LA SAL MOUNTAIN LOOP ROAD

MINERS BASIN AND MILL CREEK SEGMENTS

UT PFH 46-1(2)

FINAL GEOTECHNICAL REPORT

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SECTION ONE--INTRODUCTION

This report presents the results of the geotechnical engineering study conducted for the La Sal Mountain Loop Road, UT PFH 46-1(2), project. The project involves improvements to select locations of Forest Highway 46 (UT FH 46), referred to as La Sal Mountain Loop Road and County Route 1704 (CR-1704). La Sal Mountain Loop Road is 36.4 miles long from the intersection of Highway 191 and Old Airport Road to the intersection of Highway 128 and Mountain Loop Road/ Castleton Road, as shown on Figure A1, Vicinity Map. The route is characterized as a narrow two-lane road with switch-backs and steep grades that navigates mountainous terrain from an elevation of 4,080 feet to 8,320 feet.

Four segments along the route have been selected for improvements and are referred to as Miners Basin, Mill Creek, Ken's Lake, and Castle Valley. Miners Basin and Mill Creek segments require sections of reconstruction and are addressed in this report. Ken's Lake and Castle Valley segments consist of rehabilitation and are not discussed in this report. Both Miners Basin and Mill Creek segments are located entirely with the Manti-La Sal National Forest but are maintained by Grand and San Juan Counties, respectively. The general locations of the Miners Basin and Mill Creek Segments with respect to major topographic features are shown on Figures A2 and A3, Area Map, respectively. The rehabilitation and reconstruction of the roadway segments are designed to improve roadway geometry, replace deficient structures, improve roadway safety, and improve drainage issues.

1.1 OBJECTIVE AND SCOPE

The objectives of this study were to develop recommendations concerning structure foundations, retaining structures, embankments, cut slopes, subsurface drainage, corrosion potential, geologic hazards, material shrink/swell, and construction considerations. In accomplishing these objectives, the scope of work included field exploration, laboratory testing, correlation of available data, and engineering analysis. The field exploration included subsurface exploration and site reconnaissance.

1.2 PROPOSED CONSTRUCTION

Central Federal Lands Highway Division (CFLHD) cross-functional team and partnering agencies on the project (Grand County, San Juan County, and the Manti-La Sal National Forest) determined that reconstruction of the roadway in the Miners Basin segment will include roadway widening and minor realignment requiring the expansion of existing cut slopes and the installation of a box culvert requiring a grade raise with new embankments. Reconstruction of Mill Creek will include the use of shoulder stabilization, Reinforced Soil Slopes (RSS) and Mechanically Stabilized Earth (MSE) walls to widen the roadway and add a parking lane with minimal disturbance to the existing cut slopes. The roadways at Miners Basin and Mill Creek will also require drainage structures, safety improvements, and the construction of a new pavement surface.

Both Miners Basin and Mill Creek have portions designated as 3R (resurfacing, restoration and rehabilitation) and 4R (reconstruction) construction. 3R construction includes shoulder widening, superelevation corrections, slight corrections to roadway grade and a new pavement surface. 4R construction entails major changes to roadway alignment and grade, roadway widening and installation of structures such as MSE walls and box culverts. Detailed layouts of the proposed roadways with respect to existing roadways and site topography based on the 70% design plans, along with boring locations completed for this study, are presented on Figures A4 through A11, Boring Location Map.

1.2.1 Miners Basin

The proposed construction at Miners Basin is approximately 1.46 miles in length with 0.42 miles designated as a 3R from Station 100+00 to Station 122+10 and 1.04 miles as 4R construction from Station 122+10 to the end of the segment at Station 177+00. The installation of a box culvert is proposed at Station 126+50 to better pass debris flow events and will require the roadway grade to be raised approximately 5 feet from the existing grade. To achieve appropriate roadway bench for the proposed 10 foot lanes and 1 foot shoulders, expansion of existing cut slopes is required from Station 153+00 to the end of the segment at Station 177+00. Other items consist of ditch conditioning, crest rounding of existing cuts, slope scaling, and corrugated metal pipe (CMP) replacement.

1.2.2 Mill Creek

The proposed construction at Mill Creek is approximately 0.66 miles with 0.06 miles designated as 3R from Station 200+00 to Station 203+00 and 0.6 miles as 4R construction from Station 203+00 to the end of the segment at Station 234+42. Reconstruction of Mill Creek will include the use of a proposed 447 foot long MSE wall from Station 203+20 to Station 207+60 with maximum wall height of approximately 10 feet at Station 207+10. A second MSE wall, approximately 257 feet long with a 16 foot maximum height at Station 218+10, is proposed from Station 216+02 to 218+59 to provide a parking lane. Other items consist of ditch conditioning, expanding existing cut slopes, RSS, shoulder stabilization, CMP replacement, and subsurface drainage improvement.

1.3 SITE CONDITIONS

The Miners Basin and Mill Creek segments are located in undeveloped forested terrain within the La Sal Mountain Range. The regional topography slopes to the southwest from an elevation of 12,721 feet at Mount Peale to the City of Moab, on the Colorado Plateau at an elevation of 4,025 feet. The region containing gullies, canyons, cliffs, debris fans, landslides, and areas of relatively steep terrain. The La Sal Mountain Loop Road consists of a winding two-lane roadway with sharp curves and variable widths climbing steeply from the desert environment to an alpine mountain environment. Arid climatic conditions are present in the lower elevations of

and seasonally wet areas typical of mountainous regions are present in the higher elevations. Generally, the roadway was constructed utilizing steep cut and fill shoulder treatments with limited ditch width. Raveling of cut slopes, slumps, and debris flows have occurred along the roadway requiring re-grading or retaining wall construction. Maintenance of the roadway requires constant attention.

1.3.1 Miners Basin

The Miners Basin segment has an average roadway width of 18 feet and crosses hummocky alluvial fan deposits and steep colluvial slopes. The area was previously forested with a mixture of Gambel Oak, Douglas Fir, Juniper and Aspen trees but was burned during the 2008 Porcupine Ranch Fire and is slowly reestablishing. Located at an elevation between 7,600 feet and 7,890 feet, the Miners Basin segment climatic conditions are closely related to arid/mountainous conditions and are subject to seasonal precipitation. Due to loss of vegetation during the 2008 fire, the susceptibility of slope erosion has increased and was likely the cause of the debris flow that filled the drainage channel and covered the roadway at Station 126+50 in August of 2010.

Steep cut and fill slopes consistent with sidecast construction techniques are evident from Stations 153+00 to the end of the segment at station 177+00. Existing cut slopes extend to a height of approximately 25 feet and show evidence of continuous raveling and are typically not vegetated. Cut slopes in soil vary between 35 and 45 degrees and cut slopes in weathered bedrock range from 55 to 65, degrees while naturally occurring slopes are typically found between 25 and 35 degrees. Fill slopes are typically less than 30 feet in height and embanked at an angle not exceeding 45 degrees.

1.3.2 Mill Creek

The Mill Creek segment has an average roadway width of 17 feet and contains seeps and springs in the slopes above the roadway that have caused slope instability and pavement deterioration. The area contains two existing solider pile and lagging walls assumed to be supporting unstable cut slopes. Located at an elevation between 7,735 feet and 7,960 feet, the Mill Creek segment resides in semi-arid/mountainous conditions with seasonal precipitation. The vegetation consists of Willow, Red Osier, Dogwood, Rush, Wood's Rose, Boxelder, Larger vegetation such as Douglas Fir, Gambel Oak, and Aspen trees are also found at the site

Steep cut and fill slopes consistent with sidecast construction techniques are evident with typical cut heights between 10 and 15 feet at slopes between 30 and 50 degrees. Fill slopes are of similar heights and dimension. Naturally occurring slopes are typically found between 25 and 35 degrees. Near vertical slopes exist at the south end of the site where resistant sandstone bedrock is exposed.

SECTION TWO--GEOLOGY AND SEISMICITY

2.1 REGIONAL GEOLOGY

The La Sal Mountain Loop Road lies within the Colorado Plateau geologic province. The Colorado Plateau is primarily characterized by sedimentary rocks forming iron-stained plateaus, canyons and rivers and extends throughout most of the land between AZ, NM, CO, UT (four corners region). The province is named after the Colorado River and its main tributaries drain most of the region.

The La Sal Mountains are a cluster of Tertiary intrusions of igneous rocks within the Colorado Plateau, about 35 million years old. These clusters are referred to as laccoliths which have domed the older sedimentary rocks of the Permian, Triassic, Jurassic, and Cretaceous time periods. The sedimentary rocks were pushed upward by the rising masses of magma creating an uplift mountain building event. Increased erosion rates from the uplift have now eroded away the majority of the sedimentary units from the upper reaches of the La Sal Mountains, but they still remain on the lower flanks and in irregular rings around the intrusions. The exposed igneous formations generally consist of gray, coarsely crystallized diorite and rhyolite.

The Miners Basin segment is generally underlain by exposed igneous bedrock of rhyolite and much younger Quaternary colluvium and alluvial fan deposits. The Mill Creek segment is generally underlain by the sedimentary Morrison Formation and boarders Quaternary colluvium and slide deposits. Geologic units adjacent to Miners Basin and Mill Creek segments are discussed in Section 2.2, Site Geology. Illustrated geology at Miners Basin and Mill Creek segments are displayed in Figure A12, Geology of Miners Basin and Mill Creek.

2.2 SITE GEOLOGY

2.2.1 Miners Basin

Bedrock beneath Miners Basin is mapped as "Middle Tertiary-age (28 to 25 million years old) La Sal Mountains Intrusive Rocks," as shown on "*Geologic Map of the Moab and Eastern Part of the San Rafael Desert 30' x 60' Quadrangles, Grand and Emerys Counties, Utah, and Mesa County, Colorado*" compiled by Hellmut H. Doelling in 2002. The La Sal Mountain intrusive rocks are overlain by surfical deposits of Late Quaternary-age (11,500 years old to present) talus and colluviums, as well as alluvial fan deposits. The La Sal Mountain intrusive rocks are generally comprised of Hornblende-plagioclase trachyte, quartz-plagioclase trachyte, peralkaline trachyte, and peralkaline rhyolite, all porphyritic with fine-grained ground mass.

The talus and colluviums originated from the La Sal Mountain intrusive rocks as a product of weathering and are generally comprised of rockfall blocks, smaller angular gravel, sand and silt with an estimated average thickness of 15 feet. Alluvial fan deposits, with an estimated average thickness of 50 feet in depth, overlie La Sal Mountain intrusive rocks in the broad valley at Miners Basin. These alluvial fan deposits are poorly sorted, angular to subrounded gravels, containing cobbles and sparse boulders.

2.2.2 Mill Creek

Bedrock underlying the Mill Creek segment belongs to the "Upper Jurassic-age (~161.2 to 145.5 million years old) Morrison Formation" according to the "*Geologic Map of the La Sal 30' x 60' Quadrangles, San Juan, Wayne, and Garfield Counties, Utah, and Montrose and San Miguel Counties, Colorado*" compiled by Hellmut H. Doelling in 2004. Quaternary age (11,500 years old to present) slumps and slides are mapped as overlying the Morrison Formation on the slopes above the roadway.

The Morison Formation in the project area is comprised of two members; the Saltwash and Tidwell Members. The Saltwash Member is comprised of interbedded lenses of light-brown, white, yellow-gray, and very-pale-orange sandstone and medium red-brown and green-gray siltstone and mudstone. Local minor gray limestone and conglomeritic sandstone are present, (Doelling, 2004). Underlying the Saltwash member is the Tidwell Member. The Tidwell Member is 10 to 50 feet thick and, as described by Doelling, 2004, is a red-brown, fine grained calcareous silty sandstone with light-gray mottling in undulating thin beds. Limestone is present with accompanying red and white chert.

Slumps and landslides mapped above the roadway are described by Deolling, 2004, as irregular hummock deposits of rotated and slumped material made up of small to large blocks of sandstone cobbles and boulders within a matrix of clayey and silty material.

2.3 GEOLOGIC HAZARDS

Geologic hazards exist from both the natural environment of the project sites and from existing and proposed construction of the roadway. Geologic hazards that exist in the vicinity of the project areas are rock fall, avalanches, highly erodible granular soils, debris flows, slope instability at cut and fill slope locations, and seismic events. Variability of the geologic profile and groundwater conditions found at the sites increase the risk of failure of cut and fill slopes. Cut slope failures and rock fall, in particular, are likely to occur during construction at both sites. Debris flows are possible in many of the cross drainages in the Miners Basin segment during periods of high precipitation. The risk is particularly high during the summer monsoon season and in the wet winter and early spring months.

2.4 SEISMICITY

There are no known active or potentially active major faults within the local region of the Burn Area or Wet Area. The major fault zones within a 40-mile range to the project location are the Castle Valley faults, Fisher Valley faults; Granite Creek fault zone, Little Dolores River fault, Moab fault and deformation zones, Ryan Creek fault zone, Salt and Cache Valleys faults, Sand Flat graben faults, Sinbad Valley graben, and Ten Mile graben faults. These faults have a slip-rate of less than 0.2 millimeters per year and vary in length from 7.5 miles, as seen in the Castle Valley faults, to 42 miles in the Moab fault and deformation zones. The overall trend of the faults within 40 miles of the project location is Northwest by Southeast.

2.5 SEISMIC DESIGN PARAMETERS

The American Association of State Highway and Transportation Officials (AASHTO) criteria for seismic design of structures, allows for damage to occur when the structure is subjected to 1000-year strong ground motion, but does not allow for collapses and loss of life. AASHTO requires structures to withstand small, more frequent earthquakes without damage. For Extreme Event I Limit State Design an earthquake load and resistance factor of 1.00 should be used during the LRFD design of the bridge structure.

Recommended seismic response parameters for the La Sal Mountain Loop Road design are based on the (AASHTO) LRFD Bridge Design Specifications, 5th edition, 2010, and represents horizontal peak ground acceleration (PGA) with 7 percent probability of exceedance in 75 years (approximate 1000-year return period). The 1000-year return period uniform hazard spectrum for the La Sal Mountain Mill Creek segment MSE site located at 38.4943º N latitude and -109.3113º W longitudinal, was obtained in accordance with the AASHTO ground motion maps for the probabilistic horizontal acceleration values corresponding to specific peak ground acceleration (PGA) and the spectral coefficients, namely the short- and long- period ground acceleration (S_s and S_1 respectively) and corrected for the soil profile at the MSE wall site.

Ground motions caused by earthquakes are influenced not only by the distance from the fault planes, but also by the geology and soils found at the site. Subsurface profiles similar to the ones at Mill Creek, with soil layers overlaying bedrock that significantly differ in stiffness and density will have amplified ground motions and a resonant period governed by the layer thickness and shear wave velocity of the materials. The damage potential of strong ground motions with respect to a structure is typically affected by the period of the strong earthquake motion and the resonant period of both the soil and the structure. Based on the subsurface profile at the Mill Creek segment, the average time-weighted shear wave velocity for the top 100 feet (V_{S100}) of subsurface materials was estimated between 1,200 and 2,000 feet per second. Therefore, the site soils are classified as *Class C* according to the site class definitions specified in Table 3.10.3.1-1 of AASHTO.

A seismic hazard analysis to establish ground motions for seismic design was conducted. The recommended spectral acceleration coefficient values for probabilistic design with a return period of 1000 years were calculated using the program provided with the AASHTO LRFD Bridge Design Specifications Manual developed by the USGS (2008) entitled "Seismic Design Parameters", version 2.10 and are summarized in Table 1, Summary of Seismic Parameters Corrected for Class C Soils.

TABLE 1:- Summary of Seismic Parameters Corrected for Class C Soil

Horizontal Peak Ground Acceleration, (A_s)	0.072g
Horizontal Response Spectral Acceleration at Period of 0.2 sec, (SD_s)	0.159g
Horizontal Response Spectral Acceleration at Period of 1.0 sec, (SD_1)	0.066g
Site Factor at Zero-Period of Acceleration Spectrum, (F_{pga})	1.20
Site Factor at Short-Period Range of Acceleration Spectrum, (F_a)	1.20
Site Factor at Long-Period Range of Acceleration Spectrum, (F_v)	1.70

The 5% damped design response spectrum for Class C soils is shown in Figure 1, Design Response Spectrum Corrected for Class C Soils, and the supporting data is presented in Table 2, Summary of Design Response Spectrum Data for Class C Soils.

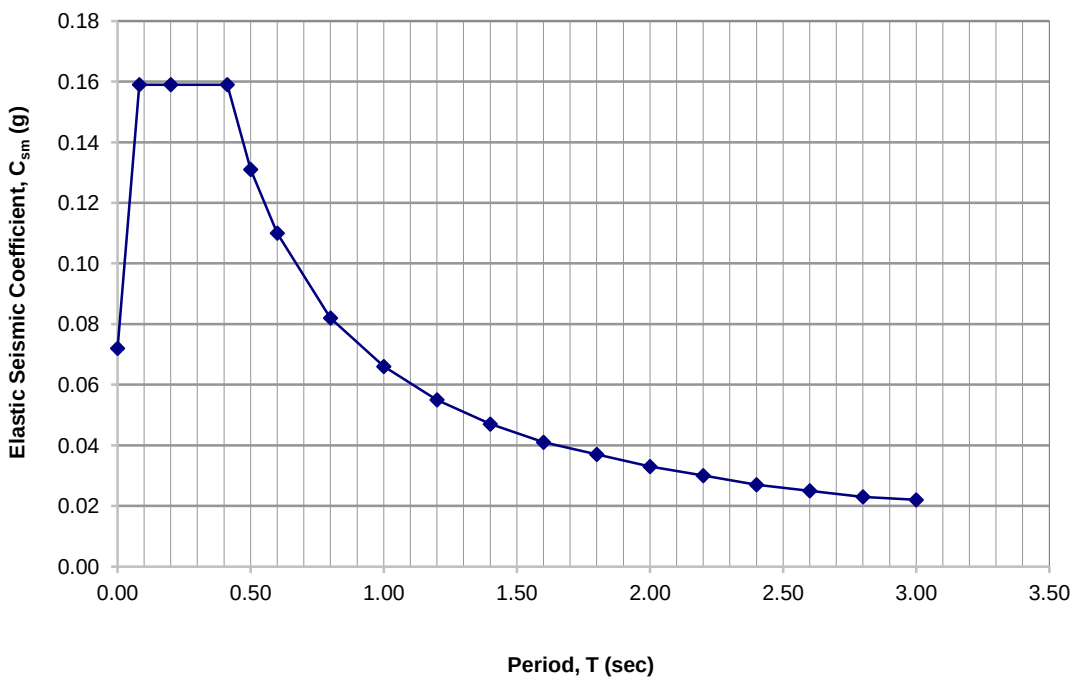

FIGURE 1:- Design Response Spectrum Corrected for Class C Soil

TABLE 2:- Summary of Design Response Spectrum Data for Class C Soil

Period (sec)	Sa (g)	Sd (in)	
0.00	0.072	0.000	$(PGA)(F_{pga}) = A_s$
0.08	0.159	0.011	
0.20	0.159	0.062	$(S_s)(F_a) = SD_s$
0.41	0.159	0.265	
0.50	0.131	0.321	
0.60	0.110	0.385	
0.80	0.082	0.514	
1.00	0.066	0.642	$(S_1)(F_v) = SD_1$
1.20	0.055	0.771	
1.40	0.047	0.899	
1.60	0.041	1.028	
1.80	0.037	1.156	
2.00	0.033	1.285	
2.20	0.030	1.413	
2.40	0.027	1.542	
2.60	0.025	1.670	
2.80	0.023	1.799	
3.00	0.022	1.927	

Based on the long acceleration coefficient SD_1 value of 0.066g calculated as $F_v.S_1$, the MSE site is assigned to seismic hazard ***Zone 1*** according to Table 3.10.6-1 in AASHTO. Seismic hazard zones reflect the variation in seismic risk in different regions needing different requirements for design as depicted in Table 4.7.4.3.1-1 in AASHTO. While the soil class, seismic parameters and hazard zone was developed for the MSE walls within the Mill Creek segment, these values are conservative for design of the box culvert in the Miners Basin Segment.

The uniform hazard spectrum presented above is most commonly used for seismic design of ordinary structures and is developed based on representative earthquake magnitudes for the region. In high seismic zone areas, a detailed evaluation of individual magnitude and distance of earthquakes most contributing to the seismic hazard spectrum known as *"deaggregation"* may be performed for each spectral period on the uniform hazard spectrum. Deaggregation was not performed for this project but the deaggregation hazard data for the PGA and the S_1 values based on the USGS 2002 records can be obtained from https://geohazards.usgs.gov/deaggint/2002/.

SECTION THREE--SUBSURFACE INVESTIGATION

3.1 FIELD EXPLORATION

A field exploration program was conducted July 19 through July 21, 2010, to obtain subsurface profiles of the materials and conditions. Seven borings, labeled B-1 through B-7, were advanced at the Miners Basin segment and eight borings, labeled B-8 through B-15, were advanced in the Mill Creek segment to depths ranging from 7.0 to 29.5 feet. Boring locations completed for this study are summarized in Table 3, Summary of Borings, and presented on Figures A4 through A11, Boring Location Map. Boring Logs are included in Appendix B.

Borings were drilled with a CME-55, truck-mounted drill rig, operated by Applied Geotechnical Engineering Consultants, Inc., of Sandy, UT. Borings were advanced from the existing roadway elevation through the overburden material with a 3.75 I.D. Hollow Stem Auger. Wireline core drilling techniques were attempted to collect continuous rock core samples in the bedrock; however, the percentage of material recovered was insufficient and it was decided to remain with the Hollow Stem Auger to retrieve samples. Piezometers were installed in four borings, B-8 through B-11, to monitor groundwater levels. Drill rig and site photos are presented in Appendix C, Photographs.

Borings were logged by representatives of CFLHD and soil and rock cores samples were classified in the field and transported to CFLHD materials lab for testing. Representative soil samples were obtained with a 2-inch outside diameter split spoon sampler using the Standard Penetration Test (SPT) in accordance with AASHTO T 206. The SPT was conducted with an automatic hammer with an assumed 80 percent hammer efficiency. A summary of the boring locations and depths are shown on Table 3, Summary of Borings.

TABLE 3:- Summary of Borings

Location	Boring No.	Stationing	Offset From Center Line	Approximate Ground Elevation (ft)	Approximate Total Depth (ft)
Miners Basin	B-7	126+40	5.0-ft Left	7734	7.0
	B-6	142+50	5.5-ft Left	7661	29.5
	B-5	155+90	4.5-ft Right	7643	20.5
	B-4	159+15	4.5-ft Left	7638	25.5
	B-3	163+90	5.0-ft Left	7628	25.5
	B-2	168+25	7.0-ft Right	7622	14.5
	B-1	172+50	5.5-ft Left	7608	29.0
Mill Creek	B-14	204+95	6.0-ft Right	7704	7.75
	B-15	205+00	6.0-ft Right	7704	17.8
	B-13	207+10	6.0-ft Left	7702	18.42
	B-12	215+60	10.0-ft Left	7698	8.5
	B-11	219+80	4.5-ft Left	7697	14.67
	B-10	224+50	5.0-ft Left	7696	20.5
	B-9	226+10	5.0-ft Left	7696	20.5
	B-8	228+15	5.0-ft Left	7697	19.0

3.2 LABORATORY TESTING

Laboratory testing was conducted on select soil samples obtained in the field to determine material properties for use in design. Soil samples were tested for gradation and classification in accordance with ASTM D 2487 and AASHTO M 145, and Atterberg limits in accordance with AASHTO T 89 and T 90 are presented in Table 4, Summary of Soil Classification Index Tests. Samples showing similar material properties were sometimes combined for more adequate sample sizes. Laboratory test results and grain size curves are also presented in Appendix D, Laboratory Test Results.

Table 4:- Summary of Soil Classification Index Tests

Location	Boring	Station	SPT Sample	Sample Depth (feet)	Percent Passing 200	LL	PI	USCS	AAASHTO
Miners Basin	B-4	159+15	SPT 1-2	4-10	19	31	11	SC	A-2-6 (0)
	B-5	155+90	SPT 1-4	4-20.5	24	26	6	SC-SM	A-1-b (0)
	B-6	142+50	SPT 1-2	14.5-20.5	51	26	13	CL	A-6 (3)
Mill Creek	B-9	226+10	SPT 1-4	4-20.5	66	38	26	CL	A-6 (14)
	B-15	205+00	SPT 1-2	4-10.5	45	23	12	SC	A-6 (2)
	B-13 & B-15	207+10 & 205+00	SPT 3 for both	14-15.5	92	27	11	CL	A-6 (8)

Analytical tests were conducted on the combined soil sample from Borings 13 and 15 at a depth of 14-15.5 feet to determine if soils may have detrimental effects on concrete and buried metals. The minimum resistivity result, in accordance with AASHTO T 288, was 2,060 ohm - cm. The pH result, in accordance with AASHTO T 289, was 8.1. Tests for sulfate and chloride content were performed because the resistivity results was less than 5000 ohm-centimeters. The sulfate content, according to AASHTO T 290, was 0.004%/ 40 ppm, and the chloride content; according to AASHTO T 291, was 0.0013%/ 13 ppm. A discussion of corrosion requirements, electrochemical test results, and recommendations for corrosion restrictions is presented in Section 4.6, Corrosion Potential.

SECTION FOUR--ANALYSIS AND RECOMMENDATIONS

The proposed roadway improvements at Miners Basin and Mill Creek will require new structures, embankments, drainage improvements, and pavement surface. The Miners Basin segment includes roadway widening and minor realignment requiring the expansion of existing cut slopes and the installation of a box culvert requiring a grade raise with new embankments. The Mill Creek segment includes the use of shoulder stabilization and Mechanically Stabilized Earth (MSE) walls to widen the roadway and add a parking lane with minimal disturbance to the existing cut slopes.

Geotechnical profiles were developed for use in design of structures and embankments at Miners Basin and Mill Creek Segments. Recommendations regarding structures, embankments, corrosion potential, and material shrink /swell are contained in the following sections. Discussions with respect to slope stability, construction considerations, specifications, and limitations are also included.

4.1 GEOTECHNICAL PROFILE

For the design of the proposed structures and embankments at Miners Basin and Mill Creek, geotechnical profiles were developed from the data collected during the subsurface investigation. Geotechnical profiles contain a discussion of materials encountered, estimated subsurface material properties for use in design, and a discussion of ground water and soil moisture conditions.

4.1.1 Miners Basin Geotechnical Profile

Borings B-1 through B-5 were drilled in the roadway below proposed expansion of existing cut slopes. In general, the borings showed a consistent pavement thickness of 0.2 feet followed by silty Sand and gravel base course fill overlying native colluvium or embankment fill consisting of clayey sand with rock fragments or silty Sand and gravel. The contact between the native colluvium and embankment fill was indistinguishable. Predominantly decomposed to slightly weathered Rhyolite bedrock was encountered below the overburden. Bedrock exhibited close to moderately close, iron stained joints resulting in a Rock Quality Designation (RQD) of zero.

Boring B-6 was drilled at the location of a proposed culvert upgrade requiring new embankment. The boring revealed a pavement section of 0.2 feet which overlays a clayey Sand and Cobble fill overlying native drainage deposits of cobbles and small boulders within a silty Clay matrix. Rhyolite bedrock was encountered below the overburden at a depth of 28 feet.

Boring B-7 was drilled at the proposed location of the Box Culvert. Asphalt pavement thickness was recorded at 0.3 feet followed by a fill of Cobbles with a silty to clayey Sand matrix. Auger refusal was encountered at a depth 7 feet below the roadway where the density of cobbles increased, presumably at the contact of undisturbed debris flow deposits.

The box culvert is anticipated to be founded in the existing fill or debris flow deposits. Material properties were estimated for foundation design based on observations during the field investigation and known empirical strength characteristics of like materials. The selected design values for soil unit weight (γ), internal friction angle (ϕ), and cohesion intercept (c) are shown in Table 5, Estimated Subsurface Material Properties for Design at Miners Basin Box Culvert.

TABLE 5:- Estimated Subsurface Material Properties for Design at Miners Basin, Box Culvert

Material	Unit Weight γ (pcf)	Cohesion c (psf)	Friction Angle ϕ (deg)
Silty Gravel with Sand Cobbles and Boulders (GM)	130	0	36

Groundwater was not detected at the time of drilling at the Miners Basin segment and soil moisture conditions were considered dry to moist. However, based on iron staining along fractures in the rhyolite and the presence of debris flow occurrences in the area, seasonal variations of groundwater and soil moisture are expected. Increased soil moisture is expected during the wet winter months, spring snow melt, and summer monsoon season. Because the box culvert is located in a natural drainage channel, surface water and groundwater is expected during and following storm events requiring dewatering and/or water diversion.

4.1.2 Mill Creek Geotechnical Profile

Borings B-8 through B-13 were drilled along the Mill Creek segment to determine subsurface conditions for design of proposed MSE walls, shoulder stabilization, and drainage improvements. The borings revealed a pavement section of 0.2 to 0.5 feet of asphalt pavement overlying silty Sand with gravel base course fill with thicknesses ranging from 3.5 to 5 feet. The silty Sand fill is underlain by sandy Clay (CL) to clayey Sand (SC) overburden material extending to bedrock at depths between 7 to more than the maximum depth explored of 20.5 feet.

