GERHART COLE INC.
GEOTECHNICAL ENGINEERS

668 E. 12225 S. Suite 203
Draper, Utah 84020
801.849.0055

TECHNICAL MEMORANDUM

To:	Mr. Lance E. Houser, PE Assistant City Engineer 290 North 100 West Logan, Utah 84321
Copies:	File
From:	Brian Peterson, EIT
Reviewed by:	Scott W. Davis, PE (UT) Ryan T. Cole, PhD, PE (UT)
Date:	April 7, 2016
Job Number:	16GCI673
Subject:	1200 South/Hwy 89-91 Intersection Realignment

PROFESSIONAL ENGINEER
4/7/16
No. 174638-2202
SCOTT W. DAVIS
STATE OF UTAH

This technical memorandum summarizes the geotechnical study authorized by Logan City under agreement dated February 22, 2016 for the realignment of the 1200 South/Hwy 89-91 intersection in Logan, Utah.

SCOPE OF SERVICES

The purpose of this study is to provide Logan City geotechnical engineering recommendations to aid in the design and construction of the planned intersection realignment. Our scope of services, as outlined in our proposal dated February 5, 2016, included:

- Drilling two (2) test holes and advancing six (6) Dynamic Cone Penetrometer (DCP) soundings along the alignment.
- Laboratory testing of select soil samples
- Data reduction, analyses, and development of recommendations for design and construction of a new asphalt-paved roadway segment.

PROJECT BACKGROUND

We understand that Logan City is planning to reconfigure the existing intersection at this location in order to eliminate the current skewed configuration and provide a perpendicular approach and intersection for 1200 South with US Highway 89-91. The planned realignment of 1200 South will consist of a three-lane asphalt-paved roadway with curb and gutter, a park strip and sidewalk on each side of the road. The planned alignment will pass through a low-lying wetland area. We understand the finished grade of the roadway through the wetland area will require raising the existing grade by approximately 3 to 4 feet.

FIELD STUDY

A field study was performed on February 23 and 24, 2016, by drilling two test holes (TH-2 and TH-3) to depths of 25 feet and 12 feet, respectively, and advancing six Dynamic Cone Penetrometer (DCP) soundings to depths of approximately 3.5 feet below existing site grade. It should be noted that TH-1, originally identified in the RFP, was deleted and replaced with the DCP soundings at the request of Logan City. A Study Location Map showing the locations of the test holes and DCP soundings is presented on Figure 1. The test holes were drilled using a truck-mounted, Simco 2800HT/HS, hollow-stem auger drill rig operated by ACache Corp, under subcontract to GCI. A handheld GPS device was used to obtain the approximate latitude and longitude of the test holes and DCP locations. Test hole data are summarized in Table 1.

Subsurface conditions were logged by a GCI field engineer at the time of drilling using a combination of methods including direct sampling and observation of drilling behavior. Standard penetration testing (SPT) was performed with standard (2-in OD, 1-3/8-in ID) split spoon samplers driven by an automatic-trip hammer consisting of a 140-pound weight falling a distance of 30 inches. The efficiency of this hammer is reported at 75 percent. The number of hammer blows required to advance the sampler in 6-inch increments was recorded in the field, with the sum of the second and third 6-inch intervals constituting the SPT blow count or "N-value". In addition to providing a sample, the SPT provides a relative consistency measurement of the soil in-situ. In addition to SPT sampling, three Shelby tubes were hydraulically pushed into the soil at selected depths in TH-2 to sample the fine grained materials.

Representative portions of the samples were packaged and transported to our laboratory for classification and testing. The test hole logs are included as Figures 2 and 3 along with a legend of soil descriptions as Figure 4. Stratification lines shown on the log represent approximate boundaries between soil types for the particular test hole location, using the field data collected during our study. Transitions may be gradational or occur between sampling depths. Interpolation or extrapolation of subsurface conditions beyond discrete study locations may not be appropriate or yield representative results.

As indicated above, DCP testing was performed to supplement the data obtained from the test holes. These tests were performed at regular intervals between Hwy 89-91 and TH-2 as indicated on Figure 1. Plotted test results for each DCP sounding are presented as Figures 5 through 10.

DCP testing offers advantages in characterizing subgrade soils due to its relatively low cost, speed and ease of operation, continuous measurement of penetration resistance, and its ability to identify weak strata. It should be understood, however, that the DCP test is intended to evaluate the *in-situ* strength of subgrade materials. In other words, the DCP test measures the strength of the subgrade materials at in-situ moisture and density conditions. As such, the CBR values calculated from field measurements may not correlate directly with soaked laboratory CBR values. However, by completing DCP tests at several locations across a project site, it is possible to identify variability in subgrade conditions and to identify areas with weaker subgrade materials.

LABORATORY STUDY

Laboratory testing was performed on selected soil samples obtained during drilling for further classification and evaluation of their engineering properties. Laboratory testing included index property testing (particle-size distribution, Atterberg limits, and moisture content), one-dimensional consolidation, moisture-density relationship (Proctor) and California Bearing Ratio (CBR) tests. The results of all laboratory tests are summarized in Table 2.

GENERAL SITE CONDITIONS

Currently 1200 South is a wide two-lane, asphalt-paved road with commercial development along the south side and undeveloped land containing wetlands along the north side. The road currently intersects Hwy 89-91 at an approximate 50 degree skew, and it is desired to turn 1200 South northward in order to create a perpendicular intersection with the highway. When realigned, the road will extend through existing wetlands with heavy vegetation. The wetland area slopes mildly downward toward the west, and ranges from approximately 3 to 5 feet lower in elevation than the adjacent roadway.

Subsurface Conditions

Based on the test holes and DCP soundings performed along the alignment, the native soil profile generally consists of soft silt and elastic silt (ML, MH overlying loose silty sand and gravelly sand (SM, SP-SM) which is underlain by soft to medium stiff clay (CL) at a depth of 12 feet which extends to the bottom of the test hole (25 feet). In TH-3, the native soils are overlain with granular fill soils (base course and subbase material) and asphalt pavement. The upper 12 inches within the wetland area contained significant organic material (root mat). Results of laboratory testing indicate the upper silt soils possess moderate to high plasticity, and have relatively low bearing strength relative to pavement support. The underlying clay soils are moderately compressible with moderate plasticity.

Groundwater

Groundwater was measured in TH-2 at a depth of one foot, and in TH-3 at a depth of 5 feet at the time of drilling. The difference in groundwater level between the two test holes can be largely attributed to the variation in ground surface elevation. While such measurements are meaningful, they may not completely reflect the actual water table depth due to insufficient time for the water in the test hole to equilibrate. Groundwater levels fluctuate seasonally and given the time of year that the field study was completed, we would expect groundwater levels to be near their seasonal low. As such, groundwater levels used in design and for construction considerations should address shallower groundwater levels than reported in this study, and may be at, or above the ground surface in the wetland area, depending on the time of year construction begins.

GEOTECHNICAL ANALYSES AND DESIGN RECOMMENDATIONS

General

As previously noted, the subgrade soils within the low-lying wetland area generally consist of relatively soft, wet silt soils with a surficial root mat and a shallow groundwater table. These factors warrant the use of soft ground site preparation and grading techniques, as well as geotextile reinforcement to create a stable subgrade sufficient to support the overlying pavement section and traffic loads. The following sections of this report present our recommendations for site preparation and grading, subgrade stabilization, structural fill placement, and pavement section design and construction.

Site Preparation and Grading

We understand that the new alignment will tie into existing pavement grade at Hwy 89-91 and at 1200 South, approximately 350 feet east of the current intersection with Hwy 89-91. Between these two points, the alignment will extend over the existing wetlands, requiring approximately 3 to 4 feet of fill to achieve design grade. Near the tie-ins with the existing roads, limited cuts will be required to accommodate the required pavement section thickness.

Prior to site grading and structural fill placement, the alignment should be stripped of all existing asphalt pavement (along 1200 South). The exposed granular fill soils beneath the pavement, and along the highway shoulder should also be stripped, but may be stockpiled for possible re-use as subbase material upon approval by the geotechnical engineer.

Within the wetland area, all vegetation and root mat material up to a depth of 12 inches below existing grade should be stripped from within the roadway alignment. Excavations deeper than 12 inches should not occur, except where required to accommodate the required pavement section, in order to reduce the potential for creating unstable, pumping subgrade conditions. Site stripping should extend laterally a minimum of 3 feet beyond the outside edge of the planned concrete sidewalk.

