NorthWest Colorado Consultants, Inc.

Geotechnical / Environmental Engineering • Materials Testing

Geotechnical and Hydrologic Investigation
Coal Refuse Disposal Area Expansion
Twentymile Coal-Foidel Creek Mine
Routt County, Colorado

Prepared for:

Twentymile Coal Company
29515 County Road 27
Oak Creek, CO 80467

Attn: Jerry Nettleton

Job Number: 08-7915

June 16, 2009

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Conclusions

Based on the results of this Geotechnical and Hydrologic Investigation, the construction of the Coal Refuse Disposal Area (CRDA) Expansion is feasible at the proposed location. The analysis and design parameters for the construction of the CRDA Expansion, Haul Roads and Surface Water Management are outlined herein.

Purpose and Scope of Study

This report presents the results of Geotechnical and Hydrological Investigation for the proposed CRDA Expansion to be constructed at the Twentymile Coal-Foidel Creek Mine in Routt County, Colorado. The approximate location of the project site is shown in Figure #1.

The purpose of this investigation was to investigate and analyze the geotechnical and hydrologic conditions related to the proposed CRDA Expansion, as well as provide design and construction recommendations conforming to the regulations of the Colorado Mined Land Reclamation Board for Coal Mining, effective August 20, 1980 and revised September 14, 2005. NWCC, Inc. is acting as the primary consultant and performed the geotechnical related investigation and design. Civil Design Consultants, Inc., as a subconsultant to NWCC, Inc. has completed the civil design related to configuration of the CRDA as well as the design and layout of the proposed haul road. Hydro-Environmental Solutions, Inc., as a subconsultant to NWCC, Inc. is the hydrologic consultant for the project.

This Geotechnical and Hydrologic Report has been prepared to summarize the data obtained from our field and laboratory investigations, results of the stability analysis and to present our conclusions and recommendations for the construction of the CRDA Expansion, haul road construction and surface and internal drainage. The Surface Water Control Plan is being presented in a separate report and has been incorporated into this report where appropriate.

Proposed Construction

It is our understanding that the proposed CRDA Expansion will consist of the construction a coal refuse stockpile with a volume of approximately 20 million cubic yards. The coal refuse will be generated from the Foidel Creek Mine, as well as the future Sage Creek Mine, which is to be located several miles to the north-northwest of this site.

The coal refuse consists of low quality coal generated from the existing wash plants located to the north of the proposed CRDA. The coal refuse product will be transported from the wash plants to the proposed refuse pile via existing surface roads from the coal refuse bin to the road currently used to access the low quality coal and overburden stockpiles. A new coal refuse haulroad will be constructed from this point to the CRDA. A Site Plan showing the general configuration of the CRDA, along with the test hole and test pit locations, is presented in Figure #2.

Previous Investigations and References

A Geotechnical and Hydrologic Investigation for the existing refuse disposal area and in the area of the proposed expansion was completed by CTL/Thompson, Inc. in a report prepared for Cyprus Yampa Valley Coal Company under their job number 18,714 and dated August 14, 1992. The Geotechnical Investigation was updated by CTL/Thompson when the area of the refuse pile was reduced, in a report prepared for Twentymile Coal Company under their job number 22,253 and dated January 17, 1995. NWCC, Inc. also prepared a Supplemental Geotechnical Investigation and Stability Analyses report for the existing refuse pile under our job number 97-3216 and dated December 18, 1997. This report was prepared for Twentymile Coal Company to supplement CTL/Thompson's 1995 report. These reports have been used to assist in the preparation of this report.

NWCC, Inc. has also been monitoring the construction and testing the fill materials for compaction in the existing refuse pile since 1995. NWCC, Inc. has also completed several other geotechnical investigations for buildings, structures and shafts within the Foidel Creek Mine.

Site Conditions and Geologic Setting

The Foidel Creek Mine facility is located within Sections 31 and 32 in Township 5 North, Range 86 West and southwest of the intersection of County Roads #33 and #27, in Routt County, Colorado. The mine facility is situated to the south of the Foidel Creek drainage. The project site is located to the east of an existing coal refuse pile situated within the Twentymile Coal-Foidel Creek Mine. The project site is located within an area that has been previously surface mined. The depth of the previous mining activity in this area is approximately 80 to 85 feet. The area was reclaimed with spoil materials in the late 1970's, which will be described in detail below.

The topography of the project site is variable due to the previous site grading and reclamation of the surface mining operations. The reclaimed areas within a majority of the project site generally slope moderately to strongly down to the north-northwest on the order of 10 to 20 percent. The vegetation on the reclaimed slopes generally consists of grasses and weeds. The existing coal refuse disposal area at the west and northwest edges of the proposed CRDA are generally constructed at 3(H) to 1 (V) slope configurations and generally slope down to the east-southeast.

The project site is situated in the Southern Rocky Mountain Province and lies at the east end of the Williams Fork Mountains. The site is located approximately 15 miles west of the west flank of the Park Range and approximately 10 miles northeast of the Dunkley Flattops. Portions of the Park Range are also referred to as the Gore Range in this area. The Dunkley Flattops are situated at the north end of the Flattops Range.

The Park Range Uplift has been interpreted as a product of the Laramide orogeny, which probably began in early Cretaceous time and reached its peak in Paleocene time. The Park Range uplift is anticlinal in nature with a core of igneous and metamorphic rocks flanked by sedimentary rocks of Upper Cretaceous age east of the project area. The Williams Fork Mountains are at the southeastern end of the Sand Wash Basin and contain upper Cretaceous rocks.

Specifically, the near surface bedrock in the project site is mapped as the Cretaceous Williams Fork Formation. The Williams Fork Formation consists of light brown to white sandstone, gray shale and coal beds from 1,000 to 2,000 feet in thickness. Gray claystone-shale bedrock materials have been encountered in previous subsurface investigations in the project area. Sandstone outcroppings were observed north of the project site and along the north side of Routt County Road #27, as well as to the west-southwest of the project site.

Overlying the bedrock in undisturbed areas, residual and colluvial clay soils are the products of chemical and mechanical erosion processes, which continue. These colluvial deposits appear to be relatively old in age, based on their consistency and density. These overburden soils and the upper bedrock materials have been removed and replaced over a majority of the project site during the mining and reclamation processes.

Structural features including folding and faulting in the region are commonly associated with the Park Range Uplift and the Laramide Orogeny Three northwest trending faults are mapped within or near the project site. A syncline (fold) structure is indicated by regional mapping just east of the project site. Movement in these structures has been inferred in Tertiary time.

Seismic activity in the project area is considered to be low. According to the Uniform Building Code (1997) all of Colorado is located in Zone 1. This classification implies the following seismic risk: "minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 second; corresponding to intensities V and VI on the Modified Mercalli Intensity Scale" (Algermissen, 1969). Based on the UBC definitions, levels of peak horizontal ground acceleration should not exceed 0.04g with a 90 percent probability level. Two earthquakes of significance have been recorded in the Steamboat Springs area since 1870. Both earthquakes, March 1895 and February 1955, corresponded to Modified Mercalli Intensities of V (Kirkham and Rogers, 1981). Based on the subsurface conditions encountered across the site and our review of the available literature, a Site Class of D would be used for this area in accordance with Table 1615.1.1 of the IBC 2003.

Field Investigation

The field investigation for this project was completed in two phases. The first phase consisted of the drilling of five (5) test holes and was completed on March 3 and 4, 2008. The second phase consisted of the excavation of seven (7) test pits and was completed on March 11, 2008. The test holes and test pits were advanced at the approximate locations shown in Figure #2 to determine the subsurface conditions for the foundation of the proposed CRDA. The client, using an instrument survey, determined locations and elevations of the test holes and test pits.

The test holes were advanced through the existing reclaim fill materials with 4-inch diameter continuous flight augers. The test holes were advanced with an all-terrain rig mounted with a CME 55 drill rig to depths ranging from 25 to 40 feet below the existing ground surface. A representative of NWCC, Inc. logged the test holes.

Samples of the subsurface materials in the test holes were taken with either a California Liner sampler or a standard split spoon sampler. The samplers were driven into the various strata with blows from a 140-pound hammer falling 30 inches. This test is similar to the standard penetration test described by ASTM Method D-1586. Penetration resistance values, when properly evaluated, indicate the relative density or consistency of the soils and bedrock materials. Depths at which the samples were taken and the penetration resistance values are shown on the logs of the exploratory test holes in Figure #3.

The test pits were excavated with a Cat 315B trackhoe. The test pits were excavated in the upper 10 to 11½ feet of the existing reclaim fill materials. A representative of NWCC, Inc. logged the test holes.

Large bulk samples of the reclaim fill materials were obtained as the test pits were excavated. Graphic logs of the exploratory test pits are shown in Figure #4. The Legend and Notes associated with the test hole and test pit logs are shown in Figure #5.

Laboratory Investigation

Samples obtained from the test holes and test pits were examined and classified in the laboratory by the project engineer. The laboratory testing included standard index property tests, such as natural moisture contents, density, grain size analyses and liquid and plastic limits. Swell-consolidation tests were also conducted on relatively undisturbed samples of the reclaim fill materials to determine the swell-consolidation potential of these materials. Moisture-density relationships using Standard Proctor tests were conducted on the large bulk samples obtained from the test pits. Unconfined-compressive (U-U) strength tests were conducted on samples of the in-place reclaim fill materials obtained from the test holes, as well as remolded samples obtained from the Standard Proctor tests. A bulk sample of the reclaim materials was delivered to Knight Piesold Consulting for triaxial shear testing. Consolidated-undrained (C-U) with pore pressure shear strength testing was performed on remolded samples of the reclaim fill materials.

It should be noted that the reclaim spoils contain a significant percentage of cobbles and boulders, which cannot be included in conventional test samples.

A summary of the standard index properties and unconfined compressive strengths from the samples obtained from the test holes are summarized in the attached Table 1. A summary of the standard index properties and unconfined compressive strengths from the remolded samples are summarized in the attached Table 2. Tables 1 and 2 along with the Standard Proctor test results, swell-consolidation test results and tri-axial shear strength test results are presented in Appendix A. All of the laboratory testing was conducted in general accordance with applicable ASTM specifications.

Subsurface Conditions

The subsurface conditions encountered in the test holes and test pits were fairly consistent and generally consisted of fill materials used to reclaim the previous surface mining operation at the site. The reclaim fill materials consisted of a layer of topsoil and organic fill materials overlying reclaim spoils to the maximum depth investigated, 40 feet. The logs of the exploratory test holes are shown in Figure #3. The logs of the exploratory test pits are shown in Figure #4. The associated Legend and Notes for the test holes and test pits are presented in Figure #5.

The topsoil and organic fill materials were encountered in all of the test holes and pits and generally ranged from 12 to 18 inches in thickness. Reclaim spoils were encountered beneath the topsoil and organic materials in all of the test holes and test pits and extended to the maximum depths investigated in each test hole/pit. The reclaim spoils generally consisted of sands, clays and silts with bedrock fragments, which were low to highly plastic, medium dense to dense, dry to moist and brown to gray in color. The bedrock (sandstone and claystone) fragments generally ranged in size from gravels to large boulders. Samples of the reclaim spoils classified as SC-SM to CL-CH soils in accordance with the Unified Soil Classification System.

Groundwater seepage was only encountered in one test hole at the time of drilling. Groundwater seepage was encountered in test hole 5 at a depth of 8½ feet beneath the existing ground surface at the time of drilling. The seepage is likely due to the proximity of the test hole to an existing drainage ditch, which was flowing at the time of our field investigation. It should be noted that groundwater conditions can be expected to fluctuate with changes in precipitation and runoff at the site.

Coal Refuse Disposal Area Analysis & Design

The location of the proposed CRDA Expansion was chosen by Twentymile Coal based on previous investigations and design for the CRDA. Analysis and design related to any potential acid or toxic properties of the coal refuse is not within the scope of this investigation.

Volume and Configuration

The required volume of the proposed CDRA Expansion requested by Twentymile Coal Company was approximately 20 million cubic yards (mcy). The design configuration presented in this report contains approximately 20.7 mcy. The maximum height of the CDRA will be on the order of 200 to 250 feet above the existing ground surface. The top of the CDRA will slope down to the southeast to minimize runoff over the face of the fill slope. The Final Grading Plan for the CRDA is presented in Figure C-101. The Phase I Grading Plan is presented in Figure C-102.

The refuse pile includes a sloped face at a 3(H) to 1 (V) slope configuration with 20 foot wide benches and associated ditches at 50 feet vertical intervals. This provides an overall slope configuration of approximately 3.5 to 1. Typical Sections through the proposed CRDA are presented in Figure C-301. The benches will be constructed to slope away from the face of the slope to a ditch, which will flow around the face of the slope to the east and west-southwest to the main drainage ditch around the CRDA. The ditches are designed with an approximately 1.5% to 4% slope.

The proposed refuse pile is not classified as a valley fill according to the Regulations. The steepest side slopes in the reclaim area are on the order of 10 to 15 degrees. The existing coal refuse area that is located along the west side of the proposed CRDA is constructed at an overall slope configuration of 3 (H) to 1 (V).

The CDRA configuration was developed to provide long-term stability working with the landforms at the site. The pile expansion will be contained by the existing coal refuse pile to the west and the existing hillsides to the south and east. An underdrain is planned to control water levels from reaching a level where the pile stability could be affected.

The CDRA is designed as a non-impounding embankment fill. A permanent drainage ditch is designed above the site and around the east and south sides of the pile and then tying into the existing ditch situated along the south and west sides of the existing refuse pile. The existing ditch currently flows into Pond D. The ditch should be constructed prior to starting construction of the refuse pile. Temporary diversion ditches should be constructed and maintained a maximum of 50 vertical feet above the refuse pile to control surface drainage between the permanent ditch and the back of the pile. As the waste pile progresses in height, the temporary diversion ditches should be moved up the slope.

Slope Stability Analysis

A stability analysis of the proposed slope configuration was completed to determine the potential for slope movement. The analysis involved the evaluation of the geotechnical properties of the coal refuse and foundation conditions. A typical cross-section of the north side of the proposed configuration was used in our analysis. The soil properties and analysis are outlined below. The results of the stability analysis are outlined below and presented in Appendix C.

The properties of the coal refuse materials were determined using results from the previous investigations, as well as data collected from the compaction testing and observation of the construction of the existing coal refuse disposal area. For this evaluation we have assumed that the coal refuse materials will be a granular, non-cohesive material. Values of 25, 30 and 35 degrees for the internal angle of friction, values of 95, 105 and 115 pcf for the unit weight and a cohesion value of 0 psf were used in the analysis of the proposed slopes.

Based on the laboratory and triaxial shear test results for the reclaim spoils encountered at the site, values of 34 and 38 degrees for the internal angle of friction, values of 110, 120 and 130 pcf for the unit weight and a cohesion value of 0 psf were used in the analysis of the proposed slopes. It should be noted that the larger particle size materials (larger gravels, cobbles and boulders) were not used in the triaxial shear test; therefore, the values for the angle of friction are conservative.

We have assumed that claystone or sandstone bedrock will be encountered below the reclaim spoils at a depth of approximately 85 to 100 feet below the existing ground surface. We have assumed a value of 25 degrees for the internal angle of friction, 120 pcf for the unit weight and a cohesion value of 5,000 psf for the underlying bedrock materials.

Using the information above, we have determined the critical section would be the fill slope on the north side of the proposed CRDA. The stability analysis was performed using the Slope/W 2007 computer program developed by GEO-SLOPE International, Ltd. A circular slip surface was assumed to be the most probable mode of failure; therefore, the Bishop's Method of Slices was used to calculate the factors of safety against slope failure. The slope stability model analyzes the driving forces (i.e., forces causing the slope to move) versus the resisting forces (i.e., the shear strength of the soils tending to resist movement). The ratio of these forces yields the factor of safety of the slope against movement (failure). A factor of safety of 1.0 indicates failure of the slope and subsequent movement. A minimum factor of safety of 1.5 under static conditions is required for the proposed slopes for the coal refuse disposal area.

Based on our analysis, the variability of the unit weight for the coal refuse and reclaim spoils did not have a significant effect on the factor of safety. It was also determined that using an internal angle of friction of 25 degrees, with a cohesion value of 0 psf, for the coal refuse yielded a factor of safety of 1.2 for the proposed fill slope. This indicated a shallow failure on the face of the fill slope. We believe this low value for the angle of friction is very conservative and would likely only occur where insufficient compaction is attained (particularly near the edge of the slope). Factors of safety of 1.5 to 1.8 were obtained when the friction angle for the coal refuse was increased to 30 and 35 degrees. These failure surfaces were also relatively shallow and in the face of the fill slope.

It should also be noted that if finer-grained soils are encountered in the coal refuse materials, resulting in a lower friction angle, the value for the cohesion will also be increased resulting in a higher factor of safety. Factors of safety increased to greater than 2.0 when the cohesion of the waste coal materials was increased to 100 psf, with an internal angle of friction of 25 degrees.

The overall global stability of the proposed CRDA failing through the foundation reclaim spoil materials yielded a factor of safety in excess of 2.0.

Internal Drainage

As noted previously, the proposed CRDA does not classify as a valley fill in the regulations. Therefore, the CRDA is not required to have a full-sized valley fill drain. However, considering possible water sources entering the fill slope (storm water, snowmelt and free water from the coal refuse fill materials), we recommend that an underdrain system be constructed at the base of the fill materials. The location of the underdrain is shown in Figure C-101 and typical cross-sections of the underdrain are presented in Figure C-301. The design of the underdrain is presented in the Surface Water Control Plan, which is being presented in a separate report.

Settlement

Settlement of the fill and foundation soils will not be excessive and should not affect slope stability or construction. The reclaim spoils and coal refuse are anticipated to behave as granular (non-cohesive) materials and we anticipate settlement to occur rapidly as loads are applied during construction of the CDRA.