The sandy CLAY (CL) was found in Borings B-8 through B-13 and contains occasional cobble and boulder size rock fragments. Boulders were encountered in the borings up to 2 feet in diameter; however boulders up to 6 feet in diameter were observed in the adjacent slopes. Uncorrected representative N-values from SPT's ranged from 4 to 21 blows per 12

inches with an average of N_{avg} = 13 indicating medium stiff to stiff consistency. Soil moisture conditions were generally moist to dry with no correlation with depth.

The clayey Sand (SC) was found in Borings B-14 and B-15 and contains cobble and boulder size rock fragments. The clayey sand is similar in color, moisture, particle size, and consistency/relative density to the sandy Clay (CL) but contains slightly more sand and less fines. The contact between the SC and the CL is assumed to be transitional and not well defined. To be conservative, the material property values for the sandy Clay (CL) should be used in design.

In general, the bedrock consists of interbedded reddish-brown Siltstone and white Sandstone. The Siltstone is described as completely weathered to highly weathered with a relative hardness of extremely weak to very weak. The sandstone was highly weathered to moderately weathered with a relative hardness of medium strong to strong. Considering the proposed structures in the Mill Creek segment and the high variability of depths that bedrock was encountered, bedrock should not be assumed in design of MSE walls.

The MSE walls, RSS, and shoulder stabilization are anticipated to be founded in sandy Clay (CL) soils. Material Properties were estimated for foundation design based on observations during the field investigation, results of laboratory testing, and known empirical strength characteristics of like materials. In addition, slope stability was conducted at embankment distress locations to calibrate estimated material values of the overburden. Detailed discussion concerning the slope stability analysis is presented in Section 4.6, Slope Stability. The selected design values for soil unit weight (γ), internal friction angle (ϕ), and cohesion intercept (c) are shown in Table 6, Estimated Subsurface Material Properties for Design at Mill Creek Segment

TABLE 6:- Estimated Subsurface Material Properties for Design at Mill Creek

Material	Unit Weight γ (pcf)	Cohesion c (psf)	Friction Angle ϕ (deg)
sandy CLAY with Gravel, Cobbles and Boulders (CL)	125	200	30

Groundwater was not detected in the borings at the time of drilling in July 2011. Standpipe piezometers were installed in Borings B-8 through B-11 to a depth of approximately 18 feet. Measurements from these piezometers indicated dry conditions on October 27, 2011. However, springs and seeps in the cut slopes and roadway inboard ditch have been observed year round and correspond to areas of embankment and pavement distress. In addition, the area contains two existing solider pile and lagging walls assumed to be supporting unstable cut slopes related to high groundwater conditions.

Site conditions indicate localized perched groundwater conditions that vary significantly within short distances and the volume of groundwater flow may fluctuate between seasons. Increased groundwater and soil moisture is expected during the wet winter and spring snow melt months. Flows from groundwater and seeps are anticipated to be significant during construction requiring dewatering/water diversion.

4.2 STRUCTURES

Structures analyzed for the LaSal Loop Road project include the box culvert along the Miners Basin segment and the MSE walls along the Mill Creek segment. The following subsections include geotechnical recommendations and material values for use in design of each structure. All foundation designs are based on the AASHTO probabilistic Load and Resistance Factor Design (LRFD) procedures (AASHTO, 2010).

4.2.1 Miners Basin Box Culvert

A new concrete box culvert (CBC) designed for the 25 year flood event is proposed at an existing low water crossing at Station 126+50. The proposed CBC will be 5 feet in height, 8 feet in width, and 37 feet in length requiring headwall and wing walls at the inlet and outlet. The grade of the roadway is to be raised providing approximately 3 feet of cover from the top of the span to the overlying roadway at the control line. Subsurface conditions for the box culvert were characterized based on boring B-7.

4.2.1.1. BOX CULVERT FOUNDATION DESIGN

The culvert, head wall, and wing walls can be supported on spread footings designed for a nominal bearing resistance of 8,000 pounds per square foot (psf) provided that up to 1.0 inch of settlement is acceptable, the slope below the wall does not exceed 1V:4H, and the minimum footing with is 18 inches. The base of the footing should be located below the depth of frost potential, which is 30 inches based on local practices. Appropriate resistance values should be applied as shown in Table 7, Resistance Factors, Miners Basin Box Culvert.

Table 7:- Resistance Factors, Miners Basin Box Culvert

Limit State	Resistance Factor(1), ϕ		
	Bearing Resistance	Shear Resistance to Sliding	Passive Pressure Resistance to Sliding
Strength	0.45	0.80	0.50
Service/ Extreme Event	1.00	1.00	1.00

(1) Resistance Factors from AASHTO LRFD Bridge Design Specifications, 2010, Table 10.5.5.2.2-1
(2) Theoretical method, in sand, using SPT
(3) Cast-in-Place concrete on sand

4.2.1.2. STATIC LATERAL EARTH PRESSURE

Active, at-rest, and passive lateral earth pressure coefficients of properly placed and compacted retained soil for use in design of the box culvert are provided in Table 8, Lateral Earth Pressure Coefficients, Miners Basin Box Culvert. The values are unfactored loads and assume that the surface of the soil slope behind the wall is horizontal.

Table 8:- Lateral Earth Pressure Coefficients, Miners Basin Box Culvert

Backfill Type	Assumed Backfill Properties	Case	Lateral Earth Pressure Coefficient (Ka)
Unclassified Borrow	c = 0 psf Φ = 30 deg γ = 125 pcf	Active	0.33
		At-Rest	0.50
		Passive	3.0

Unbalanced water behind a wall adds pore pressure and should be avoided by using structural backfill (SCR, Section 704.04) against backfilled structures and assuring a free draining gravity outlet for captured water. Unclassified borrow (FP-03, Section 704) may be used in the retained zone beyond the culvert footings. Below the mean canal level, the walls must also be designed for the full hydrostatic condition. Wing wall design should consider surcharge loading due to traffic and construction equipment.

4.2.1.3. LATERAL RESISTANCE

Lateral loads imposed upon structures due to seismic forces or static lateral earth pressures may be resisted by the development of friction between the base of the footings and the supporting soils and passive resistance. A nominal friction factor of 0.60 may be used in design for cast-in-place footings established on silty sand and gravel. The appropriate friction factor from Table 7, Resistance Factors, should be applied.

4.2.2 Mill Creek MSE Walls

Reconstruction of the Mill Creek segment will include two Mechanically Stabilized Earth (MSE) walls to widen the roadway and add a parking lane with minimal disturbance to the existing cut slopes. MSE walls tolerate larger differential settlement than other wall alternatives and were selected as the most economical due to cohesive subsurface materials and steep slopes found on-site. Concrete cantilever walls would require foundation improvement to limit deflection to within tolerable standards and to satisfy global stability requirements. A summary of the proposed MSE walls and respective geotechnical investigation boring number and location is presented in Table 9, Summary of Proposed MSE Walls.

Table 9:- Summary of Proposed MSE Walls

MSE Wall Roadway Station, ft		Wall Length, ft	Maximum Wall Height, ft	Boring Number	Boring Station, ft	Boring Offset, ft	Offset Lt or Rt of Centerline
Begin	End						
203+20	207+60	447	10	B-13	207+10	6	Lt
				B-14	204+95	6	Rt
				B-15	204+90	6	Rt
216+02	218+59	257	16	B-11	219+80	4.5	Lt
				B-12	215+60	10	Lt

Preliminary external designs conducted for proposed MSE walls at the Mill Creek Segment evaluated global stability, bearing resistance, sliding, and limiting eccentricity in accordance with AASHTO "LRFD Bridge Design Specifications" (5th edition), and FHWA Publication NHI-10-024 and NHI-10-025, Volumes 1 and 2, respectively, entitled "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" dated November 2009. Acceptance criteria used for design are shown in Table 10, Minimum Acceptance Criteria for MSE Walls.

TABLE 10:- Minimum Acceptance Criteria for MSE Walls

Stability Mode		Minimum Acceptance Criteria
Global Stability	Static	FS = 1.3
	Seismic	FS = 1.1
Bearing Resistance		CDR = 1
Sliding		CDR = 1
Limiting Eccentricity		e_{max} = L/4

Notes: FS = Factor of Safety
CDR = Capacity to Demand Ratio
Eccentricity (e_{max}) for soil foundations

The capacity to demand ratios (CDR) for bearing resistance and sliding are used to quantify the ratio of the factored resistance to the factored load. Resistance factors used in the preliminary external design for bearing and sliding are 0.65 and 1.0, respectively. Load factors for bearing, sliding, and the eccentricity check are shown in Tables 4-1 and 4-2 of FHWA Publication NHI-10-024, "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume 1," dated November 2009.

Proposed MSE walls were evaluated based on the existing site conditions and available subsurface information. Cross sections were evaluated where the wall height was at its maximum and/or where the slope in front of the fill wall was the steepest. A traffic surcharge of 250 psf was modeled in the analyses.

The MSE walls are anticipated to be founded in sandy Clay (CL) soils with material properties shown in Table 6, Estimated Subsurface Material Properties for Design at Mill Creek Segment. Groundwater was not detected in the borings but multiple perennial springs and seeps were observed in the cut and slopes above the road indicating that perched groundwater conditions exist on site. A water table at the base of the wall was included in the analyses, as the wall system will include interior drainage and is considered drained. The embankment fill material properties assumed for preliminary external design are listed in Table 11, Summary of MSE Wall Fill Design Parameters.

Table 11:- Summary of MSE Wall Fill Design Parameters

Description	Total Unit Weight, γ pcf.	Friction Angle, ϕ (deg)	Cohesion Intercept, c psf
Select Wall Backfill	125	34	0
Wall Backfill	125	30	0

The proposed MSE walls were preliminarily evaluated using the Mechanically Stabilized Earth Walls (MSEW 3.0) program developed by ADAMA Engineering. The design methodology used by MSEW is consistent with current AASHTO and FHWA guidelines for assessment of the internal and external stability of MSE walls.

Based on the results of the analyses, the proposed MSE wall system will meet the required acceptance criteria shown in Table 10, Minimum Acceptance Criteria, provided that the wall system be constructed with a minimum horizontal setback from the slope at the wall toe of 4 feet and a minimum reinforcement length equal to 70 percent of the wall height (0.7H) or 8 feet, whichever is greater.

The reinforced and retained portions of the wall system should be backfilled with select wall backfill and wall backfill, respectively. Select wall backfill and wall backfill should meet the requirements of Subsection 704.13 of the project SCR. Riprap protection at the base of each wall below culvert outlets is required. Based on laboratory testing results, ***on-site, existing fill and native soils will generally not meet the requirements for select wall backfill, unclassified borrow, wall facing fill, and foundation fill due to the high percent fines and high plasticity index.***

4.3 EMBANKMENTS

The rehabilitation and reconstruction of LaSal Loop Road in the Miners Basin and Mill Creek segments require embankment work associated with culvert replacement. In addition, RSS, shoulder repair, and underdrain installation are recommended to address embankment distress and limited roadway bench along the Mill Creek Segment. New embankments should be constructed at 1(V):2(H) slopes or flatter to maintain slope stability and facilitate vegetation growth.

Site preparation will include demolition of the existing pipe culverts and pavements, as well as removal of existing vegetation, non-engineered fills, and other deleterious materials in accordance with Section 201 of the FP-03. Removal of mature vegetation and trees should also include a major portion of their root structure. Relatively thick pockets of undocumented fill should be anticipated in some areas due to the nature of the original road construction.

Groundwater may be encountered within embankment and culvert foundations. Dewatering and stabilization methods will depend on conditions encountered.

Based on on-site observations, it is not likely that a significant depth of top soil will be present on the project sites. For estimation purposes, it should be assumed that limited topsoil will be stripped and stockpiled for re-use on the project. Topsoil is anticipated to be imported for this project.

4.3.1 Miners Basin Embankment Settlement

A new embankment is proposed from Station 122+10 to Station 130+30 to accommodate the grade raise required by the proposed box culvert at Station 126+50. The maximum grade raise, located at the box culvert location, is approximately 5 feet at the control line of the roadway. Embankment slopes are not expected to exceed 15 feet in height. Due to the granular nature of the on-site soils, settlements of the embankments are expected to be negligible with the majority of the settlement occurring during construction.

4.3.2 Mill Creek Reinforced Soil Slopes

Reconstruction of the Mill Creek segment will include two reinforced soil slopes (RSS) to accommodate a proposed widened cattle guard at Station 199+95 and guardrail end section at Station 208+00. The two proposed RSS are approximately 12 feet tall with a 1(V):1(H) slope ratio at each location. Analyses of the RSS were performed using RESSA and gSTABLE7, two dimensional, limit equilibrium computer programs from ADAMA Engineering and Gregory Geotechnical Software, respectively. The Simplified Bishop method of slices was used with isotropic soil parameters. The analysis conducted for RSS design consisted of external, compound, and interal stability in accordance with AASHTO "LRFD Bridge Design Specifications" (5th edition), and FHWA Publication NHI-10-024 and NHI-10-025, Volumes 1 and 2, respectively, entitled "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" dated November 2009.

Analyses were performed for the proposed RSS to determine embedment length, spacing, and tensile strength required of the geosynthetic reinforcement for a desired minimum static factor of safety of 1.30 and a seismic factor of safety of 1.1. Material values used in the analysis are presented in Table 17, Summary of Design Parameters. The natural slope that the RSS is founded on is approximately 28 degrees and a 250 psf vehicle traffic surcharge was included in the long-term static analysis.

The recommended RSS design consists of a reinforcement geogrid placed at 1 foot maximum spacing's with a minimum geogrid embedment length of 10 feet. When the total height of the RSS is less than 9 feet, the minimum reinforcement embedment length is 8 feet. Reinforcement should be Type VII-A biaxial geogrid reinforcement in accordance with SCR 714.03. Reinforcement layers should be wrapped at the face on slopes greater than 1(V):1.5(H). The top two layers of reinforcement should extend to centerline of the roadway regardless of length. The results of the most critical cross section cases are shown in Table 17, Summary of Design Parameters. Factors of safety values for the recommended design are presented in Table 12, Summary of Proposed RSS Analysis. Design calculations for global stability and direct sliding are in Appendix E, RSS Analysis.

Table 12:- Summary of Proposed RSS Analysis

Mill Creek RSS Roadway Station, ft		Slope Ratio (V:H)	Maximum Slope Height, (ft)	Failure Mode	Cross Section Case	Required F.S.	Calculated F.S.
Begin	End						
203+20	207+60	1:1	12	Global Stability	Static	1.3	1.33
					Seismic (7% in 75)	1.1	1.24
				Direct Sliding	Static	1.3	1.44
216+02	218+59				Seismic (7% in 75)	1.1	1.34
				Compound Failure	Static	1.3	1.58
				Internal Stability	Static	1.3	1.73

4.3.3 Mill Creek Shoulder Stabilization Locations

Embankment shoulder stabilization is recommended in areas showing evidence of embankment distress not already mitigated by MSE walls. Embankment distress was observed in the Mill Creek Segment between approximate Stations 217+50 and 232+50.

The Mill Creek segment was likely constructed utilizing sidecast construction techniques which involves cutting into the hillside above the road and casting the material onto the downhill side. Due to the steep angle of the natural slope and the absence of modern construction techniques such as keys or benches, sidecast embankment fill is typically poorly compacted. This commonly leads to creep and settlement of the embankment material.

Reinforced shoulder stabilization is a repair techniques that uses granular backfill compacted in lifts with geosythetic reinforcement. The stabilization system includes interior drainage that should daylight every fifty feet along the length of the repair. Shoulder stabilization is not a substitute for a properly constructed embankment; however, it provides an economic solution for reducing pavement distress due to slow creep and settlement rates. The recommended shoulder stabilization location and minimum depth below proposed pavement section are presented in Table 13, Shoulder Stabilization Locations. Slope stability analysis of the shoulder stabilization section is presented in Section 4.5, Slope Stability.

Table 13:- Shoulder Stabilization Locations, Mill Creek

Location	Station to Station	Length (ft)	Offset and Depth of Repair
Mill Creek	218+25 to 232+60	1435	Left outboard lane to CL at depth of 6ft

4.3.4 Mill Creek Underdrain Locations

Free water and pavement distress typical of saturated subgrade materials was observed in the Mill Creek segment. Installation of underdrain below the inboard ditch is recommended to promote drained subgrade conditions. A deep patch containing free draining backfill with less than 5 percent fines and geosynthetic reinforcement may be required in locations where saturated subgrade material is encountered during construction. The recommended underdrain location and minimum depth below proposed pavement section are presented in Table 14, Underdrain Locations.

Table 14: - Underdrain Locations, Mill Creek

Station to Station	Offset	Depth, (ft)	Comments
203+00 to 230+89	Below Inboard Ditch	5	Seeps in cut and standing water in ditch resulting in pavement and embankment distress

4.4 CUT SLOPES

Expansion of existing cut slopes are proposed to accommodate the roadway design width. Recommendations with respect to permanent and temporary cut slopes at the Miners Basin and Mill Creek segments are presented in the following sub-sections.

4.4.1 Miners Basin Permanent Cut Slopes

Existing cut slopes extend to a height of approximately 25 feet, show evidence of continuous raveling, and are typically not vegetated. Cut slopes in soil vary between 35 (1V:1.4H) and 45 degrees (1V:1H) and cut slopes in weathered bedrock range from 55 (1.4V:1H) to 65 degrees (2.1V:1H). Naturally occurring slopes are typically found between 25 (1V:2H) and 35 degrees (1V:1.4H). An infinite slope condition exists above existing cut slopes from station 154+50 to the end of the project area at 177+00.

Partner agencies requested to limit the cut slope scar height to not greater than 10 feet above the existing cut slope crest; therefore, steeper cut slopes than existing are proposed. Deep seated instability of the slope is not anticipated due to shallow bedrock and cohesiveness of the matrix within the granular colluvium. However, steeper slopes increase the likelihood and frequency of slope failure, slumping, raveling and rock fall events. In addition, the proposed ditch is not of sufficient size to be considered a rockfall catchment. Material from rockfall and major sloughing events are likely to impact the roadway. Cut slopes should not exceed slope ratios presented in Table 15, Maximum Permanent Cut Slope Ratios.

Table 15:- Maximum Permanent Cut Slope Ratios, Miners Basin

Location	Station to Station	Recommended Slope Ratios (V:H)
Miners Basin	100+00 to 161+25	1:1
	161+25 to 162+00	1.5:1
	162+00 to 164+75	1:1
	164+75 to 167+50	1.5:1
	167+50 to 168+75	2:1
	168+75 to 171+80	1.5:1
	171+80 to 173+90	1.3:1
	173+90 to 177+00	2:1

Scaling and crest rounding of existing cut slopes is recommended in locations not mitigated by proposed permanent cut slopes from station 154+50 to the end of the project area at 177+00. In addition, the conditions at the site are highly variable and may require reanalysis during construction to develop safe slopes. For example, slopes need to be flattened in areas where pot-outs are occurring. Increased overburden depths above competent bedrock discovered during construction may require larger crest rounding dimensions than shown in the plans. A CFLHD Geotechnical Engineer should be consulted during construction to verify scaling efforts and design slope ratios with encountered conditions.

Evidence of blasting is apparent in the existing cut slope. However, it is anticipated that a hoe-ram is sufficient for fragmentation of large blocks for efficient handling. Due to the weathered and jointed nature of the rock mass, special attention must be paid to minimize over-break to the final cut face. Scaling will be a critical element in arriving at stable cut slopes along the roadway.

4.4.2 Mill Creek Permanent Cut Slopes

Existing cut slopes vary between 35 (1V:1.4H) and 45 degrees (1V:1H) and extend to a height of approximately 15 feet. Naturally occurring slopes are typically found between 25 (1V:2H) and 35 degrees (1V:1.4H). Cuts from the beginning of the project at Station 200+00 to Station 224+00 are typically not vegetated but appear stable. Cuts from station 224+00 to the end of the project, at Station 234+42, show evidence of slumps and slides requiring support of soldier pile and lagging walls at two locations. Cut slope recommendations are presented as vertical: horizontal ratios in Table 16, Permanent Cut Slope Recommendations.

Table 16:- Permanent Cut Slope Recommendations, Mill Creek

Location	Station to Station	Recommended Slope Ratios (V:H)
Wet Area	200+00 to 224+00	1:1
	224+00 to 234+42	Do Not Cut

4.5 SLOPE STABILITY

Slope stability was conducted for proposed cut slopes in soil, MSE walls, and shoulder stabilization utilizing GSTABL7, a 2-dimensional limit equilibrium slope stability program. The Modified Bishop's method for a circular failure surface was used in the analyses. Slope stability was not conducted for existing slopes not impacted by roadway construction. Natural slopes appear stable; however, existing embankments and cut slopes are marginally stable through the project site.

In the Mill Creek segment, stability analyses were conducted for cross-sections taken at embankment distress locations assuming a factor of safety of approximately 1.0 with a heightened groundwater table to model the assumption that the embankment distress occurred at times of high groundwater. The results of the stability analysis were used to calibrate estimated material values of the overburden.

Generally accepted stability standards for embankments indicate that the acceptable minimum factor of safety for long-term static stability for roadway embankment is 1.3. Cut slopes were designed to a minimum factor of safety of 1.2. For seismic design, the most critical slip surface was reanalyzed using pseudostatic seismic coefficients. The seismic coefficient used in the stability analysis, representing the inclusion of static horizontal force, is equal to ½ the peak ground acceleration (PGA). The 7 percent in 75-year hazard level was used in this analysis. A minimum factor of safety of 1.1 is generally considered acceptable for the 7% in 75-year event. The seismic parameters used in the pseudostatic design are presented in Table 1, Summary of Seismic Parameters Corrected for Class C Soils.

Mohr-Coulomb strengths parameters of internal friction angle (Φ) and cohesion intercept (c) govern stability. The material properties assumed for stability analysis are listed in Table 17, Summary of Design Parameters.

Table 17: - Summary of Design Parameters

Location	Description	Total Unit Weight, pcf.	Angle of Internal Friction	Cohesion Intercept, psf
Miners Basin	Colluvial Soils (SW-GW)	125	36	100
Mill Creek	Embankment Fill Soils (CL)	125	30	200
	Colluvial Soils (CL-SC)	120	32	200
	Select Wall Backfill/Borrow	125	34	5,000[1]
	Wall Backfill	125	30	0

[1]Cohesion intercept was artificially increased to limit failure surfaces through the structure

Each cross section case was analyzed for static stability and seismic stability with the most critical case representing the similar cases. A 250 psf vehicle traffic surcharge was included in the long-term static analysis. The results of the most critical cross section cases are shown in Table 18, Summary of Stability Analyses. Design calculations and plots of the 10 most critical failure surfaces for each cross-section case are in Appendix F, Slope Stability.

Table 18: - Summary of Stability Analyses

Location	Station	Description	Cross Section Case	Required F.S.	Calculated F.S.
Miners Basin	164+00	Colluvial Cut Slope	Existing	--	1.44
			Static	1.2	1.35
	173+00	Colluvial Cut Slope	Existing		1.29
			Static	1.2	1.19
Mill Creek	207+00	MSE Critical Failure Surface	Existing	--	1.39
			Static	1.3	1.31
			Seismic (7% in 75)	1.1	1.28
	218+00	MSE Critical Failure Surface	Existing	--	1.44
			Static	1.3	1.31
			Seismic (7% in 75)	1.1	1.28
	223+00	Colluvial Cut Slope	Existing	--	1.35
			Static	1.2	1.34
	228+00	Shoulder Stabilization	Existing	--	1.14
			Static	1.3	1.32
			Seismic (7% in 75)	1.1	1.30

4.6 CORROSION POTENTIAL

Analytical tests were conducted on selected samples collected from the Mill Creek segment to determine if soils may have detrimental effects on concrete and buried metals. A combined soil sample from Borings 13 and 15 at a depth of 14-15.5 feet was tested for resistivity and pH chemical characteristics. The minimum resistivity measured was 2,060 ohm-cm, and the pH was 8.1. Resistivity and pH results indicate a possible aggressive soil environment; therefore, sulfates and chlorides were tested. Sulfate content was measured at 0.004%/ 40 ppm and chloride content at 0.0013%/ 13 ppm.

Acceptable ranges of soil aggressiveness for anticipated culverts, MSE walls, and concrete structures vary with respect to the proposed structure. For culverts, the electrical resistivity measurements indicate values above 1,500 ohm-centimeters and pH tests indicate values between 5.0 and 9.0. These test results indicate no corrosive restrictions will be necessary for the proposed type of pipe culverts used on the project.

Imported material is anticipated for Select Wall Backfill in the MSE wall reinforcement zone and is required to meet the following corrosion related requirements according to SCR Section 704, Soil, which is based on recommendations from FHWA-NHI-10-024 (2009):

- Resistivity, AASHTO T 288 — 3,000 ohm-cm minimum
- pH, AASHTO T 289 — 5.0 to 10.0
- Sulfate content, AASHTO T 290 — 200 ppm maximum
- Chloride content, AASHTO T 291 — 100 ppm maximum

MSE backfill material that meets the above criteria will be considered non-corrosive to the metallic soil reinforcement. Analytical geochemical tests should be performed on imported wall backfill during construction to determine suitability.

The concentration of water soluble sulfates represents a negligible degree of sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of negligible, moderate, severe, and very severe as presented in the American Concrete Institute (ACI, 2010) *Building Code Requirements for Structural Concrete*. Based on this information, special sulfate resistant cement will not be required for concrete exposed to the on-site soils in the Mill Creek segment. Type II cement with a maximum water to cement ratio by weight of 0.44 is recommended for concrete structures in contact with onsite soils.

Analytical geochemical tests were not conducted for the Miners Basin segment. However, only minor corrosion was observed in existing pipe culverts and no corrosive restrictions will be necessary for replacement culverts. Special sulfate resistant cement is not anticipated to be required, but Type II cement with a maximum water to cement ratio by weight of 0.44 is recommended.

4.7 SHRINK/SWELL RECOMMENDATIONS

Materials shrink/swell percentage represents the difference in volume between undisturbed bank materials and then compacted embanked volume. A material that occupies a larger volume as fill from the excavation volume (e.g. rock) is considered to swell and represented as a positive (+). A material that occupies a smaller volume as fill from the bank excavation volume (e.g. soil) is considered to shrink and represented as a negative (-).

Shrink/Swell values are dependent on subsurface conditions estimated from the borings and observations of materials found in existing cut slopes. On-site materials encountered along the Miners Basin segment generally consist of (1) colluvium, which is a brown to yellow brown sandy clay with volcanic gravels to boulders, and (2) fractured volcanic rhylolite bedrock exhibiting varying degrees of weathering. It is estimated that colluvial soils will have a shrink percentage of approximately -10 percent and volcanic bedrock will exhibit a swell percentage of 0 to +15 percent.

On-site soils encountered along the Mill Creek segment generally consist of red-brown sandy clay and clayey sand with cobble to boulder size rock (sandstone) fragments with larger boulders up to 5 feet present in existing cutslope. Without the cobble and boulder size rock fragments, the material classifies as a CL to SC material and is not anticipated to be used as embankment. However, it is estimated that such soils will have a shrink percentage ranging from -5 to -10 percent.

The recommended shrink/swell factors are based on a combination of standard tabled values for common materials in the FLH Technical Guidance Manual (2006) and experience with other CFLHD projects in similar materials. Estimated shrink/swell values within a station range were weighted to represent the area of anticipated excavation; therefore, they are intended to be an average for station ranges shown. Shrink/Swell factors shown in Table 19, Summary of Shrink\Swell Locations, were rounded to the nearest 0.05 due to variability and uncertainty within subsurface materials. Shrink/Swell values shown do not account for the materials change in volume in their movement from excavation to fill.

Table 19: Summary of Shrink/Swell Locations

Location	Station to Station	Description of Soil or Rock	Shrink(-)/ Swell(+) %
Miners Basin	100+00 to 155+90	Brown colluvium, consisting of sandy clay and volcanic rock fragments.	-10%
	155+90 to 159+65	Thin layer of colluvium overlying DG	0
	159+65 to 162+50	Light yellow brown to gray volcanic rock (rhylolite), very fractured, predominantly decomposed	+10%
	162+50 to 164+65	Brown colluvium, consisting of sandy clay and volcanic rock fragments.	-10%
	164+65 to 167+50	Light yellow brown to gray volcanic rock (rhylolite), very fractured, predominantly decomposed	+10%
	167+50 to 168+75	Light yellow brown to gray volcanic rock (rhylolite), random fractures, moderately weathered	+15%
	168+75 to 171+80	Light yellow brown to gray volcanic rock (rhylolite), very fractured, predominantly decomposed	+10%
	171+80 to 173+90	Brown colluvium, consisting of sandy clay and volcanic rock fragments,	-10%
	173+90 to 193+42	Light yellow brown to gray volcanic rock (rhylolite), random fractures, moderately weathered	+15%
Mill Creek	200+00 to 217+00	Red brown clayey sand and cobble to boulder size rock (sandstone) fragments. Boulders up to 5' present in existing cutslope.	-5%
	217+00 to 234+45	Brown sandy clay, cobble to small boulder size rock fragments.	-10%

4.8 CONSTRUCTION CONSIDERATIONS

4.8.1 Miners Basin

Roadway cuts proposed at the Miners Basin segment are proposed at steep slopes and are anticipated to encounter colluviums and weak to stong bedrock with large boulders (5-feet in diameter or larger) requiring carefully planned and uniquely adapted excavation approaches. The contractor will be required to make the final determination on the rippability characteristics of encountered material based on review of the boring logs and equipment capabilities. Long reach excavators and hoe-rams are anticipated to achieve proposed excavations and sufficient fragmentation of the large blocks for efficient handling. Due to the weathered and jointed nature of the rock mass, special attention must be paid to minimize

over-break to the final cut face. Scaling will be a critical element in arriving at stable cut slopes along the roadway.