Stripping within the wetland area should be performed using low ground-pressure, track-mounted equipment, keeping equipment passes to a minimum to limit subgrade disturbance. Stripping activities should be observed periodically by the geotechnical engineer to note compliance with these recommendations, and to note exposed subgrade conditions.

Following stripping, the exposed subgrade within the wetland area should be overlain with a non-woven geotextile separator fabric, such as Mirafi 140N, or approved equivalent. The fabric should be overlapped at the edges a minimum of 6 inches. Following fabric placement, a polypropylene biaxial geogrid such as Tensar BX1100 ("BX Type 1"), or approved equivalent, should be placed directly over the fabric. The geogrid should be unrolled in the direction of travel with a minimum overlap of 12 inches between adjacent rolls. The geogrid should be tensioned to remove wrinkles and pinned, as needed, to prevent movement during fill placement. Following placement of the geogrid, structural fill may be placed in accordance with the recommendations presented below.

Beyond the wetland area, the exposed granular subgrade should be proof-rolled and observed for deflection by the geotechnical engineer. If deflection is observed, the subgrade should be overlain with the geotextile separator fabric and geogrid as described above. If no deflection is observed, the subgrade should be scarified to a depth of 6 inches, moisture-conditioned to near optimum moisture content (+/- 2 percent), and compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D-1557.

Excavatability

Based on the subsurface soil conditions found in our test holes, we anticipate that excavations for site grading and utility construction can be performed with conventional equipment. However, as noted above, all equipment traversing directly on the soft subgrade soils should be low-pressure, track-mounted equipment.

It should be anticipated that groundwater will be found in utility excavations extending below subgrade elevation. The very moist to wet soil conditions and shallow groundwater level will adversely impact trench sidewall stability and should be considered by the contractor in all such utility construction. All excavation work should be performed in accordance with current OSHA requirements.

Structural Fill and Compaction

All fill (subbase) placed directly over the geogrid and up to base course elevation should be structural fill possessing a minimum CBR value of 25 and meeting the following gradation criteria:

Sieve Size	Percent Passing
3 in.	100
1.5 in.	50-100
#4	50 max.
#200	20 max.

The fill should be back-dumped on the geogrid and spread with low-pressure tracked equipment, keeping a minimum of 12 inches of fill between the geogrid and equipment tracks at all times. The initial lift thickness over the geogrid should be 18 inches prior to applying any compaction effort. Compaction should then be performed with a medium-weight static-drum roller. Initial compaction efforts should be observed by the geotechnical engineer to observe potential deflection of the subgrade, and to work with the contractor to establish an optimal rolling pattern to achieve the desired compaction without damaging the subgrade. The initial lift of structural fill should be carefully moisture-conditioned to avoid excess moisture penetration to the underlying subgrade. Soil moisture content should range from optimum to 2 percent below optimum, and the soil should then be compacted to 90 percent of the maximum dry density as determined by ASTM D1557. Care should be taken to avoid over-compaction of the initial lift of structural fill. Additional structural fill may then be placed in maximum 12-inch loose lifts, moisture-conditioned to near optimum moisture content (+/- 2% of optimum), and compacted to a minimum of 95 percent of the maximum dry density (ASTM D1557).

Settlement of Roadway Prism

We anticipate settlement of the roadway prism due to planned finish grades over the wetland area to be on the order of 1 to 2 inches. Lesser settlement will occur near the tie-ins to existing roadways where fill heights are reduced. We anticipate that a majority of this settlement will occur during construction, prior to final asphalt placement.

PAVEMENT SECTION DESIGN

General

The recommendations for asphalt pavement sections presented in this report are based on traffic loading conditions specified by Logan City, subsurface soil conditions found at the site, and on design methodologies from the 1993 AASHTO Guide for Design of Pavement Structures. A twenty year minimum design life is assumed. The design also reflects one principal lane of traffic in each direction.

Traffic Design Parameters

Traffic loading information provided by Logan City is summarized in Table 3, where traffic counts correspond to the traffic traveling in the design lane. The average annual daily traffic (AADT) for the current year was provided by Logan City as 1,000, with a traffic mix of 90 percent cars and light duty trucks, and 10 percent trucks (including 2- and 3-axle single unit trucks). An annual growth rate of 1.5 percent was used in conjunction with vehicle load factors for axle classifications consistent with a "rural, minor collector" to yield a total ESAL (Equivalent Single Axle Load) value of approximately 0.31 million over the 20-year design life of the pavement.

Environmental Design Parameters

Based on maximum frost penetration data reported by UDOT (KVNU radio station site, located approximately 1.8 miles north of the site), the frost depth in the vicinity of the site is approximately 36 inches, which is also consistent with the Logan City Building Department's design frost depth. Referencing UDOT guidelines, the thickness of the proposed asphalt pavement section should be at least 70% of this value (or about 25 inches) in order to provide adequate frost resistance. This value is incorporated into the recommended pavement design options presented in Table 5.

The natural water table was observed to be relatively shallow at the time of our field study, and should be expected to rise during the spring and early summer months. Natural drainage conditions, based on our field observations, are poor. However, we understand that Logan City proposes to elevate the roadway generally 3 to 4 feet above existing site grade over the majority of the alignment. We also understand that curb and gutter with catch basins will be installed to remove runoff from the roadway together with side slopes graded away from the roadway to prevent adjacent runoff from entering the pavement section. Consequently, our recommended design sections reflect no thickness increases due to adverse drainage conditions. If drainage plans change, the pavement sections may need to be revised.

Other Design Parameters

Two soaked California bearing ratio (CBR) tests were performed on select soils sampled along the roadway alignment, with results of 9.5 and 3.6. The higher value was obtained from a sample of near-surface soil at DCP-1 near the highway shoulder, and may be reflective of fill soil placed to construct the shoulder. In addition, six DCP tests were performed along the alignment. The results of the DCP tests indicate relative consistency in soil strength within the upper native soils, and serve to validate the CBR value of the native silt soil obtained through laboratory testing. Based on this data, a CBR value of 3 was used as the basis for design of the recommended pavement sections. Other parameters used in the design of the pavement sections, including serviceability indices and material property characterizations, are based on typical UDOT design values and are presented in Table 4.

Recommended Pavement Sections and Material Specifications

Based on the referenced design parameters, several pavement section options were developed at Logan City's request and are presented in Table 5. All sections include stabilization and reinforcement of the subgrade with separator fabric and geogrid.

All subgrade preparation and pavement section materials (plant mix asphalt, untreated base course and subbase) should conform to the recommendations presented in this document and all applicable Logan City and American Public Works Association (APWA) specifications. Additionally, untreated base course should possess a minimum CBR value of 70, and the granular subbase should possess a minimum CBR value of 25. The asphalt should be compacted to a minimum of 96% of the marshall (50 blow) maximum density.

It is important that all pavement grades be set to provide positive drainage to suitable drainage features. A desirable slope for drainage in paved areas is typically 1-2%. Successful realization of the intended design life requires an adequate and consistently executed pavement maintenance program.

ADDITIONAL SERVICES

Subsurface conditions are inherently variable. It is important that we observe subsurface materials and conditions exposed at the site during construction, thereby taking advantage of opportunities to recognize potentially differing site conditions and reduce the risk of unanticipated and/or adverse outcomes. Such activities include, but are not necessarily limited to:

- Observation and testing of site preparation, earthwork, geotextile, and pavement placement activities.
- Consultation as may be required during construction.

We also recommend that we review project plans and specifications for compatibility with our assessments and recommendations. Additional information regarding such services can be obtained from our office.

LIMITATIONS

The assessments, considerations, and recommendations presented in this document are based on limited field studies and laboratory testing, as well as our understanding of the project's design and manner of construction. If the project's design or manner of construction changes, or if conditions are found that are different from those described, we should be notified immediately so that we can make revisions as necessary.

This document was prepared solely for the use of the addressee for the specified project and may not contain sufficient information for other parties or uses.

We represent that our services are performed within the limitations prescribed by our Client, in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation, expressed or implied, and no warranty or guarantee is included or intended. We do not assume responsibility for the accuracy of information provided by others.

REFERENCES

American Association of State Highway and Transportation Officials [AASHTO]. (1993). Guide for Design of Pavement Structures.

Utah Department of Transportation [UDOT]. (2008). Pavement Management and Pavement Design Manual. November 1998, Updated March 2008.

