha Highway.

The existing ground surface elevations along the highway alignment generally range from about +460 feet Mean Sea Level (MSL) at Waokanaka Street and ascends to about +1,125 feet MSL near the Nuuanu Pali Tunnels, then descend to about +360 feet MSL at the intersection with Kamehameha Highway on the windward side of Oahu. Based on our field observations and the information provided, the traffic volume at the highway may be considered as moderate to heavy with the average daily traffic count (both directions) on the order of about 49,100 vehicles in the Year 2013.

The following guidelines and criteria are used in describing various types of pavement distresses and failures in this report. It should be noted that the term “Structural Defects” refers to areas where the pavement deterioration is believed to be caused by failures in the underlying base, subbase, and/or subgrade materials. The term “Ride Characteristic” refers to the response of a vehicle when passing at normal speed over the highway.

2.2.1 Areas with Minor Distresses

The existing pavements under this category are generally good with no structural defects observed. Overall pavement deterioration is restricted to light alligator cracking of low severity. The ride characteristic of the pavement is generally fair to good.

2.2.2 Areas with Moderate to Severe Distresses

The existing pavements under this category are generally in poor condition with poor-quality, moderately to highly distressed areas. Alligator and alligator block cracking are widespread and generally moderate to high in severity. The poor areas may consist of elongated, severely distressed zones of alligator block cracking with depressions, rutting and some shoving of the pavement. The ride characteristic of the highway is generally fair to slightly irregular and bumpy in the areas of poor pavements.

A pavement condition survey was conducted by our office in July 2013 to collect general information for the existing pavement conditions along the portion of the highway under consideration. In general, our pavement condition survey conducted at the project site suggested that the majority of the pavements within the project limits appear to exist in fair to good condition. However, we believe that this observation is likely a result of the recent AC overlay performed in early to mid-2013 on some of the severely distressed pavement areas, masking the deteriorated condition of the underlying pavements. Therefore, consideration should be given to reconstructing these pavement areas with a new pavement section similar to other pavement areas exhibiting moderate to severe distresses.

During our pavement condition survey, pavement areas exhibiting moderate to severe distresses requiring repairs were delineated and documented. Graphic presentations of these distressed pavement areas are shown on the Site Plans, Plates 3.1 through 3.12 in this report for reference. It should be noted that delineation of these distressed pavement areas was performed using a hand-held GPS (Global Positioning System) device, which has an accuracy of around plus or minus 10 to 15 feet. Therefore, the actual locations of these distressed pavement areas should be confirmed and/or modified in the field during the project construction. In addition, photographs depicting some of the observed distresses along the roadway are presented in Appendix F. The approximate locations where the photographs were taken are shown on the Site Plans, Plates 3.1 through 3.12.

2.3 Subsurface Conditions

Our field exploration program consisted of drilling and sampling 20 borings, designated as Boring Nos. 1 through 20, at selected locations along the roadway alignment. The borings generally extended to depths of about 3.5 to 12.5 feet below the existing pavement surface. In addition, the boring exploration was supplemented by coring the existing pavement section to depths of about 1 to 5.4 feet below the existing pavement surface at 30 selected locations, identified as C-1 through C-30. Twelve bulk samples, designated as Bulk-1 through Bulk-12, were obtained from the near-surface materials to evaluate their swelling potential and pavement support characteristics. The approximate locations of the borings/corings and bulk samples are shown on the Site Plans, Plates 3.1 through 3.12.

Our field exploration indicates that the existing pavement structure along Pali Highway generally consisted of an AC surface course with multiple overlays over base course and subbase materials underlain by in-situ subgrade soils. Based on our field exploration and laboratory testing program, the existing pavement structure and underlying subgrade materials encountered along Pali Highway are summarized below:

SUMMARY OF PAVEMENT STRUCTURE AND SUBSURFACE SOIL PROFILE						
Field Designation	Mile Post	Station Number	Existing Pavement (inches)			In-Situ Subgrade Materials
			AC	Base/ Subbase	Total Thickness	
B-20	2.63	26+27.70	6	18	24	2.7' SM / CLAY
C-1	2.63	26+29.25	8.5	21.5	30	-
B-1	2.69	29+50	9.5	20.5	30	BASALT
C-2	2.98	21+15.32	13	20.5	33.5	CLAY
C-20	3.00	22+0.79	10	14	24	CLAY
B-19	3.12	28+75	8	40	48	CLAY
B-2	3.24	34+09	14	22	36	CLAY
C-19	3.4	43+15	9.5	32.5	42	CLAY
B-18	3.47	47+30	9.5	26.5	36	CLAY
C-3	3.52	49+50	11	19	30	CLAY
C-30	3.58	52+80	8.5	18.5	27	CLAY / BASALT
C-18	3.67	57+80	10.5	25.5	36	CLAY
C-29	3.77	62+80	8	34	42	CLAY
B-3	3.81	65+10	11.5	18.5	30	BASALT
C-28	3.82	65+90	11	28	39	CLAY
B-17	3.96	73+00	12	30	42	BASALT
C-27	4.11	80+85.45	8	28	36	BASALT
C-4	4.11	80+86.60	14	21.5	35.5	BASALT