Depending on the time of year, surface water might be present during excavation and construction of the Box Culvert. Temporary diversion of stream flow away from the foundation work area may be required to meet the water quality requirements specified in Section 157 of the FP-03.

4.8.2 Wet Area

Roadway excavations conducted at the Wet Area are anticipated to encounter fine-grained cohesive soils with varying degrees of soil moisture due to perched groundwater conditions. In addition, several seeps encountered along the roadway were observed to produce significant perennial flows. Control of groundwater and surface water flows are imperative to maintaining stable working conditions. Temporary diversion, dewatering and stabilitzation methods for foundation construction will depend on conditions encountered.

4.9 SPECIFICATIONS

Special provisions were developed to be consistent with geotechnical recommendations stated above and should be incorporated into the special contract requirements (SCR) to amend the FHWA Standard Specification for Construction of Roads and Bridges on Federal Highway Projects; known as FP-03. SCR sections provided are Section 204 – Excavation and Embankment, Section 207 – Earthwork Geosynthetics, Section 255- Mechanically Stabilized Earth Walls, Section 272- Reinforced Soil Slopes, Section 623- General Labor, Section 704- Soil, and Section 714 – Geosynthetic Materials.

4.10 LIMITATIONS

The recommendations in this report are based on the data obtained from exploratory borings, field review, and the laboratory test results. The results of these explorations and tests represent conditions at the specific locations indicated. Subsurface variations across the site are likely and may not become evident until excavation is performed. The Analysis and Recommendations sections in this report include interpretations and recommendations developed by the Government in the process of preparing the design. These interpretations are not intended as a substitute for the personal investigation, independent interpretation, and judgment of the Contractor.

SECTION FIVE -- REFERENCES

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APPENDIX A

FIGURES

FIGURE A1. Vicinity Map
FIGURE A2. Area Map, Miners Basin
FIGURE A3. Area Map, Mill Creek
FIGURE A4-A8. Boring Location Map, Miners Basin
FIGURE A9-A11. Boring Location Map, Mill Creek
FIGURE A12. Geologic Map- Miners Basin and Mill Creek

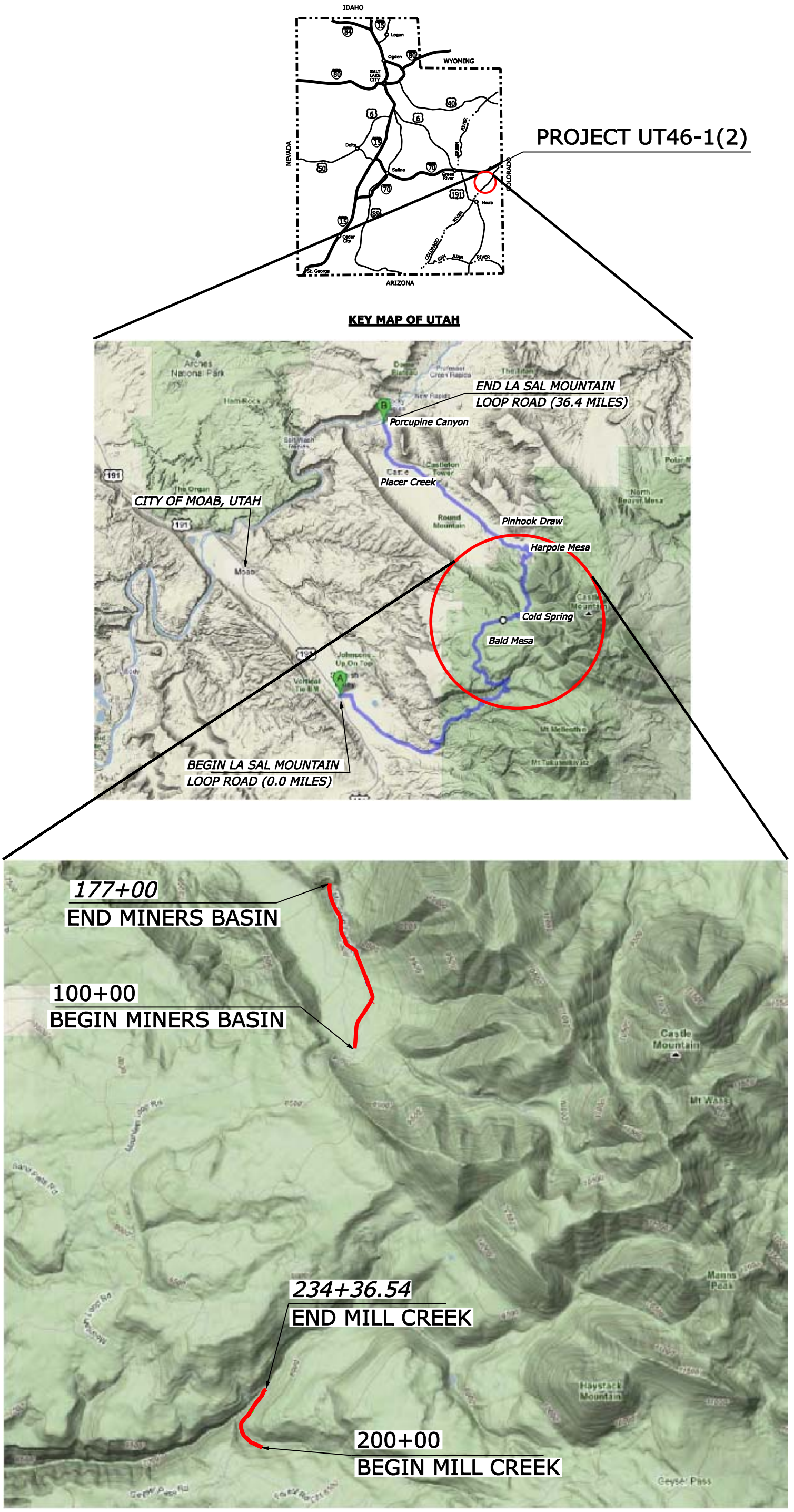

FIGURE A1. Vicinity Map- Miners Basin & Mill Creek

La Sal Mountain Loop Road
Miners Basin and Mill Creek
UT PFH 46-1(2)

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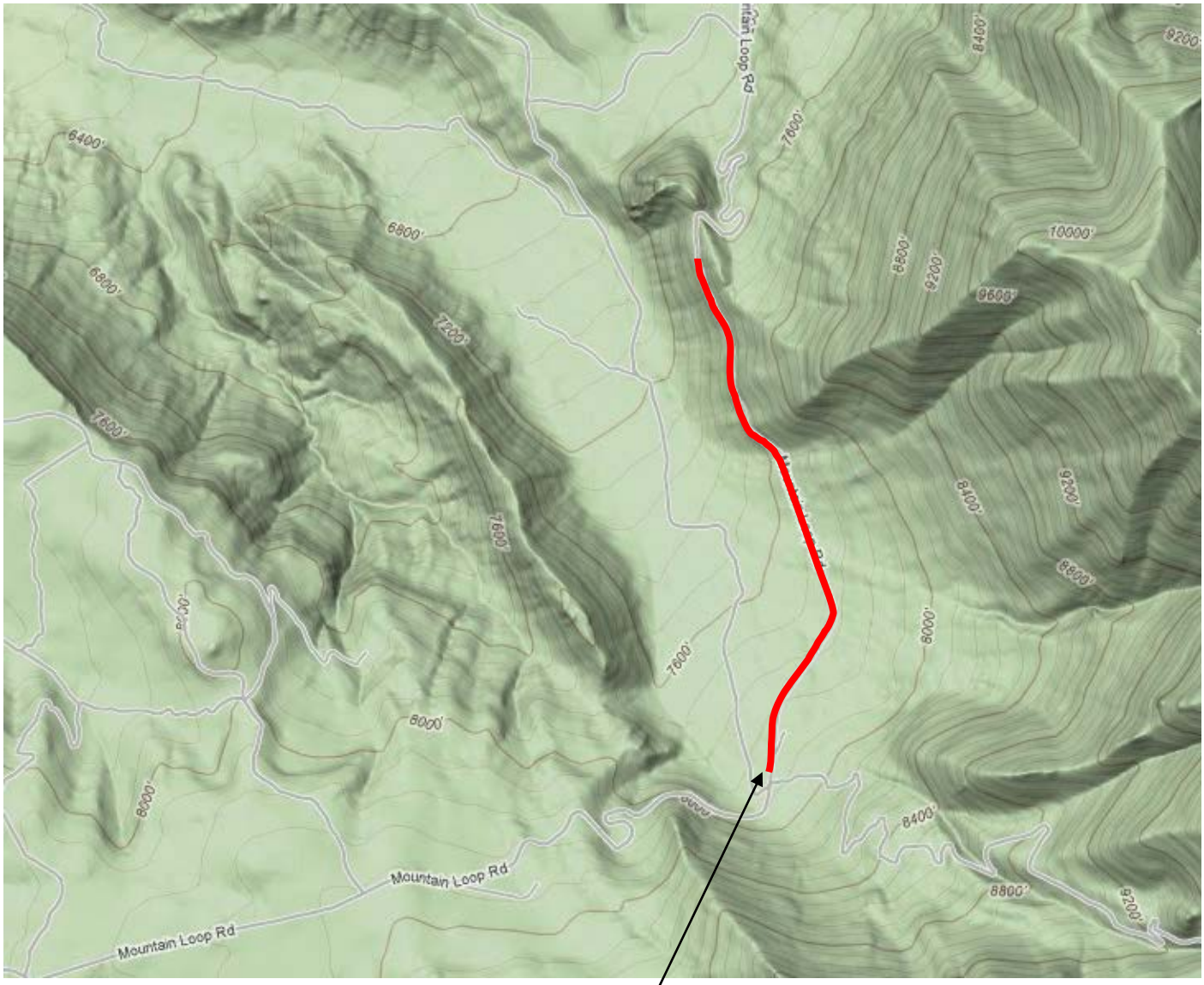


SEGMENT 1: MINERS BASIN

FIGURE A2:- Area Map- Miners Basin

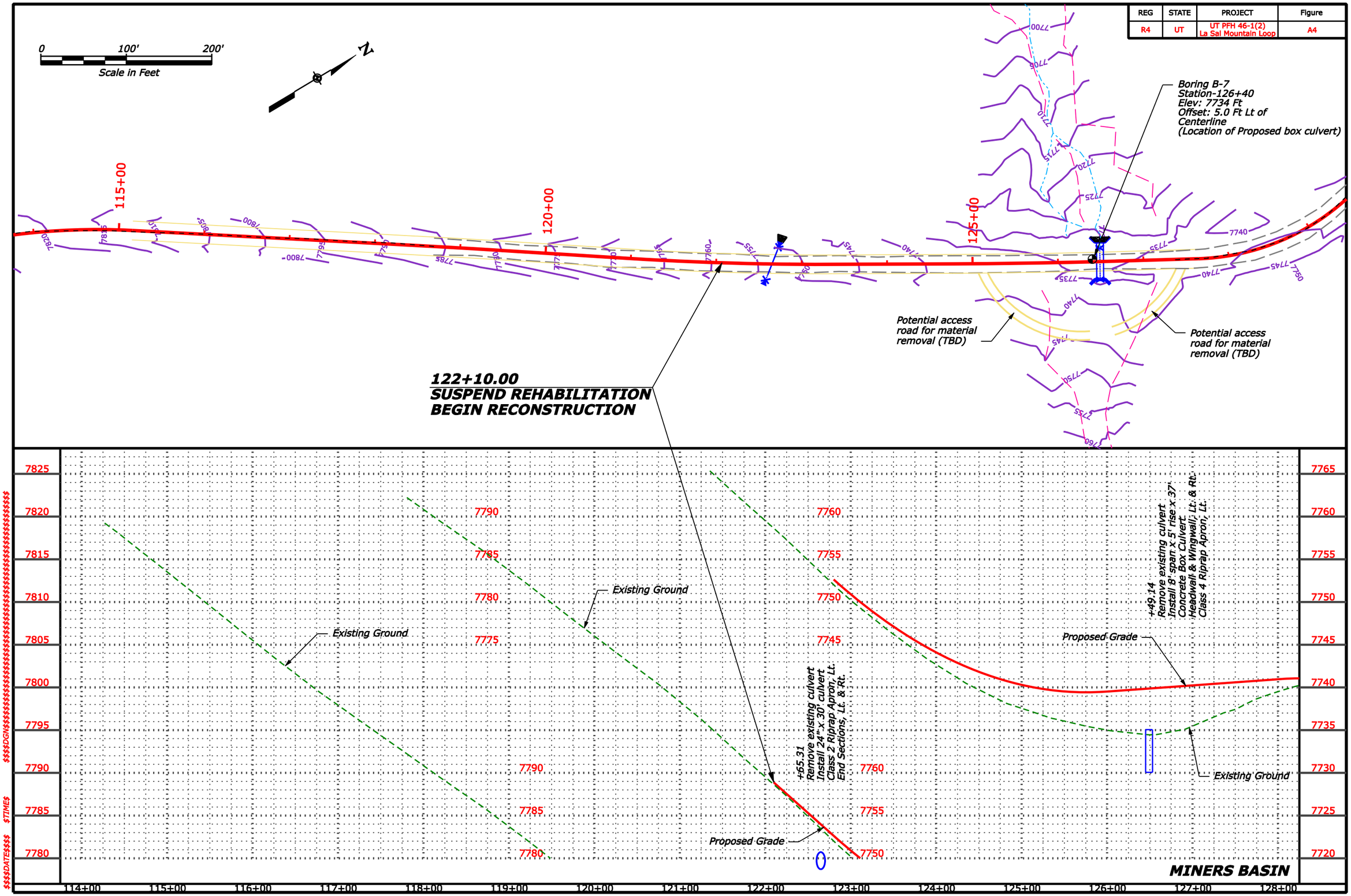
La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

SEGMENT 2: Mill Creek

FIGURE A3:- Area Map- Mill Creek

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

REG	STATE	PROJECT	Figure
R4	UT	UT PFH 46-1(2) La Sal Mountain Loop	A4



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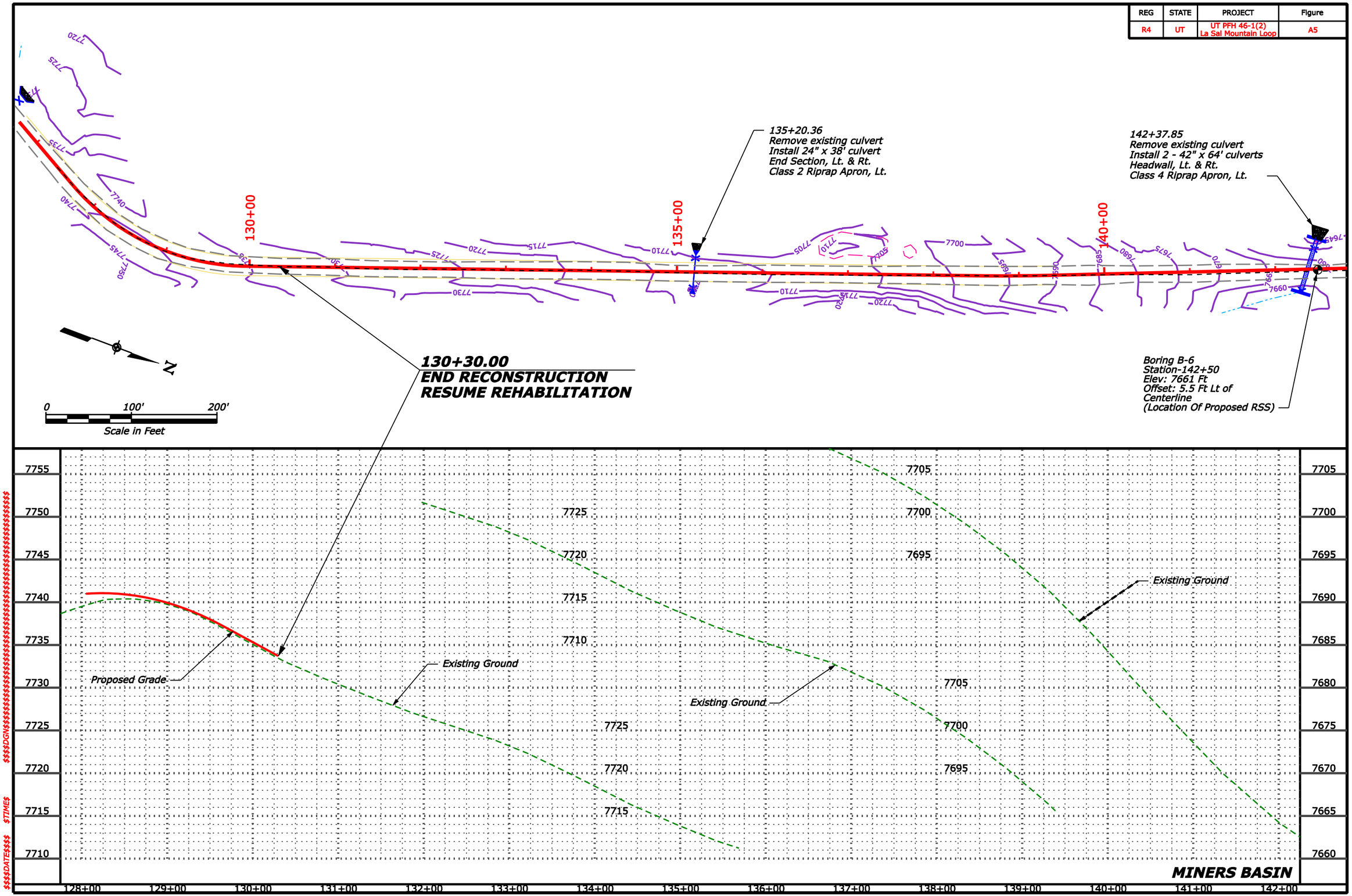
REG	STATE	PROJECT	Figure
R4	UT	UT PFH 46-1(2) La Sal Mountain Loop	A5



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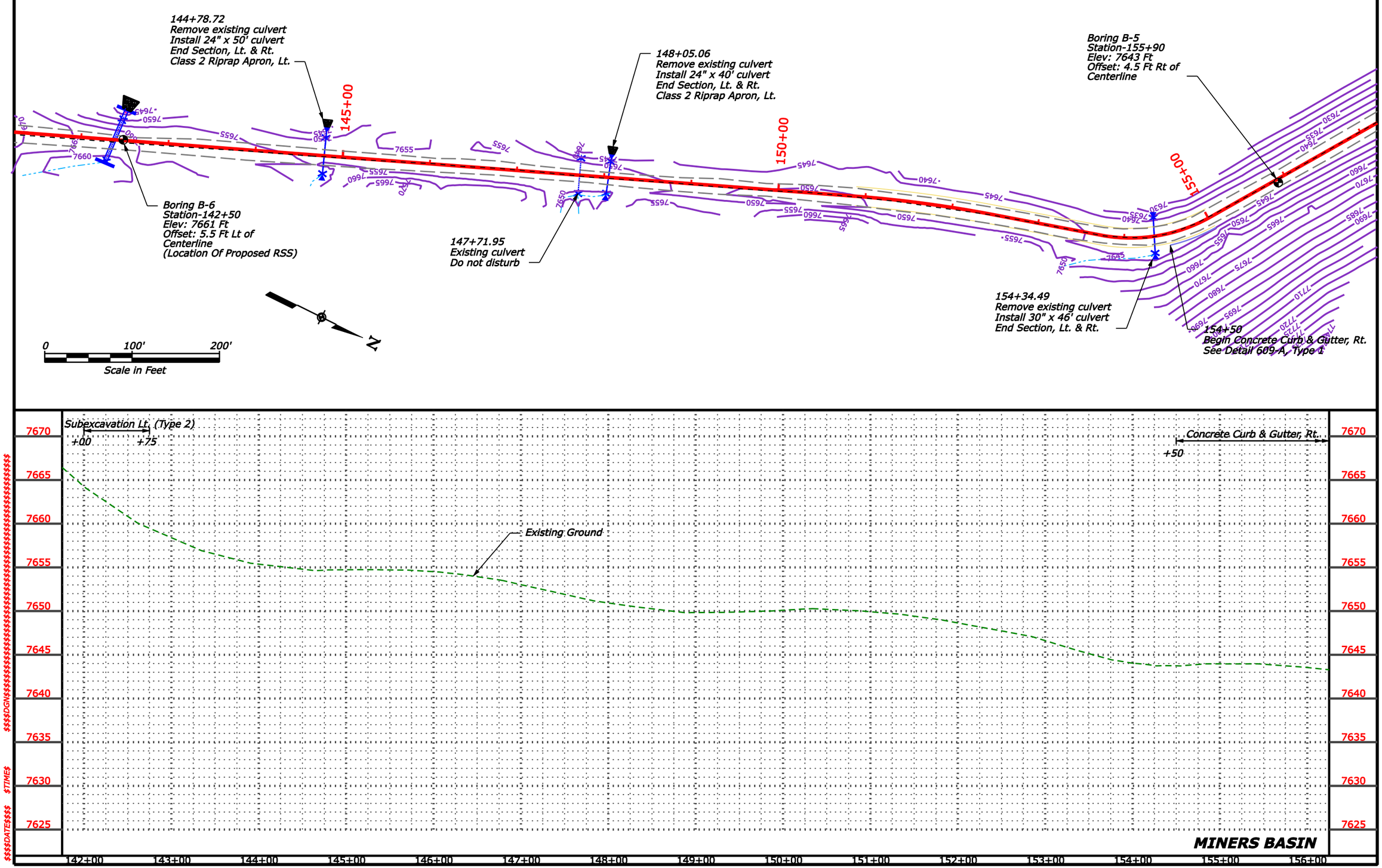
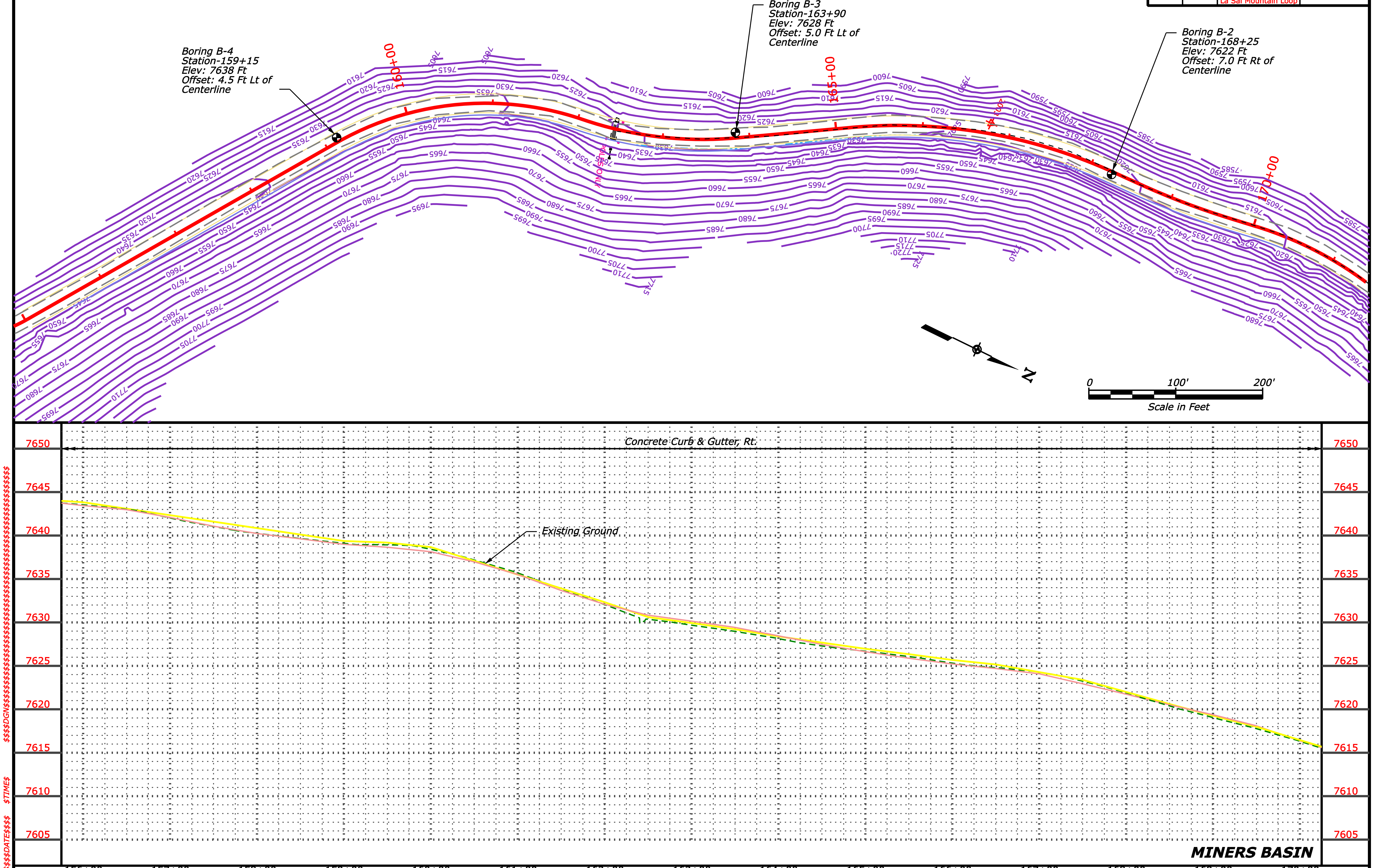
REG	STATE	PROJECT	Figure
R4	UT	UT PFH 46-1(2) La Sal Mountain Loop	A6



REG	STATE	PROJECT	Figure
R4	UT	UT PFH 46-1(2) La Sal Mountain Loop	A7



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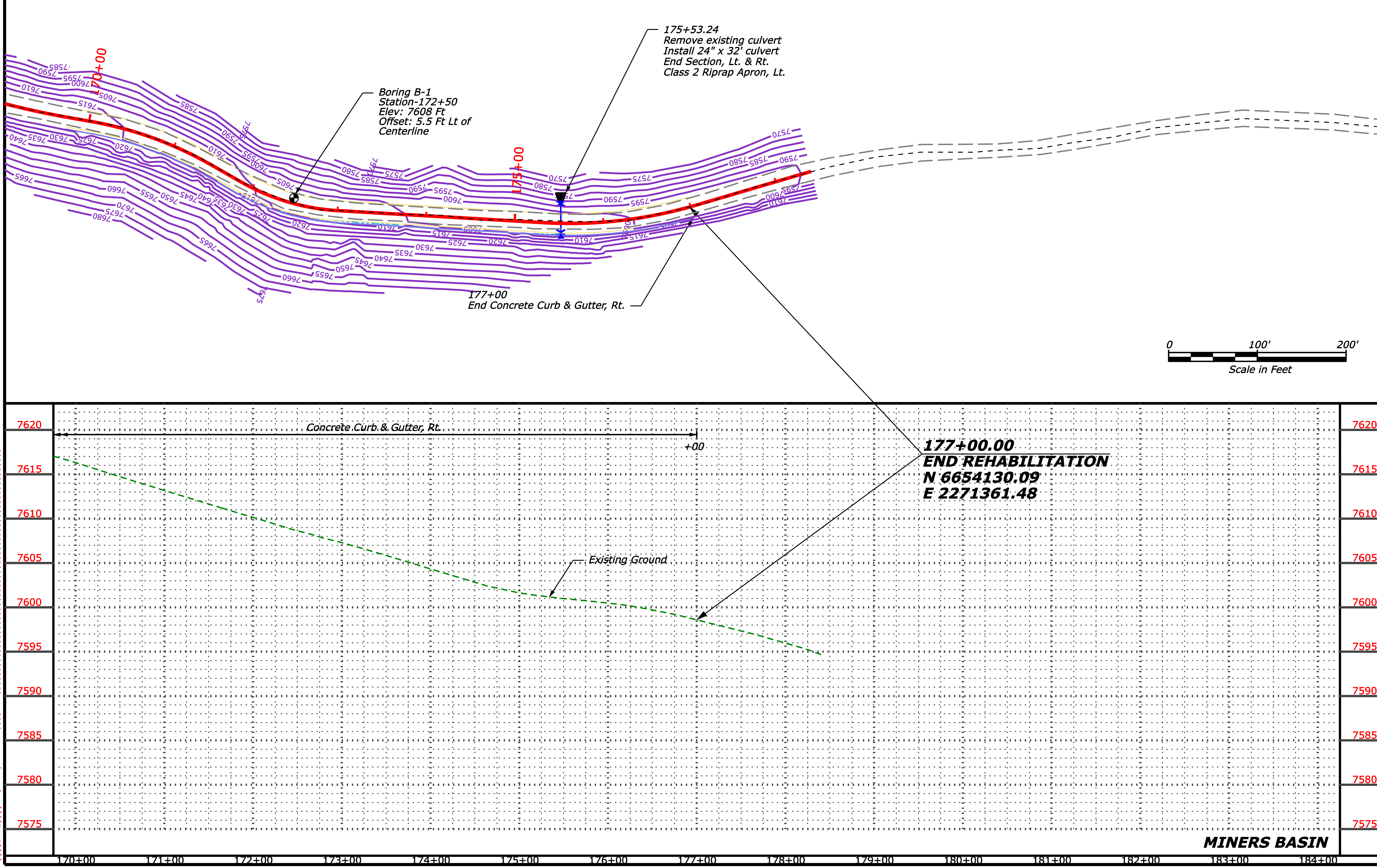
REG	STATE	PROJECT	Figure
R4	UT	UT PFH 46-1(2) La Sal Mountain Loop	A8