Utah Department of Transportation [UDOT]. (2012). 2012 Standard Specifications for Road and Bridge Construction.

Utah Department of Transportation [UDOT], Frost Depth Spreadsheet, www.udot.utah.gov.

Table 1

Test Hole Data

Test Hole	Date	Latitude (deg, N) [a]	Longitude (deg, W) [a]	Elev. (ft) [b]	Total Depth (ft)	Water Depth (ft) [c]	Test Hole Type	Comments
TH-01	-	-	-	-	-	-	-	Test Hole Deleted
TH-02	02/23/16	41.71037	-111.84105	4491	25.0	1.0	Hollow-stem Auger, SPT sampling	Test hole located at edge of wetland
TH-03	02/23/16	41.71025	-111.84046	4495	12.0	5.0	Hollow-stem Auger, SPT sampling	Test hole located on pavement

Notes:

[a] Coordinates are approximate, from hand-held, recreational grade GPS device

[b] Elevations are approximate, estimated from USGS DEM

[c] Ground water depth, at time of drilling

Table 2 Laboratory Test Result Summary

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits					Grain-Size			Grain-Size Analysis (Percent Finer)										Maximum dry unit weight, g_{d-max} (pcf)	Optimum moisture content, w_{opt} (%)	California bearing ratio at 0.2-in, CBR (%)	Other Tests (Interpretative Data in Appendix)
					LL (%)	PL (%)	PI (%)	Cohesive Index, CI	Liquidity Index, LI	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)				
DCP-01	0-2				36	25	11	0.4															110	17	9.5	
TH-02	0-2				58	35	23	0.7															91	28	3.6	
TH-02	3-5	50.0			NP																					
TH-02	10-12	13.6								44	48	9	100	85	69	56	44	33	26	19	13	9				
TH-02	12.5-14.5	32.9	90	119																						TV=0.22 tsf, 1D Consolidation
TH-03	3.5-5.5	23.9								37	43	21	100	86	76	63	51	42	35	30	25	21				
TH-03	5-7	45.2			36	29	7	0.2	2.3																	
TH-03	7.5-9.5	12.5								70	26	4	100	64	41	30	23	20	17	13	6	4				
TH-03	10-12	13.9								50	40	9	100	81	62	50	40	35	30	23	14	9				

TV = Torvane Shear Test

Table 3

Design Traffic Volume

UDOT Axle Classification and Vehicle Description	Number of Vehicles in Initial AADT*	Initial AADT in Design Lane	Annual Growth Rate (%)	20-year AADT in Design Lane
Passenger & Panel Trucks	900	900	1.5	1212
Single Unit Trucks				
2-axle, 6-tire Single-unit Trucks	90	90	1.5	121
3-axle Single-unit Trucks	10	10	1.5	13
TOTALS	1,000**	1,000		1346

Note: *AADT = Average Annual Daily Traffic
**Total traffic count provided by Logan City

Table 4

Other Parameters Used in Asphalt Pavement Design

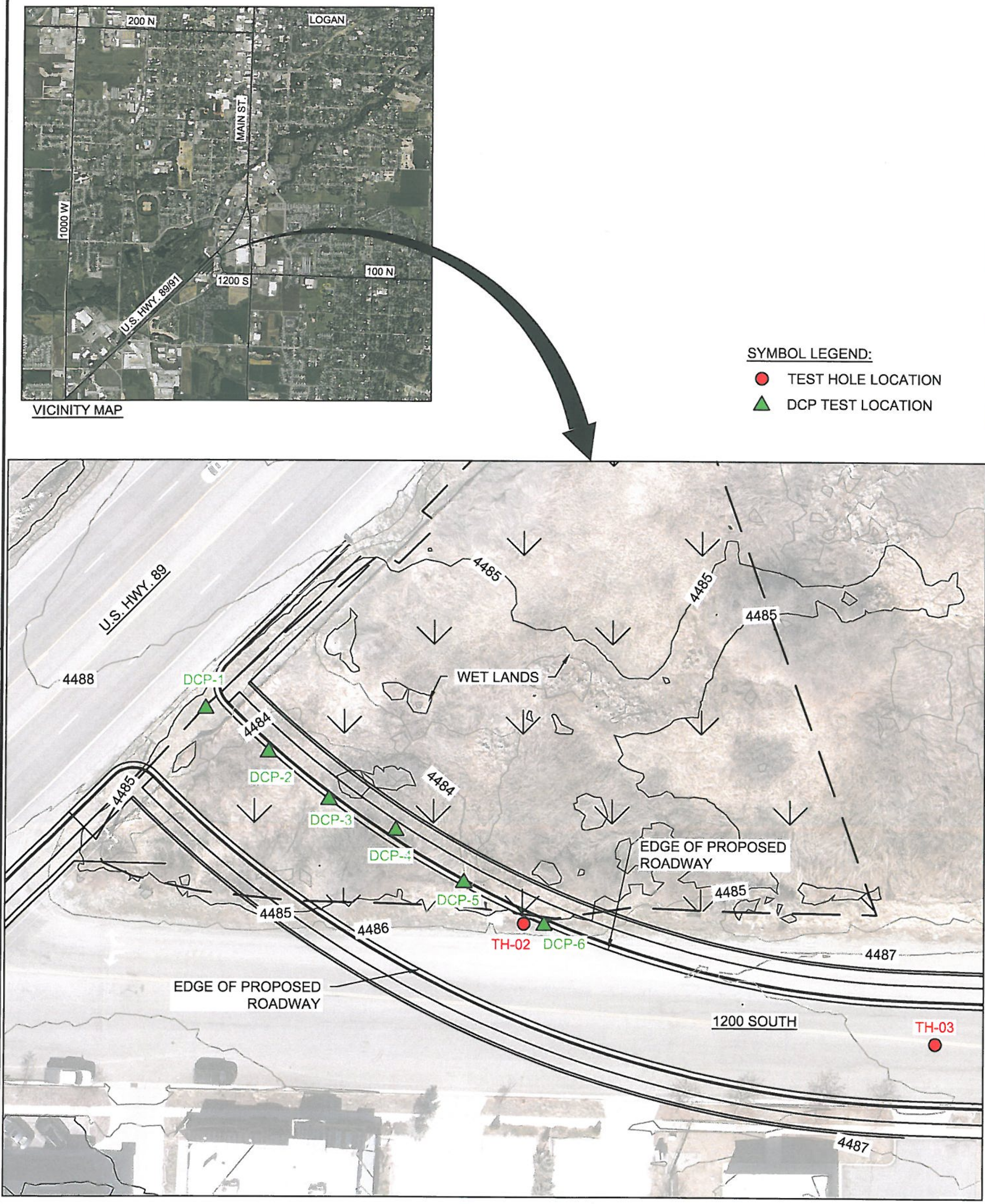
Parameter	Value
Structural Coefficients	
Hot Mix Asphalt	0.40
Untreated Base Course	0.10
Granular Subbase	0.08
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability (%)	90
Overall Standard Deviation	0.45

Table 5

Pavement Section Alternatives

Pavement Option	Section Thickness, in. Hot-Mix Asphalt	Untreated Base Course	Granular Subbase
Hot Mix Asphalt	4.5	18	n/a
Hot Mix Asphalt w/subbase	4.5	6	15
Hot Mix Asphalt w/full frost protection	4.5	21	n/a

Note: All pavement sections include geotextile reinforcement as discussed in this report.