The top surface of the CDRA is designed to drain to the southeast, away from the slope face, at approximately 2.5 to 3 percent. The elevation of the CDRA at the face is approximately 40 to 50 feet above the elevation at the back of the fill area. This will provide for adequate drainage away from the face of the fill slope, even if some long-term settlement of the coal refuse fill materials occur.

Construction Recommendations

Initial Construction and Phasing

Phase I of the project will consist of the construction of the new haulroad, permanent and temporary ditches and the permanent underdrain to allow for fill placement and approximately 2.8 mcy of the coal refuse in the CRDA. The construction of the CRDA will start at the north end and progress to the south. The construction for Phase I of the CRDA will consist of up to 100 feet of vertical construction, to the second bench, in the northern portion of the fill area. Prior to construction of the CRDA, the existing soil and cover materials will be stripped and stockpiled near the top of the proposed fill areas. A temporary diversion ditch should be placed a maximum of 50 vertical feet above the initial construction and relocated as the pile advances. Future phases will consist of further vertical placement of fill materials to the maximum height of the CRDA area. More detailed discussions of the construction are outlined below.

Haulroad Construction

A new haulroad will be constructed beginning at the northeast end of an existing haulroad located along the southern edge of Pond D and the northern edge of another existing pond. The new haulroad will be approximately 2,300 feet in length. The haulroad will extend approximately 500 feet to the northeast from the existing haulroad then curve to the south approximately 400 to 500 feet and continue southwest to the proposed CRDA at Station 23 + 00. The haulroad will have a driving surface approximately 30 feet in width. The Haul Road Plan is presented in Figure C-103.

We recommend that the gravel/pavement section for the haulroad consist of 18 inches of sub-base sands and gravels overlain by 6 inches of base course materials. The sub-base and base course materials should meet specifications for aggregates outlined by the Colorado Department of Transportation, Standard Specifications for Road and Bridge Construction, Section 703. The sub-base sands and gravels should consist of a pit run material, which meets CDOT Class 3 specifications. The base course materials should consist of a well-graded aggregate base course, which meets CDOT Class 5 or 6 specifications.

The sub-base and road base materials should be compacted to a minimum of 95 percent of the maximum modified Proctor density, as determined by ASTM D1556.

We recommend that the roadway areas be prepared by scarifying, moisture conditioning and re-compacting the existing soils to provide uniform support for the roadway section and help control differential movement. We recommend that the subgrade areas be scarified to a depth of at least 12 inches; the exposed materials be moisture conditioned by bringing the scarified soils to within +/-2 percent of the optimum moisture content; and then recompact the properly moisture treated soils to at least 95% of the maximum standard Proctor density determined in accordance with ASTM D698. After the subgrade soils have been properly moisture treated and recompacted, the subgrade should be proof rolled with a heavily loaded pneumatic tired vehicle and any areas which deform excessively under the wheel loads should be removed and replaced or stabilized prior to paving operations. Areas of soft and saturated soils may be encountered near subgrade elevations in some areas. Removal and replacement of these materials may be required and should be evaluated at the time of construction. Any additional fill materials placed under the pavement areas should be uniformly placed and compacted in 6 to 8 inch loose lifts to at least 95 percent of the maximum standard Proctor density and within +/- 3 percent of the optimum moisture content. The materials removed from cut areas can be used for subgrade fill materials, after any boulder sized fragments are removed.

Drainage ditches will be constructed along the new haul road to provide drainage away from the road section. Approximate locations of the culverts to be installed across the new haul road are presented in Figure C-103 and may have to be modified at the time of construction. Culvert sizes are shown on Figure C-103 and outlined in the Surface Water Management Plan. The road base materials should be shaped to drain away from the roadway to the drainage ditches.

Drain Construction

The underdrain location is shown in Figure C-101 and typical cross-sections and material requirements are presented in Figure C-301. The drain materials will not require compaction. The drain materials can be loose dumped to the minimum dimensions shown. The drain materials should be protected from excessive contamination by the use of two layers of filter materials. The filter materials must meet the specifications noted and be constructed to the minimum thickness shown in the cross-sections.

Coal Waste Placement and Compaction

Regulation 4.10.4.3 require the coal refuse materials be placed in lifts of 24 inches maximum and be compacted to a minimum of 90 percent of the maximum dry density as determined by AASHTO T-99. However, we recommend that the coal refuse materials be placed in lifts of 12 inches or less and be compacted to a minimum of 90 percent of the maximum Standard Proctor density, within 3 percent of the optimum moisture content, as determined by AASHTO T-99/ASTM D698.

It should be noted that thicker lifts (> 12 inches) may be possible depending on the placement process and equipment utilized. This should be confirmed with field-testing during the initial construction of the pile and approved by this office.

The moisture content of the fill materials should be monitored as the fill is placed. We recommend that the fill materials be stockpiled to allow the free water to drain prior to placement and compaction. If a considerable amount of fines are encountered in the fill materials, additional drying may have to occur prior to compaction of these materials. The moisture-density relationships (Proctor values) will vary depending on the gradation and material properties. The coal refuse fill materials should not be greater than 3 percent over the optimum moisture content at the time of placement. However, the required compaction may be achievable at 4 to 5 percent below the optimum moisture content with the more granular materials.

Cover Material

The cover layer will consist of 1.5 feet of soil material and 2.5 feet of suitable cover material for a total cover thickness of 4 feet. Cover material will be obtained by stripping the existing soil and upper weathered portion of the reclaimed spoils in the area of the proposed CRDA. The soil and cover materials will be stockpiled in the southern portion of the CRDA and placed on the finished slopes as each bench is completed.

The cover materials should be placed in 8 to 12 inch lifts and compacted to a minimum of 92 percent of the maximum Standard Proctor density and within 3 percent of the optimum moisture content, as determined by ASTM D698. Particles (boulders) larger than 12 inches in diameter should be removed from the cover materials prior to placement. The boulders may be disposed of within the core of the CRDA, with MSHA approval, or disposed of off-site. Soil materials should be placed and revegetated as required by the regulations.

The cover materials and soil will form the bench ditches; therefore, grading control of the cover and soil materials will be important to provide slope to the ditches as recommended by the Surface Water Management Plan (Appendix A). The slope of the benches is noted on the CRDA Grading Plan (Figure C-101).

Estimated quantities required for soil and cover materials for completed CRDA.

Surface area base of pile = 5,581,000 ft^2
Volume of Excavated Soil (1.5' deep) = 310,056 yd^3
Volume of Excavated Reclaim Spoils (3.5' deep) = 723,463 yd^3
Total surface area of completed pile = 5,575, 000 ft^2
Soil Volume Required = 309,722 yd^3
Cover Soil Volume Required = 567,824 yd^3

Depending on the amount of boulders in the excavated reclaim spoils, additional cover soil materials may be required. This should be evaluated at the time of stripping of the reclaim spoils.

Inspection and Testing

The CRDA Expansion must be inspected at least quarterly by an engineer from NWCC, Inc., beginning within 7 days after the preparation of the disposal area begins, in accordance with Section 4.10.2 of the regulations. The quarterly inspections must continue until the CRDA has been covered, soil has been placed and revegetated or as required by the CDRMS. In addition, the following items should be inspected and/or tested by NWCC, Inc. during construction of the CRDA Expansion.

1) After stripping of the soil materials and excavation of the proposed cover materials, to confirm the foundation conditions are as anticipated in this report.

2) Initial drain construction to evaluate construction procedures. Samples of the drain rock and filter material may require testing prior to use, in order to evaluate gradation and durability.

3) The coal waste product to be used in construction of the CRDA should be evaluated for gradation, Standard Proctor and moisture content to confirm the properties used in the design.

4) Initial placement of the coal refuse should be observed and tested to evaluate the material properties and compaction procedures established in the existing CRDA are adequate.

5) Compaction testing and observation of the fill materials and placement methods must be performed on a regular basis as the CRDA construction proceeds. The frequency will depend on the rate of pile construction. As a minimum, the fill materials should be tested at least every 4 feet vertically.

6) We recommend the construction of a minimum of two wells to monitor water conditions within the pile. The monitor wells should be constructed when the fill materials have been placed to a height of at least 50 feet.

Limitations

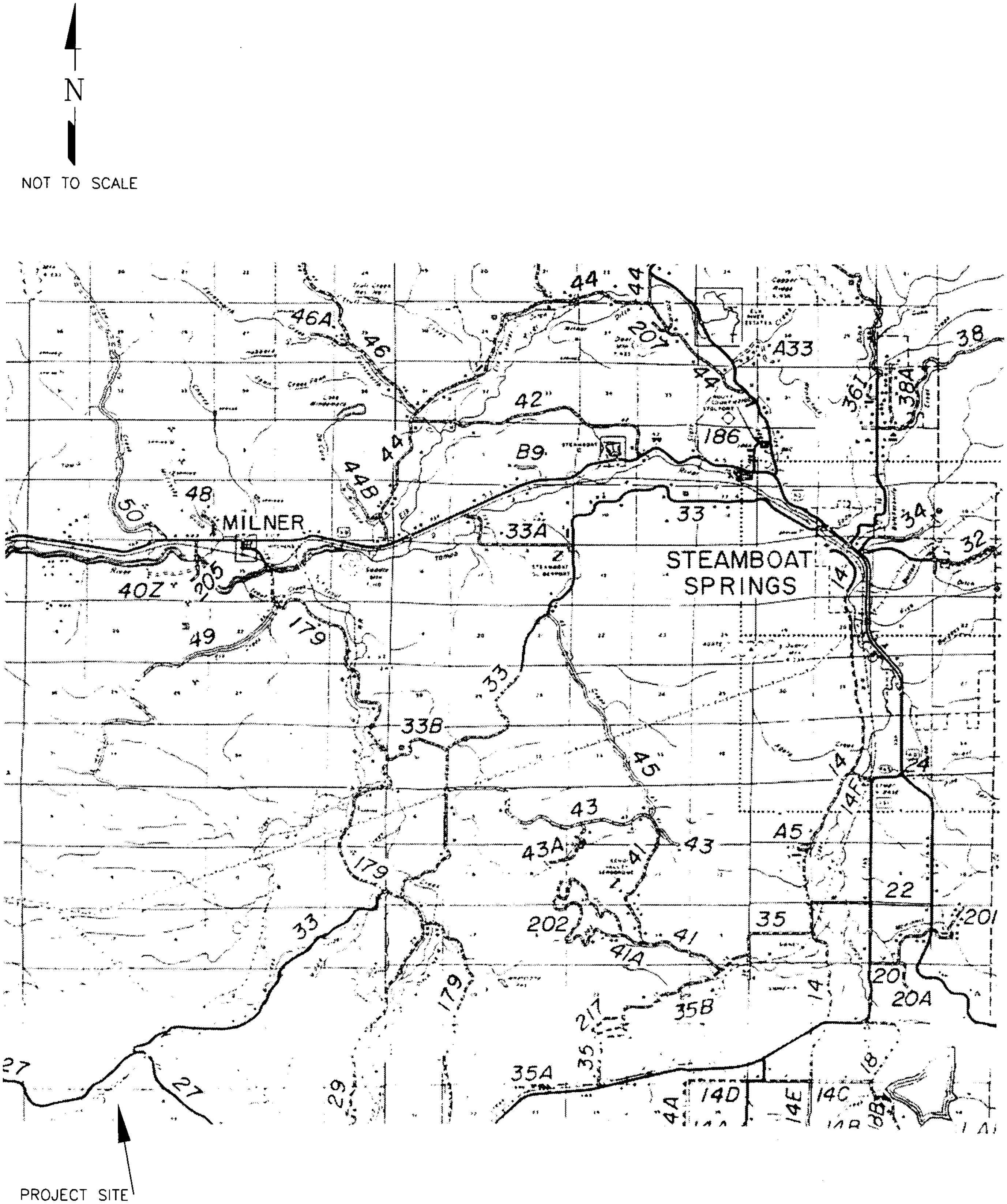
The recommendations given in this report are based on the subsurface conditions encountered in the test holes and pits, and those encountered in the construction of the current CRDA. The test holes and pits were widely spaced to determine the general subsurface profile in the CRDA. We believe that this information gives a high degree of reliability for anticipating the performance of the constructed slopes; however, our recommendations are professional opinions and cannot control nature, nor can they assume the soils and groundwater conditions beneath or adjacent to those observed. We do not guarantee the performance of the constructed slopes in any respect, only that our engineering work and judgments rendered meet the standard of care of our profession. The CRDA construction must be inspected, as required by the Regulations of the Colorado Mined Land Reclamation Board for Coal Mining, to confirm the conditions exposed during excavation and construction of the slopes and drainage are as anticipated in this design. The field monitoring will identify unanticipated conditions and allow adjustments to the design and construction methods. Uncontrolled modifications could adversely affect the stability of the constructed slopes.

If you have any questions regarding this report or if we may be of further service, please do not hesitate to contact us.

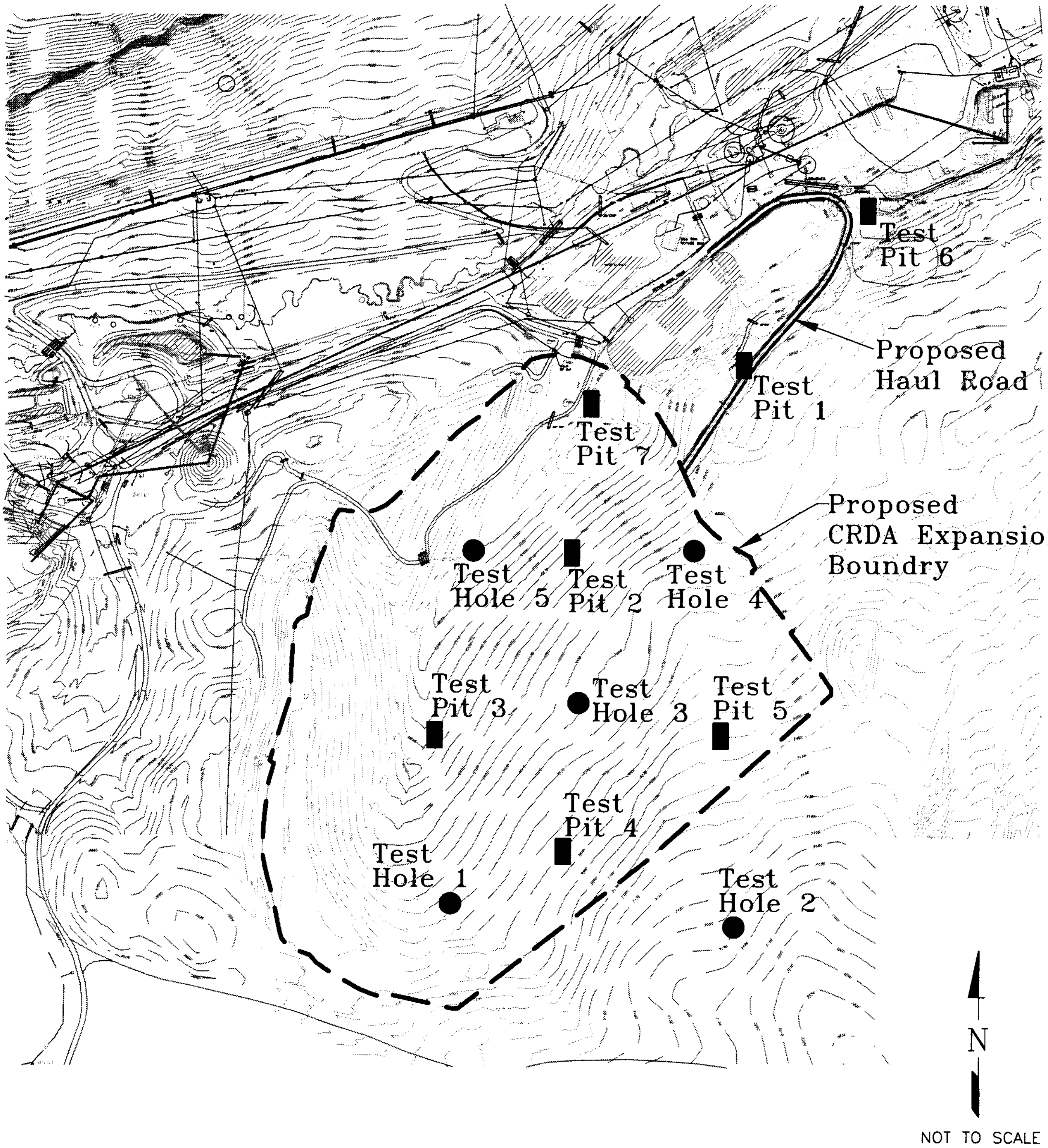
Sincerely,
NWCC, INC.

Timothy S. Travis, P.E.