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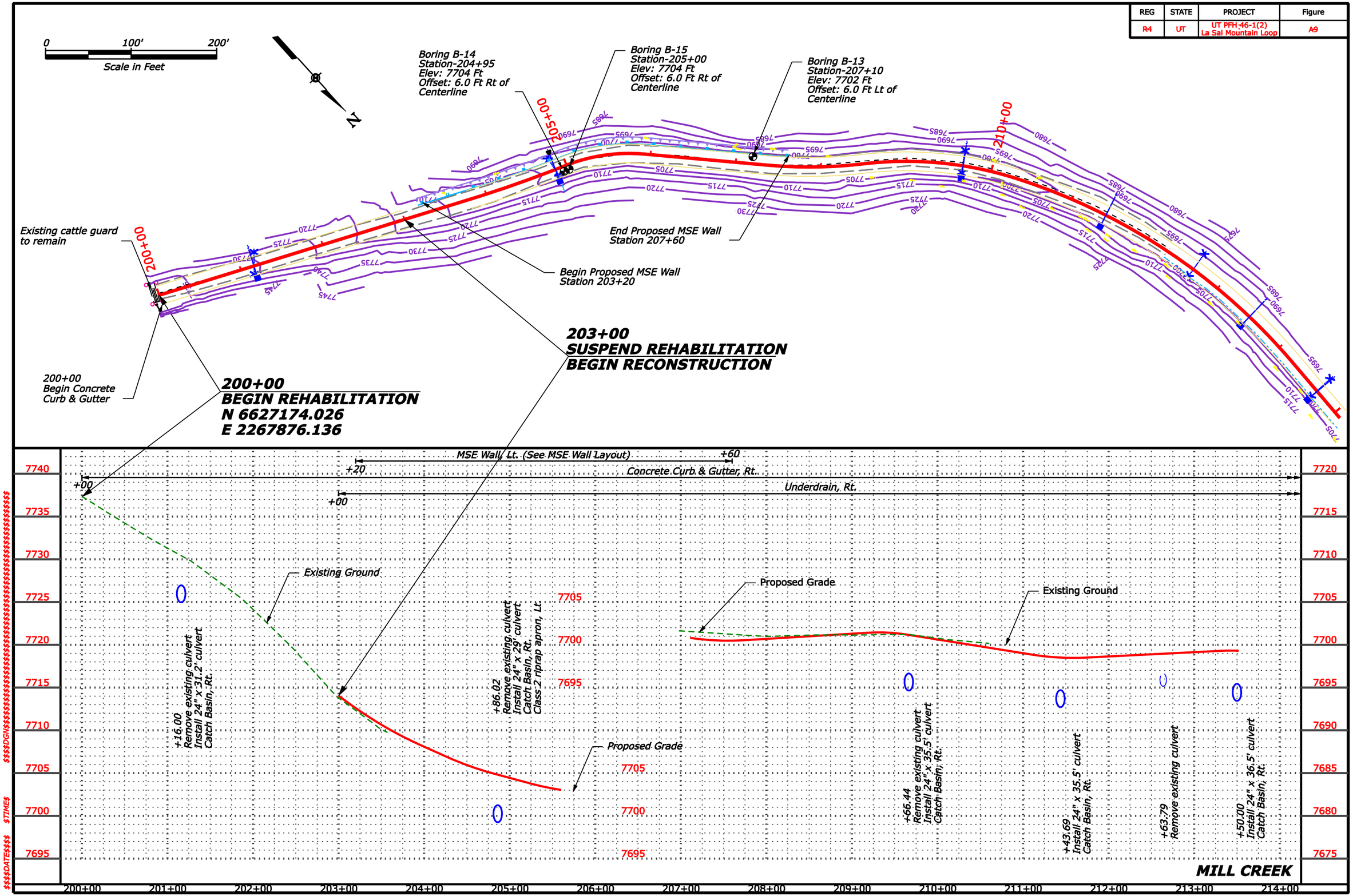
REG	STATE	PROJECT	Figure
R4	UT	UT PFH 46-1(2) La Sal Mountain Loop	A9



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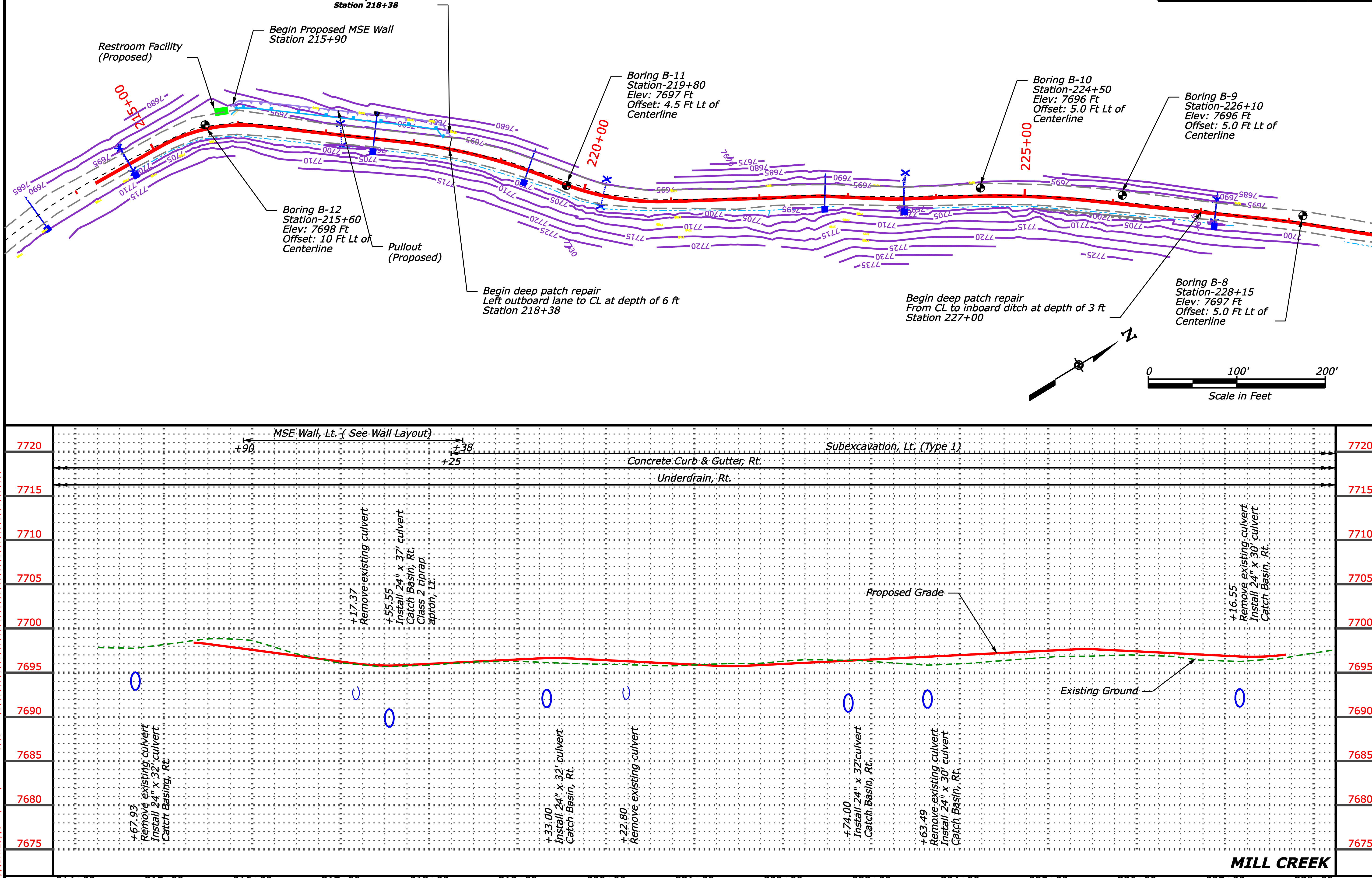
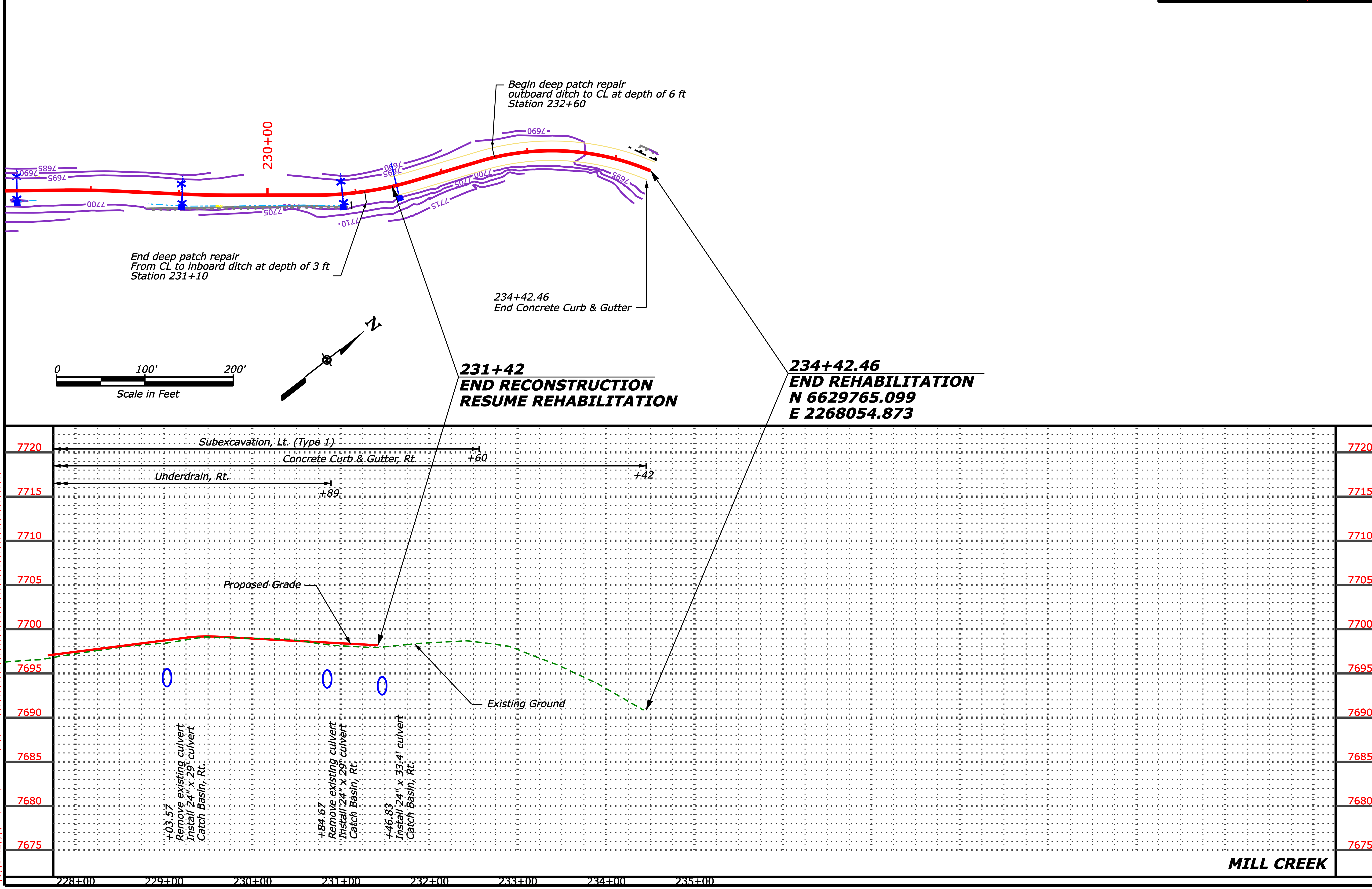
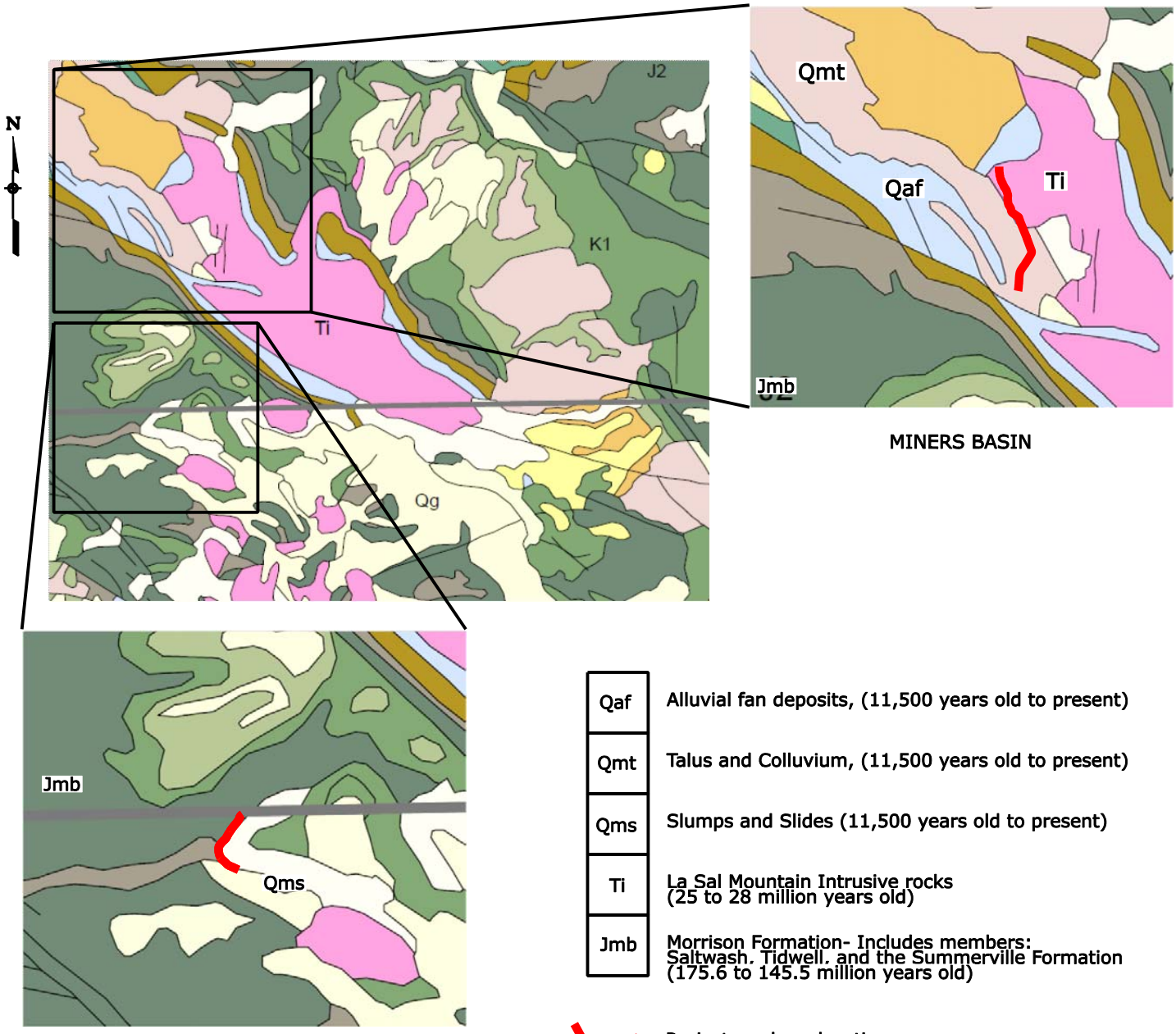
REG	STATE	PROJECT	Figure
R4	UT	UT PFH 46-1(2) La Sal Mountain Loop	A10



REG	STATE	PROJECT	Figure
R4	UT	UT PFH-46-1(2) La Sal Mountain Loop	A11





Qaf	Alluvial fan deposits, (11,500 years old to present)
Qmt	Talus and Colluvium, (11,500 years old to present)
Qms	Slumps and Slides (11,500 years old to present)
Ti	La Sal Mountain Intrusive rocks (25 to 28 million years old)
Jmb	Morrison Formation- Includes members: Saltwash, Tidwell, and the Summerville Formation (175.6 to 145.5 million years old)

Project roadway location

Source: geology.utah.gov/maps/geomap/statemap/pdf/digitalgeoutah.pdf

FIGURE A12:- Geologic Map of Miners Basin and Mill Creek

La Sal Mountain Loop Road
Burn Area and Mill Creek
UT PFH 46-1(2)

APPENDIX B

BORING LOGS

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SOIL CLASSIFICATION CHART & LEGEND

Unified Soil Classification System

MAJOR DIVISIONS				TYPICAL NAMES
COARSE-GRAINED SOILS MORE THAN HALF IS COARSER THAN NO. 200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS WITH LESS THAN 15% FINES	GW	WELL-GRADED GRAVELS WITH OR WITHOUT SAND
			GP	POORLY-GRADED GRAVELS WITH OR WITHOUT SAND
		GRAVELS WITH 15% OR MORE FINES	GM	SILTY GRAVELS WITH OR WITHOUT SAND
			GC	CLAYEY GRAVELS WITH OR WITHOUT SAND
	SANDS MORE THAN HALF COARSE FRACTION IS FINER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LESS THAN 15% FINES	SW	WELL-GRADED SANDS WITH OR WITHOUT GRAVEL
			SP	POORLY-GRADED SANDS WITH OR WITHOUT GRAVEL
		SANDS WITH 15% OR MORE FINES	SM	SILTY SANDS WITH OR WITHOUT GRAVEL
			SC	CLAYEY SANDS WITH OR WITHOUT GRAVEL
FINE-GRAINED SOILS MORE THAN HALF IS FINER THAN NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT 50% OR LESS		ML	INORGANIC SILTS OF LOW TO MEDIUM PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			OL	ORGANIC SILTS OR CLAYS OF LOW TO MEDIUM PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%		MH	INORGANIC SILTS OF HIGH PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			CH	INORGANIC CLAYS OF HIGH PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
			OH	ORGANIC SILTS OR CLAYS OF HIGH PLASTICITY WITH OR WITHOUT SAND OR GRAVEL
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS

NOTE: Coarse-grained soils with between 5% and 12% passing the No.200 sieve and fine-grained soils with limits plotting in the gray zone on the plasticity chart have dual classifications.

Abbreviations

- ▽ Water Level at Time of Drilling
- ▼ Stabilized Water Level
- **UC** Unconfined Compression
- **NR** No Recovery
- **LL** Liquid Limit
- **PI** Plastic Index
- **W** Moisture Content
- **DD** Dry Density
- **NP** Non Plastic
- **NV** No Valve

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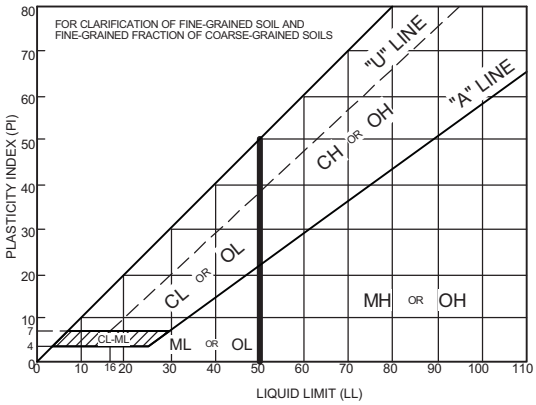
SOIL CLASSIFICATION CHART & LEGEND



Plasticity Chart

PENETRATION RESISTANCE (RECORDED AS BLOWS / 0.5 FT)				
SAND & GRAVEL		SILT & CLAY		
RELATIVE DENSITY	BLOWS/FOOT	CONSISTENCY	BLOWS/FOOT	COMPRESSIVE STRENGTH (TSF)
VERY LOOSE	0 - 4	VERY SOFT	0 - 1	0 - 0.25
LOOSE	5 - 10	SOFT	2 - 4	0.25 - 0.50
MEDIUM DENSE	11 - 30	FIRM	5 - 8	0.50 - 1.0
DENSE	31 - 50	STIFF	9 - 15	1.0 - 2.0
VERY DENSE	OVER 50	VERY STIFF	16 - 30	2.0 - 4.0
		HARD	OVER 30	OVER 4.0

MOISTURE CONTENT	
DRY	Dusty, dry to the touch
MOIST	Damp, but no visible free water
WET	Visible free water, saturated, over optimum

Material	Particle Size		Material	Particle Size	
	mm	Sieve		mm	Sieve sizes
Gravel			Silt or clay	< 0.074	< #200
Fine	4.76 to 19.1	#4 to 3/4 in.	Sand		
Coarse	19.1 to 76.2	3/4 in. to 3 in.	Fine	0.074 to 0.42	#200 to #40
Cobble	76.2 to 304.8	3 in. to 12 in.	Medium	0.42 to 2.00	#40 to #10
Boulders	304.8 to 914.4	12 in. to 36 in.	Coarse	2.00 to 4.76	#10 to #4

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-1	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 172+50, 5.5 ft. LT	Type of Boring: Auger/Core		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/19/11	Completed: 7/19/11	
Field Logged By: D. Monarco	Ground Elev: 7608.0 ft.	Weather: PC	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7607.8* *7605*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 3.0 ft. **silty SAND with gravel** (FILL); yellow brown, dry 3.0 - 27.0 ft. **clayey SAND with gravel**, dense, brown to red brown, dry to moist
SPT 1	5			0.20 13%		4/5/20	SPT 1 Rec. 0.2 ft. of rhyolite gravel. Blow counts high due to gravel in sampler shoe.
AR 2							AR 2 Augered on/through boulder from 7' to 9'.
SPT 2	10			0.20 13%		7/12/17	SPT 2 Rec. 0.2 ft. of rhyolite gravel, light tan recovered. High blow counts due to gravel.
AR 3							AR 3 Mostly rock fragments. Very hard drilling at 13'. Auger refusal at 13.5' and started coring.
RCN 1				0.00 0%			RCN 1 No recovery. Back into soil at 14'.
RCN 2	15			0.80 20%	0		RCN 2 Rec. 0.8 ft. of clayey sand, brown (6") and rhyolite rock fragment. Very easy drilling 17' to 19'. Returned to Auger drilling.
SPT 3	20			1.00 67%		10/14/15	SPT 3 Rec. 1 ft. of clayey sand with fine gravels, dense, red brown, dry to moist.
AR 4							AR 4
SPT 4	25			1.00 67%		9/12/18	SPT 4 Rec. 1 ft. of clayey sand, last 4" rhyolite fractured from SPT.
AR 5	*7581* *7579*						AR 5 27.0 - 29.0 ft. RHYOLITE; yellow brown, fractured, very hard drilling Auger refusal.
	30						No groundwater detected. BHT at 29.0 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-2	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 168+25, 7 ft. RT	Type of Boring: Auger/Core		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/19/11	Completed: 7/19/11	
Field Logged By: D. Monarco	Ground Elev: 7622.0 ft.	Weather: PC	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7621.8* *7619*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 Auger jumping and popping. Did not take SPT sample. 0.2 - 3.0 ft. **silty SAND with gravel** (FILL); yellow brown, dry to 3', fill with yellow brown rhyolite 3.0 - 14.5 ft. RHYOLITE; moderately to weathered, yellow brown to tan
AR 2	5						AR 2
RCN 1	10			1.10 31%	0		RCN 1 Rec. 1.1 ft. of Iron staining along joints. Good circulation.
RCN 2	*7607.5*			0.00 0%			RCN 2 No recovery. Lost water return, rig out of water. Approximately 300 gallons of water used on hole.
	15 20 25 30						No groundwater detected. BHT at 14.5 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-3	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 163+90, 5 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/19/11	Completed: 7/19/11	
Field Logged By: D. Monarco	Ground Elev: 7628.0 ft.	Weather: Cloudy	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7627.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 20.5 ft. **silty SAND with gravel**, loose to dense, light brown to tan, dry to moist, fine gravels of rhyolite
SPT 1	5			0.25 17%		10/8/6	SPT 1 Rec. 0.25 ft. of gravelly sand, medium dense, light tan to brown, dry.
AR 2							AR 2
SPT 2	10			1.20 80%		2/2/2	SPT 2 Rec. 1.2 ft. of silty sand, very loose, light tan to yellow brown, dry to moist, fine to medium grained.
AR 3							AR 3
SPT 3	15			1.33 89%		11/13/17	SPT 3 Rec. 1.33 ft. of silty sand, dense, light tan to yellow brown, dry to moist, fine to medium grained and fine gravels of rhyolite.
AR 4							AR 4 Boulder from 17' to 18'.
SPT 4	20			1.50 100%		13/17/26	SPT 4 Rec. 1.5 ft. of silty sand with fine gravels in the bottom 4 inches.
AR 5	*7607.5* *7605*						20.5 - 23.0 ft. **sandy CLAY**, dark brown AR 5 23.0 - 25.5 ft. RHYOLITE; yellow brown, decomposed
SPT 5	25 *7602.5*			1.50 100%		9/12/20	SPT 5 Rec. 1.5 ft. of rhyolite, decomposed, dense.
	30						No groundwater detected. BHT at 25.5 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-4	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 159+15, 4.5 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/19/11	Completed: 7/19/11	
Field Logged By: D. Monarco	Ground Elev: 7638.0 ft.	Weather: Cloudy	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7637.8* *7635*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 3.0 ft. **silty SANDwith gravel**(FILL); yellow brown, dry to moist, fill consisting of tan clayey sand 3.0 - 27.0 ft. **clayey SAND with gravel (SC)**very loose to dense, yellow brown to red brown
SPT 1	5		SC	0.25 17%		3/0/0	SPT 1 Rec. 0.25 ft. of clayey sand with fine gravel, very loose, yellow brown, dry to moist. SPT sampler advanced the last 12" from the weight of the hammer.
AR 2							AR 2
SPT 2	10		SC	1.20 80%		3/7/8	SPT 2 Rec. 1.2 ft. of clayey sand, medium dense, yellow brown, moist, fine to medium grained sand, some fine gravels.
AR 3							AR 3
SPT 3	15			1.30 87%		7/10/8	SPT 3 Rec. 1.3 ft. of residual soil.
AR 4							AR 4 Residual soil from 15.5' to 17'. Decomposed rhyolite from 17' to 19'. Drilling becoming more difficult, cuttings are sand.
SPT 4	20			1.30 87%		5/12/13	SPT 4 Rec. 1.3 ft. of decomposed rhyolite, with inclusions of harder rhyolite gravels.
AR 5							AR 5 Denser material and harder drilling with depth.
SPT 5	25			1.50 100%		13/32/41	SPT 5 Rec. 1.5 ft. of rhyolite, tan to brown, decomposed to predominantly decomposed, very dense. Some iron staining and slightly weathered fine rhyolite gravels.
	7611 *7609* 30						27.0 - 29.0 ft. RHYOLITE; yellow brown, fractured No groundwater detected. BHT at 29.0 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-5	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 155+90, 4.5 ft. RT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/20/11	Completed: 7/20/11	
Field Logged By: D. Monarco	Ground Elev: 7643.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7642.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 5.0 ft. **silty SAND with gravel** (FILL); yellow brown, dry, fill containing fine gravels
SPT 1	*7638* 5		SC-SM	1.30 87%		4/5/14	SPT 1 Rec. 1.3 ft. of sand, dark brown, dry for the upper 9" and residual soil, tan, dense for last 6". 5.0 - 8.0 ft. **clayey silty SAND (SC-SM)** tan (Residual soil)
AR 2	*7635*						AR 2 clayey silty sand, tan to 8' then changing to decomposed rhyolite. Harder drilling. 8.0 - 20.5 ft. RHYOLITE; yellow brown, decomposed to moderately weathered
SPT 2	10		SC-SM	1.50 100%		15/17/38	SPT 2 Rec. 1.5 ft. of rhyolite, tan, decomposed. Breaks down into tan to yellow brown to olive brown clayey sand, dry. Fe stained inclusions.
AR 3							AR 3 Hard drilling 12' to 14'. Rhyolite cuttings, moderately weathered.
SPT 3	15		SC-SM	1.00 100%		17/50	SPT 3 Rec. 1 ft. of rhyolite, yellow brown, decomposed. Breaks down into clayey sand, very dense, dry. Fe stained inclusions.
AR 4							AR 4 Varied weathered zones of rhyolite, yellow brown. Cuttings are slightly clayey sand.
SPT 4	20 *7622.5*		SC-SM	1.50 100%		15/19/20	SPT 4 Rec. 1.5 ft. of rhyolite, yellow brown, moderately weathered. Breaks down into clayey sand, dense, dry.
	25 30						No groundwater detected. BHT at 20.5 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-6	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 142+50, 5.5 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/20/11	Completed: 7/20/11	
Field Logged By: D. Monarco	Ground Elev: 7661.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7660.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 Drill bit "popping" on rock, very hard drilling. 0.2 - 14.0 ft. **clayey SAND and cobbles**; dark brown, dry
AR 2	5						AR 2 Mostly cobbles.
AR 3	10						AR 3
	7647						
SPT 1	15		CL	1.25 83%		5/9/24-5"	14.0 - 24.0 ft. **silty CLAY with cobbles and small boulders (CL)**; red brown SPT 1 Rec. 1.25 ft. of silty clay with fine gravel, red brown, dry, angular gravels in shoe. High blow counts due to gravel and not indicative of soil density.
AR 4							AR 4 Various cobbles and small boulders.
SPT 2	20			0.25 60%		50-5"	SPT 2 Rec. 0.25 ft. of silty clay with fine gravel, hard, red brown, dry. Angular gravels likely broken from drilling process and high blow counts not indicative of soil density.
AR 5	*7637*						AR 5 Mosty cobbles and boulders.
AR 6	25						24.0 - 29.5 ft. RHYOLITE; yellow brown, fractured AR 6 Mostly cobbles. No groundwater detected.
	7631.5						
	30						BHT at 29.5 ft.