GERHART COLE INC.
GEOTECHNICAL ENGINEERS

1200 SOUTH / US HWY 89-91 INTERSECTION

STUDY LOCATION MAP

N

0 10 25 50 Feet

Figure 1

J:\PROJECTS\Logan City\16GC\673 Pavement Design 1200 S Highway 89-91\Drawings\AutoCAD\WETLANDS IMPACTS FOR TEST HOLES.dwg

Project: 1200 S/Hwy 89-91 Intersection Realignment	Log of Test Hole TH-02
Project Location: Logan, Utah	Sheet 1 of 1
Project Number: 16GCI673	

Date(s) Drilled	2/23/16	Logged By	B. Peterson	Checked By	S. Davis
Drilling Method	H.S.A.	Drill Bit Size/Type	4.25" I.D.	Total Depth Drilled (feet)	25.0 feet
Drill Rig Type	Simco 2800	Drilling Contractor	Jay Apedaile	Hammer Weight/ Drop(lbs/in.)	AUTO
Apparent Groundwater Depth	1'	Latitude / Longitude	41.71037, -111.84105	Ground Surface Elevation (feet)	4491.5
Comments		Test Hole Backfill	Cuttings	Elevation Datum	Utah DEM

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	0						SILT, with sand, soft, moist, dark gray to black, organic odor, elastic, with organics (MH)	
4490			1	2-2-1-2 [3]	24			
			2	2-1-1-1 [2]	17		SAND, with silt, loose, wet, dark gray to black, (SM)	
4485	5		3	5-15-14 -14 [29]	NR			Pushed 3", then refused. Drove SPT. Driller noted it felt like pushing a cobble
			4		9		SAND, gravelly, some silt, loose, wet, dark gray to black, (SP-SM)	
4480	10		5	6-6-2-1 [8]				
			6		25		CLAY, trace sand, soft, wet, dark gray to gray, (CL)	Very soft push
4475	15							
			7	0-1-3-3 [4]	24		- bluish gray to gray, soft transitioning to medium stiff	
4470	20							
			8		27		- transitioning to stiff	
4465	25						Bottom of Test Hole at 25'	
	30							

SOIL TEST HOLE LOGAN PAVE DESIGN TH LOGS.GPJ GERHART.GDT 4/7/16

GERHART COLE INC.
GEOTECHNICAL ENGINEERS

Figure 2

Project: 1200 S/Hwy 89-91 Intersection Realignment	Log of Test Hole TH-03
Project Location: Logan, Utah	
Project Number: 16GCI673	Sheet 1 of 1

Date(s) Drilled	2/23/16	Logged By	B. Peterson	Checked By	S. Davis
Drilling Method	H.S.A.	Drill Bit Size/Type	4.25 I.D.	Total Depth Drilled (feet)	12.0 feet
Drill Rig Type	Simco 2800	Drilling Contractor	Jay Apedaile	Hammer Weight/ Drop(lbs/in.)	AUTO
Apparent Groundwater Depth	5'	Latitude / Longitude	41.71025, -111.84046	Ground Surface Elevation (feet)	4494.8
Comments		Test Hole Backfill	Cuttings	Elevation Datum	Utah DEM

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Sampling Resistance	SAMPLES: Recovery, inches	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	0						ASPHALT (10 inch thickness)	
							GRAVEL, silty with sand, medium dense, moist, brown (GM), (base course, subbase material), (FILL)	
		X	1	20-3-1 [4]	6		SAND, silty, with gravel, loose, moist, orange to orange brown, (SM), (FILL)	Asphalt in sampler
4490	5	X	2	0-1-1-3 [2]	14		SILT, with sand, soft, wet, dark gray to black, some organic material, (ML)	
		X	3	4-5-5-7 [10]	11		GRAVEL, some sand, loose, moist, gray to dark gray, (GP), poorly graded	
4485	10	X	4	3-3-7-11 [10]	13		- some clay	
							Bottom of Test Hole at 12'	
4480	15							
4475	20							
4470	25							
4465	30							

SOIL TEST HOLE LOGAN PAVE DESIGN TH LOGS.GPJ GERHART.GDT 4/6/16

Unified Soil Classification System (USCS)

Material Types	Major Soil Divisions		Group Symbol and Legend	Typical Names
COARSE-GRAINED SOILS >50% retained on No. 200 sieve	GRAVELS >50% of coarse fraction retained on No. 4 Sieve	Clean GRAVELS (little or no fines)	GW	Well-Graded GRAVEL, GRAVEL-sand mixtures, few fines
			GP	Poorly-Graded GRAVEL, GRAVEL-sand mixtures, few fines
		GRAVELS with fines (appreciable amount of fines)	GM	Silty GRAVEL, GRAVEL-sand silt mixtures
			GC	Clayey GRAVEL, GRAVEL-sand clay mixtures
	SANDS >50% of coarse fraction passing the No. 4 sieve	Clean SANDS (little or no fines)	SW	Well-Graded SAND, SAND-gravel mixtures, few fines
			SP	Poorly-Graded SAND, SAND-gravel mixtures, few fines
		SANDS with fines (appreciable amount of fines)	SM	Silty SAND, SAND-silt mixtures
			SC	Clayey SAND, SAND-clay mixtures
FINE-GRAINED SOILS >50% Passing No. 200 Sieve	SILTS and CLAYS liquid limit < 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel	CL	Lean CLAY, Gravelly/Sandy CLAY, low to med. plasticity
			ML	SILT, Gravelly/Sandy SILT, no to slight plasticity
		Organic	OL	Organic CLAY or SILT
	SILTS and CLAYS liquid limit > 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel	CH	Fat CLAY, Gravelly/Sandy Fat CLAY, high plasticity
			MH	Elastic SILT, Gravelly/Sandy Elastic SILT, low to high plasticity
		Organic	OH	Organic CLAY or SILT
Highly organic soils		Primarily Organic Matter; Organic Odor	PT	PEAT
Boulders / Cobbles		> 50% (by volume) particles > 3"	COBBLES BOULDERS	Boulders (>12"); Cobbles (>3" and <12")

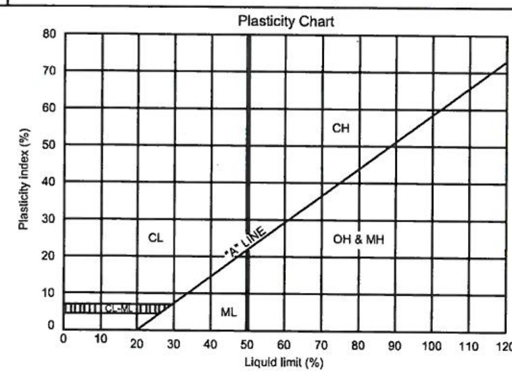
Other Material Symbols

- Bedrock
- Asphalt
- Concrete
- Topsoil
- Fill

Sample Types

- Auger Cuttings
- Continuous sampler
- Grab Sample
- No Recovery
- Shelby Tube
- Standard Penetration Test (SPT)
- California Sampler
- Rock Core
- Modified California Sampler
- Other (see remarks)
- Piston Sampler (Shelby Tube)
- Vane Shear

Apparent water level   Measured water level



Descriptors for Coarse Grained Soils

Apparent Density	Dr (%)	SPT	MC	CAL
Very Loose	0-15	<4	<6	<8
Loose	15-35	4-10	6-15	8-20
Med. Dense	35-65	10-30	15-42	20-56
Dense	65-85	30-50	42-72	56-96
Very Dense	85-100	>50	>72	>96

Descriptors for Fine Grained Soils

Consistency	Su (psf)	SPT	MC	CAL
Very Soft	< 250	<2	<2	<2
Soft	250-500	2-4	2-4	2-5
Med. Stiff	500-1000	4-8	4-10	5-11
Stiff	1000-2000	8-15	10-19	11-22
Very Stiff	2000-4000	15-30	19-37	22-45
Hard	>4000	>30	>37	>45

SPT - Standard split spoon (SPT): 2" OD, 1.375" ID
MC - Modified California: 2.5" OD, 1.875" ID
CAL - California: 3" OD, 2.375" ID

Stratification

Description	Criteria
Seam	1/16" to 1/2"
Layer	1/2" to 12"
Occasional	<= 1 per ft. thickness
Frequent	> 1 per ft. thickness

Modifiers

Description	Est. (%)
Trace	<5
Some	5-12
With	12-30
-ly	>30

Descriptors for Moisture

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Descriptors for Particle Size

Description	Criteria
Boulder	>12" : larger than a basketball
Cobble	3-12" : larger than a grapefruit
Coarse Gravel	3/4-3" : larger than a grape
Fine Gravel	No.4-3/4" : larger than a pea
Coarse Sand	No.10-4 : larger than a rock salt grain
Medium Sand	No.40-10 : larger than window screen opening
Fine Sand	No.200-40 : larger than a sugar grain

Descriptios for Particle Angularity

Description	Criteria
Angular	Sharp edges, rel. plane sides, unpolished surface
Subangular	Similar to angular, but with rounded edges
Subrounded	Nearly plane sides, well-rounded corners & edges
Rounded	Smoothly curved sides and no edges

Abbreviated Soil Classification Symbols (after ASTM D2488 X.5)

Prefix	Suffix
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

Abbreviated system for supplementary presentations when complete description is referenced. Examples:

Group Symbol and Full Name	Abbreviated
Sandy Lean CLAY	s(CL)
Poorly Graded SAND with silt and gravel	(SP-SM)g
Poorly Graded Gravel with sand, cobbles, and boulders	(GP)scb
Gravelly SILT with sand and cobbles	g(ML)sc

General Notes:

1) Stratigraphic lines on the logs represent approximate boundaries.
2) No warranty is provided as to the continuity of soil conditions beyond or between points explored and sample locations.
3) Logs represent soil conditions observed at the point of exploration on the date indicated.
4) Visual methods were used to classify the materials in general accordance with Unified Soil Classification System; actual designations based on laboratory methods may vary.