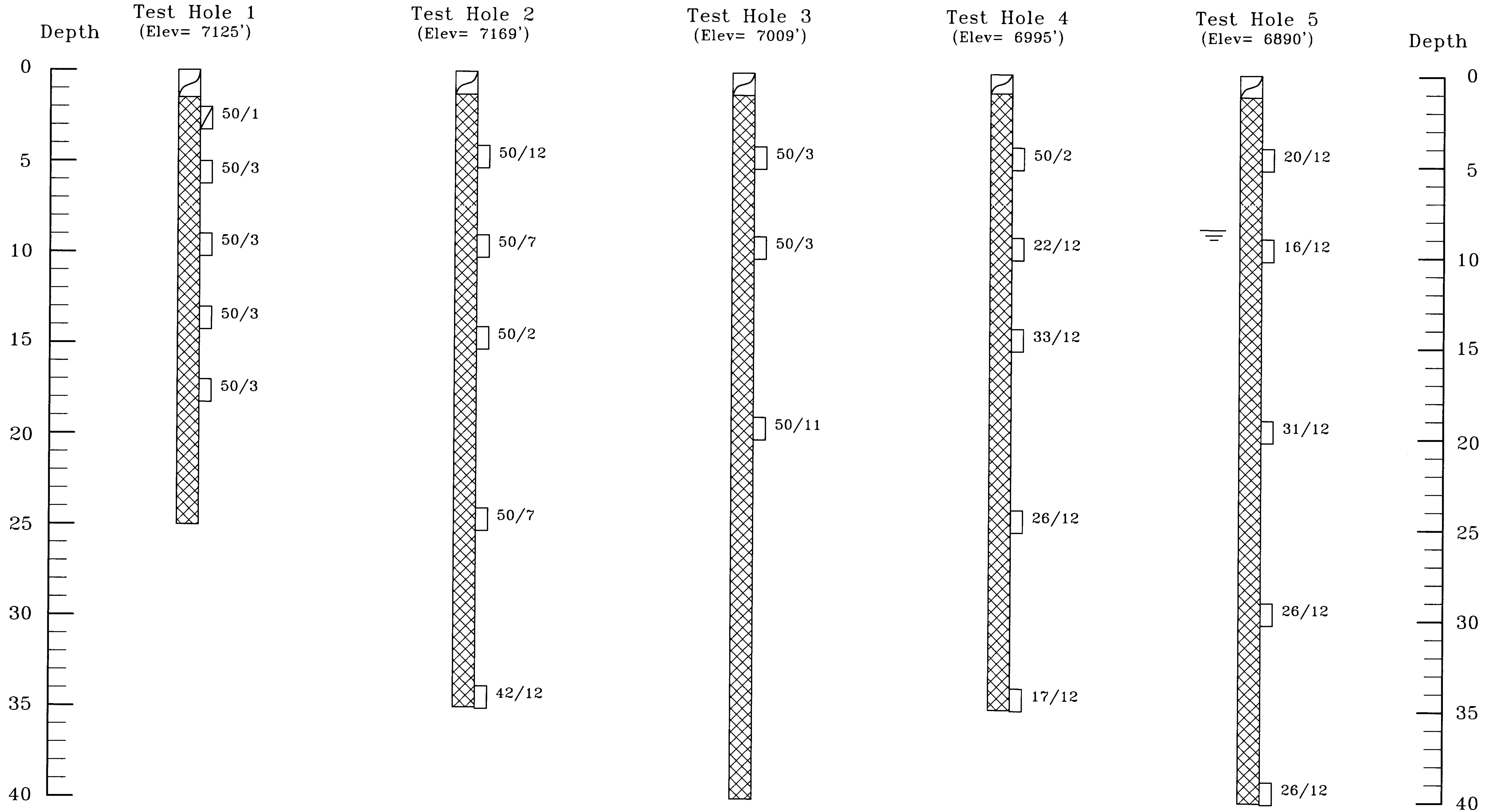
Reviewed by Brian D. Lee, P.E.



Title: VICINITY MAP	Date: 6/17/09	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering · Materials Testing (970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Job Name: Proposed CRDA Expansion	Job No. 08-7915	
Location: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #1	



Title: SITE PLAN–LOCATION OF TEST HOLES/PITS	Date: 6/17/09	NWCC North West Colorado Consultants, Inc.
Job Name: Proposed CRDA Expansion	Job No. 08–7915	Geotechnical / Environmental Engineering · Materials Testing
Location: Twentymile Coal–Foidel Creek Mine, Routt County, CO	Figure #2	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487



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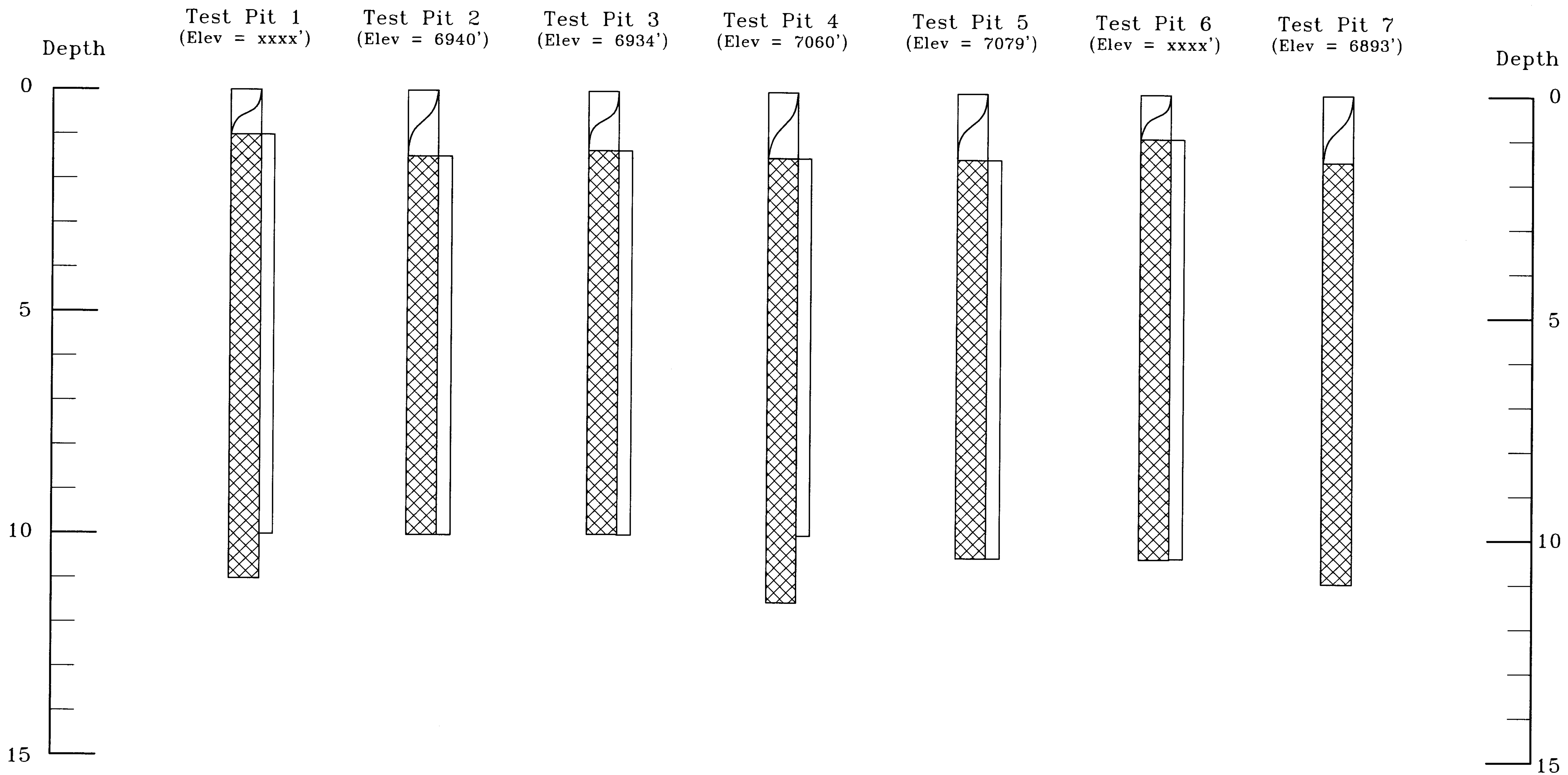
Title:	Logs of Exploratory Test Holes
Job Name:	Proposed CRDA Expansion
Location:	Twentymile Coal–Foidel Creek Mine, Routt County, Colorado

Job No.:	Date:	FIGURE:
08-7915	6/17/09	#3



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Title:	Logs of Exploratory Test Pits
Job Name:	Proposed CRDA Expansion
Location:	Twentymile Coal–Foidel Creek Mine, Routt County, Colorado
Job No.: 08-7915	Date: 6/17/09
FIGURE:	#4

LEGEND:

FILL: Reclaim Topsoil and organic materials.

FILL–RECLAIM SPOILS: Sands, clays and silts with bedrock (sandstone, claystone) fragments (gravels to large boulders), low to highly plastic, medium dense to dense, dry to moist and brown to gray in color.

Drive Sample, 2–inch I.D. California Liner Sampler.

Drive Sample, Split Spoon Sampler.

Large Disturbed Bulk Sample.

50/3 Drive Sample Blow Count, indicates 50 blows of a 140–pound hammer falling 30 inches were required to drive the sampler 3 inches.

Indicates depth at which groundwater seepage was encountered at the time of drilling.

NOTES:

1) The test holes were drilled on March 3 and 4, 2008 with an all–terrain drill rig using 4–inch diameter continuous flight power augers.

2) The test pits were excavated on March 11, 2008 with a Cat 315B trackhoe.

3) Locations and elevations of the test holes and test pits were determined by the client using an instrument survey.

4) The lines between materials shown on the logs represent the approximate boundaries between material types and transitions may be gradual.

5) The water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water levels will likely occur with time.

Title: LEGEND AND NOTES	Date: 6/17/09
Job Name: Proposed CRDA Expansion	Job No. 08–7915
Location: Twentymile Coal–Foidel Creek Mine, Routt County, CO	Figure #5

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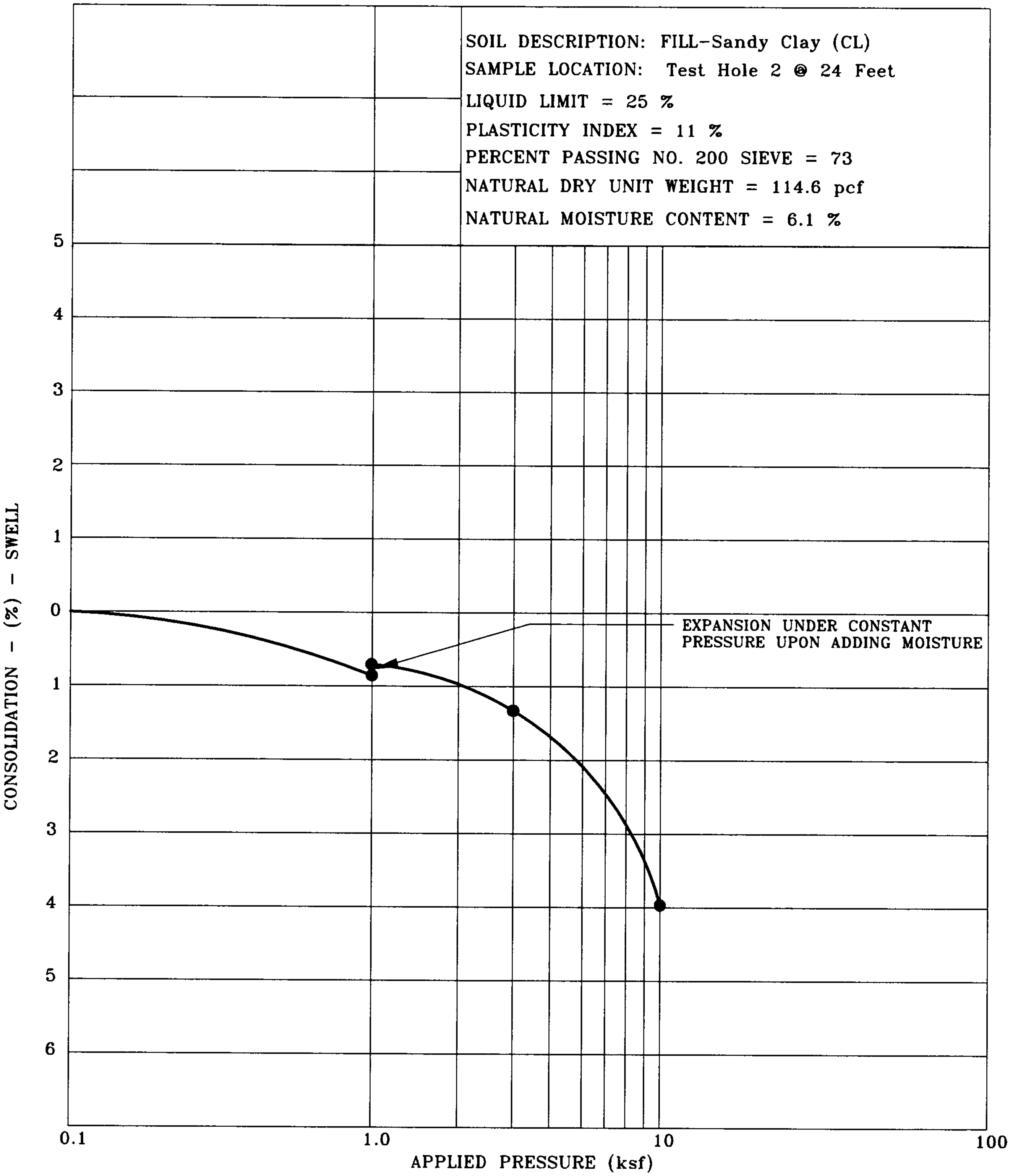
Appendix A

Laboratory Test Results



Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 6/17/09
Job Name: Proposed CRDA Expansion	Job No. 08-7915
Location: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #A1

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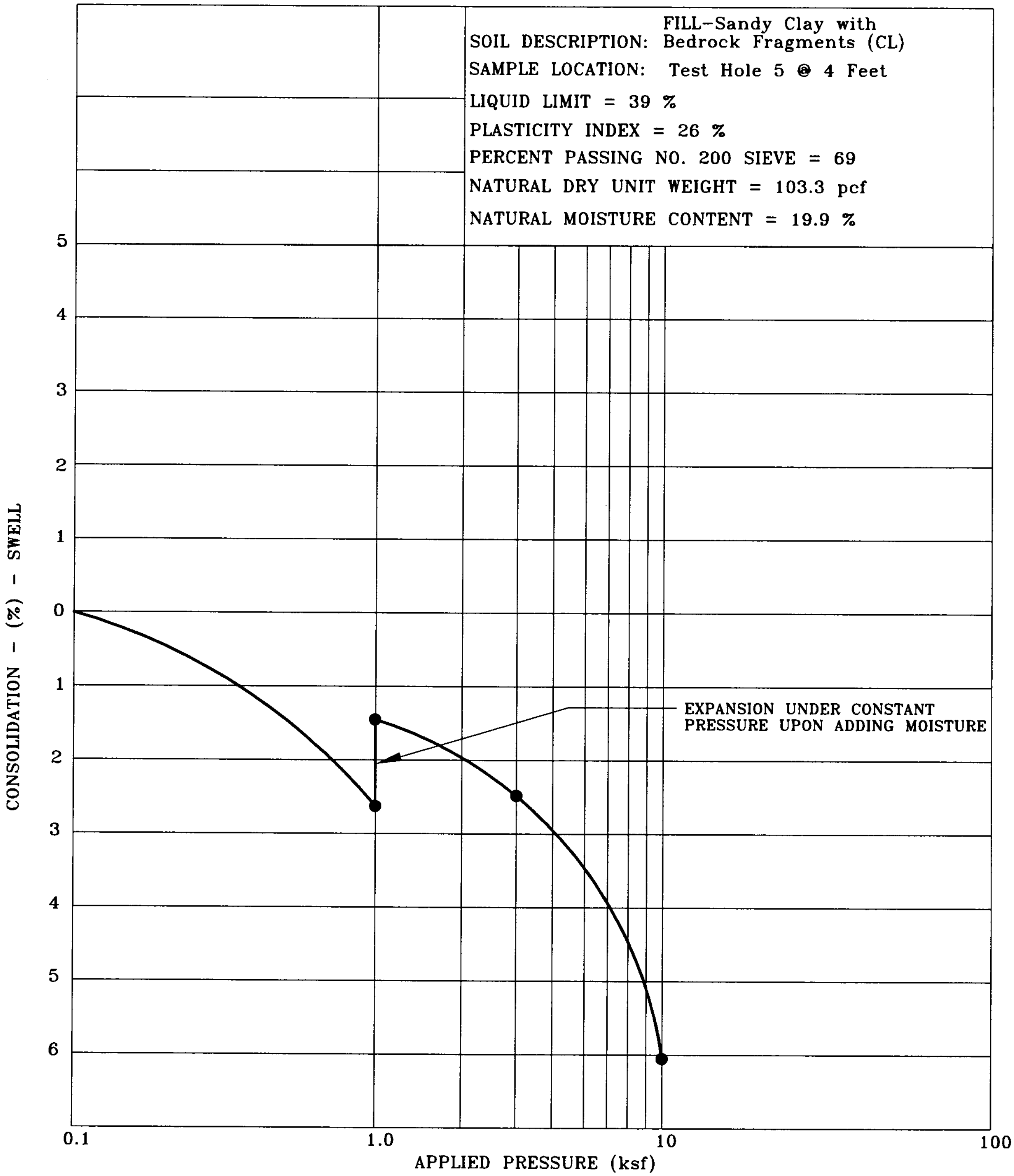
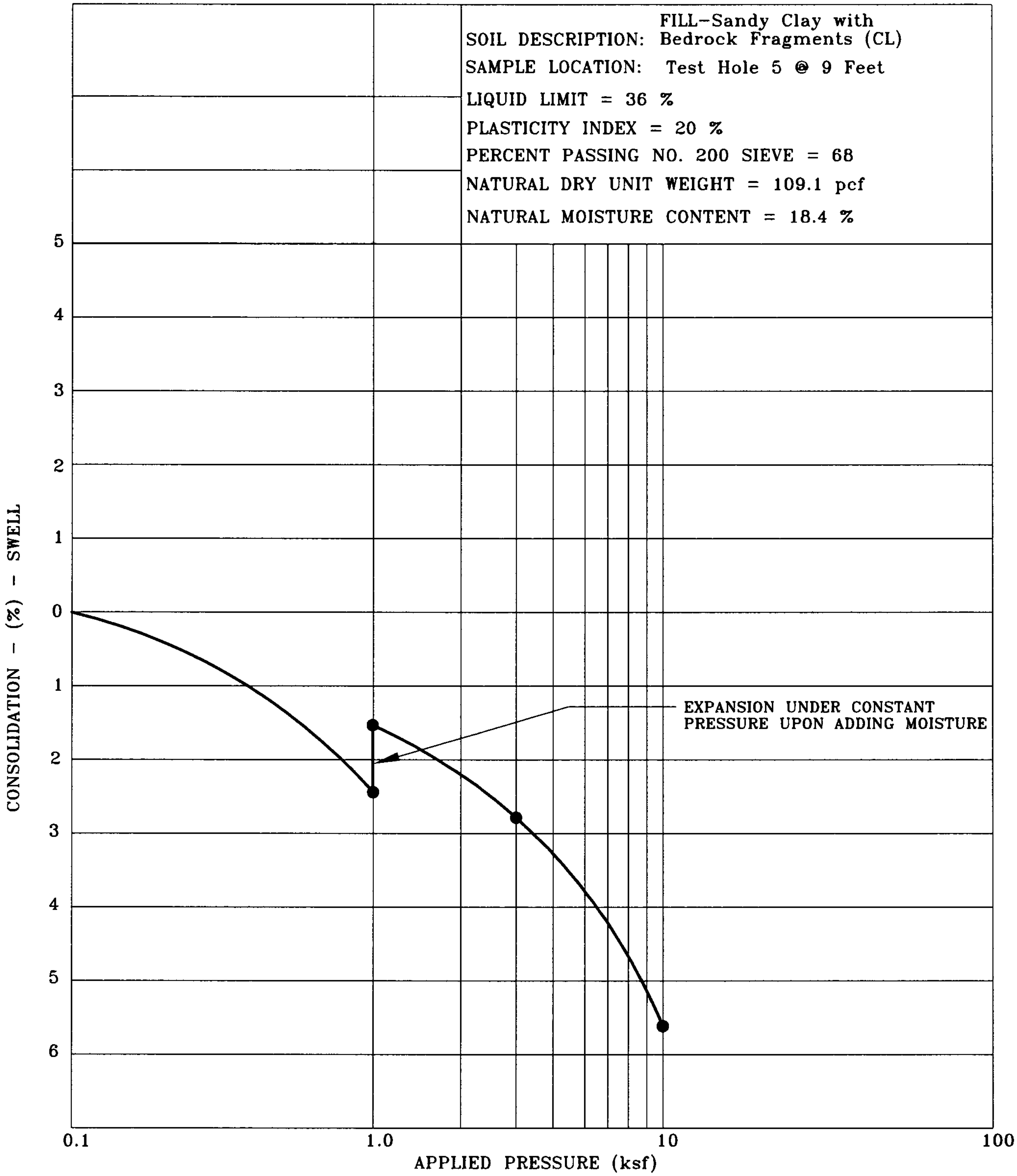


Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 6/17/09	NWCC North West Colorado Consultants, Inc.	
Job Name: Proposed CRDA Expansion	Job No. 08–7915	Geotechnical / Environmental Engineering · Materials Testing	
Location: Twentymile Coal–Foidel Creek Mine, Routt County, CO	Figure #A2	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487	



Title: SWELL–CONSOLIDATION TEST RESULTS	Date: 6/17/09
Job Name: Proposed CRDA Expansion	Job No. 08-7915
Location: Twentymile Coal–Foidel Creek Mine, Routt County, CO	Figure #A3

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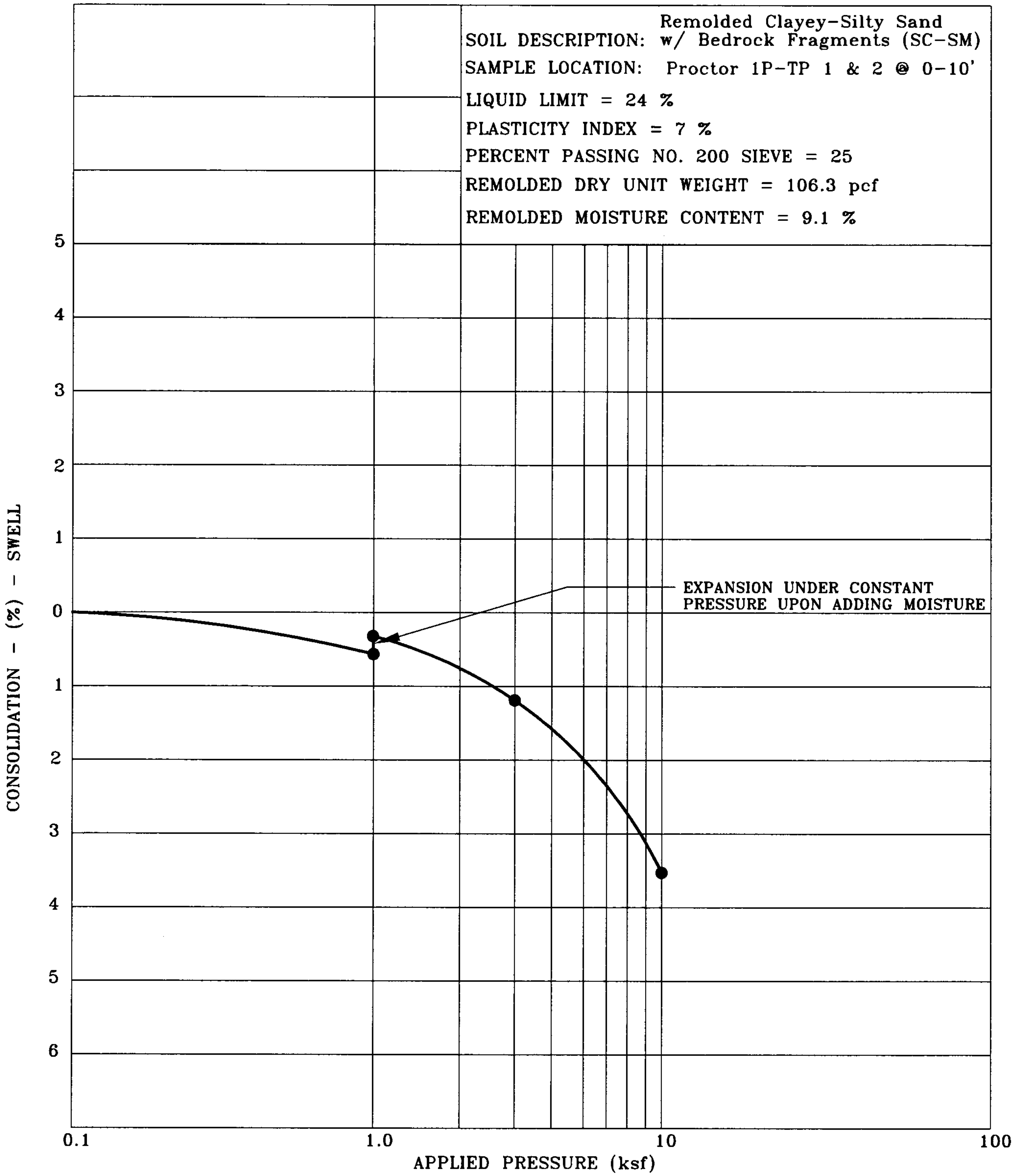

Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 6/17/09
Job Name: Proposed CRDA Expansion	Job No. 08-7915
Location: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #A4

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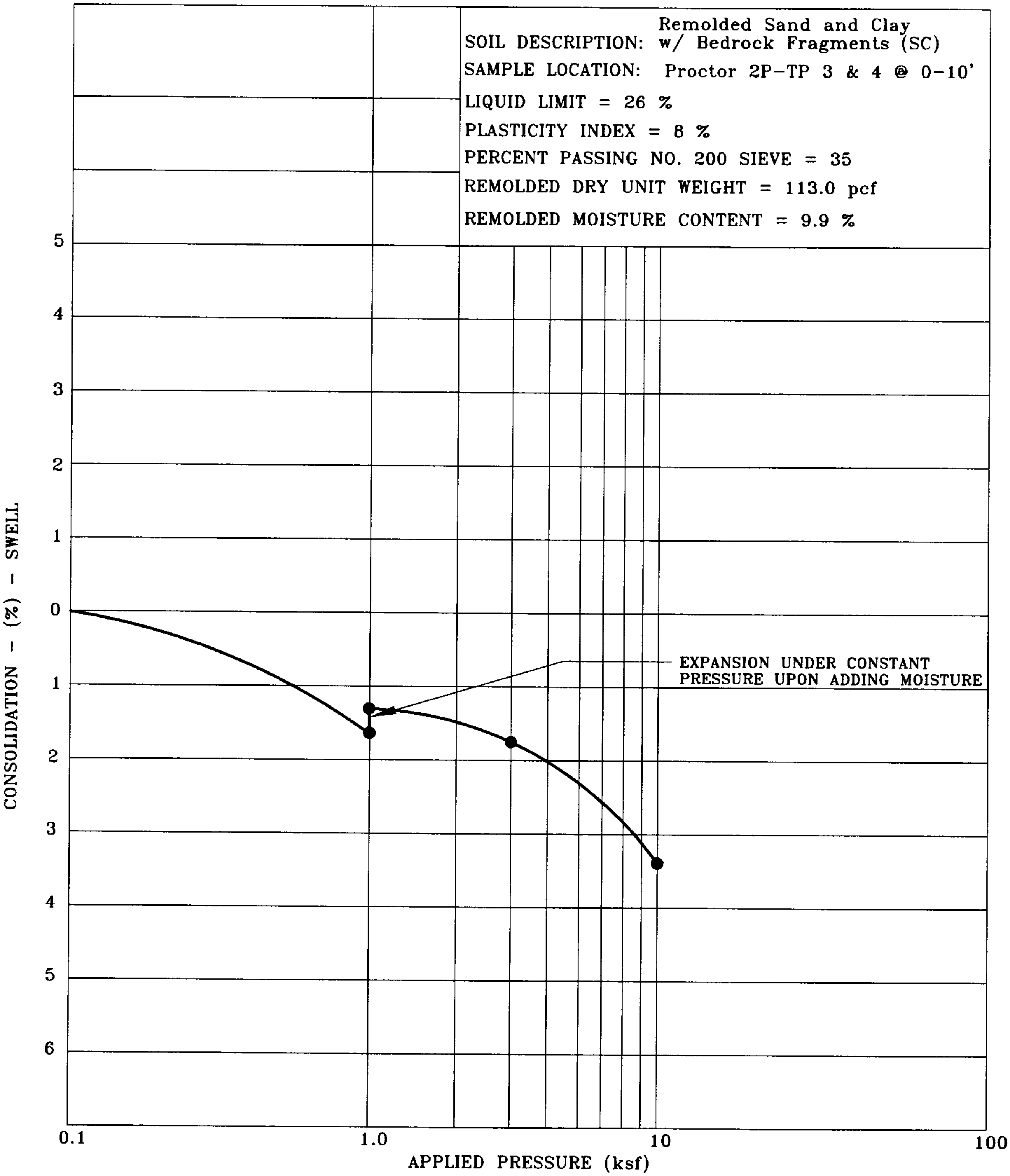

Title: SWELL-CONSOLIDATION TEST RESULTS	Date: 6/17/09
Job Name: Proposed CRDA Expansion	Job No. 08-7915
Location: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #A5

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TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	ATTERBERG LIMITS		GRADATION		PERCENT PASSING No. 200 SIEVE	UNCONFINED COMPRESSIVE STRENGTH (psf)	SOIL or BEDROCK DESCRIPTION	UNIFIED SOIL CLASS.
TEST HOLE	DEPTH (feet)			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
1	5	6.0	104.0	18	np	26	29	45	0	FILL-Sandy Silt w/ Bedrock Fragments	ML
1	13	9.6	113.8	23	5	13	49	38	1,043	FILL-Clayey Silty Sand w/ Bedrock Fragments	SC-SM
2	9	9.0	105.0	23	12	1	39	60	1,101	FILL-Very Sandy Clay	CL
2	24	6.1	114.6	25	11	0	27	73		FILL-Sandy Clay	CL
2	34	7.4	108.5	21	6	1	18	81	3,630	FILL-Sandy Clay-Silt	CL-ML
3	4	6.4	110.1	28	15	5	19	76	5,750	FILL-Sandy Clay w/ Bedrock Fragments	CL
3	39	11.5	107.8	49	31	17	36	47	3,410	FILL-Very Sandy Clay w/ Bedrock Fragments	CL-CH
4	24	9.5	101.2	26	5	21	44	35	1,586	FILL-Clayey-Silty Sand w/ Bedrock Fragments	SC-SM
5	4	19.9	103.3	39	26	6	25	69		FILL-Sandy Clay w/ Bedrock Fragments	CL
5	9	18.4	109.1	36	20	5	27	68		FILL-Sandy Clay w/ Bedrock Fragments	CL
5	19	11.1	107.8	30	10	35	29	36	3,950	FILL-Sand and Clay w/ Bedrock Fragments	CL-SC
5	29	13.2	109.6	26	8	26	34	40	2,110	FILL-Sand and Clay w/ Bedrock Fragments	CL-SC
5	39	12.7	111.9	30	13	23	31	46	5,240	FILL-Sandy Clay w/ Bedrock Fragments	CL

JOB NUMBER: 08-7915

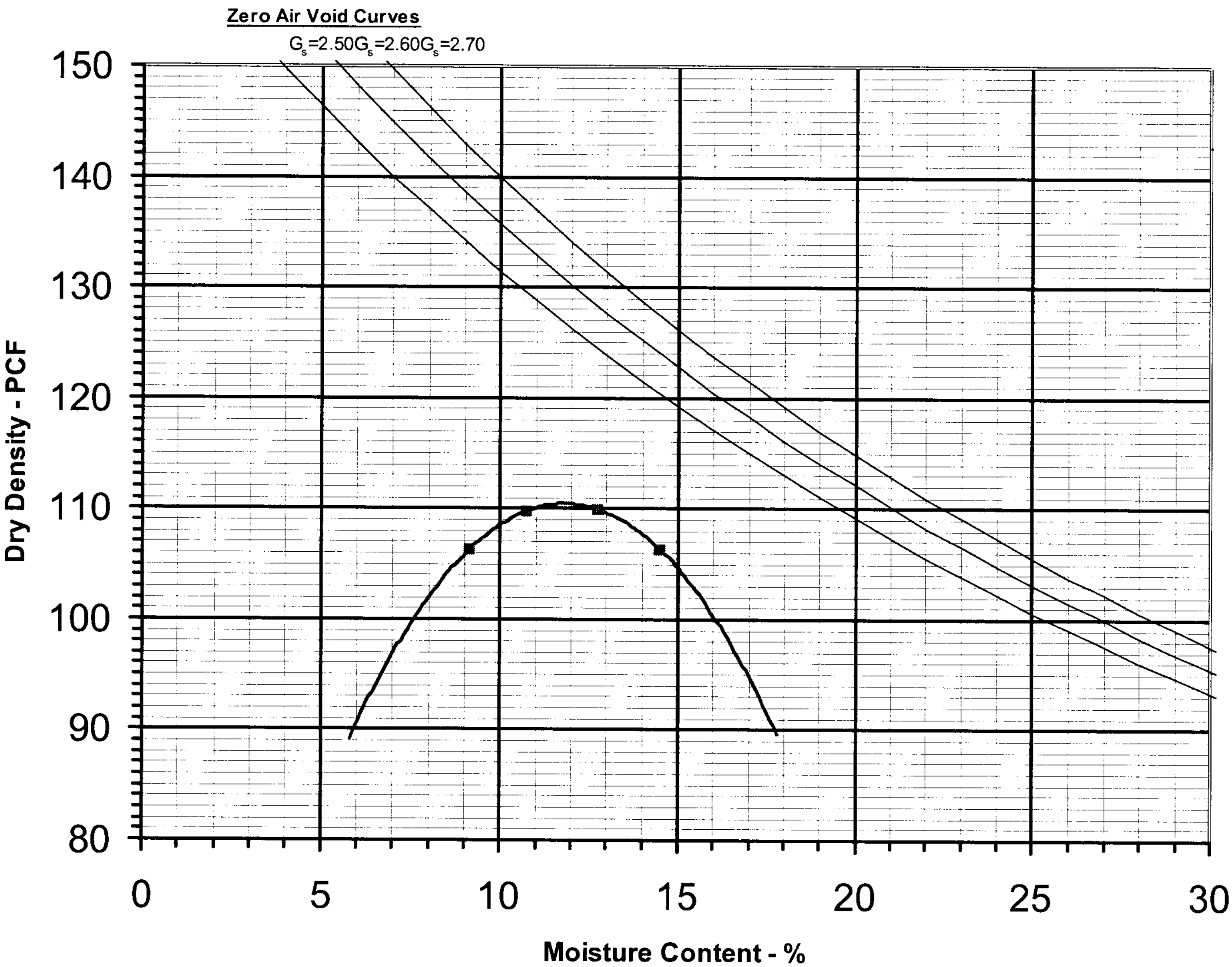
NWCC, Inc.