BORING LOG

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FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-7	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 126+40, 5 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/20/11	Completed: 7/20/11	
Field Logged By: D. Monarco	Ground Elev: 7734.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7733.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 Drill bit "popping" on rock, very hard drilling, no SPT. 0.2 - 7.0 ft. **silty GRAVEL with sand and cobbles**, dark brown, dry
AR 2	5 *7727*						AR 2 Mostly cobbles.
	10 15 20 25 30						No groundwater detected. Auger refusal. BHT at 7.0 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)		Boring No. B-8	Date: July, 2011 / Sheet 1 of 1
Boring Location: STA 228+15, 5 ft. LT		Type of Boring: Auger	
Coordinates:		Casing Used: HSA	Size: 3.75" I.D.
Drill: CME 55	Driller: AGEC	Boring Began: 7/20/11	Completed: 7/20/11
Field Logged By: D. Monarco		Ground Elev: 7697.0 ft.	Weather: Clear
Revisions/Final By: C. Martinez		Water Depth:	
		Date:	
		Time:	

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7696.8* *7693*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 4.0 ft. **silty SAND with gravel** (FILL); dark brown, dry
SPT 1	5			0.00 0%		8/7/6	4.0 - 19.0 ft. **CLAY with gravel**, brown to dark brown SPT 1 No recovery. clay and fine rock fragments, dark brown, moist.
AR 2							AR 2
SPT 2	10			0.58 39%		3/5/4	SPT 2 Rec. 0.58 ft. of clay with fine gravel, stiff, dark brown, moist, fine-grained sandstone gravels.
AR 3							AR 3 Cuttings are clay with fine gravel, brown to dark brown, moist.
SPT 3	15			0.00 0%		3/10-0	SPT 3 No recovery. clay with fine gravel, brown to dark brown, moist. Sandstone gravel fragments in shoe.
AR 4	*7678*						AR 4 Rocky material, hard drilling 15.5' to 16.5'. Cuttings are clay with fine rock fragments, dark brown, moist. Sandstone fragments on bit when removed from hole. Easier drilling 16.6' to 17.75'. Drill bit on rock,very hard drilling 17.75' to 19'. No SPT attempted.
	20 25 30						No groundwater detected. BHT at 19.0 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-9	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 226+10, 5 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/20/11	Completed: 7/20/11	
Field Logged By: D. Monarco	Ground Elev: 7696.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7695.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 4.0 ft. **clayey SAND with gravel** (FILL); dark brown, moist
SPT 1	*7692* 5		CL	0.82 55%		4/3/22	4.0 - 20.5 ft. **sandy CLAY and gravel (CL)**; dark brown to brown, moist SPT 1 Rec. 0.82 ft. of sandy clay, dark brown, moist, some fine gravel. Organic debris present in shoe. Blow counts not indicative of soil density.
AR 2							AR 2 At 7.5' auger on rock, sandstone fragments in cuttings.
SPT 2	10		CL	1.33 89%		3/4/8	SPT 2 Rec. 1.33 ft. of slightly sandy clay, stiff, moist, mottled texture. Some organics present.
AR 3							AR 3 Various rocky material, cuttings are clay with fine gravels.
SPT 3	15		CL	1.50 100%		4/7/9	SPT 3 Rec. 1.5 ft. of sandy clay, stiff, some fine sub-angular gravel.
AR 4							AR 4
SPT 4	20 *7675.5*		CL	1.50 100%		4/8/13	SPT 4 Rec. 1.5 ft. of sandy clay, stiff, few fine sub-angular gravel.
	25 30						No groundwater detected. BHT at 20.5 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-10	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 224+50, 5 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/21/11	Completed: 7/21/11	
Field Logged By: D. Monarco	Ground Elev: 7696.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7695.8* *7692.5*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 3.5 ft. **silty SAND with gravel** (FILL); dark brown, moist
SPT 1	5			1.00 67%		4/3/4	3.5 - 12.0 ft. **sandy CLAY with gravel**; dark brown to red brown Auger on rock from 3.5' to 4'.
AR 2							SPT 1 Rec. 1 ft. of sandy clay, medium stiff, dark brown, moist, some fine angular gravel and organic debris. AR 2
SPT 2	10			1.25 83%		7/8/7	SPT 2 Rec. 1.25 ft. of slightly sandy clay, red brown, dry, fine sub angular gravels.
AR 3	*7684*						AR 3 12.0 - 20.5 ft. Interbedded SILTSTONE, red brown and SANDSTONE, white At 12' grading to brown red silt, dry.
SPT 3	15			1.33 89%		10/18/16	SPT 3 Rec. 1.33 ft. of siltstone, red brown, weathered, hard, dry.
AR 4							AR 4 sandstone, white, highly fractured.
SPT 4	20 *7675.5*			1.50 100%		43/23/34	SPT 4 Rec. 1.5 ft. of interbedded sandstone, white and siltstone, red brown.
	25 30						No groundwater detected. BHT at 20.5 ft.

BORING LOG

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CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-11	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 214+80, 4.5 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/21/11	Completed: 7/21/11	
Field Logged By: D. Monarco	Ground Elev: 7697.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7696.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 5.0 ft. **silty SAND with gravel** (FILL); dark brown, dry
SPT 1	*7692* 5			0.58 39%		2/2/2	SPT 1 Rec. 0.58 ft. of sandy clay, soft, dark brown, dry to moist, some organics. 5.0 - 11.0 ft. **sandy CLAY with gravel**; dark brown to brown
AR 2							AR 2
SPT 2	10			0.92 61%		9/12/20	SPT 2 Rec. 0.92 ft. of sandy clay, brown, dry, fine sandstone gravels. Gravel in the shoe. Blow counts not indicative of soil consistency.
AR 3	*7686* *7685*						AR 3 11.0 - 12.0 ft. clayey SILT; brown red, dry 12.0 - 14.7 ft. SILTSTONE; red brown
SPT 3	*7682.3* 15			0.50 100%		19/10-0	SPT 3 Rec. 0.5 ft. of siltstone, red brown, weathered, very hard, dry.
AR 4							AR 4 No groundwater detected. Auger refusal. BHT at 14.7 ft.
	20						
	25						
	30						

BORING LOG

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FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)		Boring No. B-12	Date: July, 2011 / Sheet 1 of 1
Boring Location: STA 215+60, 10 ft. LT		Type of Boring: Auger	
Coordinates:		Casing Used: HSA	Size: 3.75" I.D.
Drill: CME 55	Driller: AGEC	Boring Began: 7/21/11	Completed: 7/21/11
Field Logged By: D. Monarco		Ground Elev: 7698.0 ft.	Weather: Clear
Revisions/Final By: C. Martinez		Water Depth:	
		Date:	
		Time:	

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7697.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 4.0 ft. **SAND with gravel**(FILL); dark brown, dry
	7694						
SPT 1	5			1.33 89%		8/9/10	4.0 - 7.0 ft. **CLAY with gravel**, red brown SPT 1 Rec. 1.33 ft. of clay with fine gravel, very stiff, red brown, dry.
AR 2	*7691*						AR 2 7.0 - 8.5 ft. Interbedded SILTSTONE, red brown and SANDSTONE
	7689.5						Drill bit "popping" on rock 7' - 8'. Cuttings siltstone, red brown with interbedded sandstone.
	10						No groundwater detected. Auger refusal. BHT at 8.5 ft.
	15						
	20						
	25						
	30						

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-13	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 207+10, 6 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/21/11	Completed: 7/21/11	
Field Logged By: D. Monarco	Ground Elev: 7702.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7701.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 4.0 ft. **SAND with gravel**(FILL); dark brown, dry
SPT 1	*7698* 5		CL	1.25 88%		6/27/50-5"	4.0 - 11.5 ft. **sandy CLAY with gravel (CL)**dark brown to gray, dry SPT 1 Rec. 1.25 ft. of sandy clay with sandstone gravel, dark brown to gray. Sandstone fragment in sampler shoe. High blow counts due to presence of gravels and not indicative of soil consistency.
AR 2							AR 2 Various rock.
SPT 2	10		CL	1.50 100%		15/21/21	SPT 2 Rec. 1.5 ft. of sandy clay, dark brown, dry (4") and sandy clay with fine sandstone gravels, hard, dark brown, dry.
AR 3	*7690.5* *7690*						AR 3 11.5 - 12.0 ft. clayey SILT; red, dry Changing to siltstone, red from 12' to 14'. 12.0 - 18.4 ft. Interbedded SILTSTONE, red and SANDSTONE, white
SPT 3	15			1.50 100%		12/18/23	SPT 3 Rec. 1.5 ft. of interbedded siltstone, weak, red and sandstone medium strong to strong, white, dry.
AR 4							AR 4 Cuttings are red silt. Driller notes drilling getting harder with depth.
SPT 4	*7683.6*			0.00 0%		50-5"	SPT 4 No recovery.
	20						No groundwater detected. BHT at 18.4 ft.
	25						
	30						

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-14	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 204+95, 6 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/21/11	Completed: 7/21/11	
Field Logged By: D. Monarco	Ground Elev: 7704.0 ft.	Weather: Clear	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7703.8* / *7702* / *7700*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 Cobble to boulders in a matrix of brown sand. 0.2 - 2.0 ft. **SAND with gravel**(FILL); dark brown 2.0 - 4.0 ft. **SAND with rock fragments**, brown
SPT 1	5			1.00 67%		3/10/20	4.0 - 7.8 ft. **sandy CLAY with GRAVEL**, red brown SPT 1 Rec. 1 ft. of sandy clay, red brown, moist, few organics.
AR 2	*7696.2*						AR 2 Drilling on boulder. Relocated boring 5' upstation (see B-15).
	10 15 20 25 30						No groundwater detected. Auger refusal at 7.75'. BHT at 7.8 ft.

BORING LOG

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

Project Name: La Sal Mountain Loop, UT PFH 46-1(2)	Boring No. B-15	Date: July, 2011	Sheet 1 of 1
Boring Location: STA 205+00, 6 ft. LT	Type of Boring: Auger		
Coordinates:	Casing Used: HSA	Size: 3.75" I.D.	
Drill: CME 55 / Driller: AGEC	Boring Began: 7/21/11	Completed: 7/21/11	
Field Logged By: D. Monarco	Ground Elev: 7704.0 ft.	Weather: Clear, breezy	
Revisions/Final By: C. Martinez	Water Depth:		
	Date:		
	Time:		

Run/Samp No.	Depth *Elevation* (feet)	Graphic Log	U.S.C.S.	Length Recov. feet ----- % Rec.	RQD	SPT Blows per 6 in	Description: (Density, Color, Type, Moisture, Other)
AR 1	*7703.8*						0.0 - 0.2 ft. **ASPHALT PAVEMENT** AR 1 0.2 - 4.0 ft. **silty SAND with gravel** (FILL); dark brown, dry to moist
SPT 1	*7700* 5		SC	1.50 100%		7/8/9	4.0 - 7.0 ft. **sandy CLAY with gravel (SC)** very stiff, red brown, moist SPT 1 Rec. 1.5 ft. of sandy clay with some fine gravels, very stiff, red brown, moist.
AR 2	*7697*						AR 2 Mostly rock fragments from 5.5' to 7'. 7.0 - 10.5 ft. **sandy CLAY with gravel (SC)** brown red, moist Sandy clay, brown red from 7' to 9'.
SPT 2	*7693.5* 10		SC	1.50 100%		24/7/6	SPT 2 Rec. 1.5 ft. of sandstone cobble, white (6") and sandy clay, red brown, moist (12").
AR 3	*7690*						10.5 - 14.0 ft. **sandy SILT with rock fragments (SC)** brown red AR 3 Sandy silt, brown red with cobble-size sandstone rock fragments, dry.
SPT 3	15			1.50 100%		13/12/36	14.0 - 17.8 ft. SILTSTONE; hard, brown red SPT 3 Rec. 1.5 ft. of siltstone, hard, brown red, dry.
AR 4	*7686.2*						AR 4 Grading into siltstone, red. Very hard drilling at 17.25'.
	20 25 30						No groundwater detected. Auger refusal. BHT at 17.8 ft.

APPENDIX C

PHOTOGRAPHS

FIGURE C1:- Photo-Miners Basin (Top-Boring B-1: Station 172+50, Bottom-Boring B-2: Station 168+25)

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

FIGURE C2:- Photo-Miners Basin (Top-Boring B-3: Station 163+90, Bottom-Boring B-4: Station 159+15)

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

FIGURE C3:- Photo-Miners Basin (Top-Boring B-5: Station 155+90, Bottom-Boring B-6: Station 142+50) B-6 at proposed Reinforced Soil Slope, (RSS)

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

FIGURE C4:- Photo-Miners Basin Boring B-7: Station 126+40 Proposed Box Culvert

FIGURE C5:- Photo-Mill Creek (Top-Boring B-8: Station 228+15, Bottom-Boring B-9: Station 226+10)

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

FIGURE C6:- Photo-Mill Creek (Top-Boring B-10: Station 224+50, Bottom-Boring B-11: Station 219+80)

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

FIGURE C7:- Photo-Mill Creek (Top-Boring B-12: Station 215+60, Bottom-Boring B-13: Station 207+10) Proposed MSE walls.

FIGURE C8:- Photo-Mill Creek (Top-Boring B-14: Station 204+95, Bottom-Boring B-15: Station 205+00)

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

Figure C9:- Photos- Miners Basin (Top-Station 160+50 looking ahead, Bottom-167+75 looking ahead)

La Sal Mountain Loop Road
Miners Basin & Mill Creek
UT PFH 46-1(2)

FIGURE C10:- Photos Mill Creek Proposed Deep Patch Typical Locations (Top- Station 227+00 looking ahead, Bottom- Station 229+00 looking ahead.

APPENDIX D

LABORATORY TEST RESULTS

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

AASHTO R18 ISO/IEC 17025

Report of Soil or Aggregate Tests

Project: Utah PFH 46-1(2) La Sal Mountain

Submitted By: Charlie Martinez & Dominic Monarco

Date Reported: 8/11/2011

Sample Number	Lab Number		11-973-SB	11-974-SB	11-975-SB	11-976-SB	11-977-SB
	Hole Number		B-4	B-5	B-6	B-9	B-13 & B-15
	Field Number		SPT 1 & 2	SPT 1-4	SPT 1 & 2	SPT 1-4	Combined
Sample Location	Station or Location		159+15	155+50	142+50	223+50	207+10 & 205+00
	Offset		Left	Left	Left	Left	Not Furnished
	Depth	Feet	4-10	4-20.5	14.5-20.5	4-20.5	14-15.5
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm					
	1"	25.0 mm	100	100	100	100	
	3/4"	19.0 mm	97	99	97	99	
	1/2"	12.5 mm	96	98	90	97	100
	3/8"	9.5 mm	95	97	88	95	99
	#4	4.75 mm	88	95	84	94	99
	#8	2.36 mm					
	#10	2.00 mm	65	80	79	91	98
	#16	1.18 mm	53	68	74	89	98
	#30	600 µm					
	#40	425 µm	36	46	66	86	96
	#50	300 µm					
	#100	150 µm	24	31	58	78	94
	#200	75 µm	19	24	51	66	92
		20 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		31	26	26	38	27
	Plasticity Index		11	6	13	26	11
Soil Classification	AASHTO M 145		A-2-6 (0)	A-1-b (0)	A-6 (3)	A-6 (14)	A-6 (8)
	ASTM D 2487		SC	SC-SM	CL	CL	CL
AASHTO T 190	R – Value						
AASHTO T 288	Min. Resistivity, ohm x cm						
AASHTO T 289	pH						
AASHTO T 290	Sulfate Content, % / ppm						
AASHTO T 291	Chloride Content, % / ppm						

Distribution:

Num. / Project File	
Laboratory	Darrell Harding
Geotechnical	Charlie Martinez
Geotechnical	Dominic Monarco
Materials	Mike Peabody

Remarks:

Reported By:

Darrell Harding
Laboratory Manager

Form FHWA 1702 Rev. 02/10

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

AASHTO R18 ISO/IEC 17025

Report of Soil or Aggregate Tests

Project: Utah PFH 46-1(2) La Sal Mountain

Submitted By: Charlie Martinez & Dominic Monarco

Date Reported: 8/11/2011

Sample Number	Lab Number		11-978-SB		11-977 & 978-SB		
	Hole Number		B-15		B-13 & B-15		
	Field Number		SPT 1 & 2		Combined		
Sample Location	Station or Location		205+00		207+10 & 205+00		
	Offset		Right		Not Furnished		
	Depth	Feet	4-10.5		Combined		
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm					
	1"	25.0 mm	100				
	3/4"	19.0 mm	94				
	1/2"	12.5 mm	90				
	3/8"	9.5 mm	89				
	#4	4.75 mm	84				
	#8	2.36 mm					
	#10	2.00 mm	77				
	#16	1.18 mm	74				
	#30	600 µm					
	#40	425 µm	70				
	#50	300 µm					
	#100	150 µm	62				
	#200	75 µm	45				
		20 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		23				
	Plasticity Index		12				
Soil Classification	AASHTO M 145		A-6 (2)				
	ASTM D 2487		SC				
AASHTO T 190	R – Value						
AASHTO T 288	Min. Resistivity, ohm x cm				2060		
AASHTO T 289	pH				8.1		
AASHTO T 290	Sulfate Content, % / ppm				0.004 / 40		
AASHTO T 291	Chloride Content, % / ppm				0.0013 / 13		

Distribution:

Num. / Project File	
Laboratory	Darrell Harding
Geotechnical	Charlie Martinez
Geotechnical	Dominic Monarco
Materials	Mike Peabody

Remarks:

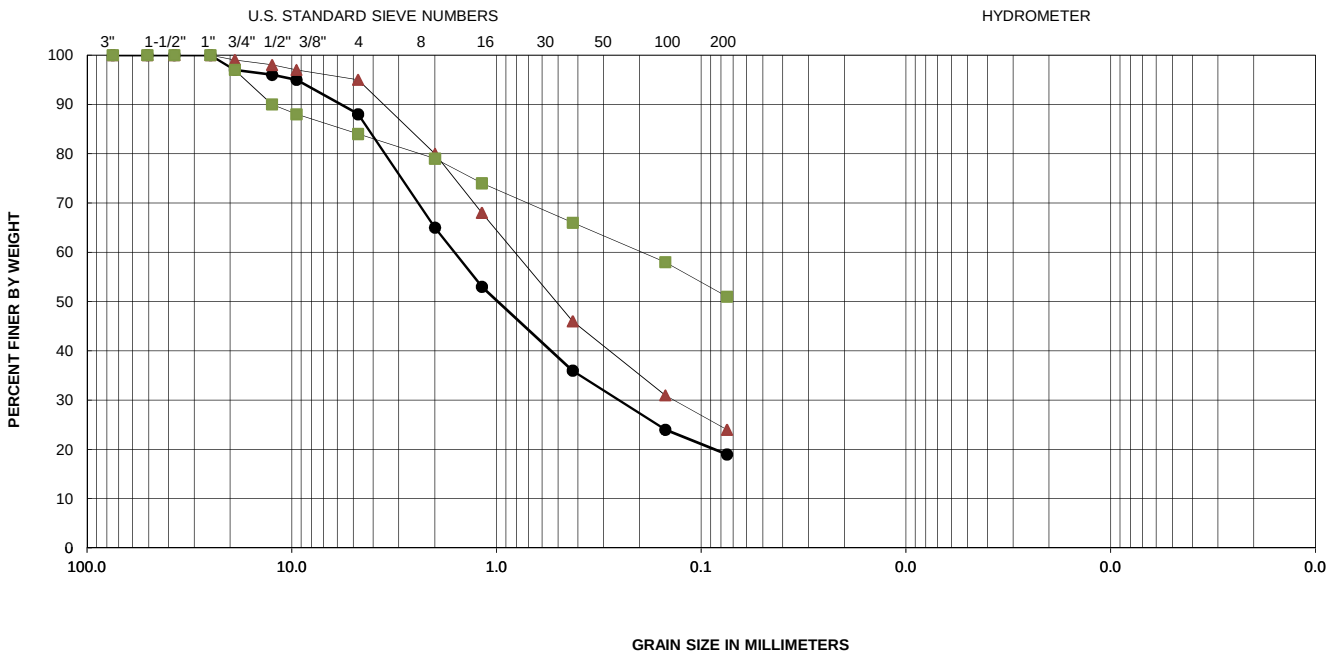
Reported By:

Darrell Harding
Laboratory Manager

Form FHWA 1702 Rev. 02/10

U.S. Department of Transportation
Federal Highway Administration

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-4	4.0' - 10.0'	31	20	11	--	--	--	--	--	19	SC
▲	B-5	4.0' - 20.5'	26	20	6	--	--	--	--	--	24	SC-SM
■	B-6	14.5 - 20.5	26	13	13	--	--	--	--	--	51	CL
◆	0	0	--	--	--	--	--	--	--	--	0	0

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422-63

US. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

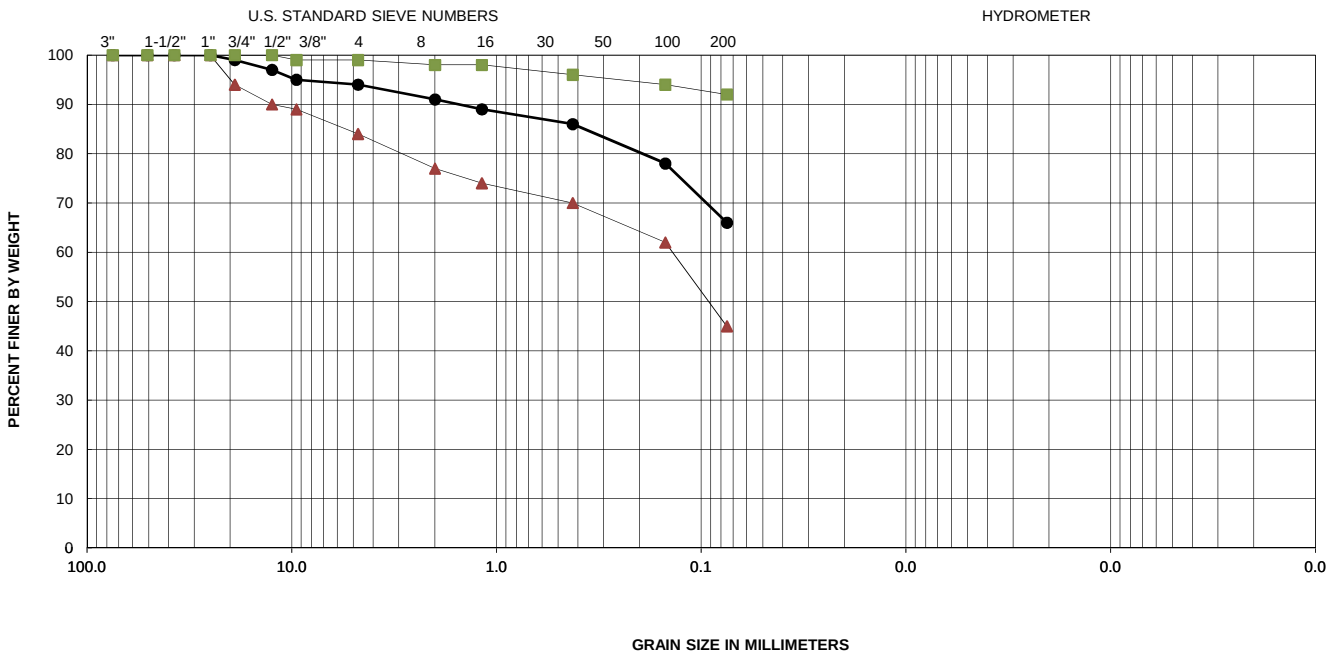
GRADATION TEST RESULTS

UT PFH 46-1(2)
La Sal Mountain Loop Road
Miners Basin

PROJECT NO.	DATE	FIGURE
UT PFH 46-1(2)	11/2011	D3

U.S. Department of Transportation
Federal Highway Administration

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-9	4.0' - 20.5'	38	12	26	--	--	--	--	--	66	CL
▲	B-15	4.0' - 10.5'	23	11	12	--	--	--	--	--	45	SC
■	B-13/B-15	14.0 - 15.5	27	16	11	--	--	--	--	--	92	CL
◆	0	0	--	--	--	--	--	--	--	--	0	0

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422-63

US. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

GRADATION TEST RESULTS

UT PFH 46-1(2)
La Sal Mountain Loop Road
Mill Creek

PROJECT NO.	DATE	FIGURE
UT PFH 46-1(2)	11/2011	D4

APPENDIX E

RSS ANALYSIS

La Sal Loop Road - Mill Creek Section

Report created by ReSSA(3.0): Copyright (c) 2001-2008, ADAMA Engineering, Inc.

PROJECT IDENTIFICATION

Title:	La Sal Loop Road - Mill Creek Section
Project Number:	UT-PFH-46-1(2) -
Client:	
Designer:	Braden Peters
Station Number:	12 foot High 1:1 Slope

Description:

Company's information:

Name:	Central Federal Lands Highway Division
Street:	12300 West Dakota Ave Lakewood, CO 80228
Telephone #:	
Fax #:	
E-Mail:	

Original file path and name: N:\UT\ut46-1(2)\Geotech\5 Analysis\RSS\12ft 1 1 slope.MSE
Original date and time of creating this file: Thu Mar 08 16:18:50 2012

PROGRAM MODE: Analysis of a Simplified Slope using GEOSYNTHETIC as reinforcing material.

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INPUT DATA (EXCLUDING REINFORCEMENT LAYOUT)

SOIL DATA

========== Soil Layer #: ==========	Unit weight, γ [lb/ft ³]	Internal angle of friction, ϕ [deg.]	Cohesion, c [lb/ft ²]
REINFORCED SOIL.....	125.0	34.0	0.0
RETAINED SOIL.....	125.0	30.0	200.0
FOUNDATION SOIL.....	125.0	30.0	200.0

REINFORCEMENT

Reinforcement Type #	Geosynthetic Designated Name	Ultimate Strength, Tult [lb/ft]	Reduction Factor for Installation Damage, RFid	Reduction Factor for Durability, RFd	Reduction Factor for Creep, RFc	Additional Reduction Factor, RFa	Coverage Ratio, Rc
1	Geosynthetic type #1	2000.00	1.20	1.10	1.67	1.00	1.00

Interaction Parameters Type #	Geosynthetic Designated Name	== Direct Sliding == Cds-phi	Cds-c	==== Pullout ==== Ci	Alpha
1	Geosynthetic type #1	0.80	0.00	0.80	0.80

Relative Orientation of Reinforcement Force, ROR = 0.00. Assigned Factor of Safety to resist pullout, Fs-po = 1.50
Design method for Global Stability: Comprehensive Bishop.

WATER

Unit weight of water = 62.45 [lb/ft ³]
Water ponding is defined by 'phreatic surface' in Total Stress Analysis.

SEISMICITY

Not Applicable

ANALYSIS w/ $A_o = 0.072$ AND $K_h = \frac{1}{2} A_o$

$FS_{MIN} = 1.34$ FOR CONTROLLING MODE OF FAILURE (SLIDING)

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DRAWING OF SPECIFIED GEOMETRY - SIMPLE

GEOMETRY

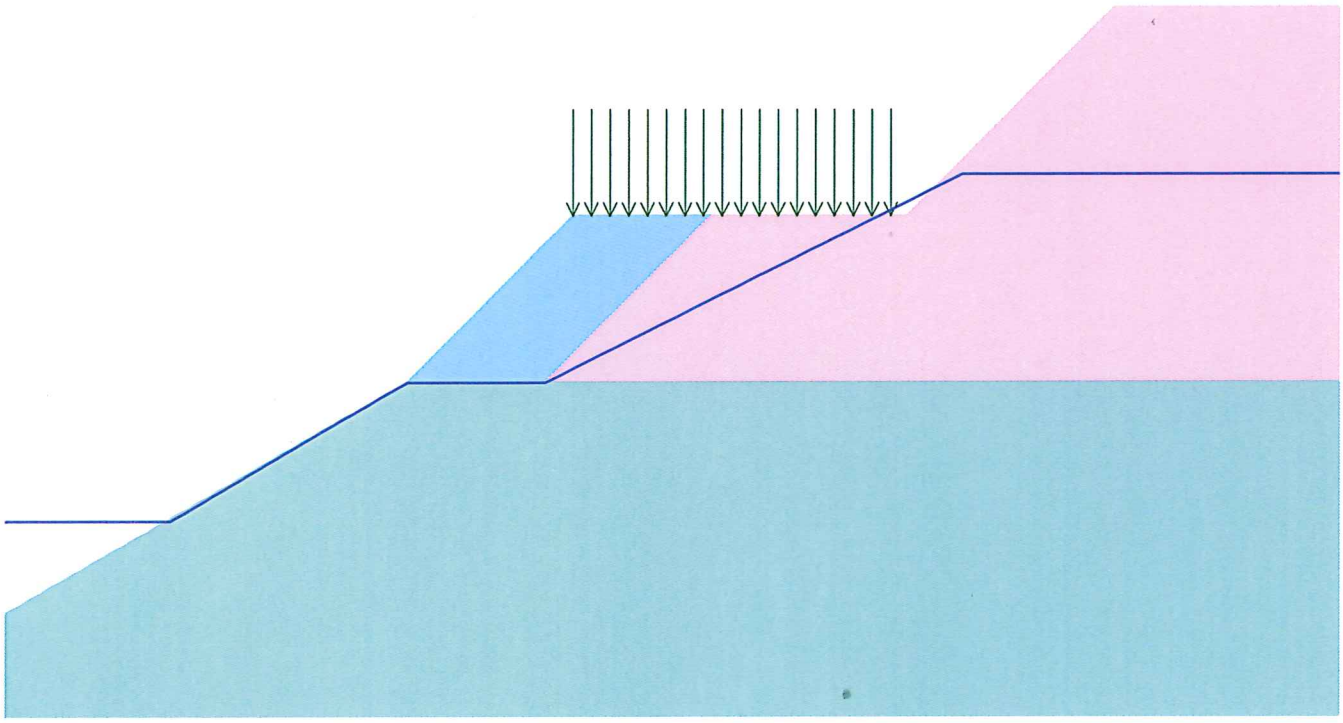
Height of slope, H	12.00	[ft]
Slope angle, i	45.00	[deg.]
Horizontal crest length, A	24.00	[ft]
Horizontal crest length, B	24.00	[ft]
Backslope angle, β	45.00	[deg.]
Sloping angle, α	30.00	[deg.]