GERHART COLE INC.
GEOTECHNICAL ENGINEERS

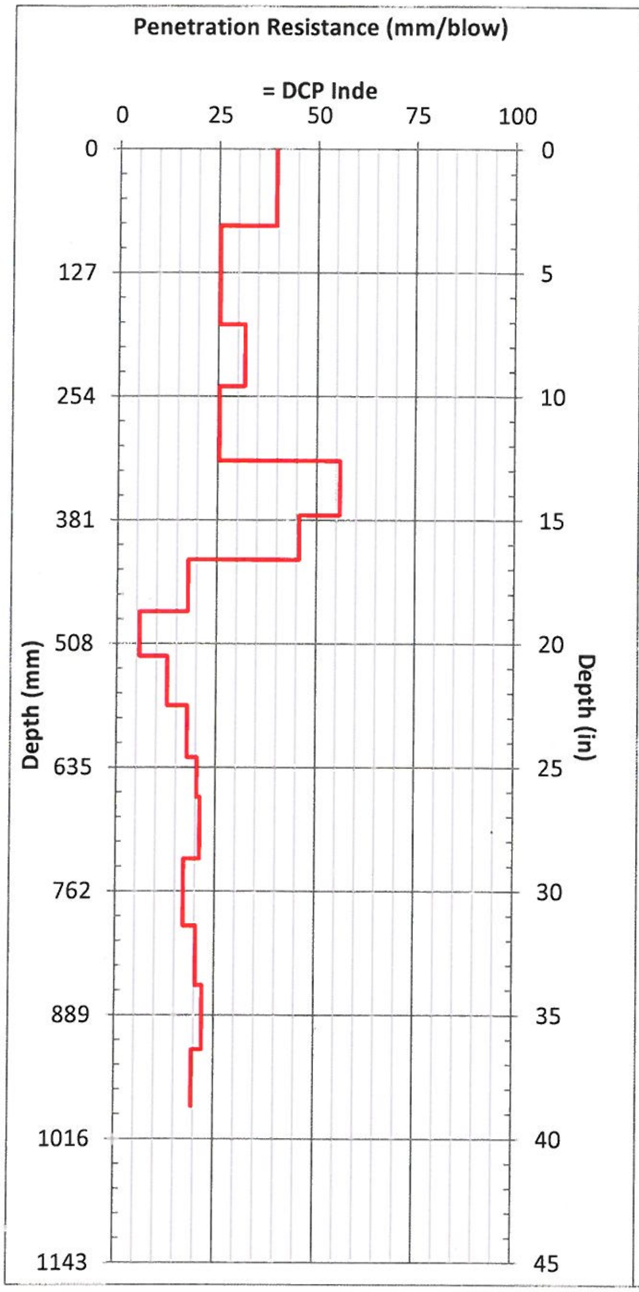
Legend to Soil Descriptions

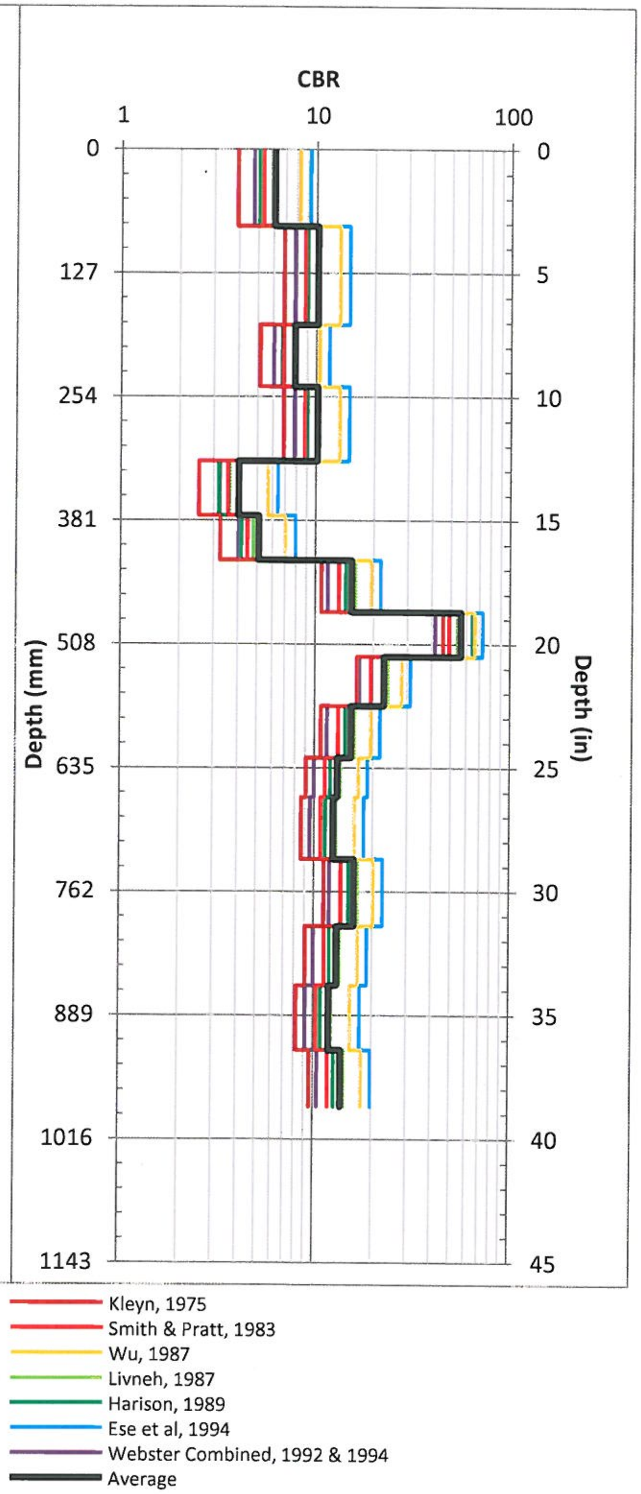
Figure 4

DCP Test Summary

GERHART COLE INC.
GEOTECHNICAL ENGINEERS

Project Name: Pavement Design 1200 S/Hwy 89-91
Project Number: 16GCI673
Location ID: DCP-1
Location: Lat: 41.71059 Long: -111.84157
Date: February 24, 2016