SUMMARY OF PAVEMENT STRUCTURE AND SUBSURFACE SOIL PROFILE						
Field Designation	Mile Post	Station Number	Existing Pavement (inches)			In-Situ Subgrade Materials
			AC	Base/ Subbase	Total Thickness	
C-17	4.39	87+37.84	7	11	18	GM
B-4	4.23	95+62.39	8.5	21.5	30	3.5' GM / CLAY
B-16	4.54	103+40	8	8	16	4.2' GM / CLAY
C-5	4.66	42+60	10	26	36	CLAY
C-16	4.83	51+10	16.5	12.5	29	CLAY
B-5	4.95	57+86.41	10	23	33	CLAY
B-15	5.11	66+03.57	10.5	19.5	30	CLAY
C-6	5.24	72+84.96	10	23	33	CLAY
C-15	5.39	80+98.64	13	32.5	45.5	CLAY
B-6	5.52	87+69.39	9	5.5	14.5	2.8' GW / CLAY
C-14	5.53	88+39.21	7.5	16.5	24	CLAY
B-14	5.67	96+00	9	15	24	CLAY
C-7	5.92	109+20	5.5	12.5	18	BASALT
B-7	6.1	117+87.83	6.5	14.5	21	SM
B-13	6.11	119+00	15	10	25	TUFF
C-21	6.14	120+60	7.5	7	14.5	GW/SM
C-26	6.24	125+80.69	4	-	-	Bridge Deck
C-8	6.28	127+56.15	10	6	16	GM
C-22	6.38	132+52.53	7	13	20	SM / BASALT
C-13	6.52	141+06.25	8	8.5	16.5	GM
B-8	6.58	141+24.27	12	3	15	3.3' GM / CLAY
C-23	6.7	150+15.85	8.5	36.5	45	CLAY
B-12	6.81	155+66.72	9	10	19	BASALT
C-24	6.83	156+93.86	6.5	9	15.5	BASALT
C-9	6.9	158+30	7.5	7.5	15	CLAY
C-12	7.1	171+17.77	10.5	9.5	20	CLAY
B-9	7.13	172+58.12	9.5	8.5	18	CLAY
C-25	7.37	185+48.40	9	9	18	GP
B-11	7.38	185+89.49	9	24	33	CLAY
C-10	7.41	187+60.14	9	9	18	CLAY
C-11	7.64	199+61.00	8	7	15	CLAY

SUMMARY OF PAVEMENT STRUCTURE AND SUBSURFACE SOIL PROFILE						
Field Designation	Mile Post	Station Number	Existing Pavement (inches)			In-Situ Subgrade Materials
			AC	Base/ Subbase	Total Thickness	
B-10	7.65	200+27.18	11	0	11	CLAY

The base/subbase materials encountered consisted of sandy gravel and are generally dense in relative density. The subgrade materials encountered below the pavement section generally consist of stiff silty clays/clayey silts with moisture contents in excess of 40 percent.

We did not encounter groundwater in our shallow borings (maximum depth of 12.5 feet below pavement surface) at the time of our field exploration. However, it should be noted that groundwater levels are expected to fluctuate depending on seasonal rainfall, time of year, surface runoff, subterranean seepage, and other factors.

Detailed descriptions of the materials encountered in the borings/corings are presented on the Logs of Borings in Appendix A. Field logs of the Dynamic Cone Penetration (DCP) tests are presented in Appendix B. Results of the laboratory tests performed on selected soil samples are presented in Appendix C. The pavement design and calculations are provided in Appendix D. Photographs of the AC cores from the existing pavements are provided in Appendix E.

2.4 Dynamic Cone Penetration Testing

In addition to borehole drilling and sampling, our field exploration program also included performance of Dynamic Cone Penetration (DCP) testing at twenty-one boring/coring locations to provide additional data and information for our evaluation and analyses.

The Dynamic Cone Penetration test provides a measure of a material's in-situ resistance to penetration. The test is performed by driving a metal cone into the ground by repeatedly striking it with a 17.6-lb (8-kg) weight dropped from a distance of 22.6 inches (575 mm). The penetration of the cone is measured after each blow and is recorded to provide a continuous measure of shear resistance up to 9 feet below the pavement surface. Test results can be correlated to California Bearing Ratio, in-situ density, resilient modulus, and bearing capacity.

The DCP tests were generally conducted at 1-inch (25.4-mm) discrete depth intervals between depths of about 21 to 108 inches below the existing pavement surface at the test locations. Field logs of the DCP tests are included in Appendix B of this report for reference. Results for the DCP field data are summarized in Plates 4.1 through 4.3 for ease of reference.

END OF SITE CHARACTERIZATION