UNIFORM SURCHARGE

Surcharge load over A, Q1	250.00	[lb/ft²]
Surcharge load over backslope B, Q2	0.00	[lb/ft²]
Surcharge load away from backslope, Q3	0.00	[lb/ft²]

WATER GEOMETRY Coordinates of water line in [ft]

#	1	Xw =	-17.00	Yw =	-10.00
#	2	Xw =	0.00	Yw =	0.00
#	3	Xw =	10.00	Yw =	0.00
#	4	Xw =	40.00	Yw =	15.00



SCALE:

0 5 10 15 20 25 30 [ft]

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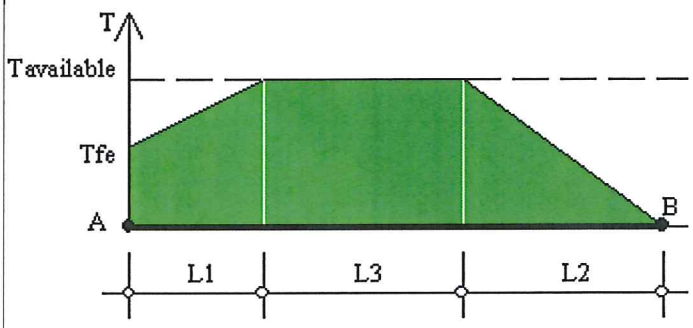
DISTRIBUTION OF AVAILABLE STRENGTH ALONG EACH REINFORCEMENT LAYER



A = Front-end of reinforcement (at face of slope)
B = Rear-end of reinforcement
AB = L1 + L2 + L3 = Embedded length of reinforcement

Tavailable = Long-term strength of reinforcement
Tfe = Available front-end strength (e.g., connection to facing)

L1 = Front-end 'pullout' length
L2 = Rear-end pullout length
Tavailable prevails along L3

Factor of safety on resistance to pullout on either end of reinforcement, Fs-po = 1.50

Reinforcement Layer #	Designated Name	Height Relative to Toe [ft]	L [ft]	L1 [ft]	L2 [ft]	L3 [ft]	Tfe [lb/ft]	Tavailable [lb/ft]
1	Geosynthetic type #1	0.20	10.00	0.00	1.38	8.62	907.28	907.28
2	Geosynthetic type #1	1.20	10.00	0.00	1.38	8.62	907.28	907.28
3	Geosynthetic type #1	2.20	10.00	0.00	1.38	8.62	907.28	907.28
4	Geosynthetic type #1	3.20	10.00	0.00	1.44	8.56	907.28	907.28
5	Geosynthetic type #1	4.20	10.00	0.00	1.64	8.36	907.28	907.28
6	Geosynthetic type #1	5.20	10.00	0.00	1.87	8.13	907.28	907.28
7	Geosynthetic type #1	6.20	10.00	0.00	2.20	7.80	907.28	907.28
8	Geosynthetic type #1	7.20	10.00	0.00	2.66	7.34	907.28	907.28
9	Geosynthetic type #1	8.20	10.00	0.00	3.35	6.65	907.28	907.28
10	Geosynthetic type #1	9.20	10.00	0.00	4.53	5.47	907.28	907.28
11	Geosynthetic type #1	10.20	10.00	0.00	7.02	2.98	907.28	907.28
12	Geosynthetic type #1	11.20	10.00	0.00	10.00	0.00	551.60	551.60 (*)

(*) This Tavailable is dictated by the pullout resistance capacity, which is smaller than the long-term strength of the reinforcement that is related to its specified ultimate strength

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	12.00	12.00	-25.36	-14.31	-16.26	12.45	28.27	2.40	
2	13.48	12.00	-21.81	-12.30	-12.59	12.08	26.06	2.09	
3	14.95	12.00	-18.06	-10.37	-9.31	12.25	24.26	1.91	
4	16.42	12.00	-18.05	-10.38	-10.17	15.22	26.79	1.78	
5	17.90	12.00	-18.04	-10.38	-12.08	20.08	31.04	1.67	
6	19.37	12.00	-18.04	-10.39	-14.76	26.59	37.12	1.58	
7	20.84	12.00	-18.03	-10.39	-18.81	35.90	46.30	1.55	OK
8	22.32	12.00	-18.40	-10.38	-17.20	35.65	46.05	1.57	
9	23.79	12.00	-18.43	-10.38	-17.15	38.22	48.62	1.58	
10	25.26	12.00	-18.45	-10.38	-17.11	40.87	51.27	1.60	
11	26.74	12.00	-22.01	-12.40	-20.49	45.46	57.88	1.62	
12	28.21	12.00	-22.03	-12.40	-20.44	48.25	60.67	1.64	
13	29.69	12.00	-22.06	-12.40	-20.39	51.13	63.55	1.67	
14	31.16	12.00	-22.08	-12.40	-20.34	54.08	66.51	1.69	
15	32.63	12.00	-22.11	-12.40	-20.29	57.12	69.54	1.72	
16	34.11	12.00	-25.00	-14.43	-25.00	64.86	79.30	1.75	
17	35.58	12.00	-25.00	-14.43	-25.00	68.20	82.63	1.78	
18	35.98	12.00	-25.62	-14.46	-29.98	80.60	95.16	1.79	
19	35.99	12.00	-25.62	-14.46	-29.98	80.65	95.22	1.79	
20	35.94	12.00	-25.64	-14.48	-31.96	85.05	99.73	1.79	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points)

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	-25.00	-14.43	20.84	12.00	-25.00	38.54	52.97	1.62	
2	-21.50	-12.41	20.84	12.00	-21.50	36.52	48.93	1.57	
3	-18.03	-10.39	20.84	12.00	-18.81	35.90	46.30	1.55	OK
4	-14.69	-8.37	20.84	12.00	-15.24	33.75	42.13	1.55	
5	-11.31	-6.34	20.84	12.00	-10.38	29.37	35.73	1.56	
6	-7.83	-4.31	20.84	12.00	-5.46	24.89	29.29	1.60	
7	-4.08	-2.30	20.84	12.00	-0.76	20.78	23.32	1.66	
8	-0.75	-0.20	19.37	12.00	4.23	14.27	15.31	1.87	
9	2.92	3.03	20.84	12.00	7.54	16.19	13.95	2.04	
10	6.41	6.55	20.84	12.00	11.36	15.27	10.03	2.75	
11	10.00	10.00	22.32	12.00	14.37	22.01	12.78	5.47	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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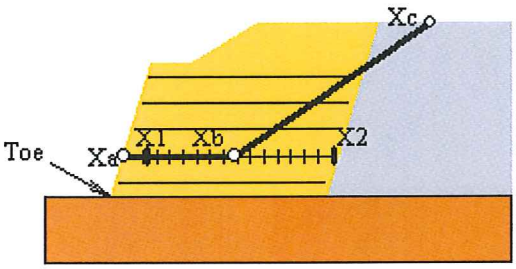
RESULTS OF TRANSLATIONAL ANALYSIS



Results in the table below represent critical two-part wedges identified between specified starting (X1) and ending (X2) search points. Wedges along all reinforcement layers and at elevation zero are reported. The critical two-part wedge, one for each predetermined elevation, is defined by Xa, Xb and Xc where Xa is the front end of the passive wedge (slope face), Xb is where the passive wedge ends and the active one starts, and Xc is the X-ordinate at which the active wedge starts.

Critical two-part wedge along each interface:

Interface	Height Relative to Toe [ft]	(Xa, Ya) [ft]		(Xb, Yb) [ft]		(Xc, Yc) [ft]		Fs	STATUS
At toe elevation	0.00	0.00	0.00	9.80	0.00	21.80	12.00	1.65	Minimum on Edge
Reinf. Layer #1	0.20	0.20	0.20	10.09	0.20	21.89	12.00	1.44	Minimum on Edge
Reinf. Layer #2	1.20	1.20	1.20	11.09	1.20	21.89	12.00	1.50	Minimum on Edge
Reinf. Layer #3	2.20	2.20	2.20	12.09	2.20	21.89	12.00	1.58	Minimum on Edge
Reinf. Layer #4	3.20	3.20	3.20	13.09	3.20	21.89	12.00	1.72	Minimum on Edge
Reinf. Layer #5	4.20	4.20	4.20	14.09	4.20	21.89	12.00	1.90	Minimum on Edge
Reinf. Layer #6	5.20	5.20	5.20	15.09	5.20	21.89	12.00	2.09	Minimum on Edge
Reinf. Layer #7	6.20	6.20	6.20	16.09	6.20	21.89	12.00	2.34	Minimum on Edge
Reinf. Layer #8	7.20	7.20	7.20	17.09	7.20	21.89	12.00	2.65	Minimum on Edge
Reinf. Layer #9	8.20	8.20	8.20	18.09	8.20	21.89	12.00	3.09	Minimum on Edge
Reinf. Layer #10	9.20	9.20	9.20	13.28	9.20	14.89	12.00	3.27	OK
Reinf. Layer #11	10.20	10.20	10.20	12.34	10.20	13.42	12.00	3.44	OK
Reinf. Layer #12	11.20	11.20	11.20	13.34	11.20	14.44	12.00	4.56	OK

Note: In the 'Status' column, OK means the critical two part-wedge was identified within the specified search domain. 'Minimum on Edge' means the critical result corresponds to a minimum on the edge of the search domain; i.e., either on X1 or X2 or the internally preset limits on Xc.

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CRITICAL RESULTS OF ROTATIONAL AND TRANSLATIONAL STABILITY ANALYSES

Rotational (Circular Arc; Bishop) Stability Analysis

Minimum Factor of Safety = 1.55
Critical Circle: Xc = -18.81[ft], Yc = 35.90[ft], R = 46.30[ft]. (Number of slices used = 56)

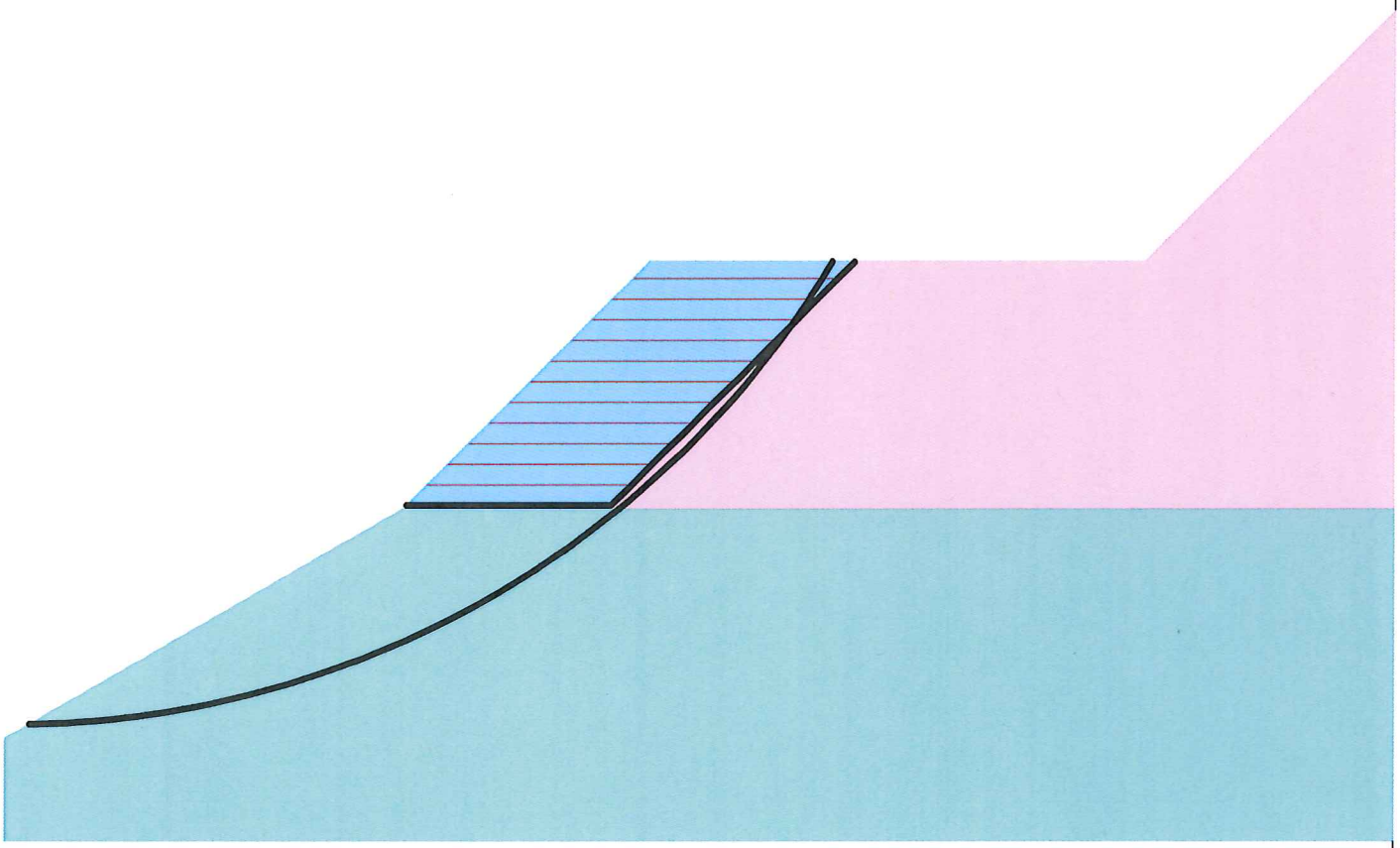
Translational (2-Part Wedge; Spencer), Direct Sliding, Stability Analysis

Minimum Factor of Safety = 1.44
Critical Two-Part Wedge: (Xa = 0.20, Ya = 0.20) [ft]
(Xb = 10.09, Yb = 0.20) [ft]
(Xc = 21.89, Yc = 12.00) [ft]
(Number of slices used = 30)
Interslice resultant force inclination = 30.53 [degrees]

Three-Part Wedge Stability Analysis

N O T C O N D U C T E D

REINFORCEMENT LAYOUT: DRAWING



SCALE:

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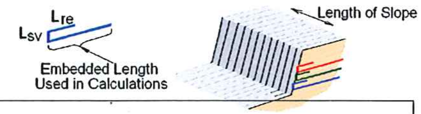
REINFORCEMENT LAYOUT: TABULATED DATA & QUANTITIES



Layer #	Reinf. Type #	Geosynthetic Designated Name	Height Relative to Toe [ft]	Embedded Length [ft]	Covergae Ratio, Rc	(X, Y) front [ft]		(X, Y) rear [ft]		Lsv * [ft]	Lre [ft]
1	1	Geosynthetic type #1	0.20	10.00	1.00	0.20	0.20	10.20	0.20	1.00	3.00
2	1	Geosynthetic type #1	1.20	10.00	1.00	1.20	1.20	11.20	1.20	1.00	3.00
3	1	Geosynthetic type #1	2.20	10.00	1.00	2.20	2.20	12.20	2.20	1.00	3.00
4	1	Geosynthetic type #1	3.20	10.00	1.00	3.20	3.20	13.20	3.20	1.00	3.00
5	1	Geosynthetic type #1	4.20	10.00	1.00	4.20	4.20	14.20	4.20	1.00	3.00
6	1	Geosynthetic type #1	5.20	10.00	1.00	5.20	5.20	15.20	5.20	1.00	3.00
7	1	Geosynthetic type #1	6.20	10.00	1.00	6.20	6.20	16.20	6.20	1.00	3.00
8	1	Geosynthetic type #1	7.20	10.00	1.00	7.20	7.20	17.20	7.20	1.00	3.00
9	1	Geosynthetic type #1	8.20	10.00	1.00	8.20	8.20	18.20	8.20	1.00	3.00
10	1	Geosynthetic type #1	9.20	10.00	1.00	9.20	9.20	19.20	9.20	1.00	3.00
11	1	Geosynthetic type #1	10.20	10.00	1.00	10.20	10.20	20.20	10.20	1.00	3.00
12	1	Geosynthetic type #1	11.20	10.00	1.00	11.20	11.20	21.20	11.20	1.00	3.00

* Vertical distance between layers.

QUANTITIES

Reinf. Type #	Designated Name	Coverage Ratio	Area of reinforcemnt [ft²] / length of slope [ft]	
1	Geosynthetic type #1	1.00	(including Lsv & Lre)	168.00

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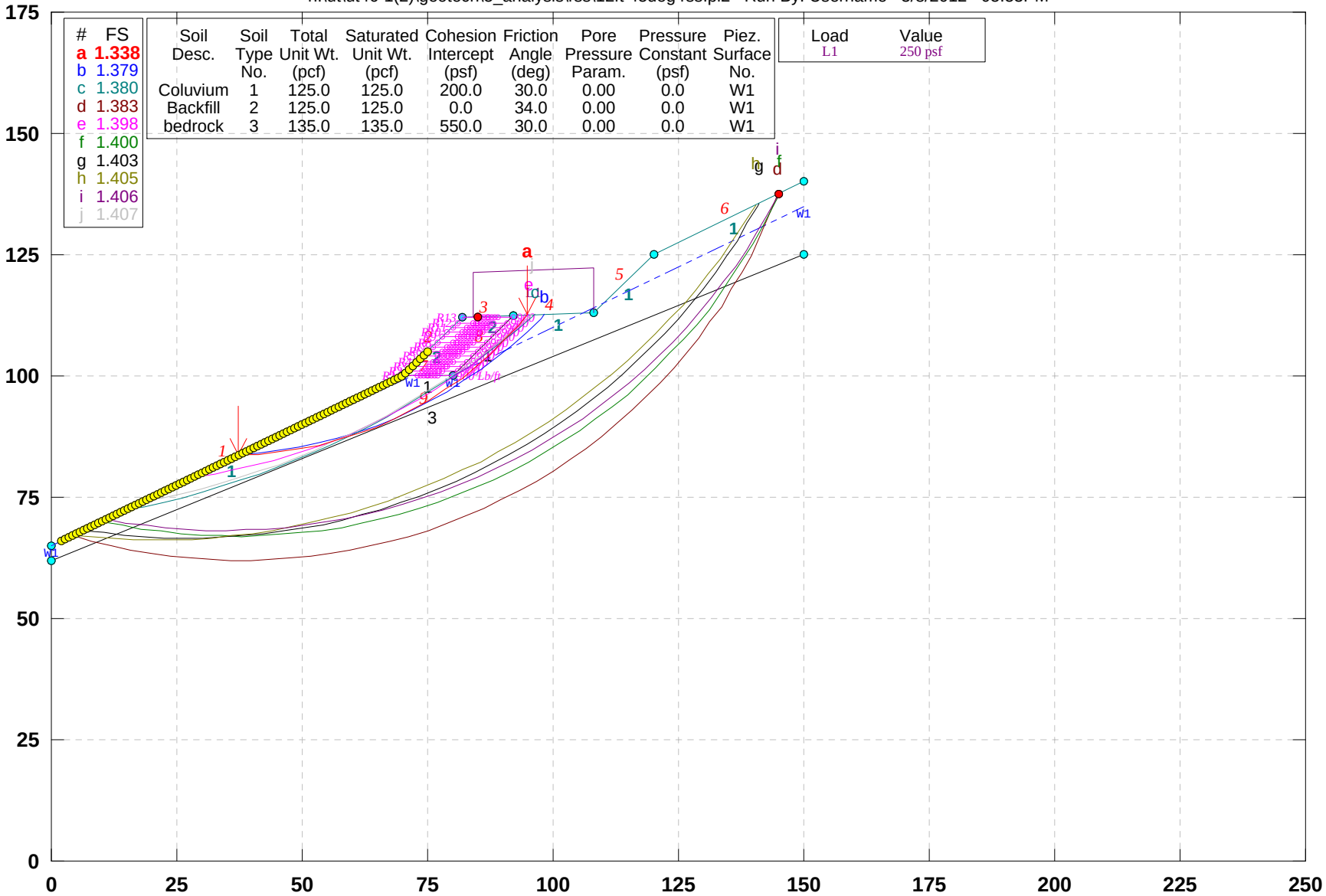
UT-PFH-46-1(2) LaSal Loop Rd - Mill Crk 12 ft High 1:1 RSS

n:\ut\ut46-1(2)\geotech\5_analysis\rss\12ft 45deg rss.pl2 Run By: Username 3/8/2012 05:53PM



GSTABL7 v.2 FSmin=1.338

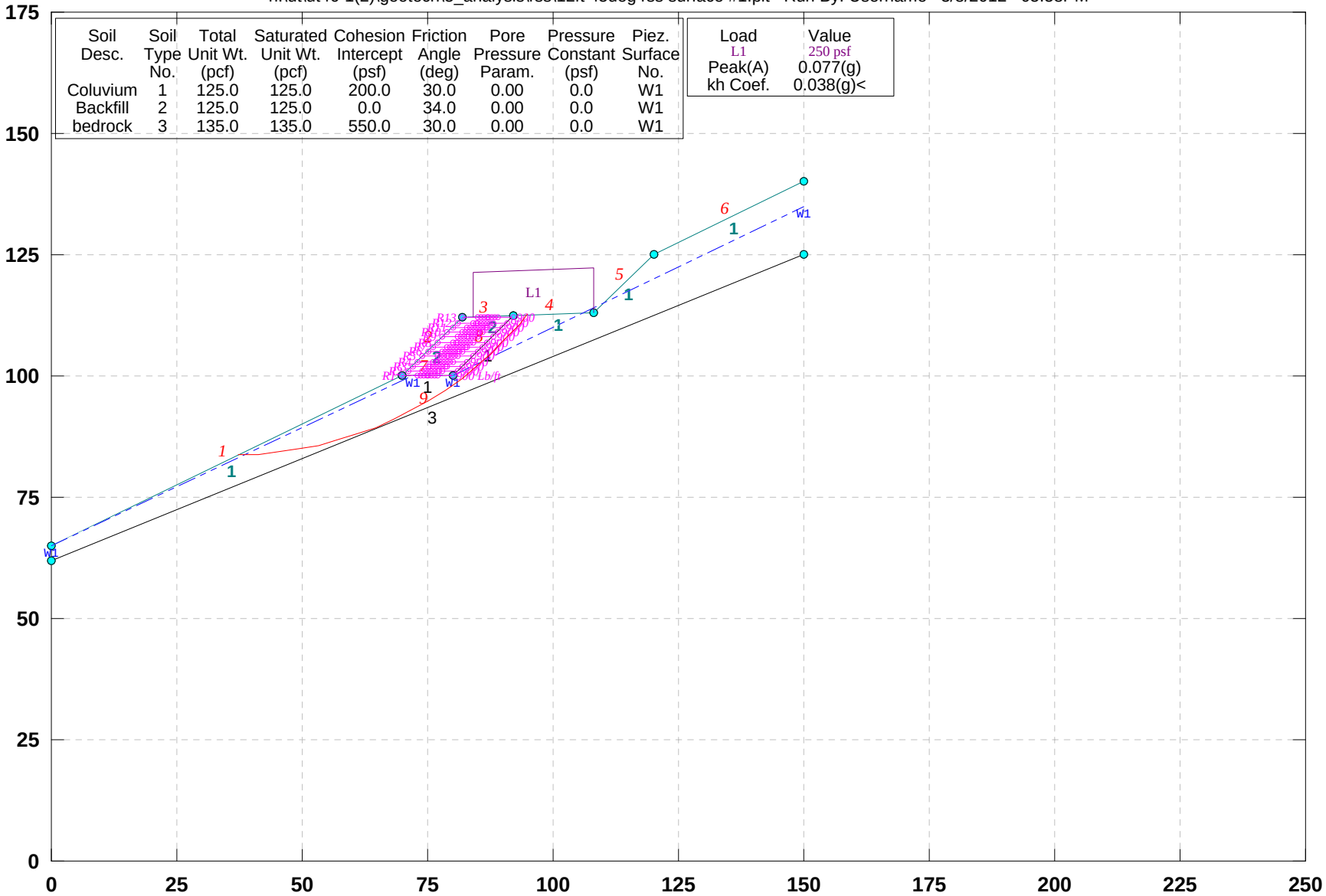
Safety Factors Are Calculated By The Modified Bishop Method

UT-PFH-46-1(2) LaSal Loop Rd - Mill Crk 12 ft High 1:1 RSS - Seismic

n:\ut\ut46-1(2)\geotech\5_analysis\rss\12ft 45deg rss surface #1.plt Run By: Username 3/8/2012 05:58PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Coluvium	1	125.0	125.0	200.0	30.0	0.00	0.0	W1
Backfill	2	125.0	125.0	0.0	34.0	0.00	0.0	W1
bedrock	3	135.0	135.0	550.0	30.0	0.00	0.0	W1

Load	Value
L1	250 psf
Peak(A)	0.077(g)
kh Coef.	0.038(g)<



GSTABL7 v.2 FSmin=1.240

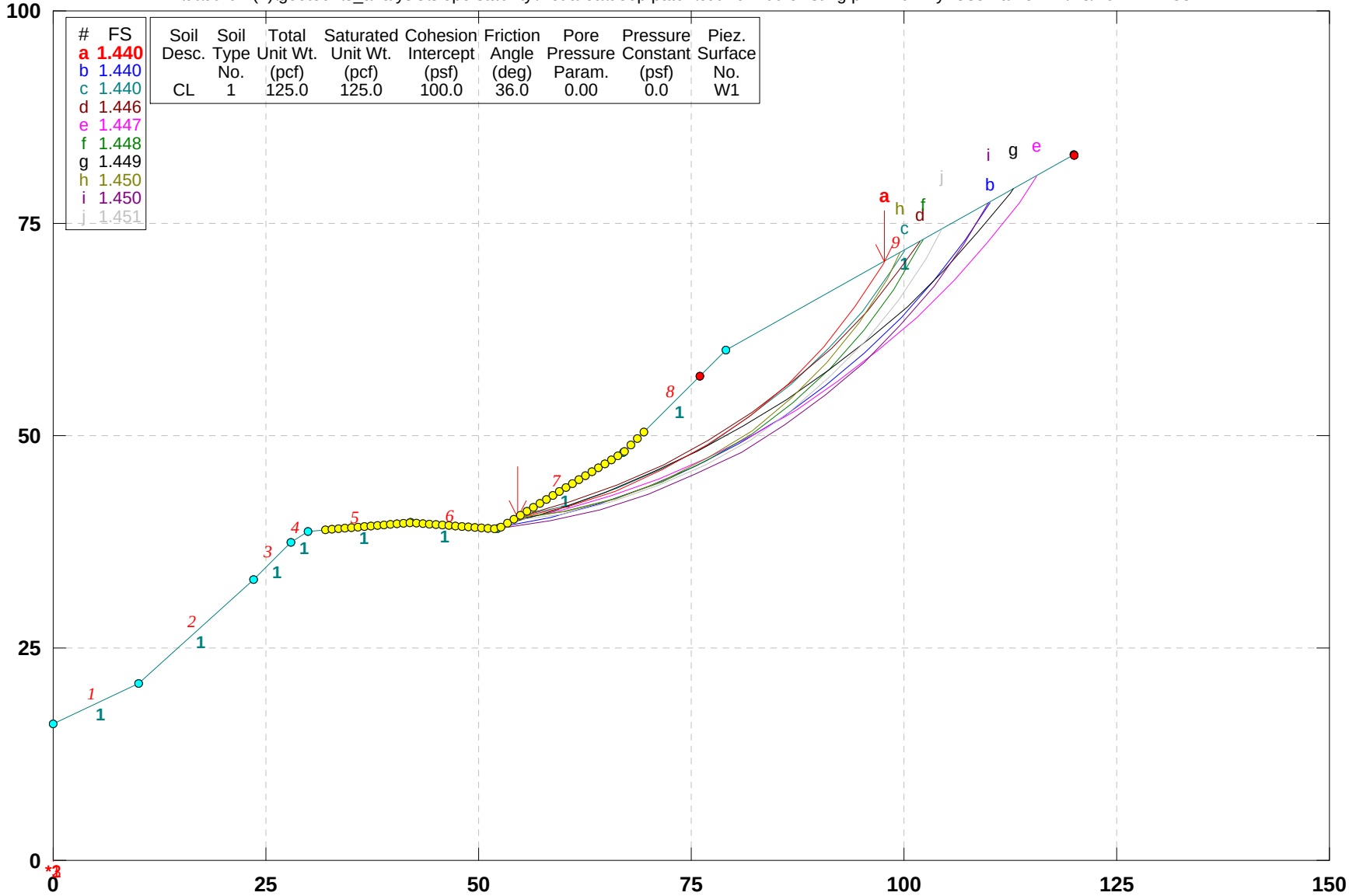
Factor Of Safety Is Calculated By The Modified Bishop Method