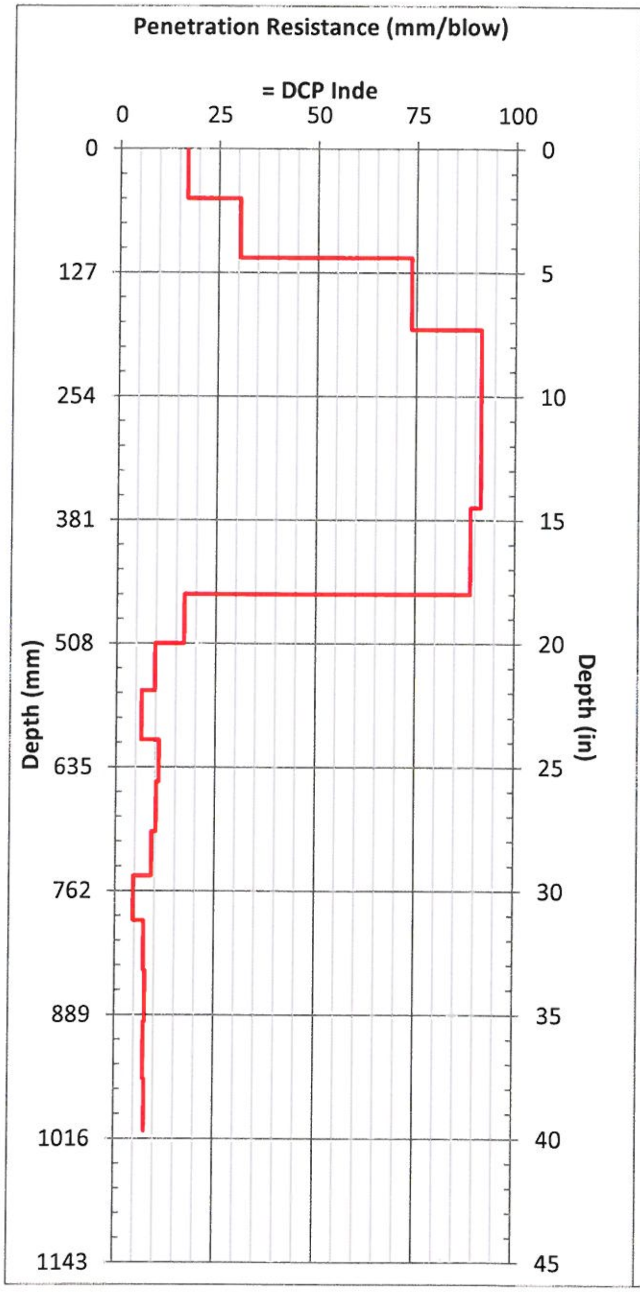


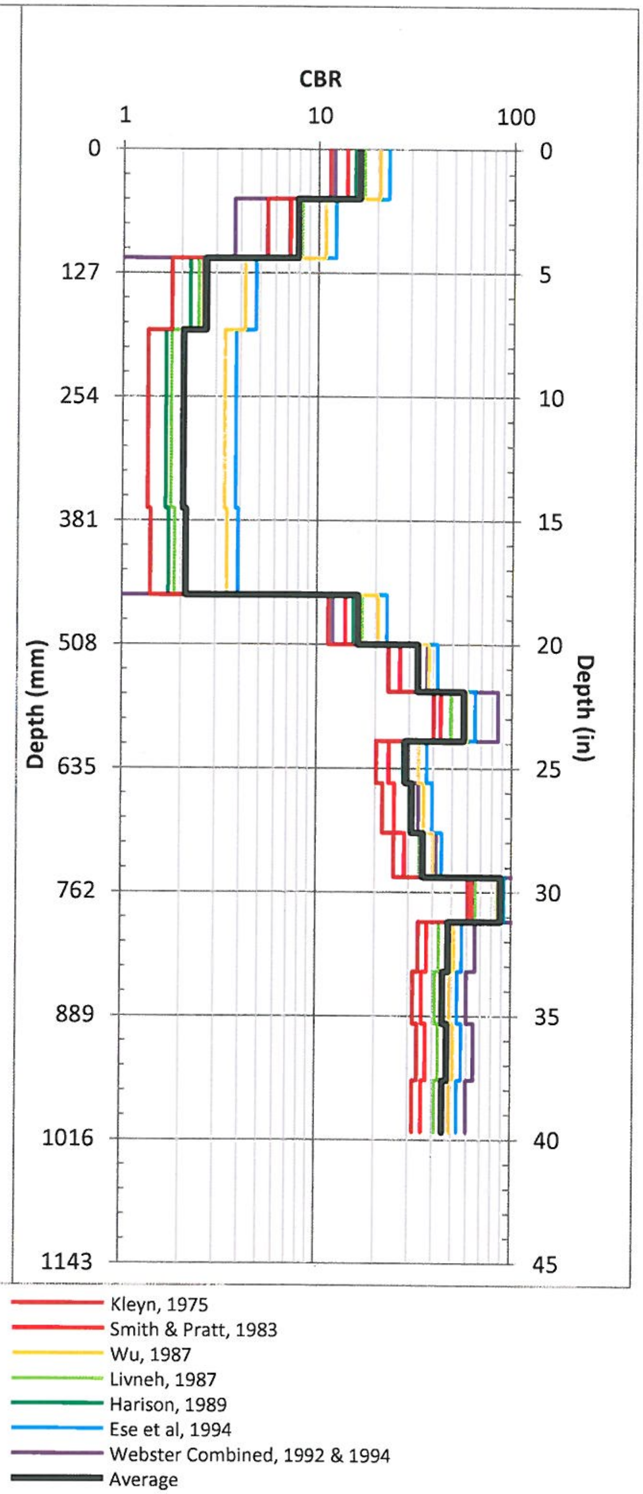


Note: CBR values based on in-situ conditions

DCP Test Summary

Project Name: Pavement Design 1200 S/Hwy 89-91
Project Number: 16GCI673
Location ID: DCP-2
Location: Lat: 41.71055 Long: -111.84147
Date: February 24, 2016