TABLE 2

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION	REMOLDED MOISTURE CONTENT (%)	REMOLDED DRY DENSITY (pcf)	ATTERBERG LIMITS		GRADATION		PERCENT PASSING No. 200 SIEVE	UNCONFINED COMPRESSIVE STRENGTH (psf)	SOIL or BEDROCK DESCRIPTION	UNIFIED SOIL CLASS.
			LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)				
Proctor 1P Test Pits 1 & 2 @ 1-10 Feet	12.8	109.8	24	7	37	38	25	1,474	FILL-Clayey-Silty Sand w/ Bedrock Fragments	SC-SM
Proctor 2P Test Pits 3 & 4 @ 1-10 Feet	14.0	112.3	26	8	27	38	35	1,861	FILL-Sand and Clay w/ Bedrock Fragments	SC-CL
Test Pits 5 & 6 @ 1-10 Feet			27	6	27	36	37		FILL-Sand and Clay w/ Bedrock Fragments	SC-CL

JOB NUMBER: 08-7915



Job Name: Cole Refuse Pile Expansion		PROCTOR TEST RESULTS	
Sample Location: Test Pits 1 & 2 at 0-10 feet			
Soil Description: Clayey Silty Sand with Bedrock Fragments		**Sample No.** 1P	
Maximum Dry Density: 110.4 pcf	**Opt. Moisture Content:** 11.8 %	**Procedure:** ASTM D698	
Liquid Limit: 24 %	**Plasticity Index:** 7 %	**Date:** 3/12/08	
Gravel: 37 % **Sand:** 38 %	**Silt & Clay (-200):** 25 %	**Job. No.** 08-7915	**Tech:** CR

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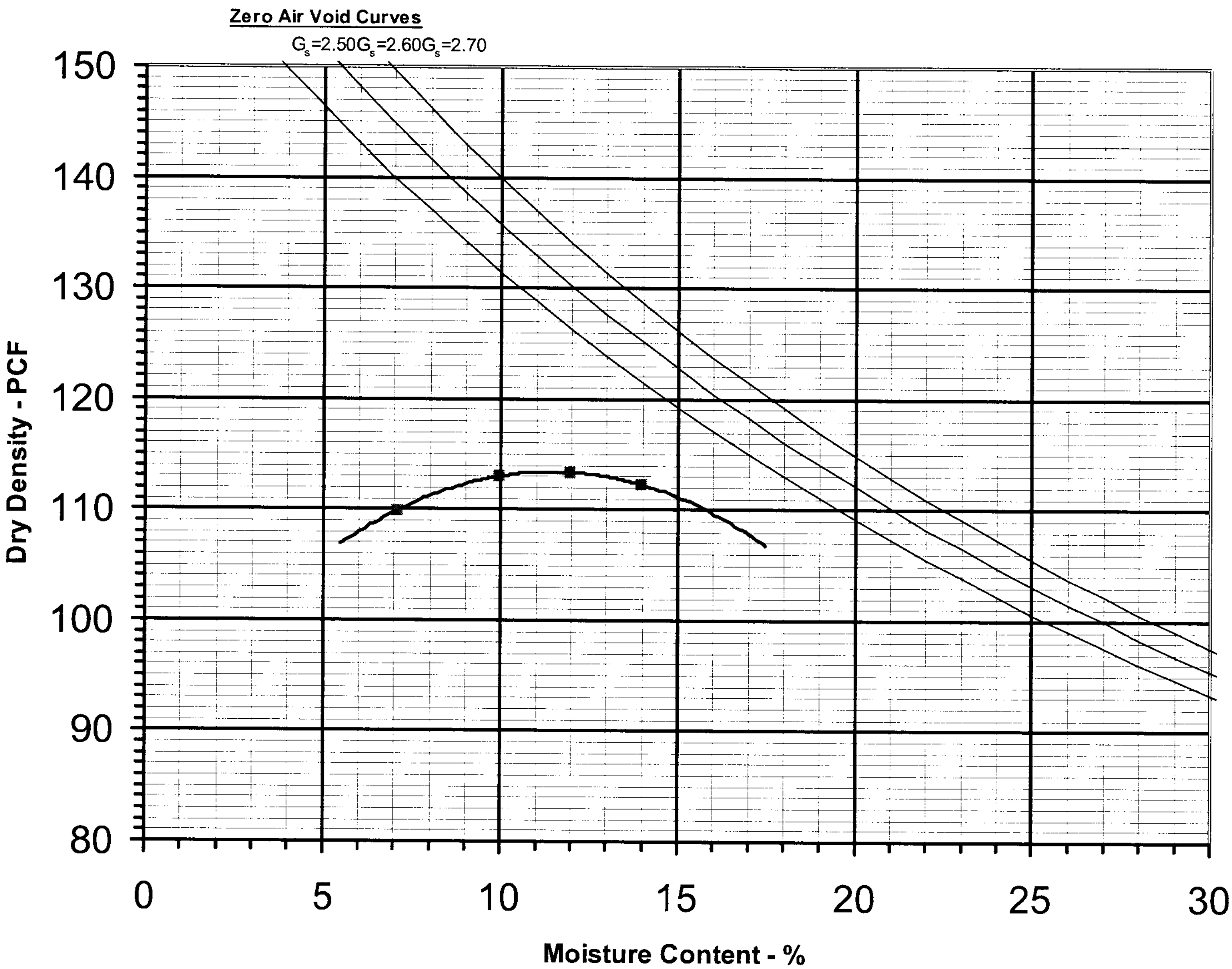

Job Name: Cole Refuse Pile Expansion			PROCTOR TEST RESULTS	
Sample Location: Test Pits 3 & 4 at 2-10 feet				
Soil Description: Sand and Clay with Bedrock Fragments			**Sample No.** 2P	
Maximum Dry Density: 113.4 pcf		**Opt. Moisture Content:** 11.5 %	**Procedure:** ASTM D698	
Liquid Limit: 26 %		**Plasticity Index:** 8 %	**Date:** 3/12/08	
Gravel: 27 %	**Sand:** 38 %	**Silt & Clay (-200):** 35 %	**Job. No.** 08-7915	**Tech:** CR

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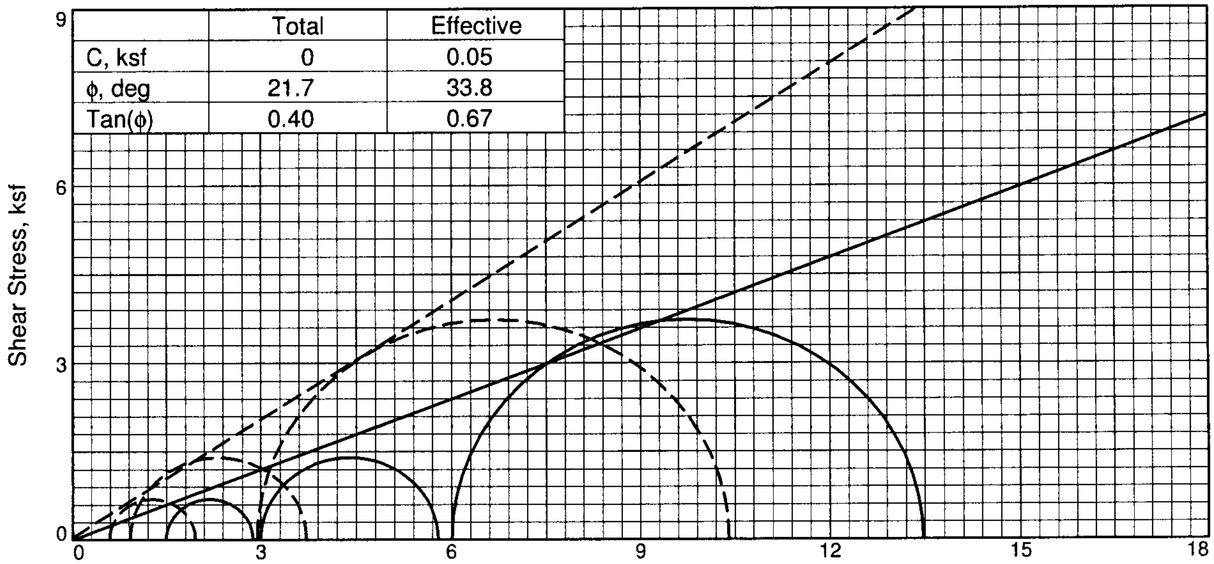
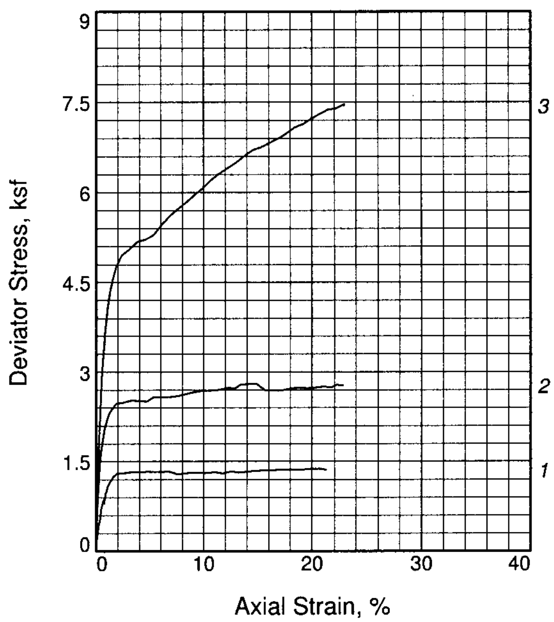
	Total	Effective
C, ksf	0	0.05
ϕ, deg	21.7	33.8
Tan(ϕ)	0.40	0.67





Sample No.		1	2	3
Initial	Water Content, %	10.1	10.0	10.1
	Dry Density, pcf	107.2	107.3	107.3
	Saturation, %	49.1	49.0	49.4
	Void Ratio	0.5435	0.5415	0.5411
	Diameter, in.	2.88	2.87	2.88
	Height, in.	5.74	5.78	5.74
At Test	Water Content, %	20.5	18.2	17.2
	Dry Density, pcf	107.2	111.6	113.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5435	0.4828	0.4560
	Diameter, in.	2.88	2.83	2.82
	Height, in.	5.74	5.71	5.63
Strain rate, %/min.		0.04	0.04	0.04
Eff. Cell Pressure, psi		10.40	20.80	41.70
Fail. Stress, ksf		1.4	2.8	7.5
Excess Pore Pr., ksf		0.9	2.1	3.1
Strain, %		20.0	15.0	22.9
Ult. Stress, ksf		1.3	2.6	6.2
Excess Pore Pr., ksf		1.0	2.1	3.7
Strain, %		4.5	6.1	10.7
$\bar{\sigma}_1$ Failure, ksf		2.0	3.7	10.4
$\bar{\sigma}_3$ Failure, ksf		0.6	0.9	2.9

Type of Test:
CU with Pore Pressures

Sample Type: Remolded, 95% MDD

Description: Sand & Clay with Bedrock Fragments

Assumed Specific Gravity= 2.65

Remarks: Failure tangents drawn at approximately peak principal stress ratio.

Fig. ________

Client: Northwest Colorado Consultants, Inc.

Project: Coal Refuse Pile Expansion

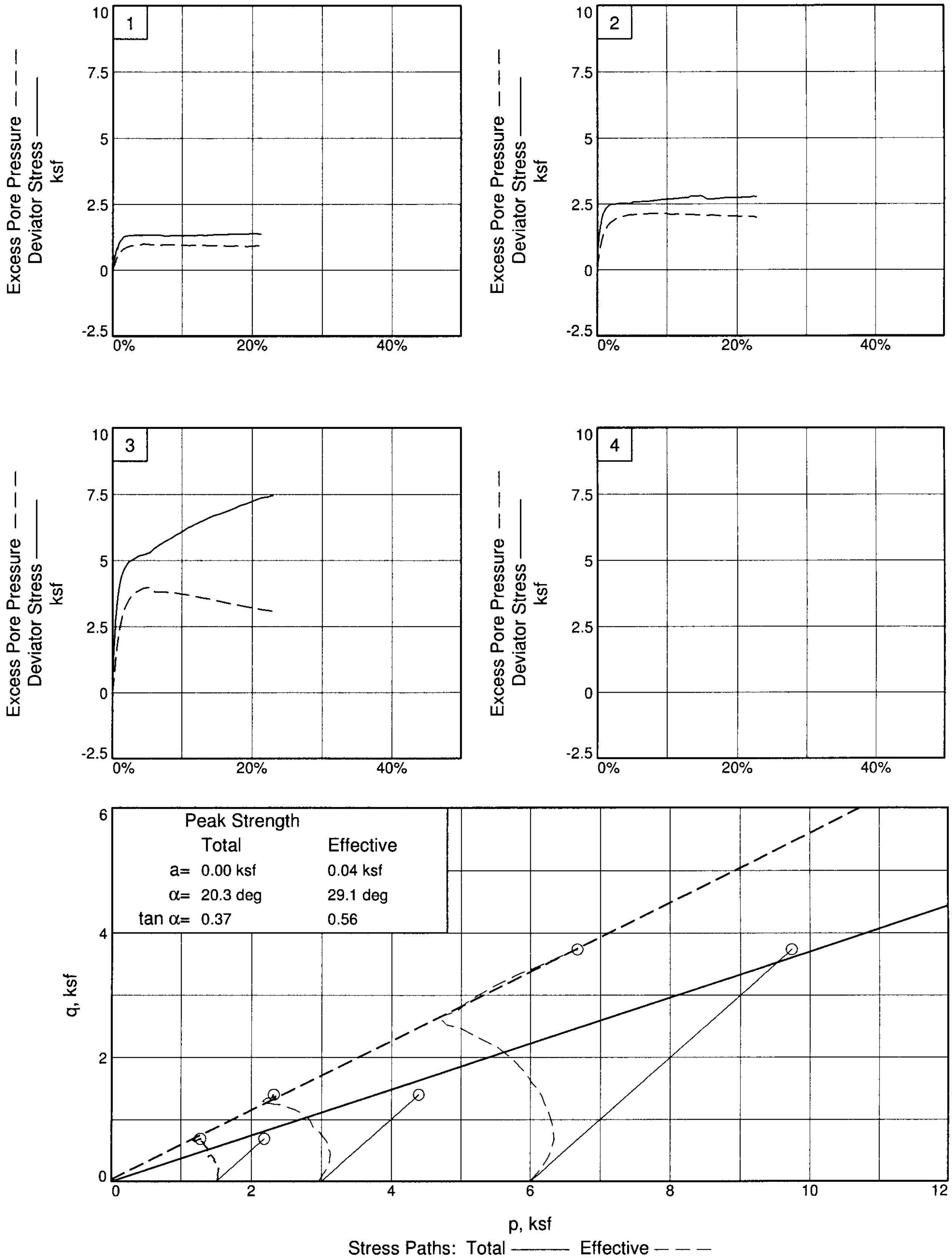
Location: Test Pits 3 & 4

Depth: 2-10'

Proj. No.: 108-27.7 **Date Sampled:** 3/26/08

Knight Piésold CONSULTING

Tested By: jdb **Checked By:** spb



Client: Northwest Colorado Consultants, Inc.

Project: Coal Refuse Pile Expansion

Location: Test Pits 3 & 4 **Depth:** 2-10'

Project No.: 108-27.7 **Fig.** 1:3

Knight Piesold Geotechnical Lab.

Tested By: jdb **Checked By:** spb

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

4/2/2008
11:35 AM

Date: 3/26/08
Client: Northwest Colorado Consultants, Inc.
Project: Coal Refuse Pile Expansion
Project No.: 108-27.7
Location: Test Pits 3 & 4
Depth: 2-10'
Description: Sand & Clay with Bedrock Fragments
Remarks: Failure tangents drawn at approximately peak principal stress ratio.
Type of Sample: Remolded, 95% MDD
Assumed Specific Gravity=2.65 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1158.000			1647.800
Moisture content: Dry soil+tare, gms.	1052.000			1471.000
Moisture content: Tare, gms.	0.000			419.300
Moisture, %	10.1	20.5	20.5	16.8
Moist specimen weight, gms.	1158.0			
Diameter, in.	2.88	2.88	2.88	
Area, in.^{2}	6.51	6.51	6.51	
Height, in.	5.74	5.74	5.74	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	118.0	129.2	129.2	
Dry density, pcf	107.2	107.2	107.2	
Void ratio	0.5435	0.5435	0.5435	
Saturation, %	49.1	100.0	100.0	

Test Readings for Specimen No. 1

Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.064 cm
Consolidation cell pressure = 50.40 psi (7.26 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 1.50 ksf
Strain rate, %/min. = 0.04
Fail. Stress = 1.38 ksf **at reading no.** 49
Ult. Stress = 1.32 ksf **at reading no.** 26