APPENDIX F

SLOPE STABILITY

UT PFH 46-1(2) La Sal Mtn Loop Road Station 164+00 Existing Condition

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\cut 164+00 existing.pl2 Run By: Username 11/28/2011 11:53AM

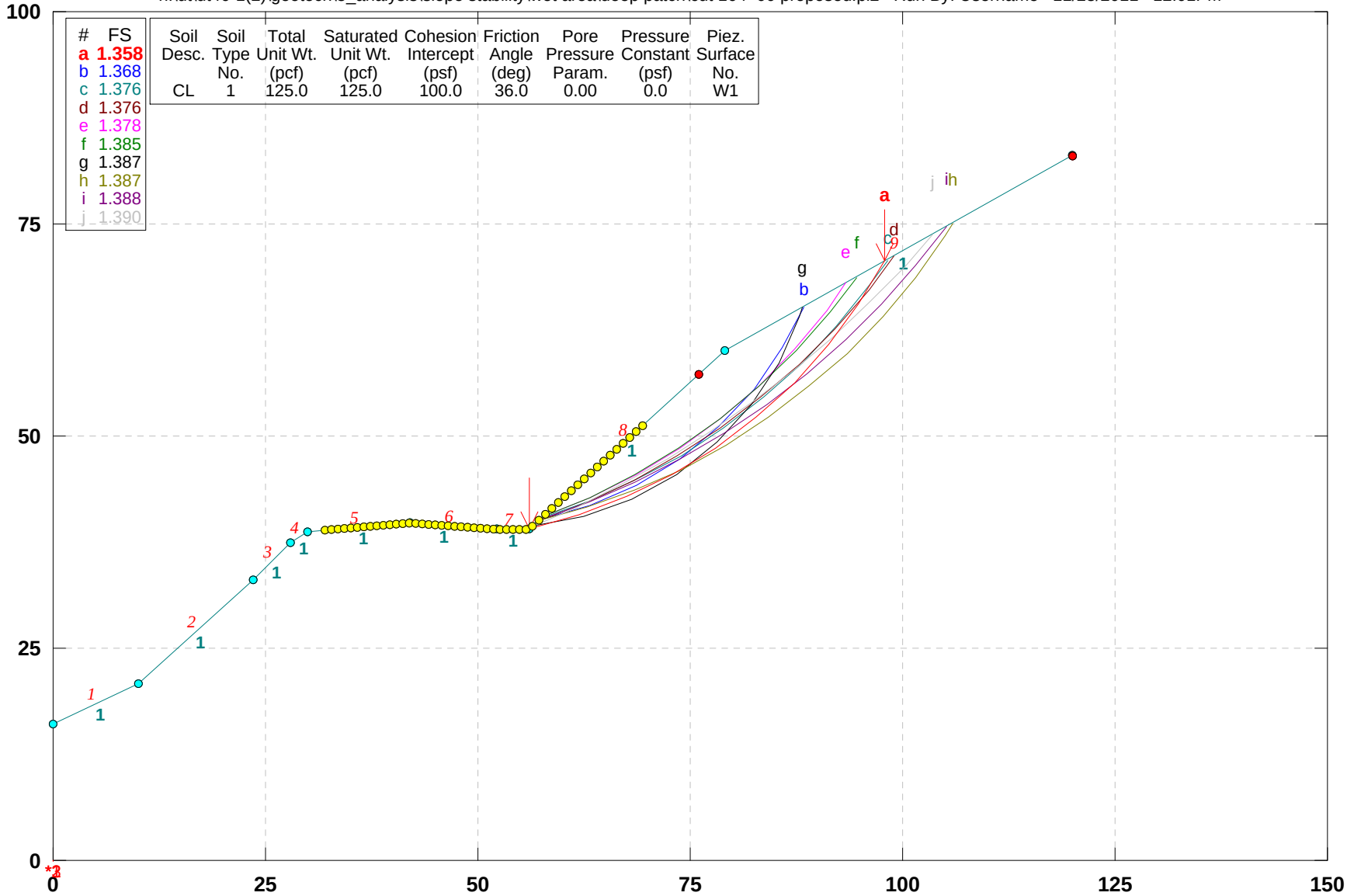


GSTABL7 v.2 FSmin=1.440

Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road Station 164+00 Proposed 1:1 Cut

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\cut 164+00 proposed.pl2 Run By: Username 11/28/2011 12:01PM

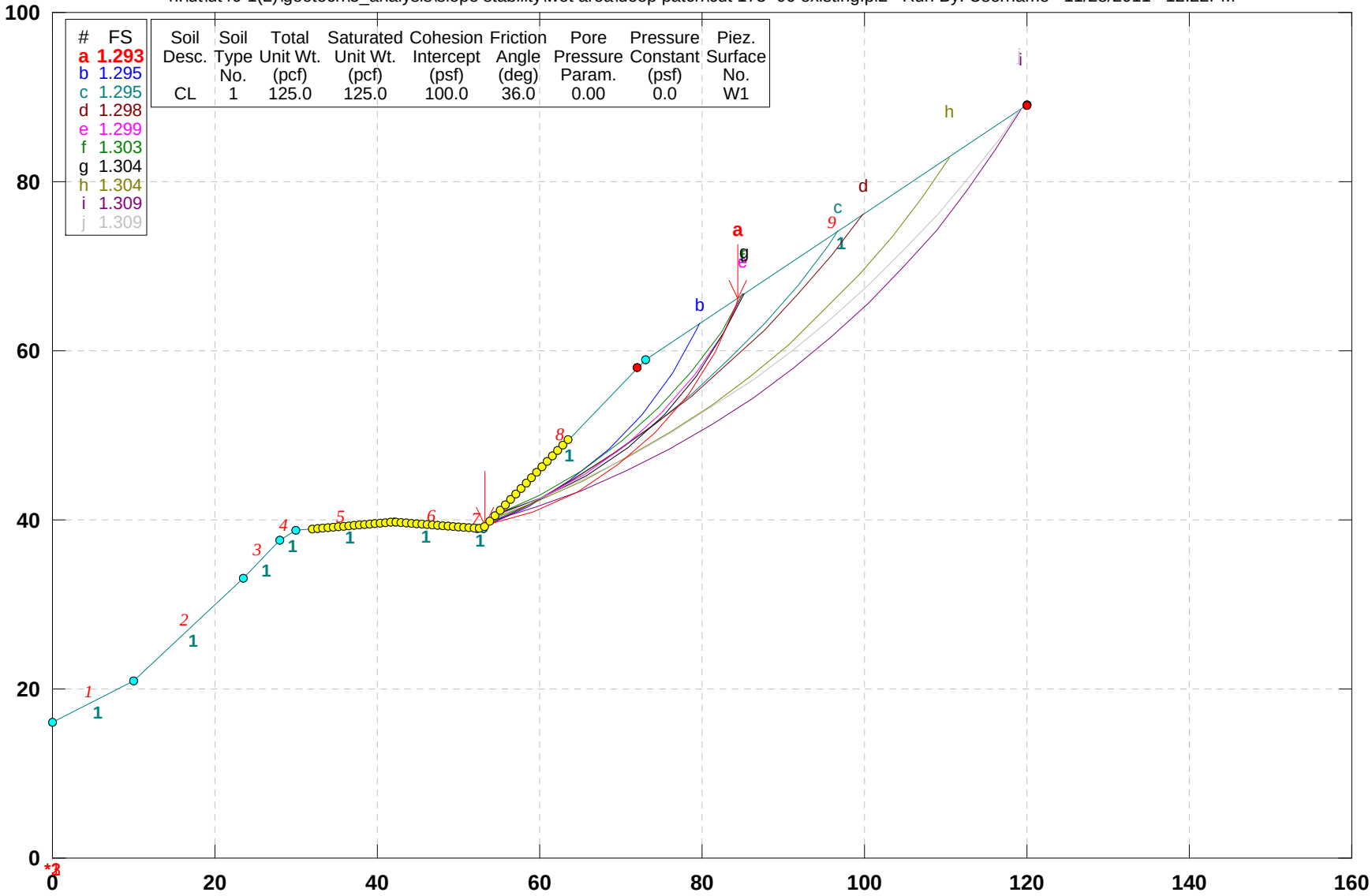


GSTABL7 v.2 FSmin=1.358

Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road Station 173+00 Existing

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\cut 173+00 existing.pl2 Run By: Username 11/28/2011 12:22PM

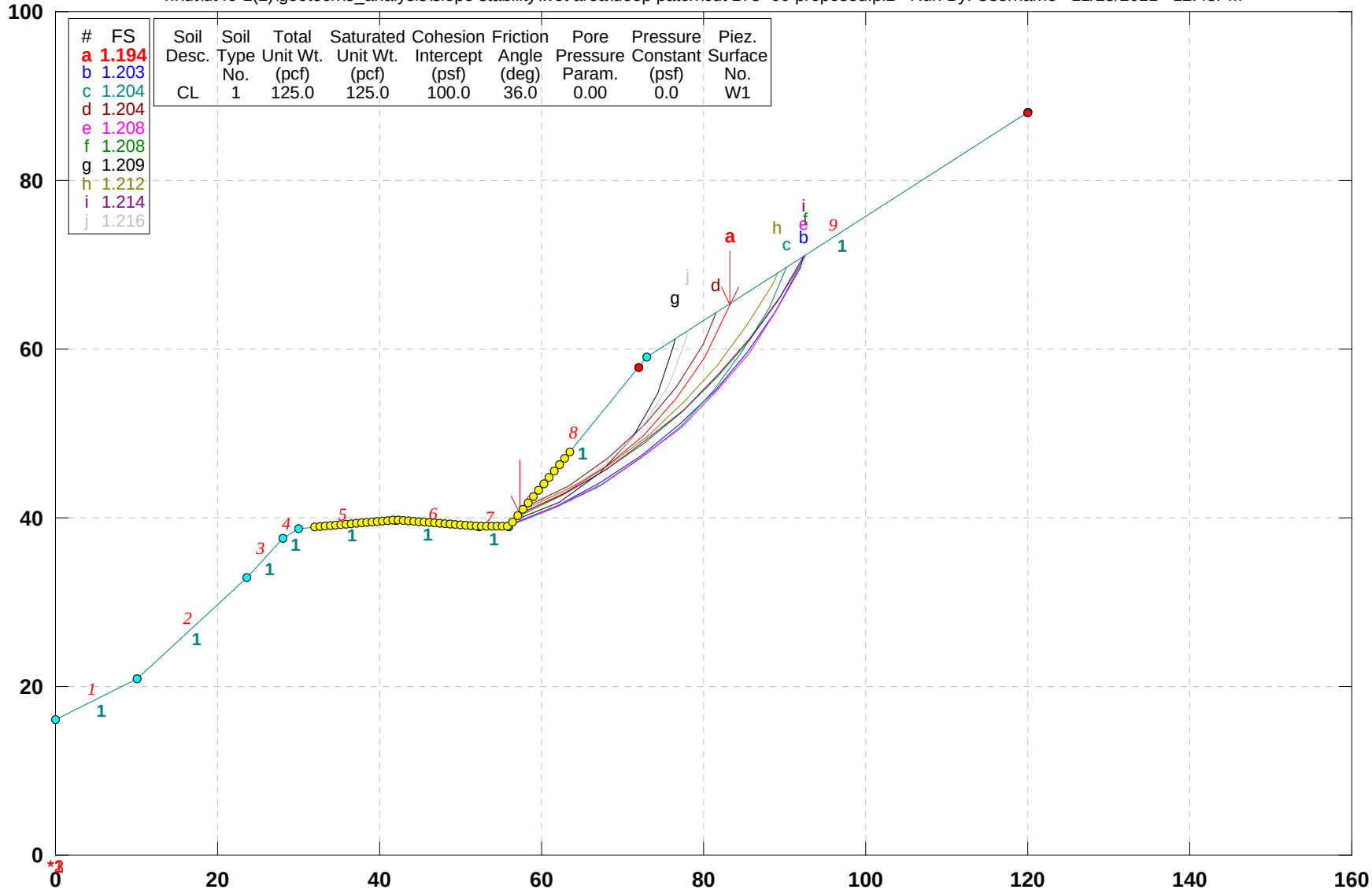


GSTABL7 v.2 FSmin=1.293

Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road Station 173+00 Proposed 1.3V:1H Cut

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\cut 173+00 proposed.pl2 Run By: Username 11/28/2011 12:43PM

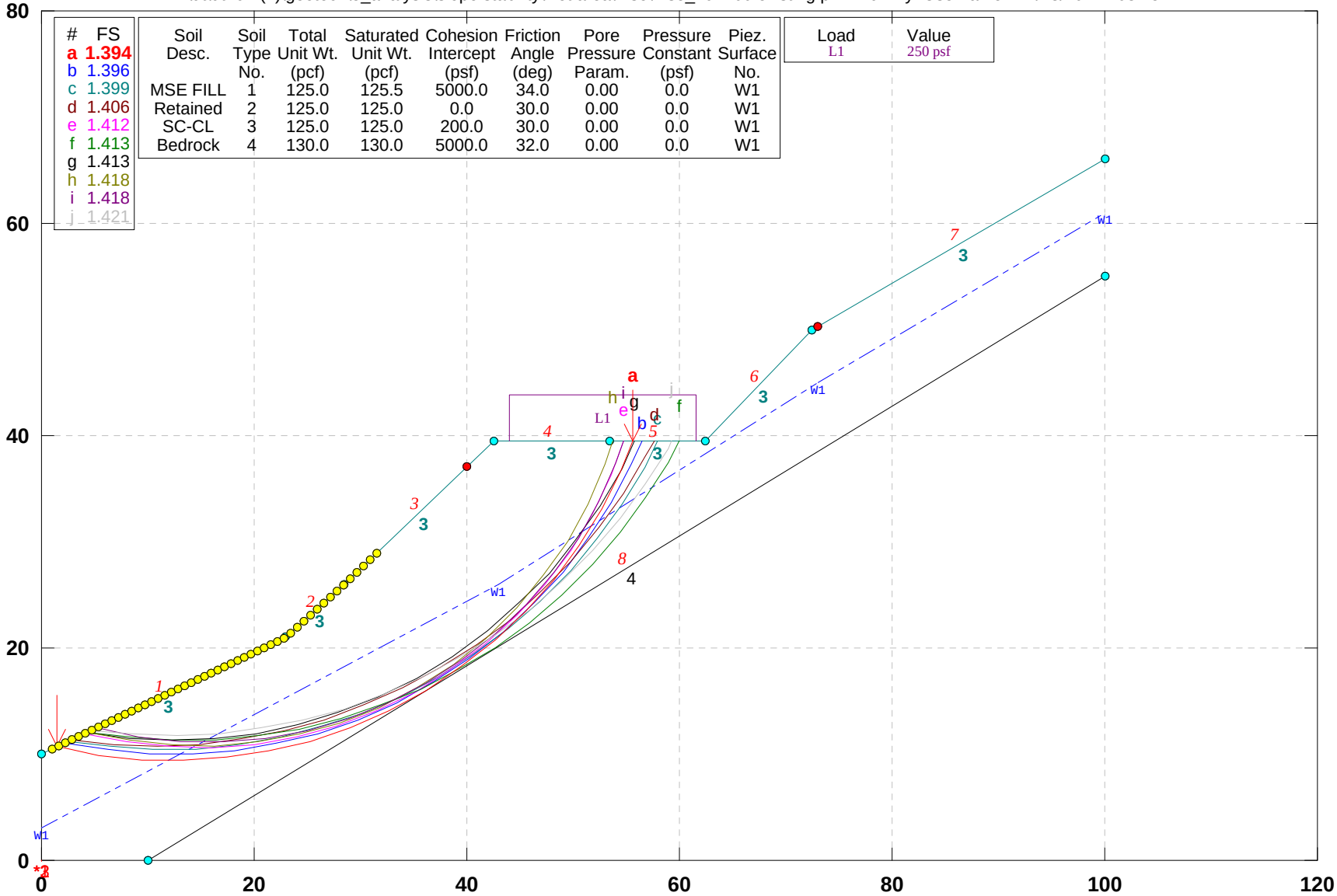


GSTABL7 v.2 FSmin=1.194

Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road MSE 207+00 Existing

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\mse\mse_207+00 existing.pl2 Run By: Username 11/23/2011 03:25PM

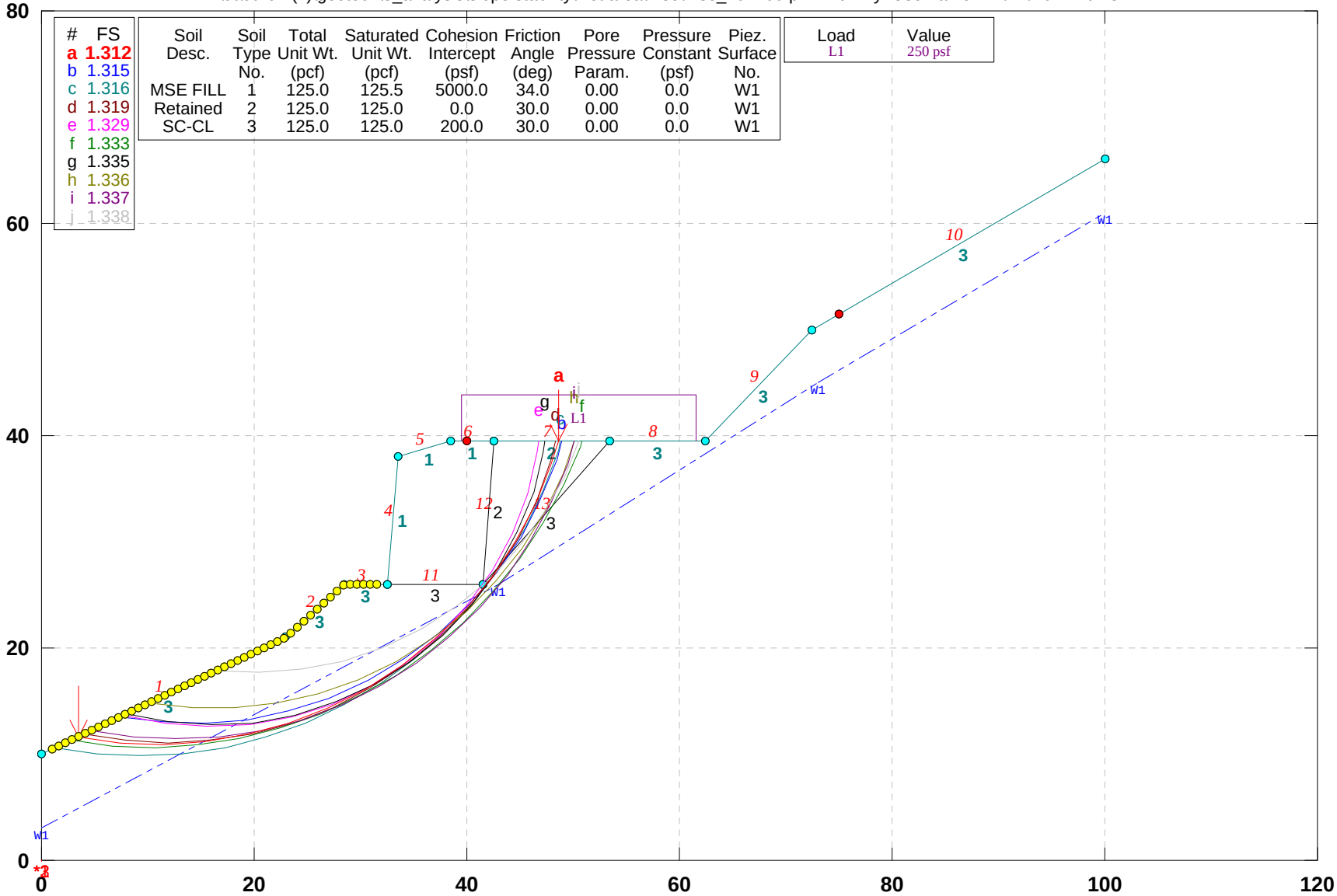


GSTABL7 v.2 FSmin=1.394

Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road MSE 207+00 PROPOSED

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\mse\mse_207+00.pl2 Run By: Username 11/17/2011 04:37PM



GSTABL7 v.2 FSmin=1.312

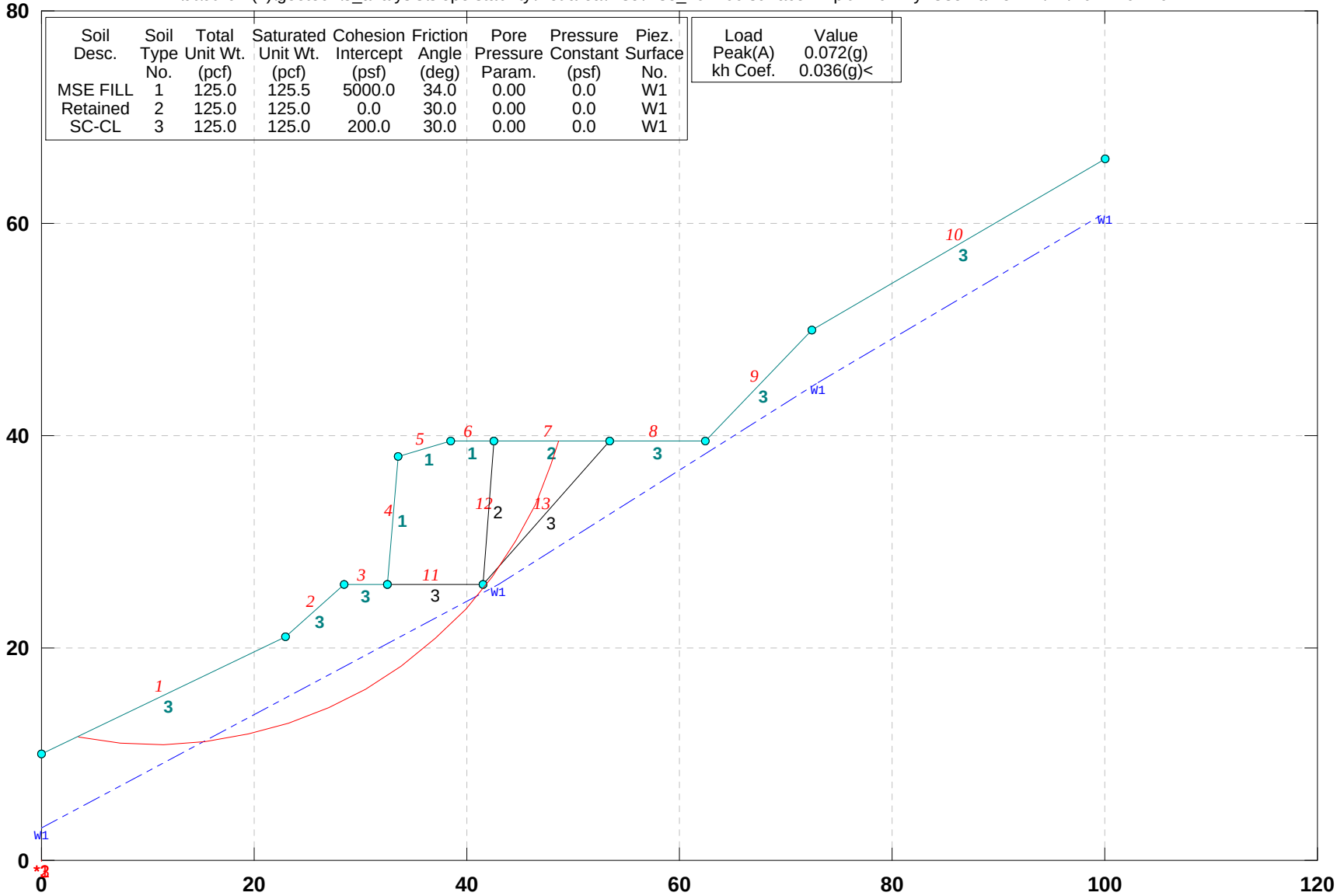
Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road MSE 207+00 PROPOSED Seismic

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\mse\mse_207+00 surface #1.plt Run By: Username 11/17/2011 04:40PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MSE FILL	1	125.0	125.5	5000.0	34.0	0.00	0.0	W1
Retained	2	125.0	125.0	0.0	30.0	0.00	0.0	W1
SC-CL	3	125.0	125.0	200.0	30.0	0.00	0.0	W1

Load	Value
Peak(A)	0.072(g)
kh Coef.	0.036(g)<



GSTABL7 v.2 FSmin=1.288

Factor Of Safety Is Calculated By The Modified Bishop Method

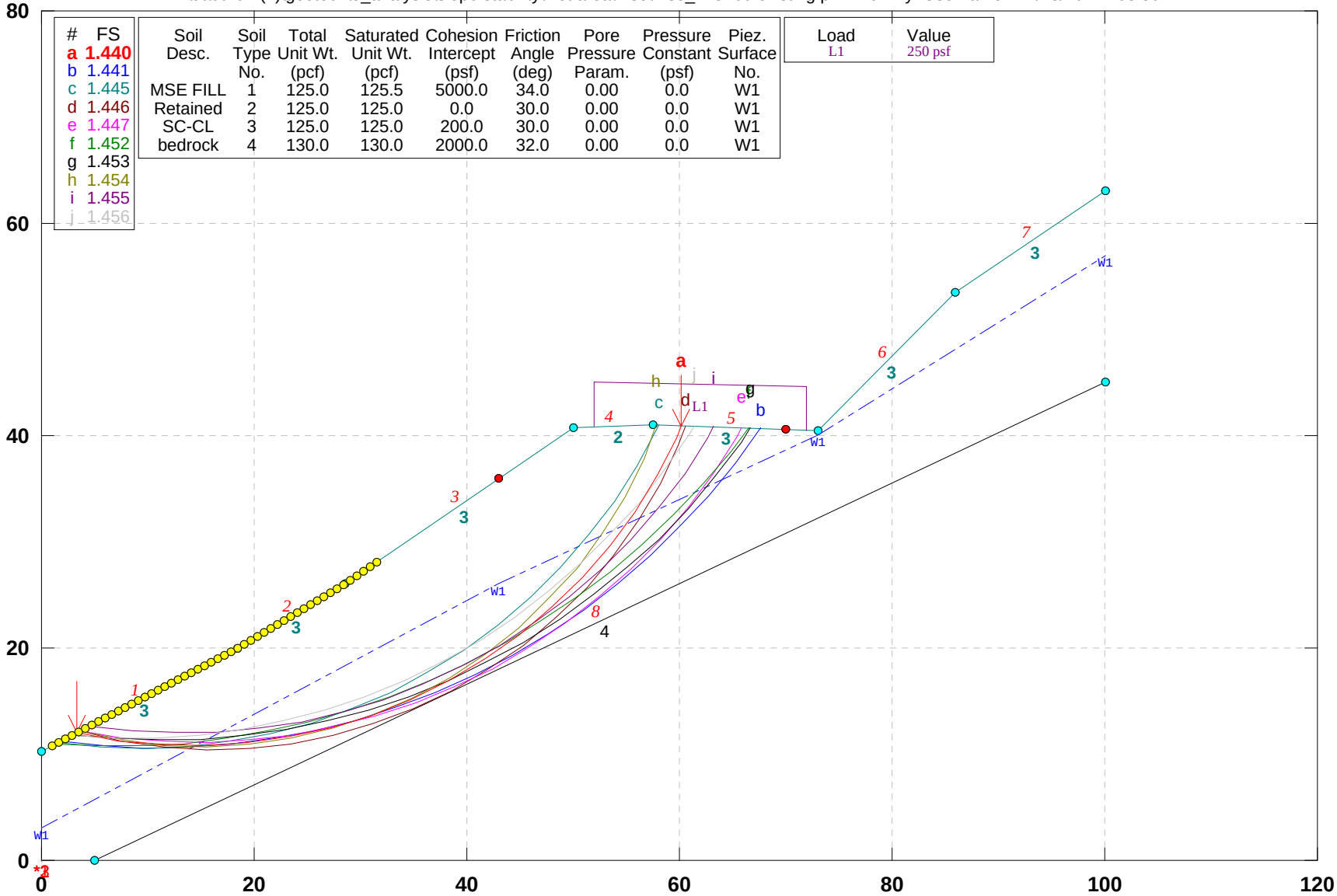
UT PFH 46-1(2) La Sal Mtn Loop Road MSE 218+00 Existing

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\mse\mse_218+00 existing.pl2 Run By: Username 11/23/2011 03:36PM