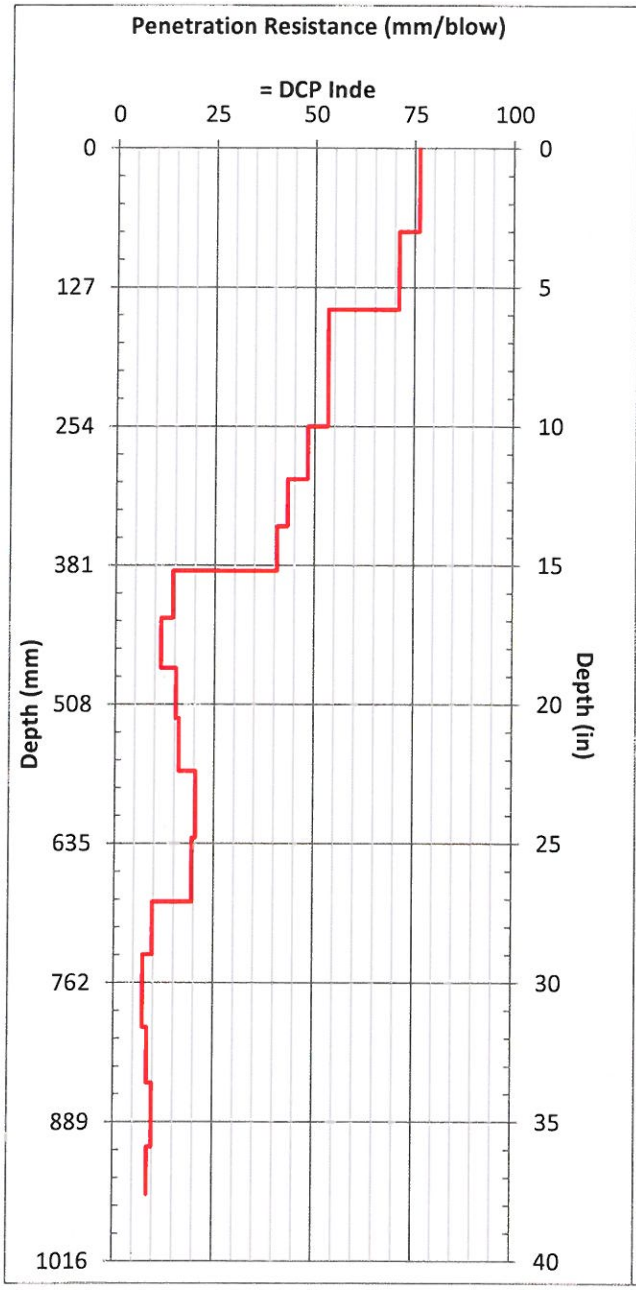


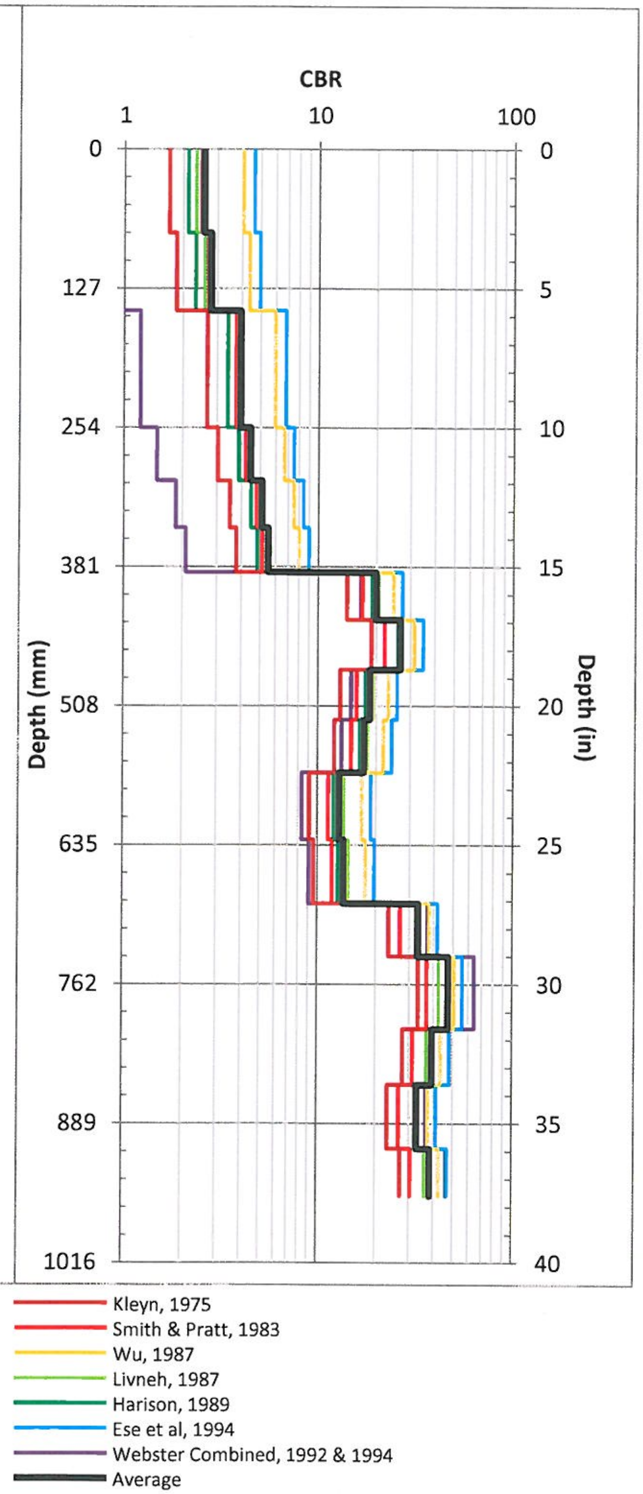
Note: CBR values based on in-situ conditions

DCP Test Summary

GERHART COLE INC.
GEOTECHNICAL ENGINEERS

Project Name:	Pavement Design 1200 S/Hwy 89-91
Project Number:	16GCI673
Location ID:	DCP-3
Location:	Lat: 41.71050 Long: -111.84136
Date:	February 24, 2016

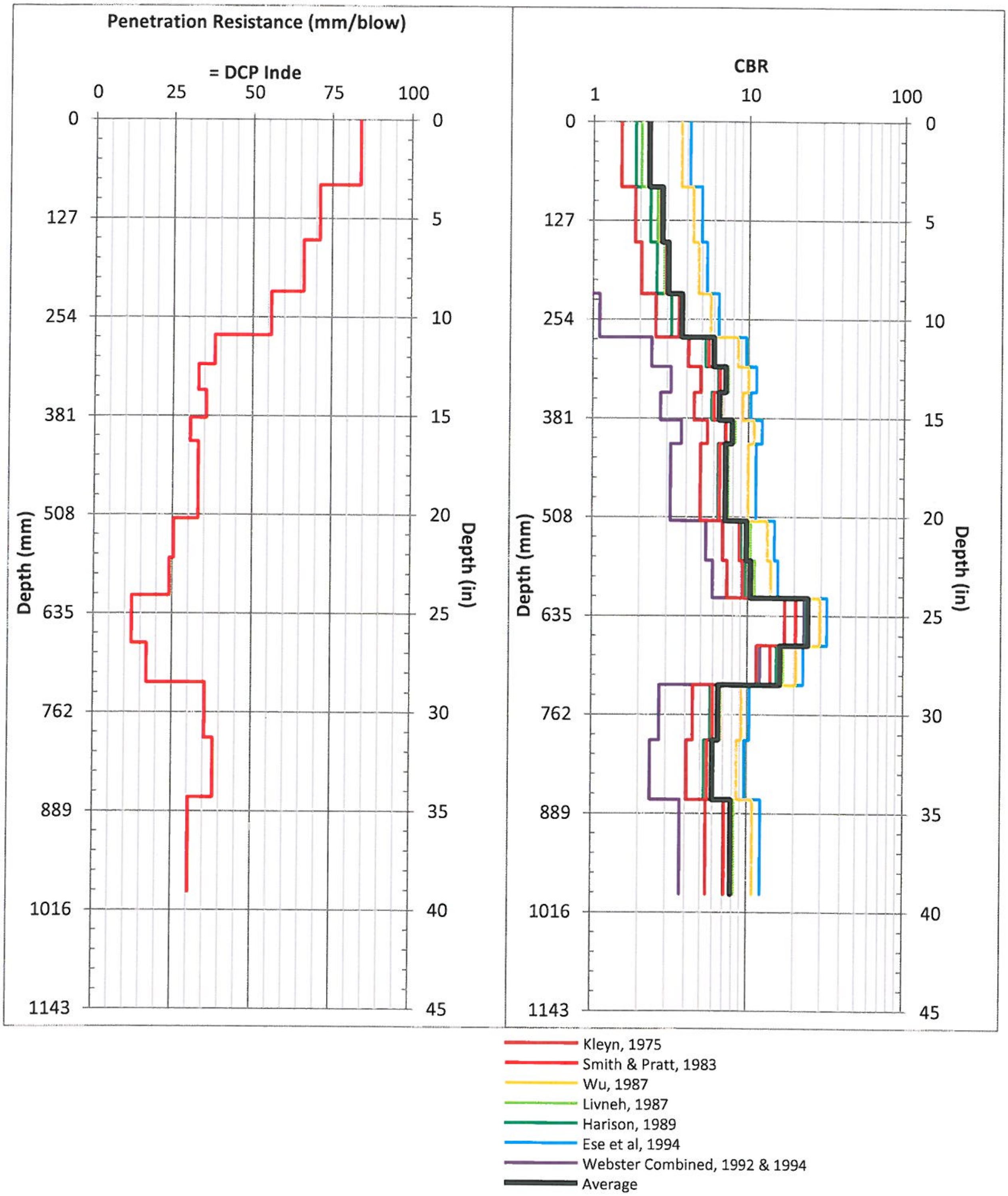




Note: CBR values based on in-situ conditions

DCP Test Summary

Project Name: Pavement Design 1200 S/Hwy 89-91
Project Number: 16GCI673
Location ID: DCP-4
Location: Lat: 41.71046 Long: -111.84126
Date: February 24, 2016