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	-5.3025	6.876	0.0	0.0	0.00	1.51	1.51	1.00	39.94	1.51	0.00
1	-5.3011	13.550	6.7	0.0	0.15	1.45	1.60	1.10	40.30	1.53	0.07
2	-5.2997	16.076	9.2	0.1	0.20	1.42	1.62	1.14	40.55	1.52	0.10
3	-5.2968	18.448	11.6	0.1	0.26	1.39	1.65	1.18	40.72	1.52	0.13
4	-5.2939	22.454	15.6	0.2	0.34	1.36	1.70	1.25	40.96	1.53	0.17
5	-5.2910	26.421	19.5	0.2	0.43	1.32	1.75	1.33	41.24	1.53	0.22
6	-5.2867	28.519	21.6	0.3	0.48	1.26	1.74	1.38	41.65	1.50	0.24
7	-5.2823	32.158	25.3	0.4	0.56	1.21	1.77	1.46	41.98	1.49	0.28
8	-5.2795	35.177	28.3	0.4	0.62	1.18	1.80	1.53	42.22	1.49	0.31
9	-5.2766	37.223	30.3	0.5	0.67	1.14	1.80	1.59	42.52	1.47	0.33
10	-5.2752	39.378	32.5	0.5	0.72	1.12	1.83	1.64	42.65	1.47	0.36
11	-5.2694	42.703	35.8	0.6	0.79	1.06	1.84	1.75	43.07	1.45	0.39
12	-5.2651	45.647	38.8	0.7	0.85	1.00	1.86	1.85	43.42	1.43	0.43
13	-5.2608	43.077	36.2	0.7	0.79	0.99	1.78	1.80	43.54	1.38	0.40
14	-5.2593	46.204	39.3	0.8	0.86	0.97	1.84	1.89	43.64	1.40	0.43
15	-5.2564	48.547	41.7	0.8	0.91	0.94	1.86	1.97	43.85	1.40	0.46
16	-5.2550	50.916	44.0	0.8	0.97	0.93	1.89	2.04	43.95	1.41	0.48
17	-5.2478	52.977	46.1	1.0	1.01	0.86	1.87	2.17	44.41	1.37	0.50
18	-5.2463	55.227	48.4	1.0	1.06	0.86	1.91	2.24	44.46	1.38	0.53
19	-5.2334	59.302	52.4	1.2	1.14	0.77	1.91	2.49	45.06	1.34	0.57
20	-5.2219	61.753	54.9	1.4	1.20	0.73	1.92	2.64	45.35	1.33	0.60
21	-5.2162	63.749	56.9	1.5	1.24	0.72	1.95	2.73	45.42	1.34	0.62
22	-5.1932	66.746	59.9	1.9	1.30	0.65	1.94	3.01	45.92	1.29	0.65
23	-5.1530	67.660	60.8	2.6	1.31	0.58	1.89	3.26	46.38	1.23	0.65
24	-5.1128	68.640	61.8	3.3	1.32	0.57	1.89	3.32	46.45	1.23	0.66
25	-5.0726	69.229	62.4	4.0	1.32	0.55	1.87	3.41	46.59	1.21	0.66
26	-5.0439	69.587	62.7	4.5	1.32	0.50	1.83	3.62	46.89	1.17	0.66
27	-5.0381	69.931	63.1	4.6	1.33	0.51	1.84	3.59	46.83	1.18	0.66
28	-5.0324	70.108	63.2	4.7	1.33	0.53	1.86	3.53	46.75	1.19	0.67
29	-5.0008	70.347	63.5	5.3	1.33	0.53	1.86	3.50	46.71	1.20	0.66
30	-4.9577	70.734	63.9	6.0	1.33	0.55	1.87	3.43	46.61	1.21	0.66
31	-4.9147	71.397	64.5	6.8	1.33	0.55	1.88	3.41	46.57	1.22	0.66
32	-4.8716	73.442	66.6	7.5	1.29	0.54	1.83	3.40	46.66	1.19	0.65
33	-4.8429	74.266	67.4	8.0	1.30	0.54	1.84	3.40	46.65	1.19	0.65
34	-4.7998	75.817	68.9	8.8	1.31	0.55	1.86	3.40	46.60	1.20	0.66
35	-4.7568	76.636	69.8	9.5	1.31	0.57	1.88	3.31	46.46	1.22	0.65
36	-4.7137	77.354	70.5	10.3	1.31	0.55	1.86	3.36	46.56	1.21	0.65
37	-4.6707	79.176	72.3	11.0	1.32	0.57	1.89	3.34	46.47	1.23	0.66
38	-4.6276	79.127	72.3	11.8	1.30	0.56	1.86	3.34	46.54	1.21	0.65
39	-4.5845	81.587	74.7	12.5	1.33	0.57	1.90	3.32	46.42	1.24	0.67
40	-4.5415	81.744	74.9	13.3	1.32	0.57	1.88	3.32	46.45	1.23	0.66
41	-4.4984	83.285	76.4	14.0	1.33	0.58	1.91	3.27	46.34	1.25	0.66
42	-4.4553	85.187	78.3	14.8	1.34	0.58	1.92	3.33	46.40	1.25	0.67
43	-4.4123	86.429	79.6	15.5	1.35	0.57	1.92	3.35	46.43	1.24	0.67
44	-4.3692	87.589	80.7	16.3	1.35	0.59	1.93	3.29	46.32	1.26	0.67
45	-4.3261	89.681	82.8	17.0	1.36	0.59	1.96	3.30	46.29	1.27	0.68
46	-4.2831	90.620	83.7	17.8	1.36	0.58	1.95	3.33	46.34	1.26	0.68

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
47	-4.2400	91.766	84.9	18.5	1.36	0.57	1.93	3.37	46.42	1.25	0.68
48	-4.1970	93.036	86.2	19.3	1.36	0.60	1.97	3.26	46.21	1.28	0.68
49	-4.1539	95.091	88.2	20.0	1.38	0.59	1.96	3.35	46.33	1.27	0.69
50	-4.1108	95.931	89.1	20.8	1.37	0.58	1.96	3.35	46.34	1.27	0.69
51	-4.0821	95.836	89.0	21.3	1.36	0.58	1.94	3.34	46.37	1.26	0.68

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1158.900			1411.100
Moisture content: Dry soil+tare, gms.	1053.400			1247.300
Moisture content: Tare, gms.	0.000			193.900
Moisture, %	10.0	20.4	18.2	15.5
Moist specimen weight, gms.	1158.9			
Diameter, in.	2.87	2.87	2.83	
Area, in.²	6.47	6.47	6.30	
Height, in.	5.78	5.78	5.71	
Net decrease in height, in.		0.00	0.07	
Wet Density, pcf	118.1	129.3	131.9	
Dry density, pcf	107.3	107.3	111.6	
Void ratio	0.5415	0.5415	0.4828	
Saturation, %	49.0	100.0	100.0	

Test Readings for Specimen No. 2

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.064 cm
Consolidation cell pressure = 60.80 psi (8.76 ksf)
Consolidation back pressure = 40.00 psi (5.76 ksf)
Consolidation effective confining stress = 3.00 ksf
Strain rate, %/min. = 0.04
Fail. Stress = 2.79 ksf **at reading no.** 39
Ult. Stress = 2.58 ksf **at reading no.** 27

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0630	0.931	0.0	0.0	0.00	2.96	2.96	1.00	40.23	2.96	0.00
1	0.0644	9.713	8.8	0.0	0.20	2.91	3.11	1.07	40.59	3.01	0.10
2	0.0659	21.124	20.2	0.1	0.46	2.86	3.32	1.16	40.95	3.09	0.23
3	0.0674	28.025	27.1	0.1	0.62	2.81	3.42	1.22	41.32	3.11	0.31
4	0.0688	34.060	33.1	0.1	0.76	2.74	3.50	1.28	41.75	3.12	0.38
5	0.0702	38.624	37.7	0.1	0.86	2.70	3.56	1.32	42.05	3.13	0.43
6	0.0717	43.402	42.5	0.2	0.97	2.64	3.61	1.37	42.47	3.12	0.48
7	0.0731	46.996	46.1	0.2	1.05	2.57	3.62	1.41	42.95	3.10	0.53
8	0.0746	50.521	49.6	0.2	1.13	2.53	3.66	1.45	43.23	3.10	0.57
9	0.0775	57.002	56.1	0.3	1.28	2.44	3.71	1.52	43.88	3.07	0.64
10	0.0804	62.413	61.5	0.3	1.40	2.34	3.74	1.60	44.55	3.04	0.70
11	0.0847	69.247	68.3	0.4	1.55	2.20	3.76	1.71	45.51	2.98	0.78
12	0.0891	74.754	73.8	0.5	1.68	2.09	3.77	1.80	46.31	2.93	0.84
13	0.0934	78.178	77.2	0.5	1.76	2.00	3.75	1.88	46.93	2.88	0.88
14	0.0978	83.130	82.2	0.6	1.87	1.93	3.80	1.97	47.40	2.86	0.93

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
15	0.1021	87.439	86.5	0.7	1.96	1.85	3.82	2.06	47.92	2.84	0.98
16	0.1065	90.886	90.0	0.8	2.04	1.79	3.83	2.14	48.37	2.81	1.02
17	0.1122	94.389	93.5	0.9	2.12	1.69	3.80	2.26	49.10	2.74	1.06
18	0.1180	98.524	97.6	1.0	2.21	1.61	3.81	2.38	49.65	2.71	1.10
19	0.1325	103.397	102.5	1.2	2.31	1.46	3.78	2.58	50.63	2.62	1.16
20	0.1499	107.445	106.5	1.5	2.40	1.31	3.71	2.82	51.68	2.51	1.20
21	0.1672	111.038	110.1	1.8	2.47	1.22	3.69	3.03	52.36	2.45	1.23
22	0.2077	112.603	111.7	2.5	2.49	1.09	3.58	3.28	53.23	2.33	1.24
23	0.2482	114.878	113.9	3.2	2.52	0.99	3.51	3.55	53.95	2.25	1.26
24	0.2887	115.646	114.7	4.0	2.52	0.95	3.47	3.65	54.20	2.21	1.26
25	0.3292	115.912	115.0	4.7	2.50	0.91	3.42	3.74	54.46	2.17	1.25
26	0.3668	120.011	119.1	5.3	2.58	0.91	3.48	3.84	54.50	2.19	1.29
27	0.4102	120.998	120.1	6.1	2.58	0.86	3.44	3.98	54.80	2.15	1.29
28	0.4536	122.351	121.4	6.8	2.58	0.89	3.48	3.89	54.60	2.18	1.29
29	0.4969	123.962	123.0	7.6	2.60	0.87	3.46	3.99	54.78	2.17	1.30
30	0.5403	126.372	125.4	8.4	2.63	0.87	3.49	4.03	54.78	2.18	1.31
31	0.5837	129.070	128.1	9.1	2.66	0.88	3.54	4.03	54.70	2.21	1.33
32	0.6270	130.973	130.0	9.9	2.68	0.87	3.55	4.08	54.76	2.21	1.34
33	0.6704	132.576	131.6	10.6	2.69	0.91	3.59	3.97	54.51	2.25	1.34
34	0.7138	134.405	133.5	11.4	2.70	0.89	3.59	4.05	54.64	2.24	1.35
35	0.7571	136.933	136.0	12.2	2.73	0.91	3.64	4.00	54.48	2.28	1.36
36	0.8005	138.068	137.1	12.9	2.73	0.90	3.63	4.03	54.55	2.26	1.36
37	0.8294	141.912	141.0	13.4	2.79	0.90	3.69	4.10	54.55	2.29	1.39
38	0.8728	143.448	142.5	14.2	2.79	0.92	3.71	4.05	54.45	2.31	1.40
39	0.9161	144.748	143.8	15.0	2.79	0.92	3.72	4.03	54.40	2.32	1.40
40	0.9595	147.898	147.0	15.7	2.68	0.94	3.62	3.86	54.27	2.28	1.34
41	1.0029	149.563	148.6	16.5	2.68	0.93	3.61	3.89	54.36	2.27	1.34
42	1.0462	151.671	150.7	17.2	2.69	0.95	3.64	3.84	54.22	2.29	1.35
43	1.0896	155.017	154.1	18.0	2.72	0.95	3.67	3.86	54.19	2.31	1.36
44	1.1329	157.782	156.9	18.8	2.74	0.95	3.69	3.87	54.18	2.32	1.37
45	1.1763	158.861	157.9	19.5	2.72	0.96	3.68	3.85	54.16	2.32	1.36
46	1.2197	161.439	160.5	20.3	2.74	0.97	3.71	3.82	54.07	2.34	1.37
47	1.2630	164.083	163.2	21.0	2.75	0.97	3.72	3.83	54.05	2.35	1.37
48	1.3064	165.638	164.7	21.8	2.74	0.98	3.72	3.80	54.01	2.35	1.37
49	1.3353	169.250	168.3	22.3	2.78	0.98	3.76	3.85	54.01	2.37	1.39
50	1.3498	169.198	168.3	22.6	2.77	0.99	3.76	3.79	53.90	2.38	1.38
51	1.3637	169.972	169.0	22.8	2.77	1.02	3.79	3.73	53.74	2.40	1.39

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	1155.900			1308.700
Moisture content: Dry soil+tare, gms.	1050.000			1162.700
Moisture content: Tare, gms.	0.000			113.010
Moisture, %	10.1	20.4	17.2	13.9
Moist specimen weight, gms.	1155.9			
Diameter, in.	2.88	2.88	2.82	
Area, in.^{2}	6.49	6.49	6.25	
Height, in.	5.74	5.74	5.63	
Net decrease in height, in.		0.00	0.11	
Wet Density, pcf	118.2	129.3	133.2	
Dry density, pcf	107.3	107.3	113.6	
Void ratio	0.5411	0.5411	0.4560	
Saturation, %	49.4	100.0	100.0	

Test Readings for Specimen No. 3

Membrane modulus = 0.124105 kN/cm^2

Membrane thickness = 0.064 cm

Consolidation cell pressure = 81.70 psi (11.76 ksf)

Consolidation back pressure = 40.00 psi (5.76 ksf)

Consolidation effective confining stress = 6.00 ksf

Strain rate, %/min. = 0.04

Fail. Stress = 7.46 ksf **at reading no.** 48

Ult. Stress = 6.21 ksf **at reading no.** 32

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	-5.4013	3.550	0.0	0.0	0.00	6.00	6.00	1.00	40.06	6.00	0.00
1	-5.3998	15.361	11.8	0.0	0.27	5.97	6.24	1.05	40.26	6.10	0.14
2	-5.3984	25.583	22.0	0.1	0.51	5.93	6.43	1.09	40.54	6.18	0.25
3	-5.3970	36.308	32.8	0.1	0.75	5.87	6.63	1.13	40.92	6.25	0.38
4	-5.3955	45.835	42.3	0.1	0.97	5.81	6.78	1.17	41.35	6.30	0.49
5	-5.3926	62.317	58.8	0.2	1.35	5.67	7.02	1.24	42.33	6.35	0.68
6	-5.3898	73.708	70.2	0.2	1.61	5.52	7.13	1.29	43.36	6.33	0.81
7	-5.3869	85.195	81.6	0.3	1.88	5.37	7.25	1.35	44.38	6.31	0.94
8	-5.3840	95.157	91.6	0.3	2.10	5.23	7.33	1.40	45.38	6.28	1.05
9	-5.3811	105.077	101.5	0.4	2.33	5.08	7.41	1.46	46.41	6.25	1.17
10	-5.3783	113.796	110.2	0.4	2.53	4.93	7.46	1.51	47.44	6.20	1.26
11	-5.3754	122.558	119.0	0.5	2.73	4.81	7.54	1.57	48.32	6.17	1.36
12	-5.3711	133.689	130.1	0.5	2.98	4.61	7.59	1.65	49.67	6.10	1.49
13	-5.3668	142.730	139.2	0.6	3.19	4.43	7.61	1.72	50.95	6.02	1.59
14	-5.3625	151.810	148.3	0.7	3.39	4.26	7.65	1.80	52.11	5.96	1.70
15	-5.3567	162.650	159.1	0.8	3.64	4.05	7.69	1.90	53.55	5.87	1.82
16	-5.3510	171.926	168.4	0.9	3.84	3.86	7.71	2.00	54.88	5.78	1.92
17	-5.3438	181.842	178.3	1.0	4.07	3.64	7.71	2.12	56.40	5.68	2.03
18	-5.3323	193.835	190.3	1.2	4.33	3.35	7.69	2.29	58.40	5.52	2.17
19	-5.3150	204.773	201.2	1.5	4.57	3.02	7.58	2.51	60.74	5.30	2.28
20	-5.2978	213.915	210.4	1.8	4.76	2.76	7.52	2.72	62.50	5.14	2.38
21	-5.2691	223.504	220.0	2.3	4.95	2.50	7.45	2.98	64.33	4.98	2.47
22	-5.2289	229.489	225.9	3.1	5.05	2.26	7.31	3.23	65.99	4.79	2.52
23	-5.1887	236.908	233.4	3.8	5.17	2.14	7.32	3.41	66.81	4.73	2.59

Test Readings for Specimen No. 3

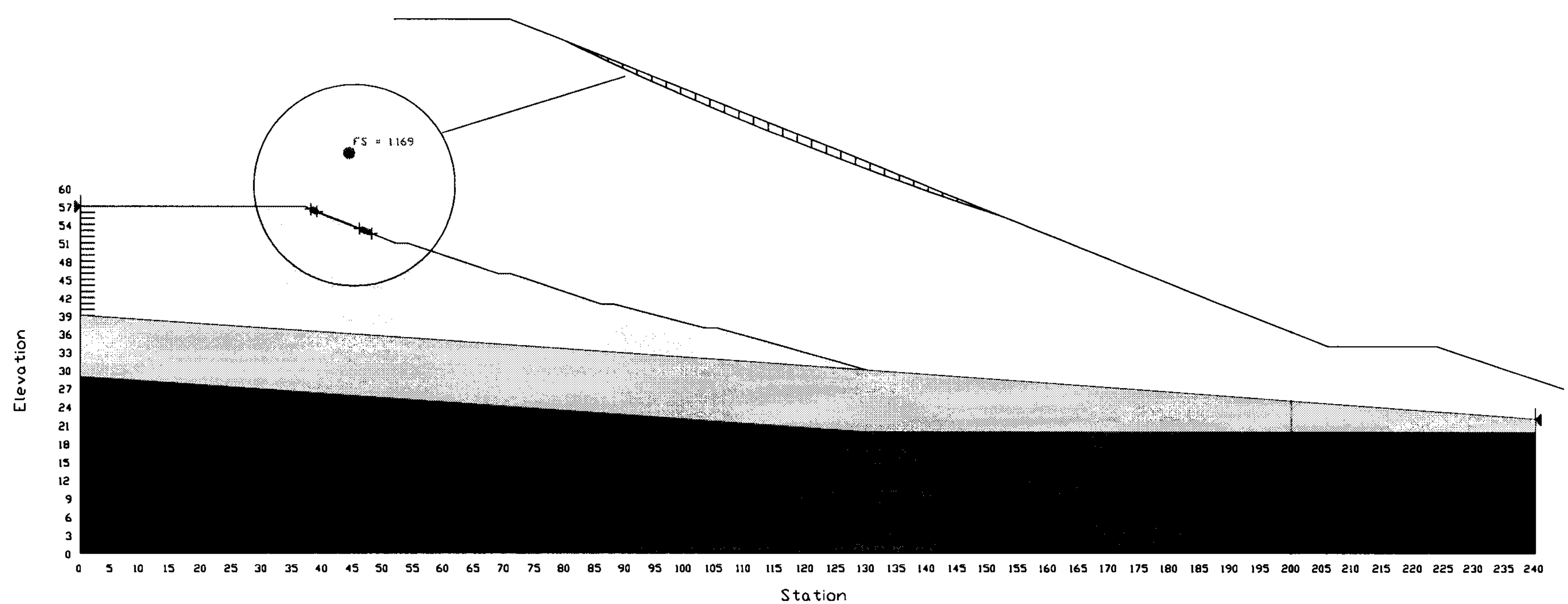
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	-5.1485	240.477	236.9	4.5	5.21	2.06	7.27	3.53	67.40	4.67	2.61
25	-5.0997	246.289	242.7	5.4	5.29	2.02	7.31	3.62	67.67	4.67	2.65
26	-5.0566	256.662	253.1	6.1	5.48	2.20	7.68	3.49	66.42	4.94	2.74
27	-5.0135	265.285	261.7	6.9	5.62	2.20	7.82	3.55	66.42	5.01	2.81
28	-4.9704	272.953	269.4	7.6	5.73	2.20	7.93	3.61	66.44	5.06	2.87
29	-4.9274	280.327	276.8	8.4	5.84	2.22	8.06	3.63	66.29	5.14	2.92
30	-4.8843	288.516	285.0	9.2	5.96	2.24	8.20	3.66	66.14	5.22	2.98
31	-4.8412	296.356	292.8	9.9	6.08	2.28	8.35	3.67	65.89	5.31	3.04
32	-4.7982	305.273	301.7	10.7	6.21	2.31	8.52	3.69	65.68	5.41	3.10
33	-4.7551	313.156	309.6	11.5	6.32	2.35	8.66	3.69	65.39	5.51	3.16
34	-4.7121	320.424	316.9	12.2	6.41	2.38	8.79	3.69	65.16	5.59	3.20
35	-4.6690	327.958	324.4	13.0	6.50	2.43	8.93	3.68	64.83	5.68	3.25
36	-4.6259	335.968	332.4	13.8	6.60	2.47	9.07	3.68	64.58	5.77	3.30
37	-4.5829	343.949	340.4	14.5	6.70	2.51	9.21	3.67	64.26	5.86	3.35
38	-4.5398	349.623	346.1	15.3	6.75	2.55	9.30	3.65	63.99	5.93	3.38
39	-4.4967	356.096	352.5	16.1	6.82	2.59	9.41	3.63	63.69	6.00	3.41
40	-4.4537	363.185	359.6	16.8	6.89	2.63	9.53	3.62	63.41	6.08	3.45
41	-4.4106	370.956	367.4	17.6	6.98	2.67	9.65	3.61	63.14	6.16	3.49
42	-4.3675	379.756	376.2	18.4	7.08	2.71	9.79	3.61	62.85	6.25	3.54
43	-4.3245	386.182	382.6	19.1	7.13	2.76	9.89	3.59	62.55	6.32	3.57
44	-4.2814	394.514	391.0	19.9	7.22	2.79	10.01	3.59	62.32	6.40	3.61
45	-4.2383	402.654	399.1	20.6	7.30	2.83	10.13	3.58	62.04	6.48	3.65
46	-4.1952	410.648	407.1	21.4	7.37	2.87	10.24	3.57	61.78	6.55	3.69
47	-4.1522	415.733	412.2	22.2	7.39	2.90	10.29	3.55	61.54	6.60	3.70
48	-4.1091	423.958	420.4	22.9	7.46	2.94	10.40	3.54	61.28	6.67	3.73
49	-4.1089	422.783	419.2	22.9	7.44	2.95	10.39	3.53	61.24	6.67	3.72