#	FS
a	1.440
b	1.441
c	1.445
d	1.446
e	1.447
f	1.452
g	1.453
h	1.454
i	1.455
j	1.456

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MSE FILL	1	125.0	125.5	5000.0	34.0	0.00	0.0	W1
Retained	2	125.0	125.0	0.0	30.0	0.00	0.0	W1
SC-CL	3	125.0	125.0	200.0	30.0	0.00	0.0	W1
bedrock	4	130.0	130.0	2000.0	32.0	0.00	0.0	W1

Load	Value
L1	250 psf

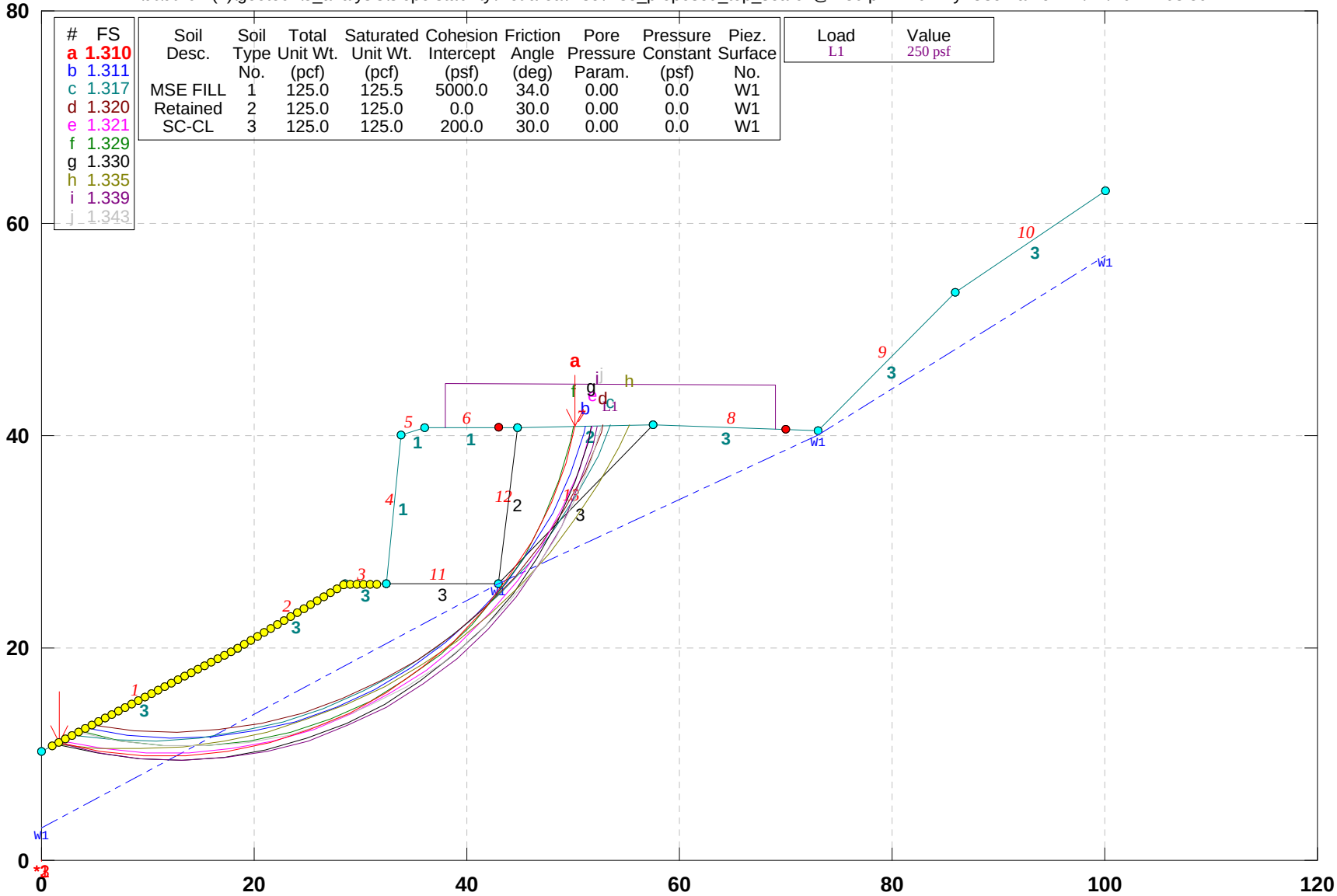


GSTABL7 v.2 FSmin=1.440

Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road MSE 218+00 PROPOSED

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\mse\mse_proposed_top_search@1.30.pl2 Run By: Username 11/17/2011 03:59PM



GSTABL7 v.2 FSmin=1.310

Safety Factors Are Calculated By The Modified Bishop Method

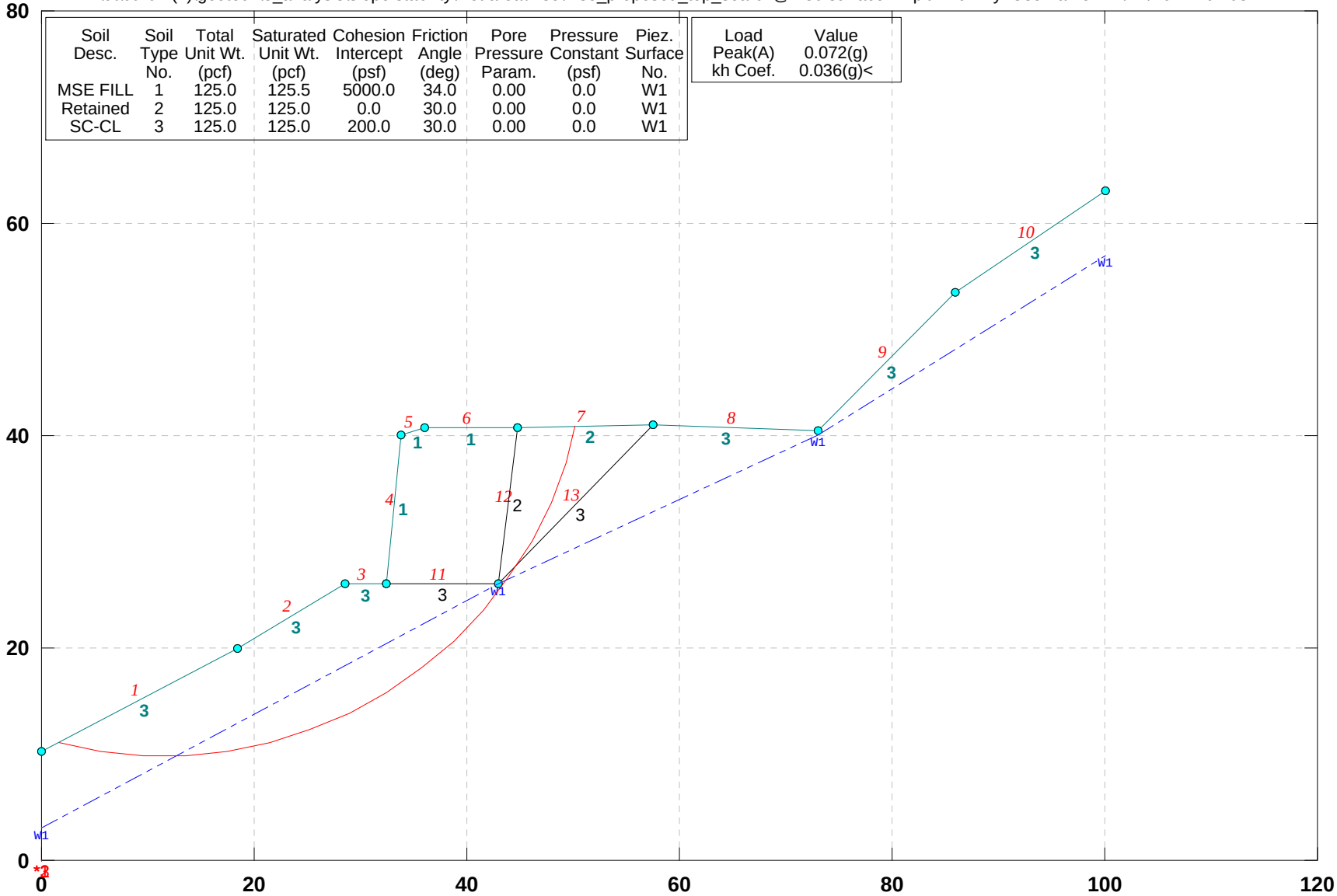
GSTABL7

UT PFH 46-1(2) La Sal Mtn Loop Road MSE 218+00 PROPOSED Seismic

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\mse\mse_proposed_top_search@1.30 surface #1.plt Run By: Username 11/17/2011 04:03PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MSE FILL	1	125.0	125.5	5000.0	34.0	0.00	0.0	W1
Retained	2	125.0	125.0	0.0	30.0	0.00	0.0	W1
SC-CL	3	125.0	125.0	200.0	30.0	0.00	0.0	W1

Load	Value
Peak(A)	0.072(g)
kh Coef.	0.036(g)<

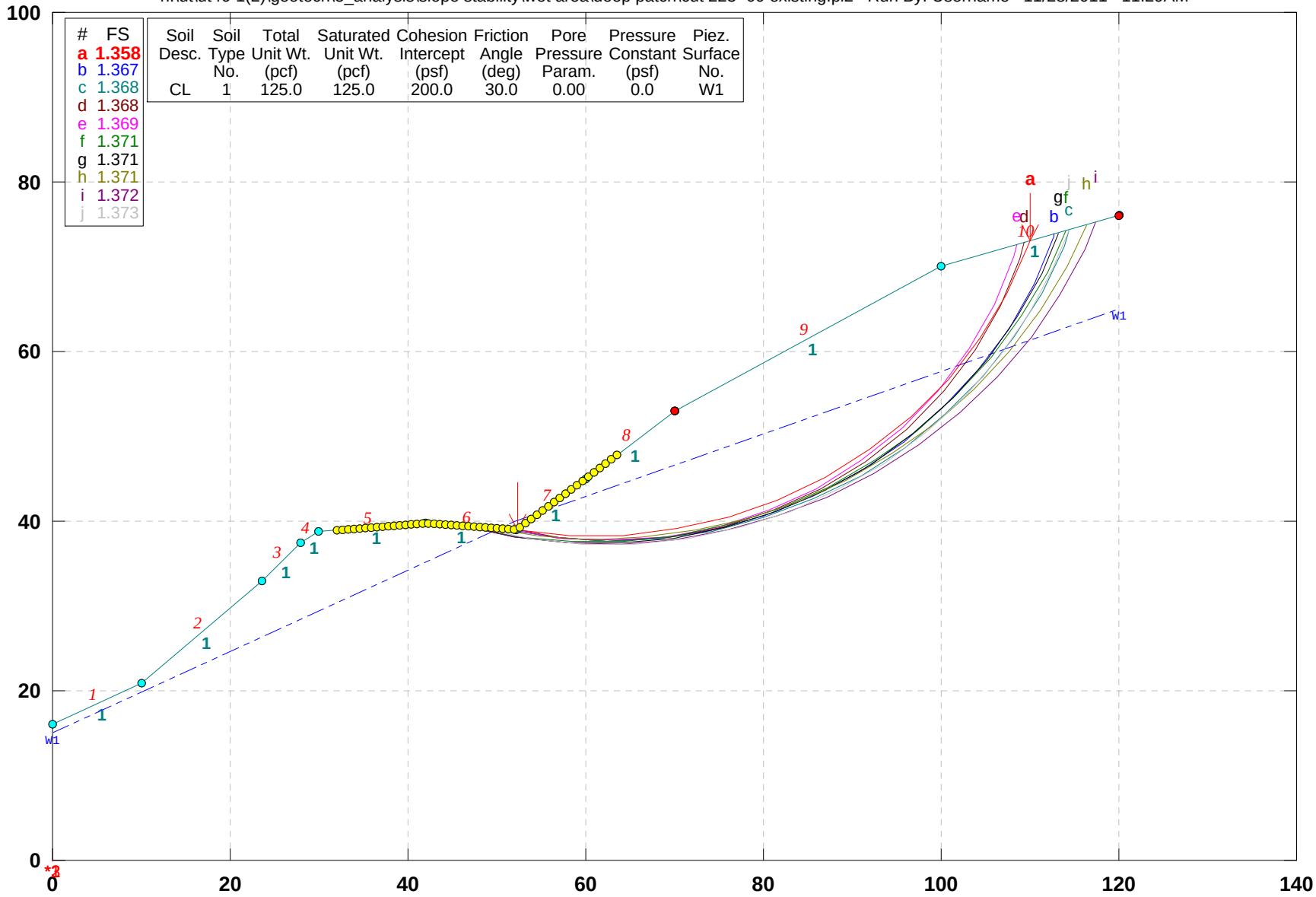


GSTABL7 v.2 FSmin=1.285

Factor Of Safety Is Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road Existing Station 223+00

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\cut 223+00 existing.pl2 Run By: Username 11/28/2011 11:29AM



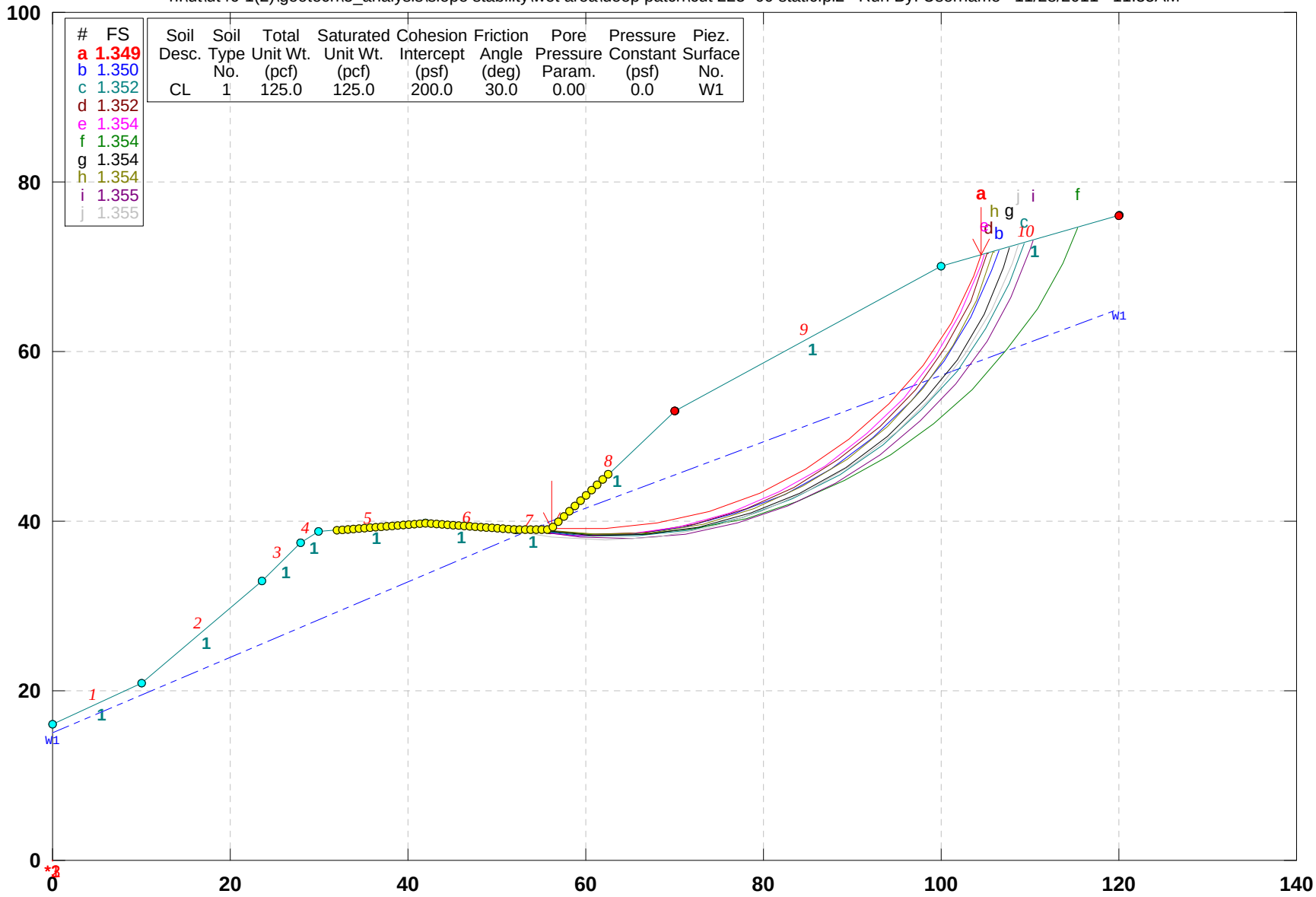
GSTABL7 v.2 FSmin=1.358

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

UT PFH 46-1(2) La Sal Mtn Loop Road Station 223+00 Proposed 1:1 Cut

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\cut 223+00 static.pl2 Run By: Username 11/28/2011 11:35AM

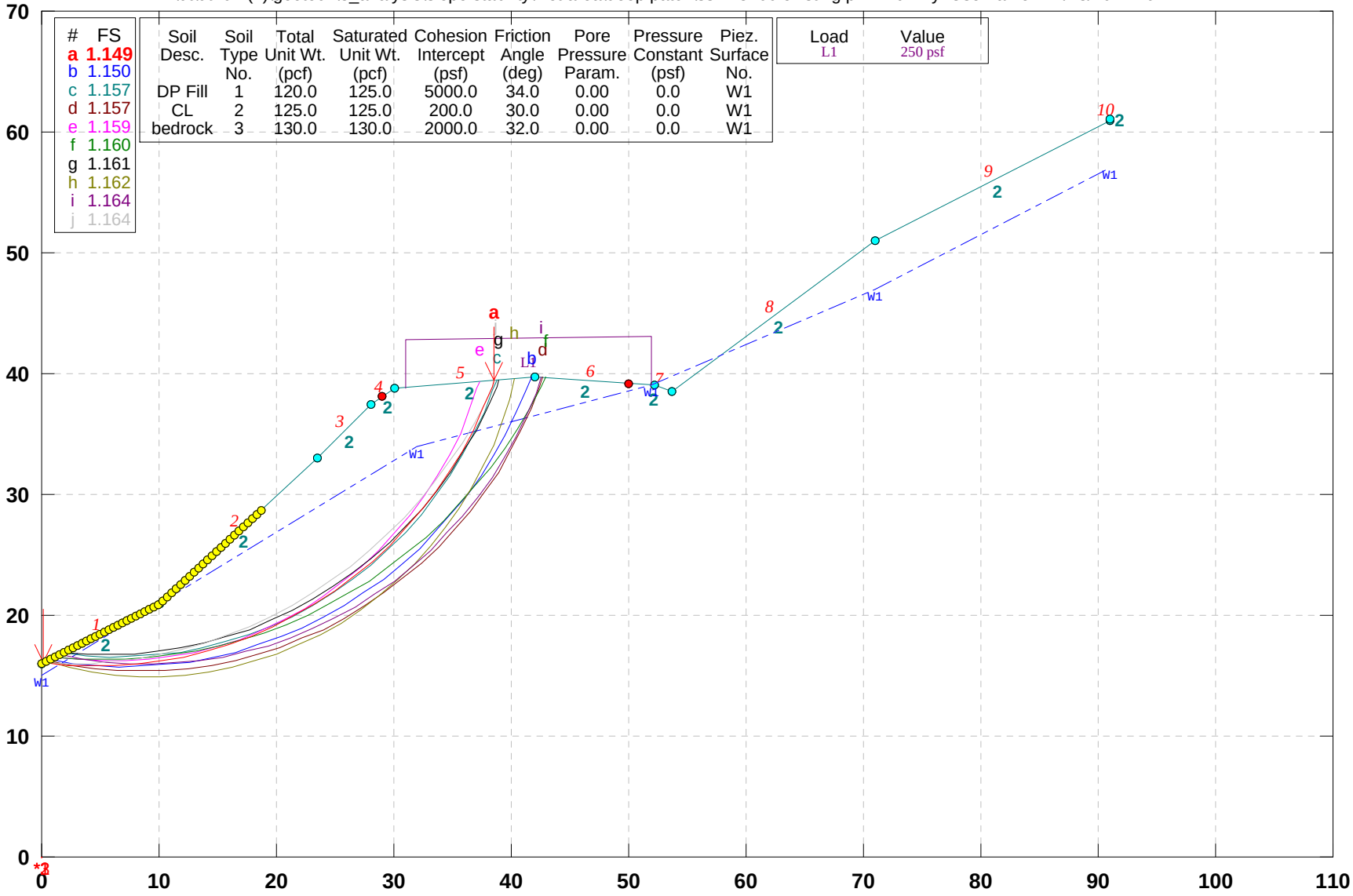


GSTABL7 v.2 FSmin=1.349

Safety Factors Are Calculated By The Modified Bishop Method

UT PFH 46-1(2) La Sal Mtn Loop Road Existing Station 228+00

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\ss 228+00 existing.pl2 Run By: Username 11/23/2011 04:14PM



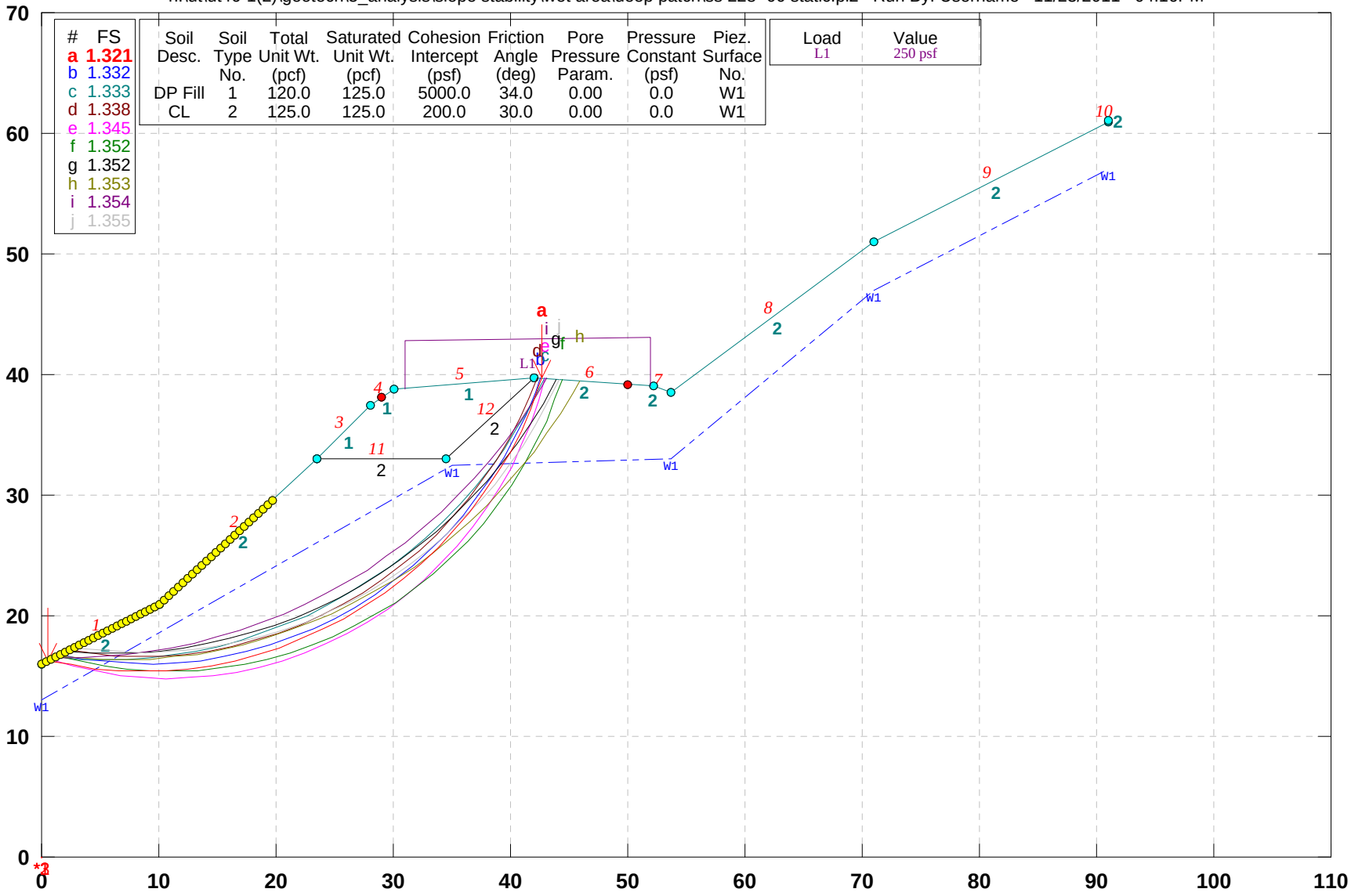
GSTABL7 v.2 FSmin=1.149

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

UT PFH 46-1(2) La Sal Mtn Loop Road Shoulder Stabilization Station 228+00

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\ss 228+00 static.pl2 Run By: Username 11/23/2011 04:16PM



GSTABL7 v.2 FSmin=1.321

Safety Factors Are Calculated By The Modified Bishop Method

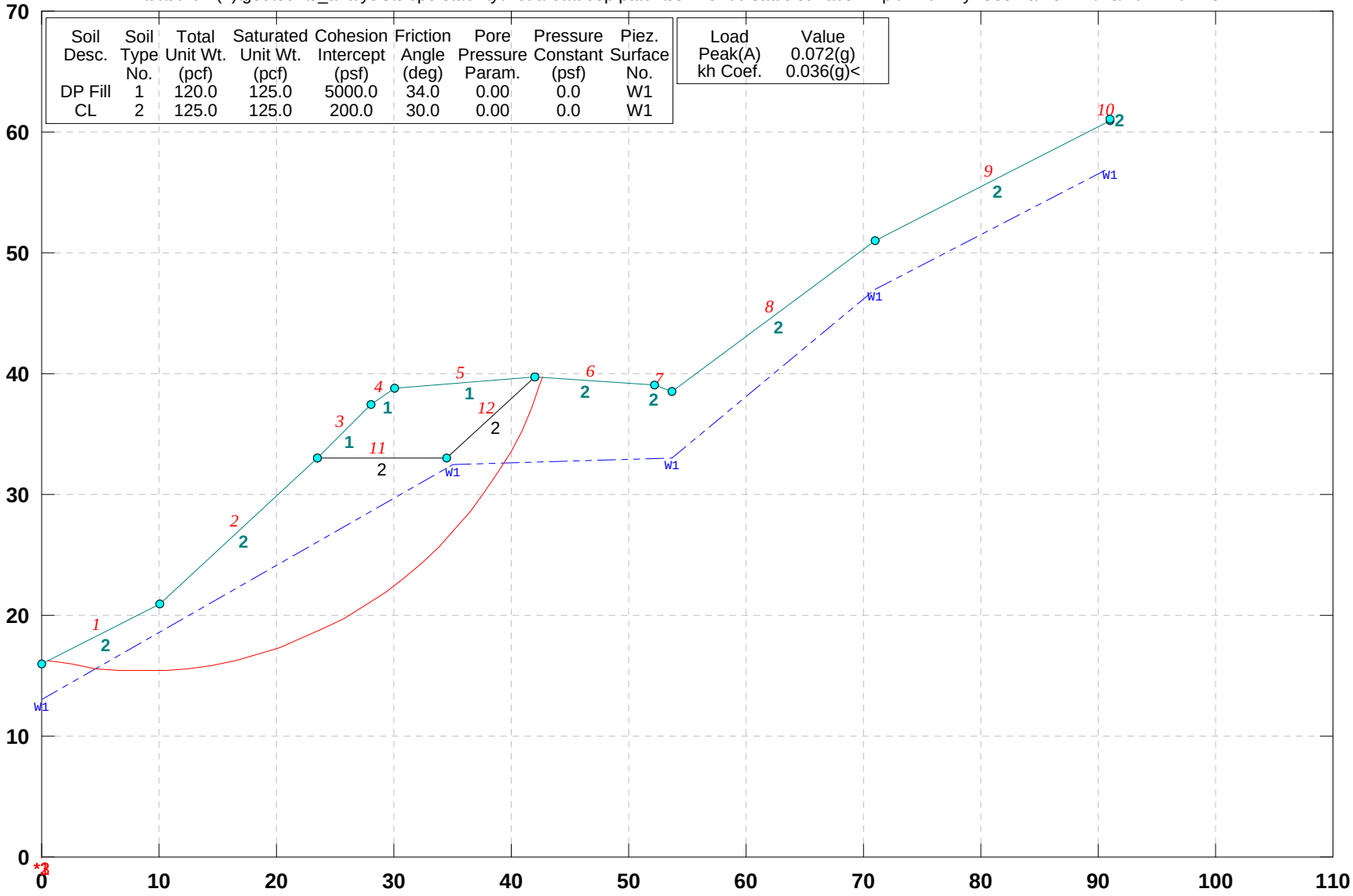
GSTABL7

UT PFH 46-1(2) La Sal Mtn Loop Road Shoulder Stabilization Seismic 228+00

n:\ut\ut46-1(2)\geotech\5_analysis\slope stability\wet area\deep patch\ss 228+00 static surface #1.plt Run By: Username 11/23/2011 04:18PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
DP Fill	1	120.0	125.0	5000.0	34.0	0.00	0.0	W1
CL	2	125.0	125.0	200.0	30.0	0.00	0.0	W1

Load	Value
Peak(A)	0.072(g)
kh Coef.	0.036(g)<



GSTABL7 v.2 FSmin=1.301

Factor Of Safety Is Calculated By The Modified Bishop Method