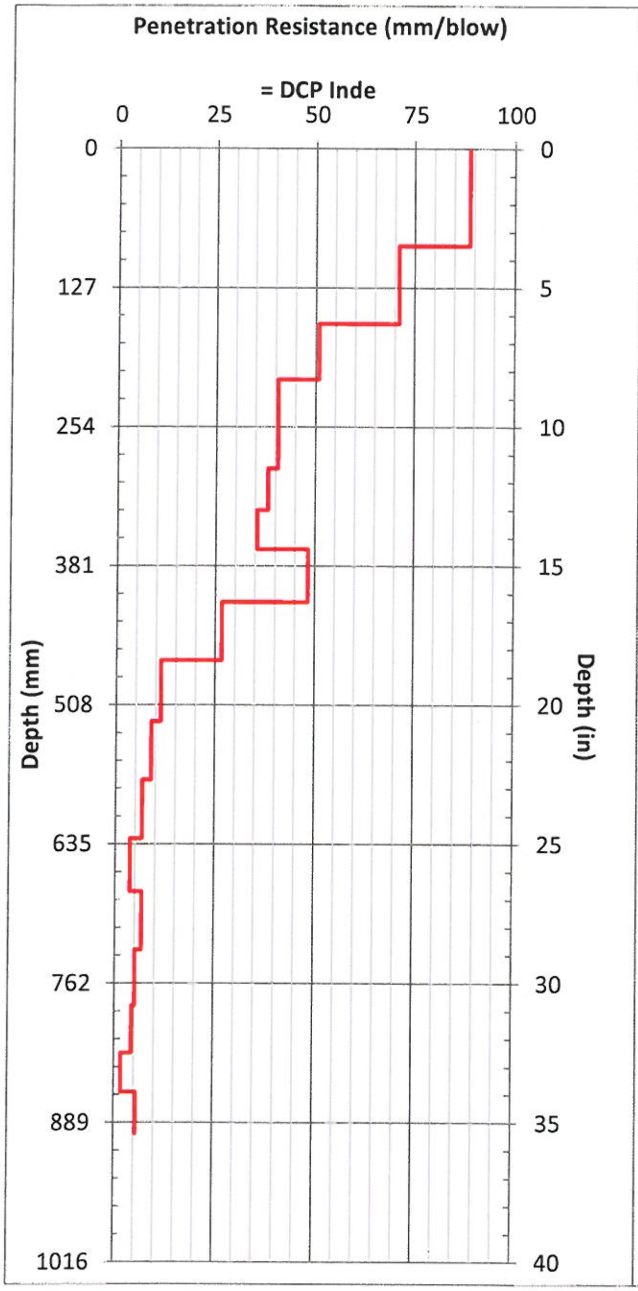


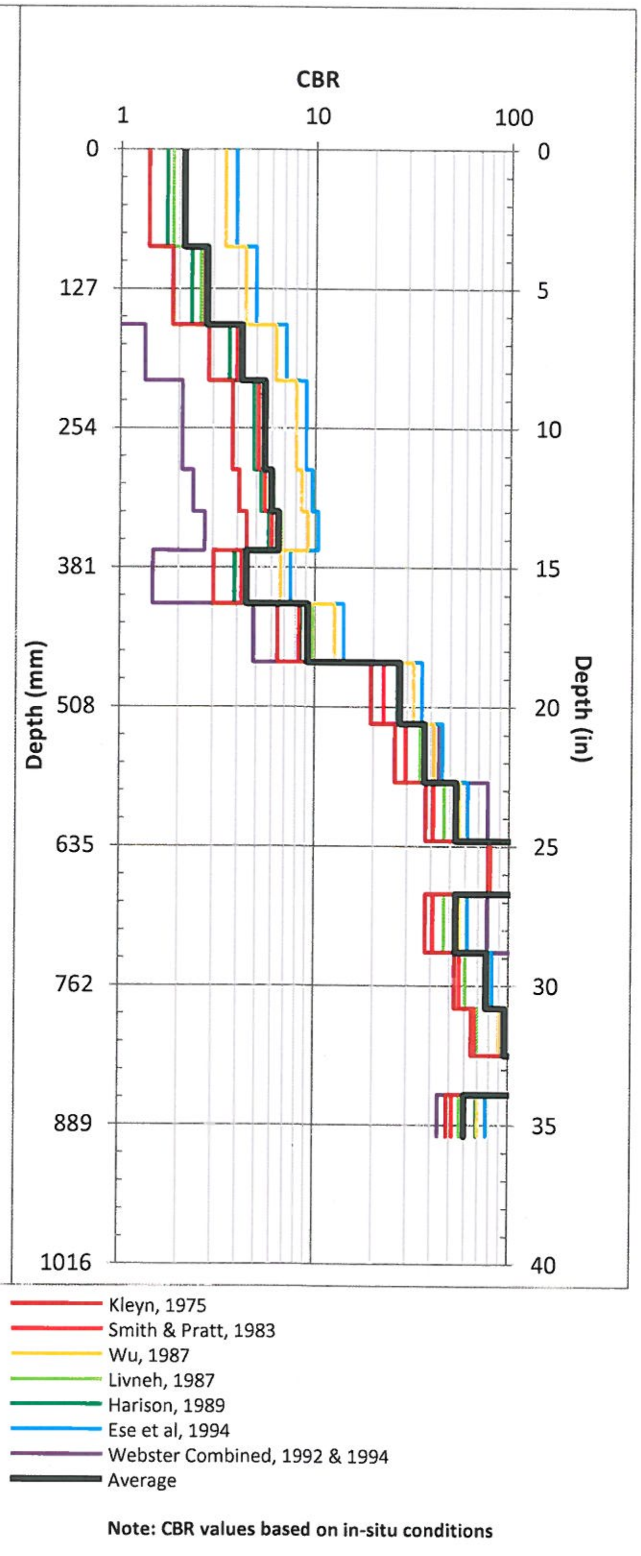
Note: CBR values based on in-situ conditions

DCP Test Summary

GERHART COLE INC.
GEOTECHNICAL ENGINEERS

Project Name:	Pavement Design 1200 S/Hwy 89-91
Project Number:	16GCI673
Location ID:	DCP-5
Location:	Lat: 41.71041 Long: -111.84115
Date:	February 24, 2016



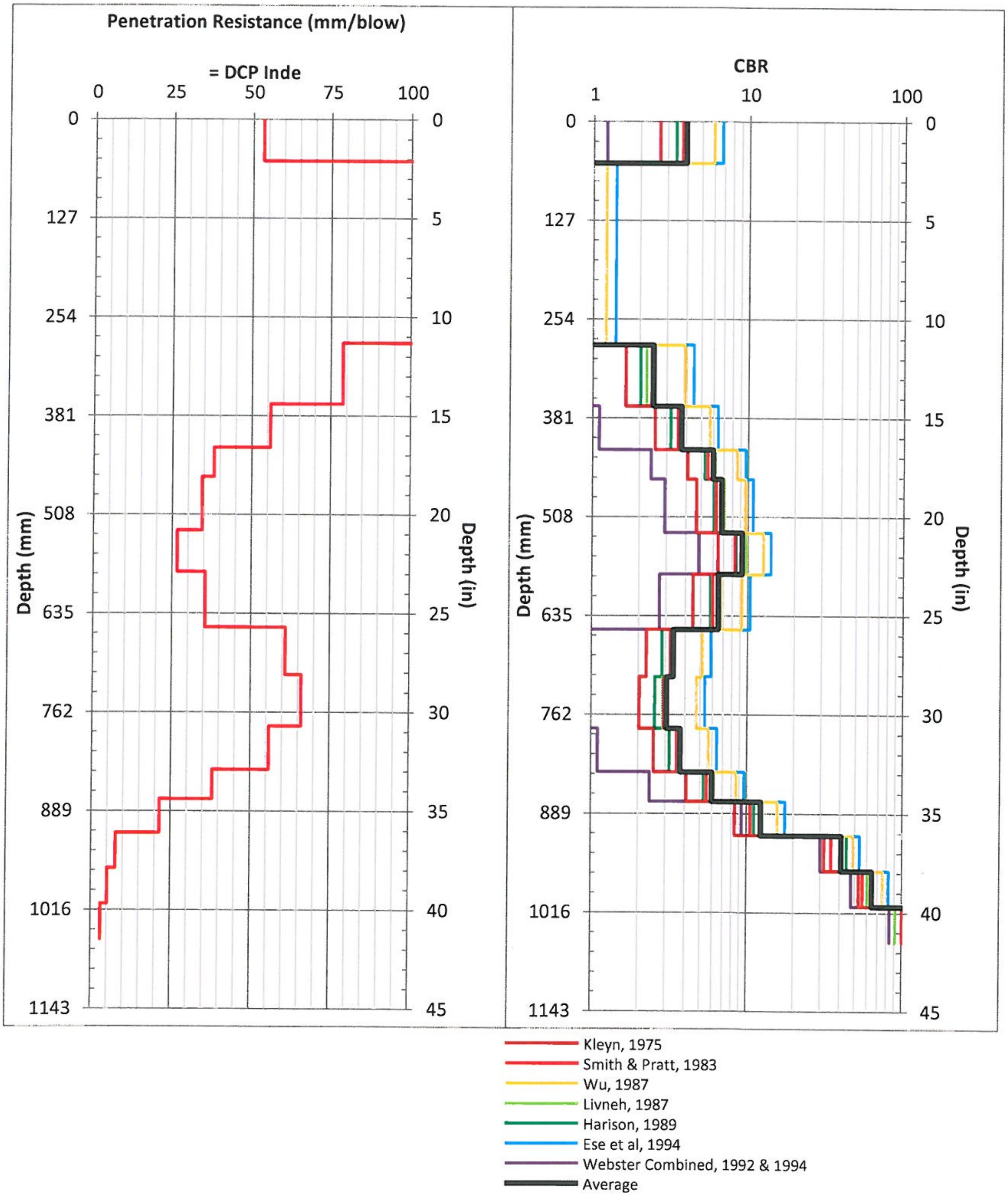


Note: CBR values based on in-situ conditions

DCP Test Summary

GERHART COLE INC.
GEOTECHNICAL ENGINEERS

Project Name:	Pavement Design 1200 S/Hwy 89-91
Project Number:	16GCI673
Location ID:	DCP-6
Location:	Lat: 41.71037 Long: -111.84105
Date:	February 24, 2016



Note: CBR values based on in-situ conditions