Appendix B

Slope Stability Analysis

FS = 1.169

Soil Properties	Coal Waste	Spoils	Bedrock
Unit Weight (pcf)	115	110	120
Cohesion (psf)	0	0	5000
Angle of Friction (degrees)	25	38	25



Title: SLOPE STABILITY SLIP SURFACE DIAGRAM	Date: 6/17/09	
Job Name: Proposed RDA Expansion	Job No. 08-7915	
LOCATION: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #C-1	

North West Colorado Consultants, Inc.
Geotechnical / Environmental Engineering · Materials Testing
(970)879-7888 · Fax (970)879-7891
2580 Copper Ridge Drive
Steamboat Springs, Colorado 80487

SLOPE/W Analysis

File Information

Revision Number: 40
Date: 5/21/2009
Time: 3:18:05 PM
File Name: WC 25 phi and L SP.gsz
Directory: \\Jfrap\josh frappart\My Documents\20 Mile Coal Refuse Pile Exspansion\
Last Solved Date: 5/21/2009
Last Solved Time: 3:18:12 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Bishop, Ordinary and Janbu
Settings
- PWP Conditions Source: (none)

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No

FOS Distribution
- FOS Calculation Option: Constant

Advanced
- Number of Slices: 30
- Optimization Tolerance: 0.01
- Minimum Slip Surface Depth: 0.1 ft
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 Â°
Resisting Side Maximum Convex Angle: 1 Â°

Materials

Waste Coal

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 25 Â°
Phi-B: 0 Â°

Spoils

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion: 0 psf
Phi: 38 Â°
Phi-B: 0 Â°

Bedrock

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 5000 psf
Phi: 25 Â°
Phi-B: 0 Â°

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (38, 56.6) ft
Left-Zone Right Coordinate: (39, 56.2) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (46, 53.4) ft
Right-Zone Right Coordinate: (48, 52.6) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 57) ft
Right Coordinate: (240, 22) ft

Critical Slip Surfaces

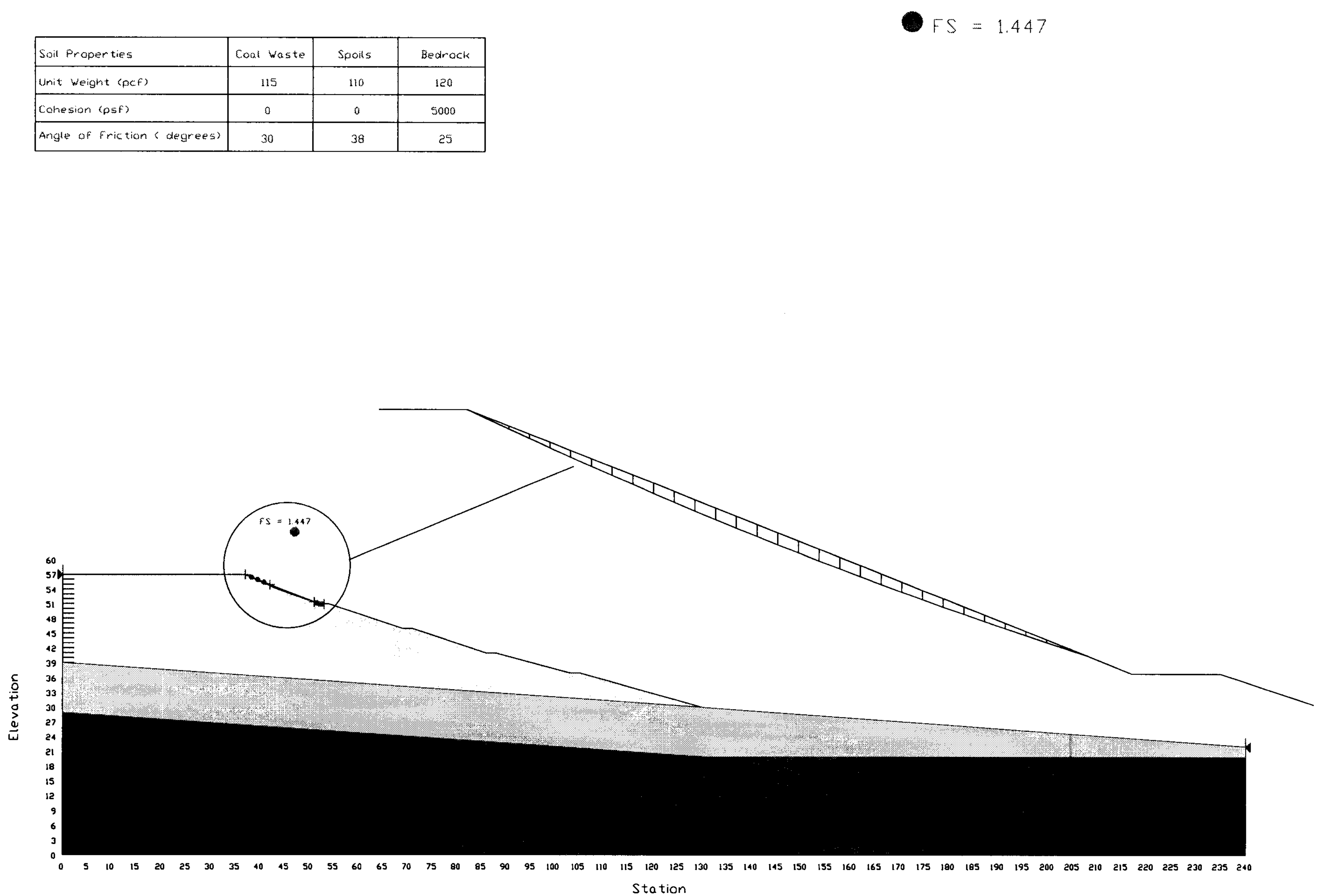
	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

1	1	1.169	(65.605, 114.014)	63.705	(38, 56.6)	(46, 53.4)

Slices of Slip Surface: 1

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohe Strei (ps
1	1	38.133335	56.53627	0	1.0043267	0.46832522	C
2	1	38.4	56.40957	0	2.9453622	1.3734449	C
3	1	38.666665	56.28438	0	4.7473151	2.2137094	C
4	1	38.933335	56.16069	0	6.4101778	2.989115	C
5	1	39.2	56.03849	0	7.9345172	3.6999261	C
6	1	39.466665	55.91777	0	9.3196441	4.3458214	C
7	1	39.733335	55.798525	0	10.566258	4.9271271	C
8	1	40	55.680745	0	11.674079	5.4437124	C
9	1	40.266665	55.564415	0	12.643181	5.895612	C
10	1	40.533335	55.44953	0	13.473678	6.2828792	C
11	1	40.8	55.336085	0	14.166066	6.6057452	C
12	1	41.066665	55.224065	0	14.71947	6.8638018	C
13	1	41.333335	55.113465	0	15.134789	7.0574679	C
14	1	41.6	55.00428	0	15.411554	7.1865258	C
15	1	41.866665	54.8965	0	15.550013	7.2510902	C
16	1	42.133335	54.790115	0	15.549758	7.2509714	C
17	1	42.4	54.68512	0	15.411442	7.1864735	C
18	1	42.666665	54.581505	0	15.134341	7.0572591	C
19	1	42.933335	54.479265	0	14.719158	6.8636562	C
20	1	43.2	54.378395	0	14.165583	6.6055198	C
21	1	43.466665	54.278885	0	13.473304	6.282705	C
22	1	43.733335	54.18073	0	12.642758	5.8954147	C
23	1	44	54.08392	0	11.673677	5.4435252	C
24	1	44.266665	53.98845	0	10.565837	4.9269309	C
25	1	44.533335	53.894315	0	9.3193683	4.3456928	C
26	1	44.8	53.80151	0	7.9344348	3.6998877	C
27	1	45.066665	53.71003	0	6.4105113	2.9892705	C
28	1	45.333335	53.619865	0	4.7481467	2.2140971	C
29	1	45.6	53.531005	0	2.9465023	1.3739766	C
30	1	45.866665	53.44345	0	1.0059208	0.46906857	C

Soil Properties	Coal Waste	Spoils	Bedrock
Unit Weight (pcf)	115	110	120
Cohesion (psf)	0	0	5000
Angle of Friction (degrees)	30	38	25



Title: SLOPE STABILITY SLIP SURFACE DIAGRAM	Date: 6/17/09	North West Colorado Consultants, Inc. NWCC
Job Name: Proposed RDA Expansion	Job No. 08-7915	Geotechnical / Environmental Engineering · Materials Testing
LOCATION: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #C-2	(970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487

SLOPE/W Analysis

File Information

Revision Number: 41
Date: 5/21/2009
Time: 3:10:17 PM
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Directory: \\Jfrap\josh frappart\My Documents\20 Mile Coal Refuse Pile Exspansion\
Last Solved Date: 5/21/2009
Last Solved Time: 3:10:22 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Bishop, Ordinary and Janbu
Settings
- PWP Conditions Source: (none)

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No

FOS Distribution
- FOS Calculation Option: Constant

Advanced
- Number of Slices: 30
- Optimization Tolerance: 0.01
- Minimum Slip Surface Depth: 0.1 ft
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 Â°
Resisting Side Maximum Convex Angle: 1 Â°

Materials

Waste Coal

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 30 Â°
Phi-B: 0 Â°

Spoils

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion: 0 psf
Phi: 38 Â°
Phi-B: 0 Â°

Bedrock

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 5000 psf
Phi: 25 Â°
Phi-B: 0 Â°

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (37, 57) ft
Left-Zone Right Coordinate: (42, 55) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (51, 51.4) ft
Right-Zone Right Coordinate: (53, 51) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 57) ft
Right Coordinate: (240, 22) ft

Critical Slip Surfaces

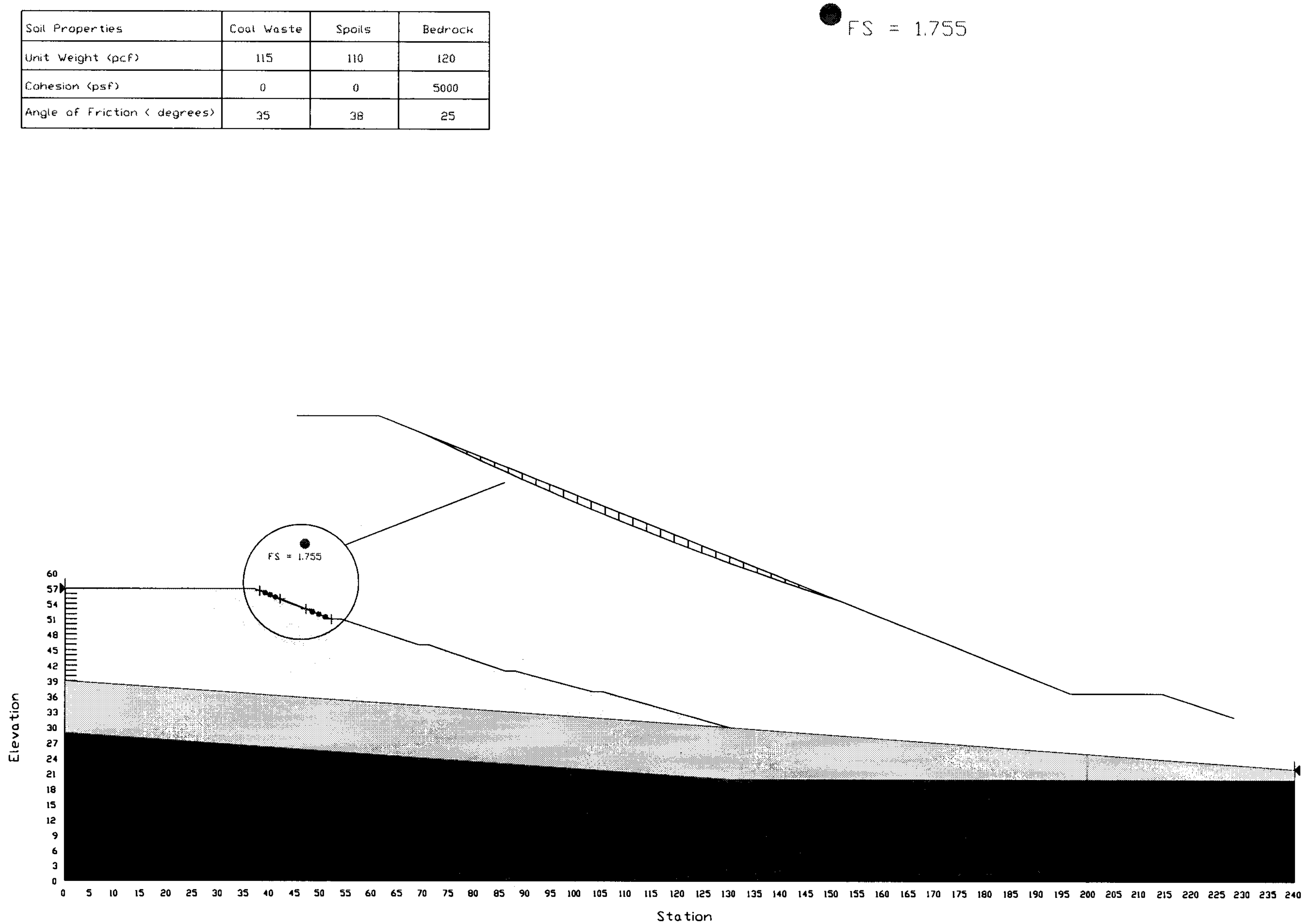
	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

1	1	1.447	(85.31, 157.474)	111.485	(37, 57)	(51, 51.4)

Slices of Slip Surface: 1

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohes Streng (psf
1	1	37.233335	56.888475	0	1.7575475	1.0147205	0
2	1	37.7	56.66675	0	5.1544824	2.9759418	0
3	1	38.166665	56.44767	0	8.3077771	4.7964973	0
4	1	38.633335	56.231215	0	11.218113	6.4767806	0
5	1	39.1	56.017365	0	13.885186	8.0166161	0
6	1	39.566665	55.806105	0	16.309327	9.4161942	0
7	1	40.033335	55.597425	0	18.490734	10.67563	0
8	1	40.5	55.391305	0	20.429855	11.795182	0
9	1	40.966665	55.187725	0	22.126016	12.774462	0
10	1	41.433335	54.98668	0	23.579972	13.613903	0
11	1	41.9	54.78815	0	24.790157	14.312604	0
12	1	42.366665	54.592115	0	25.759002	14.871967	0
13	1	42.833335	54.398565	0	26.485038	15.291144	0
14	1	43.3	54.20749	0	26.970811	15.571605	0
15	1	43.766665	54.01887	0	27.212959	15.711409	0
16	1	44.233335	53.832695	0	27.212131	15.710931	0
17	1	44.7	53.648955	0	26.969013	15.570567	0
18	1	45.166665	53.46763	0	26.486346	15.291899	0
19	1	45.633335	53.288715	0	25.75892	14.871919	0
20	1	46.1	53.11219	0	24.789556	14.312257	0
21	1	46.566665	52.938045	0	23.579129	13.613416	0
22	1	47.033335	52.766275	0	22.124522	12.773599	0
23	1	47.5	52.59686	0	20.4287	11.794516	0
24	1	47.966665	52.42979	0	18.490225	10.675337	0
25	1	48.433335	52.265055	0	16.309122	9.416076	0
26	1	48.9	52.102645	0	13.885238	8.0166457	0
27	1	49.366665	51.94255	0	11.218659	6.4770956	0
28	1	49.833335	51.78476	0	8.3091064	4.7972648	0
29	1	50.3	51.62926	0	5.1563276	2.9770071	0
30	1	50.766665	51.47604	0	1.7603956	1.0163649	0

Soil Properties	Coal Waste	Spoils	Bedrock
Unit Weight (pcf)	115	110	120
Cohesion (psf)	0	0	5000
Angle of Friction (degrees)	35	38	25



Title: SLOPE STABILITY SLIP SURFACE DIAGRAM	Date: 6/17/09	NWCC North West Colorado Consultants, Inc. Geotechnical / Environmental Engineering · Materials Testing (970)879-7888 · Fax (970)879-7891 2580 Copper Ridge Drive Steamboat Springs, Colorado 80487
Job Name: Proposed RDA Expansion	Job No. 08-7915	
LOCATION: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #C-3	

SLOPE/W Analysis

File Information

Revision Number: 44
Date: 5/21/2009
Time: 3:11:24 PM
File Name: WC 35 phi and L SP.gsz
Directory: \\Jfrap\josh frappart\My Documents\20 Mile Coal Refuse Pile Exspansion\
Last Solved Date: 5/21/2009
Last Solved Time: 3:11:30 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Bishop, Ordinary and Janbu
Settings
- PWP Conditions Source: (none)

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No

FOS Distribution
- FOS Calculation Option: Constant

Advanced
- Number of Slices: 30
- Optimization Tolerance: 0.01
- Minimum Slip Surface Depth: 0.1 ft
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 Â°
Resisting Side Maximum Convex Angle: 1 Â°

Materials

Waste Coal
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 35 Â°
Phi-B: 0 Â°

Spoils
Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion: 0 psf
Phi: 38 Â°
Phi-B: 0 Â°

Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 5000 psf
Phi: 25 Â°
Phi-B: 0 Â°

Slip Surface Entry and Exit
Left Projection: Range
Left-Zone Left Coordinate: (38, 56.6) ft
Left-Zone Right Coordinate: (42, 55) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (47, 53) ft
Right-Zone Right Coordinate: (52, 51) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits
Left Coordinate: (0, 57) ft
Right Coordinate: (240, 22) ft

Critical Slip Surfaces

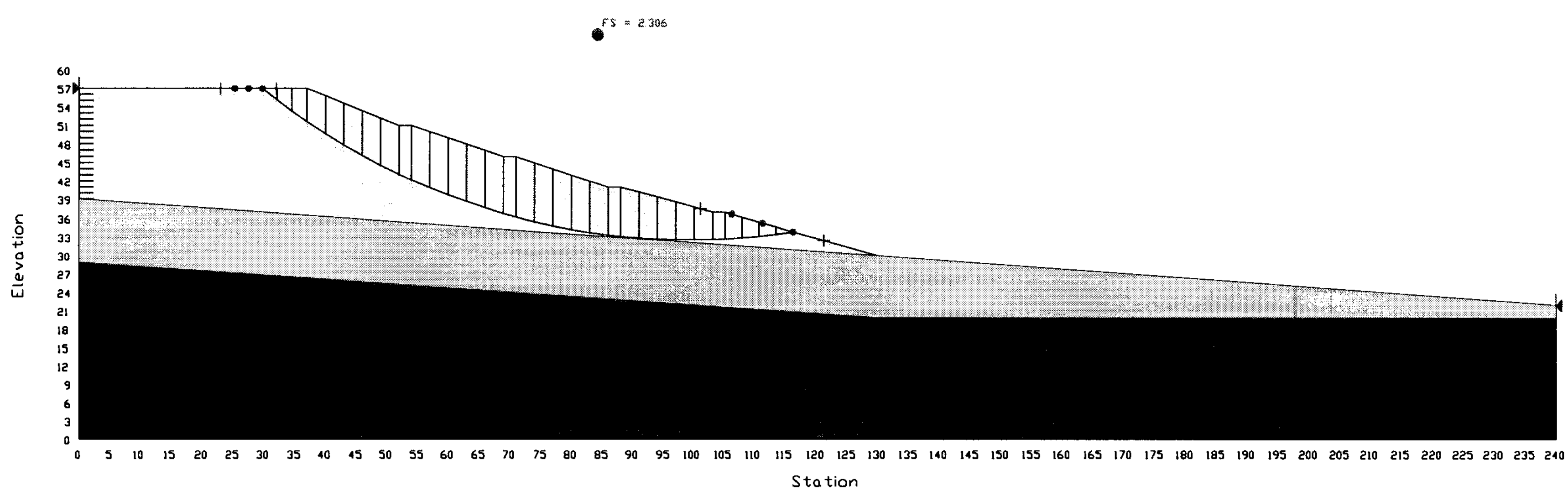
	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

1	1	1.755	(69.056, 121.19)	71.669	(38, 56.6)	(47, 53)

Slices of Slip Surface: 1

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1	38.15	56.528305	0	1.1298429	0.79112453	0
2	1	38.45	56.38577	0	3.3136915	2.3202718	0
3	1	38.75	56.24493	0	5.3407963	3.7396659	0
4	1	39.05	56.105775	0	7.2114904	5.04954	0
5	1	39.35	55.968305	0	8.9260932	6.2501177	0
6	1	39.65	55.8325	0	10.484654	7.3414339	0
7	1	39.95	55.698345	0	11.886957	8.3233369	0
8	1	40.25	55.565835	0	13.133115	9.1959065	0
9	1	40.55	55.434965	0	14.2236	9.9594719	0
10	1	40.85	55.30572	0	15.157983	10.613734	0
11	1	41.15	55.17809	0	15.936799	11.159067	0
12	1	41.45	55.05207	0	16.559684	11.595216	0
13	1	41.75	54.92765	0	17.026618	11.922166	0
14	1	42.05	54.804815	0	17.337921	12.140143	0
15	1	42.35	54.68356	0	17.493629	12.249171	0
16	1	42.65	54.56388	0	17.493501	12.249081	0
17	1	42.95	54.44576	0	17.337635	12.139942	0
18	1	43.25	54.329195	0	17.026153	11.921841	0
19	1	43.55	54.214175	0	16.559206	11.594881	0
20	1	43.85	54.100695	0	15.936354	11.158756	0
21	1	44.15	53.988745	0	15.157487	10.613387	0
22	1	44.45	53.87832	0	14.22314	9.95915	0
23	1	44.75	53.76941	0	13.132953	9.1957926	0
24	1	45.05	53.662005	0	11.886572	8.323067	0
25	1	45.35	53.556105	0	10.484614	7.3414056	0
26	1	45.65	53.4517	0	8.9261523	6.2501591	0
27	1	45.95	53.34878	0	7.2121642	5.0500118	0
28	1	46.25	53.24734	0	5.3414492	3.740123	0
29	1	46.55	53.147375	0	3.3147164	2.3209894	0
30	1	46.85	53.04888	0	1.13169	0.79241788	0

Soil Properties	Coal Waste	Spoils	Bedrock
Unit Weight (pcf)	115	110	120
Cohesion (psf)	100	0	5000
Angle of Friction (degrees)	25	38	25



Title: SLOPE STABILITY SLIP SURFACE DIAGRAM	Date: 6/17/09		North West Colorado Consultants, Inc.
Job Name: Proposed RDA Expansion	Job No. 08-7915		Geotechnical / Environmental Engineering · Materials Testing
LOCATION: Twentymile Coal-Foidel Creek Mine, Routt County, CO	Figure #C-4		

(970)879-7888 · Fax (970)879-7891
2580 Copper Ridge Drive
Steamboat Springs, Colorado 80487

SLOPE/W Analysis

File Information

Revision Number: 49
Date: 5/21/2009
Time: 3:32:06 PM
File Name: WC 25 phi 100 psf c.gsz
Directory: \\Jfrap\josh frappart\My Documents\20 Mile Coal Refuse Pile Exspansion\
Last Solved Date: 5/21/2009
Last Solved Time: 3:32:12 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Bishop, Ordinary and Janbu
Settings
  PWP Conditions Source: (none)
SlipSurface
  Direction of movement: Left to Right
  Use Passive Mode: No
  Slip Surface Option: Entry and Exit
  Critical slip surfaces saved: 1
  Optimize Critical Slip Surface Location: No
FOS Distribution
  FOS Calculation Option: Constant
Advanced
  Number of Slices: 30
  Optimization Tolerance: 0.01
  Minimum Slip Surface Depth: 0.1 ft
  Optimization Maximum Iterations: 2000
  Optimization Convergence Tolerance: 1e-007
  Starting Optimization Points: 8
  Ending Optimization Points: 16
  Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 Â°
Resisting Side Maximum Convex Angle: 1 Â°

Materials

Waste Coal

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 25 Â°
Phi-B: 0 Â°

Spoils

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion: 0 psf
Phi: 38 Â°
Phi-B: 0 Â°

Bedrock

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 5000 psf
Phi: 25 Â°
Phi-B: 0 Â°

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (23, 57) ft
Left-Zone Right Coordinate: (32, 57) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (101, 37.53333) ft
Right-Zone Right Coordinate: (121, 32.52) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 57) ft
Right Coordinate: (240, 22) ft

Critical Slip Surfaces

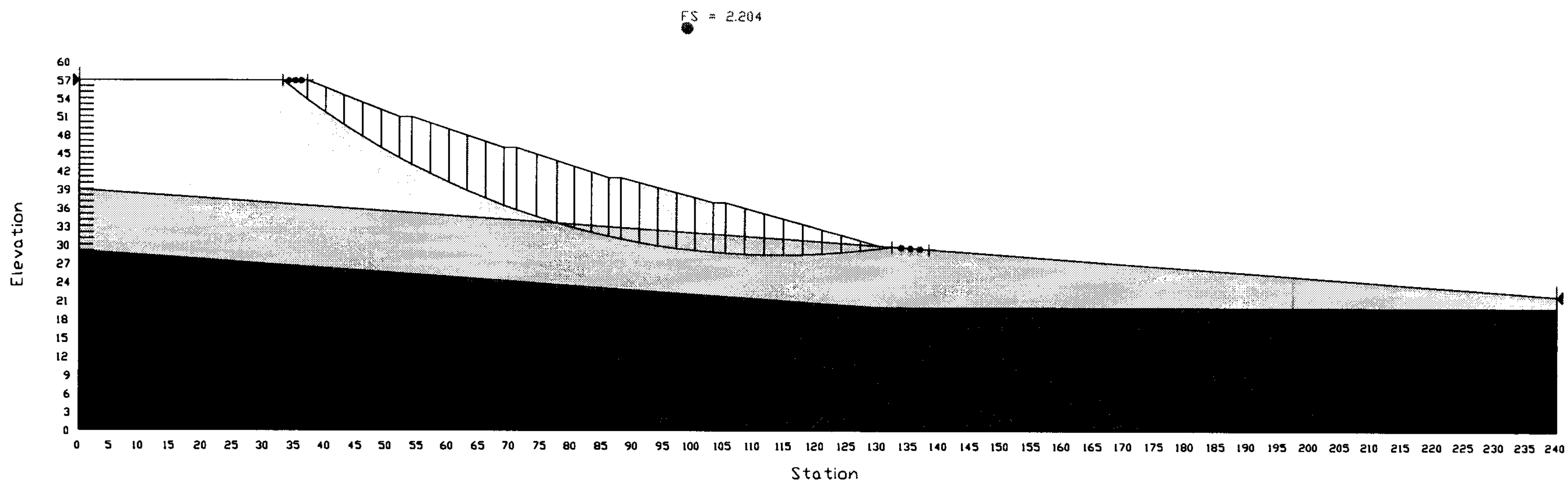
	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

1	92	2.306	(99.008, 143.078)	110.482	(29.75, 57)	(116.02, 33.9143)

Slices of Slip Surface: 92

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	92	30.958335	56.055115	0	64.550765	30.100516	100
2	92	33.375	54.217745	0	250.5229	116.82075	100
3	92	35.791665	52.482105	0	428.797	199.95132	100
4	92	38.5	50.6569	0	558.18013	260.28367	100
5	92	41.5	48.760265	0	635.77345	296.46603	100
6	92	44.5	46.99473	0	700.64147	326.71448	100
7	92	47.5	45.35317	0	753.27296	351.25695	100
8	92	50.5	43.82943	0	793.97475	370.23651	100
9	92	53	42.638235	0	861.92593	401.92266	100
10	92	55.5	41.53745	0	931.43105	434.33343	100
11	92	58.5	40.30351	0	963.71135	449.38598	100
12	92	61.5	39.170825	0	985.30384	459.45473	100
13	92	64.5	38.136115	0	996.34836	464.60487	100
14	92	67.5	37.1965	0	997.02461	464.92021	100
15	92	70	36.47801	0	1026.7628	478.78736	100
16	92	72.5	35.83512	0	1048.3492	488.85327	100
17	92	75.5	35.137665	0	1022.2048	476.66194	100
18	92	78.5	34.52759	0	985.95807	459.7598	100
19	92	81.5	34.003425	0	939.63867	438.16071	100
20	92	84.5	33.563935	0	883.24971	411.86611	100
21	92	87	33.255875	0	866.68456	404.14165	100
22	92	89.5	33.016945	0	853.38808	397.9414	100
23	92	92.5	32.798835	0	793.11997	369.83792	100
24	92	95.5	32.66265	0	722.76858	337.03252	100
25	92	98.5	32.60809	0	642.25982	299.49067	100
26	92	101.5	32.63503	0	551.45975	257.1499	100
27	92	104	32.7141	0	499.40436	232.87608	100
28	92	106.37755	32.851425	0	441.58289	205.91348	100
29	92	109.1326	33.0703	0	328.95916	153.39618	100
30	92	111.88765	33.358775	0	206.95977	96.506928	100
31	92	114.6427	33.717405	0	75.380947	35.150713	100

Soil Properties	Coal Waste	Spoils	Bedrock
Unit Weight (pcf)	115	110	120
Cohesion (psf)	0	0	5000
Angle of Friction (degrees)	30	30	25



Title: SLOPE STABILITY SLIP SURFACE DIAGRAM

Date: 6/17/09

Job Name: Proposed RDA Expansion

Job No. 08-7915

LOCATION: Twentymile Coal-Foidel Creek Mine, Routt County, CO

Figure #C-5

NWCC North West Colorado Consultants, Inc.
Geotechnical / Environmental Engineering · Materials Testing
(970)879-7888 · Fax (970)879-7891
2580 Copper Ridge Drive
Steamboat Springs, Colorado 80487

SLOPE/W Analysis

File Information

Revision Number: 64
Date: 5/21/2009
Time: 3:12:29 PM
File Name: global.gsz
Directory: \\Jfrap\josh frappart\My Documents\20 Mile Coal Refuse Pile Exspansion\
Last Solved Date: 5/21/2009
Last Solved Time: 3:12:34 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Bishop, Ordinary and Janbu
Settings
- PWP Conditions Source: (none)

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No

FOS Distribution
- FOS Calculation Option: Constant

Advanced
- Number of Slices: 30
- Optimization Tolerance: 0.01
- Minimum Slip Surface Depth: 0.1 ft
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 Â°
Resisting Side Maximum Convex Angle: 1 Â°

Materials

Waste Coal

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 30 Â°
Phi-B: 0 Â°

Spoils

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion: 0 psf
Phi: 30 Â°
Phi-B: 0 Â°

Bedrock

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 5000 psf
Phi: 25 Â°
Phi-B: 0 Â°

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (33, 57) ft
Left-Zone Right Coordinate: (37, 57) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (132, 29.85455) ft
Right-Zone Right Coordinate: (138, 29.41818) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 57) ft
Right Coordinate: (240, 22) ft

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

1	2	2.204	(113.432, 156.236)	127.738	(33, 57)	(132, 29.8546)

Slices of Slip Surface: 2

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	2	35	55.44369	0	148.67699	85.838701	0
2	2	38.5	52.800735	0	347.90242	200.86156	0
3	2	41.5	50.69179	0	439.91428	253.98463	0
4	2	44.5	48.7079	0	521.11527	300.86604	0
5	2	47.5	46.842255	0	591.73523	341.6385	0
6	2	50.5	45.088895	0	652.09515	376.48731	0
7	2	53	43.70258	0	735.72587	424.77153	0
8	2	55.5	42.402195	0	821.74021	474.43193	0
9	2	58.5	40.924255	0	876.82474	506.235	0
10	2	61.5	39.54215	0	922.62846	532.67979	0
11	2	64.5	38.25251	0	959.27212	553.83602	0
12	2	67.5	37.05233	0	986.88211	569.77665	0
13	2	70	36.11269	0	1038.6926	599.68945	0
14	2	72.648415	35.19571	0	1083.69	625.6687	0
15	2	75.94525	34.13421	0	1087.5667	627.90693	0
16	2	78.994725	33.23587	0	1080.7042	623.94484	0
17	2	81.796835	32.48545	0	1064.7534	614.73566	0
18	2	84.598945	31.80265	0	1041.4932	601.30638	0
19	2	87	31.266505	0	1052.5157	607.67023	0
20	2	89.5	30.768885	0	1067.095	616.0876	0
21	2	92.5	30.23359	0	1042.9405	602.14199	0
22	2	95.5	29.77172	0	1010.6574	583.50332	0
23	2	98.5	29.382465	0	970.13584	560.10819	0
24	2	101.5	29.065165	0	921.32023	531.92448	0
25	2	104	28.85039	0	904.92277	522.45741	0
26	2	106.5625	28.6922	0	878.05545	506.94555	0
27	2	109.6875	28.562225	0	799.04835	461.33078	0
28	2	112.8125	28.508825	0	710.61559	410.2741	0
29	2	115.9375	28.53191	0	612.58599	353.67669	0
30	2	119.0625	28.63152	0	504.75681	291.42148	0
31	2	122.1875	28.80783	0	386.95964	223.41125	0

32	2	125.3125	29.061165	0	258.9206	149.48788	0
33	2	128.4375	29.391985	0	120.38292	69.50311	0
34	2	131	29.71569	0	24.152766	13.944606	0